Geomorphological Study of Belayim Bay, the Eastern Coast of Suez Gulf, Egypt

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Abstract

Belayim Bay is one of the most morphological features along in the Suez Gulf. The study area is located in the middle part of coastal zone of Suez Gulf. The investigated area lies between longitudes 33° 14′ 10″ and 33° 15′ 53″, and latidudes 28° 32′ 23″ and 28° 34′ 44″ . It lies north west of Gebel Qabaliat which is located in Sw Sinai at latitude 28° 30′ N and longitude 33° 28′ E.

The area extends from an open sea (water depth more than 60m), to a shallow water (water depth gradually decrease to 2m). The water depth shows an abrupt change going towards western part of area, where a steep escarpment reduces in few meters. Behind this the water depth remains constantly shallower than 2 meter.

Introduction

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Fig (1) : Satallite Imagine of Gulf of Suez

The study area is divided according to the bathymetric contours (Fig. 2) into three different sub-area, the deep water, the sallow water and the land-tranisition.

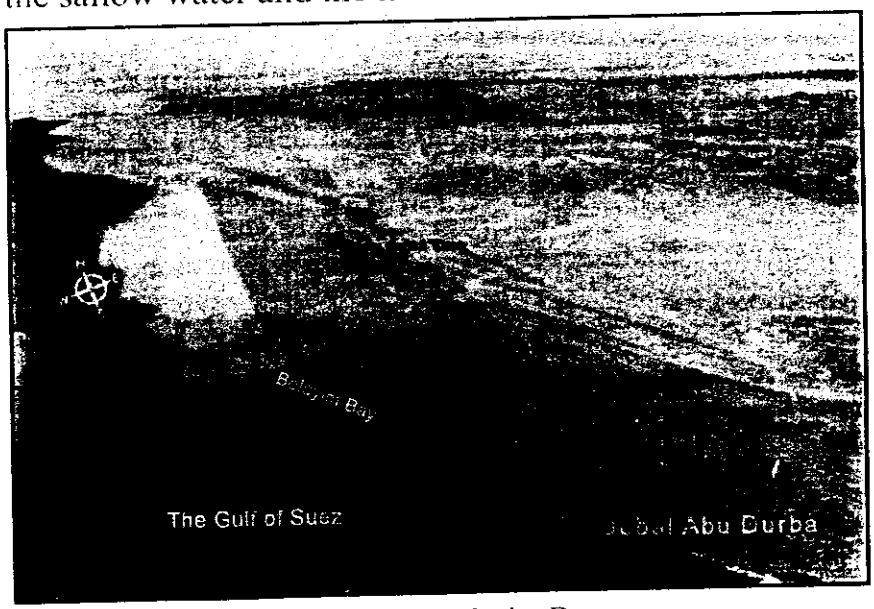


Fig. (2) : Satellite imagine show Belayim Bay.

The area concerned by the Zigzag acquisition wa' divided in two parts due to operational constraints.

The area extends from an open sea (water depth more than 60m), to a shallow water (water depth gradually decrease to 2m). The water depth shows an abrupt change going towards western part of area, where a steep escarpment reduces in few meters. Behind this the water depth remains constantly shallower than 2 meter.

The offshore is crowded by more than 40 oil facilities and the related sea-lines and wires laying on the sea bottom. On the surface land three broad installations and more than 20 nodding donkeys, lined on the coastline, plus the related network of pipes and wires are present.

Fig. (3) : The Supervised image of the studied area in 1990.

The heavy ambient noise present in the area, mainly due to the Suez ship traffic and oil industry related activity also had to be taken into account.

The area can be considered environmentally quit sensitive the main limitation of the explosive utilization interdiction along the coast.

In addition to this the severs security rules established for the area do not allow to anybody either to stay or to leave equipment on the beach after darkness and before down.

A special care was adopted for preserving the coral reef environment.

Previous studies :

The gemorphological studies are considered with studying estuaries, temporary and mobile coastal landforms, as an example, the study of ***Emabai, N.S 1982, 1984, El-Sayed El-Husseini 1988, Ashour, M.M., Mohammad Sabry Mahsoub 1991, and Mona El-Kaily 2002***.

The district of Gulf Suez was lucky to be studied from geologists to allocate the formation and geological structure and invention petro from it. H. Abd El-Kader 1993 was studied the geomorphological of district of eastern coast of

Suez Gulf, but these studies didn't concentrate on coastal features of Belayim Bay and process.

Study objectives :

The present study aims to realize the following :

(1) This study is focused on the temporary and mobile coastal features of Belayim Bay and process related to its.

(2) This study also introduces simple attempt to define temporary coastal features in Belayim Bay by using landsat-TM scenes, data as a one of the most tools are used to detect and description of morphological features.

Materials and Methods :

The following materials and methods are used to carry out the objectives of this study :

1- Maps :

The topographic maps of scale 1:50.000 was used create the Digital Elevation Model (DEM) of the study area.

The geological maps and Isochroous maps are used to show and analysis fault systems and stratigraphic formation in Belayim area.

2- Landsat-TM

Landsat-TM scenes were used in this study (Fig. 4). It is one of the most tools are used to descript morphological features.

3- Software

The following software are used during this study :

- ERDAS Imagine.
- ARC GIS.

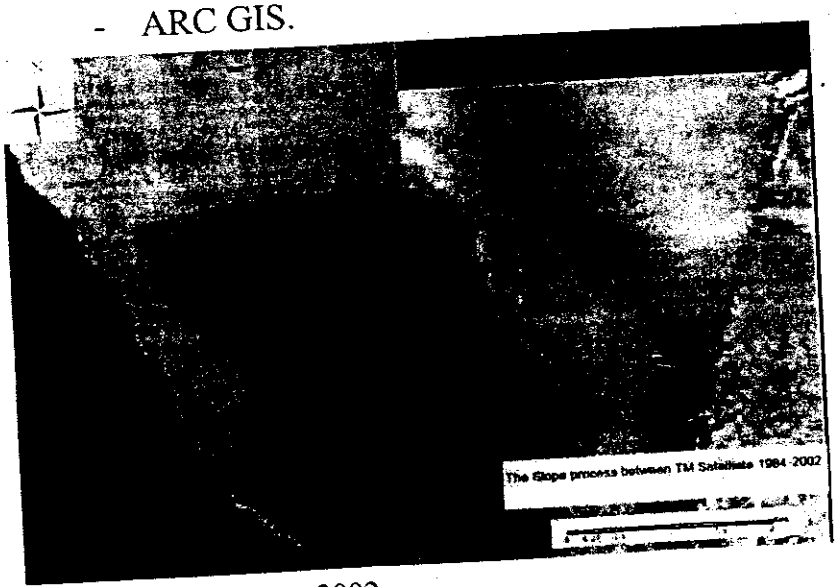


Fig. (4) : TM Satellite 2002.

4- Field Data

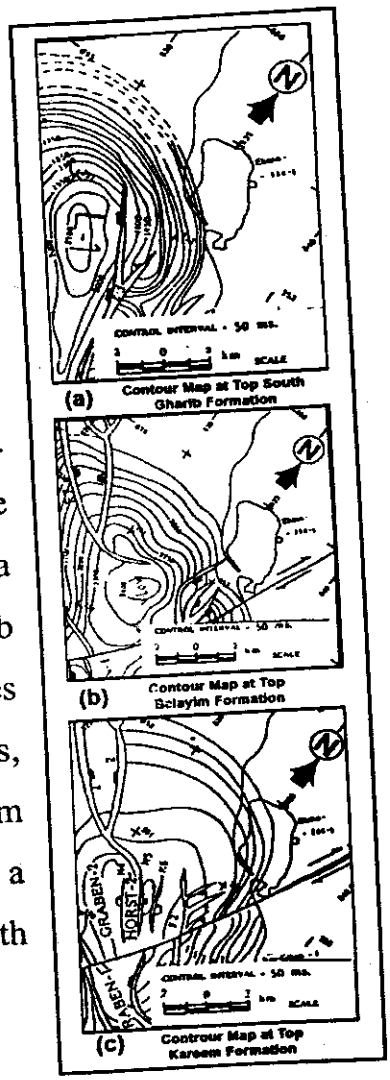
Extensive efforts were made to collect data about landforms through field observations.

Generally, the most important factors affecting in the area study are wind condition at the surface, currents direction resulting rotation of the Earth, the monthly mean level variation and Tidal speed.

Physical Characteristics :

(1) Deposition and rifting phase :

The deposition phase ended with a regional uplifting and a marine regression. Continental deposits prevailed in the Oligocene (shale and Coarse sandstone), known as the "Gharandel group" deposited during the lower micene. The middle and upper Miocene are characterized by the deposition of a sequence known as the "Ras Malaab Group". It is evaporate series consisting of carbonates, anhydrits, salt, chalks and shale. The bottom of Belayim bay lithology is a patchwork of sand areas mixed with mud and dead coral mounds.



Source : (Mounir, N. 1995)

Fig. (5) : Contour map of formation at the study area.

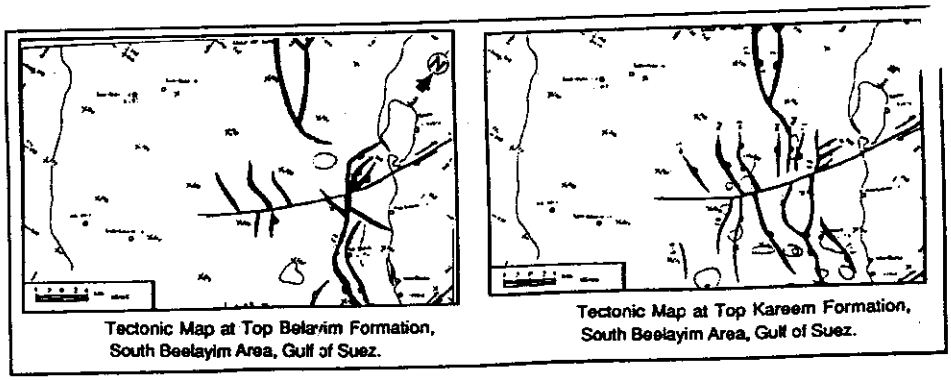
The isochronous map for Gharib formation (Fig. 5a). The area steady may be a unique deep basin with estimated maximum time 1.6 sec at the location L_1. AEN trending fault is existed alone is the eastern portion (Mounir. A. Ismail, 1995: p 160).

The isochronous map for Belayim Formation (Fig. 5b) indicate that the area is structurally highs and affected by salt domes, dyke intrusions and two fault systems than existed on Tops of zeit and south Gharib formations (Mounir A. Ismail, 1995 p. 166). These fault systems had been explained (Tawfic, 1986) as slumping NW-SE trend and normal NE-SW trend.

The isochronous map of top Kareem formation (Fig. 5c) represents rather the similar features as in Top Belayim formation. The existed faults are forming together sequences of horsts and grabens which may be returned to the compressional or tangential regional NE-SW forces.

The rifting phase :

The rifting phase produced two main tectonic trends. The effect of these main faults, trending NW-SE and WSW-ENE, defined a typical horst and graben structural setting. Each single crustily block shows strata dip up to 30 degrees and fault walls up to 60 degrees. The blocks are characterized by siliciclastic and carbonates ascribed to the "Nubia Complex" (Devonian-lower Cretaceous) and represents the reservoir of the area.



Source : (Mounir, A. 1995).

Fig. (6): Tectonic map of the area study.

(2) Wind condition and direction

Rady (1993) indicate that when winds prevail from W to NE, the sea surface slopes upwards from Suez in the North to the entrance in the South.

The area study is Swept all year by a North Western wind.

The velocity usually ranges between 29.5 Km/h and 0.05 Km/h with an average of 9-6 Km/h is Summer and between 22 Km/h and 0.04 with an average of 9.1 Km/h in Winter (Table 1).

Table 1 : Wind Speed in 2002 (Km/h) at Tur.

Season	Max	Min	Average
Winter	22	0.4	9.1
Spring	21	0.01	8.2
Summer	29.5	0.005	9.6
Autumn	15	4.5	8.1

Source : Meteorological Station Inst.

The strength is very inconstant and unpredictable ranging among 1-2 KMS, with sudden decrease and increase.

In Spring West winds mostly dominate, which are known Khamsin. The sea state can change from almost flat condition to more than 4 meters Swells in a few hours.

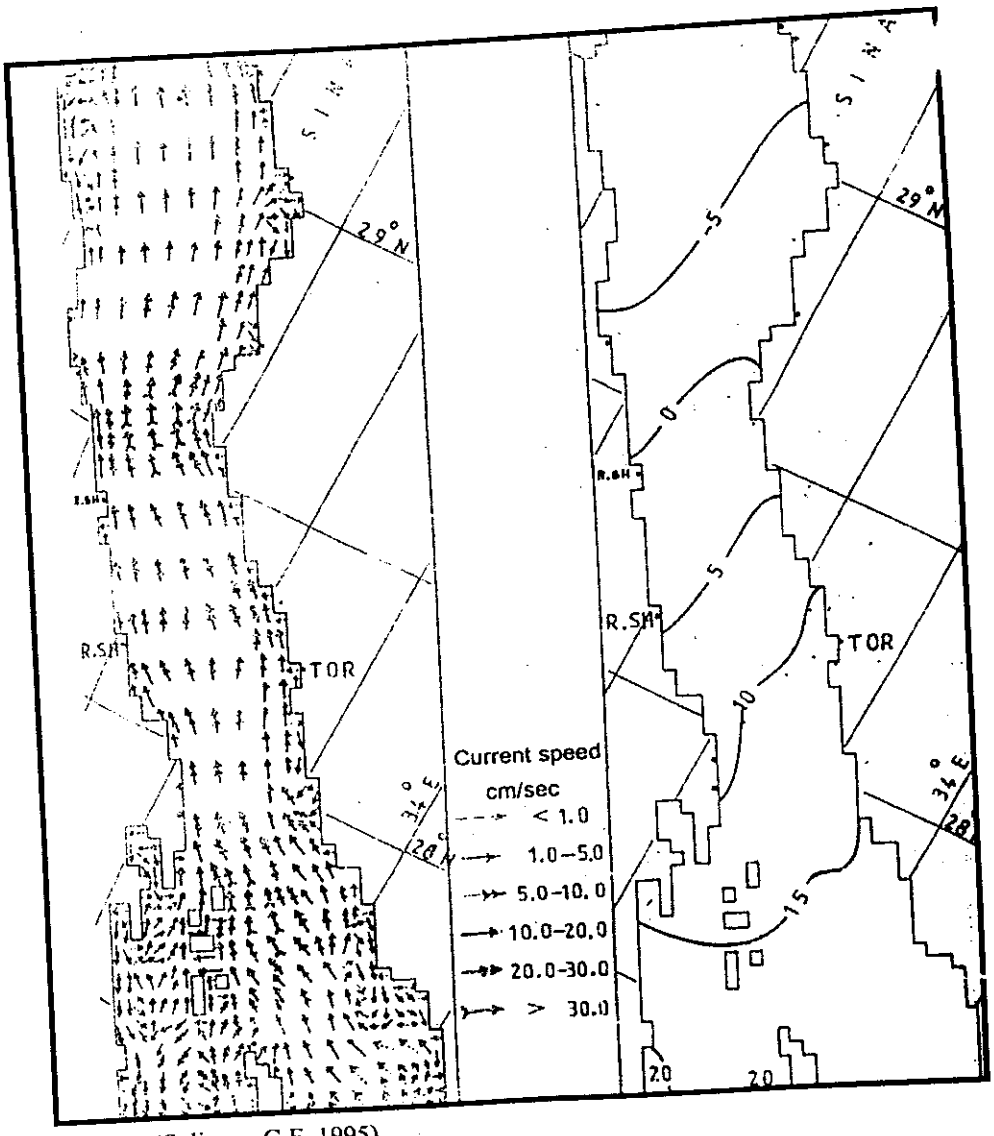
The influence direction wind affirmed that :

1) If the affected wind is NNW (Fig. 7)

- Negatively strong surge is produced in case of ebb.
- Less positively surge is produced in case of flood.

2) If the prevailed wind is SSE, then :

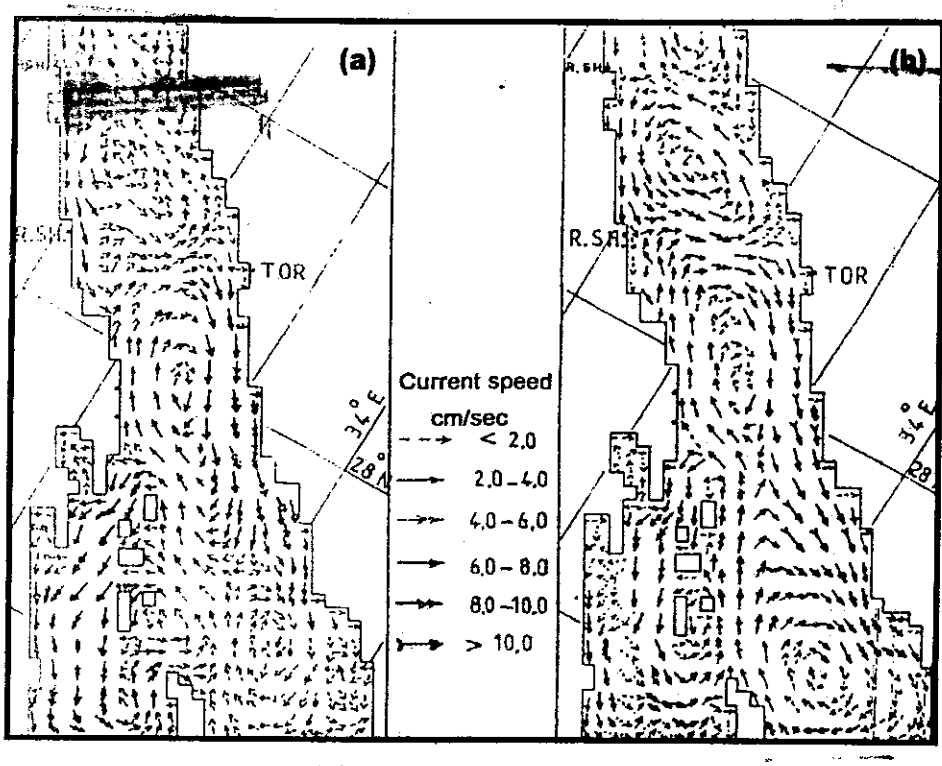
- Strong positively surge is produced in case flood.
- Less negatively surge is produced in case of ebb ***(Soliman, 1995. p9)***.



Source : (Soliman, G.F. 1995).

Fig. (7): The influence of NNW-wind and the accombained M2-tide.

The water flow is significantly influenced by bottom topography. Any change happen in the direction of wind its influence appears only in deflection extent of the cross current.



Source : Soliman, G.F., S.H. Sharaf 1995.

Fig. (8) : Wind in induced currents :
a- due to NNW-wind and wind stress of 1.0 dynes/cm^2.
b- due to W-wind and wind stress of 2.0 dynes/cm^2.

(2) Currents direction

The main currents present in Belayim area streaming in N-S direction. Its flow crossing straight through the area between the main reef and the beach. The currents flow with speed frequently exceeding 4 Km. Fig (8) represents the tide excursion averagè is about 1-5 m in the areas study.

(3) Tidal ranges

The table (2) shows that the spring tide recorded on the 10th March 2.1 meters and the neap tide recorded was 0.3 meters. The mean of tide range between 1.7 m and 1 m this is shows that spring in the area study season recorded the highest and lowest level of tide: The movement of sediment on the eastern and western sides of Belayim lagoon bring the temporary raise and decrease of tidal waters as well as the western Barrier.

Table (2) : Data and mean monthly record of spring tide and neap tide (meters) in the area study (2005).

10/1	9/2	10/3	8/4	8/5	6/6	6/7	5/8	3/9	3/10	2/11	1/12
0.4	0.3	0.3	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.5	0.6
2.1	2.1	2.1	2.1	1.9	1.7	1.4	1.4	1.5	1.7	1.9	2.0
0.4	0.3	0.3	0.4	0.6	0.6	0.6	0.5	0.5	0.5	0.6	0.7
1.9		2.0	2.0		1.8			1.6	1.7	1.8	1.8

(4) Tidal speed

In area study, Tidal speed based on linear theory and calculated using equations (1 and 2) (Defant, 1961).

$$C = \sqrt{gh} = \frac{L}{T} \qquad (1)$$

$$L = T\sqrt{gh} \qquad (2)$$

Where :

g is the gravitation

h is the water depth

T is the tidal period

C is Tidal speed

From Equations (1) and (2) Tidal speed ranges between about 4 m^{s-1} and 4.41 m^{s-1}, an average depth 2 meters.

(5) Rain

Type of storms are connective or frontal. Type of storms, direction, intensity, extent, rate of movement recurrence and variation in time. Connective storms occur under unstable weather at the end of winter. Rain duration is short from few minutes to few hours. Rain intensity is high.

Coastal Landforms

The importance of tidal range to landforms of the coast has only recently been emphasized. Hayes (1975) distinguish between tidal landforms and wave landforms. If the tidal range is less than 2m it may be assumed that wind waves provide the dominate coastal process, in this case beaches, spits and barrier will be the dominant features of the coast ***(John Pethich, 1984. p 62)***. In between 2-4 meters, two extremes of tidal range be coastal areas with inter-mediate tidal ranges whose landforms reflect both wind and tidal wave processes.

According to the detailed studies landforms based on interpretation of space images and data colleted about landforms through field observations.

The major morphological features of the area study are the following :

- Shoreline.
- Tidal inlet.
- Tidal Flats.
- Mud Feats.
- Lagoon.
- Creeks.
- Beaches.
- Barrier sand.
- Spit.

(1) Shoreline

The shoreline shows a wide curved shape in the western and eastern side while a compound recurred in south, it is formed from wide bay. The length of shoreline of area study is 3981 meters. The beach is formed from sand and mud.

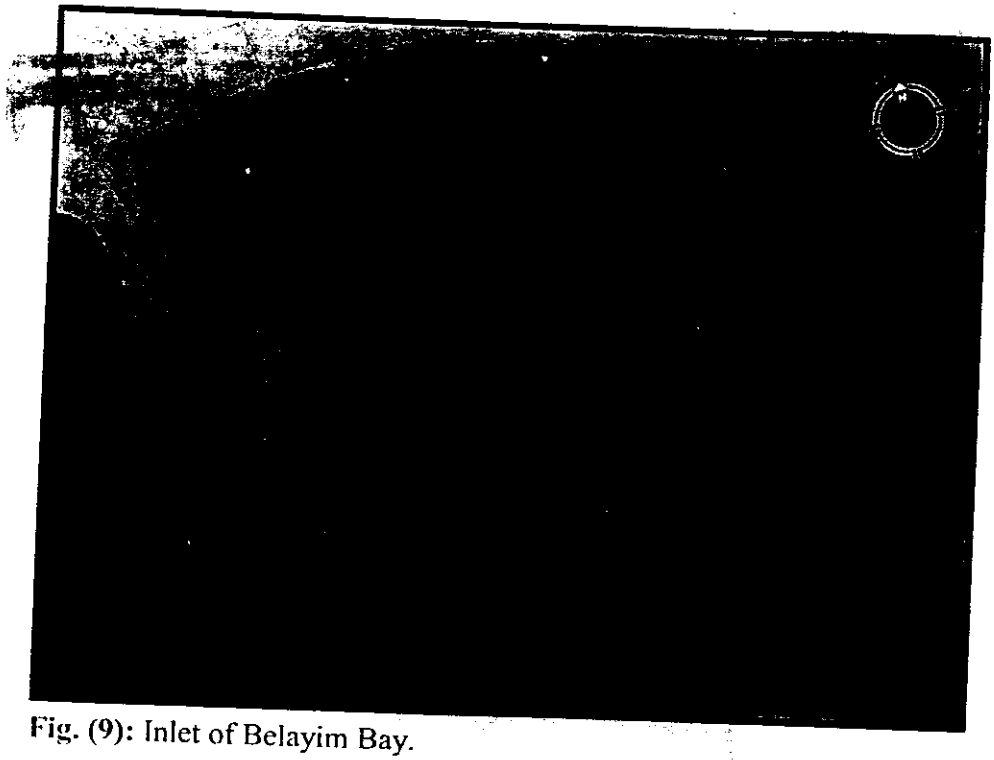


Fig. (9): Inlet of Belayim Bay.

(2) Tidal Inlet

Tidal inlet is a short, narrow passage connecting two larger and wider bodies of water tidal inlet link barrier lagoons of Belayim with the Gulf of Suez and maintained largely by tidal currents (Fig. 9).

Tidal inlet include :

- An inlet throat is narrowest and deepest part of inlet which tidal currents attain their maximum velocities.

- A flood-tidal delta consisting of material deposited by deceleration of flood-tide currents lagoon ward of the inlet throat .
- An Ebb-tide delta consisting of material deposited by deceleration of Ebb-tide currents gulf ward of the inlet throat.

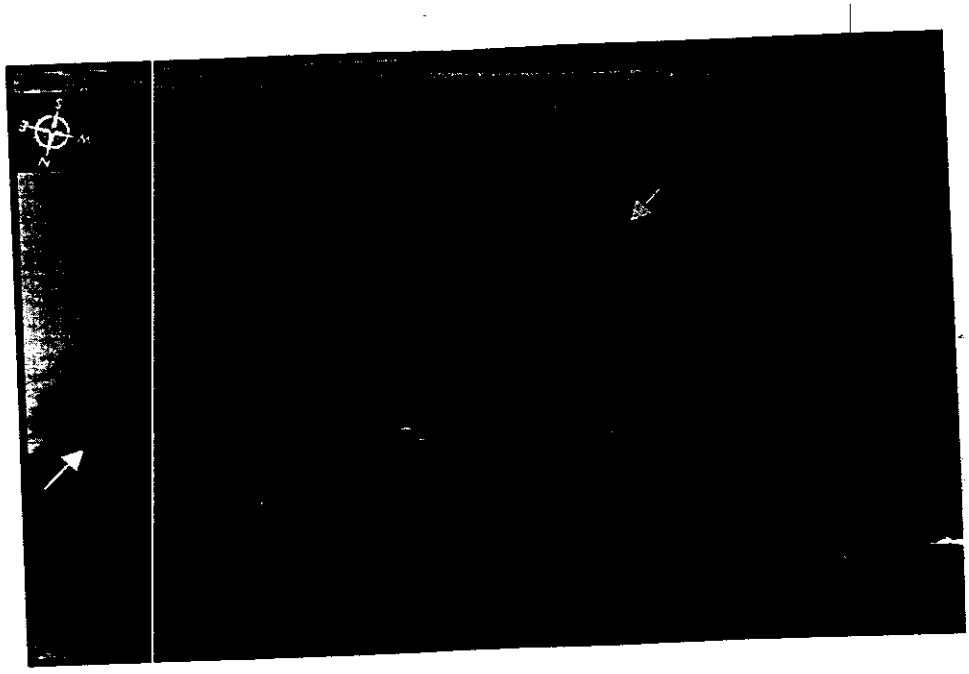


Fig. (10): A flood tidal delta inlet throat.

(3) Tidal Channels

In the area study, there are three major of tidal channels Fig. (11).

1- Inter tidal channels which drain inter tidal falts during low and falling tide. Fig. (11).

2- Tidal creeks.

3- Wide -mouthed tidal channels.

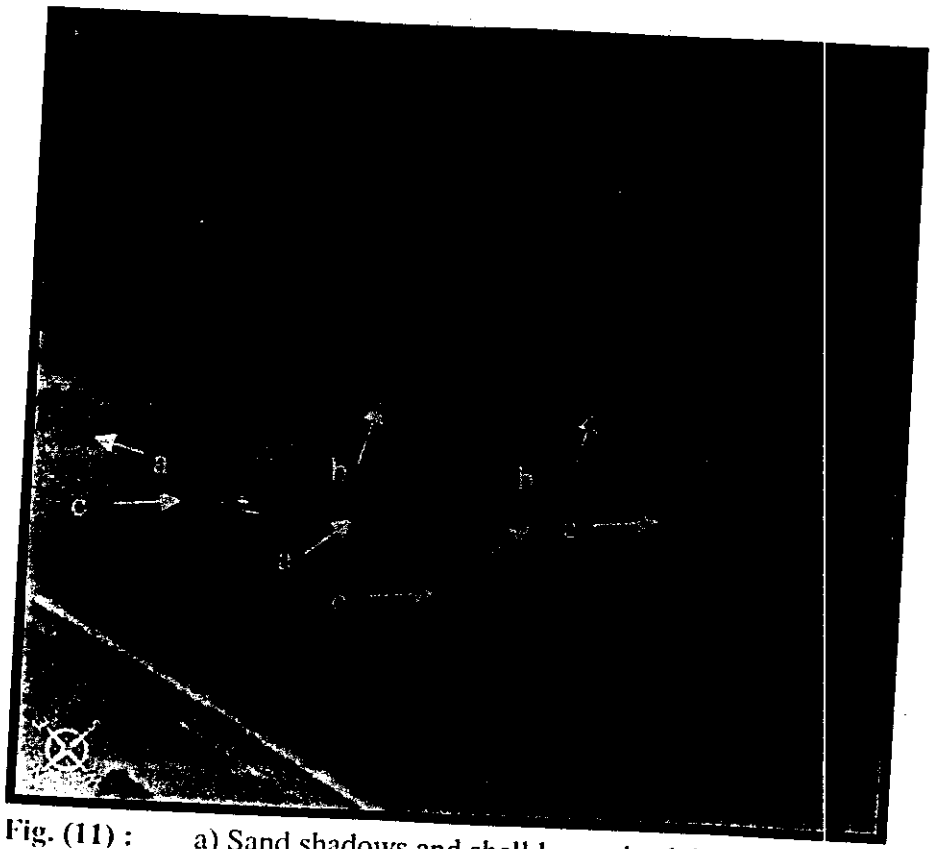


Fig. (11) : a) Sand shadows and shell lag on back beach
b) A multilobate Food tidal.
c) Inter tidal channels.

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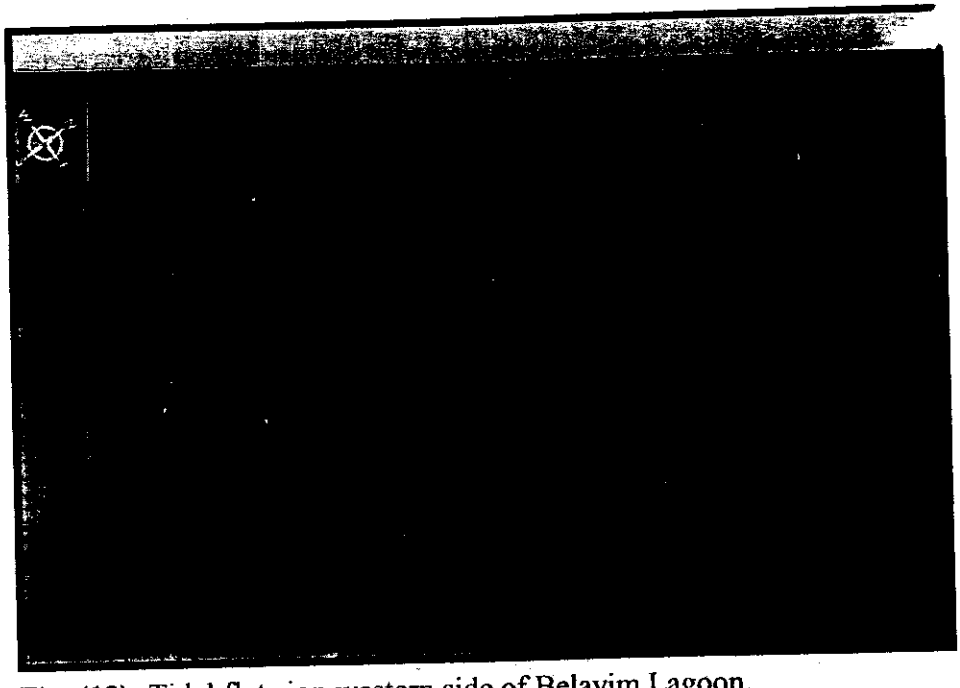

Fig. (12): Tidal flats ion western side of Belayim Lagoon.

Tidal channels in the Belayim Bay are characterized by relatively low sinusitis, low depth/width ratios which range between 1/600 to 1/750 and funnel shapes with pronounced Gulf ward.

(4) Tidal Flats

The margins of Belayim Lagoons are rimmed by un-vegetated inter-tidal zones of sediment accumulation called tidal flats. The width and extent of it are related to tidal range and to the morphology area. The nature of the tidal currents

and currents of Suez Gulf tend to be the controlling factors in both the rate and nature of sediment accumulation.

Tidal flat areas are located in the south Eastern side of Belayim Bay (Fig. 12). These areas are submerged during tides even low tides. Tidal flats in the area study are representing depositional form composed of mixed sediments of sand and mud (Fig. 12).

(5) Mudflat

Mudflats are very exhibit a naked break in slope at about mid-tide level, which the surface slopes steeply towards low-water mark (Fig. 13). The increase in deposition rates on the higher flats caused by the low velocities, will cause these area to rise in height faster than below mid-tide. The difference in velocity between the channel flow within the creek and mudflat flows causes the creek to be swept clear.

(6) Lagoon

Belayim Lagoon is water area separated from the Suez Gulf by narrow and low-lying land strips arise at the edge of shallow low-lying shore and form a string of narrow water area extending along the coastline.

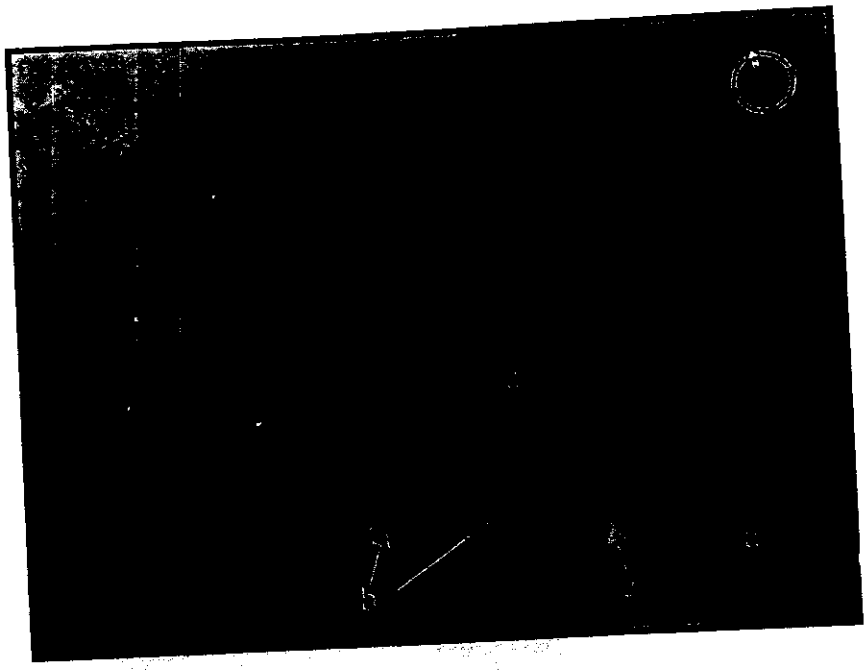

Fig. (13): a-a\ Belayim Lagoons
b- Spit phaform
c- Compound recurred spit.

The two Lagoons of Belyaim area represent one of the largest coastal landform in the area study. The extend in nearly N-W trend. The first one cover about 9.0172 sq Kilometers the Smallest Lagoon about 0.3874 sq Kilometers.

They are very shallow (less than one meter to 2 meters depth. The maximum depth is range from 2-3 meters).

The largest Lagoon extend for about 4.87 Km from the North Western to the South Eastern. Its maximum width reaches about 2.23 Km. The smallest Lagoon extend for about 2.249 Km from the north western to the south eastern. Its

maximum width reaches about 7.3 Km. The largest Lagoon is connected to the Gulf of Suez by inlet.

The distribution of sediments in Belayim Lagoons is controlled by wave -generated currents, water depth, salinity and amount of available sediment.

(7) Creeks

When the upper inter tidal areas are extensive, they may be drained by small inter tidal creeks that feed into three main channels (Fig. 14).

Fig. (14): a- Sandy inter tidal creek.
b- an unstable, migrating tidal inlet.

Creeks in the study area are dry for a significant part of the tidal cycle and extended from large lagoon to small lagoon in the eastern south. At high water, the tidal current is usually slack, when the creeks are full. The strongest occur lat in the falling tide currents submerged by creeks entirely. The sudden change in flow conditions as the water level moves from the channel confines out onto the inter tidal platform results in a general pattern of decreasing suspended materials concentration and depositions rate.

The field work showed that sediment grain size grades from sand to mud.

(8) Beaches

Viewed from the air, it appears that the most beaches curved in outline or regularly spaced along their length. Dolan (1971) has shown that crescent and rhythmic forms possess on hierarchical relationship between their size and their geomorphic lifespan (Fig. 15) show, a concave beach profiles are often seen on real beaches. These consist of two slope facets, a low angle facet to Belayim lagoon ward associated with finer sediments and a steep landward facet formed in coarser sediments.

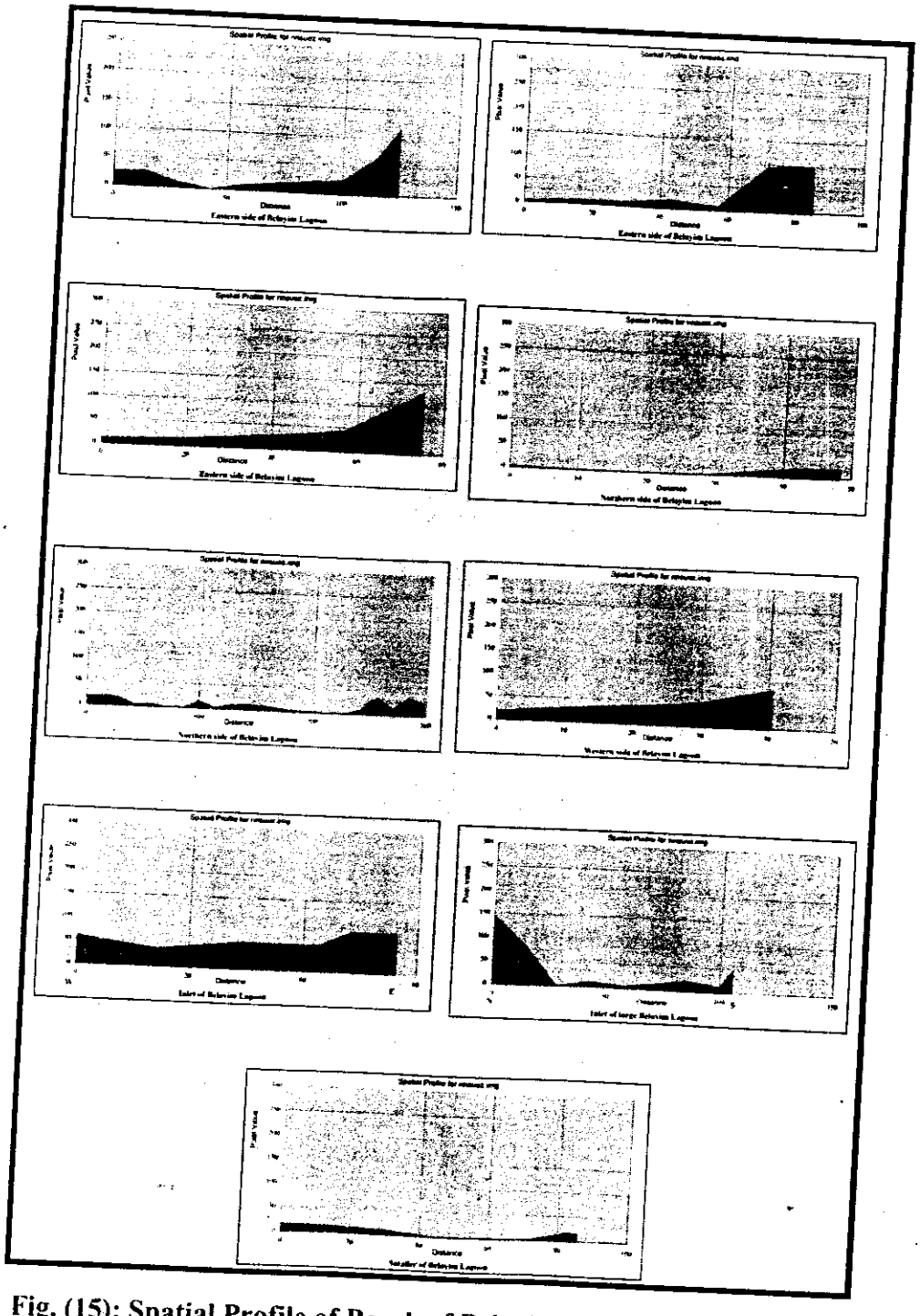

Fig. (15): Spatial Profile of Beach of Belayim Lagoon.

From field observation, step beaches were associated with coarser sand while shallow segments of profiles were formed in the finer sand sizes.

The length of Beach profiles range from 25 meters to 39 meters at eastern side of Belayim lagoon and from 32 meters to 45 meters at the western side.

Shallow beaches have a wide flat low tide terrace. Assuming a tidal range of 2.1 meters a range of beach gradients from 5° to 15° would give inter tidal beach width of 10 meters for steep beaches and 80 meters for shallow beaches.

Beach Step :

The beach step is a small, submerged scarp located at the base of the eastern, northern and western of beach face of Belayim Lagoon. It can range in height from 30 centimeters to over one meter. Their morphology is therefore most pronounced on steep, consisting of Fine Sand, coarse sand, gravel and mud.

(9) On Shore

In the on-shore, large installations such as a power plant, an oil treatment plant, a gas treatment plant (Fig. 16) and a water injection station cover part of the area.

(10) Barriers :

Barriers can be defined as elongated shore-parallel sand bodies that extented above sea level ***(Roy et al., 1994)***.

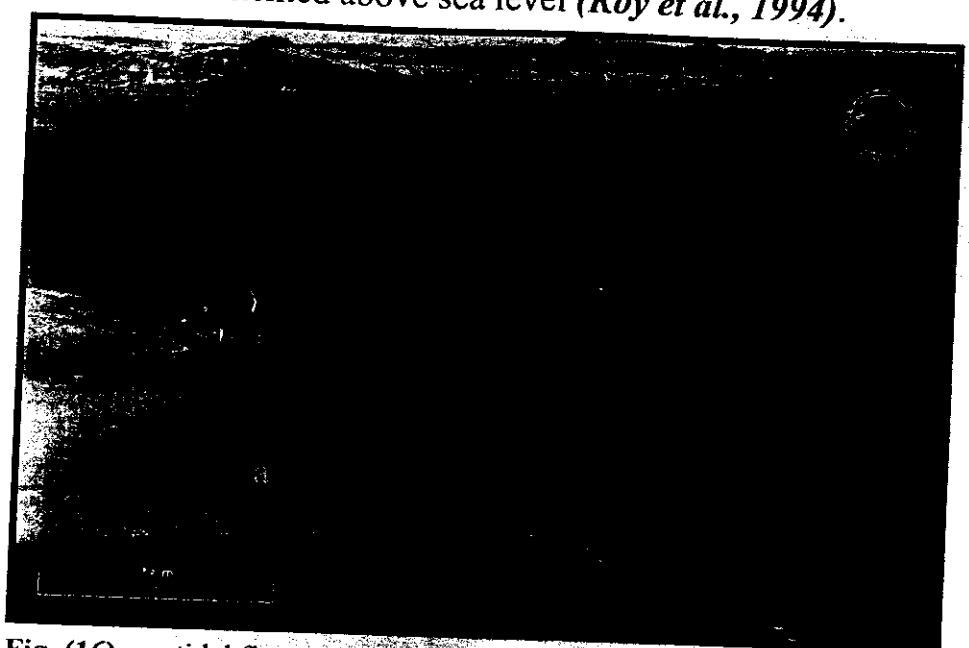

Fig. (16) : a- tidal flats b- Barrier beach complex.

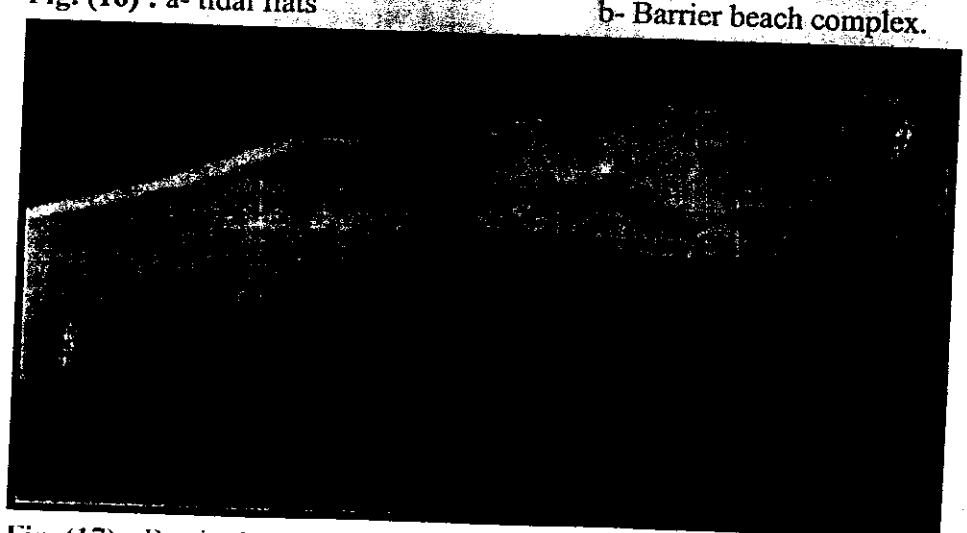

Fig. (17) : Barrier beach complex.

Barrier sand or beach of Belayim lagoon formed an elongated offshore ridge extended parallel to the gently slopping sand coast plain of Balim area. It composed of medium to coarse grained sand. It is elevation ranges between 1-6 m. It may be characterized by very gentle slope with a tidal range in area study (Fig. 17, 18).

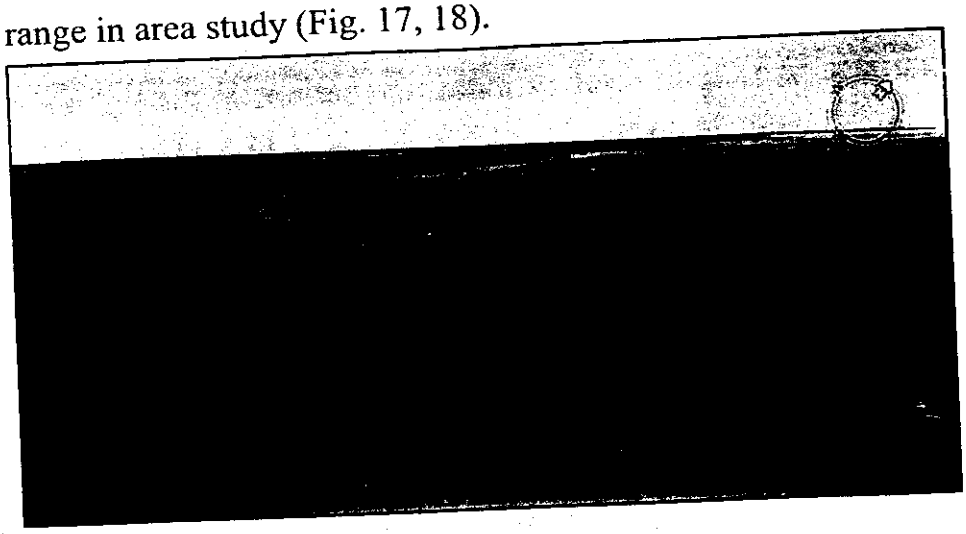

Fig. (18): Spits.

Barriers consist of a number of facies, including beach shore face, inlet and washovers. The total length are 7.3 kms. The plan form shape of barriers in the area study and weight is 2.3 kms (Fig. 16, 17, 18) in drift-aligned coast. It is oriented obliquely to the crest of the prevailing wave. The shoreline of drift-aligned coasts is primarily controlled by longshore sediment transport processes.

(11) Spit :

A spit of Belayim Bay (Fig. 19) represents long shore deposition and is morphologically defined s extending from land into the offshore zone at the western side of Belayim lagoon. The spit is curved shoreward to the south. The length of Belayim Bay spit is 4.1 km. Compound spit of Belayim possess several recurves from episodic growth. Large tidal variations appear to enhance the amount of curvature by increasing wave refraction at high tidal end and deposition around the top. Beach drifting seems to be the primary mechanism for spit growth upon the current deposited platform. A long the spit periodic fluctuations in the sediment budget repute in cyclic beach erosion and prorogation (Fig. 19). The inlet of Belayim bay may act as a sediment barrier causing downdraft starvation of the beach.

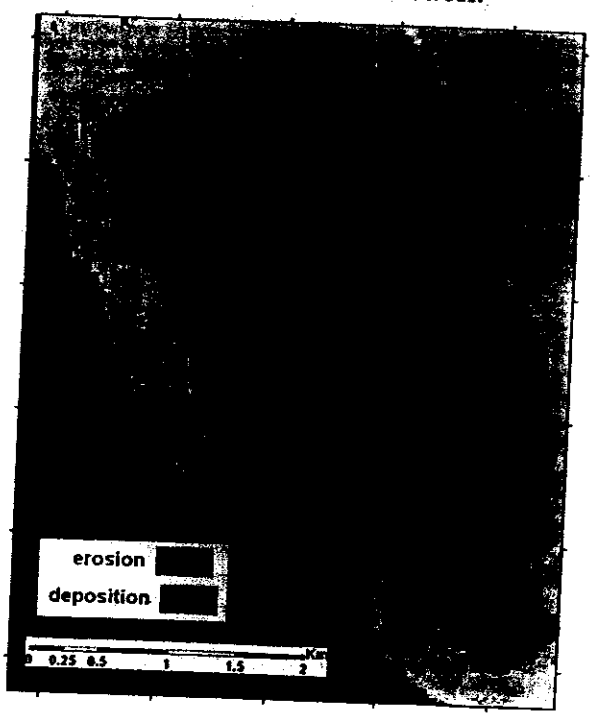

Fig. (19) : The change detection image of the study are between 1984, 2002 and TM image satellite in 2002.

Mechanical processes :

Deposition

Fig. (19) show locations of deposition. Deposition from a suspended sediment flow may be predicted. The rate of deposition depend on the ratio between the critical suspension shear velocity and the actual shear velocity. During at high and low tide shear velocities drop to zero and the deposition rate depended on the suspended sediment concentration.

Erosion

Deposition occurs as discrete grains but erosion as inter mitten failure of the bed. Erosion usually appears as deposition is prevalent in the most tidal flats.

In intermediate and shallow water current velocity decreases with decreasing water depth. Current will break in water that has a depth similar to the current height. In the surf zone, wave energy is either dissipated by wave breaking or reflected at the shoreline.

Wave set-up and swash produce a landward and up ward displacement of the shoreline allowing wave to act at higher levels on the beach.

Sands are moved onshore by wave abrasion is generally absent at low-tide levels. Onshore abrasion seems to be concentrated on the upper, shore ward of platform ***(Trenhaiie 1980).***

Mechanical wave erosion is the basic platform process in western side of barrier sand the quarrying of rock by wave action may be produced by wave shock, wave hammer.

The rate of erosion caused by hydrostatic pressure variation and abrasion are though to be relatively low compared to quarrying.

Mechanically eroded platforms will exhibit a gently shopping surface extent between the two tide levels.

Conclusions :

(1) The physical characteristics of the area study contributes a lot in form and growth the coastal features of Belayim Bay such as, Lagoons, barrier, Greeks, Spit and tidal flats.

(2) Tidal currents helped in form morphological coastal features at the area of study. It also helped in permutation morphological landscape. It helps the overflow of tidal water from the inlet of Belayim lagoon and form the unstable inlet of small lagoon.

(3) The Beaches of area study appears most current in outline or regularly spaced along their length a concave beach profiles are often seen on real beaches. These consist of two slope facets, a, low angle facet to Belayim lagoon ward associated with finer sediments. These western beaches are characterized with their continuous change and growth affected with daily tidal movements and the two seasons as it is affected with deposit in the two moderation as well as in summer.

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دراسة جيومورفولوجية لخليج بلاعيم

الساحل الشرقى لخليج السويس - مصر

د. على مصطفى كامل مرغنى

يعـد خلـيج بلاعيم أحد الظاهرات الجيومورفولوجية على الساحل الشرقى لخليج السويس، وتنحصر منطقة الدراسة بين خطى طول ١٠// ١٤/ ٣٣° و٥٣// ١٥/ ٣٣° شرقاً وبين دائرتى عرض ٢٣// ٣٢/ ٢٨° و٤٤// ٣٤/ ٢٨° شـمالاً ، وهى تقع إلى الشمال الغربى لجبل قليت وتنتشر بالمنطقة عـدة ظاهـرات جيومورفولوجية مثل الشواطئ والألسنة البحرية، وقنوات المد، والبحيرات الساحلية ودلات المد.

الهدف من الدراسة :

١- تهدف الدراسة إلى إبراز الظاهرات الساحلية بمنطقة بلاعيم والعمليات المؤثرة فيها باستخدام التقنيات الحديثة مثل المرئيات الفضائية وبرامج الحاسب الآلى.

٢- تحديد الظاهرات الساحلية الوقتية بمنطقة بلاعيم والعمليات المرتبطة بها.

نتائج البحث :

١- ساهمت الخصائص الطبيعية لمنطقة الدراسة فى تشكيل وتطور الظاهرات الساحلية بمنطقة خليج بلاعيم مثل البحيرات الساحلية والحواجز والألسنة.

٢- ساعدت تيارات المد فى تشكيل مورفولوجية الكثير من الظاهرات الساحلية المؤقتة بمنطقة الدراسـة، كما عملت على تعديل المظهر المورفولوجى، حيث ساهمت فى تدفق مياه المد مـن المدخل الجنوبى لبحيرة بلاعيم الساحلية الكبيرة، وأسهمت فى تكون مدخل غير ثابت للبحيرة الساحلية الجنوبية بخليج بلاعيم.

٣- تتميز شواطئ منطقة الدراسة بأنها منحنية من حيث شكل امتدادها، وقلة انحدارها حيث بلغ متوسـط انحـدارها ٥°، وتـتألف من رمال ورواسب طينية وقواقع ومحارات، كما تتسم قطاعـات الـشواطئ الغربية بالتغير والتطور بتأثير حركة المد والجزر اليومية والفصلية حيث تتعرض للإرساب فى الاعتدالين وفصل الصيف.

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* أستاذ مساعد الجغرافيا الطبيعية بقسم الجغرافيا بكلية الاداب بينها.