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Late Quaternary foraminiferal, molluscan and ostracod assemblages from a core succession in the Trigno River mouth area (Central Adriatic Sea, Italy)

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KEY WORDS - Foraminifers, Molluscs, Ostracods, Core, late Quaternary, Central Adriatic Sea.

ABSTRACT - The results of palaeontological analyses carried out on foraminifers, molluscs and ostracods from a 15 m thick core (MBS3), drilled offshore in the Trigno River mouth area (northern sector of the Molise Adriatic coast), ca. 200 m from the present coastline, are reported.

Four main lithostratigraphic units were recognised in the core. At the bottom, 1.8 m thick, barren gravels (unit A), are present. Grey clays (unit B), 1.5 m thick, containing freshwater and terrestrial molluscs, freshwater ostracods and reworked marine foraminifers and ostracods, overlay unit A. Brown silty clays (unit C), 2.7 m thick, containing marine foraminifers and ostracods, rare marine molluscs, and subordinate freshwater ostracods, follow. The core is closed up by brown sands (unit D), 9 m thick, recording the dominance of marine foraminifers, molluscs and ostracods. Chronological constraints for the studied sedimentary succession are based on AMS (Accelerator Mass Spectrometry) radiocarbon dating.

The lower gravel unit A of the core MBS3 deposited in an alluvial environment. The sedimentological and palaeontological characters of unit B indicate marshy freshwater environments. Two AMS C dates of this unit gave ages of 19945 ± 345 and 19165 ± 195 yr cal BP, respectively. The sedimentological and palaeontological characters of unit C indicate the development in the Trigno River mouth area of a bay or outer estuarine environment. Finally, as revealed by the deposition of unit D, about 8000-8200 yr BP a shoreface developed in the Trigno mouth area.

RIASSUNTO - [Associazioni a foraminiferi, molluschi e ostracodi del tardo Quaternario in sedimenti carotati alla foce del Fiume Trigno (Adriatico centrale, Italia)] - *In questo lavoro sono illustrati i risultati delle analisi paleontologiche (foraminiferi, molluschi e ostracodi) effettuate su una carota di sedimenti (MBS3) prelevata a mare nel settore settentrionale della costa molisana, a poca distanza dalla foce del fiume Trigno, a circa 200 m dalla attuale linea di costa dove il fondale è situato circa quattro metri sotto il livello del mare.*

La carota MBS3, avente una lunghezza di 15 metri, può essere suddivisa litostratigraficamente, procedendo dal basso, in un intervallo ghiaioso (unità A, 1,8 m) su cui poggiano argille grigie (unità B, 1,5 m), seguite da argille limose brune (unità C, 2,7 m) e, infine, da sabbie dello spessore di 9 metri (unità D). Quarantasei campioni di sedimento prelevati lungo la carota sono stati sottoposti ad analisi paleontologiche. L'inquadramento cronologico della carota è basato su tre datazioni al radiocarbonio, di cui due relative all'unità B e una alla base dell'unità D.

L' unità A è risultata sterile. Nell'unità B sono presenti associazioni a foraminiferi, molluschi e ostracodi. I foraminiferi sono presenti con esemplari rimaneggiati; le associazioni a molluschi sono povere e oligotipiche, e composte da gasteropodi terrestri o di acque dolci. Le associazioni a ostracodi rivelano la presenza di esemplari di specie sia dulcicole autoctone sia marine rimaneggiate. Nell'unità C predominano le faune marine; fra i foraminiferi sono presenti associazioni abbastanza diversificate. Le associazioni a molluschi sono povere sia di esemplari sia di specie. Anche fra gli ostracodi predominano le specie marine, mentre è meno significativa la presenza di specie dulcicole. Infine nell'unità D sono presenti associazioni faunistiche composte prevalentemente da specie marine; per quanto riguarda i foraminiferi le associazioni sono meno diversificate rispetto a quelle dei campioni dell'unità C; le associazioni a molluschi e ostracodi sono invece più ricche di esemplari e maggiormente diversificate rispetto a quelle delle unità precedenti.

La deposizione dell'unità ghiaiosa inferiore (A) è riferibile a un ambiente fluviale. Per quanto riguarda l'unità B, le sue caratteristiche litologiche e il contenuto faunistico indicano la presenza di ambienti palustri con acque dolci. Le due datazioni effettuate su questa unità hanno restituito età rispettivamente di 19945 ± 345 e 19165 ± 195 anni cal BP. Le caratteristiche litologiche e il contenuto fossilifero dell'unità C sono riconducibili a un ambiente di baia o di estuario esterno. L'unità D sabbiosa, in cui prevalgono le associazioni faunistiche marine, testimonia l'instaurarsi nell'area di studio di un ambiente marino di spiaggia sommersa a partire da circa 8000-8200 anni fa.

INTRODUCTION

The study of fossil assemblages, finalised to palaeoenvironmental reconstructions, is an useful tool to investigate the phenomena associated with sea level changes occurred in the past (e.g., Barra et al., 1996; Mazzini et al., 1999; Carboni et al., 2010; Aucelli et al., 2012).

During the Last Glacial Maximum (LGM), about 22 ky BP, global sea level was about 130 m lower than today

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(Yokoyama et al., 2000; Siddal et al., 2003; Vai & Cantelli, 2004). The subsequent phase of deglaciation led to the sea level rise up to the present day values causing great physiographic and environmental changes, particularly in the low coast sectors (e.g., Vai & Cantelli, 2004).

The Mediterranean area and, particularly, the Italian Peninsula have been object of research interests in recent years, which also involved palaeontological analyses, aimed to investigate the various aspects and processes that characterised the post-LGM marine transgression, at global, regional and local scale (e.g., Barra et al., 1996; Mazzini et al., 1999; Fiorini & Vaiani, 2001; Lambeck et al., 2004; Lambeck & Purcell, 2005; Amorosi et al., 2008; Carboni et al., 2010; Aucelli et al., 2012).

The analysis of a core (MBS3), drilled in front of the Trigno River mouth (Fig. 1), was part of a multidisciplinary study aimed to reconstruct the late Quaternary palaeoenvironmental evolution of the northern sector of the Molise coast (Frezza et al., 2012). The results of the palaeontological analyses (foraminifers, molluscs and ostracods), carried out on the core MBS3, are hereby reported.

GEOLOGICAL SETTING

The northernmost sector of the Molise coast, including the Trigno River mouth (Fig. 1), is located at the junction between the two major structural arcs of the Apenninic chain (Patacca et al., 1992). A transgressive-regressive sedimentary succession, which forms the local filling of the Plio-Pleistocene foredeep basin, crops out in this area (Bracone et al., 2012a, b and references therein). This succession is made up of marine blue clays (Montesecco Clays, Upper Pliocene-Lower Pleistocene p.p.) overlain by nearshore yellow sands (Serracapriola Sands, Lower Pleistocene) covered in turn by predominantly fluvial conglomerates (Campomarino Conglomerates, Middle Pleistocene). The Montesecco Clays mainly crop out near the coastal alluvial plain of the Trigno River (Bracone et al., 2012a).

In the study area late Quaternary units consist of mostly terraced alluvial deposits made up of gravels, sands and clays. Clayey-sandy colluvial deposits widely cover the fluvial scarps that border the Trigno River valleyfloor. The alluvial coastal plain of the Trigno River is characterised by sandy to gravelly fluvial sediments, alternating with swamp-back barrier clays and backshore-foreshore sands (Aucelli et al., 2009). The recent evolution of this sector of the Molise coast is characterised by a strong coastline retreat, which started from the beginning of the 20th century and is partially still active (Aucelli et al., 2009).

MATERIALS AND METHODS

The core MBS3 is 15 m long and has a diameter of 10 cm. It was drilled offshore ca. 200 m from the present coastline, 4.1 m below sea level and ca. 600 m north of the Trigno River mouth (Fig. 1b). Coring was performed through a continuous perforating system guaranteeing high recovery percentages. The core is stored at the

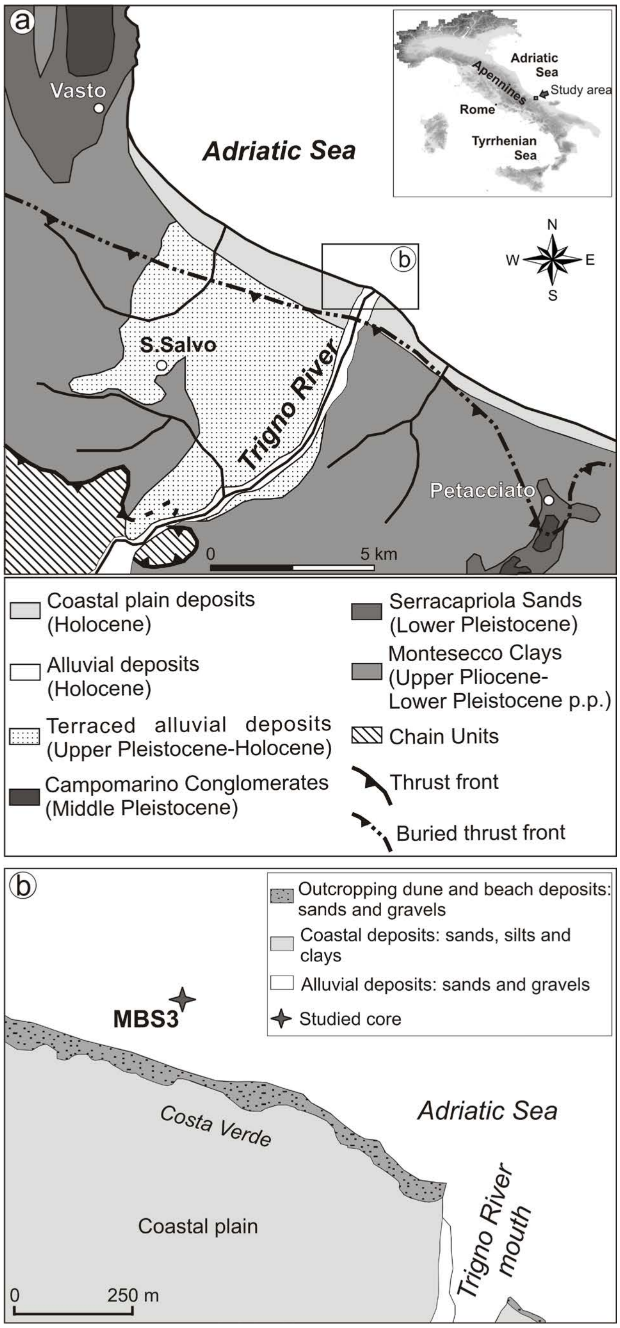

Fig. 1 - a) Geological sketch of the Molise-Abruzzo coastal sector including the Trigno River mouth area and b) close up of the Trigno River mouth area with the location of the studied core MBS3.

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The core succession has been characterised in terms of main lithostratigraphical units on the basis of its sedimentological features. The chronological framework relies on three AMS C dates. Particularly, plant remains of two samples collected from clayey deposits were analysed at the Centro di Datazione e Diagnostica (CEDAD, Università di Lecce, Italy), while benthic foraminifers (*Ammonia* spp.) of a sample collected from a sandy unit were analysed at the Centro di Ricerche Isotopiche per i Beni Culturali e Ambientali (CIRCE, Caserta, Italy).

A total of 46 samples (dried weight ranging from 100 to 200 g) were collected from the core for palaeontological analyses. The samples were dried (ca. 24 h at 50 °C), soaked in 20% H_2O_2 (ca. 48 h), gently washed over 63 µm sieves and then dried (ca. 24 h at 50 °C).

Foraminifers, molluscs and ostracods were studied using a binocular microscope and SEM.

Benthic and planktonic foraminifers were classified according to Loeblich & Tappan (1987). Moreover, the identification of benthic foraminifers was also based on Cimerman & Langer (1991), Sgarrella & Moncharmont Zei (1993) and Fiorini & Vaiani (2001), whereas for the planktonic foraminifers Kennet & Srinivasan (1983) and Hemleben et al. (1989) were considered.

Molluscs were identified mostly according to Kerney & Cameron (1979), Cossignani et al. (1992) and Cesari (1994). Taxonomy of the species follows both the World Register of Marine Species (WoRMS) database for marine taxa (accessed at http://www.marinespecies.org on 2012-07-08) and the Italian Ministry of Environment's Checklist of the Italian Fauna (accessed at http://www.faunaitalia.it/checklist/ on 2012-07-08) for non-marine taxa. Ecology of marine species was defined after Pérès & Picard (1964), Pérès (1982), Todd (2001) and Rueda et al. (2009); that of non-marine species follows Kerney & Cameron (1979) and Kerney (1999).

Ostracod species have been identified according to classic and recent literature dealing with Neogene-Recent Mediterranean ostracod taxa (e.g., Müller, 1894; Barbeito-Gonzalez, 1971; Bonaduce et al., 1976; Breman, 1976; for extensive references see Aiello & Barra, 2010).

Taxa of foraminifers, molluscs and ostracods have been considered autochthonous, displaced or reworked depending on assemblages' general features, specimen's preservation and the stratigraphical context in which the fauna was recovered.

Studied specimens of foraminifers, molluscs and ostracods are housed in the Collezione Micropaleontologica at the Dipartimento di Scienze della Terra, Sapienza Università di Roma, in the Collezione Malacologica at the Dipartimento di Bioscienze e Territorio, Università degli Studi del Molise, and in the Aiello & Barra Micropaleontological Collection (A.B.M.C.), at the Dipartimento di Scienze della Terra, dell'Ambiente e delle Risorse, Università degli Studi di Napoli Federico II, respectively.

The lists, including ecological groups of foraminiferal, mollusc and ostracod species and their distribution along the core succession, are reported in the Supplementary Online Material.

RESULTS

On the whole, along the core 83 species of foraminifers (six in open nomenclature), 66 species of molluscs (21 in open nomenclature) and 49 species of ostracods (9 in open nomenclature) were found (Supplementary Online Material).

Among foraminifers only 33 species, typical of infralittoral zone, were considered autochthonous whereas the remaining 37 benthic species, normally living in the circalittoral-bathyal zones (Supplementary Online Material), and planktonic taxa can be considered reworked from the Montesecco Clays, a Plio-Pleistocene marine formation cropping out near the study area (Bracone et al., 2012a) and eroded by the Trigno River. Any alteration or erosional signs affected the foraminiferal tests so that their conservation status can be considered generally good.

Molluscs comprise 53 marine infralittoral, 12 terrestrial and one freshwater taxa (Supplementary Online Material). All the identified species have previously been reported from the modern non-marine and marine settings of the Mediterranean area. Conservation status of shells is generally good.

Ostracod taxa have been divided into four ecological groups (1, 2, 3 and 4) (Supplementary Online Material). Group 1 ("shallow marine water species") comprises shallow marine water taxa mostly living in the Mediterranean. They are well preserved in most of the samples and present both adult and juvenile specimens. This group comprises species mainly considered autochthonous. Group 2 ("freshwater species") consists of ostracod taxa currently encountered in continental waters. These species have alternatively been considered as either autochthonous, thus indicating non-marine palaeoenvironment, or as displaced on sea bottom sediments. Group 3 is monospecific, including only the euryhaline species *Cyprideis torosa* (Jones, 1850). Finally, group 4 ("reworked species") is formed by specimens preserved in the Plio-Pleistocene Montesecco Clays cropping out near the study area, subsequently eroded and transported towards the coast by the Trigno River. The valves of species of this latter group show various states of preservation; they are frequently darkened, sometimes well preserved, and represent species typical of an outer circalittoral - bathyal palaeoenvironment, which is consistent with the palaeoenvironmental interpretation of the Montesecco Clays given by Bracone et al. (2012a). A limited number of taxa - e.g., *Acanthocythereis hystrix* (Reuss, 1850), *Costa batei* (Brady, 1866), *Cytherella vulgatella* Aiello, Barra, Bonaduce & Russo, 1996, *Cytheropteron ruggierii* Pucci, 1955 - is dubitatively assigned to group 4 due to insufficient data (Supplementary Online Material).

In the following sections results of palaeontological analyses are described in the context of the lithostratigraphical framework of the MBS3 core. It is formed, from bottom to top, starting from 19.10 m below sea level, by four lithostratigraphical units (Fig. 2):

Unit A (15.00-13.20 m core depth)

It consists of matrix supported gravels, 1.8 m thick, made up of heterometric and poorly sorted sub-spherical calcareous clasts; the matrix consists of light brown silty sands. This unit is devoid of fossils.

Unit B (13.20-11.70 m core depth)

It overlays unit A and is made up of 1.5 m thick homogeneous grey clays. Two AMS radiocarbon dates obtained from plant remains from the base and the top of this unit, gave ages of 19945 ± 345 and 19165 ± 195 yr cal BP, respectively (Fig. 2, Tab. 1).

In unit B foraminiferal tests are few and two samples (12.90 and 12.60 m core depth) are barren. In the samples where foraminifers were recovered, species

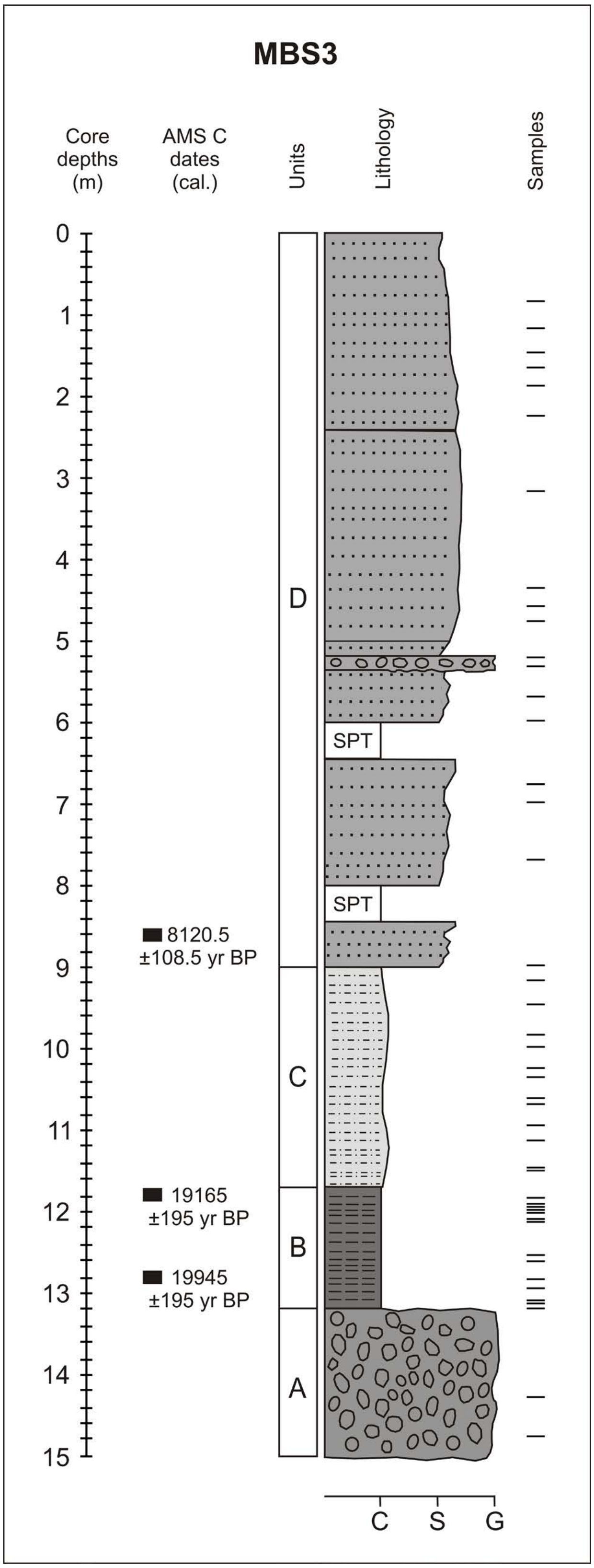

Fig. 2 - Lithostratigraphy of the core MBS3. SPT in the lithological column indicates lacking intervals due to Standard Penetrometric Test. C = Clay, S = Sand, G = Gravel.

richness ranges from one to 10 (Fig. 3). Foraminiferal assemblages are constituted of reworked benthic species

Sample identifier	LTL4940A	LTL5282A	DSH1637
Material	plant remains	plant remains	*Ammonia* spp.
Laboratory	CEDAD Lecce	CEDAD Lecce	CIRCE Caserta
Core depth (m)	12.8	11.90	8.6
Depth b.s.l. (m)	16.91	16.01	12.71
Stratigraphic unit	B	B	D
Radiocarbon age	16778 ± 150	15883 ± 90	7220±59
$\delta^{13}C$ (%)	-39.5 ± 0.6	-30.9 ± 0.5	-3±2
Calibrated age 2σ (95.4%)	19945 ± 345 yr BP	19165 ± 195 yr BP	8120.5 ± 108.5 yr BP

Tab. 1 - AMS C dates for selected samples in the studied core.

- e.g., *Ammonia* spp., *Cassidulina carinata* Silvestri, 1896, *Cassidulina crassa* d'Orbigny, 1839a, *Cibicidoides pseudoungerianus* (Cushman, 1931), *Globocassidulina subglobosa* (Brady, 1884), *Uvigerina mediterranea* Hofker,1932 - and planktonic taxa (globigerinids, globorotalids, neogloboquadrinids and *Orbulina universa* d'Orbigny, 1839b) probably coming from the Montesecco Clays (Bracone et al., 2012a).

Molluscs are completely lacking in the lower portion of unit B, from 13.20 to 13.00 m core depth. The remaining upper part of this unit is characterised by poor and low-diversity (oligotypical) molluscan assemblages (species richness ranging from one to three) (Fig. 3), composed of freshwater and prevailing terrestrial taxa typical of marshy environments, such as *Galba truncatula* (O.F. Müller, 1774), *Succinea* sp., *Truncatellina cylindrica* (Férussac, 1807), *Vallonia pulchella* (O.F. Müller, 1774), *Punctum pygmaeum* (Draparnaud, 1801), *Vitrinobrachium breve* (Férussac, 1821), Helicidae indet. and Limacidae indet.

Also ostracods are quite poorly abundant in unit B. They were found from 13.20 to 12.87 m core depth. Samples containing ostracods show a species richness ranging from one to four (Fig. 3). In sample at 12.80 m core depth a few allochthonous specimens of *Pontocythere turbida* (G.W. Müller, 1894) were observed (group 1: "shallow marine water species"). In the upper portion of the unit, except for the sample at 12.07 m core depth, where only very rare *Loxoconcha ovulata* (O.G. Costa, 1853) and *Semicytherura incongruens* (G.W. Müller, 1894) specimens (group 1) were recovered, ostracod assemblages are dominated by species pertaining to the ecological group 2 ("freshwater species") with subordinate species included in group 1 (Fig. 3).

Unit C (11.70-9.00 m core depth)

It consists of 2.7 m thick brown consolidated silty clays.

Foraminiferal assemblages in this unit show higher values of species richness, ranging from two to 23 (Fig. 3), compared to those in unit B. The assemblages are constituted by few benthic specimens of typical infralittoral taxa,

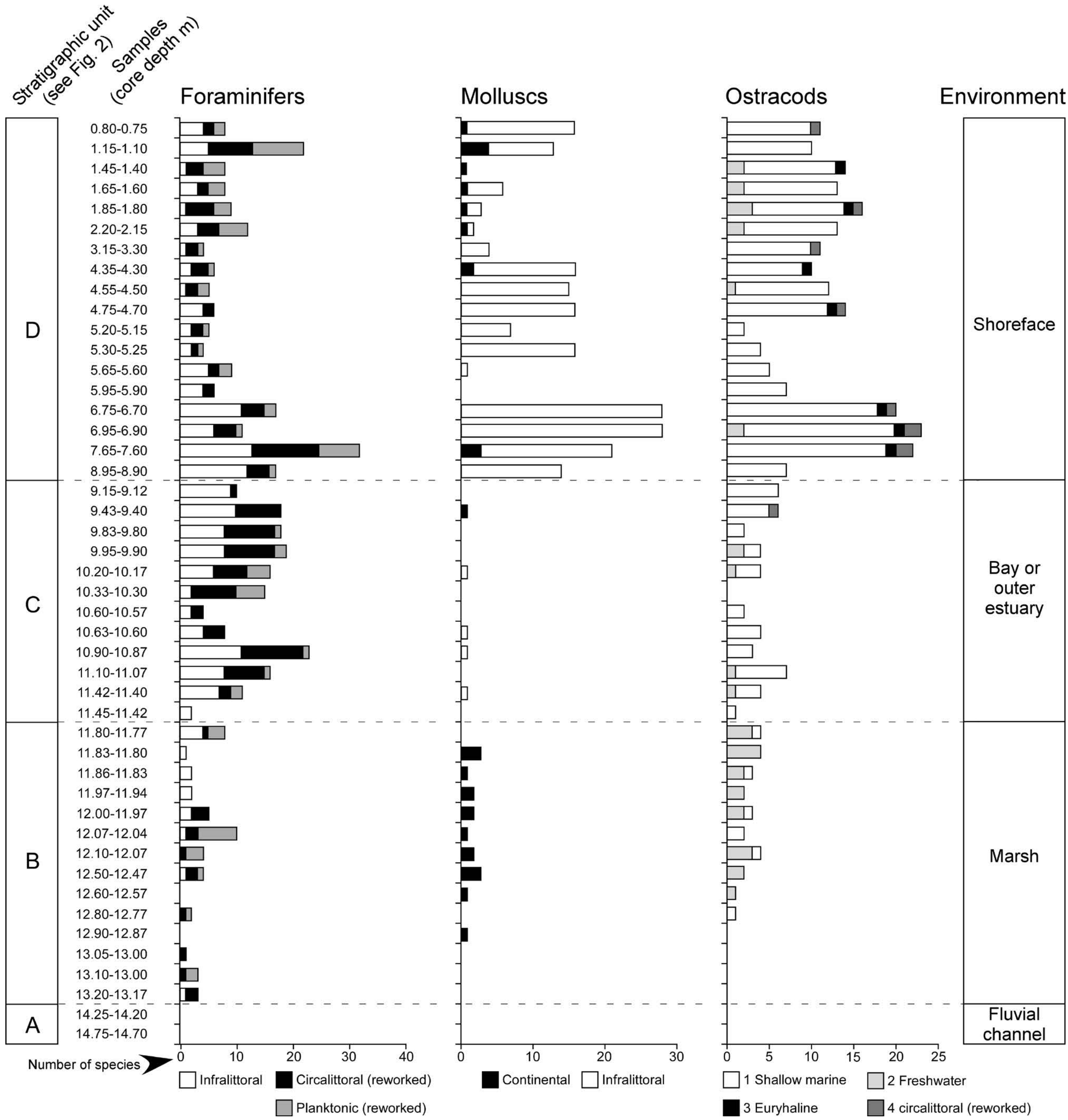

Fig. 3 - Comparative diagrams showing the distribution of the number of species for foraminifers, molluscs and ostracods and their ecological meaning in the analysed samples of the core MBS3. Reworked taxa (circalittoral foraminifers and ostracods, planktonic foraminifers) are also reported to show the reworking degree recorded along the core. The palaeoenvironmental interpretation of the core is also reported.

generally represented by *Ammonia beccarii* (Linnaeus, 1758), *Ammonia inflata* (Seguenza, 1862), *Ammonia papillosa* (d'Orbigny 1850) and *Quinqueloculina seminulum* (Linnaeus, 1758). In some samples (at 10.90, 10.33 and 9.83 m core depth) foraminiferal assemblages are affected by a high reworking degree for the abundance of *Bulimina marginata* d'Orbigny, 1826, *C. carinata* and *Valvulineria bradyana* (Fornasini, 1900), species normally living in the circalittoral zone, and rare planktonic foraminifers represented mainly by *Globigerina bulloides* d'Orbigny, 1826, *Globorotalia scitula* (Brady, 1882), *Neogloboquadrina dutertrei* (d'Orbigny, 1839b) and *Turborotalita quinqueloba* (Natland, 1938).

A. beccarii and *A. inflata* are common in the shallow-marine sediments, especially in front of river deltas (Cimerman & Langer, 1991; Bellotti et al., 1994; Muñoz et al., 1996; Mendes et al., 2004; Frezza & Carboni, 2009). *A. papillosa* is characteristic of sandy bottoms and strong hydrodynamic energy (Tomadin et al., 1984). *Q. seminulum*, the most frequent miliolid of this assemblage, is widely distributed from marshy and coastal environments but can also occur in the circalittoral zone (Albani & Serandrei Barbero, 1990; Sgarrella & Moncharmont Zei, 1993; Frezza & Carboni, 2009).

Among molluscs, marine infralittoral species are scanty (Fig. 3) and represented by juveniles of *Bittium reticulatum* (Da Costa, 1778), *Lucinella divaricata* (Linnaeus, 1758) and *Striarca lactea* (Linnaeus, 1758). The first taxon is a soft bottoms epifaunal and micro-herbivore species (Rueda et al., 2009), usually quite abundant, characteristic of the *Posidonia* meadows biocoenosis (HP; Pérès & Picard, 1964; Pérès, 1982), but lives on all kinds of infralittoral, usually vegetated bottoms; *L. divaricata* is a soft bottom infaunal and symbiont-bearing species (Rueda et al., 2009) typical of the upper muddy-sands in sheltered areas biocoenosis (SRPV; Pérès & Picard, 1964; Pérès, 1982). Finally *S. lactea* is a hard bottoms epifaunal and filter feeder species (Todd, 2001), and on the basis of the sedimentological characters of unit C (clays) can be considered displaced.

In unit C ostracods are not abundant; the assemblages generally show higher values of both species richness, ranging from one to seven (Fig. 3), and abundance compared to those in unit B. Marine taxa, included in group 1, prevail, followed by subordinate continental species (group 2). Very rare reworked specimens of *C. ruggierii* (group 4) also occur.

Unit D (9.00-0.00 m core depth)

It consists of nine m thick brown sands. From its base to 6.45 m core depth, it is made up of fine to medium brown sands with local centimetric silty layers. From 6.00 to 5.00 m core depth, fine to medium amalgamated brown, silty sands are present; particularly, between 5.35 and 5.15 m core depth, an about 20 cm thick layer of matrix-supported gravels with well-rounded pebbles and cobbles is present. Fine-grained sands are present from 5.00 to 2.40 m core depth. The upper portion of the unit (and therefore of the core succession) is characterised by medium to fine brown sands with local silty sands and dark grey organic matter. The lower boundary of this unit is characterised by an erosional surface. An AMS radiocarbon date of the lower part of unit D gave an age of 8120.5 ± 108.5 yr cal BP (Fig. 2, Tab. 1).

In this unit foraminiferal assemblages show values of species richness ranging from four to 32 (Fig. 3). The foraminiferal assemblages are characterised by shallow water species, among which *A. beccarii*, *Ammonia parkinsoniana* (d'Orbigny, 1839b), *Buccella granulata* (Di Napoli Alliata, 1952) and *Elphidium granosum* (d'Orbigny, 1846) are the most frequent. *A. parkinsoniana*, which is the most frequent species, is commonly found in shallow Mediterranean, marine waters, mostly on sandy bottoms (Sgarrella & Moncharmont-Zei, 1993). It tolerates salinity variations in environments influenced by fresh-waters input (Jorissen, 1988; Carboni & Di Bella, 1996; Frezza & Carboni, 2009). *B. granulata* is found in infralittoral sands, and also near river mouths (Jorissen, 1988; Sgarrella & Moncharmont-Zei, 1993). *E. granosum* is recorded from lagoonal and shallow marine sediments (Albani & Serandrei Barbero, 1990; Bellotti et al., 1994; Frezza & Carboni, 2009).

In unit D molluscan assemblages are generally more diversified and richer than those of the previous units (Fig. 3). In its lower portion, from 8.95 to 6.70 m core depth, shells are abundant and well preserved. The assemblages are composed of marine infralittoral taxa typical of different biocoenoses. Soft bottom infaunal species strongly prevail, mainly with filter feeders, i.e, *Chamelea gallina* (Linnaeus, 1758), *Corbula gibba* (Olivi, 1792), *Donax semistriatus* Poli, 1795, *Dosinia lupinus* (Linnaeus, 1758), *Glycymeris nummaria* (Linnaeus, 1758), *Lentidium mediterraneum* (O.G. Costa, 1829) and *Spisula subtruncata* (Da Costa, 1778). Deposit feeders, namely *Antalis dentalis* (Linnaeus, 1758), *Abra alba* (W. Wood, 1802), and *Tellina nitida* Poli, 1791, microalgae herbivores (*B. reticulatum*) and symbiont-bearing species (*L. divaricata*) are also present.

From 5.95 to 5.25 m core depth only very badly preserved and reworked marine molluscs occur. In particular, rare undeterminable shell fragments were collected at 5.95 m and 5.65 m. Only one specimen of the marine infralittoral species *L. mediterraneum* occurs at 5.65 m (Fig. 3). At 5.30 m, reworked individuals and fragments of different marine infralittoral species - *A. dentalis*, *Bela nebula* (Montagu, 1803), *B. reticulatum*, *Tricolia pullus* (Linnaeus, 1758), *C. gallina*, *C. gibba*, *Dosinia lupinus* (Linnaeus, 1758), *G. nummaria* - are present.

Samples from the remaining upper portion of unit D are generally characterised by molluscan assemblages dominated by the soft bottom infaunal filter feeder species *C. gallina*, *D. semistriatus* and *L. mediterraneum* of the upper clean-sand biocoenosis (SFS; Pérès & Picard, 1964). An exception is represented by the interval 2.20-1.40 m core depth (Fig. 3), which is characterised by the co-occurrence of marine infralittoral and terrestrial mollusc assemblages, both with low species richness and low specimen abundances. Here marine record consists mainly of juvenile individuals and fragments of *B. reticulatum*, *C. gallina*, *D. semistriatus*, *G. nummaria* and *L. mediterraneum*. Non-marine assemblages consist of relatively better preserved *P. pygmaeum*, *Succinea* sp. and *T. cylindrica* specimens, and Helicidae indet. and Hygromiidae indet. shell fragments.

Ostracod assemblages are more diversified and richer than those of the previous units. Species richness ranges from two to 23 (Fig. 3). The assemblages show the strong dominance of group 1; the main species are *Cytheretta subradiosa* (Roemer, 1838), *L. ovulata*, *Loxoconcha rubritincta* Ruggieri, 1964, *Neocytherideis muelleri* (Kruit, 1955), *Palmoconcha turbida* (G.W. Müller, 1912), *Pontocythere turbida* and *S. incongruens*. Groups 2, 3 and 4, considered allochthonous in this unit, are represented by scattered and rare specimens.

DISCUSSION AND CONCLUSIONS

According to its sedimentological characters the gravel unit A of core MBS3 con be referred to an alluvial environment.

In unit B both the lithological features and the taxonomic composition of the molluscan assemblages are indicative of marsh (or flood basin) environments developed in an alluvial setting. This interpretation is consistent with the characters of the ostracod assemblages, which mainly comprise freshwater taxa. The foraminifers and the marine ostracods recovered in unit B are likely reworked from the Montesecco Clay. The two AMS radiocarbon ages of 19945 ± 345 and 19165 ± 195 yr cal BP, respectively (Fig. 2, Tab. 1), are consistent with the inferred continental characters of the sediments. Literature indicates that about 20000 yr BP the sea level was 100-120 m lower than current level and the Adriatic coastline in the study area was located several km seaward with respect to the present one (Antonioli et al., 2000; Vai & Cantelli, 2004).

Both units A and B record the lowstand sedimentation during the Last Glacial Maximum.

Lithological and palaeontological characters of unit C indicate most likely a bay or outer estuarine environment, giving first evidence of the approaching last post-glacial marine transgression in the study area.

On the whole, the sandy unit D, in which marine shallow water assemblages dominate, can be related to a shoreface environment which developed in the study area about 8000-8200 yr BP. The basal erosion surface of this unit is interpreted as the ravinement surface of Swift (1968) and Nummedal & Swift (1987). On the basis of the fossil record, the stratigraphic features and the chronological data, we hypothesize that the lower part of this unit, from about nine to six m core depth, records the last post-glacial marine transgression in the Trigno River coastal plain. The remaining upper portion of unit D is the expression of a prograding shoreface system, which developed probably after the beginning of the mid-Holocene highstand phase. However, the available data are not sufficient to give a precise location of the limit between transgressive and highstand deposits. Generally, our hypotheses are consistent with the sea level change-influenced late Quaternary stratigraphic framework, which was reconstructed along the coastal areas of the Italian Peninsula (e.g., Barra et al., 1996; Mazzini et al., 1999; Amorosi & Milli, 2001; Amorosi et al., 2005; Ricci Lucchi et al., 2006; Aguzzi et al., 2007; Canali et al., 2007; Amorosi et al., 2008; Carboni et al., 2010; Parlagreco et al., 2011; Aucelli et al., 2012).

The sedimentological and paleontological characters of the uppermost portion of unit D record the strong shoreline retreat, which has affected the Trigno River mouth area from the beginning of the 20th century (Aucelli et al., 2009).

However, further stratigraphic, geomorphological, palaeontological and geochronological researches in the Trigno River mouth area and adjacent coastal areas will better clarify the stratigraphic framework and the palaeoenvironmental evolution related to late Quaternary climate changes and relative sea level variations that have affected the Central Adriatic Sea from Late Pleistocene to Holocene times.

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