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Full length Research

Quantification and Origin of Vertical Movements Maritime Quaternaire of the Cote De Bizerte

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Because of its position NE in North of Africa, Tunisia is part of the Western Mediterranean. It knows an intense deformation related to successive tectonic phases associated or not eustatic pulses which generate a large deformation in the form of horizontal and vertical movements. By focusing our study all along the coast of Raf Raf- Metline and on the shores of Bizerte Lake and Ichkeul Lake and through the acquisition of GPS topographic data field. We could determine vertical movements with eustatic and tectonic origin between 19 and 128 m in 120000 years, corresponding to an uplift rate of between 0.008 and 0.1 cm / year,

Keywords: Quaternary marine, eustatism, Tectonic Uplift

INTRODUCTION

Assessing Uplifts (vertical movement) coastal or intercontinental is favorable from marine and continental deposits dated, The marine Quaternary was the most requested because it marks both the final stage of transgression and also the most recent tectonic movements, and in general, the processes responsible for vertical movements are varied (Dauteuil in BIESSY and al 2005, 2005) they can cause deformation of the entire region and involve local process. Several studies have focused on quantifying eustatic variations and the direct or indirect relationship with the vertical movements. These studies have mainly focused on the marine Quaternary deposits exposed on the coast. The palaeo-features of the coast are morphologically recorded in the form of marine terraces, notches, nearshore, in some cases barrier beaches. Next tectonic movement sequences are emergent morphological (for lifting) or submerged (in case of subsidence), therefore, its use to calculate, in a comprehensive manner, the uplift rate. More realistic models are sought, for example the presentation of an evolution curve of the coast over time (Pirazzoli and al. (1993) Generally, the lifting and subsidence are responses of isostatic compensation movements and tectonic forces and expression uplift rate by integrating the age of the series and the elevation above sea level (HARDENBAL and al. (1998) The lifting means rate was obtained by dividing the absolute elevation corrected by the estimated age of rocks. The observed variation in elevation along the same area of study may therefore report with a simple analytical method (MASELLI and al. (2010) that allows the quantification of the total subsidence of the basin, and the calculation of contributions drivers' loads of sediment and water and tectonics.

In the dynamic sense, erosion is a response to excessive weight following a tectonic deformation (mountain chain formation). The mountain range, is close to the equilibrium state, the uplift rate is offset by the erosion rate (ANDREW M and al., (2010). The erosion rate of a watershed is currently treated by the study of incision valleys created in the reliefs at different times (timeline terraces) and KERBY HOWARD (1983) and Howard and al. (1994). Tunisia offers in this part of the Quaternary marine outcrops along the coast (almost). The Bizerte region is part of this coast in addition to two lakes (Ichkeul and Bizerte) where the Quaternary marine (PASCOFF, 1983) offers the opportunity to contribute to the study of Uplifts and the possible relationship with the eustatic and tectonic. This study sought to quantify the Uplifts based on simple geological criteria and correlated: Altimetry, sea states located horizontally (undistorted) lithostratigraphic marker (reference time). The results are correlated with those published for the same age land flush on the shores of the Mediterranean. According to the literature, radiocarbon dating indicates that the last interglacial

period occurred at 120 ka. The correlation curves transgression with global sea level allowed the calculation of the local lifting rate for rates Pleistocene.

METHODOLOGY

Method and equipment

Figure1: Location of the study area (satellite image Source: GOOGLE Earth - Data SIO, NOAA, US Navy, NGA, EBCO, Images 2010 Cnes / Spot Image

Bizerte is a 3685 km2 area located in the extreme North-East of Tunisia (Figure1) whose southern boundary is located about thirty kilometers from the capital, home to the northernmost point of Africa. It is bounded by the Mediterranean Sea to the north (250 km).

During the mission on the ground in November 2012. the nature of the coastal plains: terraces and cliffs, marine erosion surface have been identified and also different geological and morphological indices were located by GPS and survey.

The study area can be divided into two distinct parts on: Metline the coast, and eastern part around the southern edge of Lake Bizerte and the northern edge of Lake Ichkeul. The cards were made by scanning geological maps to 1:50 000 of the latter regions by the use of ArcView GIS 3.2 and ENVI + IDL.

All along the coast of Bizerte, the Quaternary marine deposits are studied where access is possible. In each locality, the Quaternary deposits are analyzed and surveys (cutting and sampling). Many sites are selected to quantify the rate of uplift. Interest was focused on historical grounds (bedrock) and also for the fauna content. Once completed the full treatment, dressed topographical profiles are obtained with geological information on the 1:50 000 maps Four profiles illustrate the various observations made in the field and the different geometry : From north to south, three profiles on the coast of Metline and 1profiles around Menzel Bourguiba.

we were able to determine the location of the different sea levels and limits their expansion along the coast of Bizerte, based on various observations made on topographical profiles, location and dating of marine shells. It shows two compartments having different characteristics.

Samples are harvested Pleistocene age greater than one ten elevation hundred meters above the level of modern sea. The samples were found to the original position (not transported or disturbed). the equation used is that of HENDERBAL to find the average rate and the lifting speed (figure 2).

Uplift = $\frac{U}{T}$ et $U = E - S$

With:

U: Lifting corrects;

T: absolute Estimated age of the rocks;

E: Current elevation coastal (marker);

S : The global sea level at the time of the rock formation investigated.

The marine deposits of the study area are located at the hills, which are affected by tectonics. From equation of Abbott et al., 1997, tectonic uplift rate can be calculated

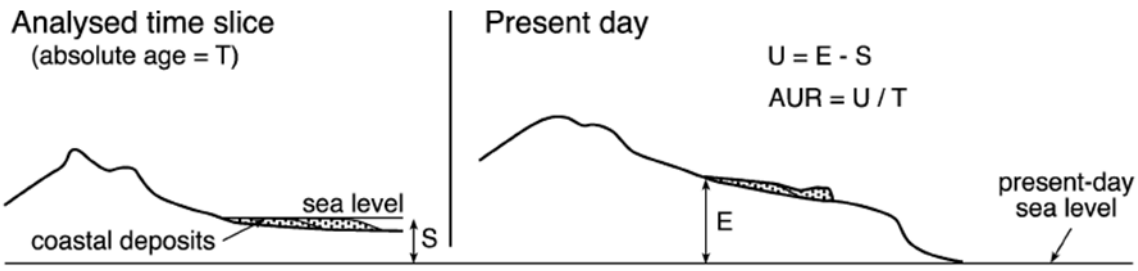

Figure 2: Current elevation markers rocks littoral- of each slice of time analyzed (E) has been fixed with available data on the position of global sea level (HARDENBAL et al., 1998) at the time of formation of rocks studied (S) for lifting the latter from filing (U). S can be negative

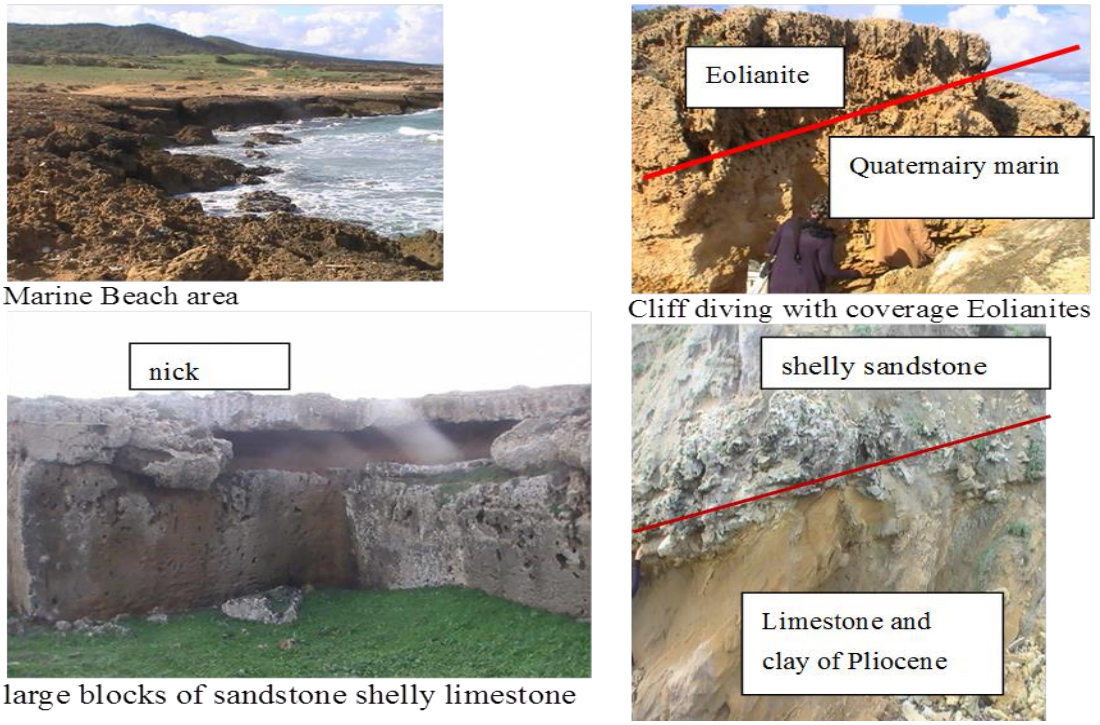

Figure 3: The main morphological markers on the coast of Metline

for each part. In this case, the following equation is applied to calculate the rate of uplift of the tectonic surface.

TUST = $\frac{1}{N}\sum_{i=1}^{N} U\text{i}$

With:

N: Number of measured point in each part;

Ui: the uplift of each point

RESULT

Geological and Morphological Observation

a) North Coast Methline

The coast of Methline (Figure 3) is characterized by a sea cliff, with a well marked foot, covered by old pad areas or by recent sediments of dead dune types, as there is more or less flat surfaces covered with very rounded pebbles, illustrating a constant back and forth waves at these locations. Deposits in large blocks for a long time are subject to intensive exploitation by quarrying.

Rass Djebel

The marine deposits occupy topographic surfaces of different heights which observed Ras Jebel (Figure 4.a.), Quaternary marine to 2 m high, formed by fossil bivalves and gastropods in sandstone and unconformity angular with alternations of clays and limestones of Pliocene.

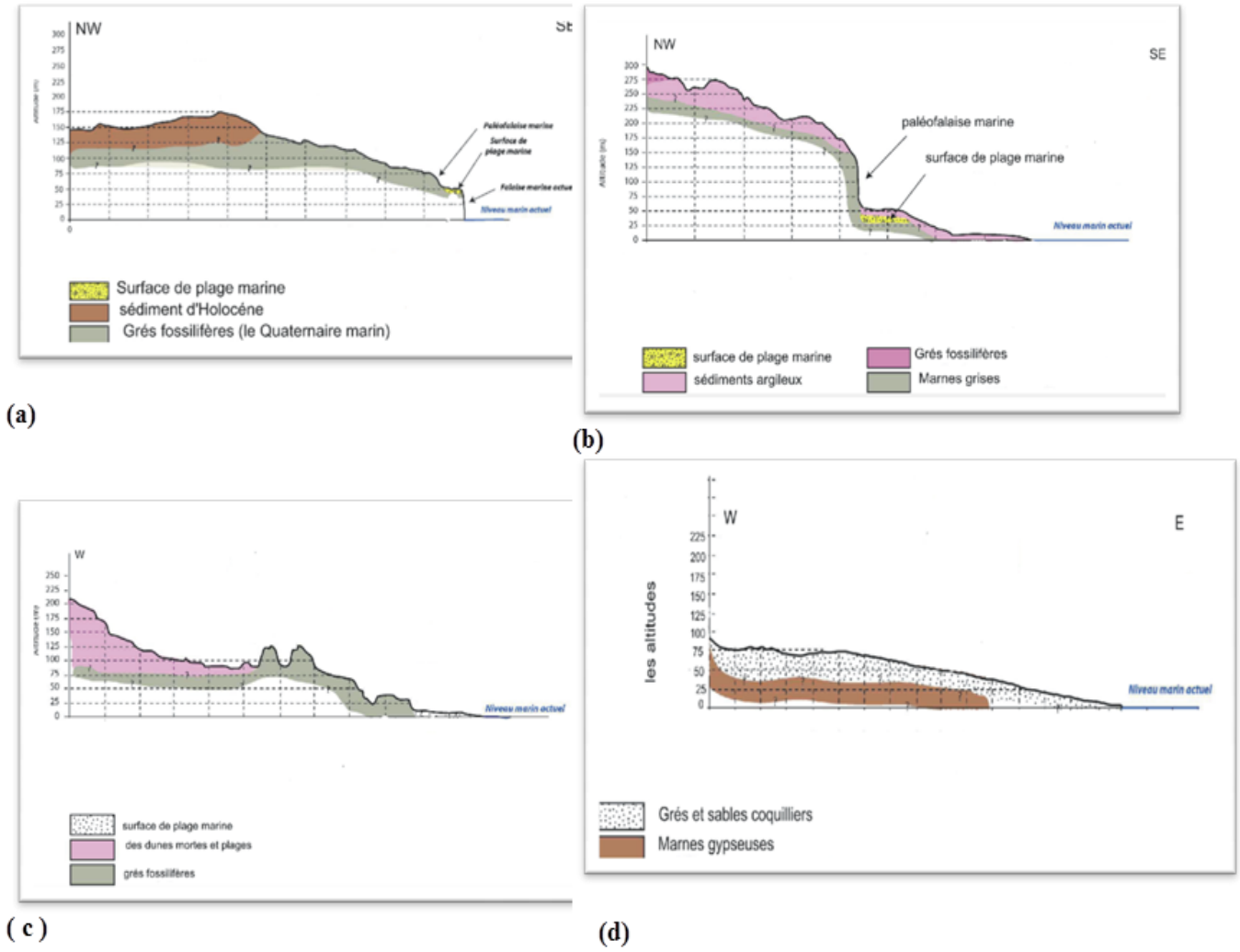

Figure 4: topographical profiles: (a) Ras Jebel, (b) North Metline, (c) El Alia, (d) the southern edge of Lake Bizerte and Ichkeul northern border.

Cap Zbib

A thick marine layer covered by the sands of the Holocene on the beach of Cap Zbib, consisting of sandstone fossil in limestone cements, discordant with the Pliocene, it reflects both a significant period of time and a radical change of the environment. On the other hand, the fauna Association marks the last interglacial stage of the Pleistocene. These deposits are located at different altitudes higher relative to the current level of the sea as a result (Figure 4.b.)

- A level of 25m: Deposits are covered by dunes.
- A level of 5 to 7m: A coastal cliff covered by a conglomeratic level.

El Alia

Similar deposits, flush in the region of El Alia and along a line parallel to that of the current bank, in horizontal layers composed of two sets (Figure 4c.) :

- The assembly (A), marine facies corresponds to fossil sandstone more indurated an angular unconformity with clays and sandstones of the Miocene reached an altitude of 134 m above present sea level and can reach 114m
- while the set (B) consisting of sandstone fossil discordant on clays and Pliocene marl with an altitude of 83m.

The region Menzel Bourguiba

Quaternary marine stands on Lake Bizerte and along the northern edge of Garaàt Ichkeul. It is either

concordant or discordant in the last levels of the marine Pliocene. Representative facies mark a clear shift towards deposits mudflat beach deposits.

The southern edge of Lake Bizerte

The Quaternary deposits are discordant in the last Pliocene sandstone levels (training Raf Raf). In the study sites (Figure 4.d.), we note the presence of basal conglomerates and paleosols. The dip is from 5 to 15 ° towards the North.

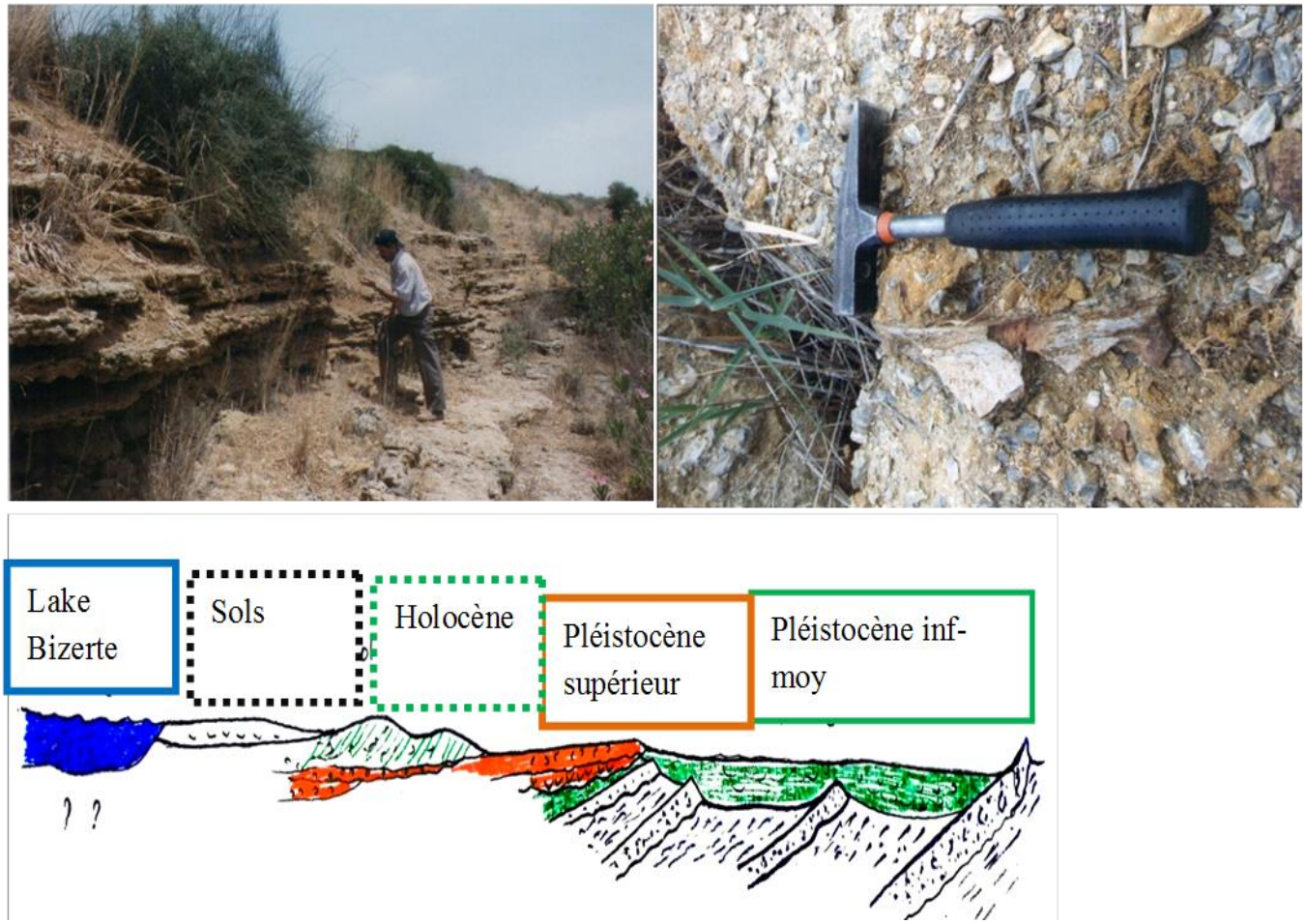

Figure 5: Schematic section SN, Quaternary marine S on the edge of Lake Bizerte

A regional study of marine Quaternary deposits of the south coast of Lake Bizerte (Figure 5) shows in the area of Umm Heni, the marine Quaternary deposits reach a height of 60m based on paleosols are characterized by the presence of benthic foraminifera and spines of echinoids while the macrofauna is represented by the species *Ostreat lamellosa.*

In Sidi Mansour series is started by a sandy silt facies unconformably altitude of 40m with Pliocene sandstone. In these deposits, the omnipresence of internal molds and marine gastropods dominated Glycymeris, This fauna, although preserved in a fragmentary state, is diverse and composed of several species of different sizes,

The northern edge of Lake Ichkeul

The Quaternary deposits are discordant on the Pliocene sand and clay. Two cases arise (Figure 4.d.):

- *The clays and sands Cardium sandstones and clays cap the Pliocene that are vertically;*
- *The Cardium deposits are discordant (10 °) on the last words of the Pliocene sandstones with conglomeratic base.*

The components of macrofauna found in all marine facies series of the Quaternary on the northern edge of Lake Ichkeul are abundant and diverse (Figure 6). sea

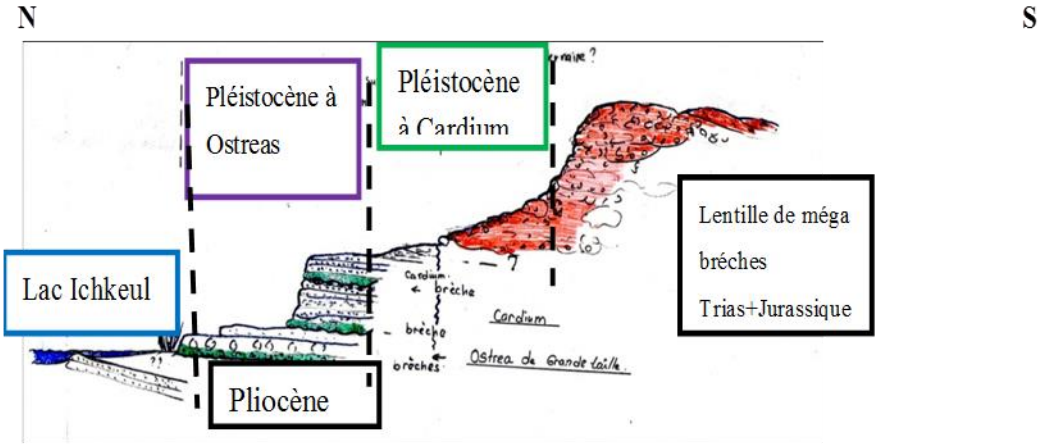

Figure 6: SN Schematic section showing the superposition of the Quaternary sea on the edge of a cliff carved on the border N Lake Ichkeul

level is represented by calcareous sandstone conglomeratic dominated Ostreas 9m altitude eg : *Cyrnus pay, Ostrea SP*, this set is covered by sands rich in *Turritella aspera* finally 20m Quaternary is represented by clays *Cardiums: Cerastoderma edule, Cerastoderma lamarki* with microfaunas. This series is unconformably on the sandstone of the Pliocene. Fossil markers were reported from different localities along the Mediterranean basin, particularly in Spain, Italy, Greece, and are of Pleistocene age.

Quantification of Tectonic and Eustatism Movements

Outcrops studied marine Quaternary used to report the following:

- In general, the dominant facies are represented by calcareous sandstone coquillers to cement with locally Fossil plastic clays. The thickness varies from 5 to 10m.
- These deposits are still discordant on previous deposits (Miocene and Pliocene sup and also Villafranchian.). Two cases:

➢ angular unconformity with basal conglomerates and gully area ;

➢ quaternary marine horizontal discordant on previous verticalized deposits with or without basal conglomerates ;

From these data, Uplifts rates are quantified (table. 1). Thus, the age of the deposits is secured from the collected fossils, dating and regional correlation also with deposits with similar characteristics studied on the Tyrrhenian coast (especially Italy), so age is the late Pleistocene.

The relatively large tectonic uplift (table. 2) in the Metline region is of the order of 0.035 cm / year, and decreases in Menzel Bourguiba region for an extended period (120 000 years) which was immediately recognized by of transgression and regression alternations. Differences in behavior as the regions concerned have been observed.

Table 1: Quantities and eustatic uplift speeds along the coast of Bizerte (120 000 y).

	Coaste of Metline			Menzel Bourguiba region		
	Rass Djebel	Cap Zbib	El Alia	La Bordure sud de lac Bizerte		La bordure nord de lac Ichkeul
				Sidi Mansour	Oum Heni	
U (m)	-4	19	128	24	54	3
		-1 à +1	77	28		14
				41		
Speed of uplift (cm / year)	-0.0033	0.015	0.10	0.028	0.045	0.0025
		-0.0008 à +0.0008	0.064	0.023		0.0011
				0.034		

Table 2: Quantities and uplift rates of the tectonic surfaces

	The Coaste Metline	Menzel Bourguiba région
TUST	0.035 cm/an	0.022 cm/an

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The relatively large tectonic uplift in Metline region is approximately 0.035 cm / year, and decreases in Menzel Bourguiba region for an extended period (120 000 years) which was immediately recognized by transgression and alternations regression. Differences in behavior as the regions concerned have been observed.

DISCUSSION

This study presented for the first time the results of the quantification of UpLifts from the age of the marine Quaternary terrains Bizerte region (table 3). High amplitude movements (up to 0.10 cm / year) and for a long period of time could be identified; also low amplitude movements (<0.008 cm / year) for longer periods of time (120, 000 years to the present).

The uplift rate varies from one place to another; this indicates differing structural situations. Indeed, the lakes of Bizerte and Ichkeul would have evolved as faulted syncline (Figure 7a.). The coast of Ras Jebel - Raf Raf inherits a collapsed structure (7B).

Table 3: Elevation levels containing a marine fauna and rate of uplift.

Location	Name fauns	Altitude (m)	Uplift (cm/year)
Rass Djebel	a fragmented wildlife	2	-0.0033
CapZbib	Plugins gastropods and bivalves are clearly visible	25	0.0015
	a fragmented wildlife	5 à 7	-0.0008 à +0.0008
El Alia	a fragmented wildlife	134	0.10
	a fragmented wildlife	83	0.064
Sidi Mansour	*Glycymeris :groupeBimaculata* *Saxolucina SP* *Natica millepurcta* *Glycymeris bimaculata* Clanculus SP *Cerithium SP* *Foraminifères benthiques*	40	0.028
Sidi Mansour	*Bittium SP* *Murex SP* *Potamides lamarki* *Cylichna clathrata* *Natica millepunctata* *Chlamys opercularis* *Radioles d'échinides* *Loxoconcha elliptica*	34	0.023
Sidi Mansour	*Arca SP* *Conus virginalis* *Calliostoma simulans* *Calliostoma seguenzai* *Cerithium* du Lutécien *Triphora perversa* Pseudotextularia Natica cate *Gibberula philipii* *Foraminifères benthiques*	47	0.034
Oum Heni	*Ostreat lamellosa* *Foraminifères benthiques* Radioles d'échinides *Loxoconcha elliptica*	60	0.045
The northern edge of Ichkeul	*Cyrnusi pay* *Ostrea SP* *Loxoconcha elliptica*	9	0.0025
The northern edge of Ichkeul	*Turritella aspera* *Cerastoderma edule* *Cerastoderma lamarki* *Loxoconcha elliptica* Radioles d'échinides *Foraminifères benthiques*	20	0.0011

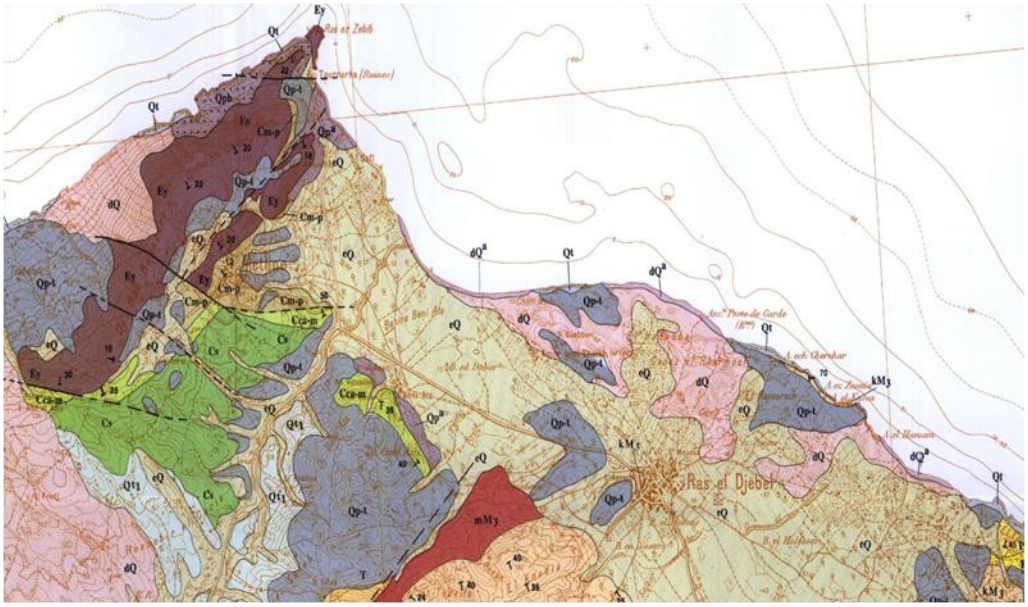

Figure 7a: Extract of a geological map of 1:50 000 North Coast Metline with the structural model from the calculations of UpLifts: Flaws collapse determined by Uplifts

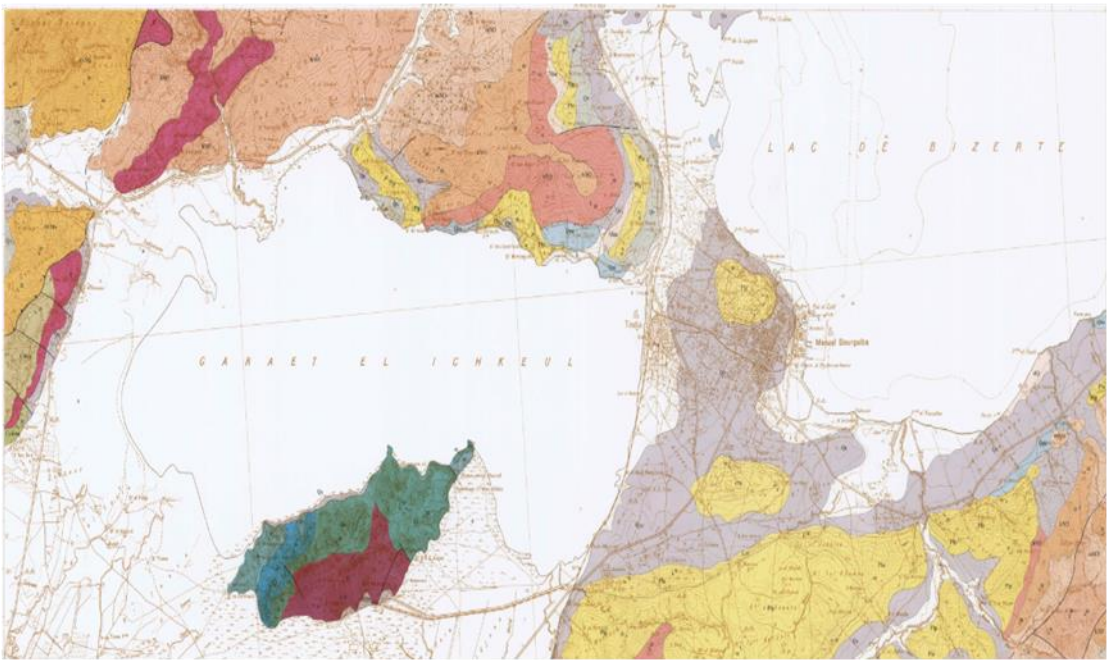

Figure 7b: Extract of a geological map of 1:50 000 Area Menzel Bourguiba with the structural model from the calculations of UpLifts. Collapse faults determined by UpLifts

CONCLUSION

This literature review focused primarily on the Mediterranean Quaternary aims to put into relief the importance of the study of UpLifts during this time period. . Indeed, the marine Quaternary offers opportunities to quantify the effect of Quaternary UpLifts post on the organization of the current coastline.

The Quaternary of the Bizerte region (coast) is influenced by tectonic events affecting particularly the Tyrrhenian Sea. These events marked the distribution of facies (deposits Cardium conglomeratic sandy deposits, beach deposits debris shells, deposits Ostréas, fossil clay deposits.

The results are also correlated with most recent data published for the Italian coast (Sicily, ...). The

UpLifts rates are almost equivalent especially for coastal Ras Jebel - Raf Raf (Bizerte) -0003 to + 0.10cm / year and the Sicilian coast -0.01 to +0.09 cm / year.

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