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Geomorphological characteristics on the continental shelf of Côte d'Ivoire (West Africa)

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Abstract: Recent marine surveys (CHALCI 93, CHALCI 94, BATHY 94 & BATHY 95, SEDICOT 96) aim to review the topography of the continental shelf of Cote d'Ivoire. In fact almost 30 years, there have been significant technological advances that should allow a change in our knowledge of the continental shelf. In geological oceanography, the emergence of GPS, digital echo-sounders and acoustic mapping equipment of seabeds has clarified little known aspects of the morphology of the continental shelf. These technics are used during these surveys. It is therefore right that our work will have unique features: (i) the coastline is better positioned using GPS and (ii) significant morphological structures have been identified. Particularly, depressions in seabed of 70 and 100 m off Abidjan and off Tabou. Their origin is in epidiagenetic process and also on structurally controlled bottom currents

Keys-words . Morphobathymetry, continental shelf, coastal, morphology, Côte d'Ivoire.

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1. INTRODUCTION

Recent bathymetric techniques have been implemented for a better understanding of the Gulf of Guinea. Backed that the investigations in this marine environment began in the 19th century [1]. The accuracy of the study in West Africa was based on economic issues. Indeed, "regular map was only reserved for areas that by their economic situation. For other regions, we are just a temporary map, made faster, cheaper" [1].

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Thirty years ago, advances in oceanography and geodesy intervened. They revealed some anomalies of previous studies, for example, the accuracy of the coastline on current maps of Ivorian coast:

- map from vessels (Nizery & ANTEA of the French Institute of Research for Development-IRD) shows that Vridi channel must be moved from 300 m to the East;

- Navigation map of the campaign SEDICOT 96 (Fig. 1) was built by using a conventional digital map from Fresco to Tabou. On this plan, the -20 m isobaths is between 7.5 and 14 km on the mainland, which is wrong. It will then bring the coastline further north.

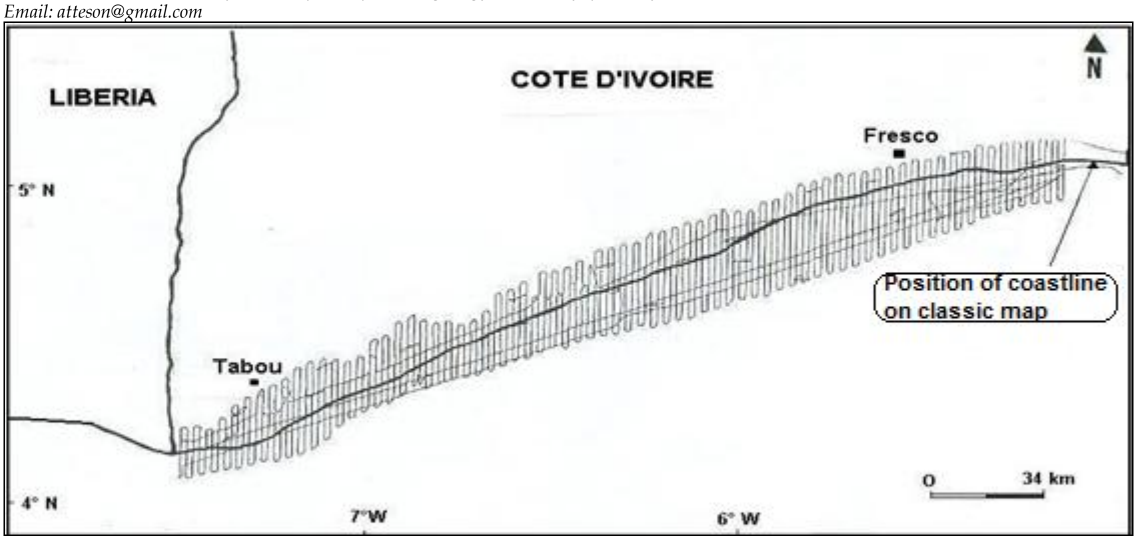

Figure 1: Ship positions during survey Sedicot 96. The map shows the abnormal positioning of the coastline.

These abnormalities seen on conventional maps show that a more accurate plot of the coastline is required. This paper proposes a new line of coastal shoreline of Côte d'Ivoire. It also boasts, with morpho-bathymetric analysis, recent approaches morphostructural in the Gulf of Guinea

2. OCEANOGRAPHIC SURVEYS OF THE CONTINENTAL SHELF

Marine surveys (BATHY 94, 95 and BATHY SEDICOT 96) were performed on the Ivorian platform by using oceanographic's shipboard of IRD. These bathymetric surveys cover the continental shelf, from Assinie to Tabou. New investigative techniques have been implemented during these campaigns.

2.1. POSITIONING SYSTEM

The positioning data was made by GPS (Global Positioning System). During the oceanographic survey BATHY and SEDICOT 96, we used the GPS receiver 590 of Raystar RAYTHEON MARINE COMPANY. It has an absolute accuracy of about 15 meters [2].

2.2. DETECTION SYSTEM: SONAR OSSIAN

This digital sounder has the multiple functions of a computer (memory box, raw digitized data storage, double gain / waterfall display which allows for example a color representation of bottom hardness). We have used version 1500 of Ossian sounder with frequency of 38 KHz for in our marine survey. The trace of the echo is reproduced on paper by a color printer.

2.2.1. MESH OF CONTINENTAL SHELF

The bathymetric survey of the Ivorian continental shelf has been following 230 NS profiles, 18 EW profiles and 6 oblique profiles. This operation resulted in the acquisition of approximately 10,000 echo-sounding measurements. Hydrography has been made in the seabed 20 to 120 m from east to Assinie to Tabou in the west.

2.2.2. CORRECTIONS SOUND

The depth is measured on the echogram at the intersection between the trace of the echo and a registration mark down to the scale bar. The corrections are mainly due to the influence of tide and wave at the echo-sounding. The correction of the depth of immersion of the transducer (2.5 m) is done automatically by the sounder OSSIAN. The apparent slope of the continental shelf is very small. So it's not necessary to make a correction of obliquity.

a) Correction of tide

On the Ivorian coast, the sea level rises for 6 hours. Then it also falls for 6 hours to a minimum (low water). The tidal range is the difference between high and low water in succession.

The tidal correction is made from tide tables 1994, 1995 and 1996 of the SHOM. From these data, we divide into six equal ranges the time difference and the tidal range [2]. Then we subtract (during high tide) or we add (during low tide) the value of tidal range in the depth measured. By this method we find the hydrographical zero of marine map.

b) Swell's correction

Vertical movements of the bases of the sounder compared to the average level of the sea require a correction of the data. In practice, we draw a line average, which smooths the small bumps on the echogram [3]. On the continental shelf of Cote d'Ivoire, the bottom is smooth and the roughness of the sea is low to moderate. Usually an average line located at 2/3 of peaks above the echogram is drawn, in the absence of a system to measure roll, pitch and heave [3].

c) Crossings depth

They are obtained when the profiles are plotted so as to overlap [4]. The network of parallel profiles NS is intersected by a number of crossings. Thus, for a given position, we have at least two sensor values. The difference (ΔH) evaluates the depth error. We can then monitor or improve the bathymetric interpretation. We performed about 500 crosses. The distribution of the error depth shows that 60% of the depths are identical, 25% to less than 1 m and 15 % near 2 m. These results show the accuracy of the echo sounding.

2.2.3. MODELING BATHYMETRIC

After corrections and analysis of crosses, the actual depth at each point is determined by the expression: Dc = Ds x Ev ± CM

With Dc = corrected depth (m), Ds = Depth measured after smoothing the echogram (cm) and Ev = vertical scale and CM = tide correction.

Thus, the bathymetric model that integrates the depth measured and corrections for a simplified analytical expression: D = Dl / 1000 CM

With D: Depth; scale bar: 1/1000; Dl: Depth evaluated after smoothing the echogram and CM: Tidal correction

2.3 MAKING THE BATHYMETRIC MAP

The map was drawn in Lambert projection (Clarke 1880): corrected depths are plotted on a plan position. Then we draw an isovalue curves.

2.3.1. MAP SCALE

For detailed surveys on the continental shelf, we used a large scale: 1/50.000. This is a particularly suitable scale to represent accurately a very small area.

2.3.2. COASTLINE PLOTTING

The plot of the coastline was made from satellite images (SPOT) and geodetic data. These geographic data and our data echo sounding (position by GPS) are compatible as expressed in the geocentric coordinate system WGS-84 (World Geodetic System 1984). Maps of the coastline of Côte d'Ivoire based on the Clarke Ellipsoid of 1880. GPS uses the geocentric coordinate system WGS-84 or WGS-84 Ellipsoid. The transition from one datum to another requires prior corrections, any direct transposition was wrong. Transco software (Nicolas Florsch, University of Pierre and Marie Curie, France) was used to make the transition from Clarke 1880 to WGS-84.

2.3.3. DIGITIZATION OF MAPS

We digitized bathymetric maps using mapping software (MapInfo and Microstation). The digitization of maps has three advantages:

- First, a practical aspect. We had maps whose total length is estimated at 10 m, which is cumbersome.
- Then the opportunity to change easily the maps formats (scale) with a plotter.
- Finally, a scientific interest: the possibility of overlap with other documents and mapping differences.

3. RECENT BATHYMETRY MAP OF CONTINENTAL SHELF

The DST map [2] shows the bathymetry of the continental shelf of Côte d'Ivoire from Assinie (3°20'W) to Liberian’s border (7°30'W). The first curve from the coast is 20 m isobath beyond 20 m, the contour interval is 10 m to the limit of the continental shelf (120 m). The map (DST map-Département des Sciences de la Terre) is divided into five sheets with detailed analysis allows us to characterize the morphology of the continental shelf (profiles, slopes, morpho-structures, etc.).

The first curve from the coast is 20 m isobath beyond which the equidistance is 10 m until the lower limit (120 m) of the continental shelf. Two significant morphostructures at 100 m isobath near Abidjan and at 70 m isobath near Tabou.

3.1. GENERAL PROFILE AND MORPHOLOGICALS SUBDIVISIONS OF SHELF (ASSINIE-ABIDJAN)

The profile of the continental shelf between Abidjan and Assinie shows (Fig. 2):

- a relatively constant slope (0.40% in seabed from 0 to 40 m and 0.55% in the depths of 80 to 120 m between Assinie and Grand-Bassam);
- a general high slope in the seabed -80 to -120 m (0.84% off Abidjan and 0.55% between Assinie and Grand Bassam).

The continental shelf is very wide from Abidjan to Assinie. Its width is about 32 km off Assinie. We distinguish with depth:

- the inner continental shelf, about 10 km wide between Assinie and Grand-Bassam, which become narrows near the submarine canyon "Trou-Sans-Fond" (3 km).

- the intermediate continental shelf is very wide in Abidjan (20 km), but narrows to Grand-Bassam (9 km) and widens to Assinie (16 km).

- the outer continental shelf has a constant width (7 km) from Grand Bassam to Assinie but become narrow off Abidjan (4.5 km).

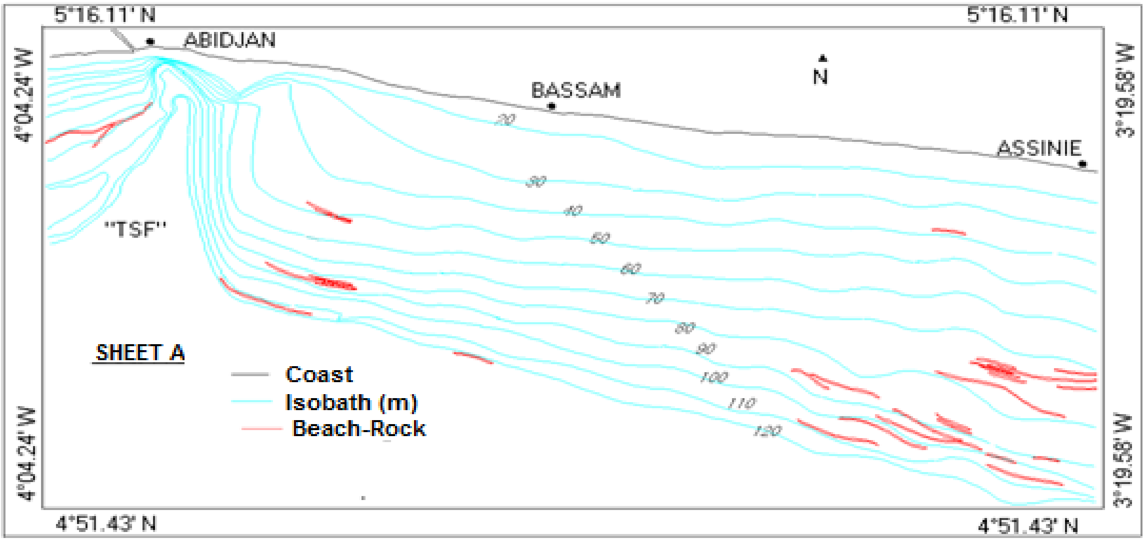

Figure 2 : Bathymetry of the continental shelf from Assinie to Abidjan [2]

3.2. GENERAL PROFILE AND BATHYMETRIC SUBDIVISIONS OF SHELF (ABIDJAN TO GRAND-LAHOU)

The calculations of the continental shelf slopes from Abidjan to Grand-Lahou (Fig. 3), gave the following results:

- Off Abidjan (Vridi);
- 0 to 40 m: 1.14%;
- 40 to 80 m: 0.78%;
- 80 to 120 m: 0.44%.
- Off Jacqueville, the slope is 0.55% in the first 80 meters. But it becomes high (0.76%) in seabed -80 to -120 m.

We distinguish three parts on the shelf:

- an inner continental shelf (0-40 m): It is narrow off Vridi (Abidjan) with a width of 3.5 km, and then gradually widens (7 km off Jacqueville and 13 km off Grand-Lahou).
- an intermediate continental shelf (40-80 m): It has a constant width of 6 km from Abidjan to Grand Lahou.
- an outer continental shelf (80 to 120m): It is characterized by a progressive narrowing; width of 9 km in the Abidjan area, it has only 5 km off Jacqueville and finally 2.5 km off Grand-Lahou. This part of the continental shelf is very narrow with an important break slope.

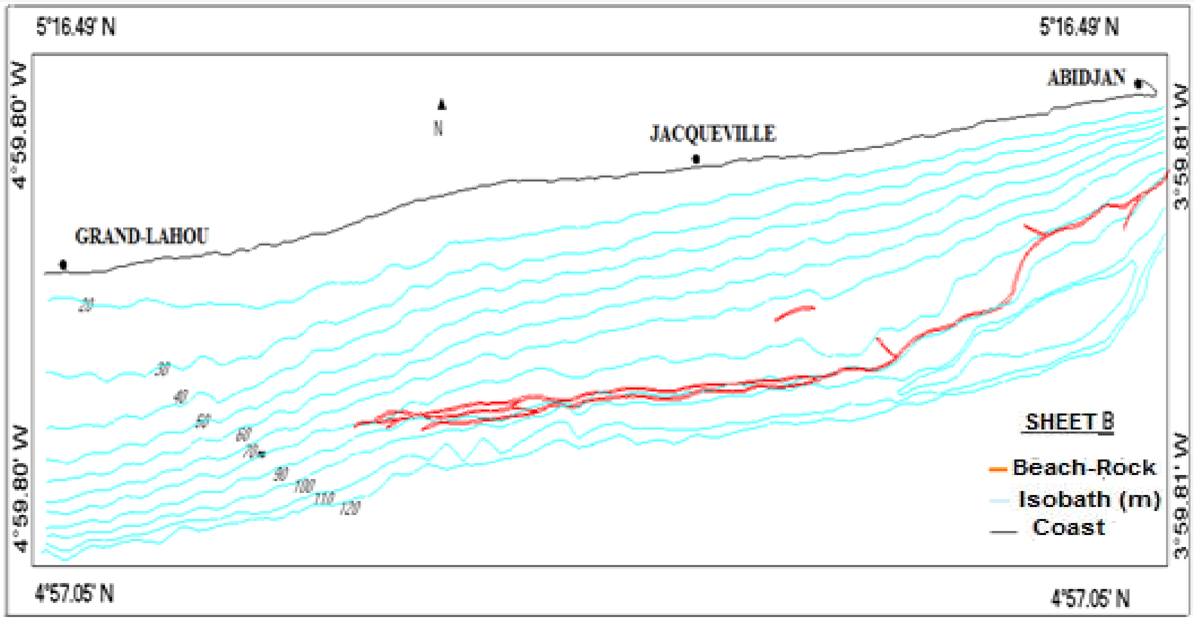

Figure 3: Bathymetry of the shelf from Abidjan to Grand-Lahou [2]

3.3. GENERAL PROFILE AND BATHYMETRIC SUBDIVISIONS OF SHELF (GRAND-LAHOU TO FRESCO)

Off Grand-Lahou, analysis of the slopes gives following results based on the seabed:

- 0 to 40 m: 0.3%;
- 40 to 80 m: 0.7%;
- 80 to 120 m: 1.15%.

Off Alékédon (between Grand-Lahou and Fresco - 5°20'W) from 20 nautical miles of Grand-Lahou, the slopes varying with depth:

- 20 to 40 m: 0.35%;
- 40 to 80 m: 0.5%;
- 80 to 120 m: 0.7%.

Off Fresco, the average slope is 0.34% but it increases gradually and reaches a value of 0.7%.

- 0.33% in the first 50 meters;
- 0.3% between 50 and 80 m;
- 0.66% over 80 m.

Off Grand-Lahou to Fresco the continental shelf (Fig. 4) has a width of about 22 km. However the width of the various parts varies. We distinguish:

- an inner continental shelf 15 km wide off Grand Lahou, which narrowed to a width of just over 6 miles wide off Alékédon and Fresco. Its general slope is 0.32%.
- a very narrow intermediate continental shelf through off Grand-Lahou (6 km) but gradually widening off Fresco (13 km). Its general slope is between 0.3 and 0.7%.
- an outer continental shelf (80-120 m) of 6 km wide on average off Fresco and Alékédon but narrow at Grand-Lahou (3.5 km). This narrow steep reflects the high slope off Grand Lahou and an average slope of 0.7 % off Alékédon and Fresco. This is the area where the break slope limits the continental shelf.

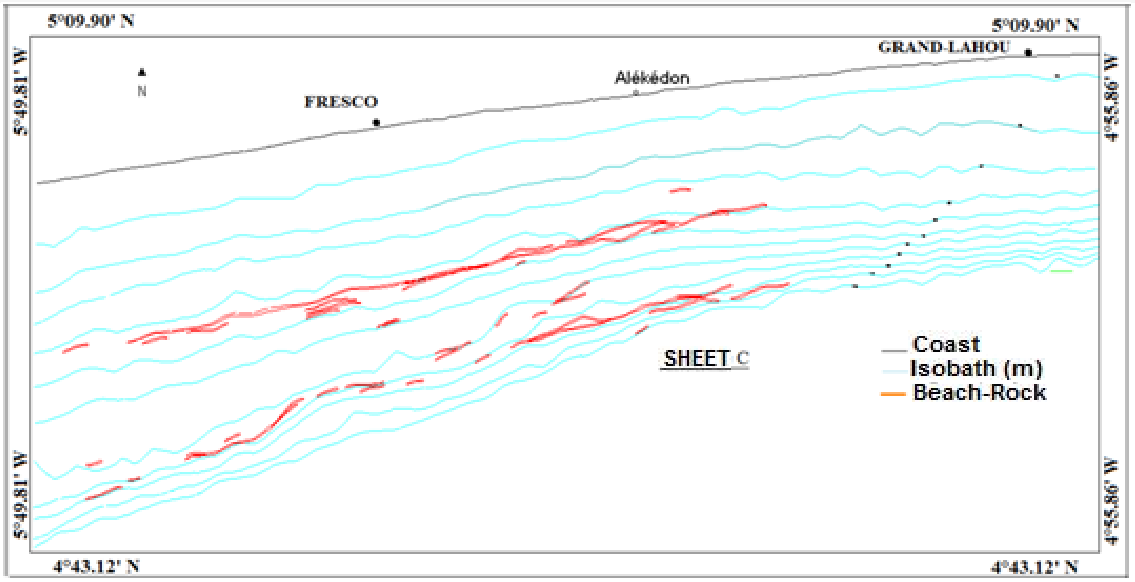

Figure 4: Continental shelf's bathymetry from Grand-Lahou to Fresco [2]

3.4 PROFILE AND BATHYMETRIC SUBDIVISIONS OF SHELF (FRESCO - SAN PEDRO)

Off Sassandra, the slope initially low (0.28 %) became very strong after 80 m depth:

- 0.26% between 20 and 50 m;
- 0.3% within 50 m after;
- 1.14% between 80 and 120 m.

Off San Pedro, the first 50m has a relatively steep slope, which increases after 80 m:

- 20 to 50 m, the slope is 0.4%;
- 50 to 80 m, it is of 0.31%;
- Then 0.76% between 80 to 120 m.

Analysis of the slopes of the continental shelf (from Fresco to San Pedro – Fig. 5), shows that:

- the inner continental shelf is very wide (more than 11 km) with an average slope of 0.26% off Sassandra. However, off San Pedro, it not only shrinks (7.5 km) but it is steep.
- the intermediate continental shelf retains an average width of 10 km off Sassandra to San Pedro with a slope of 0.3%.
- the outer continental shelf is narrow off Sassandra (3.5 km) but expanded to San Pedro (5 km). The slope is moving in the opposite direction: 1.14% off Sassandra and 0.76% off San Pedro.

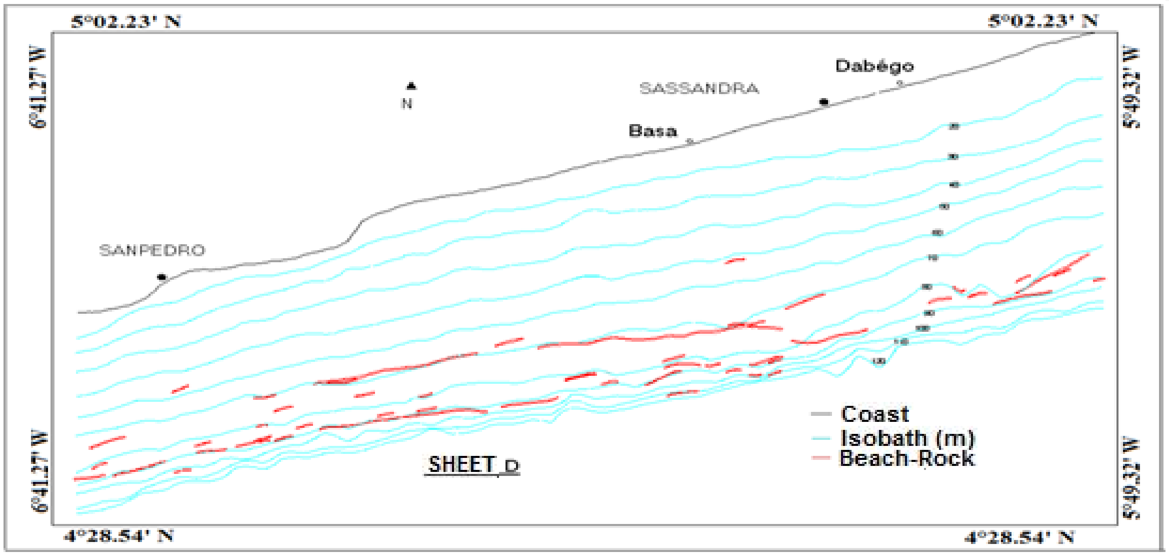

Figure 5: Bathymetry of the continental shelf from Sassandra to San-Pedro [2]

3.5. PROFILE AND BATHYMETRIC SUBDIVISIONS OF SHELF (SAN-PEDRO TO TABOU)

Analysis of the slopes of the continental shelf to the Ivorian-Liberian border (7°30'W) is as follows (Fig. 6):

- 20 to 40 m: 0.3%;
- 40 to 80 m: 0.53%;
- 80 to 120 m: 0.2%.

Off Taboo (7°19'W), we obtained the following results:

- 0.46% 20 to 40 m;
- 0.25% from 40 to 80 m (0.15% from 70 to 80 m);
- 1.45% after 80 m (4% from 100 to 120 m).

Off Gnégbagbo (7°10 'W) the slopes are of the order of:

- 0.47% in seabed -20 to -40 m;
- 0.2% in seabed from 40 to 80 m (with 0.15% from 60 to 80 m);
- 1% in depths from 80 to 120 m:

Off Grand Béréby (6°55 'W), the slopes vary over the continental shelf as follows:

- 0.32% in the first 80 meters;
- 0.77% after 80 m.

The width of the continental shelf (Liberian border to San Pedro) varies between 20 and 25 km. We distinguish the following subdivisions:

- the inner continental shelf with a width of 5 to 7 km (eg 4.5 km off Taboo and 7 km off Grand-Béréby) with a general slope ranging between 0.3 and 0.45%.
- the intermediate continental shelf having a general slope between 0.2 and 0.5%. Its width is from 8 to 20 km.
- the outer continental shelf is narrow (off Tabou: 2.5 km, off Grand-Béréby: 5.2 km) with a high slope.

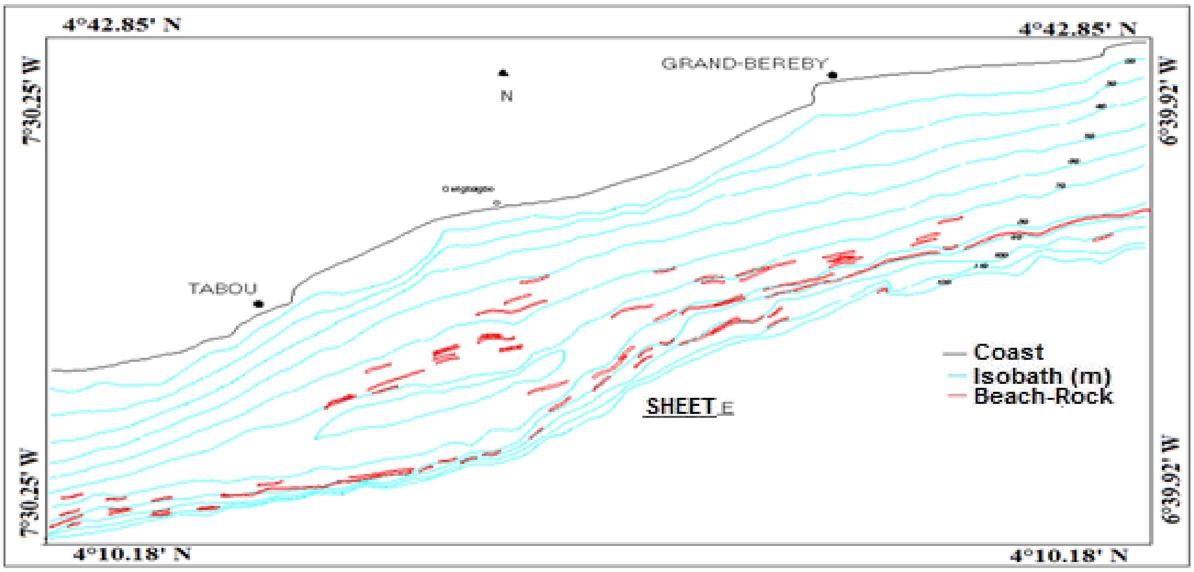

Figure 6: Bathymetry of the continental shelf from San-Pédro to Tabou[2]

3.6 EDGE OF CONTINENTAL SHELF

The continental shelf, on structural point of view, is limited not by an arbitrary depth (which is here the -120 m isobath), but the break slope or "edge".

3.6.1. BREAK OF SLOPE

For different morphology of the seabed, we determined the depth at which is the break slope that ends the continental shelf:

- off Assinie to Abidjan, the edge is generally at -115 m. But in some places (off Abidjan), it is at -100 m.

- the break slope off Abidjan to Fresco is at -120 m. But sometimes it is before (-95 m) or after (1-40 m) 120 m depth.

- The edge of the shelf is generally at -110 m (but sometimes at -130 m) off Sassandra to San Pedro.

- off San Pedro to Tabou, where the break slope is usually at 120 m depth. But in some places it is at -90 m or -135 m.

Note that the break slope that separates the continental shelf to the continental slope is at varying depths. These variations could be due to recent tectonic movements or "Neotectonics" during the stability of the "old" Precambrian basement of Côte d'Ivoire.

3.6.2. ORIGIN

The continental shelf of Côte d'Ivoire has two general characteristics: it is always flat and smooth, with important fossil bars of sandstone or beach-rock, and it ends at depths (variables) that are always the same order of magnitude. The origin of the break slope has led to various hypotheses, the most common are:

a) Submarine terrace: Bourcart [5] shows that the continental shelf is a zone of deltas filling submarines (current). We have either a portion of a river delta on the continental shelf extending or an accumulation underwater on the continental margin sediments of terrigenous, transported by turbidity currents down by submarine canyons. On Ivorian continental shelf, seismic surveys would "see" if there are canyons (buried or aborted) elsewhere than submarine canyon Trou-Sans-Fond and traces of buried river deltas.

b) Deltas submarines (current): We have either a part of a river delta on the continental shelf extending or an accumulation underwater on the continental margin of terrigenous sediments transported by turbidity currents down through canyons submarines.

3.6.3. EDGE'S STRUCTURE

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The edge of the Ivorian continental shelf has various aspects (shape and size). We made a classification according to the shape of the slope. We distinguish edges with low slope, steep edges and edges with mean slope. Analysis of slopes of different edges indicates that (Fig 7):

- Low gradient edges have an average slope of 12% - A
- Steep edges have an average slope of 55% -B
- The edges to have a mean slope gradient of 23% - C

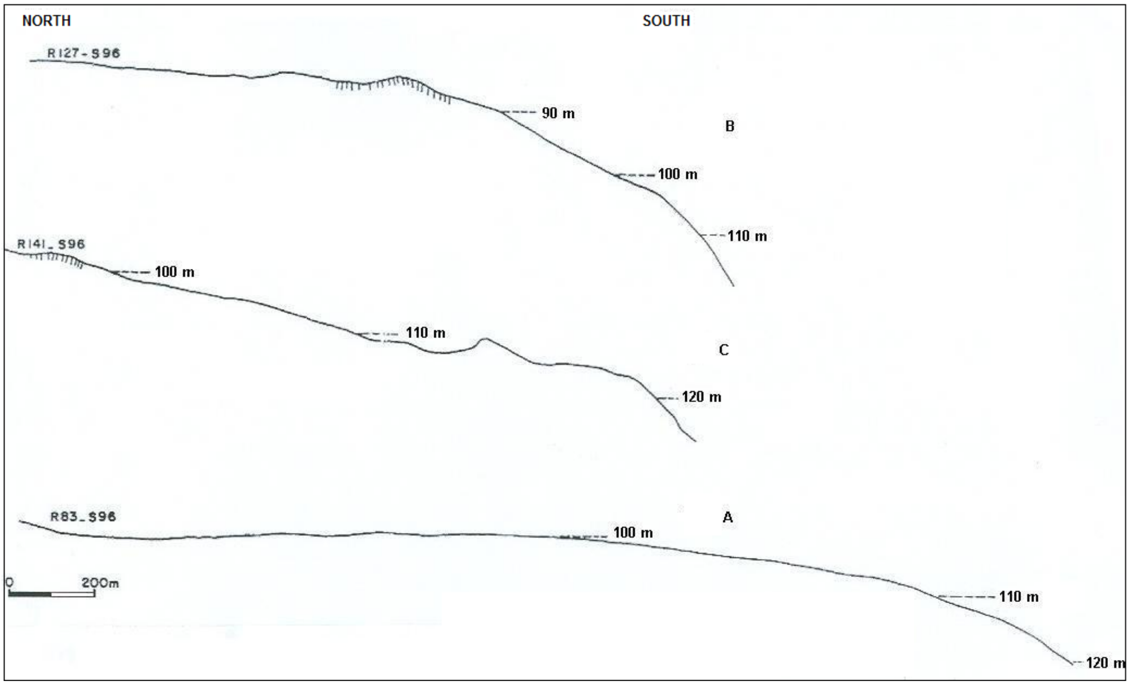

Fig. 7: Classification scheme of the shelf break of the continental shelf of Côte d'Ivoire

3.6.4. RELATIONSHIP MORPHOLOGY-EXTENSION OF THE SHELF

Relationships between these kinds of edge and, on one hand, the morphological kinds and also the extension (width) of the continental shelf are show on Table I.

TABLE I. EDGES, MORPHOLOGY AND EXTENSION OF THE SHELF [6].

Edge	Morphological kind	Extending of shelf
A (slope 10%)	Convex	30 km
B (slope 55%)	Concave	15 km
C (slope 25%)	Intermediate	20 km

3.6.4.1. MORPHOLOGICAL EDGE'S TYPES

- Low slope edges occur off the mouths of major collectors with a large current sedimentation. They are associated with morphological kind of convex areas.
- The steep edges are observed in the sandy regions and are located between areas of sediment supply current. In these areas the continental shelf has a concave profile. They are usually breaks slope corresponding to the bars of sandstone and located generally at 90 m depth.
- The mean slope edges occur in areas of morphological intermediate type. We observe them between the types defined above. They are associated with the boundaries of recent sedimentation.

3.6.4. 2. EDGE TYPES AND EXTENDED CONTINENTAL SHELF

The general extension of the continental shelf is between 18 and 35 km with an average of 22 km.

- edge with low slope occur in areas of high extension as off Assinie (32 km);

- The steep edges are located in areas where the width of the continental shelf is the lowest;

- The average slope edges characterize the average areas extension of 22 km.

3.7. MORPHO-STRUCTURES OF THE CONTINENTAL SHELF

Isolated depressions have been identified on the continental shelf of Côte d'Ivoire off Abidjan (Fig. 8) and off Tabou (Fig. 9). They have respectively a hollow of 6 m and 2 m depth and the isobaths 100 m and 70 m. These depressions have not only the same size (20 km) but also the same structural direction (N70°).

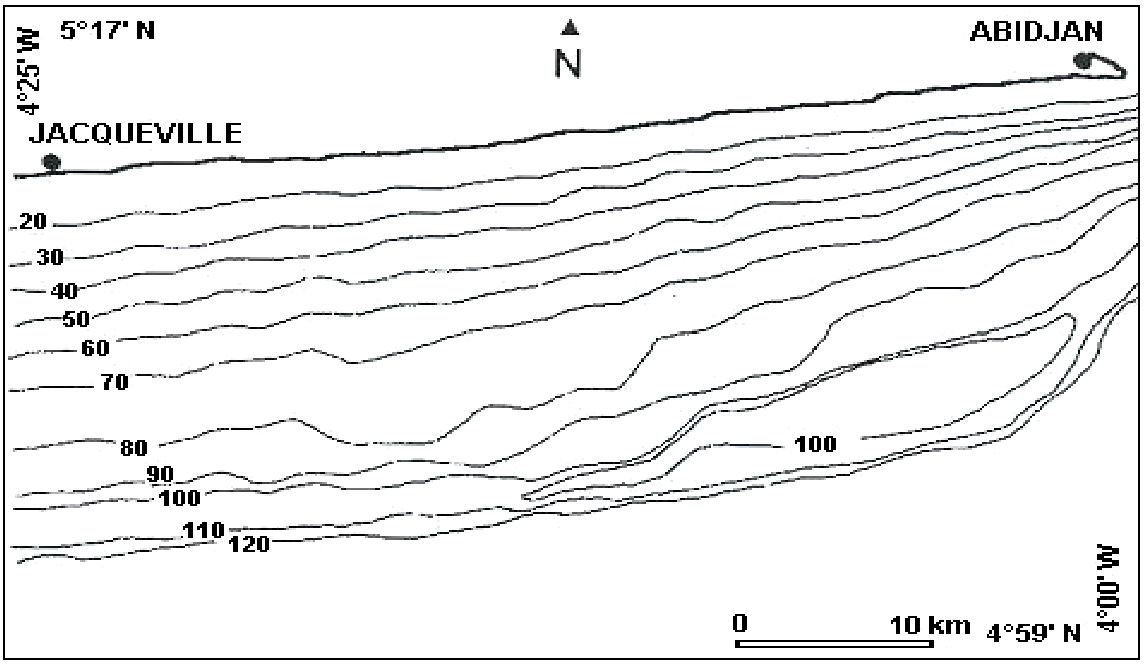

Figure 8: Newly identifed morphostructure near the submarine canyon "Trou-sans-fond" off Abidjan. The depression is located at 100 m isobath.

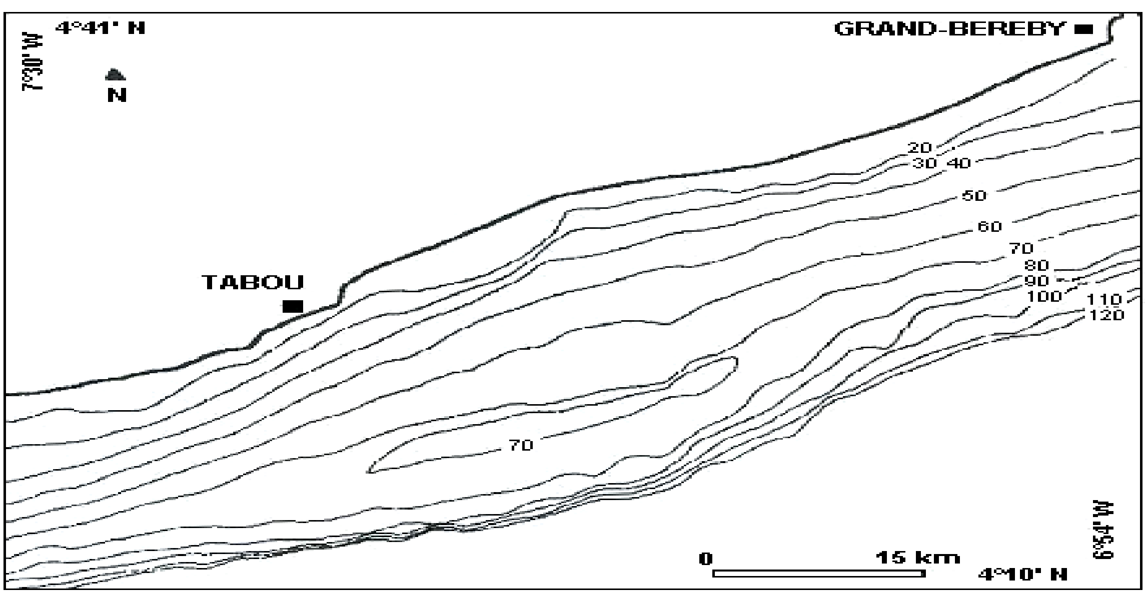

Figure 9 : Newly found depression off Tabou is at 70 m isobath.

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The major direction of these depressions (N70°) suggests a control by tectonic movements in the Gulf of Guinea. Besides observations on the Côte d'Ivoire - Ghana ridge show that:

- Fractures of Saint-Paul and Romanche, direction sub-equator off the coast are recovering gradually adopt a direction N70°-80° to approach the coast [7];
- The major direction (N60°) of dextral faults of Côte d'Ivoire's continental margin is very similar to the depressions mentioned above [8].

These depressions would then correspond to compartments of collapsed formations without deposition because of the bottom current that run through them. In these depressions of tectonic origin is set up a strong current which opposes the action of sedimentation [9, 10, 11, 12].

3.8 IMPACT OF RECENT TECHNICAL AND BATHYMETRIC SURVEYING

3.8.1 MORPHOLOGICAL ABNORMALITY ISOBATHS

Off the outlet of the Sassandra river, Martin's map [13] introduced two important notches at isobaths 20 and 30 m. But we have not found them despite of multiple passes over these areas (Fig. 10).

At Basa (Western Sassandra) isobath 30 m showed a significant notch that we could not find either (Fig. 18).

Off Grand-Lahou, in the seabed of 120 m, there is a notch whose orientation (NW-SE). It is contrary to that of Martin's map [13] shows (Fig. 11).

These abnormal positions of the coastline and the appearance of classical isobaths on the maps could be explained by:

- limits and accuracy of positioning systems used for the survey;
- reference's kind chosen for the realization of these maps [14].

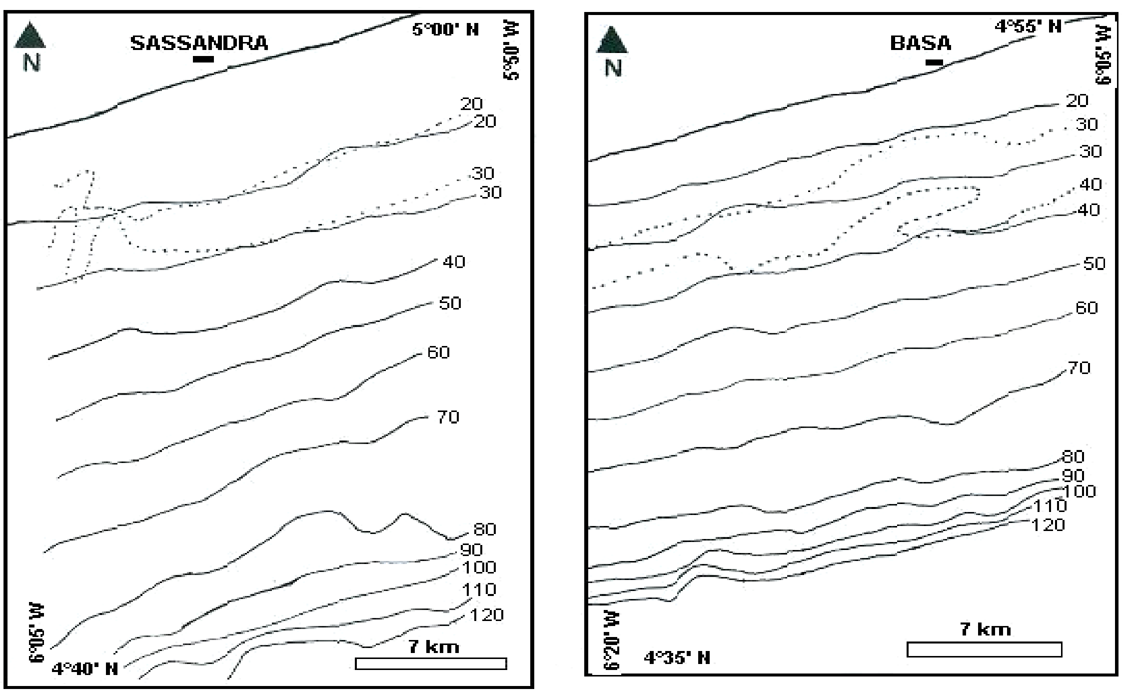

Figure 10 : Comparative study. Unditentify morphostructures at 20 and 30 m isobaths off Sassandra and Basa (30 and 40 m). They were indicated on Martin's map but not on DST map. Smoothing exmple (isobath 40 to 120 m). Legend: Martin's map (……) and DST map (___)

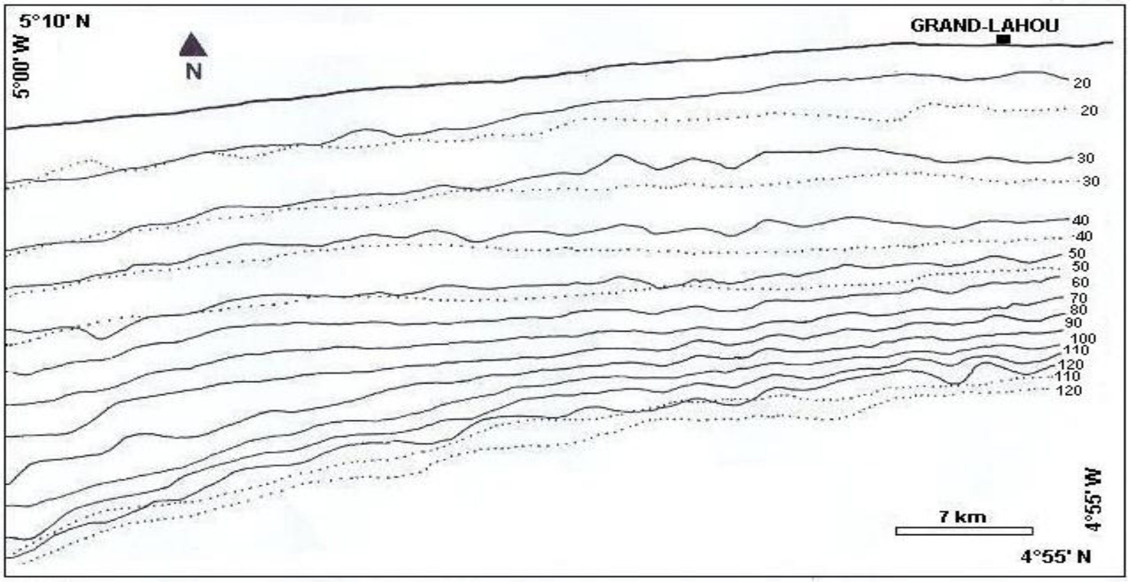

Figure 11 : Example of curve fitting bathymetric off Grand Lahou. Isobaths 20-50 m and 110-120 m, slopes are very smooth on classic map (Legend: Martin's map (……) and DST map (___))

3.8.2 POSITIONING SYSTEMS

Technical notes of Martin (1973) studies disclose the use of Toran systems, radar and sextant for positioning data. Let's present some background on these positioning systems (Table II).

3.8.2.1 SEXTANT

It is an instrument for measuring angles. Determining the point position is astronomically. The point is calculated to 3' near or with a circle of uncertainty of 5.55 km of diameter [15]. Such an inaccuracy arises mainly from measurements of longitude. But using an auxiliary vessel, anchored, the position is determined to 5" is almost in a circle 150 m of diameter, although sufficient accuracy to 1/100000.

3.8.2.2 RADAR

The principle of this system is the measurement of travel time between the transmission of an electromagnetic wave and its reflection from obstacles or "natural" landmarks in the path of the waves emitted. The distance to the reflector is equal to half the product of travel time by the speed of the waves emitted. It is functional 24 h/24.

Major drawbacks: First, the scope is theoretically limited to the horizon by the curvature of the earth's surface. In the tropics and subtropics, marked temperature gradients in the atmosphere are likely to refract the signal emitted by the mobile (boat). On the other hand, better reflector is rarely defined with accuracy better than 50 m.

3.8.2.3 TORAN SYSTEM

This system is based on using radio waves to locate a ship in relation to fixed stations on shore. Its principle is based on measuring the difference in travel time of signals from one or more shore stations. The Toran is a phase comparison system:

Toran accuracy decreases as the width of channels increases, that is to say when we move away from ground stations, it is the same if the angle of intersection of the hyperbolas decreases. The accuracy is about 30 to 100 m [16]. The limitations of scope are related firstly to the problems of interference with waves reflected from the ionosphere. On the other hand, the sunrises and sunsets are always sensitive periods for the quality of measurements (At these times of the day, the ionospheric layer undergoes major changes that significantly disrupt the signals. It sometimes becomes impossible to maintain the channel, a key factor in the accuracy of Toran).

3.8.2.4 GPS

For the sake of greater precision, we have had uses satellite imagery and geodetic points whose coordinates were expressed in the same reference system which is used by GPS. These data were used for the delineation of the coastline of our map. Recall that the GPS differs from Toran in its precision and ability to continually provide the position of a point regardless of the time of day.

Accuracy: GPS provides a convenient answer to the problems of positioning at sea. Minimum of three satellites visible simultaneously give the position of an object without the assistance of another positioning system. GPS accuracy of the Ante is 15 m.

Limitation: The most significant error results from the ionosphere. A layer of electrically charged particles is between 130 and 190 km above the earth. These particles affect the speed of light, and therefore the speed of radio signals from satellites. The daily variation of the velocity averages under ionospheric conditions can be expected. For this, a correction factor is applied to all measurements. After the passage of signals in the ionosphere, they enter in the Earth troposphere. Water vapor in it can also affect these signals. Errors are similar in magnitude to those caused by the ionosphere, but easily corrected. To this end, some GPS receivers have models of ionospheric and tropospheric delays that normally eliminate at least 50% of the error.

TABLE II. ACCURACY AND LIMITATIONS OF POSITIONING SYSTEMS

SYSTEMS	ACCURACY	LIMITS
Sextant	6 km of diameter	longitudes's measurements
Radar	50 m	Earth curvature-temperature gradients
Toran	30 to 100 m	ionospheric variations
GPS	15-50m	Ionospheric and tropospheric delay

3.9 REFERENCE ELLIPSOID

There are several kinds of reference ellipsoid, including the Clarke 1880 ellipsoid and the WGS-84 ellipsoid. They differ in latitude. Also, the use different approximations to the projection of the Earth's 3-D shape on to a flat plane. The Clarke 1880 ellipsoid uses latitude (angle from the normal to the reference ellipsoid with the equatorial plane). This standard may differ locally from the vertical-which is the normal result of the geoid heights [17]. Data analysis in these reference systems we can determine the difference (λ) between the ellipsoidal (α) and geocentric latitudes (ψ). In Abidjan area this difference is to 466 m or 0.0042°. It is a very small angle to be significant (Table III).

TABLE III: EVALUATION OF ΔΛ IN ABIDJAN (PORT-BOUET'S AREA)

Stations	Ellipsoidal latitude (α m)	Geocentric latitude (ψ m)	λ (m)	λ (Angle)
La Vigie	579985,82	580451,66	465,84	0,004193°
Canal	580503,82	580969,89	466,07	0,004194°
Le Phare	580017,72	580483,70	465,98	0,004193°
Vridi	579541,84	580007,78	465,94	0,004193°

4. CONCLUSION

The Marine geology study of the continental shelf of Côte d'Ivoire we have presented is the result of several recent marine surveys. These surveys (CHALCI 93, CHALCI 94, BATHY 94 & BATHY 95, SEDICOT 96) aim to review the topography of the continental shelf. In fact the accuracy of the bathymetric map of the continental shelf made since Martin [13] does not meet the expectations of potential users. In particular, problems arise: installation of pipelines for petroleum, tearing nets for fishermen, the position of the coastline, etc.

Also in almost 30 years, there have been significant technological advances that should allow a change in our knowledge of the continental shelf. In geological oceanography, the emergence of GPS, digital echo-sounders and acoustic mapping equipment of seabeds has clarified little known aspects of the morphology of the continental shelf.

We used these technics during our various surveys. It is therefore right that our work will have unique features:

- The coastline is better positioned using data from satellite imagery and geodetic control points (GPS);
- The shape of the isobaths is more detailed because of the pollsters and performing echo-sounding mesh operations. This resulted in a bathymetric map (DST map) of the continental shelf 1/50000;
- Significant morphological structures have been identified. Particularly, depressions in seabed of 70 and 100 m off Abidjan and off Tabou. Their origin is in epidiagenetic process and also on structurally controlled bottom currents;

This inventory work needed for future research on the bathymetry of the continental shelf, has not only scientific interest (new approaches to our understanding of the morphology of the continental shelf) but also economic interests). Bathymetric maps are useful for projects with underwater work for the planned development of important research studies and exploitation of hydrocarbons.

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