OBSERVING AND MAPPING THE COASTLINE RELIEF IN THE ROMANIAN SECTOR OF THE BLACK SEA USING SATELLITE IMAGES

ABSTRACT: The Romanian seashore of the Black Sea is 245 km long, almost straight and has a lower altitude. The Midia Cap delimits two sectors: a northern sector, which is longer and at very low altitude, of accumulation origin (with delta and lagoons sectors); and a southern sector, higher (less than 50 m), dominated by marine abrasion, where sea cliffs alternate with beaches. Present geographically researches, based on field observations and topographic maps, aerophotogramms and satellite images analysis, are focused on the rigorous knowledge of the natural changes in the coastline and of those induced by tourism and port activities. In this paper, we will demonstrate how the Landsat images facilitate the observation and mapping of the coastline relief (punctual, sectorial and general), at a certain moment or in its dynamic. The analysis of the selected zooms, in the delta sector, at the mouth of the Danube branches (Chilia, Sulina and Sfântu Gheorghe), in the lagoon sector (Razim-Sinoie complex), in the southern sea cliffs and beaches sector, emphasizes the detailed geomorphologic features of the seashore and its present-day dynamic. This analysis also allows us to define the favorable sectors and to determine the sectors where the infrastructure is at risk (stable sectors or unstable sectors – sea cliffs, undermined sectors, with landfalls, accumulation at the Danube mouth, the decrease or the disappearance of some seashore belts, and of some beaches). Taking into consideration the importance of Romanian seashore of the Black Sea, the observation data and maps obtained through space images analysis are addressed to the port and tourism planning projects.

1 INTRODUCTION

Due to its numerous lagoons and to the Danube Delta, the Romanian coastline, measuring 245 km in length, certainly presents the most active dynamics among the shorelines of the Black Sea. The cliff sector, representing just 1/3 of its length, most of it arranged for port and tourist activities, is generally stable.

The research concerning nowadays coastline morphodynamics in the Romanian sector currently uses the images provided by remote sensing satellites (Landsat, SPOT, Orbview etc.) (Fig. 1).

This paper demonstrates the way how Landsat images make it possible to observe and map the coastline processes and forms of different sectors or of the entire Black Sea shoreline, both as they appear at a certain moment and in their dynamics. For the most dynamic sectors (sector of Danube Delta), the results are comparable with those obtained by means of traditional methods.

The analysis of the zooms selected from the deltaic sector from the mouths of the three branches of the Danube (Chilia, Sulina and Sfântu Gheorghe), from the sector of lagoons (Razim-Sinoie, Siutghiol) and from the sector of cliffs and beaches from the south highlights the minute features of the coastline morphology and present morphodynamics, showing the favorable areas as well as the areas presenting different degrees of risk for certain infrastructure works (stable sectors, unstable sectors: active cliffs, undermined by abrasion, with glidings; submersed and emerged accumulations at the mouths of the Danube;
the reduction or disappearing of certain offshore bars; the diminishing or disappearing of certain beaches).

The data and maps obtained through the analysis of satellite images are used in the projects of port and tourist arrangements, taking into account the vocation of the Romanian coastline of the Black Sea.

2 METHODOLOGY

– multitemporal analysis of Landsat satellite images in order to show the dynamics of the geomorphological processes and of the coastline limit during a determined period of time (1990-2000);
– comparing the satellite images with the geomorphological maps achieved based on outdoor observations;
– the comparative visual interpretation of the satellite images was achieved for sectors, based on the characteristic zooms, which allowed the presentation of the details, and for the whole coastline, which made it possible to obtain a synthetic view of the Romanian shoreline;
– mapping the limit of the coastline at two different moments caught by Landsat images (1990 and 2000) for sectors and for the entire coastline, in order to present its tendencies: going forward by means of accumulation, withdrawal due to abrasion or stagnation;
– the software used in the analysis of the images: Global Mapper 5.
3 RESULTS

The observation of the modifications undergone by the Romanian coastline between 1990 and 2000, the mapping of these modifications were achieved for the two main sectors (the northern sector, of accumulation, in which one can notice a deltaic sub-sector and a sub-sector of lagoons; the southern sub-sector, predominantly one of abrasion) and for smaller areas within them. The results are presented for each sector as well as for the entire Romanian coastline (Fig. 2, 3, 4).

Figure 3. Changes of the Black Sea coastline in Danube Delta sector between 1990 and 2000 observed by Landsat 5 and Landsat 7(A) and mapped (B); → progression process of the coastline; ← regression process of the coastline

1. The deltaic subsector (the Danube Delta)
   – the coastline afferent to the Danube Delta is the most active one in the entire basin of the Black Sea, registering important changes at small intervals of time.
   – the dominant process is the accumulation of the alluvial deposits (in suspension) thrown into the sea by the three branches of the river, the result being the general moving on of the Delta.
   – its processes take place mostly under natural conditions; more important modifications occurred at the mouth of Sulina branch, due to the construction of a protective dam.
   – the factors favoring the moving on of the delta: the important supply of alluvial deposits in suspension (around 60 million tons/year), distributed proportionally to the liquid
flow of the three branches: 60% for Chilia; 21.2% for Sfântu Gheorghe; 18.8% for Sulina(1); the significant extension of the continental platform, with shallow waters, in the northwestern part of the Black Sea; the reduced intensity of the tides, their amplitude being of only 9 to 12 cm.

– the coastline morphodynamics presents different aspects for different sectors of the deltaic shoreline, which account for the variations in the dynamics of the coastline: the accumulation of alluvial deposits and the moving on of the shoreline at the river mouths, processes that are proportional with the liquid flow and the alluvial deposit flow of the three branches (ii), (iii);

– the three microdeltas formed at the mouths of the branches (secondary deltas of the main delta) (Mississippi-like, that is digited, at the river mouth of Chilia branch; Tibris-like at the river mouth of Sulina branch; Vistula-like, respectively barred, at the river mouth of Sfântu Gheorghe branch) continue to develop, but their rhythm of development differs (iv);

Figure 4. Morphodynamic of abrasion coastline (south Constanta) observed by Landsat 5 and Landsat 7 (A) and mapped (B); ← regression process of the coastline.
the comparison between the Landsat TM satellite images registered at an interval of only 10 years (1990-2000) highlights the following aspects: it is certain that the processes are more ample at the river mouths of Chilia branch, where two small islands have appeared out of the submerged banks formed on the continental platform in front of the delta; it is important, therefore, to update the topographic and geographic maps (Fig. 3). The same images show that the accumulative process at the mouth of Sfântu Gheorghe branch has not registered modifications between 1990 and 2000, Sacalin Island seems not to have changed its dimensions and configuration.

2. The subsector of lagoons (Razim-Sinoie lagoon; Siutghiol lagoon)

- the comparison between the Landsat TM satellite images from 1990 and 2000 indicates the fact that this sector is generally stable, an observation which is in concordance with the data provided by outdoor observations.
- according to outdoor observations, the offshore bars which separate the lagoon from the sea presents small portions that moved on alternating with others that withdrew.
- a more obvious tendency of withdrawal of the coastline due to the washing away of the sand by coast currents and by waves has been noticed lately in the sector of the beach from Mamaia (north of Constanta), which separates the sea from Siutghiol Lake; it is a process with negative consequences on the heliomarine station of Mamaia.
- the seashore is modified a lot in the port and industrial sector from Navodari.

3. The southern seashore, where the beaches and the cliffs alternate (the Cape of Singol-Vama Veche)

- seashore sculpted in the deposits (Sarmatian limestone, Quaternary loess) of a plateau of low altitude (under 35 m), largely winding, along which the beaches and cliffs alternate (the latter ones bar a series of salty seashore lakes (fluvial-maritime banks: Lake Techirghiol, Lake Mangalia, etc.).
- it is a sector where the coastline and marine dynamics have been modified to a great extent by works specific to port areas (the ports from Constanța and Mangalia) and arrangements for beach protection; the coastline and marine dynamics are completely modified in the port precincts.
- under natural conditions, the tendency of the coastline is of withdrawal in the areas of active cliffs affected by abrasion and earth fall, as well as in some beach areas undergoing degradation (affected by coast currents and strong waves); in order to protect the shores and to facilitate port and tourist activities, dams have been built on scores of kilometers; few places have remained unarranged (Fig. 4).

4 CONCLUSIONS

Broadly speaking, the observation and mapping of the coastline relief and processes based on the Landsat images registered in 1990 and 2000 have made it possible to notice the tendencies of evolution of the Romanian shoreline in its different sectors: deltas, lagoons and cliffs. During this 10-year period, the most significant modifications have occurred at the mouths of the Danube, especially in the sector of the secondary delta of Chilia, where, due to submerged accumulations, two islands have appeared. The latest geomorphologic maps,
based on rigorous outdoor observations, have confirmed them. No important modifications
have been seized in the sector of lagoons or in that of cliffs. We mention that most of the
cliff sector has been modeled by arrangement works. Only the small areas of active cliffs
present a tendency of withdrawal due to marine abrasion. These are the places that continue
to require arrangement works.

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