The morphodynamics of coastal dunes from Sărăturile beach ridge plain during 1995–2001

Alfred VESPREMEANU-STROE, Luminița PREOTEASA

Cuvinte-cheie: cordon dunicol, dune oblice, morfodinamica, eolizație

In this paper it is presented the evolution of coastal dunes from the Saraturile (beach ridge plain) during 1995–2001. Starting from the present-day configuration of coastal dunes on stands out four subsectors grouped into two, in the Sf. Gheorghe shore with a stationary dynamics and in a sandy barrier affected by a rotational retreat. We discussed the dune modern morphodynamics following the analyisis of general coastal evolution (resulted from the comparison of a series of topographic profiles troughtout the backshore) and of meteo-marines factors (wind hourly data, wave spectrum). We distinguished two stages: 1995–1998 and 1998–2001 separated by the great storm from January 1998. On the Sf. Gheorghe dissipative shore there is a stable dune barrier, protected against the storms by the large beach , the existence of the foredunes and by moderate slope of submerse shore. The accentuated dynamics from Sf. Gheorghe arm mouth is responsable for local dune's high vulnerability. In the frame of sandy barrier R49 – R53 the dune barrier has a cyclic evolution often interrupted by winterstorms events. In the northern end of Saraturile chennier plain's shore a specific feature of the sandy barrier is represented by the presence of transversal dune barriers built obliquely to shoreline by overlapping on the seaward prolongations of continental levees.

Introduction

Although the Danube Delta is one of the most studied regions from Romania the morphology of its coastal dunes never was studied apart. However there are datum and theoretical approaches in papers which deal with the evolution of deltaic coastline (Gâștescu, 1977, Gâștescu, Driga, 1984, Vespremeanu, Ștefănescu, 1989), romanian coastal nomenclature (Vespremeanu,1987), evolution of Danube arms mouth (Vespremeanu, 1983) and genesis of coastal scarps (Vespremeanu-Stroe, Constantinescu, 2000).

The dunes from the romanian shore are found in the following sectors: Sulina, Sărăturile chennier plain's shore, the northern end of Sacalin Barrier Island and the southern part of Chituc chennier plain's shore. The Sărăturile chennier plain's shore, stretched on the southern half of Sulina – Sf. Gheorghe interdistributary shore (fig. 1), represents the sector with the biggest surface occupied by coastal dunes from Romanian shore. It's important to notice that morphometric characteristics of the dunes from all these areas are likewise (heights of dunes are about 1-3 meters above beach level with a mean absolute altitude of 3 meters) with big differences in dune barrier extent.

Work methods

For the analysis of coastal dunes dynamics we performed more measurements types and observations concerning their position and morphometry, degree of vegetation covering, vegetation types, the inner structure of the dunes.

The topographic measurements, especially cross shore profiles, were made at an interval of 2-3 months during this period (1995-2001) using the geometric levelling supported on benchmarks coastal network. For an estimation of dune barrier orientation and of initial vegetation cover we used a series of aerial photos made in September 1995. We also digged some dune sections for identify the contact between eolian cross-bedding structure and laminar structure of the (paleo)

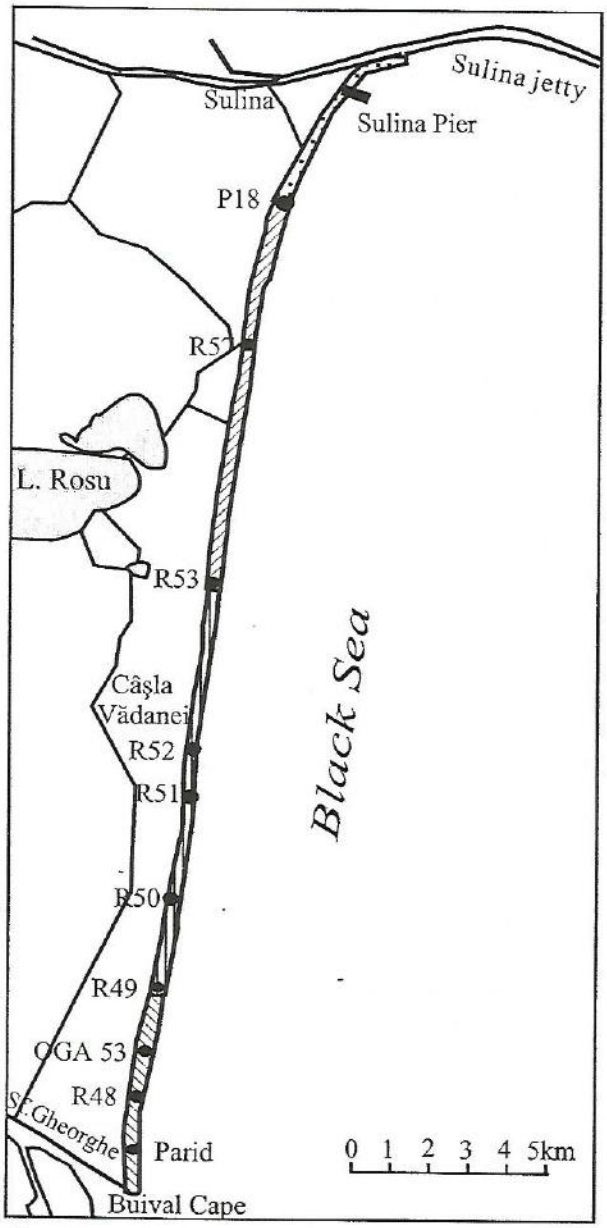

Fig. 1. Landmarks net on the Sulina – Sf. Gheorghe Shore including Sărărturile chennier plain's (Buival Cape – R15)

beach hydraulic deposits in order to establish the dune barrier position in differents evolution stages.

The wind data, hourly data – four cases a day, with reworking potential (wind speed higher than 5 m/s) were processed during 1990–1999 period at Sf. Gheorghe station

Discussions

Regarding to the foredunes morphodynamics on the Sărăturile bench ridge plain during 1995–2001 on distinguish two stages: 1995–1998 and 1998–2001 separated by the great storm from January 1998 which induced majors changes in all of the shore units morphology.

Starting from the present-day configuration of the dunes barrier on this shore on distinguish out four sectors: Buival Cape – Parid, Parid – R 49, R 49 – R 52, R 52 – R 53.

Taking into account the characteristics of coastal dynamics, the discussed shore consists in Sf Gheorghe shore with a stationary dynamics and a sandy barrier affected by a rotational retreat: R 49 – R 53.

A. Sf. Gheorghe Shore. Buival Cape – Parid Sector

This sector, in length of 800 meters, corresponds spacially to the southern extremity of the Sf. Gheorghe shore. The specific feature of this shore is given by the dynamic equilibrium state conferred by the coexistence of the compensatory erosional and depositional processes. The dune barrier in this sector is just sketched because of its last decade's evolution. It is composed by pyramidal individual dunes (with heights less than 1,5–2 m, diameters of 10–20 m) very well strengthen by wooden vegetation like *Salix, Hippophae, Tamarix* and incipient bimodal dunes. Piramidal dunes represents remnants of the dunes barrier broken by waves in January 1998's storm. Bimodal dunes arised as a result of sand reworking from interdunal space and new-formed over wash fans.

Before the great storm from January 1998, dunes were concentrated in three ridges occupying a larger surface close by the waterline. The great extension of the dunes barrier owned to the intense deposition resulted from the cutting of Sf. Gheorghe arm's meanders. During 1984–1988, the period of hidrotehnical interventions, the fluvial erosion begin to work a new equilibrium river profile. Therefore Danube carried and accumulated at its mouth a great volume of alluvia which induced the progradation of the south extremity of Sf. Gheorghe shore as well as the dunes. Thus in a short period, the enti-

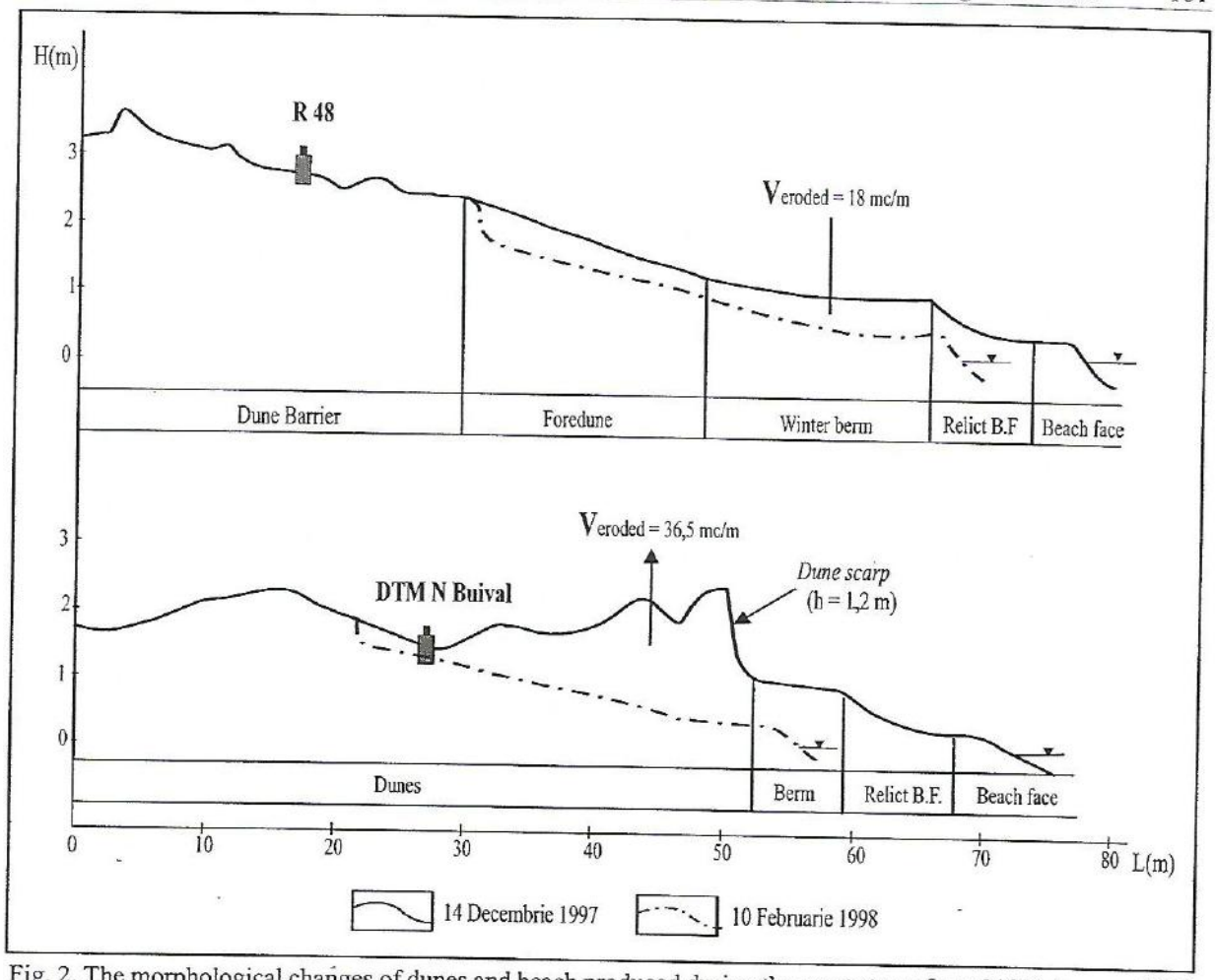

Fig. 2. The morphological changes of dunes and beach produced during the great storm from 21024 January 1998

re sector got a pronounced crescentic configuration; Buival Cape advanced seaward with 30–50 m. Gradually, the sand volume carried by Sf. Gheorghe arm diminished; thus at the half of ninety's years coastal erosion has begun to affect all this area. These processes induced the appearance of a permanent dune scarp (1–1,5 m high) often reactivated during 1995–1997 (Vespremeanu – Stroe A., Constantinescu St., 2000).

Due to the narrow beach and the presence of dune scarp the seaward face of the dune barrier was completely erased. The dislocated sand volume in this sector was estimated by us as being of 20–40 mc/m (fig. 2). During 1998–2000 was developed an ample process of reconstruction of the emerged shore followed by the complete restoration of the beach units; the winter berm starts being parasitated with foredunes gathered around *Sueda Maritima* shrubs.

Parid - R 49 Sector

This sector occupies the central and the northern parts of the complex Sf. Gheorghe shore. The dune barrier corresponding to the area disscused is the most compact and best consolidated on the entire Sărăturile chennier plain's shore, because of efficient protection given by the position in the frame of the interdistributary Sulina – Sf. Gheorghe Shore (south of deltaic and sandy barriers which represents mains sources for nourishing of southward dominant longshore current and also at just 1–5 km north of Sf. Gheorghe arm's mouth). This emplacement also promoted a big extension of beach, the existence of foredunes and the presence of three submerse bars on the shore terrace which ensure a good protection at stormwaves attack. The stability of dunes barrier is increased by a curtain of wooden vegetation (*Hippophaea rhamnoides, Salix alba, Tamarix ramossissima*) with 40–70 m breadth,

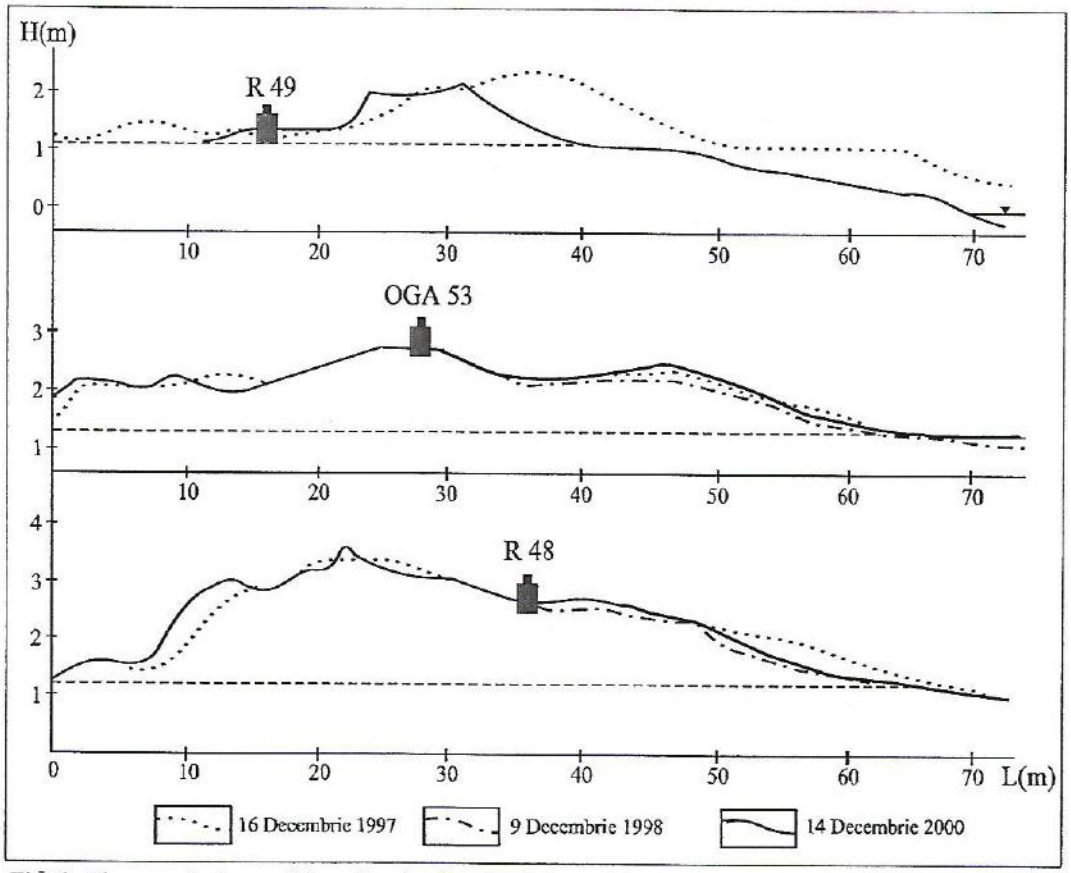

Fig. 3. The morphology of dune barrier (profiles) from Sf. Gheorghe Shore

emplaced on chennier plain - dunes contact. In this conditions the dynamics of the dune barrier is moderated and it represents a succession of stages and shapes often reversible.

Comparing the profiles made in 1997, 1998, 2000 on remarks little variations of the seaward face of the dune barrier produced by the storms, as well as their slight tendency of landward extension because illegal and irrational deforestation. Thus, in the southern part of discussed sector (R 48) the width of dunes barrier varies between 50–60 m and the height between 2,5–3,5 m, with a net differentiation between dunes and foredunes. In the central part the dune barrier records a little decrease in altitude (2–3 m high) and a distinct morphology with two ridges divided by an interdunal trough breadth of 15-20 m.

To the northern extremity of this sector, close by R 49 landmark, it's noticeable the narrowing of dunes barrier (fig. 3). Here, the morphological characteristics differs from previous sector. The weak presence of foredunes and the decrease in height and the width of beaches increased the vulnerability of the shore which led to the destruction of a big part from dunes barrier (fig. 3) and to the appearance during January 1998 of a impressive dune scarp stretched on 1300 m south to the R 49 and high of 1–1,5 m (foto 1). The losses recorded here, on the emergent shore: 25 – 35 mc/m, were comparable with the losses registered in Buival Cape – Parid sector.

Beside morphological changes due to the marine agents there are eolian processes which lead to the intense raising of foredunes (5–20 cm/year) and a slower rate of increasement for the seaward side of dunes barrier (1–10 cm/year). The dune's crest had very little changes in 1995–2001, manifested like slow southward migration of the blow-outs (< 0,5 m/year), with a sedimentary bilance close by zero.

On the inner side of the dunes barrier encounters discontinuos advances of sand due to local deforestations.

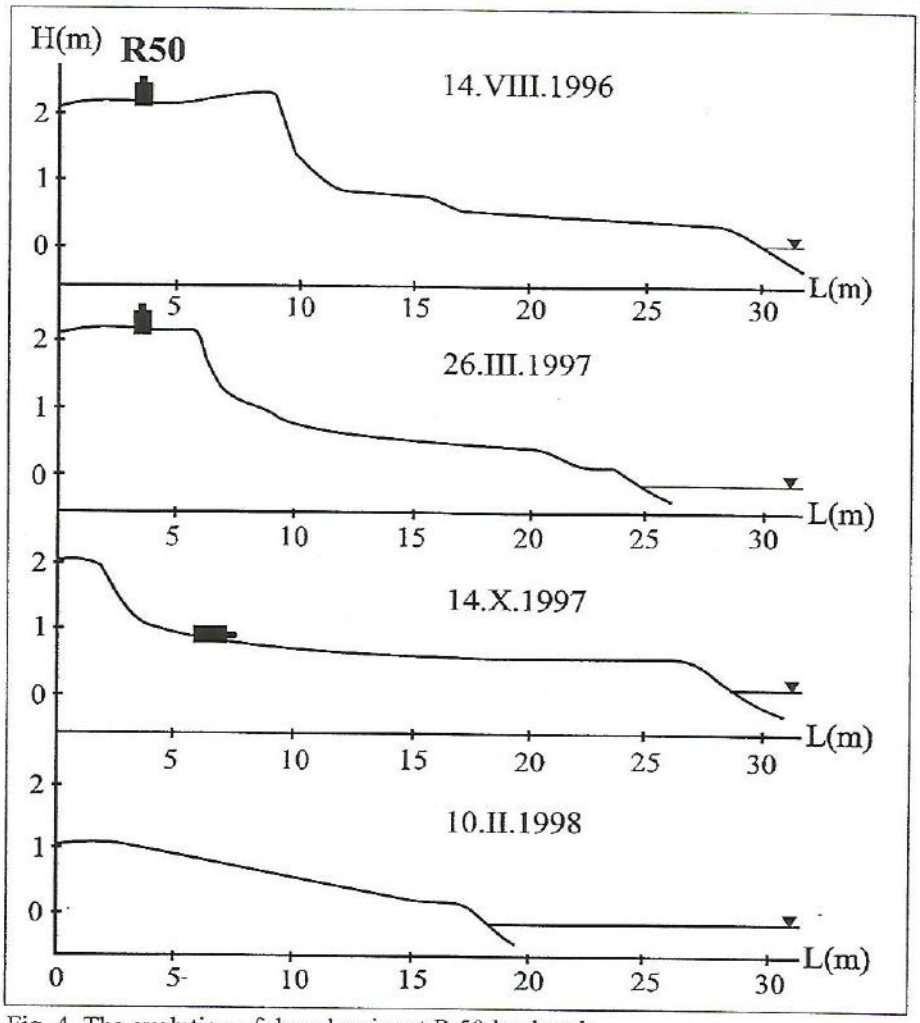

Fig. 4. The evolution of dune barrier at R 50 landmark

B. ***R 49 – R 53 Sandy Barrier.*** *R 49 – R 52 Sector*

This sector corresponds to the central-southern part of the sandy barrier lied in a rotational retreat; it represents that part of the Sărăturile chennier plain's shore lied in a constant retreat. The barrier is affected by erosional processes on all its extent, which are more and more intense northward. The entire sandy barrier has narrow beaches, without foredunes and dune barrier. The actual dunes are very recently and they took birth beginning to summer 2000 by sand eolisation on the limit between over-wash fans and beach. Here and there they joined forming sandy ridges (10–15 m width, 1,5–2 m height) that sketch a feable dunes belt.

Before January 1998 existed a dunes barrier, stretched on two kilometers (R 49 – R 50), somehow high (2–3 m) but narrow due to coastal erosion often manifested during 1995–1997 when it was founding a very stretched dune scarp (fig. 4). In these conditions the dunes barrier was very vulnerable to the ordinary storms, so that during the great storm from January 1998 it was completely destroyed.

R 52 - R 53 Sector

This sector, in length of 3 km, representing the northern end of Săraturile chennier plain's shore, on distinguish as given the previous sectors by penetration of continental levees in the frame of emergent shore. The ends continental levees of Saraturile chennier plain, after a still period of about three years from a great storm, allow the formation of short dunes belt by overlapping. These transversal dunes barriers keep the same oblique orientation

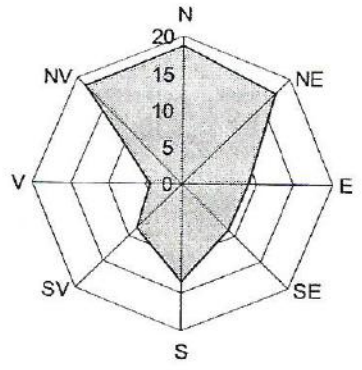

Fig. 5. The wind frequecy (%) with eolisation potential at Sf. Gheorghe station (1990–1999)

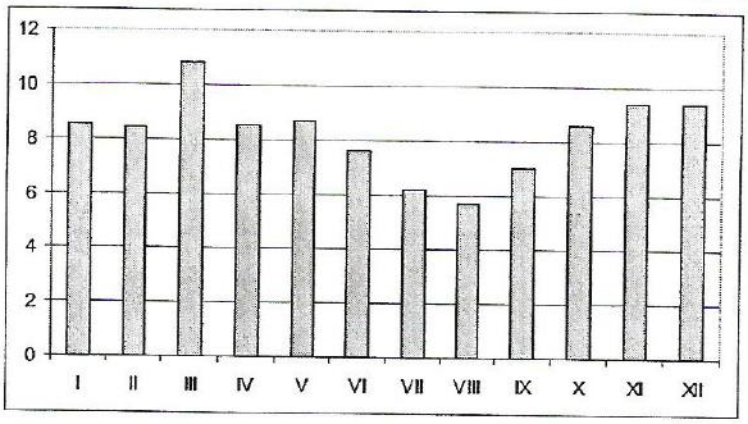

Fig. 6. The mean monthly distribution (5) of the wind with eolisation potential at Sf. Gheorghe station (1990–1999)

to waterline (about 60°), thus the dimensions are smaller than usually: 50–80 m length, 8-12 m width, 0,7–1,2 m height (over the beach level).

The space between these dune barriers superimposed on continental levees is occupied by wash-over fans; their eolisation removes the sand to transversal dune barriers but also can develop in situ the mobile dunes usually disposed perpendicular to wind direction. The (intermittent) presence of transversal dunes bariers from this area is unique on the entire romanian shore while the appearance of these mobile dunes is promoted by the absence of wooden vegetation. From the analysis of the wind data, hourly data – four cases a day, with eolisation potential (wind speed bigger than 5 m/s) during 1990–1999 period at Sf. Gheorghe station, results the important prevalence of northern winds (fig. 5).

The morphologic impact of vegetation

The eolian dynamics of dunes belt expressed by the changes of migration's rate and/or the variations of dune barrier's volume (Thomas, 1991) is proportionally with the wind speed and reverse proportionally with the degree of vegetation covering (Ash, Wasson, 1983).

The significance of vegetation is given mainly by its density. The extension of vegetation cover contributes to rugosity's increase of dunes, foredunes and winter berms creating favourable conditions for the fastening of sand grains eolian carried. The growth of plants stimulates the increase of sand volume massed around to them and reverse a big sand accumulation imposes a faster development of sandy plants.

In the frame of Sărăturile chennier plain's shore there are more differentiations concerning to disposionof vegetation types. Thus the pyramidal dunes, especially found in Buival Cape - Parid Sector, are fixed by *Salix alba, Tamarix ramossissima* and *Hippophae rhamnoides* bushes which compose the entire spectrum of wooden vegetation. The bimodal dunes concentrate usually around the same bushes but much younger and smaller. Except the pyramidal and bimodal dunes the wooden vegetation is a compact presence just on the landward side of dune barrier. In the foredunes the sand groins are captured by the dense *Sueda Maritima* shrubs and rarely by *Artemisia maritima*. The grassy vegetation of dune barrier is composed by *Eryngium maritimum* (on the great dune barrier from Sf. Gheorghe Shore this thistle represent about 80% from mass vegetation), *Euphorbia sequeriana, Elymus sabulosus* (especially found in the frame of R 49 - R 53 sandy barrier), *Cynodon dactylon* and *Festuca vaginata*.

The wooden vegetation dates from 1969–1972 when Sf. Gheorghe forestry plantation was found it. Beginning to ninety years on exerts a hard pression on this vegetation due to local arsons and cuttings illegally made by inhabitants. These activities have major implications for the dynamics of the

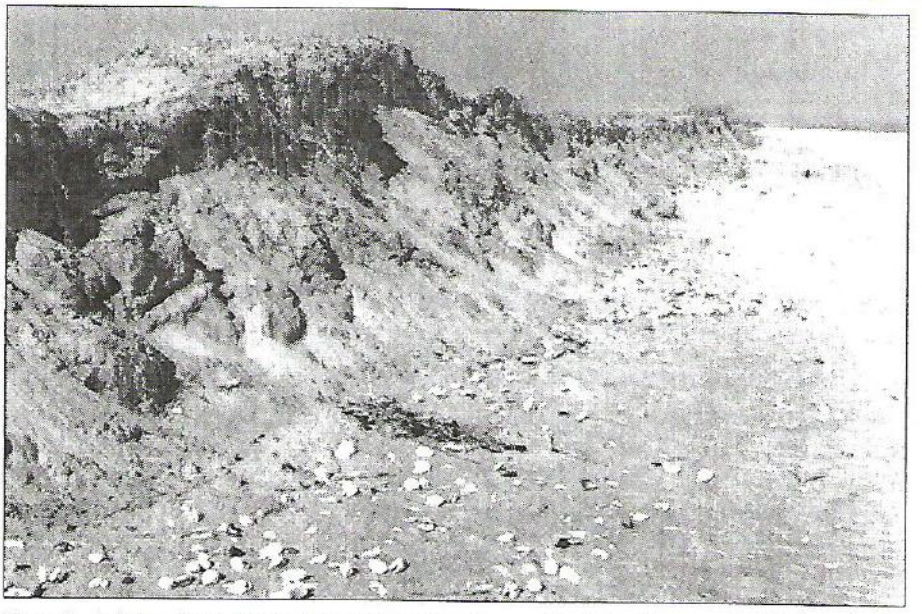

Foto 1. A long dune scarp digged by wavestorm attack in January 1998 close by R 49 landmark

dunes because the sand fixed one day, after the deforestation becomes may be sweeped away generally landward.

Conclusions

In the analysis of dunes morphodynamics from the Sărăturile beach ridge plain during 1995–2001 on distinguish two stages: 1995–1998 and 1998-2000 separated by the great storm from January 1998 which induced majors changes in all of the shore units morphology.

Starting from the present-day configuration of the dunes barrier on this shore on stands out four sectors: Buival Cape – Parid, Parid – R 49, R 49 – R 52, R 52 – R 53 grouped by twos in the Sf. Gheorghe shore (Buival Cape - R 49) with a stationary dynamics and in a sandy barrier affected by a rotational retreat (R 49 - R 53).

In the southern end of Sf. Gheorghe shore, between Buival Cape and Parid landmark, the dune barrier is just sketched because of its last decade's evolution. Before the great storm from January 1998, dunes were concentrated in three ridges occupying a larger surface near to the waterline, this big extension owning to the intense deposition proceeded from the cutting of Sf. Gheorghe arm's meanders. At present the high shore is composed by pyramidal individual dunes (with heights of 1,5–2 m, diameters of 10–20 m) very well strengthen by wooden vegetation like *Salix, Hippophae, Tamarix* and incipient bimodal dunes. Piramidal dunes represents remnants of the dunes barrier broken by waves in January 1998's storm. Bimodal dunes arised as a result of sand eolisation from interdunal space and new-formed over wash fans tend to build a new dune barrier situated at about 30 meters behind of the previous one.

Next dune barrier (Parid - R 49) has a very moderated dynamics represented by a succession of stages and shapes often reversible. Comparing the profiles made during 1995-2001 on remarks little variations of the seaward face of the dune barrier produced by the storms and a slight tendency of landward extension because illegal and irrational deforestation made by inhabitants. The breadth of dunes barrier varies between 50–60 m and the height between 2,5–3,5 m, with a net differentiation between dunes and foredunes.

Further to the north the sandy barrier R 49 - R 53 has moderate-narrow beaches, without foredunes and proper dune barrier. The actual dunes are very recently and they took birth beginning to summer 2000 by sand eolisation on the limit between over-wash fans and beach. Here and there

they joined forming sandy ridges (10–15 m width, 1,5–2 m height) that sketch a feable dunes barrier.

A specific feature of the sandy barrier is represented by the presence of transversal dune barriers built by overlapping on the seaward prolongations of continental levees from Sărăturile chennier plain. Coastal dunes from this northern sector (R 52 - R 53) are a unique joining on the romanian shore between short transversal dune barrier (50–80 m length) obliquely laid to waterline (about 60°) and mobile dunes formed by eolization of wash-over fans.

BIBLIOGRAPHY

ANTHONSON, K.L., CLEMMENSEN, L., JENSEM, J.H., (1996), *Evolution of a dune from crescentic to parabolic form in response to short climatic changes: Rabjerg Mile, Skagen Odde - Danemark*, Geomorphology, 17

ARENS, S.M., (1998), *Rates of eolian transport on beach in temperate humid climate*, Geomorphology, 22, 2

ASH, J. E., WASSON, R.J. (1983), Vegetation and sand mobility in the Australian desert dune field, Z. Geomorph. N.F. suppl.,75, 7-25.

BIGARELLA, J.J., (1969), *Dune sediments: characteristics, recognition, and importance*, Bull. Am. Assoc. Petroleum Geologists, 53

BIGARELLA, J.J., BECKER, R.D., DUARTE, G.M., (1969), *Coastal dune structure from Parana (Brazil)*, Marine Geology, 7

CARTER, R.W.G, WOODROFFE, C.D., (1994), *Coastal evolution: Late Quaternary Shoreline Morphodynamics*, Cambridge Univ. Press, 517 p

CENDRERO, A., FISCHER, D.W., (1997), *A procedure for assessing the environmental quality of coastal areas for planning and management*, J. Coastal Research, 13, 3

GÂȘTESCU, P., DRIGA, B. (1984), *Long term evolution of the Black Sea Coast in front of the Danube Delta between Sulina and Sf. Gheorghe arms*, RRGGG, ser. geogr, T. **28.**

GÂȘTESCU, P. (1977), *Modificările țărmului Mării Negre în dreptul Deltei Dunării în perioada 1857 - 1975*, SCGGG, t XXIV

GÂȘTESCU, P., DRIGA, B. (1984), *Long term evolution of the Black Sea Coast in front of the Danube Delta between Sulina and Sf. Gheorghe arms*, RRGGG, ser. geogr, 28

GOLDSMITH, V., (1973), *Internal geometry and origin of vegetated coastal sand dunes*, J. Sed. Petrology, 43

SIMEONI, U., CALDERONI, G., TESSARI, U., MAZZINI, E., (1999), *A new application of system theory to foredunes intervention strategies,* J. Coastal Research, 15, 2

STOENESCU, S.M., (1965), *Regimul vânturilor pe litoralul românesc al Mării Negre*, Studii de hidraulică, IX-1

TRACI, C., MĂNESCU, M., DRĂGUȚ, N., (1988), *Împădurirea nisipurilor din Delta Dunării*, Inst. Cerc. Amen. Silvice, 76 p

VESPREMEANU, E. (1983), *Geomorphological evolution of the Sf.Gheorghe arm mouth in the last 200 years*, RRGGG, ser.geogr., t. 27

VESPREMEANU, E., (1987), *Probleme de Geomorfologie Marină*, Ed. Univ. București, 128 p

VESPREMEANU, E., Ștefănescu, D. (1988), *Present –day geomorphological processes on the Romanian Delta and Lagoon Littoral*, Analele Univ. București, XXXVII

VESPREMEANU-STROE, A., CONSTANTINESCU, Șt., (2000), *Scarpuri de plajă pe țărmul românesc*, Comunicări de Geografie, IV

WHITE, B.R., TSOAR, H., (1998), *Slope effect on saltation over a climbing sand dune*, Geomorphology, 22