OLD DOBROGEAN BLACK SEA COASTLINES
Black Sea. Upper Quanternary. Shelf geomorphology.

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Seismo-acustic profilings performed along the Romanian Black Sea shelf, corroborated with lithostratigraphic littoral drillings data revealed the importance of the Upper Quaternary Black Sea level changes. During the post-Wurmian transgression, the sea level rise recorded a few moments of relative stability, when corresponding coastlines (accumulative or erosional) were formed. Their traces are identified on the shelf surface in the shape of the submarine relict terraces or the relict barrier beaches.

1. Introductions

The geological and sedimentological survey of the Romanian Black Sea shelf was developed mainly since 1979 by the Marin Geological Laboratory from Constantza.

Special studies concerning the geomorphology and sedimentology of the Black Sea shelf, in accordance with the Quaternary marin level changes, were elaborated by Panin N. (1983; 1988), Wong H. K. et al. (1994), as well as by Caraivan D. (1982-a;b), Caraivan G., Hertz N. and Noakes J. (1986).

2. Shelf geomorphology

From the north to the south of the Dobrogea region, one can distinguish three major geological units: the Predobrogean Depression, the North Dobrogean Orogenous, and the Moesian Platform. These units are separated by two major fault lines: the St. George fault, and the Peceneaga-Camena fault. The Capidava-Ovidiu fault is, also, very important (fig. 1).

The batimetrical, seismo-acustical and sedimentological studies of the Romanian shelf permit us to divide it into three distinct units: the littoral zone, the inner shelf and the outer shelf. On this background, one can separate a very distinct unit: the Danube Delta (fig. 1).

Littoral zone

The Romanian coast is 240 km long. From a genetical and geomorfological point of view, there are two types of shores:

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- **primary coasts**, respectively the northern shore, corresponding to the Danube Delta, and the Razelm-Sinoe lagunar complex, and

- **secondary coasts**, respectively the southern zone, between Cape Midia and Vama Veche, prevailing the erosional cliff shores, with two sub-units:

* Cape Midia-Cape Singol zone, having a transition character, with large barrier beaches, connecting a series of active head-lands, and

* Cape Singol-Vama Veche zone, in wich, clearly prevail the active erosional shores, interrupted only, in front of lagunas, by barrier beaches.

The littoral zone is dominated energeticaly by the action of the waves (0-6m deep) and of the coastal currents (6-12m deep) against the sea floor. This zone extends off-shore up to 1000-3000m far for the coast, with a slope of 2,3-6‰ north of Constantza, and 8,4-22‰ in the southern part.

The coastal geomorphological features are the result of the combined action of many factors (from the geological to the hidrodynamical and antropogenical ones).

The littoral zone between Mussura branch and Cape Midia comprises the Danube Delta coast, including the deltaic front and its submarine slope, until 5-12m depth. It is also notable the presence of the Sahalin barrier island southward from the St. George branch's mouth.

The aggressive shore erosion rate in the last 25 years is determined by a deep unbalance of the sedimentary processes. These are, firstly, influenced by the geological tendency of the littoral zone, and then by the decrease of the solid river input into the Black Sea bassin. In the southern part of the Romanian sea shore, the sources of sediments are much more poor. Besides that, the coastline configuration is seriously modified by antropogenic hydrotechnical structures (harbours, groins, jetties, breakwaters).

Inner shelf

The Romanian Black Sea inner shelf is very well defined, having 10-15 km width in the northern zone, and cca 1-5 km, soutward of Constantza (fig. 1). The modern sediments mask locally, the relict geomorphological features. Northward of Cape Midia, the bottom slope varies between 1,1‰ and 4‰, while to the south of Constantza, the relict features are better preserved, especially the submarine terraces; the slope is higher (1,6-6‰).

To the east, the inner shelf border is marked by the isobathes of 27-30m.

The inner shelf sedimentary processes are dominated by the alternation of fear weather (fine sediments) and storms, during wich characteristic "sandy sheets" are deposited.

The relative high hydrodynamic regime of the inner shelf blured the relict accumulative features (old barrier beaches), their previous existance being marked only by the relict mineralogical and faunistic components found in the superficial sediments.

Across the inner shelf, there are many positive relief features, considered to be relict barrier beaches. These are disposed at the critical depths of 25m, 27m, 32m, 35m, pointing the former positions of the accumulatives shores. Other type of slope breaks have been interpreted to be traces of submarine terraces, disposed at the depths of 10m, 17m, 23m, 27m, 35m, indicating the positions of older erosional coasts.

From a hydrodynamical and sedimentological point of view, the Danube Delta front is the equivalent of the inner shelf unit (fig. 1).

Outer shelf

From its western limit, along the izobathes of 27-30m to the east, the outer shelf is developing, having a very gentle slope (below 1‰), extending eastward until its offshore limit (about 200m depth).

The sedimentation rates are very reduced on the surface of the outer shelf so, one can find a lot of relict geomorphological features: submarine terraces, barrier beaches, submarine valleys in the extension of the modern land rivers. The most spectacular feature is the canyon Viteaz, genetically connected with the Danubian arm St. George.

The Danube Prodelta (fig. 1), respectively the outer shelf, display all the known types of deformation processes of non-consolidated sediments (Panin N., 1988).

2.1. Relict geomorphological features

Romanian Black Sea shelf reveals the presence of some positive and negative geomorphological features, witnesses of the older coastal and land environments, such as: submarine terraces, barrier beaches, submarine valleys etc. (fig. 1).

2.1.1. Submarine relict terraces

Taking into account their depth and slope, it is possible to identify a few generations of submarine terraces.

The coastal marine terraces are moulded by the waves during a period of relative stability of the sea level.

It is very well known that in the Upper Quaternary, the sea level suffered a lot of oscillations. Consequently, the shelf surface was marked, along some critical depths, by lines of submarine terraces, from wich, the most important generations are the following:

*generation 1-mean depth: 10m; slope: 10-20‰;
*generation 2-mean depth: 13m; slope: 7-20‰;
*generation 3-mean depth: 17m; slope: 8-20‰;
*generation 4-mean depth: 23m; slope: 13-20‰;
*generation 5-mean depth: 27m; slope: 15-30‰;
*generation 6-mean depth: 32m; slope: 12-25‰;
* generation 7-mean depth: 33m; slope 12-15‰;
*generation 8: mean depth: 35m; slope: cca 20‰.

There are, also, many submarine relict terraces at depths greater than 40m across the surface of the outer shelf.

We assume that the modern shelf configuration resulted mainly during the last rising of the Black Sea level (Flandrian Transgression), proceeding along the last about 12.000 years. Than, the submarine relict terraces are so older as they are placed seeward.

In fig. 1, the submarine relict terraces are drawn along the depth range of the local bottom slope break. These features represents the traces of previous erosional coasts, very similar to the modern ones, found in front of the modern ones, found in front of the headlands.

2.1.2. Relict barrier beaches

Panin N. et al. (1975) consider the positive geomorphological features founded

along the shelf surface as traces of the older barrier beaches.

On the inner shelf surface, where the sedimentation rates are greater, the relict features were, partly, blured (fig. 1).

During the post-wurmian transgression, the sea level stationed sometimes, inducing the rising of accumulative coastlines of "beach barrier" type. In the same time, in front of the head-lands, erosional cliff coast were moulded.

Many of the relict barrier beaches are lying at the base of submarine terraces, sugesting a concomitant genesis.

Other terraces were cut directly in the eastern side of the relict barrier beaches. In this case, the terrace is newer than the adjacent barrier beach.

Usually, the amplitude of the relict barrier beaches is 1-6m, and the breadth of 150-200m, sometimes to 1500m; the seaward side is longer, with more gentle slope than the landward one.

The coastal barrier beaches are sandy deposits settled by the waves along the shore during a period of relative stability of the sea level.

As well as in the case of the submarine terraces, one can identify a few generations of relict barrier beaches, placed at critical depths, as follows: 23m, 25m, 27m, 28m, 32m, 35m, 37m, 42m etc.

2.1.3. Other geomorphological features

The seismo-acustical prospecting reveals also the presence at the shelf surface of many other geomorphological features, like:

* depression zones, with sub-bottom filling structures, suggesting old lacustrine or lagunar environments;

* submarine valleys, with "V" profile shape, prolonging seaward the adjacent land rivers;

* waved surfaces, suggesting old littoral dune plaines.

From the depths of 35-40m seaward, the bottom slope is very gentle. Its surface is very irregular, owing to the relict geomorphological features, created in continental environments, along the former littoral plaine, resulted after the retrait of the sea waters during the wurmian regression.

3. Upper Quanternary shore evolution.

The lithostratigraphical studies of the deposits intercepted in the drillings made on the Mamaia barrier beach (Caraivan G., 1982; Caraivan G., Hertz N. and Noakes J., 1986) corroborated with the geomorphological data of the Black Sea Romanian shelf make possible the reconstruction of paleogeographic and sedimentation environment in the studied area, during the Upper Quaternary times.

The oldest strata intercepted in the Mamaia drillings are continental deposits, formed in the conditions of a very low sea level (fig. 2 - zones A-D3).

The first level, surely of marine type is represented by the 26-22m level, with marine fauna (fig. 2 - zones D4-E). According to the radiocarbon data (26.925±690 y.B.P.), this level belongs to the Middle Würm interstadial (Arcy-Stillfried B interstadial), wich corresponds to the Surojskian Beds (Scerbakov F. A. et al. (1978).

The Upper Würmian glaciation entails the regression of the sea level to about 100-130m below to the present day one (Ross D.A., 1978). A minumum level is reached about 18.000-12.000 years B.P., followed than by the continuos sea level rise toward the

present one. Durring this stage, the beach deposits of the zone "E" (23-22m level) from the studied borehole (Upper Surojskian Beds) are cemented under continental conditions.

The relict barrier beach lying at the depths of 23m and 27 m are marked by the presence of red shells ("Red Coquina" - Caraivan G., 1982). Red Coquina is a bulk of coastal marine molluska shells, intensively polished and colored in redish-brown. This physical state is due to a longtime reworking of the molluska shells under subaerian oxidant conditions.

We assume that the age of the relict coastal traces (terraces and barrier beaches), lying at the dephs of 23m and 27m is about the same to the "beach rock" deposits about the same to the "beach rock" deposits (fig. 2-zone E) from the Mamaia drilling. Both of them formed according to the gradual sea level retrait, during the last wurmian regression (18.000-12.000 years B.P.).

The submarine relict terraces, cut in the seaward side of the relict barrier beaches were formed during the last rise of the sea level.

The prelude of the "Black Sea "stage (fig. 2 - zones F, G, H, I, J, K, L) is represented in the Mamaia zone by continental deposits, containing brackish water fauna, synchronous with the "Bugazian Beds", at the depth of 21m (fig. 2 - zone F).

In the same time, on the inner shelf surface appear the terraces cut in the seaward side of the barrier beaches, at the depths of 23m and 27m, containing "Red Coquina".

During the stage subsequent to the Holocene transgression, in the Mamaia zone "Viteazian Beds" have deposited (fig. 2 - zone G).

In the same time, in front of the head-lands (Cape Singol, Cape Constantza, Cape Agigea), the 17m depth terraces have formed. Between these promotories long and width barrier beaches developed.

The next stage marked the continuous rise of the sea level. In the begining of this stage ("Lover Kalamitian Beds"), the littoral waters, populated by brackish water molluska fauna, are influenced by fresh water supply. Later on, ("Upper Kalamitian Beds"), the influence of Mediterranean water becomes general. The sea level rises, being 1-2m higher than the present day one; the western cliff shores of the Siutghiol and Agigea Lakes are generated by wave abrasion.

During the next stage: Phanagorian Regression (fig. 2-zone J), in the Mamaia region widespred lagoon appear, with characteristic peat deposits. The sea level is, probably, about 2m lower than the present day one, the witness being the relict abrasion submarine terrace, found at that depth.

The absolute age of molluska shells, taken from this bed, is 3.125 ±75 years B.P. The morphologic study of these shells points to their resedimentation from a lower level deposit (possible the zone I).

In the Black Sea history, the Phanagorian Regression stage (4^{th} century B.C. 4^{th} century A. D.) correspond to the most intensive ancient colonisation of the western Black Sea coasts (e.g. Histria, Calatis, Tomis etc.).

The last stage-The Nymphean Transgression - generalised the present - day marine conditions (fig. 2, the zones K, L).

Concluding, we emphasize the importance of the Upper Quanternary sea level changes (mainly the last 30.000 years), that determined the repeated passage of the coast line across the western Black Sea shelf.

During the relative stability of the Black Sea level, coastal accumulative (barrier

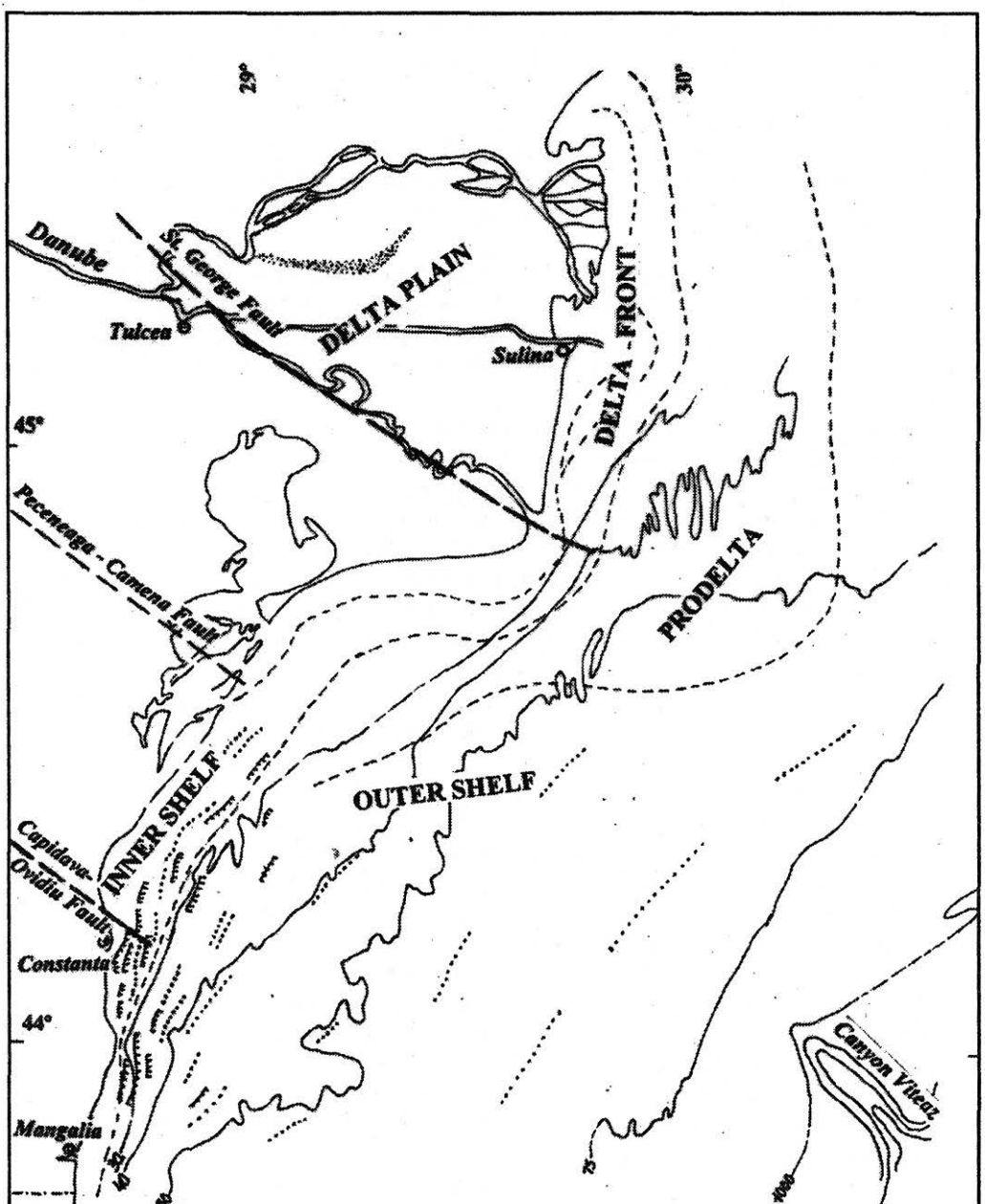

Fig.1 Geomorphological features of the Romanian Black Sea shelf (Panin N., 1988; Caraivan G.,1982).

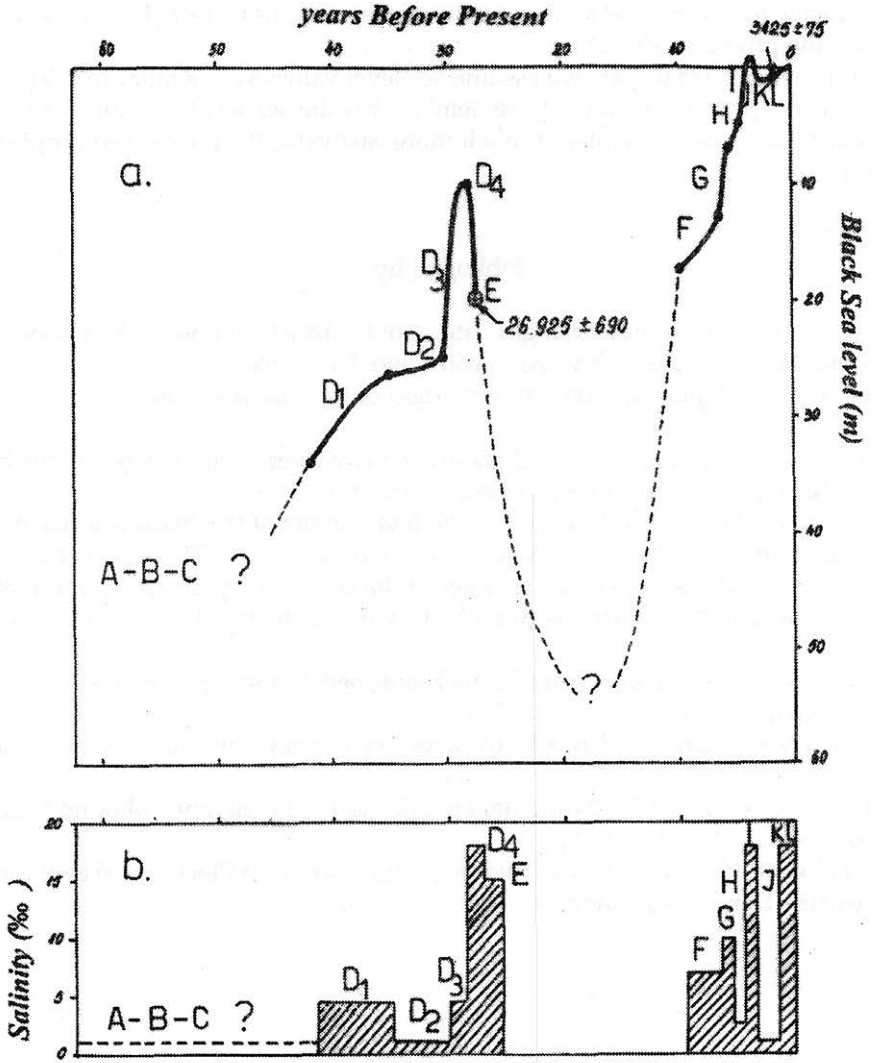

Fig.2 a. Upper Quaternary Black Sea level changes in the Mamaia region - Romanian coast;
b. Salinity variation
(Caraivan G., 1982)

beaches), or erosional (abrasion terraces) features appeared.

The Dobrogean rivers prolonged their valleys across the former shelf, until the corresponding shore, placed at very low level.

Consequently, the coastal ancient human communities established their sites mainly on the protected shores.

If, for ther last 3.000 years we assume sea level values very similar to the present ones for the older times we must to remember that the sea level was much lowered. These older coast lines were placed much more eastward, the littoral geomorphology being very complex.

Bibliography

Caraivan, G. 1982. **The sedimentological study of the beach and inner shelf deposits in front of the Romanian coast between Portitza and Tuzla**. Thesis.

Caraivan, G. 1982. **Upper Quaternary evolution of the Mamaia zone.** - Pontica, 15, p. 15-32.

Caraivan, G. and Selariu, O. 1985. **Quanternary environmental changes of the Black Sea** - Rev. Roum. Geol., Geophys., Geogr., Geographie, Tome 29, p. 13-19.

Caraivan, G., Hertz, N. and Noakes, J. 1986. **New proofs of the Black Sea rise during the Middle Wurm interstadial.** - D.S. Inst. Geol. Geofiz., vol. 70-71/ 5, p. 57-62.

Panin, N. 1983. **Black Sea coast line changes in the last 10.000 years. A new attempt of identifying the Danube mouths as described by the ancients.** - Dacia, N.S. 27, 1-2, p. 175-184.

Panin, N. 1988. **Danube Delta: genesis, evolution, sedimentology**, - Rev. Roum. Geol. Geophys., Geogr., Geographie, 33, p.25-36.

Ross, D.A. 1978. **Summary of results of Black Sea drillings**, in: Initial Reports of the Deep Sea Drilling Project, XLII, 2.

Scerbakov, F.A. et al. 1978. **Osadkonakoplenie na kontinentalinoi okraine Cernogo Moria**, Izd. Nauka, Moskva, 210 p.

Wong, H.K. et al. 1994. **Morphology and post Chaudian (Late Pleistocene) evolution of the submarine Danube fan complex.** - Terra Nova, 6.