MORPHOLOGICAL AND PALAEOENVIRONMENTAL EVOLUTION
OF THE VENDICIO COASTAL PLAIN IN THE HOLOCENE
(LATIUM, CENTRAL ITALY)

G. Aiello1, D. Barra1, T. De Pippo1, C. Donadio1, P. Miele2 & E. Russo Ermolli1

1 Dipartimento di Scienze della Terra, Università degli Studi di Napoli Federico II
2c/o Dipartimento di Scienze della Terra, Università degli Studi di Napoli Federico II
10, Largo San Marcello – 80138 Napoli (Italy)
corresponding author: prof. Tommaso De Pippo depippo@unina.it

ABSTRACT: Morphological and palaeoenvironmental evolution of the Vendicio coastal plain in the Holocene (Latium, Central Italy). (IT ISSN 0394-3356, 2007).

Morphological, stratigraphical and palaeoecological studies carried out along the Vendicio coastal plain (southern Latium) allowed us to reconstruct the palaeoenvironmental evolution of the plain in relation to Holocene sea-level changes.

On the basis of altitude, texture, microfossil and pollen content of sediments recovered in a 20 m borehole carried out on the backshore, three main transitional palaeoenvironments were recognised. Particularly, the 14C dating of a peat layer at the boring base (~16 m a.s.l.), interbedded between sandy silt with organic matter and silty peat levels, gives an age of 7620 ±100 yr BP, equivalent to 8354-8524 cal yr BP. Over these deposits, sands with pebbles, sometimes alternated with silt and sandy silt levels, lay. Microfossil content, together with sediment features, confirms a transitional sequence from marsh (oligohaline) to lagoon (mesohaline-polyhaline), and finally to marine (littoral) environment, probably due to the last sea ingression related to the mid-Holocene Climatic Optimum peak (~6000 years BP). Pollen analysis reveals the existence of a deciduous forest association, rich in high-humidity demanding elements, and fits in with recent morphological evolutionary models of other minor coastal plains of Latium.

RIASSUNTO: Evoluzione morfologica e paleoambientale della piana costiera di Vendicio (Lazio, Italia centrale). (IT ISSN 0394-3356, 2007).

Lo studio delle caratteristiche morfologiche, stratigrafiche e paleoecologiche, connesso a variazioni del livello marino, ha permesso di ricostruire l’evoluzione paleoambientale olocenica della piana costiera di Vendicio, ubicata nel Lazio meridionale. Sulla base delle quote, dei caratteri tessiturali, dei microfossili e di analisi palinologiche condotte su campioni di sedimento, estratti da una carota della spiaggia emersa, sono stati riconosciuti tre differenti palaeoambienti di transizione. In particolare un campione di torba alla base della carota (~16 m s.l.m.), posto tra alternative di limi sabbiosi organici e livelli di torbe limose, ha fornito un’età radiometrica 14C di 7620 ±100 anni dal presente pari ad un’età calibrata di 8354-8524 anni BP. Questa successione sedimentaria è troncata da depositi sabbiosi con ciottoli, talora alternati a livelli siltosi e siltoso-sabbiosi. Le associazioni a microfossili calcarei di tali depositi, insieme ai caratteri sedimentologici, confermano una progressiva transizione da un ambiente oligalino a mesosaline-polialine (da palustri a lagunari) ed infine il rapido passaggio a quello marino (littore), in seguito all’ultima ingressione del mare correlabile al picco dell’optimum climatico medio-olocenico (~6000 anni BP). L’analisi pollinica indica la presenza di una ricca associazione di foresta decidua, rich in high-humidity demanding elements, and fits in with recent morphological evolutionary models of other minor coastal plains of Latium.

Key-words: Coastal geomorphology, lagoons, sea-level changes, Holocene, Italy.

1 INTRODUCTION

The recovery of a sediment core, on the backshore of the Vendicio beach, allowed a palaeoenvironmental reconstruction to be performed through paleoecological, sedimentological and palynological analysis and correlated with the evolution of adjacent coastal sectors during the early Holocene, where differential vertical movements occurred especially in Quaternary times (BORDONI & VALENSISE, 1998; ANTONIOLI et al., 2006; DE PIPPO et al., 2007).

2 GEOLOGICAL AND GEOMORPHOLOGICAL OUTLINE

The Vendicio coastal plain is located in southern Latium and extends for about 2 km from the headland...
of Mount Conca, to the W, to Marina di Castellone, to the E (Fig. 1).

The coastal sector is bounded, to the NE and NW, by NW-SE faults. One of such faults, named Gaeta-Itri-Monte Calvo, sharply separates the northeastern area, where Cretaceous carbonate dominates, from the southwestern area, where Triassic-Giurassic dolomite outcrops prevail (Servizio Geologico d’Italia, 1968). Moving further away from this line and up in the succession more limestones, Giurassic in age, are present, as one can observe along the slopes of Lisantro and Dragone mounts (De Riso, 1964).

Finally, the coastal exposures show the top of the succession, mainly represented by Cretaceous limestones, followed by prevalingly continental Pleistocene and Holocene deposits (HEARTY et al., 1986a; 1986b; HEARTY, 1986; ACCORDI & CARBONE, 1988). The carbonatic succession, heavily crossed by a network of structural discontinuity with Apenninic (NW-SE) and anti-Apenninic (NE-SW) trends (AMBROSETTI et al., 1987; CERISOLA & MONTONE, 1992; CARRARA, 1995a; 1995b; CARRARA et al., 1995), have a pronounced influence on the local geomorphological setting.

Owing to the strict correlation between the tectonic structure and the morphological evolution of the area, the slope of the relief are fault scarp or fault-line scarps, locally also modelled by karstic and denudation processes. Therefore, the landscape is characterised by a series of scarp and scarp-line scarps, which generally are of a structural type and separate valleys, which develop according to local tectonic lines, mainly with NW-SE and NE-SW trends, subordinately E-W ones.

The alternation of pocket beaches along the coast is also related to the presence of faults, prevalingly those NE-SW oriented. Cliffs were also controlled by tectonics in their development, as noted for the dead or fossil cliffs of Mount Orlando and those of Mount Moneta, in the hinterland of the plain of Sant’Agostino, to the SW. The headland of Mount Orlando, the highest Moneta, in the hinterland of the plain of Sant’Agostino, fossil cliffs of Mount Orlando and those of Mount Conca, bordering the western side of the Vendicio beach, continues under the sea down to about -5 m, where a sandy bottom is present. This coastal segment is characterised by a sandy beach, locally with pebbles, located between the rocky headlands of Mount Conca and Formia. Behind the modern dune ridge, hardly dismantled, a minor alluvial plain is also present, delimited in the NE by the southwestern slope of Costamezza hill, a palaeo-colluvial NW-SE, as the local tectonic alignment.

Evidence of ancient sea-level standings are scarcest along the cliffs of the rocky headlands bordering the beach. At their bases a sandy bottom is usually present, which gently degrades down to -15/-25 m. Steep slopes, in a range between -20 and -50 m depth, are present along the submerged southwestern sector. The NE-SW trend (ANTONIOLI, 1991; 1995; VALENTE, 1999; MIELE, 2003) of such morphological elements suggests a structural control, which also influences the direction of the transversal elements, such as the wide fractures which tend to isolate stacks as at Montagna Spaccata, to the SW. Here, some caves, remodelled both by waves and karstic phenomena, continue under the sea-level.

Along the southwestern coast, evidence of paleo-sea-level positions are numerous (ANTONIOLI et al., 2006; DE PIPPO et al., 2007). In particular, along the slopes of
Moneta and Lisantro mounts, sea-notches, marine terraces, fringe boring by bivalve such as Litophaga litophaga LINNEO and drapes of sediments are present. Some marine forms are also preserved along the fossil sea cliffs bounding the Vendicio coastal plain. In the western area, along the Mount Conca cliff and at the back of the waterfront, a sea-notch can be observed at about +0.5 m, bored by L. litophaga LINNEO. Some relics of marine terraces are also present, partially covered by breccias probably referable to the Würm regression (MIS 2). Such breccias are heterometric, seaward dipping, often rubefact in the matrix. In the lower stratigraphic terms mollusc shell debris occurs, consisting of minute bivalve (i.e. Glycymeris sp.) and gastropod fragments. Such deposits, originated in the intertidal zone, where clasts either from the sea and from the land were deposited without a significant transport, are rather diffuse along this coast, even if sometimes with a negligible thickness.

A careful observation of the isobaths, concave seaward in the area in front of the beach and convex and close together in the area where the rocky coast is stretched out, confirms that, under the loose sedimentary mantle which at present covers the sea-bottom, the morphology of the submerged coast, characterised by marine terraces (Segre, 1949; Antonioli, 1991; 1995), is controlled by the same structural pattern of the emerged area.

3 MATERIALS AND METHODS

A 20 m long soil boring was carried out on the backshore of the Vendicio plain (Fig. 2). A peat level is present at the boring base (-16 m a.s.l.), interbedded between sandy silt with organic matter and silty peat levels (a: between -17 and -3 m a.s.l.). The AMS 14C dating of the bulk (Geochron Laboratories - USA, sample nr. GX-32021) gives a 7620±100 yr BP age equivalent to 8354-8524 cal yr BP (CALIB 5.01 – Stuiver & Reimer, 1993; Reimer et al., 2004). Above these deposits, sand with pebbles, sometimes alternated with silt and sandy silt layers, lay (b: between -3 and -1.5 m). Finally, over these sediments an anthropogenic top soil formed by colluvial layers, carbonatic boulders with Litophaga litophaga boreholes, pebbles, sand and landfill, lay (c: between -1.5 and +3 m a.s.l.). Geomorphological surveys have been performed along the emerged coastal belt, characterised by limestone cliffs bordering a plain with dune ridge and partially anthropised. The geomorphological features have been considered in order to obtain a complete outline of the morphostructural arrangement of the investigated area. Environmental features related to ancient positions of the sea-level have been recognised and interpreted, and therefore ascribed to a certain chronological interval thanks to the 14C dating of a boring sample.

The correspondence existing between some of the recovered elements, their dating and the sea-level position in the last 8400 years (MIS 1), allowed a correlation with the eustatic curves relative to the Tyrrenian Sea in the same range of time. Remarkable discrepancies exist among the eustatic curves plotted for different geographic areas. Therefore, the curve covering the last 22,000 years, after Alessio et al. (1996), and
that covering the last 10,000 years, after Lambeck et al., (2004a), both plotted by those authors with data collected in the more stable coastal areas of the Tyrrenian Sea, were chosen as a reference.

Paleoecological and palynological analysis were only carried out on the lower part of the core where the sediment grain size and nature was more suitable for fossil preservation. Eleven core samples (300 g dried weight) were disaggregated, washed with water through 200 mesh sieves (75 µm) and analysed with the aim of studying calcareous microfossil assemblages. Attention was focused especially on ostracod and foraminifer taxa. All the samples yielded at least a few calcareous fossil remains. Assemblages are characterised by the presence of ostracods, benthic foraminifers, bivalves, gastropods (shells and opercula) and charophyte oogonia.

Pollen analysis was carried out on 8 core samples, from -16.55 to -15.15 m a.s.l. Chemical (HCl and HF) and physical (10µ filtering 200µ, heavy liquid separation) procedures were used to concentrate the pollen grains in the residue. All samples resulted rich and with a good pollen preservation. Pollen sums range from 379 to 684 pollen grains. Concentration values oscillate around 70-100,000 grains/g and reach about 200,000 grains/g in the richest levels.

### 4 CALCAREOUS MICROFOSSIL ASSEMBLAGES

The benthic foraminifer assemblages include six species pertaining to five genera; the ostracod assemblages consist of seven species in seven genera. Taxa are listed in Table 1. Some species have been figured in Plate 1.

Semiquantitative abundance of fossil taxa in the samples is represented by the following abbreviations: vr (very rare), r (rare), u (uncommon), c (common), a (abundant). Palaeoecological interpretations follow the modern literature on recent paralic/shallow-marine benthic foraminifers and ostracods (i.a. Barbeito-Gonzalez, 1971; Hiller, 1972; Bonaduce & Masoli, 1974; Vesper, 1975; Bonaduce et al., 1976; Hartmann & Hiller, 1977; Meisch, 2000). The studied specimens are housed in the Aiello Barra Micropaleontological Collection (A.B.M.C.), Dipartimento di Scienze della Terra, Università degli Studi di Napoli Federico II, Naples (Italy).

Assemblage analysis allows the analysed section to be subdivided into three intervals (Fig. 2): a1 – the lowermost sample, V1, yielded an ostracod assemblage dominated by Candona neglecta and subordinately by Potamocypris fallax. Ilyocypris bradyi is rare as well as gastropods. These species indicate a

<table>
<thead>
<tr>
<th>TAXA</th>
<th>samples</th>
<th>depth (m a.s.l.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V1</td>
<td>V2</td>
</tr>
<tr>
<td>Foraminiferida</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ammonia tepida</em> Cushman, 1926</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bolivina sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Elphidium cuvilleri</em> Lévy, 1966</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Elphidium paralium</em> (Tintant, 1954)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Fursenkoina acuta</em> (d’Orbigny, 1846)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Quinqueloculina milletti</em> (Wiesner, 1912)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ostracoda</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ilyocypris bradyi</em> Sars, 1890</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Candona neglecta</em> Sars, 1887</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Cyprideis torosa</em> (Jones, 1850)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Leptocythere rara</em> (G.W. Müller, 1894)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Loxoconcha stellifera</em> G.W. Müller, 1894</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Potamocypris fallax</em> Fox, 1967</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pseudocandona sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIVALVIA</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>GASTROPODA</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHARACEAE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tab. 1 - Semiquantitative distribution of the calcareous remains in the Vendicio plain core (a = abundant, c = common, u = uncommon, r = rare, vr = very rare).

Distruzione semiquantitativa dei microfossili calcarei presenti nel sondaggio della piana di Vendicio (a = abbondante, c = comune, u = poco comune, r = raro, vr = molto raro).
Plate 1 -
fig. 1 - *Quinqueloculina milletti*, 4 chamber side, V9, (x 67).
fig. 2 - *Elphidium paralium*, side view, V9, (x 53).
fig. 3 - *Elphidium cuvillieri*, side view, V9, (x 37).
fig. 4 - *Ammonia tepida*, spiral side, V9, (x 48).
fig. 5 - *Cyprideis torosa*, left valve, V7, (x 68).
fig. 6 - *Cyprideis torosa*, right valve, V7, (x 77).
fig. 7 - *Loxoconcha stellifera*, right valve female, V7, (x 66).
fig. 8 - *Loxoconcha stellifera*, left valve female, V7, (x 66).
fig. 9 - *Potamocypris fallax*, left valve, V1, (x 68).
fig. 10 - *Leptocythere rara*, right valve, V9, (x 76).

Plate 1 -
fig. 1 - *Quinqueloculina milletti*, veduta del lato a 4 camere, V9, (x 67).
fig. 2 - *Elphidium paralium*, veduta laterale, V9, (x 53).
fig. 3 - *Elphidium cuvillieri*, veduta laterale, V9, (x 37).
fig. 4 - *Ammonia tepida*, veduta del lato spirale, V9, (x 48).
fig. 5 - *Cyprideis torosa*, valva sinistra, V7, (x 68).
fig. 6 - *Cyprideis torosa*, valva destra, V7, (x 77).
fig. 7 - *Loxoconcha stellifera*, valva destra femminile, V7, (x 66).
fig. 8 - *Loxoconcha stellifera*, valva destra maschile, V7, (x 66).
fig. 9 - *Potamocypris fallax*, valva sinistra, V1, (x 68).
fig. 10 - *Leptocythere rara*, valva destra, V9, (x 76).
depositional paleoenvironment characterised by continen-
tal, oligohaline to mesohaline, relatively cold (<20°C), stagnant waters. Benthic foraminifers are not present;
a2 – the overlying interval is represented by three sam-
ples (V2, V3, V4) devoid of both ostracod and foramin-
ifer specimens. Calcareous fossil remains are represen-
ted exclusively by rare gastropods fragments and ope-
cula. The sediment consists largely of carbonaceous
matter derived from plant remains. The accumulation of
organic matter generates the formation of acidic bot-
tom and pore waters, due to the high concentration of
metabolically produced carbon dioxide (CO₂). A low
carbonate saturation index may cause the dissolution
of the delicate ostracod shells. Consequently, these
sediments possibly indicate the effect of a cold and arid
climate phase in a swampy environment (i.e. GLIOZZI &
MAZZINI, 1998; BELIS et al., 1999);
a3 – in the seven samples belonging to the upper part of
the core (V5 – V11) benthic foraminifers are present and
the fossil assemblages are generally richer and less olli-
gotypic than in lower deposits. These portions show a
more or less marked influence of marine waters, and the
assemblages indicate four different paleoenvironments:
- samples V5, V6, V7, V11. Ostracod assemblages
  consist of two species: Cyprideis torosa, which is
  very abundant, and, subordinately, Loxoconcha stelli-
  fera. The foraminifer assemblages are characterised
  by Ammonia beccarii, Quinquelocula milletti and the
genus *Elphidium* (these latter not present in sample
V6). The assemblages evidence a deposition in
polyhaline waters;
- sample V8. Abundant carbonaceous matter, rare spec-
cimens of *Ammonia beccarii* and *Elphidium cuvilleri*
and the absence of ostracod shells indicates that
these sediments were deposited in conditions similar
to those in interval 2, but in polyhaline waters;
- sample V9. Three ostracod and six foraminifer spe-
cies occur, including *Leptocythere rara*, *Fursenkoina
acuta* and *Bolivina* which are recorded exclusively in
this assemblage. The highest diversity possibly corre-
sponds with the maximum influence of sea waters;
- sample V10. This assemblage is the only one which
shows the presence of *Ilyocypris bradyi* and
*Pseudocandona* sp., nonmarine taxa, together with the
“marine-brackish” species *L. stellifera*, *Q. milletti*
and *E. cuvilleri*, suggesting a deposition in mesohali-
ne-polyhaline waters, possibly with rapid (seasonal)
salinity variations.

5 PALYNOLOGY

Pollen analysis results are presented in a detailed
pollen diagram (Fig. 3) where all the recognised taxa
show their percentage values plotted against depth. The
arboreal taxa percentage (AP/Total curve in Fig. 3)
was calculated on a pollen sum excluding indetermina-
te grains, water plants and spores. AP values oscillate
around 90% all along the investigated succession
giving the image of a rather dense forested landscape
(i.a. Heim, 1970) in which the main arboreal elements
were *Alnus*, *Corylus*, deciduous *Quercus*, *Carpinus*
and *Ulmus*. The only AP reduction is observed at 15.50 m
depth where a rise in Poaceae turns the AP down to
68%. The arboreal taxa percentage (curve AP/Total in
Fig. 3) oscillates from 60 to 80% giving the image of a
rather dense forested landscape (i.a. Heim, 1970). The
main arboreal elements are *Alnus*, *Corylus*, deciduous

![Fig. 3 - Detailed pollen diagram. Taxa percentages are plotted against depth.](Diagramma di dettaglio dei pollini. Le percentuali dei taxa sono restituite con le relative profondità.)
Quercus, Carpinus and Ulmus.

Deciduous Quercus and Carpinus do not show important variations. They probably represent the main elements of a slope forest association, established on well drained soils. On the contrary Alnus, Corylus and Ulmus, which are high soil-humidity demanding elements, show more significant percent variations maybe linked to waterbed oscillations. In fact, they should have occupied the Vendicio plain in a forestal association by now not represented by a regional modern analogue.

Vegetation associations dominated by Alnus, Corylus, Carpinus and Ulmus now characterise high humidity environments linked to microclimatic conditions, well represented all over Italy (Pedrotti & Gaeta, 1996). These elements are also commonly present in alluvial environments of temperate regions in central Europe (Pollunin & Walters, 1987) where they form plain-wood strips, by now relics in Italy and have almost disappeared from southern Italy, a part from the higrophylous woods of Mount Circeo (Stanisci et al., 1998).

Small amounts of Fagus and Betula are the only representatives of the mountainous vegetation belt. Mediterranean elements are present but rare all along the analysed succession apart from a slight increase in Quercus ilex towards the top.

Poaceae are the main representatives of the herbaceous elements; their percentages are always below 10% apart from the sample at -15.50 m where they reach 30%. The low percentage of spores and the relative lower percentages of Alnus at the same core depth could indicate the reduction of dump soils around the drilling site. Cyperaceae are rare but show a slight increase at -15.90 and -16.15 m; the correspondence with the highest values of Alnus could indicate the extension of wetlands in the Vendicio plain.

It is very interesting from a phytogeographical and bioclimatic point of view the constant presence of Vitis sp. The species vinifera, as its wild representative, are now associated with the above mentioned arboreal elements in thermophilous humid forests from central to southern Italy (Pignatti, 1982) even if the wild representative is in constant regression all over Europe (Arnold et al., 1998).

The 14C age of 7620+/-100 yr BP (8354-8524 cal yr BP) obtained at -16 m a.s.l. places the analysed succession at the beginning of the Atlantic chronozone (about 9000-5700 cal yr BP), the Holocene thermal optimum (Ravazzi, 2003), which is characterised by wetter (about +200 mm/a) and cooler (about -1.5ºC TANN) climatic conditions in respect to modern values (Terral & Mengual, 1999; Davis et al., 2003; Magno et al., 2003). These climatic conditions associated with the humid edaphic conditions typical of a coastal plain can explain the existence of a forestal association like the one recognised in the core.

6 DISCUSSION AND CONCLUSIONS

In this work the morphological and palaeoenvironmental evolution of the Vendicio coastal plain is depicted for the first time (Fig. 4) as sedimentological and ecological signatures of ancient coastlines. The analysed sedimentary succession starts in the early Holocene (about 8400 yr BP) and covers the main phases of the mid-Holocene eustatic sea-level rise. Three main transitional palaeoenvironments are recognised in the basal part of the core, on the basis of height, texture, microfossil and palinological analyses.

Pollen analysis reveals for the first time the existence of humid soils around the drilling site with the occurrence of a plain-forest where elements such as Vitis are also recorded. Microfossil assemblages together with sediment characteristics, indicate a transitional sequence from oligo-mesohaline to meso-polyhaline (from marsh to lagoon), and finally to marine (littoral) environment, due to the last sea ingression related to the mid-Holocene Climatic Optimum peak (~6000 yr BP). Such environmental succession was also described in two 6 m long boreholes, carried out along the coastal sector west of Formia. According to Sewink et al. (1984), lagoonal clays with interbedded fine sand levels indicate a transition from brackish, with fresh water, to marine-brackish, probably littoral, environment. These deposits, intercalated towards the top with several paleosols, are locally covered by Roccamonfina tuffs, after an erosive phase. Over this volcanic material, reddish, yellowish and reddish brown eolian sands as well as anthropogeneous colluvial layers are present, confirming the evolution towards a continental environment.

In order to delineate the morphodynamic evolution of the Vendicio coastal plain in the Holocene, two eustatic curves (Alessio et al., 1996; Lambeck et al., 2004a), were chosen as a reference. The present position of the dated peat level in the study soil boring (-16 m a.s.l.) could indicate both stable conditions or the occurrence of a slight subsidence in the plain, in agreement with literature data (Ferranti et al., 2006).

On the basis of the chosen references, the sea level position at 8400 years BP was about -15 m lower than the present. The dated peat position at -16 m is consistent with a marsh to shallow water lagoon environment, in stable tectonic conditions. However, a slight subsidence could also be deduced for the considered time interval. No data are specifically available in this area which could better detail the sea level rise during the early Holocene, but at 2000 years BP considering geocarcenological data Alessio et al. (1996) indicate a sea level of about 0.6-1.5 m lower than the present, while Lambeck et al. (2004b) calculate a sea level of about 1.35 m lower than the current for the sites of Sarinola and Serapo, close to the study area. As a matter of fact differential movements between adjacent coastal sectors have occurred up to recent times (De Pippo et al., 2007). Such movements would have occurred along the NW-SE faults that represent the borders of the pocket beach system characterising the entire coastal physiography. Moreover, such discontinuities act as unblocking elements for adjacent coastal sectors. This fact suggests that the coastline did not behave homogeneously during the late Quaternary tectonic phases, as hypothesized for some sectors of the Campanian coastline (Cinque & Romano, 1990; De Pippo et al., 1998; Esposito et al., 2003).

Such dislocations, which occurred in the studied coast, can be referred to a sector of the central Apennine included between the two main coastal plains of Fondi and Formia-Garigliano where a slight subsi-
Fig. 4 - Probable palaeoenvironmental evolutionary model of the Vendicio coa-
stal plain, desumed from soil borings (see Fig. 2 and citations) and morpho-
gical features: A) upper Pleistocene -
lower Holocene: marsh environment
characterised by a coastal pond with
debouching stream, dune ridge and
beach; B) 8400 years BP - mid
Holocene: development of the lagoon
with debouching stream and the mouth
cutting the dune; retreating beach due
to sea level rise; C) mid Holocene - pre-
sent-day: gradual disappearance of the
dune and lagoon; beach retreat due to
both sea level rise and recent strong
anthropogeneous intervention along the
plain; 1) carbonatic rock; 2) duna rossa
antica (ancient red dune) Formation; 3)
carbonatic talus; 4) marsh deposits; 5)
eolic deposits; 6) marine deposits; 7)
lagoon deposits; 8) landfill. The block-
diagram is not in scale; the vertical
wired arrow shows the sea level rise,
while the horizontal grey the shoreline
retreat.

Modello della probabile evoluzione
paleoambientale della piana costiera di
Vendicio, desunto da sondaggi (cfr. Fig.
2 e citazioni) e caratteri morfologici; A)
Pleistocene superiore - Olocene inferio-
re: ambiente palustre con stagno costie-
ro alimentato dal corso d’acqua, cordo-
ze dunare e spiaggia; B) 8400 anni BP -
Olocene medio: sviluppo della laguna
alimentata dal corso d’acqua, con foce
discesa la duna; spiaggia in arretra-
mento a seguito dell’ingressione marina;
C) Olocene medio - attuale: graduale
scomparsa della duna e del retrostante
ambiente lagunare; arretramento della
spiaggia a seguito sia dell’ingressione
marina sia dell’intensa antropizzazione
recente della piana; 1) roccia carbonati-
ca; 2) Formazione della duna rossa anti-
ca; 3) detrito carbonatico; 4) depositi
palustri; 5) depositi eolici; 6) depositi
marini; 7) depositi lagunari; 8) colmata
artificiale. Il diagramma stereo non è in
scala; la freccia verticale indica la varia-
zione del livello marino, mentre quella
orizzontale grigia l’arretramento della
linea di riva.
dence is recorded. In fact, according to recent papers, the whole eastern Tyrrhenian margin can be considered from stable to slowly subsiding from MIS 5.5 (Ozer et al., 1987; Ferranti et al., 2006), even if in southern Latium local uplift movements are estimated (De Pippo et al., 2007).

REFERENCES


Davis B.A.S., Brewer S., Stevenson A.C., Guiot J. & Data Contributors (2003) - The temperature of Europe during the Holocene reconstructed from pollen data. Quaternary Science Reviews, 22, 1701-1716.


Hartmann G. & Hiller D. (1977) - Beitrag zur Kenntnis der Ostracodenfauna des Harzes und seines nörd-


LAMBECK K., ANTONIOLI F., PURCELL A. & SILENZI S. (2004a) - Sea-level change along the Italian coast for the past 10,000 yr. Quaternary Science Reviews, 23, 1567-1598.


RAVazzi (2003) - An overview of the Quaternary continental stratigraphic units based on biological and climatic events in Italy. II Quaternario, 16 bis, 11-18.


SERVIZIO GEOLOGICO D’ITALIA (1968) - Foglio 171 - Gaeta, Carta Geologica d’Italia, II ed., 1:100.000.


Ms. ricevuto il 30 maggio 2007
Testo definitivo ricevuto il 3 settembre 2007
Ms. received: May 30, 2007
Final text received: September 3, 2007