Geodynamic and hydro-geological constraints regarding the extension of the prospective archaeo-cultural area within the northern Romanian coastal zone

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**ABSTRACT**

An obvious discrepancy is noticed between the very few archaeological sites discovered until now on the Danube Delta plain area and the large number of such sites, whose ages range from the Middle Paleolithic to the Middle Ages and more recently, identified on its higher topography surroundings.

The combined effects of the regional subsidence of the coast and delta area, with amplitudes of ~2 to ~4 mm/yr and of the secular mean sea level rise (~0.5/1.0 mm/yr) continuously change the "land-mean sea level" relative relationship, placing the prospective archaeo-cultural layer corresponding to the Late Prehistory – Antiquity period at a burial depth which now exceeds 4–5 m. This situation partly explains the limited success of the archaeological research carried out until now within the Danube Delta plain area and recommends a systematic use of the geophysical investigation methods in future. The integrated interpretation of the coastal zone bathymetry and sedimentology mappings and of the shoreline geomorphological evolution in time highlights the sedimentary processes that presently shape the littoral study zone allowing to divide it in sectors where either sediments accumulation or erosion processes prevail. The study draws attention to the Împutânta – Câșa Vadianei and Conșa – Vadu littoral sectors where the intense marine erosion of the shoreline and the adjacent seabed also imminently endangers their prospective archaeo-cultural load.

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1. Introduction

The historical region of Dobruja, also known as Dobrogea (in Romanian), Dobrudja or Dobrudzha (in Bulgarian), is located on the western coast of the Black Sea, and is bordered to the west and north by the River Danube. Today, the region belongs both to Romania (Tulcea and Constanța counties) and Bulgaria (the administrative regions of Dobrich and Silistra). The study area (Fig. 1), located in northern Dobruja, entirely covers the Danube Delta and its adjacent littoral sector.

Although the archaeo-cultural heritage of the Dobruja region is quite impressive, the number of archaeological sites discovered until now within the Danube Delta plain area is surprisingly low. The paper synthesizes information on this region's crustal geodynamics, Late Pleistocene – Holocene geological evolution of the Danube Delta area, and on the recent eustasy, and tries to make a reliable prediction on the extension and burial depth of the prospective archaeo-cultural layer corresponding to Ancient times. The paper also gives an integrated interpretation of the hydro-geomorphological processes which shape the modern littoral and the shallow seabed of the study area, trying to draw special attention to those sectors where marine erosion causes rapid shoreline retreat and imminently endangers the prospective archaeological heritage.

1.1. Regional setting

The main structural units of the regional basement (Fig. 1) are, from north to south, the Scythian Platform, represented here by the downthrown compartment of the Pre-Dobruja Depression, the North Dobruja Folded Belt, conventionally confined between the Peceaneagă-Camene and Șăntu Gheorghe Faults (the latter is well-known in the offshore as the Sulina-Tarkhankut Fault; Dinu et al., 2005) and the Moesian Platform, represented by its uplifted Central Dobruja Unit. The lithological units of the Cimmerian folded belt and Moesian Platform are sealed by the post-tectonic late Cretaceous sediments of the Babadag Syncline, extending beneath the young, unconsolidated sediments of the southern Danube Delta towards the Histria Depression on the Black Sea continental shelf. The Danube Delta sedimentary successions include both marine and lacustrine littoral deposits, fluvial, marsh and loess-like deposits (Panin, 1996).

The Late Pleistocene and Holocene evolution of the Danube Delta (Fig. 2) includes the following main phases (Panin, 1999): (1) the formation of the Letea-Caraorman initial spit, 9700–5500 BC; (2)
Fig. 1. Study area (dashed line ellipse) located on the north-western Black Sea coast, in the coastal zone of the Northern Dobruja Region, and the main structural units beneath it (regional geological map after Sandulescu et al., 1978, with modifications).
the formation of the Sfântu Gheorghe I secondary delta, 7000–5200 BC; (3) the formation of the Sulina secondary delta, 5200–0 BC, followed by its erosion until present; (4) the formation of the Coșna-Sinoie secondary delta, 1500 BC–500 AD, and (5) the formation of the Sfântu Gheorghe II and Chilia secondary deltas, 800 BC–present. As Fig. 2 illustrates, due to the delta lobes' evolution over time, the coastline also suffered important displacements with notable consequences on the number and position of the Danube River's branches discharging mouths and on the related human activities such as habitation, navigation, and trade.

According to ancient historians (e.g. Herodotus in the 5th century BC, Polybius in the 2nd century BC, Strabo in the 1st century BC, Pliny the Elder in the 1st century AD, Ptolemy in the 2nd century AD and others), that time, the Danube (Istros) River discharged its waters into the Black Sea through five to seven mouths (branches), among which the most important was the Hieron Stoma (Holly Mouth), identified today as being the Sfântu Gheorghe branch of the Danube (Gâștescu and Știucă, 2006).

1.2. Archaeological heritage

The territory of Dobruja has been inhabited since the Middle and Upper Paleolithic (Radulescu and Bitoleanu, 1979), as the remains discovered at Babadag, Enisala, and Gura Dobrogei (Fig. 3), among other places, certify. During Neolithic time, Dobruja was part of the Hamangia, Boian and Karanovo V cultures. Later, at the end of the 5th Millennium, the Gumelnita culture occurred in the region. During Eneolithic time, the cultural blend of local populations and tribes originating from the northern Black Sea territory gave birth to the Cernavoda I to III cultures. Archaeological sites (i.e. remains of habitation, settlements and tells) belonging to Prehistoric times, have only been found on the higher lands that border the Danube Delta, along the southern distributary of the River Danube (i.e. Sfântu Gheorghe branch) at Tulcea, Malcoci, Nufărul and along the western bank of the present-day Razelm-Sinoie lacustrine complex at Sabangia, Sarichioi, Enisala, Tașburun Hill, Jurilovca, Vișina, Lunca, Sinoie Mound, Istrău, Vadu, Corbu and Cape Midia (Fig. 3). During prehistoric and ancient times, the Razelm-Sinoie area was a gulf of the Black Sea (Halmyris Bay).

Starting from the 8th century BC, the entire area was dominated by the presence of the Geto-Dacian population, whose habitation and settlement remains and necropolises were found at Victoria, Beștepe, Dunăuvașul, near the Sfântu Gheorghe branch and at Enisala, Tașburun Hill, Salcióara, Vișina, Istrău, Nuntaș and Histria fortress on the western bank of the former Halmyris Bay (Fig. 3). Tumular (mound) complexes, probably of Scythian origin and ages starting with the 6th century BC, are present in the entire study area at Mahmudia, Murighiol, Agighiol, Sinoie area, and along the western bank of the present-day Razelm-Sinoie Delta, except for the transit point for merchandise (5th–3rd centuries BC) excavated near Caraorman (Bauman, 2006).

The most numerous archaeological sites discovered until now in the study area belong to the Roman — Byzantine period, between the 1st century BC and the 13th century AD (Fig. 3), with many breaks after the 6th century AD due to the pressure of the migration period and the rule of the first and second Bulgarian empires. Archaeological works revealed the fortresses and fortifications built along the defensive line of the Danube River: Tulcea (Aegyssus fortress), Ilgani de jos, Nufărul, Mahmudia (Salsovia fortress), Murighiol (Halmyris fortress) and Dunăuvaș; and those located on the north and western banks of the Razelm-Sinoie lacustrine complex: west of Dunăuvaș de jos (Zaporojeni fortress), Babadag, Cape Iancina, Cape Doloșman (Argamum fortress) and Sacele sandbank (Histria fortress). Habitation remains and settlements of the same age were discovered almost in all localities lying on the southern bank of the Sfântu Gheorghe branch and the shore of the former Halmyris Bay, including Tulcea, Malcoci, Nufărul, Băltenii de jos, Beștepe, Mahmudia, Murighiol, Plopu, Sarinasuf, Agighiol, Izurul, Sabangia, Sarichioi, Babadag, Visterna, Enisala, Tașburun Hill, Salcióara, Jurilovca, Vișina, Lunca, Ceamurlia de Jos, Bâa Dobrogea, Sinoie Mound, Mihai Viteazu, Istrău, Nuntaș, Chituc Sandbank, Vadu, Sacele, Corbu and Cape Midia.

Relatively numerous remains of habitation and settlements of medieval age (9th–18th centuries AD), were found (Fig. 3) at Tulcea, Nufărul, Victoria, Mahmudia, Murighiol, Dunăuvaș de Sus, Agighiol, Izurul, Sabangia, Sarichioi, Babadag, Enisala, Tașburun Hill, Salcióara, Jurilovca, Vișina, and Vadu. Fortifications remains dating from the Middle Ages are known at Tulcea, Ilgani de jos and Enisala (the Heraclea fortress, 15th–17th centuries AD). The remains of the medieval settlements found within the highest lands of the Danube Delta at Chilia, Periprava and Caraorman are also notable.
2. Methods and results

The average level of the Danube Delta topography ranges between 1 and 3 m for the fluviatile sandbanks and between 2 and 13 m for the marine beach ridges. Due to its flat topography, the entire littoral zone corresponding to the Danube Delta has high vulnerability relative to the recent and present effects of the global changes. The continuous modification of the coastline occurring during the last 11,700 years (Fig. 2), since the Letea-Caraorman initial spit came into being, reflects the changes of the land-mean sea level relative relationship in time. The main causes that change this relationship are as follows: (1) vertical \( \pm \) horizontal movements of the crust originating from geological issues (i.e. regional subsidence and isostasy) or from global tectonics such as the relative motion of the lithosphere plates; (2) downward movements due to soil compaction that affects the young, unconsolidated sediments and the loessoid deposits of the Danube Delta; and (3) secular variation of the Black Sea mean sea level.

As a unitary reference system, that could include both information from the geodetic networks and the tide-gauges in Dobruja, had been lacking until recently, all modifications of the land-mean sea level relationship were only relative. The current implementation of ETRS (European Terrestrial Reference System) and EUVN (European Vertical Reference Network) finally allow separation of the individual contributions of epeirogenesis, sediment compaction and eustacy to the overall phenomenon.

Fig. 3. The most important archaeological sites located within the Danube Delta area and vicinity (compiled according to the Romanian Archaeological Record, 2008). A brief description of sites is presented in Table 1.
2.1. Crustal movements

The subsiding regime of the Romanian littoral zone and of the northern Dobruja was first documented by geophysical-geodetical measurements carried out after 1950 (e.g. Ciocârdel and Esca, 1966). Subsidence of 1 mm/y was measured at Mangalia, and over 2 mm/y was estimated for the Danube Delta area, in good correlation with the value of 5 mm/y measured near the Dniester Liman (Fig. 4a). Later geodynamic research (Cornea et al., 1979; Popescu and Drăgoescu, 1986) found amplitudes of the littoral zone subsidence ranging from 1 mm/y to over 2 mm/y, and higher values being estimated within the Danube Delta area (Fig. 4b and c). Even higher values of subsidence (2–4 mm/y) have been reported by Polonic et al. (1999) for the littoral sectors (Fig. 4d). The intense subsidence of the entire delta area, over the last thousands of years, is also confirmed by elephant and rhinoceros skeletons found (Murgoci, 1912) during the digging of the Sulina Canal, about 6 m below the present Black Sea level, and by the position, 2 m below the present-day groundwater level, of some Hellenistic and Roman graves discovered at Histria.

Geodetic repetitive measurements carried out by Grigore et al. (1996) within the Moesian Platform indicated a 1.14–1.85 mm/y NW displacement of the Dobruja compartment relative to the Wallachian one (western part of the Moesian Platform). A general movement toward the SSE (2.5 mm/y) of the entire south-eastern Romanian territory, including the Dobruja region, is documented by the recent GPS measurements (van der Hoeven et al., 2005).

2.2. Mean sea level variation

The first measurements of the Black Sea mean sea level started on the Romanian coast in 1856, at the tide-gauge in Sulina. Later, measurements were also carried out at the tide-gauges in Constanta and Mangalia. According to the estimation made by Bondar and Filip (1963), based on the data recorded at Sulina and Constanta tide-gauges, the relative Black Sea mean sea level is relatively rising at

![Fig. 4. Maps of the actual vertical movements [mm/y] of the earth crust in Dobruja: (a) – after Ciocârdel and Esca (1966), (b) – after Cornea et al. (1979), (c) – after Popescu and Drăgoescu (1986) and (d) – after Polonic et al. (1999).](https://example.com/fig4.png)
+4 mm/y this value being in good accordance with the values of
+7 mm/y and +3 mm/y reported respectively for the tide-gauges in
Odessa and Sevastopol. All these values also include the component
due to local subsidence and/or soil compaction.

Reprocessing the raw data for longer and longer time intervals,
Bondar (1989, 2007) found a value of +0.5–1 mm/y for the mean
sea level rise. The author was also able to estimate the subsidence
at Sulina and Constanta at 2.3–3.2 mm/y and 1.7–2.3 mm/y,
respectively. These average values of the mean sea level rise are in
relatively good accordance with those reported by Panin (1996) and
Cazenave et al. (2002) for the Black Sea, and those reported
(Pirazzoli, 1996) for the Mediterranean Sea (+1.5 mm/y) and for the
Planetary Ocean (+0.5–3 mm/y).

2.3. Littoral sedimentological processes and shoreline evolution

The shallow waters of the Sfântu Gheorghe—Vadu littoral
sector were recently covered (Dimitriu et al., 2008) by a high
density geophysical lines network (over 4600 km) and a complex
sampling network. Sediments, water, biota were sampled over 400
selected locations. Fig. 5a–b illustrates the sea floor morphology
and sedimentology of the coastal zone. Comparison with similar
results achieved based on the bathymetry and sedimentology data
acquired about two decades ago clearly highlights the amplitude
and evolution trends of the sedimentary processes that currently
shape the shoreline and the seabed within the littoral sector.

A generalized shoreward isobath migration trend is noticed as
a consequence of the erosion dominance over accumulation. A
relatively unchanged hydro-morphological regime was only
observed in the Gura Portița-Sacalin Island sector, at depths greater
than 20 m. Intense erosion is present off the Sacalin Island—Sfântu
Gheorghe littoral sector, at water depths over 15 m, deepening the
seabed by 5–10 m in the last 20 years (Fig. 6a, b). Erosion has also
been noticed in the Gura Portița—Perișor sector, within the 5–10 m
bathymetric interval. Intense seabed erosion (deepening of 3–4 m
during the last two decades) is also present in the Chituc—Gura
Portița sector, for the water depth interval ranging from 0 to 10 m
and beyond.

Fig. 5. Bathymetry (a) and sedimentology (b) of the Sfântu Gheorghe—Vadu littoral sector of the Black Sea.
The single relatively stable littoral sector in the entire study zone was found at Vadu (Fig. 6a, b). The slight seaward shift of the shoreline observed during the last decades there suggests the local dominance of accumulation processes versus the erosion and transport ones.

A very good correlation between the information regarding the presence and amplitude of erosion and accumulation sedimentary processes in front of the shoreline, illustrated in Fig. 6, and the actual tendencies of the evolution of the shoreline itself (Fig. 7) is found for the Sfântu Gheorghe – Sacalin Island and Perișor – Vadu littoral sectors. High retreat rates of the shoreline observed along Sacalin Island (up to 70 m/y) and the Gura Portița – Vadu sector (10–12 m/y) indicate intense erosion shaping the coastal seabed and erasing the remnants of the former Sinoie – Coșna paleodelta beach ridges, including all its potential archaeo-cultural heritage.

In the sector West Ciotica – Perișor, the shoreline retreat (10–20 m/y) corresponds to a weak accumulation of sediments within the 3–7 m depth bathymetric interval, which is a distant effect of the continuous elongation westward of the Sacalin spit. In all cases, the underwater sedimentary processes observed clearly anticipate the further evolution of the shoreline.

A high pace of shoreline retreat (5–30 m/y) is also observed (Fig. 7) in the Impuțita – Cășla Vădanei sector, indicating the intense erosion of the submerged beach ridges belonging to the former Sulina secondary delta (Fig. 2). A relatively stable shoreline is noticed in the Cardon – Impuțita and Cășla Vădanei – Sfântu

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**Fig. 6.** Maps of (a) erosion and accumulation rates [m/y], (b) seabed depth modification [m] and (c) modification of sand content [%] in surface sediments during 1985–2005 in the Sfântu Gheorghe – Vadu littoral sector of the Black Sea.

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sediments mainly represent erosion of the paleo-beach ridges and their increasing sand content are notable. The sandy littoral sector, which became obvious during the last two decades and quantify coarse sediment dominance along the shallow water secondary delta, advancing up to 68 m/y.

Fig. 7. Present-day tendencies of the Black Sea shoreline evolution in front of the Danube Delta (compiled according to Giosan et al., 1999; Panin, 1999, and Găstescu and Stiuca, 2006).

Gheorghe littoral sectors. An advancing shoreline is only documented for the Sfântu Gheorghe—West Ciotica sector, sheltered and fed by the Sacalin spit island and also in front of the Chilia secondary delta, advancing up to 68 m/y.

Recent coastal investigations (Dimitriu et al., 2008) also confirm and quantify coarse sediment dominance along the shallow water littoral sector, which became obvious during the last two decades (Fig. 6c). Both the increased areal extent of the coarse surficial sediments and their increasing sand content are notable. The sandy sediments mainly represent erosion of the paleo-beach ridges belonging to the former secondary deltas. The fine sediments mainly originate from the Danube River, their spatial distribution being heavily influenced by the marine currents and the waves directions.

Undoubtedly, the coastline morphology is also heavily influenced in this sector by the inflows of water (276 km³/y) and sediments (61 million t/y) brought by the Danube River (65% and 81%, respectively, of the entire inputs) and its northern neighbors (Wong et al., 1994). The drastic diminishing of the Danube River sedimentary discharge from a multi-annual average value of over 50 million t/y (Bondar and Blendea, 2000) to less than 20 million t/y at the beginning of the 21st century, combined with other anthropogenic or natural causes, clearly disturbed the local balance between littoral erosion and accumulation.

3. Discussion

The entire Danube Delta area has an important archaeo-cultural potential, as demonstrated by its numerous documented archaeo-

sites located on the hill system south of the Sfântu Gheorghe distributary from Tulcea to Dunărea and also on the western bank of the Razelm—Sinoe lacustrine complex, the number of archaeo-

cultural sites presently known on the delta plain is unexpectedly low, despite its undoubted habitation mentioned by the ancient historians.

Although the geodynamic and hydro-geomorphic information has not identified new archaeological sites within the Danube Delta plain, integrated interpretation may outline those areas with higher probability to host sites and also to estimate their burial depth. The interpretation of this information also draws attention specifically to those littoral sectors whose archaeo-cultural heritage is irreversibly endangered by the current marine erosion.

Research on the Dobruja earth crust geodynamics clearly ascertained the subsidence of the entire coastal and Danube Delta zone. Estimations of the amplitude of the phenomenon generally range from 2 to 4 mm/y, which places any prospective archaeo-cultural layer corresponding to the last stage of late Prehistory and earliest Antiquity at a burial depth that exceeds 4–5 m. This could explain the lack of success of all archaeological research focused on the discovery and uncovering of Histria’s and Argamum’s ancient harbours.

Taking into consideration the burial depth of the prospective archaeo-cultural layer corresponding to Late Prehistoric—Antiquity, the only feasible way to investigate it within the Danube Delta territory is offered by geophysical methods: magnetometry, electrometry (resistivity, electromagnetics, etc.) ground penetrating radar, high resolution seismic analysis, and others. The applicability of these methods is very closely linked to the ability of ancient human beings to modify, through their past activities, the habitation environment by generating local petrophysical contrasts (i.e. modifications of the normal magnetic susceptibility, density or resistivity of materials, soil and rocks). Such contrasts of physical properties, all of anthropogenic origin, which all geophysical investigation methods rely on, were only generated when the ancient inhabitants of the Danube Delta realm started to use fire on an increasingly larger scale (producing hearths, ovens, kilns, baked clay, fired pottery and bricks, etc.), to excavate (ditches, trenches, graves, etc.), to build (dwellings, walls, burial monuments, etc.) especially when using materials of allochthonous origin (stone blocks, fired bricks, cement, etc.), and to use metallic tools and weapons. According to information gathered on the archaeological sites excavated on the adjacent Northern Dobruja, all these steps occurred since the 8th–6th centuries BC (Early Iron Age), a period when the Dobruja territory was dominated by the presence of the Greco-Dacian tribes, the start of the Greek colonization and the penetration of the first Scythian groups.

Approximately 800 BC, the Sulina secondary delta was close to its maximum area. The position of the shoreline at that moment is presented in Fig. 2. The higher lands belonging to the Chilia Promontory and to the Letea—Caraorman spit, and the marine beach ridge system to the east, were emerged and suitable for habitation. After 0 AD, the expansion of the Sulina secondary delta ceased, and the eastern third of its lobe subsequently was eroded. The intense erosion that affects the shoreline of Impușita – Cășa Vadanei littoral sector (Fig. 7) today is an immediate threat to the entire prospective archaeo-cultural heritage hidden within the beach ridge systems of the Sulina and Sfântu Gheorghe II delta lobes, with ages ranging from the 8th century BC to the 1st century AD.

The present position of the inhabited areas suggests the ancient ones were also located along the paleo-branches of the Danube, in the vicinity of the shoreline, at a safe distance from the effects of the major storms on the sea. Therefore, the most promising areas in
Table 1
Location and a brief description of the archaeological sites within the Danube Delta area and vicinity (numbering according to Fig. 3).

<table>
<thead>
<tr>
<th>Site no.</th>
<th>Location</th>
<th>Site type</th>
<th>Historic period</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Chilia Veche Village</td>
<td>Tumuli complex</td>
<td>Unspecified age</td>
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<tr>
<td>2</td>
<td>Periprava Village</td>
<td>Settlement</td>
<td>Middle Ages</td>
</tr>
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<td>3</td>
<td>Tulcea Town</td>
<td>Habitation</td>
<td>Iron age, Hellenistic, Roman and Middle Ages</td>
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<td>4</td>
<td>North-East Tulcea Town</td>
<td>“Aegyssus” Fortress</td>
<td>Roman and Middle Ages</td>
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<td>Malcoci Village</td>
<td>Habitation Settlement</td>
<td>Iron age and Roman age 4th-2nd centuries BC</td>
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<td>Nufaru Village</td>
<td>Fortress Complex</td>
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<td>7</td>
<td>Ilgani de Jos Village</td>
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<td>Baltenii de Jos Village</td>
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<td>Beștepe Village</td>
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<td>Plopu Village</td>
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<td>Caraorman Village</td>
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<td>Sabangia Village</td>
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<td>Visterna Village</td>
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<td>Settlement complex</td>
<td>Neolithic, Iron Age, 4th–2nd centuries BC, Roman-Byzantine and Middle Ages</td>
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<td>South Enisală Village</td>
<td>Necropolis</td>
<td>Roman-Byzantine and Middle Ages</td>
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<td>Settlements complex</td>
<td>Roman-Byzantine and Middle Ages</td>
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<td>Cape Iancina</td>
<td>Tumuli complex</td>
<td>Roman-Byzantine age</td>
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<td>Sălcioara Village</td>
<td>Settlements complex</td>
<td>4th–3rd centuries BC and Middle Ages</td>
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<tr>
<td>35</td>
<td>Baia Bobrogea Village</td>
<td>Necropolis</td>
<td>Hellenistic and Roman-Byzantine age</td>
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<td>36</td>
<td>Ceanurula de Jos Village</td>
<td>Settlement</td>
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<td>37</td>
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<td>38</td>
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<td>42</td>
<td>Cape Bisericuța</td>
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<td>5th–4th centuries BC, Hellenistic, Roman-Byzantine and Middle Ages</td>
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(continued on next page)
this regard are located in the vicinity of the Sfântu Gheorghe, the most important ancient distributary of the Danube River.

The probability that the beach ridges formed before approximately 500 AD in the Coșna — Vadu sector (Fig. 7), due to the southwestward development of the Coșna — Sinoie secondary delta, contain remains of ancient settlements is low. However, there is a high probability of finding remains of fortified points and shipwrecks, connected with trade between Histria and Argamum and other harbours of the Black and Mediterranean Seas. The relatively numerous fragments of pottery brought by waves to the beach southward of Gura Portița could be reworked from submerged beach ridges, supporting the hypothesis.

The Lupilor sandbank, that delimits lakes Zmeica and Sinoie, and sandbanks Sacele and Chituc, that border the southern half of lake Sinoie, have high probabilities of containing sites of Roman age, in addition to those discovered at Sinoie Mound and near Vadu (Fig. 3).

4. Conclusions

There is indubitable evidence for an important modification during the Late Pleistocene — Holocene time of relative sea level. An accurate assessment of the present subsidence and eustasy will only be possible in the future, based on the geodetic measurements carried out with the stations of the forthcoming geodynamic network in Dobroja. Based on the long records from the tide-gauges in Sulina and Constanța, the amplitude of the mean sea level rise is now appraised at 0.5—1.0 mm/y. The estimates of crustal subsidence within the Danube Delta area ranged between 2 and 4 mm/y. Therefore, due to both the intense subsidence and the secular mean sea level rise, all ancient archaeological sites located within the Danube Delta, previously at low heights above sea level, are now buried at depths that exceed 4—5 m.

Active erosion and accumulation coexist in front of the Danube Delta littoral zone. The future extent of the prospective cultural area and its entire archaeological record in the littoral zone and the adjacent offshore is now heavily menaced by the high erosion rates observed in several littoral sectors (e.g. Împuțita — Câșa Vadanean, Sacalin spit, West Ciotica — Perișor, Coșna — Vadu sectors) which cause rapid retreat of the shoreline and seabed deepening of 0.25—0.5 m/y (Fig. 6). Over the last two decades, the littoral depositional environment also suffered a severe change in sediment grain size, sandy sediments becoming dominant.

Among the most important causes that shape the coastline and generate the noticed rapid changes of the seabed hydro-geomorphology are the historical delta front erosion trend, the diminishing Danube River sediment influx, and anthropogenic modification of the longshore sediment transport regime. All these are superimposed on the regional subsidence of the Danube Delta area and the secular rising of mean sea level.

Due to deep burial and weak petrophysical contrasts between anthropogenic and natural features, geophysical detection of any archaeo-cultural layer of Paleolithic — Eneolithic age beneath the surface of the Danube Delta is unlikely. The areas with the highest probability of hosting a prospective cultural layer at a depth of 4—5 m beneath the surface, with an age from the 8th century BC, are the higher lands of the Chiilia Promontory, the Leta — Caraorman spit, and the beach ridge system adjoining it to the east (Fig. 2).

The entire archaeological record, with ages ranging from the 8th century BC to the 1st century AD, contained by the Împuțita — Câșa Vadanean littoral sector is in imminent danger of being removed by the intense erosion that affects the shoreline as well as the adjacent seabed. Also endangered by marine erosion are artifacts, mainly ancient shipwrecks, hidden by the beach ridge system developed until the end of the 5th century AD in the Coșna — Vadu littoral sector. The sandbanks that border Lake Sinoie are less subject to erosion, and could host some archaeological sites of Roman age and younger.

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