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STATUS OF THE SHORE AREA FROM TIENGIANG TO CAMAU – CAUSES OF ACCUMULATION AND EROSION

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ABSTRACT The paper presents some results of the research programs which had been performed during 1996-1999 ("Studying of river-sea interaction in the mouth of Tien river" and KHCN.06.08). Based on these results the morphological schemes of the shore areas from Tiengiang to Camau were compiled; causes and mechanics of accumulation and erosion were also determined. These results may be used as scientific basis for forecasting the development of the shoreline, it will contribute to the management, protection and reasonable exploitation the shore areas.

HIEN TRAÏNG KHU VÖÏC BÔÌ BIEÏN TÖØ TIEÀN GIANG ÑEÁN CAØ MAU – NGUYEÂN NHAÂN BOÀI TUÏ VAØ XOÙI LÔÛ

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TOM TAÏT Bai baùo trình bay moät soá keát quaû nghieân cöùu trong nhöõng naêm 1996-1999 cuûa ñeà tai Nghieân cöùu töông tac soáng bieån khu vöïc cöûa soâng Tieàn vaø ñeà tai KHCN 06.08. Döïa treân caùc keát quaû naày chuùng toâi ñaõ thaønh laäp caùc sô ñoà hieän traïng bôø bieån töø Tieàn Giang ñeán Caø Mau vaø xaùc ñònh caùc nguyeân nhaân chuû yeáu cuøng nhöõ cô cheá cuûa quaù trình boài tuï-xoùi lôû bôø. Caùc keát quaû naày laø caùc cô sôû khoa hoïc ñeå döï baùo sö phaùt trieån cuûa vuøng bôø phuïc vuï cho vieäc quaûn lyù, baûo veä vaø khai thaùc hôïp lyù vuøng ven bieån.

INTRODUCTION

The west part of South Vietnam is one of the important economic regions of the country. In recent years, local socio-economic development was recorded, especially in the sectors of marine economy. However, the excessive and unplanned exploitation of the biological resources as well as the water and land resources along the shore areas is one of the main causes leading to environmental deterioration and partly increasing natural disasters, especially the process of shore accumulation and erosion. This has badly affected the community's life and living.

In this paper the status of the accumulation and erosion in the shore area from Gocongdong (Tiengiang) to Datmui hamlet (Camau) was mentioned together with the mechanics of accumulation-erosion process. Additionally, some measurements related to the prevention of negative impact of this phenomenon were proposed.

MATERIALS AND METHODOLOGY

The data used in this paper are the results of investigations which had been carried out in 1996-1997 period (Research Program on "Study of river-sea interaction in the mouth of

Tien river") and in June 1999 (Research Program KHCN.06.08) at shore areas from Gocongdong, Tiengiang, to Datmui hamlet, Camau (Fig. 1).

In field trips topographical profiles were measured together with meteorological and hydrological parameters (location of sites was determined using GPS Fuso FGP-722). Some photos and videotapes were taken. Besides, some data collections from secondary sources were performed. Based on measured data, topographical profiles and morphological schemes of shore areas were compiled. Present shoreline was compared with the shoreline described in US Navy Chart (scale 1:50000) which was published in 1967

In laboratory sediment samples were analyzed for grain size and lithological composition.

RESULTS AND DISCUSSION

1. Characteristics of shore areas from Tiengiang to Camau

General characteristics: Results of mechanical and lithological analysis indicate that the whole of studied shore areas is constituted by layers of ancient alluvium (their main components are brown mud and brown sandy mud with interlocked layers of bioclastic materials). In these areas mangroves develop with different covers. The shoreline locates in relatively flat area which is often 1.2-1.6 m higher than sea level. Depending on the formation process and the general development of the Mekong delta, the shoreline in the studied areas has different directions.

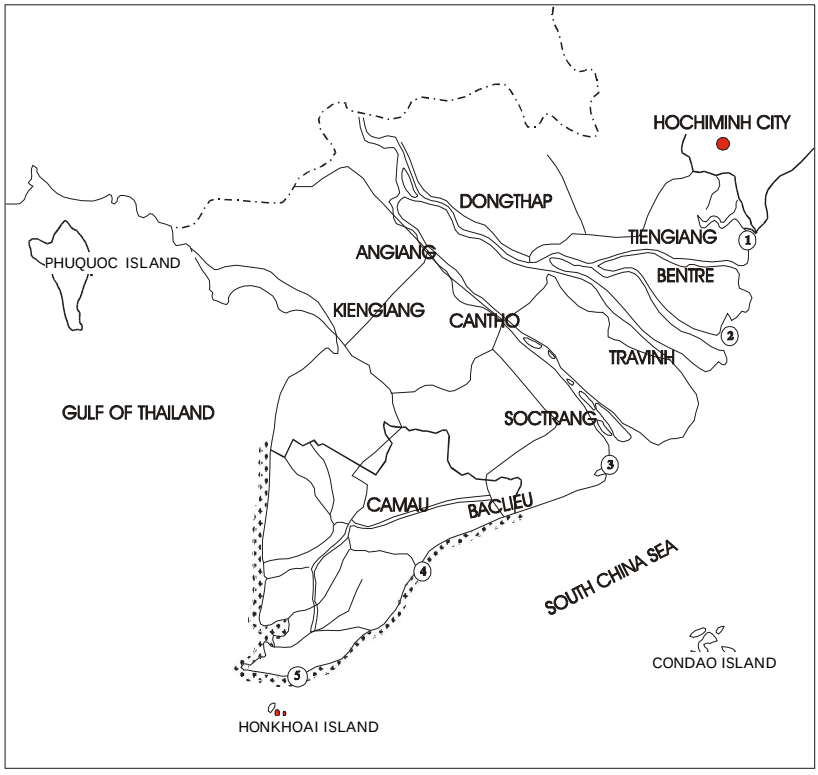

Figure 1: Location of studied areas (June 1999 survey; Scale: 1:1 500 000)

1: Region of Tandien-Tanthanh, Gocongdong distr., Tiengiang prov.
2: Region of Hamluong river mouth, Thanhphu and Batri distr., Bentre prov.
3: Region No. 6, Vinhchau town, Soctrang prov.
4: Region of Ganhhao river mouth, Damdoi distr., Camau prov. & Ganhhao town, Baclieu prov.
5: Region of Datmui, Ngochien distr., Camau prov.

Besides of major rivers (now only 8/9 are operating) flowing into the East Sea (the South China Sea), there are also a fairly great number of canals, streams, and brooks flowing into the sea with different rates. In recent years, due to the rapid increase of aquacultural activities along the littoral areas, the amount of canals has increased considerably. The increased water exchange between sea and river is one of the factors causing the penetration of sea water into the continent.

1.1. The shore area from Tandien to Tanthanh, Gocong district, Tiengiang province

This is one of the important shore areas of the Mekong delta. Transgression takes place strongly, affecting considerably the local people's life and living.

The shoreline is nearly north south in direction from Kienphuoc to Rachcung, and is northeast southwest in direction from Rachcung to Cuatieu.

The development trend is different in various part of this shore area due to the differences in their directions and formations and the influence of the riverine and marine dynamic factors. The section between Kienphuoc and North Tanthanh is always eroded, especially during northeastern monsoon. Average rate of transgression is 25-30 m/yr. (maximum rate may reach 50-60m/yr. during sea-storms, Storm No. 5 in 1997 for example). Accumulation and erosion prevail alternatively in the section elongated from Rachcung to Cuatieu; however, the accumulating process is comparatively dominant, especially during southwestern monsoon.

Sandy tidal flat is large. Its width is gradually increases from the north to the south. Maximum width of the tidal flat may reach over 10 km (the section between Rachcung and Cuatieu).

Due to the continuous transgression, the local people have constructed protective dykes. The present national protective dyke is the third since 1970. There are also protective forests on both inside and outside of the dyke. In spite of this, transgression is still threatening the community's living, especially in the area from Tandien to Tanthanh (Fig. 2). In Tanthanh, transgression takes place more quickly because of human activities: destruction of the mangroves and unplanned construction of aquacultural ponds.

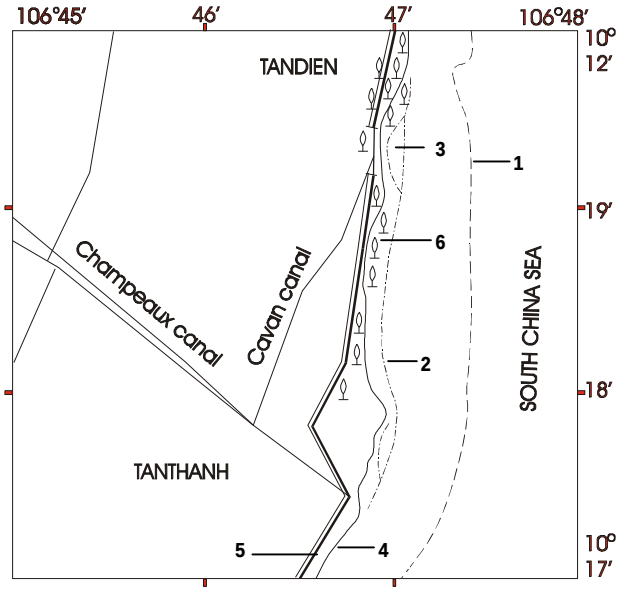

Fig. 2: Changes of the shoreline in Tanthanh-Tandien regions
1: The shoreline in 1967; 2: The shoreline in 1992; 3: The shoreline in 1995
4: The shoreline in June 1999; 5: The national protective dyke; 7: Protective forests

1.2. The shore area nearby Hamluong river mouth, Bentre province

This area is administratively belonging to two districts: Batri (the northern part, Tanthuy) and Thanhphu (the southern part, Thanhhai) (Fig. 3).

In the northern part ($9^0$58'367''-$9^0$58'386'' longitude; $06^0$38'468''- $06^0$38'564'' latitude), the shoreline is 240^0 in direction. Signs of accumulation and erosion which occur alternatively resulted in ragged form of the shoreline. The area adjacent to the river mouth is strongly eroded during northeast monsoons. This process has left the obvious marks, which have not been cleared by further accumulative materials. Well-sorted fine-grained sand fraction of eroded materials have been deposited on the outside (10-15m off shore), mud fraction have been transported farther.

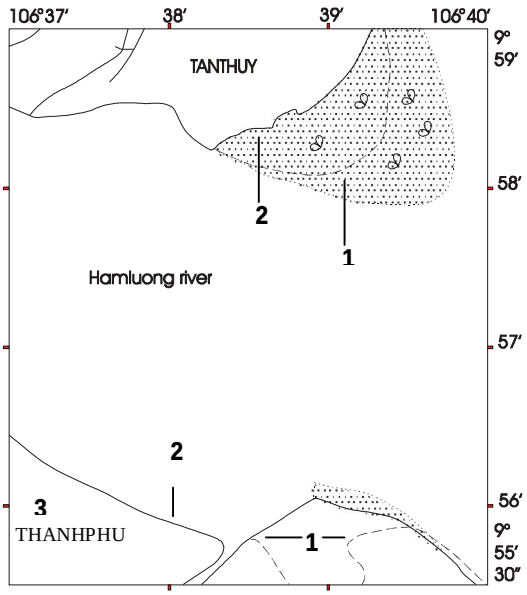

Figure 3: Changes of the shoreline nearby Hamluong river mouth

1: The shoreline in 1967; 2: The shoreline in June 1999; 3: Protective forests

From the northern part of Hamluong river mouth to Binhdai (approximately 300-400m long) the shore is in accumulated status. About 25-30m off from the shoreline there is a long sandy body, which run thousands of meters down to river mouth. Its width varies between 20 and 35m and average height is about 0.25-0.30m at ebb. For us, sand materials (forming the long sandy body) have been mainly brought from the inshore Binhdai during northeast monsoon. Between the shoreline and this long sandy body there is the tidal channel of 0.3-0.4m in depth at ebb. The bottom of this tidal channel is formed with compacted reddish brown clay.

This tidal flat, of great width and low slope, has been used in longtime for mussel culturing and exploiting area. The mussel density is fairly high, properly reaching hundreds/ m^2.

In the southern part direction of the shoreline varies from 130^0 to 160^0. The shore materials are sandy, covered with a varied vegetation. This shore area is continuously accumulated at the moderate speed, except for unusually erosion in 1997 (during storm No 5). But right after the storm, the accumulation recurred and up to now (survey time). Now the eroded mark still shows off at places that have not partially covered by further deposited materials. The upper tidal flat is not wide (10-15m) and at a slope of 8-10^0, with some places covered with a rather dense layer of sea-flowers on the surface. The lower tidal flat has smaller slope and forms a tidal channel running parallel with the shoreline. One or two small long sandy bodies appearing at ebb are connected to the shoreline beyond the river mouth.

On the tidal flat, laterite and sandstone grains with various sizes are often found. Besides, a sample of consolidated sandstone (12 x 8 x 0.2 cm) was found. Encrusting organisms develop in one side of it. On the other side, one can still notice abrasion marks caused currents. It is mainly constituted of transparent quartz grains, other minerals are black mica and other colored minerals. In our opinion, this rock sample is derived from ancient marine terrace located in the area. By correlation with characteristics of the other sample collected in the vicinity of Cochien river mouth (at depth over 16m), this sample could be considered to have an age Pre-Pleistocene.

The section just outside the river mouth is presently quite strongly accumulated. On the tidal flat, there still remain vestiges of the tidal channels, which have not been fully covered by the accumulating process.

The tidal flat here is steep and fairly wide and is formed by fine sand and sandy mud containing bioclastic materials. Together with the tidal flats in Binhdai and Batri, this area has developed into big "mussel fields" with a highest density of mussel population in the southern part.

Right in the river mouth a submerged barrier (1.2-1.5m deep at ebb) was formed. This morphological structure will result in a developing of long and wide confronting barrier at the front of the river mouth. This is also the typical morphological feature of most river mouths in the Mekong delta system.

1.3 The shore area of Section 6 in Vinhchau town, Soctrang province

The shoreline is in northeast- southwest direction. It is located in a transitional area between the accumulated area in the north and the eroded area in the south. For some decades, this shore area has been often eroded; average speed of transgression is approximately 10-15m/year. Especially for the past three years, the sea has encroached into the mainland for over 100m. Transgression often takes place strongly during northeastern monsoon, especially during the storm No. 5 in 1997. According to data from secondary sources, from early 1999 to June 1999, this shoreline is being extended with accumulation. The newly accumulated layer consists of dark brown mud covering on the eroded surface with the greatest thickness of about 20 cm. The speed of accumulation increases gradually from Trande – Mythanh river mouths to Vinhchau. This phenomenon may be the consequence of increasing influence of Tranhde and Mythanh rivers which is abundant in alluvial materials.

The landscape is quite different from other studied areas (Fig. 4). The shore area is smooth and formed by different sediment layers: the upper layer (30-40 to 50-60cm thick) constituted by terrigeneous fine-grained sand and bioclastic materials. The below is a layer of reddish brown ancient alluvium. On the surface, there is a coverage of scattered vegetation. The mangroves only develop in patchy form.

Along the present shoreline, despite the accumulation is strongly prevailed, marks of erosion as well as vertical walls (25-40cm, vestige of erosion in the past) are obviously found.

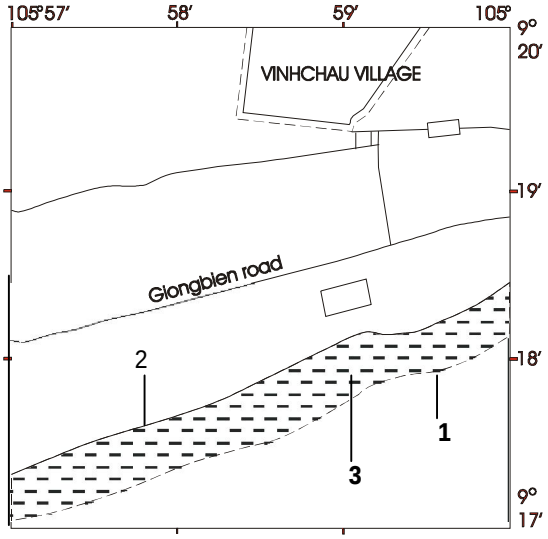

Figure 4: Changes of the shoreline in Vinhchau region

1: The shoreline in 1967; 2: The shoreline in June 1999; 3: The high tidal beach

The tidal flat is fairly wide. Its width is gradually decrease in the southward direction (from 2-3 km to about 1km). The tidal flat is smooth and can be distinguished into two parts: the upper tidal flat has width varying from 400-500 m to thousands of meters; its surface is covered by layers of brown mud (20-30 cm). The lower tidal flat is an eroded layer of ancient reddish brown alluvium. Tidal channels which are perpendicular with shoreline and other marks of the erosion process are observed. The boundary between the upper and the lower tidal flat is a vertical cliff running almost parallel to the present shoreline; this is the mark of the shoreline that

exited in 1967 (according to surveys and maps compiled by the US Navy in 1967). The lower tidal flat is smooth and covered by well-sorted fine-grained sand containing bioclastic materials. Below of this layer reddish brown ancient alluvium occurs.

1.4. The shore area in the vicinity of Ganhhao river mouth (Baclieu and Camau provinces)

The shoreline in the vicinity of Ganhhao river mouth, belonging administratively to both Baclieu and Camau provinces, is one of the quickly eroded areas in studied region (Fig. 5).

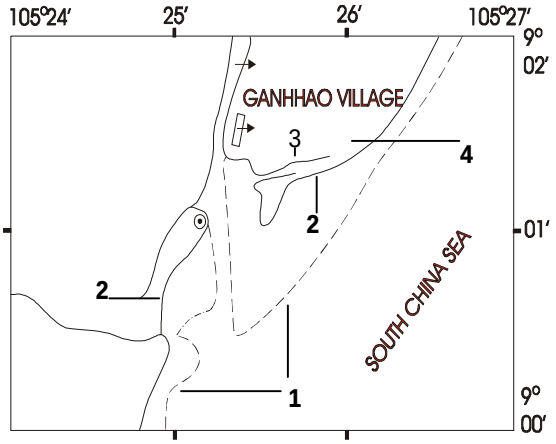

Figure 5: Changes of the shoreline nearby Ganhhao river mouth
1: The shoreline in 1967; 2: The shoreline in June 1999; 3: The national protective dyke; 4: Protective forests

The southwestern part is administratively belonging to Tanthanh commune, Damdoi district, Camau province. The shoreline is north-south and north northeastern - south southwestern in direction. Along the shore area there is an aquacultural area with scattering and low remaining mangrove forests. The present shoreline is the outer side of the abandoned shrimp-raising ponds. Along the shoreline steep cliffs are obviously observed, they are the signs of erosion that has been taking place in the area. The tidal flat is quite wide and has a slope of $2\text{-}4^0$; it is an eroded surface with dead tree trunks located somewhere. Remained vegetation is very scattered. The tidal flat is covered by green mud spotted with brownish yellow. On its surface a block of spotted yellow claystone containing lateritic grains with different sizes was found. The junction area between the high and low tidal flat is a tidal channel covered with newly formed sediments (wet brown yellow mud) right on the eroded surface. The lower tidal flat is smooth, it is covered by well-sorted fine-grained sediments containing bioclastic materials. These come out from the shore through erosion.

The shore area in Ganhhao (located north of the river mouth) bears the shape of a cape running from west-southwest to north-northeast. The shore is formed by brown mud covered by grass; mangrove forest vegetation is low and scattered. Transgression has taken place quite strongly and continually in the past few decades at an average speed of 30-34m/yr. Especially during the past three years (1996-1998) this speed has taken place too fast, eradicating section I of Ganhhao township, which is now 150-200m offshore from the present shoreline. Transgression has also considerably enlarged the river mouth. Protective contouring dykes are now set up along the northeastern shore.

1.5. The shore area at Datmui hamlet, Ngochien district, Camau province

The survey area located south of Datmui hamlet (Fig. 6). The shore area were formed with materials derived from the erosion of ancient and recent alluvium during transgression. The covering vegetation is a mainly mangrove with various densities. Most of the covered areas are new developing natural forests (in accumulated area) and only some are new planted protective forests (in eroded area).

According to the survey results, the shoreline can be divided into two sections with Vamsay canal as boundary. The eastern section is the eroded area and western section is the accumulated one.

The eastern section (within $8^0$35’55’’N, $104^0$45’181’’E and $8^0$35’22’’ N, $104^0$47’213’’ E) was covered by ancient alluvium. The coverage of mangrove was from unsatisfactory

to average. It gets denser as we move farther to the east. Some scores of meters from the present shoreline at the inside are fairly well developing protective forests. The present shoreline has a rugged shape interlaced between the low topography of the eroded surface and the high topography of the remaining eroded points (where wild grass grows fairly thick and the mangroves remain undestroyed) during the present process of erosion. At concave places there are now signs of material accumulation: sand at some places and vegetation humus at others. The farther to the east (towards Rachtho canal), the accumulation presents itself more evidently and totally prevails at the section between Oro canal and Khelong.

Generally, in this section the transgression takes place at an average strength of 200m/10years during the past decade. Yet, especially during the three years between 1996-1998, at the shoreline adjacent to Vamsay river mouth, the sea encroached 60-70m and specially strongly during Storm No. 5 in 1997.

The tidal flat here is quite wide (from hundreds to thousands of meters) with a smooth surface covered by various types of sediments.

The upper tidal flat is an eroded surface of ancient sediment (brown mud) with a width of only scores to around 100m. At many places we could see several mangroves remaining lonely with a whole root system showed out. Compared with the surface level of the present shoreline, this eroded surface is 0.6-1.1m lower. Next to this is a newly accumulated surface of well sorted fine-grained gray sand containing bioclastic materials. They are derived from the eroded shore. This sandy layer is only about 2-3 cm to 5-10 cm thick. They cover on an eroded surface of green clay which is formed in a few past years. In the outside of Vamsay river mouth, the section from Canal 17 to Bahuong canal, there is an sand bar running approximately 1 km along the shoreline.

The lower tidal flat is kilometers wide with a flat and fairly declined surface. The sediments on the surface are well-sorted gray sand and brownish yellow muddy sand. In the outside beyond a narrow tidal channel (60-70m wide, over 1m deep at low tide) there is a sand bar running parallel to the shore. The surface of this bar is about 80-90cm higher than water level at ebb.

The western section is an accumulated shore area. However, it was sometimes eroded: the section from Vamsay to the outside of National Coordinate Landmark 001 was eroded in 1997, the evidence of which is the collapse down of the National Landmark (built in 1993, 300m from National Coordinate Landmark 001). The accumulation takes place, mangrove forests develop naturally or get planted and accordingly aquatic resources increase considerably, especially crabs and shrimps.

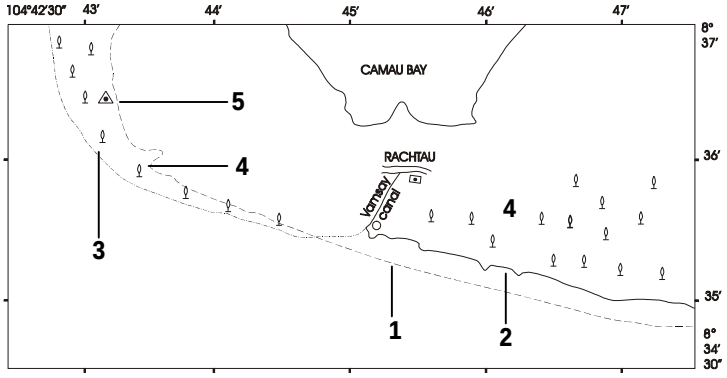

Figure 6: Changes of the shoreline in the region of Datmui (Camau)
1: The shoreline in 1967; 2: The shoreline in June 1999; 3: Supposed shoreline in June 1999
4: Protective forests; 5: The national landmark No. 0001 CDDBDNN, 1/1995, coordinates No. IV

2. The causes and the mechanics of shore accumulation and erosion

2.1 The causes

From the above results we can classify the following types of shores: (1) frequently eroded shores (Gocongdong, Ganhhao, the eastern section of Vamsay river mouth); (2) accumulated shores (from Binhdai down to northern Tanthuy of Bentre province, the western part of Datmui, Camau province); (3) shores with alternative accumulation and erosion (Hamluong river mouth); and (4) shores transferring from erosion to accumulation (Section 6, Vinhchau township, Soctrang province).

The shore areas from Gocongdong (Tiengiang) to Datmui (Camau) belong to the type of delta shore with mangroves, of the group of shores formed mainly by non-wave factors (Nguyen Thanh Son and Trinh Phung, 1981). Morphologically, the shore is low, flat, divided by estuaries and much covered by mangrove forests. Through a dense system of rivers and canals, there has been a yearly huge volume of water (about 1.4 km^3/yr.) and accompanied solid materials brought into the sea from the continent. They are the favourable factors for the expanding of the shore toward the sea. Yet, the reality during the past few years and survey results (June 1999) show a fairly complex pattern of accumulation-erosion, which depends on many different factors.

The factors influencing the accumulation and erosion are: the formation of the shoreline, the direction of the shoreline, the impacts of the tide, alongshore current, waves and especially human activities.

As mentioned above, the shore areas from Gocongdong (Tiengiang) to Datmui hamlet (Camau) were mainly formed by deposits of ancient alluvium constituting by brown or reddish brown mud and sandy mud. At some places, especially in Datmui (Camau), the shore area was formed by new alluvium.

Ancient alluvium, upon being covered by thick layers of vegetation, would have high levels of stickiness. Meanwhile, at places where the vegetation is scattered or where there is no vegetation, exposed to frequent sunlight leading to a lack of water, these sediments shrank, then eventually got cracked and spongy; as the result, when there is water again, they got loosened and crumbed down. With only a very small affecting force, they would be removed and carried away by water. This is a main reason leading to the strong erosion.

The direction of the shoreline also plays an important role. Survey results show that at areas with open shoreline (Gocong, Ganhhao, the eastern section of Vamsay river mouth), the process of erosion took place more strongly than in other areas. This also means that at places where the shoreline is partly hidden, there are either alternate periods of accumulation and erosion or there is only accumulation.

Naturally, one of the main factors leading to the accumulation and erosion is hydrodynamic forces: waves, tides, currents … The analytical results of the measurement data (of June 1999 investigation) show that, during the hydrodynamic regime of the southwestern monsoon, erosion nearly did not take place and accumulation could be observed at most shore areas. Thus, erosion at open shore occurs only during the period of northeastern monsoon and eastern wind.

One important cause leading the shore erosion is human activities. In the past few years, aquaculture have strongly developed in the shore provinces of the whole country, especially in the provinces between Tiengiang and Camau. These activities have become a spreadhead economy of many provinces. Yet, this unplanned and fast spreading development has devastated thousands of hectares of mangrove forests along the shore, bringing out environmental deterioration. The immediate consequence is the loss of lithodynamic equilibrium in the shore areas, leading to serious erosion in many places.

Besides, the phenomenon of water rising during storms and the rising of seawater levels of the seas and oceans during the past few decades have also played a significant part in the process of eroding the shore areas.

2.2 Mechanics of accumulation and erosion of shore areas

Depending on the above-mentioned reasons, the process of accumulation and erosion takes place differently at various areas. At shore areas frequently accumulated or accumulated and eroded alternately with prevalent accumulation (Binhdai-Tanthuy, Hamluong river mouth, Bentre province, western Datmui, Camau province) or in transitional areas of erosion and accumulation (Section 6, Vinhchau township, Soctrang province), this process depends mainly on the amount of materials flowed out by the rivers. Sedimentary materials accumulate under the influences of sea currents or the river-sea interaction (condence at the front of the estuaries) which form accumulated bars blocking the estuaries or accumulation in the upper part of the delta.

For the eroded shore areas, the mechanics take the same pattern: mechanical erosion. At low tide, the whole upper tidal flat is exposed and the surface of muddy clay gets cracked due to the shrinkage caused by the lack of water; at high tide, the water would fill these cracks, the glue components are dissolved and the grains come loose. In these conditions, only wind at 2-3m/s would loosen the cracked muddy clay and without nay glue, the shoreline would come off. When the tide comes out, all the eroded materials would follow the tide out to the sea. It is during this time mechanical differentiation of the sediments gets a start: sandy materials are accumulated mainly at the outside of the upper tidal flat, sometimes piled up into alongshore high bars in the upper section of the lower tidal flat; muddy materials are brought out farther and at favourable conditions would be accumulated at avant delta or brought southwards by alongshore current, a part of which accumulates at tidal channels or retained at places with grass and small bushes. After each tidal cycle, the uncovered parts of the shore come off a little and the high tidal flat is washed away. It can be clearly observed that the washing away of the surface reached only the definite depth (at an average of 0.6-0.8m compared to the surface of the previously accumulated formation). This means that when this washed away surface gets frequently wet due to submersion or immersion, creating a flat eroded surface with a high level of stickiness. the process would stop. This process takes place continually and strongly during season of northeastern monsoon. This mechanics is schematically presented in Fig. 7 for a cyclic period of many years.

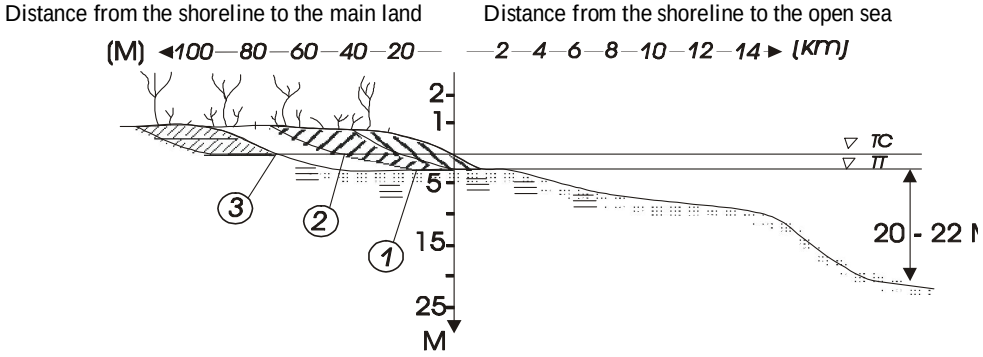

Figure 7: Scheme representing the mechanics of erosion of typical shoreline in the area from Tiengiang to Camau

Coastal areas with salinized trees; ..... Well selected small sand; == Eroded surface; 1,2,3 Erosion periods/year

For accumulated shore areas the common feature is that there must be a supply of sedimentary materials, but depending on their characteristics the factors contributing to the process of accumulation may be different.

Muddy materials are accumulated along the areas with a development of new mangrove forests with thick-growing small trees. These small trees decrease the wave force and act as sediment traps.

The sandy materials are accumulated at shore areas. The direction of these accumulated bodies is parallel with current direction. The shore area is accumulated mainly due to the sand piled by the waves. The sand is piled up in a horizontal direction in the case where the formation of sand bars takes place; and this would take a vertical direction in the case of developing sand capes.

Remarks and proposals

From the above survey and study results, we would like to forward the following remarks and proposals:

1. The development process of shore areas from Tiengiang to Camau has been fairly complex in term of space and time due to strong influences of the Mekong River system and due to the continuous river-sea interactions.
2. The accumulation and erosion at shore areas due to many different causes. Yet, human activities prove to be one of the main causes, especially in areas where the shore is eroded and the sea encroaches into the mainland. Excessive exploitation of the land-water resources has been creating dangers of speeding up the deterioration of shore areas.
3. The mechanism of erosion has the pattern of detaching each layer until reaching a stable surface leveling low tide. This pattern may be characterizing for mangrove delta shore areas.
4. On the basis of above-mentioned data, we would like to suggest the following:

- It is necessary to manage and protect strictly mangrove forests, especially those along the shore.
- It is advisable to restore destroyed mangrove forests, to plant protective forests with trees (apart from mangroves) suitable to natural conditions and capable of defending against erosion.
- It is necessary to plan and orient aquacultural areas on the approach of sustainable development.

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