Il Quaternario
Italian Journal of Quaternary Sciences
9(2), 1996, 445-458

THE VERSILIAN TRANSGRESSION IN THE VOLTURNO RIVER PLAIN (CAMPANIA, SOUTHERN ITALY): PALÆOENVIRONMENTAL HISTORY AND CHRONOLOGICAL DATA (*)

D. Barra[1] - P. Romano[2] - A. Santo[3] - L. Campajola[4] - V. Roca[4] - C. Tuniz[5]
[1]Dip.to di Paleontologia, Università di Napoli "Federico II", Napoli, Italy
[2]Dip.to di Scienze della Terra, Università di Napoli "Federico II", Napoli, Italy
[3]Istituto di Geologia Applicata, Facoltà d'Ingegneria, Università di Napoli "Federico II", Napoli, Italy
[4]Dip.to di Scienze Fisiche, Università di Napoli "Federico II", Napoli, Italy
[5]ANSTO, Sydney, Australia

RIASSUNTO - *La trasgressione versiliana nella piana del fiume Volturno (Campania, Italia meridionale): evoluzione paleoambientale e dati cronologici* - Il Quaternario *Italian Journal of Quaternary Sciences*, 9(2), 1996, 445-458 - La piana costiera del fiume Volturno costituisce la porzione centro-settentrionale del "graben campano", una delle principali depressioni tettoniche che marginano il fianco tirrenico della catena appenninica. Questa depressione si originò come bacino estensionale all'inizio del Quaternario, a seguito del collassamento delle unità meso-cenozoiche della catena sud-appenninica . Durante il Pleistocene fu interessata da un tasso medio di subsidenza di 2-3 mm/anno mediamente compensato da ritmi di sedimentazione che consentirono l'alternarsi di ambienti variabili dal marino poco profondo al transizionale. I dati della letteratura sull'assetto stratigrafico della porzione più superficiale del riempimento sedimentario evidenziano una decisa diminuzione dei ritmi di subsidenza durante il tardo Quaternario, che, unitamente ad un aumento degli input sedimentari e vulcanoclastici, permise il progressivo colmamento del paleo-golfo e la progradazione della linea di costa sino alla sua odierna posizione. Gli studi condotti nel presente lavoro hanno permesso di dettagliare l'evoluzione di breve termine dell'area e di ricostruire le variazioni degli ambienti di sedimentazione succedutesi nel settore costiero meridionale della piana durante e dopo la trasgressione versiliana. Essi si sono avvalsi di uno studio geomorfologico e dell'analisi di tre sondaggi (A, B e C) effettuati in sinistra del fiume Volturno, le cui stratigrafie sono state confrontate con quelle di limitrofi sondaggi esistenti. Sui campioni prelevati dalle carote sono state effettuate osservazioni litostratigrafiche, analisi sulla ostracofauna e datazioni ^{14}C di alcuni livelli torbosi, basate su misure effettuate con AMS. Nel settore costiero della piana la base olocenica della trasgressione post-glaciale è rappresentata da depositi di spiaggia, attraversati dal sondaggio A ubicato ad 800 metri dalla linea di costa. Essa si rinviene ad una profondità compresa fra 23.5 e 22.5 metri che ben si accorda con la posizione glacio-eustatica del livello marino di 10 ka BP circa proposta dalla letteratura. I depositi marini poggiano sulla formazione dell'Ignimbrite Campana (di età compresa fra 42 e 27 ka BP) che costituisce il substrato eroso del pacco sedimentario olocenico in tutta la piana. Sono inoltre coperti da un livello piroclastico, tentativamente correlabile al *pyroclastic fall* di Agnano, datato 9.5 ka, sia in base all'età massima dell'Ignimbrite Campana che a quella del primo livello torboso datato ad esso sovrastante (8 ka BP). L'ingressione, legata al persistere della risalita del livello marino, procede nella piana sino a circa 1.5 km oltre la linea di costa odierna, causando la progressiva retrogradazione di un complesso sedimentario cuneiforme rappresentato da cordoni litorali e retrostanti depressioni sede di sedimentazione lagunare, le cui facies torboso-salmastre sono state attraversate per 10 metri nel sondaggio B (ubicato a 2.5 km dalla spiaggia odierna). Successivamente si assiste alla crescita di un complesso sabbioso regressivo che determina la progradazione della costa sino alla posizione odierna. Esso costituisce gli ultimi 10 metri circa della successione olocenica, formata da sabbie di *shoreface* e *transition zone* passanti verso l'alto a sabbie eoliche, ed è rappresentato in superficie dalla fascia di cordoni di spiaggia ed eolici estendentisi dalla costa verso l'interno per 1.5-2 km. Sebbene l'età 14C ottenute per alcuni livelli della successione lagunare non consentano di porre dei precisi vincoli cronologici, sembra che il passaggio dalla tendenza trasgressiva alla progradazione della linea di costa vada a collocarsi nel periodo corrispondente alla fine della risalita glacio-eustatica del livello marino (secondo alcuni autori avvenuta intorno a 4 ka BP, secondo altri intorno a 6 ka BP) ed al suo stabilizzarsi (a meno di piccole fluttuazioni) intorno allo zero odierno.

ABSTRACT - *The Versilian transgression in the Volturno river plain (Campania, Southern Italy): palaeoenvironmental history and chronological data* - Il Quaternario *Italian Journal of Quaternary Sciences*, 9(2), 1996, 445-458 - In order to reconstruct the Holocene evolution of the Volturno river coastal plain, a geomorphological survey was carried out and three boreholes (A,B and C) were drilled in the southern sector of the area. Further stratigraphical data were available from pre-existing boreholes from scattered locations on the plain. For samples obtained from boreholes A,B and C, ostracod analysis, lithostratigraphical observations and AMS ^{14}C dating were carried out. The Holocene deposits outcrop along the coastal beach-ridges of the strand plain, and in the flat back-barrier depression, the northern area of which is partially occupied by the composite and raised meander belt of the Volturno river. These deposits lie on the subaerial erosional landscape carved in the Campanian Ignimbrite formation (the latter being 42 to 27 ka BP in age) during the last glacio-eustatic low stand. The wedge-shaped sedimentary body (up to 30 m thick) is composed of sands and silts near the coast (penetrated by core A) and of clays, peats and silts (cores B and C) in the inner part of the plain. Both the sedimentary reconstructions carried out on the well-logs and the three dimensional arrangement of the Holocene sedimentary units allowed for both the reconstruction of the sediment geometry and the assessment of the major paleoenvironmental changes occurred in the area as a result of relative sea-level changes. The lower part of the Holocene succession is represented by a transgressive barrier-lagoon system, the onset of which is marked by beach sands, recognized in borehole A at a depth of 23-22 m b.s.l. The inferred age for this marine layer is about 10 ka BP. Due to the persistence of the sea-level rise, the barrier complex shifted inland, up to a maximum distance of 1.5 km from the modern position, and the lagoon depression also migrated inland. The subsequent late Holocene environmental history was characterized by a regression phase dominated by deposition, which resulted in the progradation of the palaeo-shoreline to its modern position. This progradation is identified by up to 10 m of Holocene deposits composed of dune sands (exposed across the area), which pass downwards to sands of shore-face and transition zone. Although no precise chronological constraints are available for the ^{14}C dates obtained from peaty

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(*) Diana Barra analysed and interpreted the ostracod assemblages; Paola Romano and Antonio Santo collected, analysed and interpreted the geomorphological and stratigraphical data; Luigi Campajola, Vincenzo Roca and Claudio Tuniz carried out ^{14}C measurements and dating.

layers, it seems that the change from a transgressive to a regressive trend on this coastline occurred when the phase of the sea-level rise ended and gave way to minor fluctuations around its present position (i.e. between 6 and 4 ka BP).

Key words: Stratigraphy, geomorphology, palæoecology, AMS ^{14}C dating, Holocene, Volturno river plain, Southern Italy
Parole chiave: Stratigrafia, geomorfologia, paleoecologia, datazioni ^{14}C con AMS, Olocene, pianura del Volturno, Italia meridionale

1. INTRODUCTION

The Volturno river coastal plain is located in the Campana Plain, which is one of the major structural depressions dissecting the Tyrrhenian side of the Apennine chain. This depression, extending along a NW-SE direction, is surrounded by carbonate rock morpho-structural highs (Mt. Massico, Mt. Maggiore, Mt. Sarno, Mts. Lattari) and consists of two coastal river plains (Volturno and Sarno river plains) separated by the Somma-Vesuvio and the Campi Flegrei volcanoes, which are Upper Pleistocene to Holocene in age (Fig. 1). The depression originated through the collapse of the Meso-Cenozoic Apennine units, which now form the substratum of the plain at a depth of about 5000 m as measured by geophysical explorations (Ortolani & Aprile, 1979). On-shore deep-well data (Ippolito *et al.*, 1973) indicate that the overlying sediments consist of marine and transitional deposits in which *Hyalinea baltica* is present from 3000 m depth upwards. These biostratigraphical and geophysical data suggest that the subsidence in the Volturno river plain started at the beginning of the Lower Pleistocene and continued with a mean rate of 2-3 mm/year. The sedimentation rate matched the subsidence rate, thus yielding an alternation of transitional and shallow marine deposits (Cinque *et al.*, 1987; Brancaccio *et al.*, 1995).

A detailed stratigraphical reconstruction based on nearly 600 boreholes scattered throughout the plain (Romano *et al.*, 1994) suggests that a gradual decrease of the tectonic subsidence mean rate occurred during the Late Quaternary and that a contemporaneous increase of the sedimentation rate ensued due to a pyroclastic input supplied by the nearby Campi Flegrei volcanic centre. These phenomena caused the final infilling of the depression and the progradation of the coastline up to its modern position (Fig. 2). In particular, the position of Eutyrrhenian marine layers (dated by Th/U measurements on fossil *Cladocora coespitosa* corals; Romano *et al.*, 1994) indicate a mean subsidence rate of about 0.6-0.8 mm/year since 129 ka BP and the position of Oxygen Isotope Stage 3 marine-transitional deposits suggests a mean rate of 0.2-0.3 mm/year during the last 50 ka. Besides this long term tectonic tendency, the area has probably experienced alternating phases of uplift and subsidence of volcano-tectonic origin, due to the activity of the Campi Flegrei volcanoes.

The aim of the present paper is to reconstruct the sedimentological and geomorphological evolution of the Volturno river plain during and after the Versilian transgression, which has recived little attention hitherto. The studies were carried out in the southern coastal zone of the Volturno river plain, where a geomorphological survey was carried out and three boreholes were drilled in the area between the Volturno river mouth and the Patria lake (cores A, B and C, Fig. 3). The stratigraphical data obtained from these wells were compared with those coming from pre-existing boreholes to better understand the three dimensional arrangement of the Holocene depositional units. The samples taken from the cores were analysed for Ostracod species distribution and stratigraphy and dated by means of the AMS ^{14}C method.

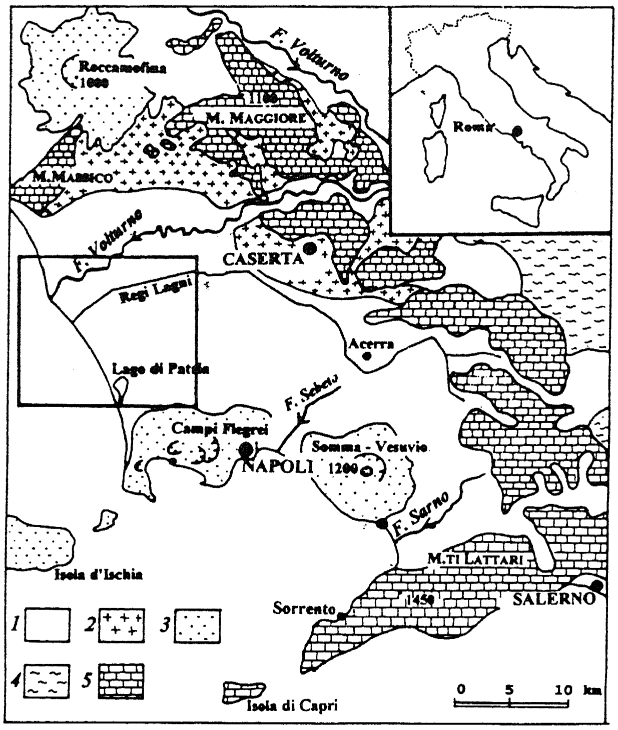

Fig.1 - Geological scheme of the Campanian Plain. 1) continental, transitional and marine deposits (Holocene); 2) Campanian Ignimbrite formation (45÷27 ka BP); 3) pyroclastic deposits and lavas (Pleistocene - Holocene); 4) terrigenous Cenozoic units; 5) carbonatic Mesozoic units. The square shows the studied area.

Schema geologico della piana campana. 1) depositi continentali, transizionali e marini dell'Olocene; 2) Ignimbrite Campana Auct. *(42÷27 ka BP); 3) lave e piroclastiti (Pleistocene-Olocene); 4) unità terrigene cenozoiche; 5) unità carbonatiche mesozoiche. Il riquadro delimita l'area studiata.*

2. GEOMORPHOLOGICAL AND STRATIGRAPHICAL SETTING

Some different morphological units were recognized in the studied area, on the basis of the aereophotointerpretation and the topographic map recostructed with a 1 m spaced contour lines (Fig. 3).

The coastal sector is represented by the slightly pro-

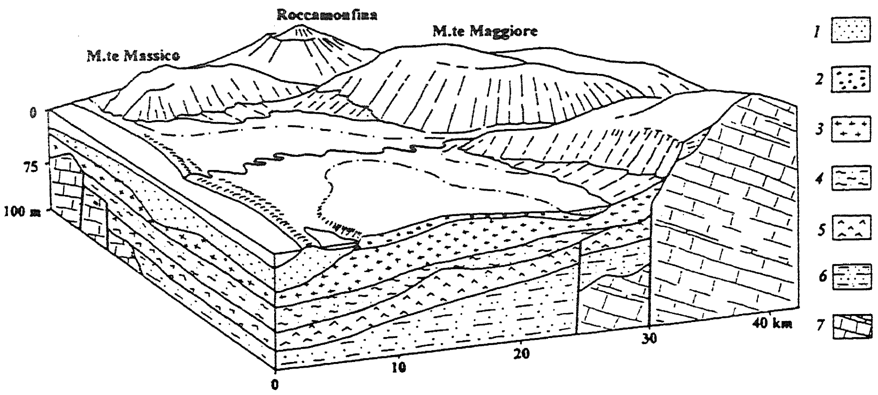

Fig. 2 - Block diagram showing the Upper Quaternary sedimentary succession of the Volturno river plain. For the age of the Quaternary units see Romano *et al.*, 1994. 1) Holocene marine, transitional and continental deposits; 2) Early Holocene pyroclastic fall deposits; 3) Campanian Ignimbrite formation (42÷27 ka BP); 4) marine-transitional deposits correlated with the Oxygen Isotope Stage 3 relative high stand; 5) subaqueous and subaerial volcanoclastic deposits (130-50 ka BP); 6) Euthyrrenian marine deposits; 7) Mesozoic carbonatic units of the Appennine chain.

Block *diagramma illustrante la porzione tardo quaternaria della successione sedimentaria della piana del Volturno. L'età delle unità quaternarie sono tratte da Romano* et al., *1994. 1) depositi marini, transizionali e continentali dell'Olocene; 2) piroclastiti dell'Olocene antico; 3) Ignimbrite Campana (42÷27 ka BP); 4) depositi marini e transizionali correlati allo Stadio Isotopico 3; 5) vulcaniti subacquee e subaeree (130-50 ka BP); 6) depositi marini dell'Eutirreniano; 7) unità carbonatiche mesozoiche della catena sud-appenninica.*

truding cuspate delta of the Volturno river, which at present is affected by wave erosion because of human-induced reduction of fluvial discharge. It gives way laterally to a beach-ridge strand plain, 1-2 km wide, mainly formed during the historical period (Cocco *et al.*, 1992). In this area, behind the innermost dune, whose top is at +8 m, the drilling site of core A is located, at a ground surface level of 2 m a.s.l. Further inland, a back-barrier depression lies at an altitude between 0 and –2 m with respect to present sea-level. This was an ancient lagoonal and marshy area, which was reclaimed starting from the end of the 18th Century. Both cores B and C were drilled in this geomorphological unit. The first borehole lies in its central sector (2.5 km from the coastline at altitude of 0 m) and the second one is close to its inner rim (at altitude of 2 m a.s.l.). A composite, lobe-shaped, raised meander belt of the Volturno river occupies the northern sector of this depression.

The south-eastern side of the plain is represented by a gentle slope formed by the *Ignimbrite Campana* formation (whose age ranges from 42 to 27 ka BP; Capaldi *et al.*, 1985; Scandone *et al.*, 1991), overlain by thin layers of Early Holocene pyroclastic fall deposits erupted from the Campi Flegrei volcanoes. This slope occupies the southern part of a wider structural volcanic landscape, formed through several phases during the upper Pleistocene, and which has been modified by an erosional, subaerial phase during the last glacio-eustatic sea-level low stand (*i.e.* during Oxygen Isotope Stage 2). This was followed by the formation of a fluvial drainage network, the main valley of which, located in the central part of the plain (Fig. 2), was then infilled by marine, transitional and continental deposits during the Versilian Transgression. The resulting Holocene sedimentary succession outcrops in the coastal sector of the plain and is formed by a wedge-shaped body up to 30 m thick. This consists of sand and silt near the coast and of clay and peat in the inner part of the plain.

All the boreholes penetrated the sediment succession up to the base of the Holocene and to the top of the underlying *Ignimbrite Campana* formation. In core A, the volcanic formation is found between 28 and 24 m b.s.l.

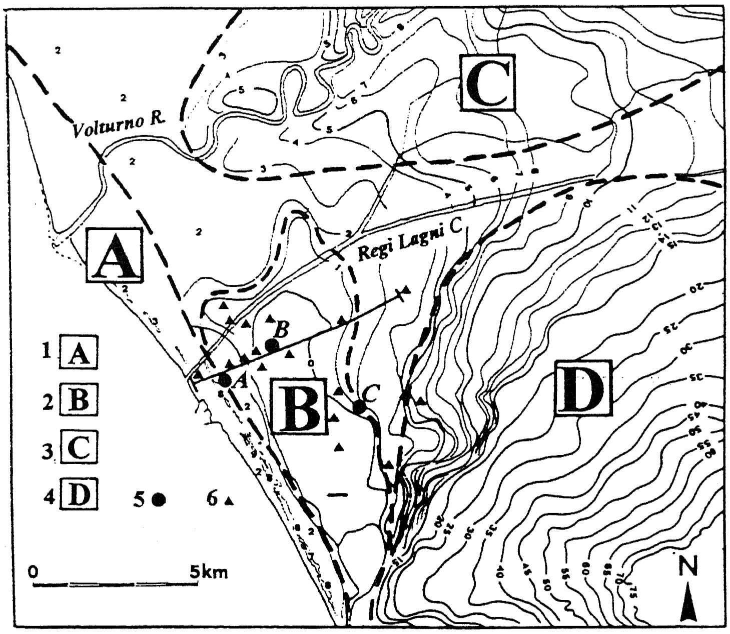

Fig. 3 - Geomorphological scheme of the southern coastal sector of the Volturno river plain. 1) beach-ridge strand plain including the delta mouth of the Volturno river; 2) back-barrier depression; 3) composite and raised lobe-shaped meander belt; 4) gentle deeping slope formed by the Campania Ignimbrite formation; 5) drilling site of cores A, B and C; 6) location of preexisting boreholes. The dotted line shows the Volturno delta position in 1950.

Schema geomorfologico del settore meridionale della piana del Volturno. 1) area della pianura costiera costituita da cordoni di spiaggia ed eolici e dal delta del f.Volturno; 2) depressione retro-dunare; 3) letto fluviale a meandri pensile e reinciso; 4) pendio domiforme impostato nella formazione dell'Ignimbrite Campana; 5) ubicazione dei carotaggi A,B e C; 6) ubicazione di sondaggi preesistenti. La linea puntinata indica la posizione del delta del Fiume Volturno nel 1950.

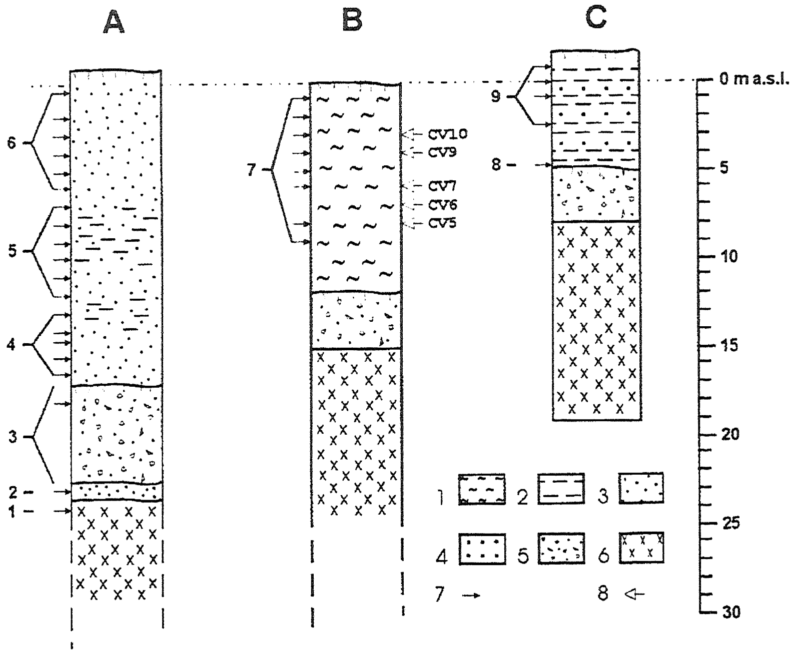

Fig. 4 - Stratigraphycal logs of cores A, B and C. 1) Peaty clayes; 2) silts; 3) sands; 4) pyroclastic levels; 5) red and grey pumices; 6) Campanian Ignimbrite formation; 7) samples for ostracodes analysis; 8) samples for ^{14}C measurements. The numbers are referred to the Intervals cited in the text.

Colonne stratigrafiche dei sondaggi A, B e C. 1) argille torbose; 2) limi; 3) sabbie; 4) livelli piroclastici; 5) pomici grigie e rosse; 6) Ignimbrite Campana; 7) livelli campionati per l'analisi dell'ostracofauna; 8) livelli campionati per le datazioni ^{14}C. I numeri posti di fianco alle colonne si riferiscono agli intervalli citati nel testo.

(Fig. 4). This passes to a 1 m-thick layer of sands, which separates the Ignimbrite from up to 7 m coarse red and grey pumices. The upper 19 m of core A consist of sands and silty sands, which coarsen upward where abundant marine and continental shell fragments are present. In cores B and C (25 and 19 m deep, respectively) the Holocene sedimentary succession is entirely represented by clayey and silty clayey deposits interbedded with peat beds and rare, thin ash layers. It overlies a 2 to 4 m thick layer of red and grey pumices that, in turn, rests directly on the *Ignimbrite Campana* formation.

3. PALAEOENVIRONMENTAL INTERPRETATION OF THE WELL-LOGS

Ostracod assemblages and lithostratigraphical characters were used to reconstruct the environment of deposition for the sedimentary successions of cores A, B and C.

For ostracod analysis, the residue of 35 samples washed through a 150 mesh screen was examined. For each sample, the abundance of the ostracod fauna and its diversity were measured for all species identified in the samples. Species representing more than 20% of the totals were defined as "dominant" species, those between 10 and 20% as "frequent" and below 10% as "rare". Table 1 lists only the samples in which ostracods were present, the species found and their frequency. Sixty-four species from 34 genera have been identified and listed (Table 1) according to the systematic order of Hartmann & Puri (1974). In the Appendix, the fundamental synonym is reported together, in some cases, with short taxonomical comments for each species. *Aurila* sp. e *Loxoconcha* sp. are left with no comments because they are here represented by young instars only, and these cannot be identified at the species level. All of the species identified are presently living in the Mediterranean and their areal and bathymetrical distribution, as well as the assemblages characteristic of different biotopes, are well defined in literature (Müller, 1894; Fox, 1965; Barbeito-Gonzalez, 1971; Uffenorde, 1972; Bona-duce *et al.*, 1973-74; Breman, 1975; Bonaduce *et al.*, 1976; Bonaduce *et al.*, 1988; Colizza *et al.*, 1987; Ghetti & Mc Kenzie, 1981).

On the basis of previous knowledge, the ostracod fauna has been subdivided into 3 groups:

1 – Species living exclusively in fresh-oligohaline waters (salinity between ±0.5 to ±5‰) represented by forms with a very thin carapace which is smooth or pitted; this group is restricted to a small number of genera, identified by the following species: *Candona angulata, C. candida, C. aff. C. fragilis, Candonopsis kingsleii, Cyclocypris ovum, Heterocypris salina, Ilyocypris gibba, I. aff. I. quinculminata, Limnocythere inopinata, Pseudocandona aff. P. marchica, P. sarsi, P. aff. P. sucki;*

2 – Brackish-water species (salinity between ±5 to ±30‰): these are highly specialized, with carapaces still rather thin, but with better developed ornamentation. *Cyprideis torosa* is constantly dominant followed by *Loxoconcha stellifera* and by rare specimens of *Aurila arborescens* and *Leptocythere lagunae*;

3 – Marine species (salinity between 30 to 40‰): forms with thick carapaces that are well ornamented; this group is represented on the whole by the highest number of species. Their distribution is related to bathymetry, the nature of the substratum and the presence or absence of a vegetation cover. Consequently, it is possible to subdivide them into the following sub-groups:

a) more or less strictly phytophilous species, such *Paradoxostoma angustum* e *P. versicolor* or those living in the sand around vegetation: *Neocytherideis fasciata, Procytherideis subspiralis, Semicytherura alifera, S. inversa, S. quadridentata, S. rara, Bairdia corpulenta, Cytheroma variabilis, Callistocythere pallida*;

b) species linked to sandy or pelitic-sandy bottoms lacking vegetation of the inner infralittoral zone: *Pontocythere turbida, Semicytherura incongruens, S. sulcata, Cytheridea neapolitana, Leptocythere levis, L. macella, L. ramosa, Cytheretta adriatica, C. subradiosa, Cistacythereis (Hiltermannicythere) turbida, Urocythereis margaritifera*;

c) ubiquitous species that can thrive either on vegetation or on median- to coarse grained sands and infralittoral muds: *Xestoleberis communis, Aurila convexa, Loxoconcha affinis, L. rhomboidea*;

d) species which occur on muddy bottom down to the circalittoral zone: *Carinocythereis whitei, Costa batei, C. edwardsi, Cytheropteron rotundatum.*

Twenty sandy samples from borehole A have been examined for ostracod content, 10 of which lacked microfauna. From the base, the following intervals have been defined on the basis both of the ostracofaunal content and lithological variations (Fig. 4):

Interval 1: 24.00 m b.s.l. (sample 20 for ostracofauna analysis). This sample was devoid of microfaunal remains; the lithological unit is correlated with the *Ignimbrite Campana* formation.

Interval 2: 23.50 to 22.50 m b.s.l. (sample 19 for paleontological analysis). Very poor ostracod fauna with respect to both species and number of specimens: *Leptocythere levis, Cyprideis torosa, Pontocythere turbida, Semicytherura sulcata,* which characterize an assemblage typical of a very shallow, sandy marine environment in close proximity to a brackish lagoon, as demonstrated by the presence (rare) of *Cyprideis torosa.*

Interval 3: 22.50 to 17.50 m b.s.l. Sample 18 was sterile. It was obtained from the uppermost part of a coarse red and grey pumiceous layer overlain by a thin inceptisol.

Interval 4: 16.50 to 12.50 m b.s.l (samples 17 - 13). In this interval a total of 38 species has been found. Samples 17, 16 and 15 show a fairly moderate diversity, with species which characterize a wide range of environments. Species typical of marine sandy or pelitic-sandy bottoms (*Leptocythere levis, L. macella, Urocythereis margaritifera, Cytheretta subradiosa, Pontocythere turbida, Semicytherura sulcata, Loxoconcha affinis, Xestoleberis communis* between the more frequent) dominate the assemblage. Brackish water species (*Cyprideis torosa* and *Loxoconcha stellifera* are frequent, followed by *Aurila arborescens* and *Leptocythere lagunae*) and rare fresh water types (*Pseudocandona* aff. *P. marchica, P. sarsi, Limno-cythere inopinata*) have also been found. This interval is characterized by an assemblage typical of the marine inner infralittoral zone, but contaminated by brackish and fresh water species. In samples 14 and 13 (from –13.50 to –12.50 m), the ostracod assemblage becomes less diversified (*Carinocythereis whitei, C. torosa, Semicytherura sulcata, P. turbida*), and only *P. turbida* is frequent.

Interval 5: 11.50 to 6.50 m (samples 12 to 7). This fossiliferous interval is interrupted at –7.50 m (sample 11) and –8.50 m (sample 8) by two barren layers. A total of 50 species has been identified. The autochthonous assemblage is typically marine, with species of the sandy or pelitic sandy inner infralittoral zone (*Leptocythere ramosa, Cytheretta adriatica, C. subradiosa, P. turbida, S. incongruens, Xestoleberis communis*), and species indicating a vegetal cover (*Paradoxostoma angustum, P. versicolor, Bairdia corpulenta, N. fasciata, S. quadridentata*) associated with species of a deeper environment (*Carino-cythereis whitei, Costa batei, C. edwardsi, Cytheropteron rotundatum*). *C. torosa* is rather common, and fresh water species (*Candona candida, Heterocypris*

Tabella 1 - Semiquantitative distribution of the ostracode species in the fossiliferous layers of the well A and B. (D = dominant; F = frequent; R = rare).

Distribuzione semiquantitativa degli ostracodi nei livelli fossiliferi dei pozzi A e B (D = specie dominanti; F = specie frequenti; R = specie rare).

	Pozzo A										Pozzo B								
Specie / Campioni	19	17	16	15	14	13	12	10	9	7	28	22	19	16	9	7	6	2	1
Bairdia corpulenta							F	F	R										
Bairdia gr. B. mediterranea								R	R										
Tetracytherura angulosa			R	R															
Leptocythere bituberculata			R					R											
Leptocythere lagunae			R																
Leptocythere levis	R	R	D	F			R	R		R									
Leptocythere macella			F	R			R	F											
Leptocythere ramosa								F											
Leptocythere rara			R				R	R											
Callistocythere diffusa									R										
Callistocythere protracta			R																
Callistocythere pallida			R																
Callistocythere sp. 1			R																
Limnocythere inopinata				R			R	R											
Cytheroma variabilis								R											
Cyprideis torosa	R	F	F	F	R		F	F	F		D	D	D	R	D	D	D	F	D
Cytheridea neapolitana							R	R											
Pontocythere turbida	R	D	D	D	F	D	D	D	D	F									
Neocytherideis fasciata			F	F			R	F	R										
Procytherideis subspiralis			R					R											
Carinocythereis whitei			R	R		R	F	F	R										
Costa batei							R		R										
Costa edwardsi				R				F	R										
Cistacythereis (H.) turbida			R				R	R	R										
Aurila arborescens			R	R															
Aurila convexa			R	F			R												
Aurila sp.								R											
Tenedocythere prava							R												
Urocythereis flexicauda							R												
Urocythereis margaritifera		R	F	F			R	R											
Cytheretta adriatica				R			F	R											
Cytheretta subradiosa				F			F												
Loxoconcha affinis		R	F	R			R												
Loxoconcha ovulata				R			R												
Loxoconcha rhomboidea							R	R											
Loxoconcha turbida				R															
Loxoconcha stellifera		D	D	F			F	F	R		F		F		F	F	F	R	R
Loxoconcha sp.			R																
Paracytheridea bovettensis			R					R											
Cytheropteron rotundatum								R											
Hemicytherura defiorei			R					R											
Semicytherura alifera								R											
Semicytherura incongruens		F	F	F			F	F											
Semicytherura inversa		R	R	R			R												
Semicytherura quadridentata								F											
Semicytherura rara			R	R				R											
Semicytherura sulcata	R	F	D	D	R	R	F		R	R									
Xestoleberis communis		R	F	F			F	F	F										
Xestoleberis aff. X. fuscomaculata		R	R	R															
Pseudocythere caudata								R											
Cytherois joachinoi				R															
Paradoxostoma angustum								R											
Paradoxostoma versicolor								R											
Ilyocypris gibba								F	R			R						F	
Ilyocypris aff. I. quinculminata									R										
Candona angulata													R		F	F	F		
Candona candida							R	R											
Candona aff. C. fragilis																			R
Candonopsis kingsleii														R				F	
Pseudocandona aff. P. marchica				R				R			R	R	R	D	F	F	F	F	
Pseudocandona sarsi				R				F	R		R							F	
Pseudocandona aff. P. sucki								R			R		R	F				F	
Cyclocypris ovum																			F
Heterocypris salina								F					R				R		
Numero totale di specie	4	11	30	26	3	3	27	39	16	3	5	3	6	4	4	4	5	7	4

salina, Ilyocypris gibba, I. aff. *I. quinculminata, Limnocythere inopinata, Pseudocandona* aff. *P. marchica, P. sarsi, P.* aff. *P. sucki*) are relatively abundant with respect to Interval 4. This interval appears to have been deposited in a deeper marine environment with respect to interval 4. The observed increase of brackish and fresh water species can be ascribed to an increase of fluvial discharge due to climate and/or to the progradation of the river mouth.

Interval 6: from -6.50 m to the top. All samples lacked ostracod remains. This interval is characterized by alternating coarse and fine sandy leyers containing scattered mollusc shells and intercalated ochre sandy beds in the upper part. The lithological features are indicative of either a littoral or a continental (eolian) environment, the latter restricted to the top part of the interval.

Nine samples were examined from borehole B. Collected from clayey and peaty layers (Fig.4), they yielded an

Tabella 2 - Radiocarbon ages and calibrated ages of the samples taken in core B.
Età convenzionali ed età calibrate dei campioni prelevati nel sondaggio B.

Sample	Depth	R.C. age	R.C. age	mean R.C. age	error	Calibrated interval (1 σ)
	(m.s.l.m.)	(y BP)	y (BP)	(y BP)	(y)	(y BP)
		Sidney	Napoli			
CV10	-3	4010 ± 80	4440 ±160	4220	± 215	5030 ÷ 4500
CV9	-4	5560 ± 70	5950 ± 180	5760	± 215	6850 ÷ 6310
CV7	-6	4910 ± 90	4930 ±150	4920	± 215	5910 ÷ 5330
CV6	-7	5510 ± 70	5370 ±180	5440	± 215	6620 ÷ 5950
CV5	-8	6620 ± 60	-	6620	± 215	7630 ÷ 7270

ostracod fauna consisting of a total of 11 species. The brackish *Cyprideis torosa* is dominant and *L. stellifera* frequent. The following fresh water species are also well represented with respect to both number of species and specimens: *Candona angulata, C. aff. C. fragilis, Candonopsis kingsleii, Cyclocypris ovum, H. salina, I. gibba, Pseudocandona* aff. *P. marchica, P. sarsi, P.* aff. *P. sucki.* This assemblage is indicative of a brackish, lagoonal environment, into which fresh water species (Interval 7) were transported.

Six samples were examined from borehole C and were obtained from silty layers (Fig. 4). Only sample 6 (located between –5 and –4 m depth, Interval 8) yielded rare specimens of the brackish *Cyprideis torosa,* characteristic of lagoonal environments. The others, sampled between –4 and +2 m of depth (Interval 9) were devoid of ostracod remains. This last interval is characterized by many very thin pyroclastic layers (made up of fine pumice) intercalated within the silts, as well as by traces of weathering indicative of a continental environment.

4. AMS ^{14}C MEASUREMENTS AND DATING

Small wood pieces, with an average total weight of a few grams out of about 100 g of argillaceous peat, were found in five layers from borehole B, at –8, –7, –6, –4 and –3 m below sea level. Two aliquots of about 0.5 g for each layer were treated according to the standard protocols in use at the Accelerator Mass Spectrometry facility of the Physics Department of the University of Naples "Federico II" (Romano M. *et al.*, 1995). After ultrasonic washing, wood fragments were chemically processed with standard acid-basic-acid treatment, in order to remove carbonates and humic acids. After pyrolysis in nitrogen flow, the samples were oxidized to CO_2 with CuO and then graphitized by using the iron-catalized Vogel reaction in H_2 atmosphere, in a quartz vessel. The prepared samples were than measured by accelerator mass spectrometry at two different mass spectrometers: the AMS at Naples (Terrasi *et al.*, 1990) and the AMS at the ANTARES centre of ANSTO at Sydney (Tuniz *et al.*, 1994). Isotopic $^{14}C/^{13}C$ ratios were determined by normalization to an ANU sucrose standard. Background subtraction was applied by using blank samples, and standard fractionation corrections were derived from the literature (Gupta & Pollak,1985).

Table 2 shows the radiocarbon ages, with their statistical errors, determined in the two series of measurements. Note that the two independent determinations for each sample do not always agree within the laboratory error ranges. In particular, the inferred ages of samples CV10 and CV9 differ by about two standard deviations, whereas for CV7 and CV6 fair agreement is found. An inter-laboratory cross-check, based on measurements performed on several samples of both known and unknown ages indicated the probable absence of systematic errors in the measurements at AMS sites. The observed discrepancies were therefore ascribed to differences in the average ages of the two aliquots sampled within each layer. Variations of this order of magnitude, or even larger, have been found in other cases with similar samples. As the maximum value of the difference between the two radiocarbon ages for each layer turns out to be 430 y, we have assumed this interval as representative of the maximum scatter of the age within each layer, and the arithmetic mean of the two results as the best estimate of the average age of the layer. The results of this procedure are shown in the 4th and 5th columns in Table 2. The corresponding calibrated intervals at 68% confidence level, deduced using the Stuiver & Pearson's (1993) calibration tables, are also reported in the last column.

The radiocarbon ages of samples CV9 and CV7 obtained from both the Naples and ANSTO ANTARES centre spectrometers are inverted. Since there is good agreement between both sets of results, the sampled and treated wood fragments can be considered as indicative of a reworking of fossil wood.

5. SEDIMENTARY AND GEOMORPHOLOGICAL EVOLUTION OF THE VOLTURNO RIVER PLAIN DURING AND AFTER THE VERSILIAN TRANSGRESSION

As shown in the cross-section of Figure 5, the lower part of the Holocene sedimentary wedge is represented by a transgressive barrier-lagoon system that lies on a widespread, pumiceous pyroclastic unit. The contact between this unit and the underlying *Ignimbrite Campana* formation is an erosional surface that can be recog-

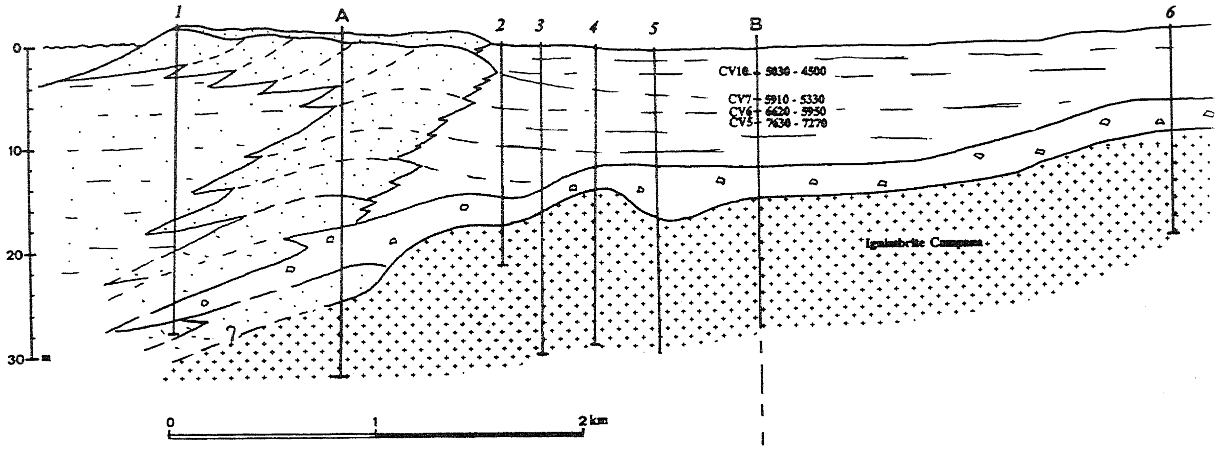

Fig. 5 - Geological section across the middle sector of the studied area. See Fig. 3 for the location and the text for the comment. Ridge numbers and dimensions of the transgressive and prograding barrier beach complex are schematic.

Sezione geologica attraverso la parte centrale dell'area studiata (cfr. Fig. 3 per l'ubicazione e Cap. 5 per la spiegazione). Il numero e le dimensioni dei cordoni costituenti il complesso sedimentario sabbioso trasgressivo e regressivo sono schematici.

nized in many other borehole records obtained from the plain (Romano *et al.*, 1994). The geomorphology of this buried landscape is that of a network of wide and gentle fluvial valleys (Fig. 2), the downcutting of which commenced during glacio-eustatic lowstand of Isotope Stage 2 and probably continued during the beginning of the post-glacial sea-level rise.

In the coastal sector of the investigated area, the onset of the Holocene transgression is represented by the sandy beach deposits found in core A from 23.5 to 22.5 m b.s.l. (Interval 2, Fig. 4 & 5), packed between the *Ignimbrite Campana* and the layer of red and grey pumices (Int. 3). We have no direct dating for this pyroclastic layer, but the fact that it is younger than the *Ignimbrite Campana* (27 ka in age), and that it predates the peat deposits dated to about 8 ka BP, suggests its correlation with either the Neapolitan Yellow Tuff or the Agnano eruption, which are the only two tephras of the region falling within this time interval. Since the sea-level was much lower (–45 ÷ –65 m; Shepard, 1963; Tooley, 1978) than the beach immediately underlying the pomiceous layer during the eruption of the Neapolitan Yellow Tuff (12 ka BP; Cioni *et al.*, 1994), the correlation with the Agnano tephra layer (9.5 ka in age; Cioni *et al.*,1994) seems more probable. As a consequence, the beach deposits of Interval 2 must be about 10 ka in age or slightly younger. The presence of microfossils of the brackish water (*Cyprideis torosa*) in this marine layer indicates that small lagoons did already exist at that time behind the beach ridge, probably further to the north of the section investigated (*i.e.* closer to the river mouth).

A subsequent short phase of shoreline progradation is documented by both the subaerial facies of the volcanic Interval 3 and the thin inceptisol at its top. It was caused either by volcanoclastic aggradation or by a short phase of volcano-tectonic uplift, related to the eruption of the red and grey pumices.

Due to the persistence of the eustatic sea-level rise, a new marine transgression followed and gave rise to successive backsteps of the barrier-lagoon system. During this stage, the barrier complex did not reach further inland than 1.5 km from the modern coastline, as demonstrated by the lack of beach sands in the boreholes located landward of drilling site A. A transgressive trend is also shown by the ostracofaunal content of Intervals 4 and 5 of well A, which provides evidence for a gradual increase in water depth. Analogous inferences are based on the lithostratigraphic succession of well 1, in which a transition from sands to silty sands, and silts is recognized between 25 and 7÷10 m b.s.l.

At the end of this transgressive period the evolutionary trend of the coastal plain changed, and the growth of a regressive barrier system took place (Fig. 5) as a probable consequence of the beginnin of the growth of a prominent delta at the mouth of the Volturno river. The regressive barrier lithofacies is represented by the sandy upper part of the Holocene sedimentary succession in the area between the modern coastline and the location of well 2. The regressive lithofacies has a maximum thickness of 10 m, and is composed of dunal fine sands (extensively exposed across the area) passing downwards into coarse to medium-grained beach sands and silty sands of the transition zone.

The ^{14}C dates discussed above suggest that the rate of sedimentation within the back-barrier depression was of the order of 1 mm/y between about 7600 and 5900 y BP, and increased up to more than 3 mm/y between 5900 and 5000 yr BP. Unfortunately, good mate-

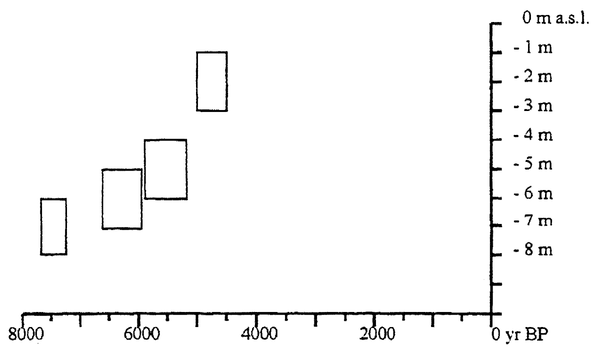

Fig. 6 - Sea-level graph for the last 8000 years.

Grafico del livello marino negli ultimi 8000 anni.

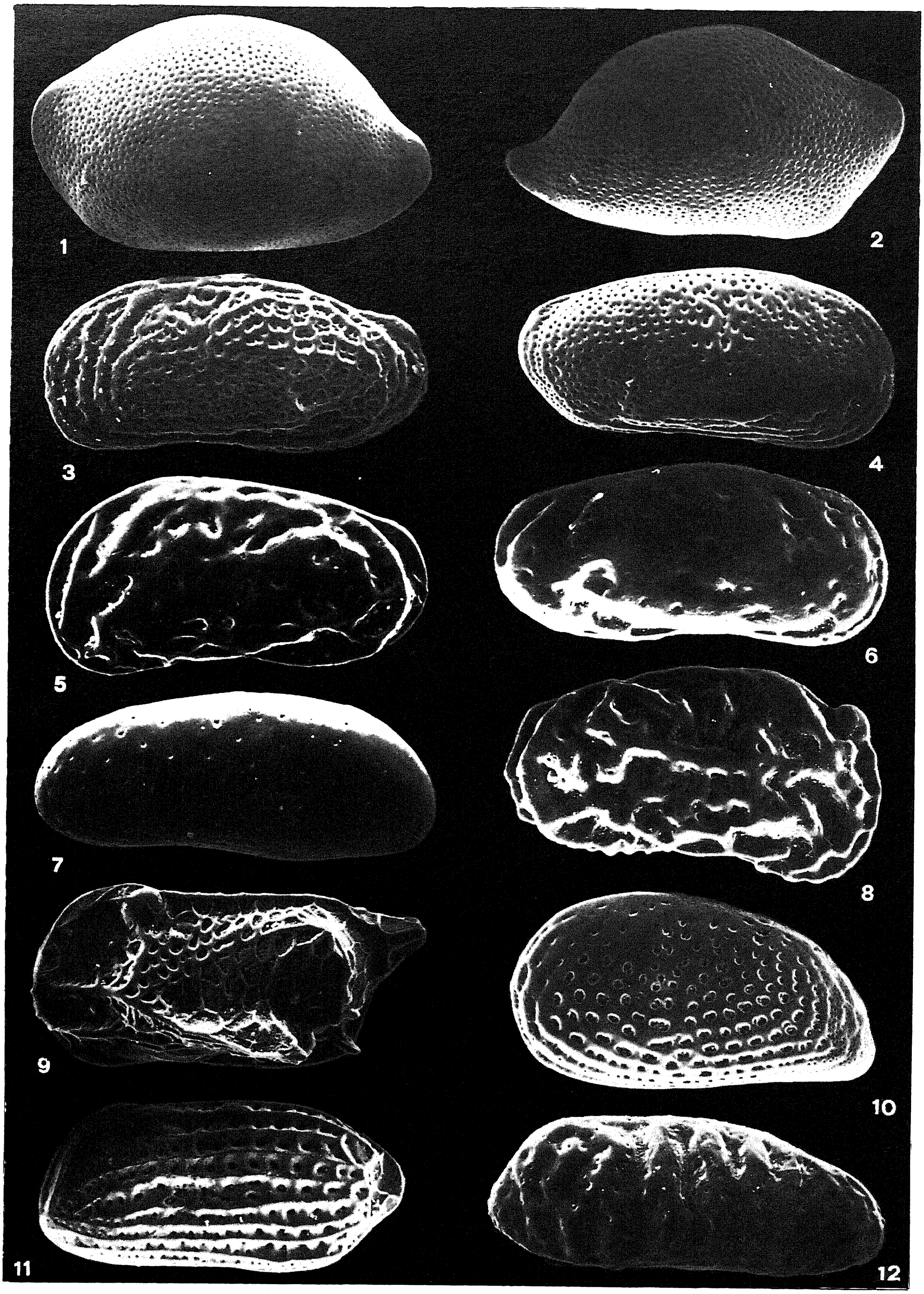

Fig. 7 - SEM pictures of ostracods in lateral exterior view: 1 - *Bairdia corpulenta* G.W. Müller, left valve, A 12, (x 67); 2 - *Bairdia corpulenta* G.W. Müller, right valve, A 12, (x 67); 3 - *Leptocythere lagunae* Hartmann, left valve male, A 16, (x 92); 4 - *Leptocythere rara* G.W. Müller, right valve, A 16, (x 142); 5 - *Callistocythere* sp. 1, left valve, A 16, (x 142); 6 - *Leptocythere levis* (G.W. Müller), right valve, A 16, (x 142); 7 - *Pontocythere turbida* (G.W. Müller), left valve, A 12, (x 67); 8 - *Callistocythere pallida* (G.W. Müller), right valve, A 16, (x 142); 9 - *Semicytherura alifera* Ruggieri, left valve male, A 10, (x 136); 10 - *Cytheridea neapolitana* (cont. p. 453)

rial for ^{14}C dating was not found within the uppermost three meters of the back-barrier infilling, which is composed of grey organic clay and minor peat layers with ostracods of brackish and fresh waters, but without wood fragments. The span of time represented by this undated portion of borehole B succession is tentatively estimated to no more than a thousand years by assuming that the rate of sedimentation was never lower than 3 mm/year.

As the lagoons of the central Mediterranean region do not normally exceed a water depth of $2 \div 3$ m, the lagoonal layer with a ^{14}C age of about 5000 yrs BP (sample CV10 at 3 m b.s.l.) can be probably ascribed to a relative sea-level close to the present-day level, or slightly lower. This reconstruction agrees with the eustatic sea-level curves reported in the literature [some authors assign to the end of the post-glacial rise an age of 6000 yrs BP (Thom & Roy, 1985; Chappell, 1987; Gagan *et al.*, 1994); other authors suggest an age of 4000 yrs BP (Shepard, 1963; Tooley, 1978; Shennan, 1987)] and suggests that no appreciable subsidence has occurred in the area during the second half of Holocene. The sea-level graph constructed on the basis of both the ^{14}C ages and the depths of the lagoonal layers is shown in Figure 6. The rectangles give account of the horizontal dating errors and, on the vertical side, of the uncertainties associated with the peaty layers used as sea-level indicators. In fact, if the already mentioned variability of the water depth of lagoons is taken into account, a peat has to be considered only as a minimum sea-level mark. Therefore, the data-set of the graph allows the reconstruction of various sea-level curves, each one of which shows either minor fluctuations or different rates in sea-level rise.

If one considers the transition from the initial period of transgression to the subsequent episode of depositional regression of the Volturno plain coastline, no precise chronological constraints can be given on the basis of the data presented here. However, it can be argued that, until at least 5000 yrs BP (maximum age limit for the end of the lagoonal deposition at the rear of the coastal barrier) the regressive system of coastal ridges had not yet started to grow, or was still narrow and discontinuous enough to allow a good mixing of fresh and salty waters. Therefore, it seems that the change from a transgressive to a regressive tendency of the coastline is chronologically close to the moment when the sea-level ended its phase of rise and started fluctuating around its present position.

AKNOWLEDGEMENTS

Research financially supported by MURST 60%, 1995 (10.1.63.), chief scientist Prof. A. Cinque.

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← (cont. from/da p. 452) Kollmann, left valve, A 12, (x 77); 11 - *Semicytherura sulcata* (G.W. Müller), left valve, A 17, (x 119); 12 - *Procytherideis subspiralis* (Brady, Crosskey & Robertson), right valve, A 10, (x 96).

Fotografie al SEM di ostracodi in norma laterale esterna: 1 - Bairdia corpulenta *G.W. Müller, valva sinistra, A 12, (x 67); 2 -* Bairdia corpulenta *G.W. Müller, valva destra, A 12, (x 67); 3 -* Leptocythere lagunae *Hartmann, valva sinistra maschile, A 16, (x 92); 4 -* Leptocythere rara *G.W. Müller, valva destra, A 16, (x 142); 5 -* Callistocythere *sp. 1, valva sinistra, A 16, (x 142); 6 -* Leptocythere levis *(G.W. Müller), valva destra, A 16, (x 142); 7 -* Pontocythere turbida *(G.W. Müller), valva sinistra, A 12, (x 67); 8 -* Callistocythere pallida *(G.W. Müller), valva destra, A 16, (x 142); 9 -* Semicytherura alifera *Ruggieri, valva sinistra maschile, A 10, (x 136); 10 -* Cytheridea neapolitana *Kollmann, valva sinistra, A 12, (x 77); 11 -* Semicytherura sulcata *(G.W. Müller), valva sinistra, A 17, (x 119); 12 -* Procytherideis subspiralis *(Brady, Crosskey & Robertson), valva destra, A 10, (x 96).*

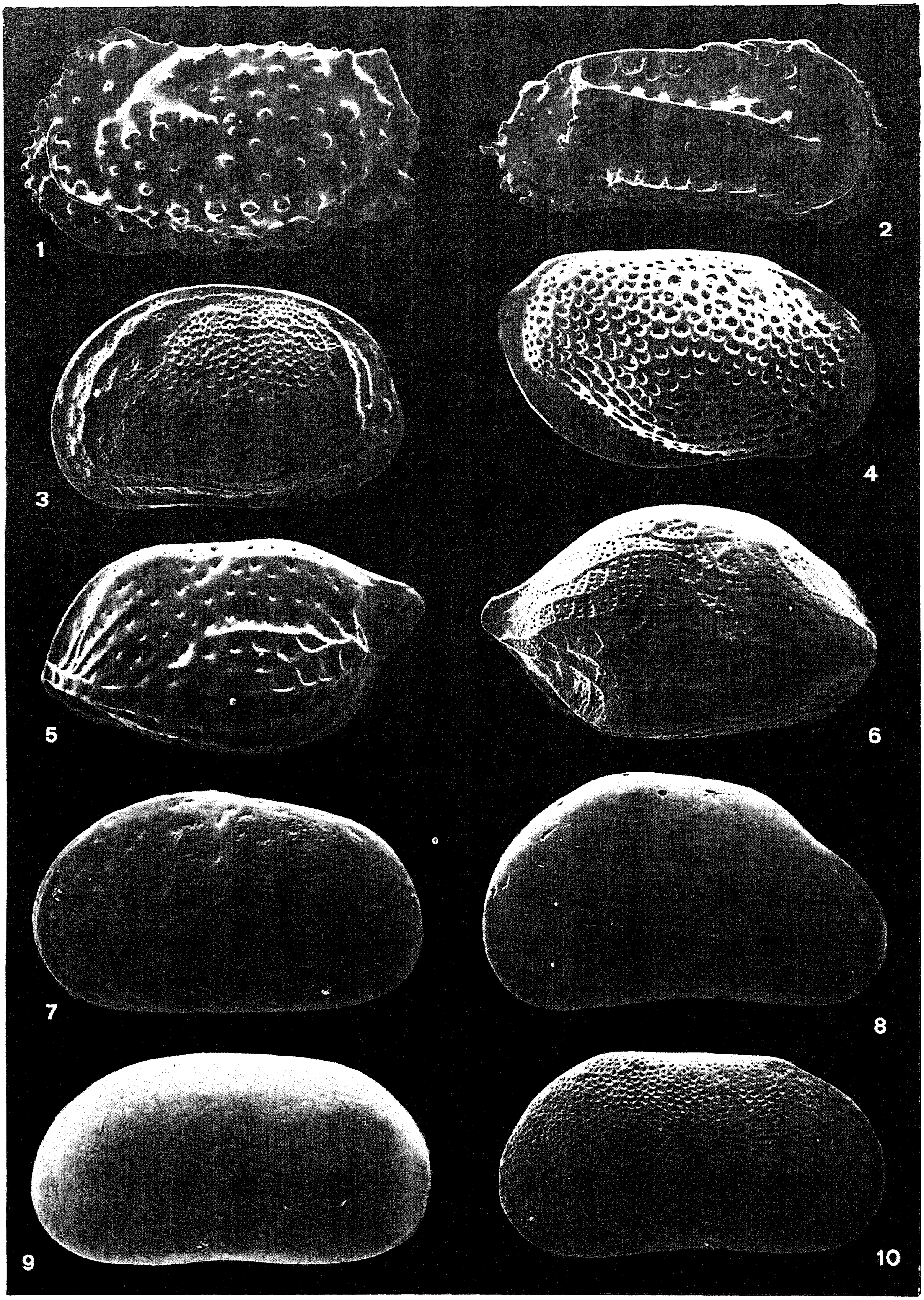

Fig. 8 - SEM pictures of ostracods in lateral exterior view: 1 - *Carinocythereis whitei* (Baird), left valve, A 12, (x 87); 2 - *Costa batei* (Brady), right valve, A 12, (x 71); 3 - *Aurila arborescens* (Brady), left valve, A 16, (x 73); 4 - *Loxoconcha affinis* (Brady), right valve male, A 16, (x 100); 5 - *Semicytherura incongruens* (G.W. Müller), left valve, A 15, (x 124); 6 - *Semicytherura inversa* (Seguenza), right valve, A 17, (x 119); 7 - *Cyprideis torosa* (Jones), left valve, A 15, (x 71); 8 - *Pseudocandona* aff. *P. sucki* (Hartwig), right valve, B 16, (x 62); 9 - *Pseudocandona* aff. *P. marchica* (Hartwig), left valve, B 22, (x 96); 10 - *Pseudocandona sarsi* (Hartwig), right valve, B 2, (x 77). (cont. p. 455)

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SYSTEMATIC APPENDIX

All the species found, together with the fundamental synonymy, are listed below in alphabetic order. Some comments on few species are added and are numbered at the left side of the list.

1 *Aurila arborescens* (Brady) = *Cythere arborescens* Brady, 1865 [Fig. 8, no. 3]

Aurila convexa (Baird) = *Cythereis convexa* Baird, 1850

Aurila sp.

Bairdia corpulenta G. W. Müller, 1894 [Fig. 7, nos. 1, 2]

2 *Bairdia* gr. *B. mediterranea* G. W. Müller, 1894

Callistocythere diffusa (G.W.Müller) = *Cythere diffusa* G.W.Müller, 1894

Callistocythere protracta Ruggieri & D'Arpa, 1993

Callistocythere pallida (G.W.Müller) = *Cythere pallida* G.W.Müller, 1894 [Fig. 7, no. 8]

3 *Callistocythere* sp. 1 [Fig. 7, no. 5]

Candona angulata G. W. Müller, 1894 [Fig. 9, no. 1]

Candona candida (O.F. Müller) = *Cypris candida* O.F. Müller, 1785

4 *Candona* aff. *C. fragilis* Hartwig, 1898

Candonopsis kingsleii (Brady & Robertson) = *Candona kingsleii* Brady & Robertson, 1870

(cont. from/da p. 454) *Fotografie al SEM di ostracodi in norma laterale esterna: 1 -* Carinocythereis whitei *(Baird), valva sinistra, A 12, (x 87); 2 -* Costa batei *(Brady), valva destra, A 12, (x 71); 3 -* Aurila arborescens *(Brady), valva sinistra, A 16, (x 73); 4 -* Loxoconcha affinis *(Brady), valva destra maschile, A 16, (x 100); 5 -* Semicytherura incongruens *(G.W. Müller), valva sinistra, A 15, (x 124); 6 -* Semicytherura inversa *(Seguenza), valva destra, A 17, (x 119); 7 -* Cyprideis torosa *(Jones), valva sinistra, A 15, (x 71); 8 -* Pseudocandona *aff.* P. sucki *(Hartwig), valva destra, B 16, (x 62); 9 -* Pseudocandona *aff.* P. marchica *(Hartwig), valva sinistra, B 22, (x 96); 10 -* Pseudocandona sarsi *(Hartwig), valva destra, B 2, (x 77).*

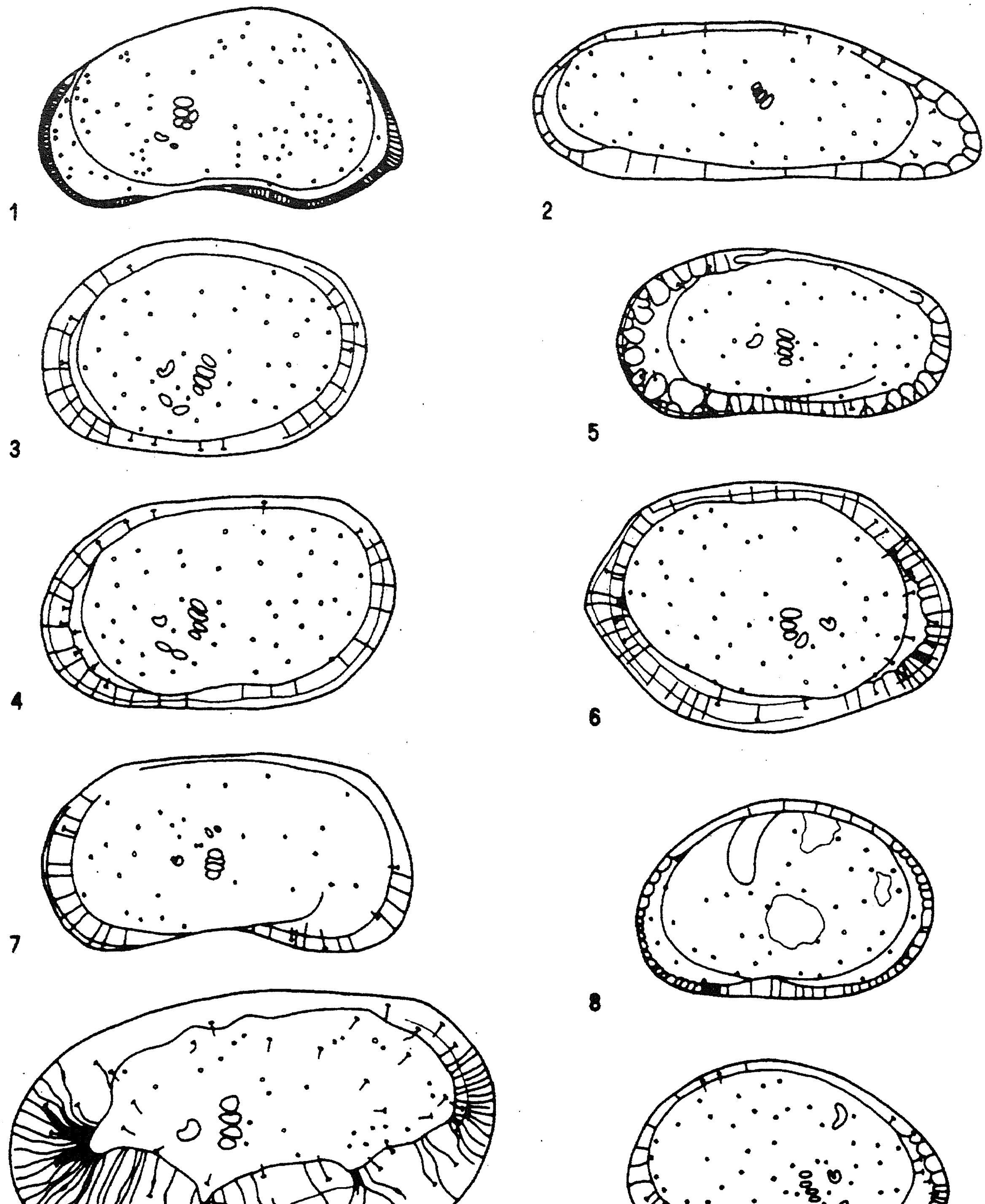

Fig. 9 -. Transparence drawings of ostracods done by Visopan Reichert in lateral exterior view; if not specified, magnifications x 100: 1 - *Candona angulata* G.W.Müller, left valve, B 6, (x 33); 2 -*Neocytherideis fasciata* (Brady & Robertson), right valve, A 16; 3 - *Loxoconcha stellifera* G.W. Müller, left valve female, A 22; 4 - *Loxoconcha stellifera* G.W. Müller, left valve male,A 22; 5 - *Leptocythere macella* Ruggieri, left valve, A 10; 6 - *Loxoconcha turbida* G.W.Müller, right valve, A 15; 7 - *Limnocythere inopinata* (Baird), left valve, A 10; 8 - *Xestoleberis communis* G.W. Müller, left valve, A 15; 9 - *Cytheretta subradiosa* (Roemer), left valve, A 15; 10 - *Xestoleberis* aff. *X. fuscomaculata* G.W. Müller, right valve, A 16.

Disegni per trasparenza di ostracodi ottenuti con Visopan Reichert in norma laterale esterna; se non specificato, ingrandimenti x 100: 1 - Candona angulata *G.W. Müller, valva sinistra, B 6, (x 33); 2 -* Neocytherideis fasciata *(Brady & Robertson), valva destra, A 16; 3 -* Loxoconcha stellifera *G.W. Müller, valva sinistra femminile, A 22; 4 -* Loxoconcha stellifera *G.W. Müller, valva sinistra maschile, A 22; 5 -* Leptocythere macella *Ruggieri, valva sinistra, A 10; 6 -* Loxoconcha turbida *G.W.Müller, valva destra, A 15; 7 -* Limnocythere inopinata *(Baird), valva sinistra, A 10; 8 -* Xestoleberis communis *G.W. Müller, valva sinistra, A 15;* (cont. p. 457)

5 *Carinocythereis whitei* (Baird) = *Cythereis whitei* Baird, 1850 [Fig. 8, no. 1]
Cistacythereis (Hiltermannicythere) turbida (G. W. Müller) = *Cythereis turbida* G. W. Müller, 1894
Costa batei (Brady) = *Cythereis batei Brady,* 1866 [Fig. 8, no. 2]
Costa edwardsi (Roemer) = *Cytherina edwardsi* Roemer, 1838
Cyclocypris ovum (Jurine) = *Monoculus ovum* Jurine, 1820
Cyprideis torosa (Jones) = *Candona torosa* Jones, 1850 [Fig. 8, no. 7]
Cytheretta adriatica Ruggieri, 1952
Cytheretta subradiosa (Roemer) = *Cytherina subradiosa* Roemer, 1838 [Fig. 9, no. 9]
Cytherideа neapolitana Kollmann, 1960 [Fig. 7, no. 10]
Cytherois joachinoi Barra, 1992
Cytheroma variabilis G. W. Müller, 1894
Cytheropteron rotundatum G. W. Müller, 1894
Hemicytherura defiorei Ruggieri, 1953
6 *Heterocypris salina* (Brady) = *Cypris salinus* Brady, 1868
Ilyocypris gibba (Ramdohr) = *Cypris gibba* Ramdohr, 1808
4 *Ilyocypris* aff. *I. quinculminata* Sylvester - Bradley, 1973
Leptocythere bituberculata Bonaduce, Ciampo & Masoli, 1976
Leptocythere lagunae Hartmann, 1958 [Fig. 7, no. 3]
Leptocythere levis (G. W. Müller) = *Cythere levis* G. W. Müller, 1894 [Fig. 9, no. 6]
Leptocythere macella Ruggieri, 1975 [Fig. 9, no. 5]
Leptocythere ramosa (Rome) = *Cythere ramosa* Rome, 1942
Leptocythere rara G.W. Müller, 1894 [Fig. 7, no. 4]
Limnocythere inopinata (Baird) = *Cythere inopinata* Baird, 1850 [Fig. 9, no. 7]
7 *Loxoconcha affinis* (Brady) = *Normania affinis* Brady, 1866 [Fig. 8, no. 4]
8 *Loxoconcha ovulata* (O.G. Costa) = *Cytherina ovulata* O.G. Costa, 1863
Loxoconcha rhomboidea (Fischer) = *Cythere rhomboidea* Fischer, 1855
Loxoconcha stellifera G.W. Müller, 1894 [Fig. 9, nos. 3, 4]
Loxoconcha turbida G. W. Müller, 1912 [Fig. 9, no. 6]
Loxoconcha sp.
Neocytherideis fasciata (Brady & Robertson) = *Cytherideis fasciata* Brady & Robertson, 1874 [Fig. 9, no. 2]
Paracytheridea bovettensis (Seguenza) = *Cytheropteron bovettensis* Seguenza, 1880
Paradoxostoma angustum G.W. Müller, 1894
Paradoxostoma versicolor G.W. Müller, 1894
Pontocythere turbida (G.W. Müller) = *Cytheridea turbida* G.W. Müller, 1894 [Fig. 7, no. 7]
Procytherideis subspiralis (Brady, Crosskey & Robertson) = *Cytherideis subspiralis* B., C. & R., 1874 [Fig. 7, no. 12]
Pseudocythere caudata Sars, 1866
4 *Pseudocandona* aff. *P. marchica* (Hartwig, 1899) [Fig. 8, no. 9]
Pseudocandona sarsi (Hartwig) = *Candona sarsi* Hartwig, 1899 [Fig. 8, no. 10]
4 *Pseudocandona* aff. *P. sucki* (Hartwig,1901) [Fig. 8, no. 8]
Sagmatocythere napoliana (Puri) = *Loxoconcha napoliana* Puri, 1963
Semicytherura alifera Ruggieri, 1959 [Fig. 7, no. 9]
Semicytherura incongruens (G. W. Müller) = *Cytherura incongruens* G. W. Müller, 1894 [Fig. 8, no. 5]
9 *Semicytherura inversa* (Seguenza) = *Cytherura inversa* Seguenza, 1880 [Fig. 8, no. 6]
Semicytherura quadridentata (Hartmann) = *Cytherura quadridentata* Hartmann, 1953
Semicytherura rara (G. W. Müller) = *Cytherura rara* G. W. Müller, 1894
Semicytherura sulcata (G. W. Müller) = Cytherura sulcata G. W. Müller, 1894 [Fig. 7, no. 11]
Tenedocythere prava (Baird) = *Cythere prava* Baird, 1850
Tetracytherura angulosa (Seguenza) = *Cytheridea angulosa* Seguenza, 1880
Urocythereis flexicauda Bonaduce, Ciampo & Masoli, 1976
Urocythereis margaritifera (G.W. Müller) = *Cythereis margaritifera* G.W. Müller, 1894
Xestoleberis communis G.W. Müller, 1894 [Fig. 9, no. 8]
10 Xestoleberis aff. X. fuscomaculata G.W. Müller, 1894 [Fig. 9, no. 10]

1 *Aurila arborescens:* species known in most of the literature as *A. woodwardi* (Brady, 1868) which is its junior synonym as demonstrated by Athersuch *et al.* (1985).

2 *Bairdia* gr. *B. mediterranea.* The variability of very closed species does not allow a more precise determination, possible only trough the stdy of the soft parts; consequently these forms are grouped together.

3 *Callistocythere* sp. 1 is close to *Callistocythere folliculosa* Bonaduce, Ciampo & Masoli, 1976 in the general scheme of the ornamentation; it differs in the absence of secondary ornamentation which in *C. folliculosa* is constituted by small foveolæ in the cental area, completely absent in this specimens.

4 *Candona* aff. *C. fragilis, Ilyocypris* aff. *I. quinculminata, Pseudocandona* aff. *P. marchica* and *Pseudocandona* aff. *P. sucki* (Hartwig). A more precise identification was impossible due to the fact that for a correct diagnosis a study of the soft part is needed.

5 *Carinocythereis whitei* is cited in most of the literature as *Carinocythereis antiquata* (Baird, 1850) or *Carinocythereis bairdi* Uliczny, 1969. Athersuch & Whittaker (1987) in an accurate revision demonstrate that both species are junior synonyms of *Carinocythereis whitei* (Baird).

6 *Heterocypris salina* (Brady) emended name for *Heterocypris salinus* (Brady).

7 *Loxoconcha affinis:* known in most of the literature as *L. bairdi* G.W. Müller, 1912, which is its junior synonym as shown by Athersuch (1976).

8 *Loxoconcha ovulata,* which can be considered *nomen oblitum,* has been anyway reexhumed by Atersuch (1979) and accepted in this paper in consideration of the numerous citations with this name. In part of the literature it is also cited as *Loxoconcha tumida* Brady, 1869.

9 *Semicytherrura inversa* is in most of the literature cited as *Semicytherura cribriformis* (G.W. Mueller, 1894). Ruggieri (1989) point out that *Cytherura cribriformis* G.W. Mueller corresponds exactly in both the diagnosis and the original drawings to the species of Seguenza.

10 *Xestoleberis* aff. *X. fuscomaculata* differs from *Xestoleberis fuscomaculata* G.W. Mueller in the bigger size (*X. fuscomaculata* L = 0.55÷0.60 mm; *X.* aff. *X. fuscomaculata* L = 0.64 mm) and in the posterior extremity less regularly rounded.

Ms received : May 6, 1996
Sent to the A. for a revision: Aug. 17, 1996
Final text received: Nov. 29, 1996

Ms. ricevuto: 6 maggio 1996
Inviato all'A. per la revisione: 17 agosto 1996
Testo definitivo ricevuto: 29 novembre 1996

(cont. from/da p. 456) *9 -* Cytheretta subradiosa *(Roemer), valva sinistra, A 15; 10 -* Xestoleberis *aff.* X. fuscomaculata *G.W. Müller, valva destra, A 16.*