ETAP Memoir

N° 26 - 2006

EPC' 2006

Tunis, October 30th - November 3rd, 2006

PROCEEDINGS OF THE 10th TUNISIAN PETROLEUM EXPLORATION & PRODUCTION CONFERENCE

ENTREPRISE TUNISIENNE D'ACTIVITES PETROLIERES

THE UPPER CRETACEOUS CARBONATIC FACIES IN CENTRAL –EASTERN TUNISIA: ELECTROFACIES, SEDIMENTARY CHARACTERS AND ECONOMIC IMPLICATIONS

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ABSTRACT: In Central –Eastern Tunisia (Kairouan –Sfax area), the Upper Cretaceous interval, includes various hydrocarbon plays as confirmed by the numerous discoveries in this area. Production comes from multiple reservoirs ranging in age from the Upper Cenomanian to the Maastrichtian. The main producing fields are Sidi El Kilani (within the Abiod Formation), Miskar, El Jem (within the Upper Aleg carbonates), Gremda, Rhemmouda, El Aïn, Guebiba, Mahares and El Jem (within the Bireno Member). The main objectives of the present study will be to show, by means of electrofacies analyses the main interesting sectors in terms of reservoirs potential and source rocks availability. On the other hand, surface-subsurface integrated study helps a lot for the reconstitution of palaeoenvironments especially in cases of subsidence, deepening etc.

The identification of various electrical expressions, mainly based on Gamma-Ray and Sonic logs, leads to a subdivision of the Upper Cretaceous into numerous units and subunits. In addition, correlable discontinuities were identified in certain formations, such as in the marly El Haria Formation. In fact, integrated biostratigraphic and wire-line logs studies lead to the identification of the clear shift separating the Paleocene shales from the Maastrichtian marls. This shift expresses an unconformity which is correlable, at least, at a regional scale.

Within the Abiod Formation, four units were identified. The Upper Units (Units 1 and 2) constitutes the Upper Abiod Member, the Unit 3 corresponds to the Middle Abiod, and the Unit 4 corresponds to the Lower Abiod. The Unit 2 which is relatively rich in marl intercalations expresses a progressive transition from the marly Middle Abiod to the carbonatic Upper Abiod. The four units are obvious, especially in Sidi El Kilani-El Jem sector. Laterally, facies changes are very common.

Within the Bireno Member, three units are identified; they consist of two carbonatic units (B1 and B3) separated by a marly unit (B2). Laterally facies are globally homogenous, excepting the effect of diagenesis, especially dolomitisation, mainly transforming the Lower (B1) and the Upper (B3) Bireno.

The Annaba marls exhibit homogenous facies within the whole studied area; the electrical expression is comparable.

The Bahloul Formation, considered as a potential source rock, consists, in our study area, of laminated limestones containing organic-rich facies. These carbonates which appear represented in all sectors, exhibit lateral changes essentially in terms of organic matter content.

I - INTRODUCTION

In Central-Eastern Tunisia, the Upper Cretaceous series constitutes a good petroleum hydrocarbon system. This is mostly due to the combination of their regional extension and their interesting petroleum system including source rocks (Bahloul: laminated limestone), reservoir (carbonates of Bireno, Douleb members and Abiod Formation) and cap rock (clays of the El Haria Formation) (Fig. 1).

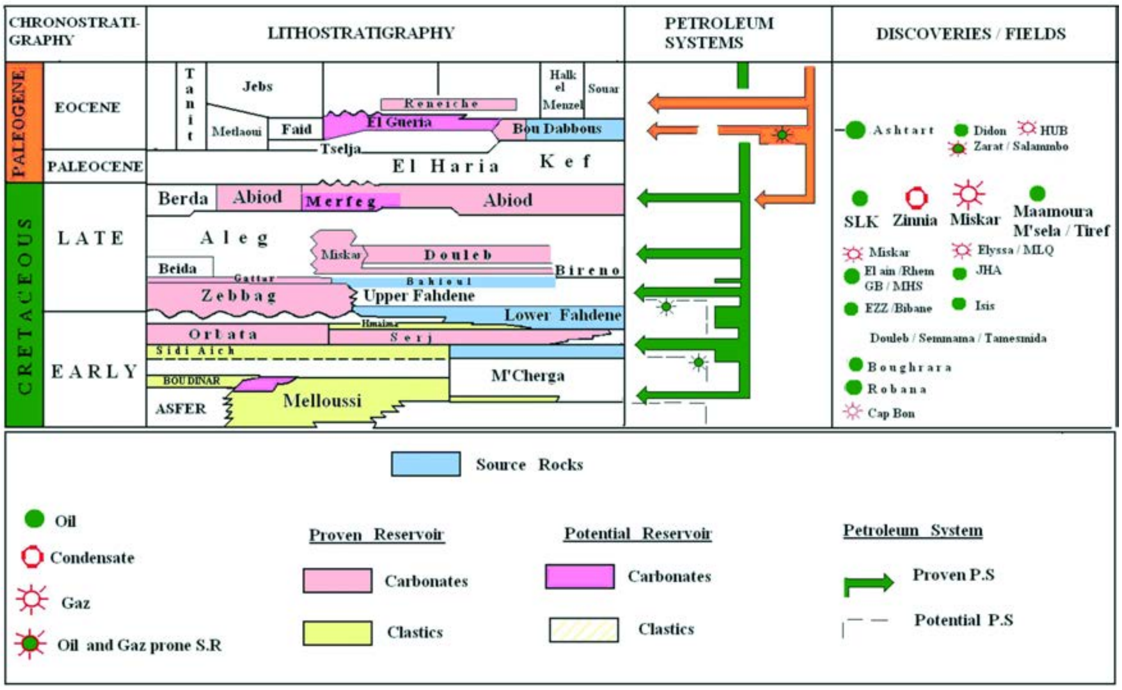


Figure 1: Tunisian Stratigraphic Chart (ETAP, 2001)

The high flows of these reservoirs are obtained by production tests in Sidi El Kilani, Tiref, Zinnia, Tazerka field (within the Abiod formation) Miskar, El Jem (within the upper Aleg carbonates) Gremda, Rhemoura, Guebiba, El Jem and Mahares fields (within Bireno member).

In addition, according to the outcrops study, these high flows are related also to fracturing, that could provide sufficient permeability enhancement and to diagenetic process, especially dolomitisation / dedolomitisation.

Due to the absence of the Upper Cretaceous facies outcrops in the studied sector, our study is primarily based on subsurface data sets (Composite logs, with paleontologic and biostratigraphic data and seismic).

The main objectives of this paper are:

- To establish a synthetic log representing the Upper Cretaceous successions in Central – Eastern Tunisia.
- To find a relationship between the Log expression, sedimentary characters and reservoir potential.
- To reconstitute the palaeotopography and palaeogeography of the studied area, on the basis of subsurface mapping.

II – LITHOSTRATIGRAPHIC CHARACTERS

The Late Cretaceous including Albian and, locally, Clansayesian, is represented:

-To the South, by the Zebbag Formation (Mid-Late Albian, Cenomanian and Earliest Turonian; Razgallah and al., 1994), the Aleg Formation (Turonian to Early Campanian; Fournié, 1987; Ben Ferjani and al., 1990), the Abiod Formation (Campanian to Early Maastrichtian: Khessibi, 1978; Negra, 1994) and the Lower part of The El Haria Formation (Maastrichtian).

-In North of Kairouan area, the Late Cretaceous interval includes the Fahdene Formation (Clansayesian to Cenomanian, including the terminal horizon Bahloul: Late Cenomanian to Earliest Turonian), the Aleg Formation, Abiod Formation and El Haria Formation.

The present study was focused on Late Cenomanian to Maastrichtian seria (Figure 2).

The Late Cretaceous sequences in the Sahel (the central part of Oriental Tunisia) includes thick units (locally reaching more than 1800m) of carbonates, marls and argillaceous limestones that were deposited in shallow marine to deeper environments ranged from inner platform (within Bireno member) to pelagic and hemipelagic setting (within Aleg and Abiod Formation). This deposits show important changes in lithologic facies and thickness, especially within the Abiod Formation (Negra, 1994; 1996)

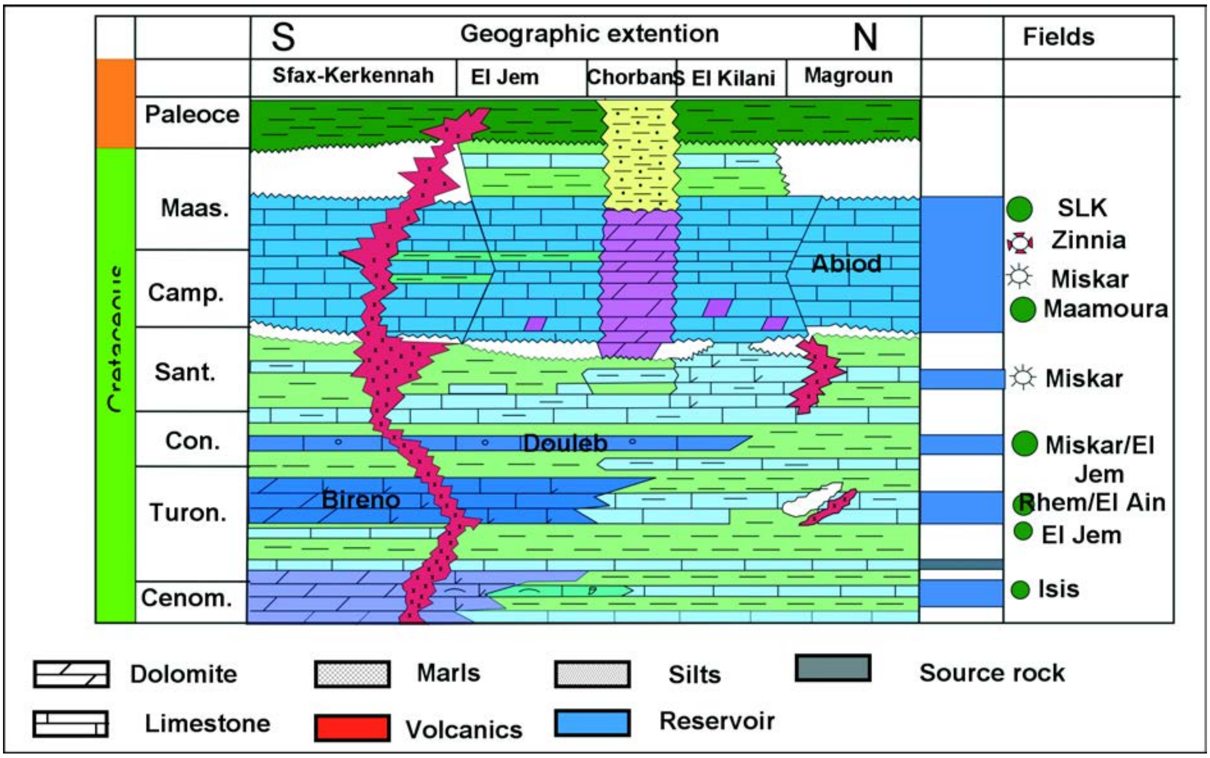


Figure 2: Lithostratigraphic Charts and Petroleum system in the studied area

III – GEOLOGICAL AND GEOGRAPHICAL SETTING

1- Geographical setting

Our studied area extended from Kairouan to Sfax is limited by the North- South Axis, to the West, the Pelagian Bloc to the East, the latitude of Sousse, to the North and the latitude of Sfax-Kerkennah, to the South (Figure 3).

2- Geological setting

According to the subsurface study (Bedir, 1994; 1995; Ouahchi, 1997; Khomsi et al., 2005; Ben Gacha and Damak, 2006), the Northern part of our study area is composed of horsts and grabens (ig: Monastir-Kuriat, Boumerdes-Mahdia grabens and Chorbane horst). In contrast, the southern part is composed of relatively correlable homogenous facies "Djebiniana platform" (Bedir, 1994; Bedir and al., 1998).

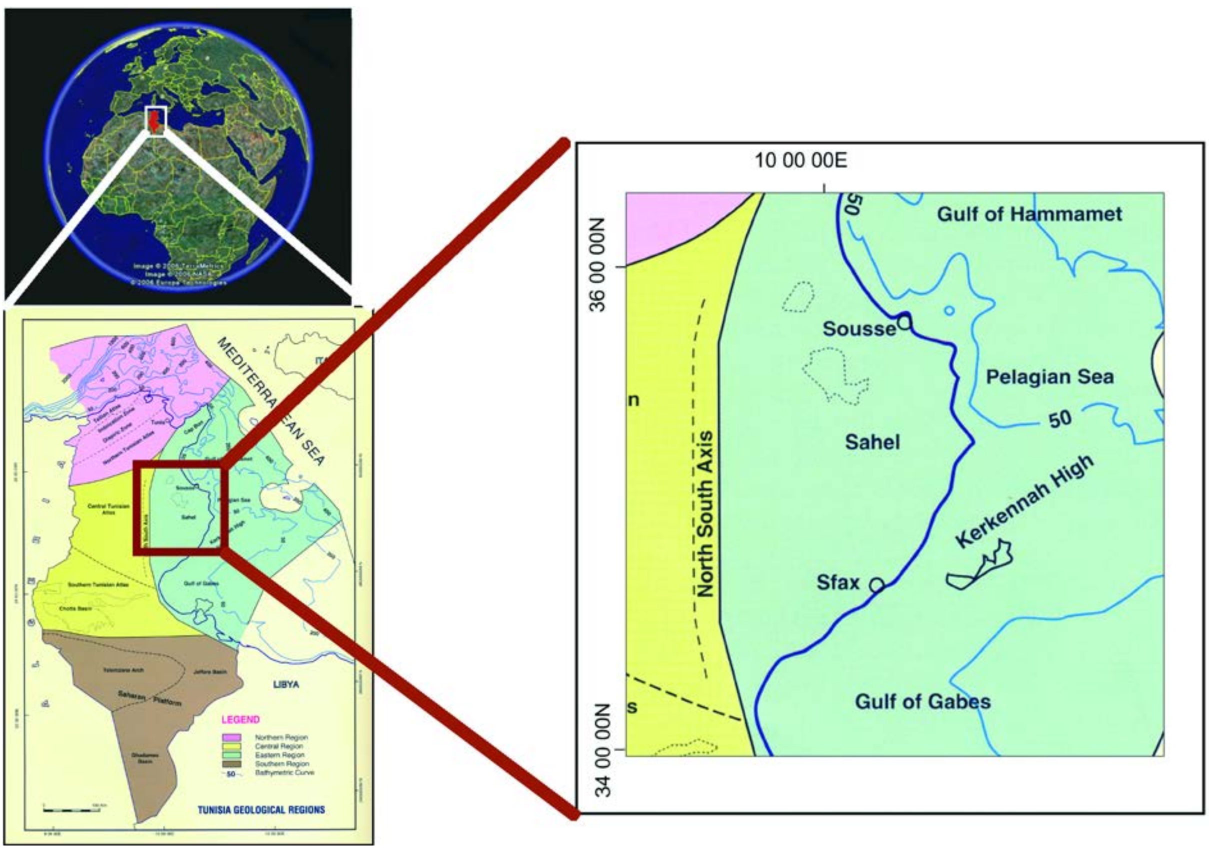


Figure 3: Geographic setting of the study area (ETAP, 2001)

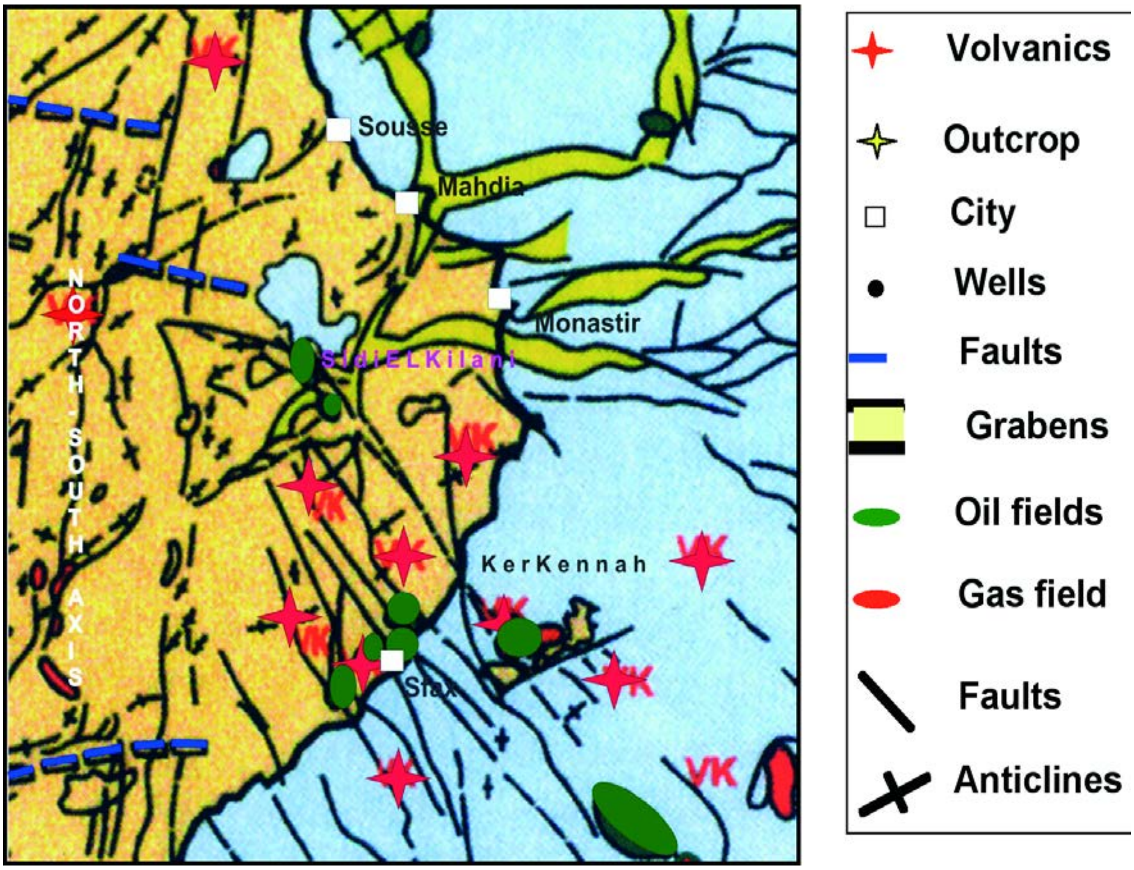


Figure 4: structural setting of the study area (ETAP, 2003)

The Sfax-Kerkennah area (Onshore and Offshore) is affected by NW-SE distension faults (Fig.5) (Haller, 1983; Ellouze, 1984).

In addition, our study area was identified during the Late Cretaceous volcanic activity (Fig.4).The chemical characters of these volcanic material shifts progressively from basaltic intrusion to pyroclastites and tuffs (Ouazaa, 1994; Ouazaa et al., 1998). These various magmatic eruptions occurred along E-W, N-S and NW-SE accidents (Ellouze, 1984; Ouazaa, 1994; Bedir, 1995)

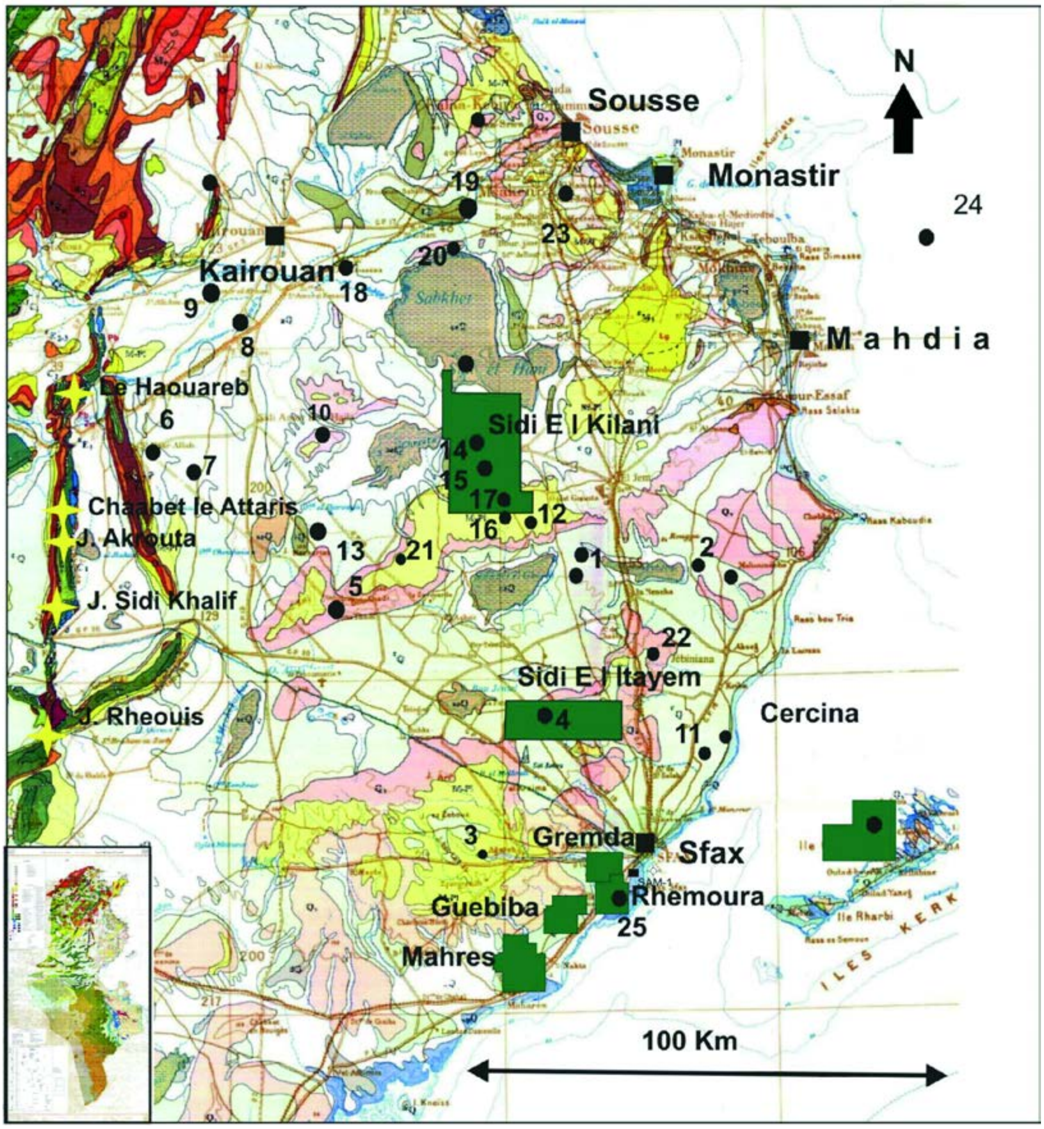


Figure 5: geological setting of the study area (Ben Haj Ali et al., 1985)

IV – MAIN LOGS EXPRESSIONS WITHIN THE LATE CRETACEOUS SERIES

Wherever faunal age details were not available, litholog variations were considered to differentiate the formations boundaries and their subdivision into numerous units and subunits. In the other way, due to the absence of outcrops in our sector, detailed interpretation using Wire-line logs (Gamma-Ray, Sonic, Density and Neutron) from more than 24 wells leads to identify electrofacies signature of the Upper Cretaceous facies.

IV- 1- BAHLOUL FORMATION

The Bahloul Formation (Late Cenomanian-Earliest Turonian: (Abdallah, 1987; Razgallah,

1983) is considered as one of major source rocks in Tunisia, especially in the Central East of Tunisia. It consists of thin laminated black or dark grey limestones or argillaceous limestones, white weathering and rich in organic matter (up to 14% of TOC; Ben Ferjani et al., 1990). According to the combination of Gamma-Ray and Sonic logs, the Bahloul log signature was defined into several wells. Bahloul facies exhibit only minor variations (Fig.6).

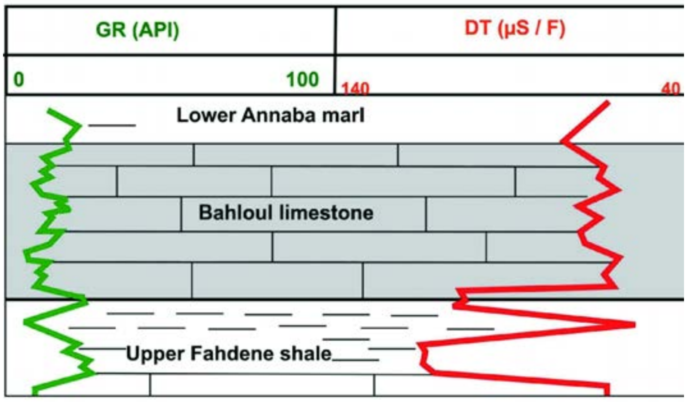


Figure 6: Electrofacies signature of the Bahloul Formation

IV- 2- ANNABA FORMATION

According to the electrical logs, the Annaba Member (Early Turonian) was subdivided into three units (Fig. 7), named A, B and C. A corresponds to the transition of Bahloul limestone to the Annaba marls. B corresponds to the shales of Annaba. C corresponds to marls and argillaceous limestones expressing the transition to the carbonatic Bireno Member. This log signature was consistent over several wells of the study area with some particular variation with in relation with their environmental deposits.

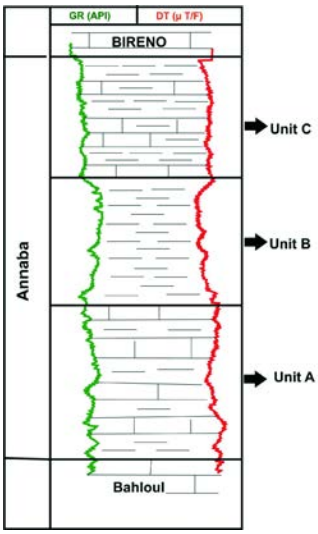


Figure 7: Electrofacies signature of the Annaba Formation

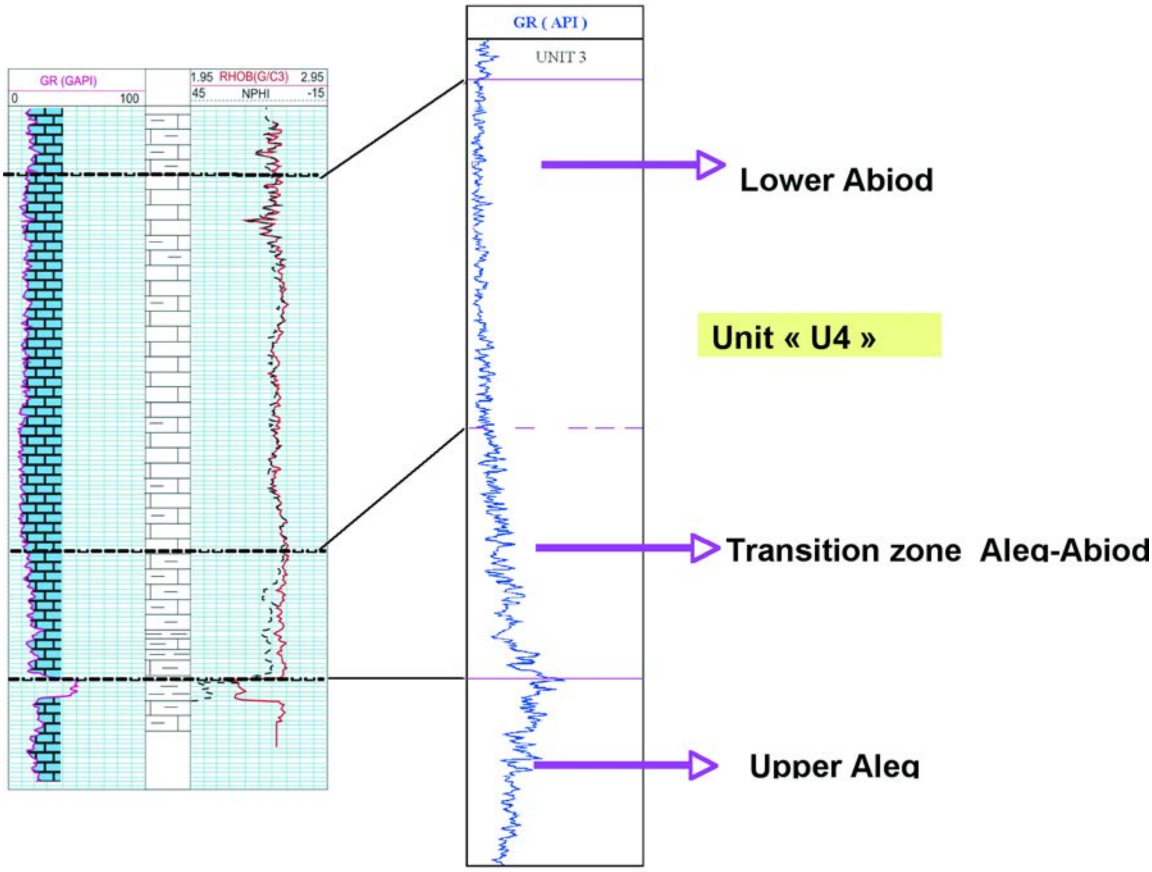
IV- 3- ABIOD FORMATION

** In Sidi El Kilani-Souassi area,*

By combining lithofacies data and wire-line-logs (Gamma-Ray, Sonic, Density, Neutron), the succession was subdivided into four units:

- Unit 4 "U4": is subdivided into two subunits:

-The lower part of Unit "U4" (Fig. 8) shows an increase in gamma-ray response and a decrease in sonic velocity values coincides with a change from Aleg Formation upper marls to argillaceous limestones of the Aleg-lower Abiod transition. This part is characterized by a chaotic wire-log profile reflecting the interbedded claystone-limestone (the limestones beds are more common than the argillaceous limestones interbeds). The lower part of this



unit constitutes the Aleg-Abiod transitional zone.

Figure 8: Wire-line log signature of Units "U4"

- The upper part of the "U4" unit is characterized by homogenous gamma-ray responses with low values, coinciding with a change to pure blocky limestone. This part corresponds to the lower member of the Abiod Formation.

- Unit 3 "U3": is characterized by a low decrease in the gamma-ray response and separation of Neutron/Density curves reflecting the change from limestone unit to argillaceous limestone rich in marl intercalation unit. The “U3” unit constitutes the middle Abiod (Fig 9).

- Units “U2” and “U1”: These two units constitute the Upper Abiod Member. The “U2” unit, which is relatively rich in marl intercalations, expresses a progressive transition from the marly Middle Abiod to the carbonatic Upper Abiod corresponding to unit “U1” (Fig. 10.)

** In Sidi El Kilani-Souassi area,*

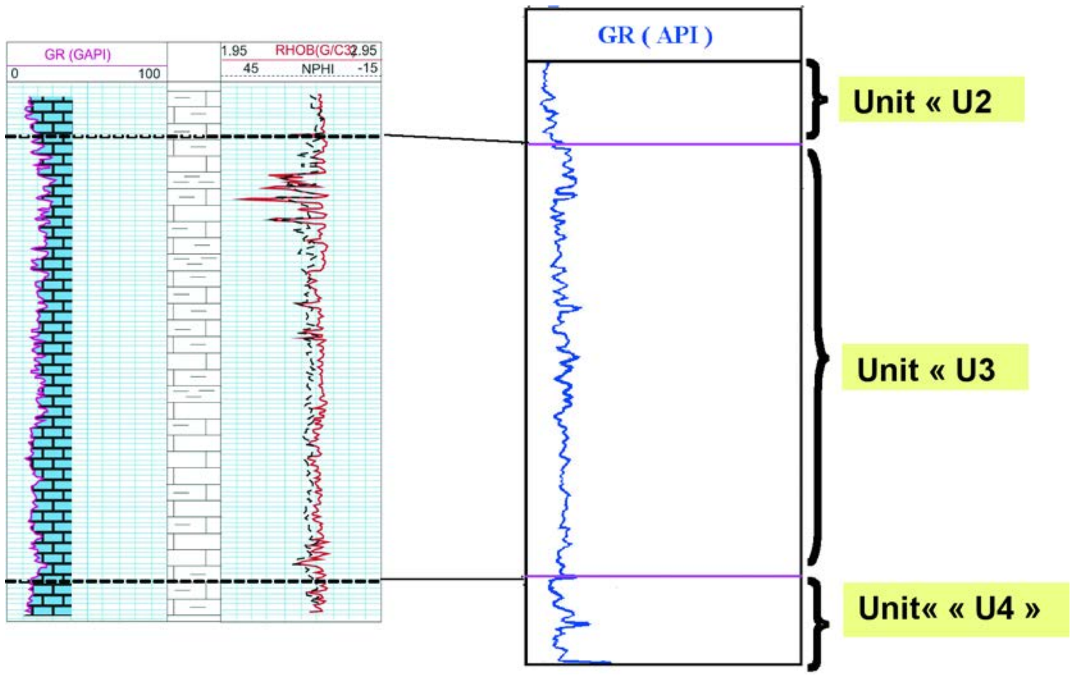
The Abiod Formation is represented by two particular electrofacies signatures (Fig. 11.). The first corresponds to the classic Abiod which is constituted by two limestone Members separated by a marly member. This case is very frequent in North –South Axis outcrops. When the Abiod is represented only by one limestone unit, the latter could correspond to the Upper Abiod, the Lower Abiod or to the three Members associated in an only one Member.

IV- 4- EL HARIA FORMATION

In this study, only the lower part (Maastrichtian) of El Haria Formation (Fig. 12) is discussed. This part is subdivided into two units:

- Maastrichtian Unit 1 or “UM1”: noted the Lower Maastrichtian.

Maastrichtian Unit 2 or “UM2” noted the Upper Maastrichtian.



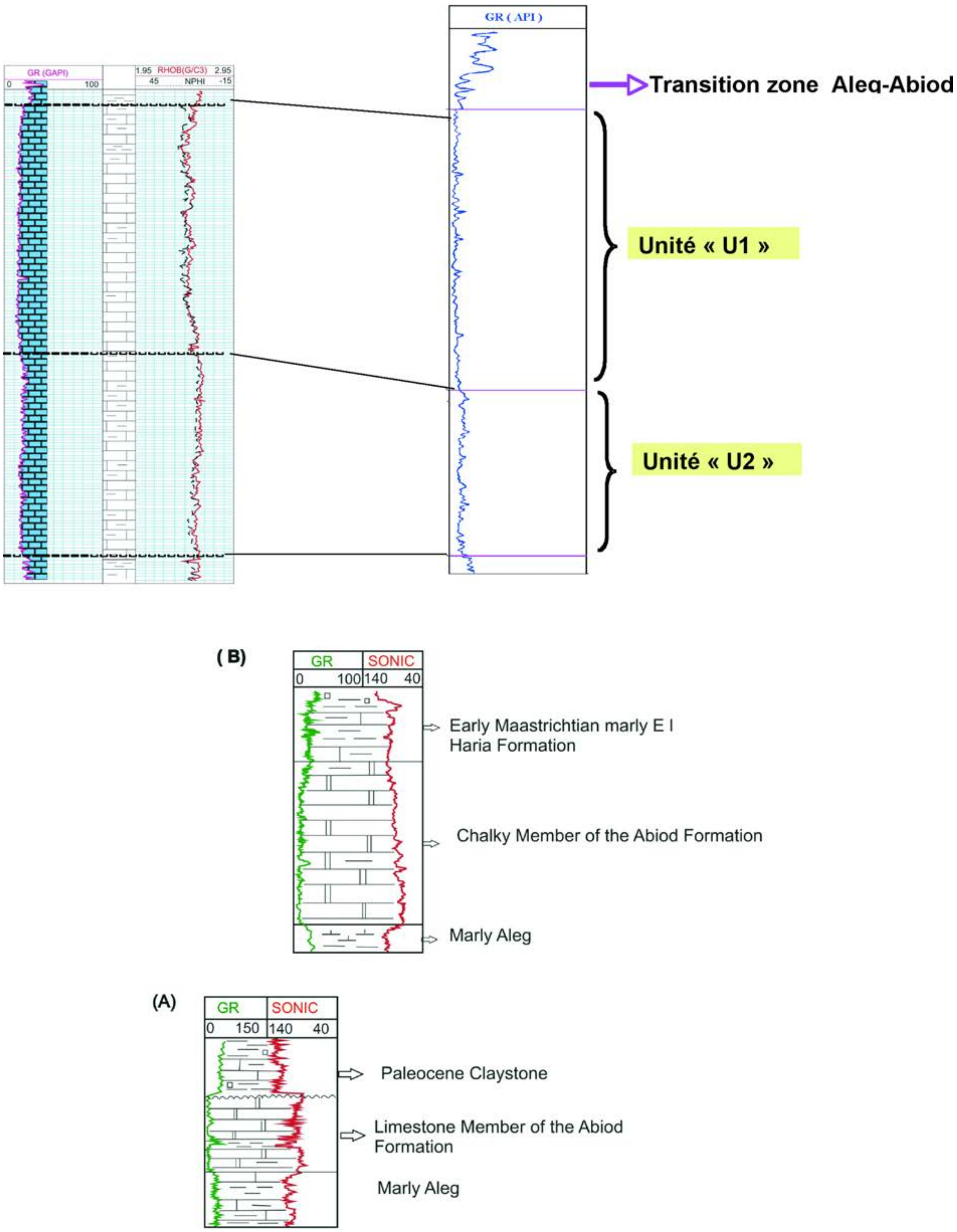


Figure 9: Wire-line log signature of Units "U3"

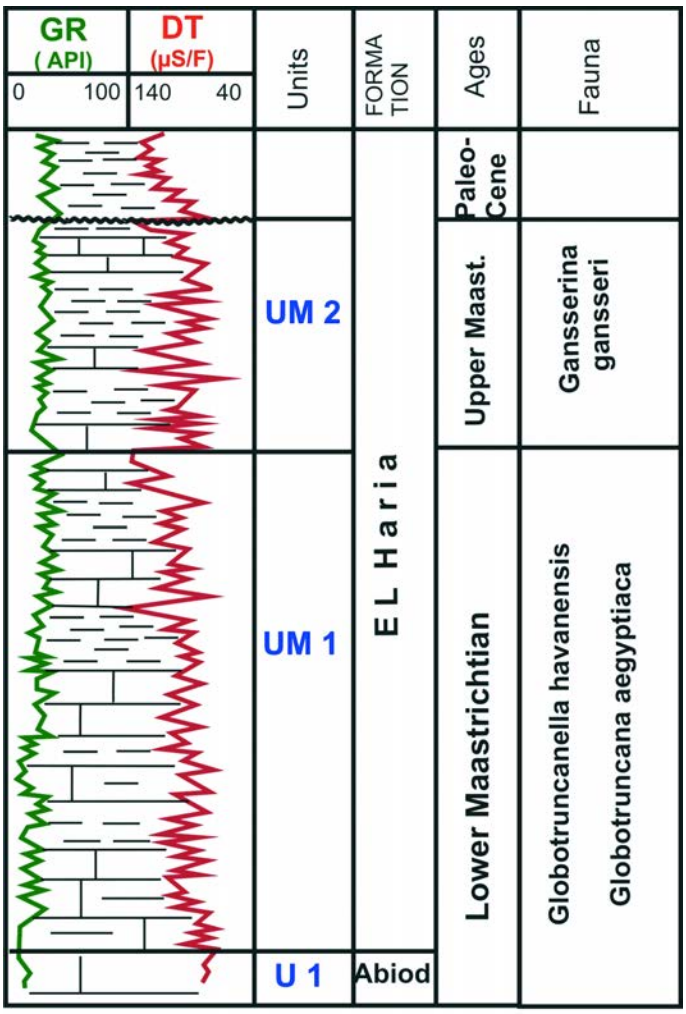
Figure 11: Electrofacies signature of the Abiod Formation within the Sfax- Kerkennah sector

The Top of the Maastrichtian is represented by a clear shift. It expresses an unconformity between the Maastrichtian and the Paleocene.

This signature could be summarized in an electrical log showing the vertical evolution through the studied Late Cretaceous interval.

We have identified two sectors showing different evolutions through the Late Cretaceous. We propose two types of electrical expression in relation with their facies evolution in each sector. (Fig. 13).

- To the North sector (Sidi El Kilani-Souassi area) the Late Cretaceous series are relatively subsident (more than 1800 m thick). The Abiod formation is more than 600m thick. Vertical evolution is clearly progressive. Consequently, the identification of electrofacies image within this sector is not obvious.



- To the south sector (Sfax - Kerkennah area), the upper Cretaceous evolution is rather abrupt. Vertical changes are easy to detect in well logging characterises each facies change.

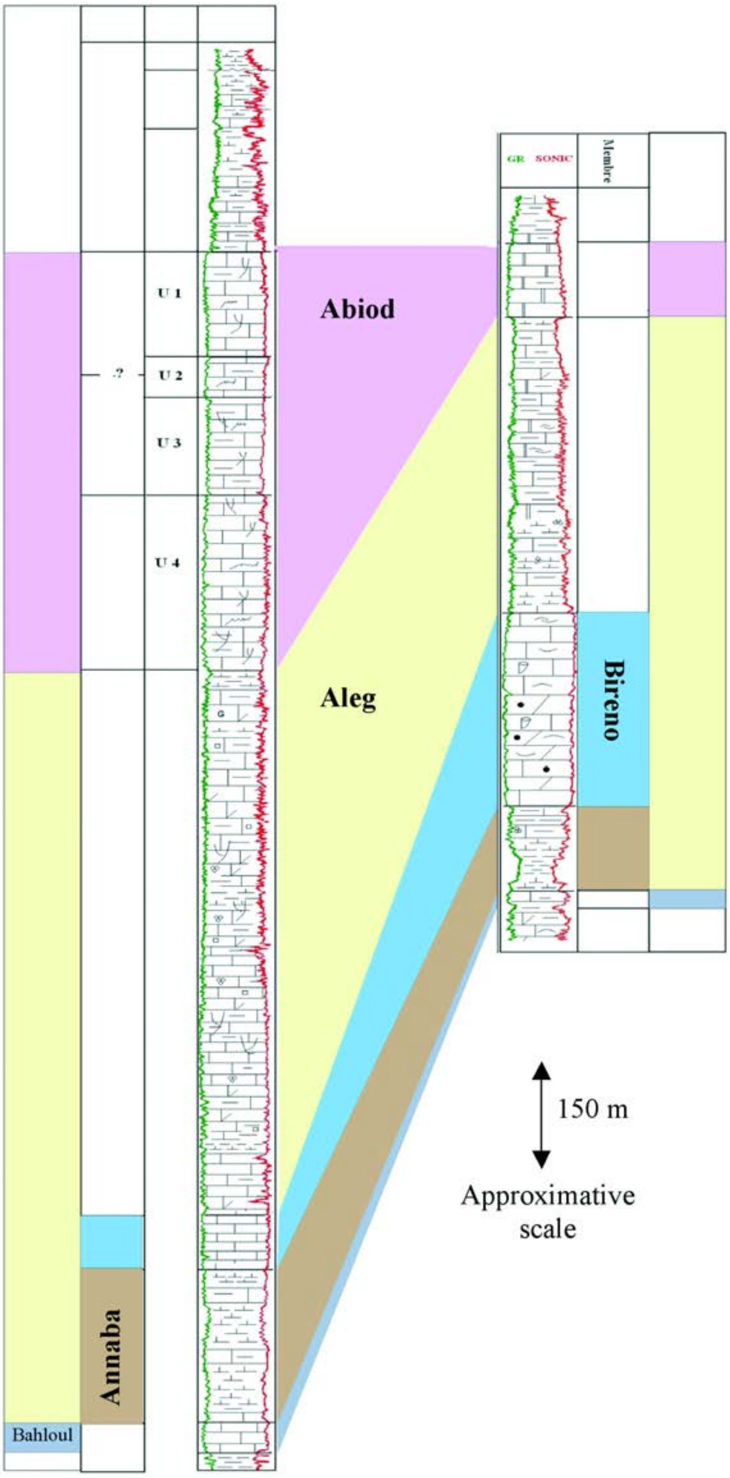


Figure 12: Log signature within the Maastrichtian part of the El Haria Formation
Sidi El Kilani – Souassi area Sfax –Kerkennah area
Figure 13: Electrofacies signature of the Upper Cretaceous within the study area

V – RELATION-SHIP BETWEEN SEDIMENTARY CHARACTERS ANDRESERVOIR POTENTIAL

V -1 – Sedimentary facies and their electrical response within the Bireno Member and Abiod formation:

V-1-1- Bireno Member

The Lower to Middle Turonian Bireno Member carbonates (Zagrarni., 1999) are proven reservoir, producing oil in Gremda, El Aïn, Rhemoura, Guebiba and Mahares fields (Sfax area) and gas in Miskar fields (Gulf of Gabes). It tested 3770 BOPD in Selloum -1 well, 3.7 MMCFPD of gas in El Jem -1 well and recently 1500 BOPD in Guebiba-3 well (Troudi et al., 2002)

The reservoir quality of these carbonates which is medium to good is regionally variable and related to facies association and especially to differential diagenesis (Troudi et al., 2002).

A – Sidi El Itayem area:

A new well-Log interpretation for well P4 (Fig.14) which is crossing Sidi El Itayem area (Southern part of the study area) proposes to subdivide the Bireno Member into two electrofacies:

A1- The Lower Bireno electrofacies

- Lithology: The Lower Bireno (155 m) consists of dolomites or dolomitised limestones with thin minor marlstone interbeds (in the Lower part).

-Wire-line-log characteristics: the Lower boundary is sharp. An abrupt increase in GR response and decrease in sonic response coinciding with a change from the Annaba marls to Bireno dolomitic Member. In addition, this Lower electrofacies has a cylindrical form (SHELL classification) reflecting the homogenous evolution into this electrosequence. According to these very low values of sonic velocity, this dolomite could be very compact and microcrystalline with poor to negligible porosity.

A2- The Upper Bireno electrofacies

- Lithology: The Upper Bireno (42 m) consists of dolomitic limestone, occasionally argillaceous with a thin interbedded of claystone and limestone.

- -Wire-line-log characteristics: the top of the Upper electrosequence was located at a distinct gamma log break to lower average values than for the overlying marly Aleg Formation. This Upper electrosequence is characterized by a serrated gamma and sonic logs profile reflecting the interbedded nature of this unit.

B – El Jem area:

The Bireno Member in Well P1 (68 m thick) is subdivided into two lithologic units' which corresponds respectively to the Lower dolomite Bireno Member and the Upper bioclastic limestone Bireno Member (Fig.15).

B1- The Lower Bireno electrofacies

- Lithology: The dolomitic Bireno Lower Member which is very finely to coarsely crystalline, is dark grey to dark brown. Ghost bioclasts and grains within the dolomite

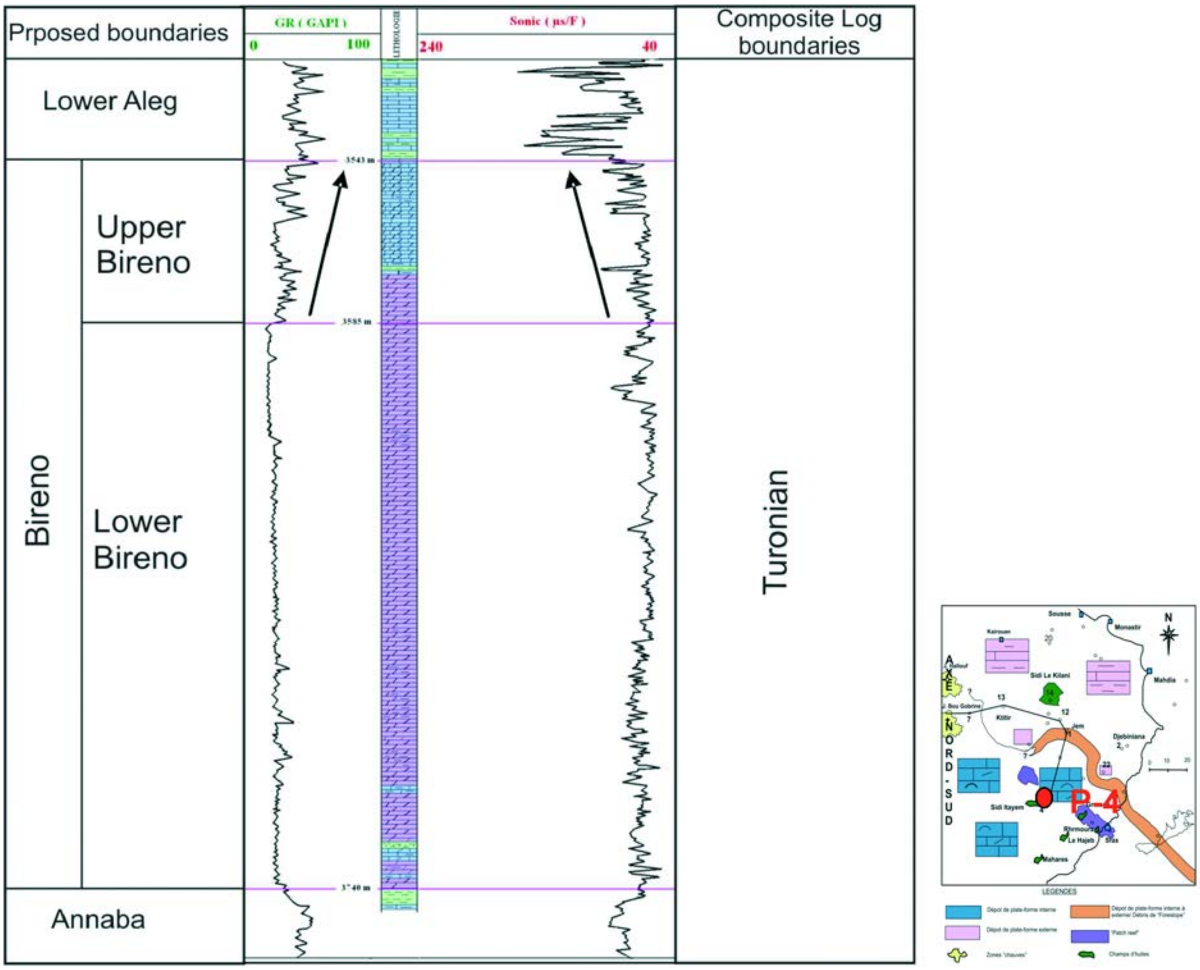


Figure 14: Electrofacies analysis within the Bireno Member in Sidi El Itayem Area

include echinoderm fragments, bivalve fragments, rudist fragments, bryozoa fragments, solitary scleractinian coral fragments and peloids.

-Wire-line-log characteristics: According to the combination of Wire-line logs (GR, Sonic, Density (RHOB)), the dolomitic Bireno Lower Member can be subdivided into two subunits named (B1) and (B2) respectively corresponding to the calcareous Lower section and the dolomitic Upper section.

***The calcareous Lower section (6 m thick) is characterized by a high gamma-ray and density values and a low sonic velocity values. These characters deal with a deep water mudstone to wackestone environment that had previously been considered as transition between Annaba Member and Bireno Member. The high density values marking the lower porosity.

***The dolomitic Upper section (17 m) shows a high fluctuation in density curves which reflect a good reservoir quality with values of porosities ranging from 10% to 25% (intercrystalline porosity).

Paleoenvironment: According to well preserved textures mainly represented by packstones and grainstones, carbonates appear deposited in a shelf environment characterized by a high energy peri-shoal or peri-reef setting. The rudist and coral fragments most likely reflect detritus from isolated "patch reefs" or carbonate platform edges.

B2- The Upper Bireno electrofacies

- Lithology: The Upper bioclastic Bireno Member is classified as a packed biomicrite and biosparite (intraclast – peloid - bioclast rich packstone with local wackestone and grainstone) interbedded with a picked argillaceous biomicrite (intraclast - peloid - bioclast rich packstone to wackestone).

- -Wire-line-log characteristics: this intercalation is well represented by the density curves (RHOB) where the reservoir bioclastic level is slightly thicker and more interbedded with non porous packed biomicrite.

Paleoenvironment: the occurrence of calcispheres, echinoderm fragments , pelecypods, mollusc fragments, green algae, coralline red algae, scleraction, coral fragments, bentonic

foraminifera and rare planktonic foraminifera and the presence of sedimentary features associated with bioturbation reflecting inner to outer platform marine environment.

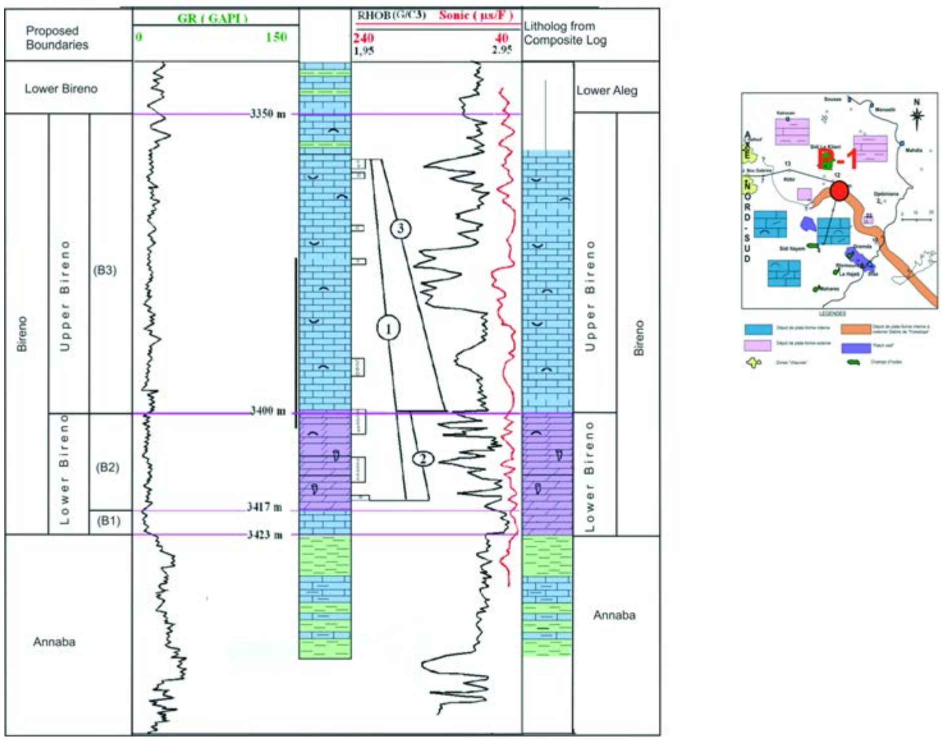


Figure 15: Electrofacies analysis within the Bireno Member in El Jem Area

V-1-2- Douleb Member

The Douleb Member, in our study area, appears more homogenous in facies than the Bireno Member.

A– El Jem – Sfax area:

The Douleb Member is dominated by oolites and bioclasts with a local pelloïdal and oolitic wackestone containing abundant fossil fragments, calcispheres forams and milliolids locally occurence.

B – The North of Kairouan:

The Douleb Member in the Kairouan –Souassi area is not well differentiated and generally constituted by a chalky argillaceous limestone.

V -1 –3 Abiod Formation

The Abiod Formation (Campanian to Early Maastrichtian) is one of the major hydrocarbon producing reservoirs in Tunisia (i.e. Sidi El Kilani, Zinia, Tiref and Miskar).

It commonly consists of two micritic limestones members separated by a marly one. Whereas in Central East Tunisia, the Abiod formation is dominated by chalky limestone section with a thickness up to 500 m. In This case, the identification of three members is difficult to distinguish. For this reason, a new relation-ship was found between biostratigraphic subdivision (Bismuth, 1994; North Kairouan Permit) and electrical subdivision (KUFPEC, 1998; Sidi El Kilani field. The opportunity to identify a relation-ship between these two subdivisions has afforded a better understanding of the lateral evolution in Sahel area and could improve the procedure to interpret and calibrate well-log data within analogous facies observed in outcrops.

A– Sidi El Kilani area:

From bottom to top, four electrical units are recognized into the Abiod Formation, respectively corresponding to “U4”, “U3”, “U2” and “U1”. This case is observed in Sidi El Kilani – El Jem area (case studied: Sidi El Kilani (Fig.16).

A1- Unit “U4”

- Lithology: The Unit “U4” in well 14 (562 m thick) is dominated by limestones with a minor stringers of dolomites in the upper part.

-Wire-line-log characteristics: the presence of dolomite is detected by a high density values (D=2.71 G/CC) and the separation of density and neutron curves (neutron curve at left and the density one at right).

The Lower part shows low decrease in GR response and an increase in sonic velocity values reflecting the less interbeded of argillaceous limestone.

-Stratigraphy: This unit “U4” corresponds to the Lower Abiod including Globotruncana elevata and G. stuatiformis zone.

A2 - Unit "U3"

- Lithology: the unit "U3" (55 m thick) consists of limestones with minor interbeded of claystones and shales.

-Wire-line-log characteristics: this unit shows the following electrical characters:

- decrease in GR values
- separation of neutron /Density curves (Density curve at right and Neutron one at left)
- low resistivity values (DDL : Deep Laterolog)
- Stratigraphy: this unit "U3" corresponds to Middle Abiod including Rosila subspino (Salaj, 1985).

A3- Units "U2"and "U1"

- Lithology: these two units consist of chalky limestone, white to cream and generally firm.
- Wire-line-log characteristics: The only difference between these units is the clay content. The "U2" Unit represents the transition facies to upper unit "U1".
- Stratigraphy: these two units correspond to the Upper Abiod including Globotruncana arca biozone and Glotruncana ventricosa biozone (Bismuth, 1994).

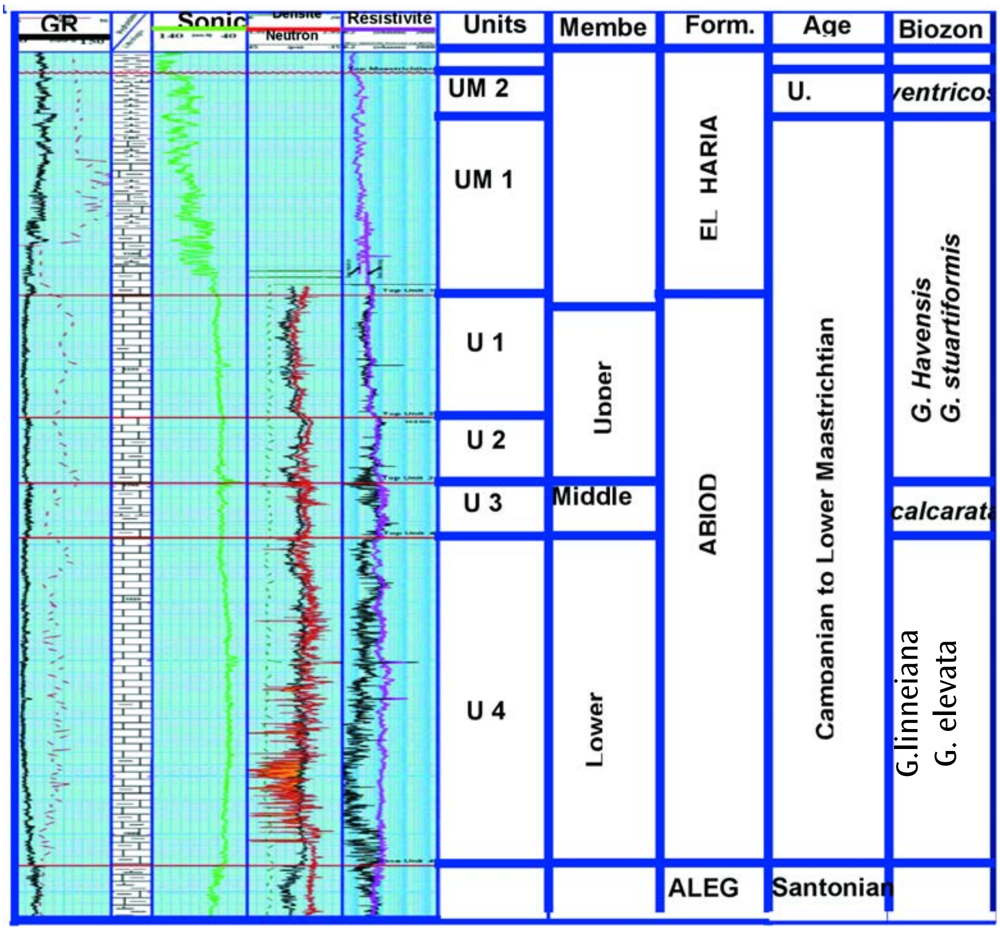


Figure 16: Stratigraphic and electrical units correlation within the Abiod Formation in Sidi El Kilani area (Well 14)

B– El Hdadja area:

Electrologs show very important values changes within these four units. This variation is due to the position of well over paleohigh or basin. For example, in well 18 which crossing the El Hdadja basin, we noted a high GR values (GR= 10-20 API, normally 10 API <GR>0.5 API)

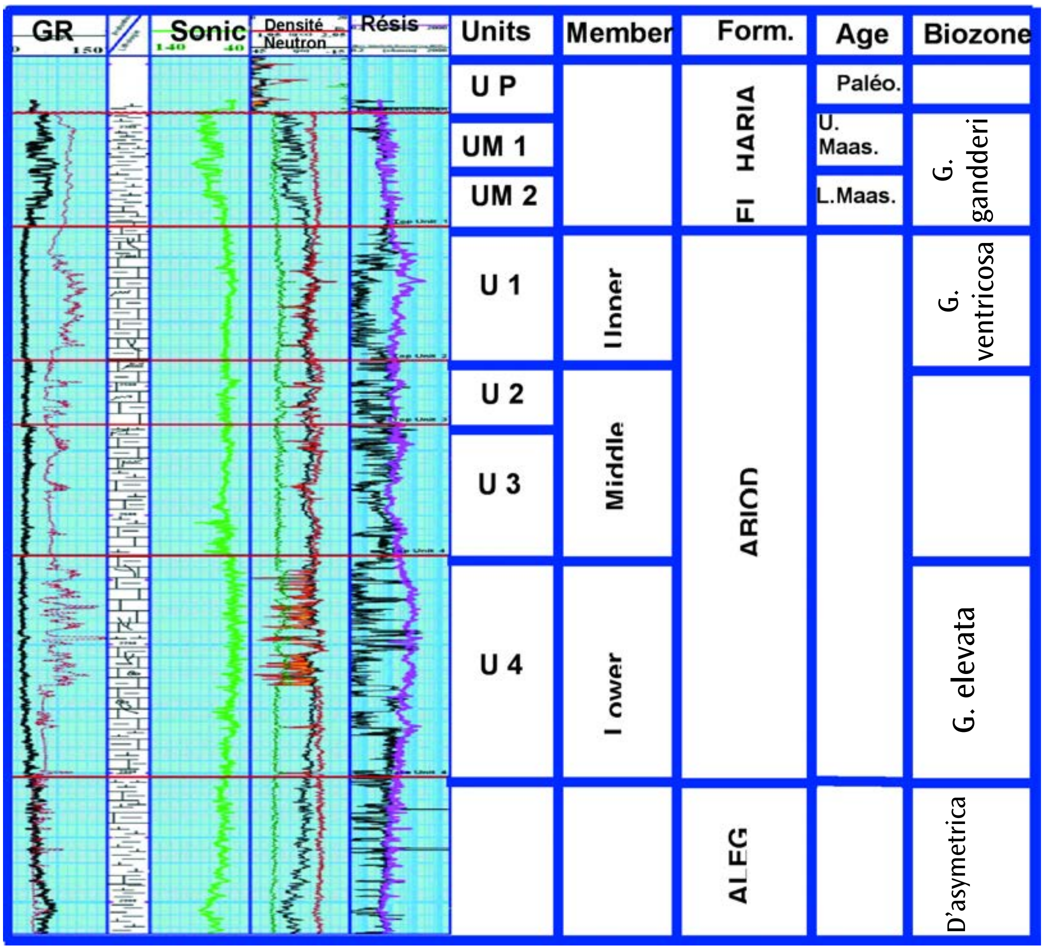


Figure 17: Stratigraphic and electrical units correlation within the Abiod Formation in El Hdadja area (Well 18)

C– North Kairouan and Sfax-Kerkennah areas:

In some cases, the Abiod Formation is represented by two particular electrofacies signatures. The first one corresponds to the classic Abiod which is constituted by two limestone Members separated by a marly Member. This case is very frequent in North-South Axis outcrops (Negra, 1994)

The second one which is represented by one limestone unit could correspond to Upper Abiod, Lower Abiod or the three Members associated in an only one Member. We propose two hypotheses for this particular case:

*Hypothesis 1: carbonates of the lower Member laterally changes to marls. In that case, the Abiod is represented by its limy Upper Member and the majority of limestone section can be corresponding to Upper Abiod Member (Fig. 18). The typical section crops out in Jebel Sidi Khalif South (Negra, 1994).

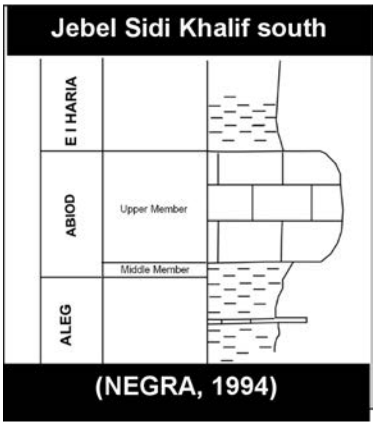


Figure 18: **The Abiod Formation in Jebel Sidi Khalif (South section; Negra, 1994)**

* Hypothesis 2: the Upper Member unconformably overlains the Upper Aleg marls. This electrical signature can be correlated with some outcrops of North-South Axis (Jebel El Abiod, Jebel Touila and Jebel Nara; Negra, 1994).

V -2 – Relation-ship between sedimentary facies, electrical response and reservoir potential:

A relation-ship between sedimentary facies, log signature and reservoir potential which was established into Bireno Member and Abiod can be summarised in tab. 1 and tab. 2.

Sedimentary characters				Electrical Log	Reservoir properties			
Disturbed area	environments	Lithology	Log		Shale Volume (%)	Porosity Ø (%)	Type of Porosity	K (md)
Sfax area P25 (Onshore)	inner platform peritidal	Dolomitic limestone + Anhydrite			2.2 - 15.53 0 (Anhydrite)	12.42- 19.65 0 (Anhydrite)	intergranular	9.31-14.87
	Middle platform to platform edge	Limestone (P,G, W)+large fragments rudists, corals and echinoderms			0.18 - 10.17	14.21 - 20.44	interparticle	2.12-24.08
	inner to outer platform	Lime mudstone slightly dolomitic argillaceous			0 - 12	0 -1.5		Very Low
	Middle to outer platform	Lime M grades to W interbedded with G			0- 0.3	0 - 3	interparticle	Low
E L Jem area P1 (Onshore)	Inner to outer platform Foreslop deposional	Limestone (biomicrite and biosparite with intraclasts, peloids, bioclasts P, locally W and G			0.6- 3.2	9 -17.6	Vuggy Intergranular Fracture	Low
	perishoal to shelf	Dolomite:Ghost bioclasts and debris of echinoderms, bivalve rudists, corals and peloids			0.18 -1.2	>20 (11.8)		0.43
Sidi E l Itayem area P4 (Onshore)	Inner Platform	Dolomitic limestone, occasionally argillaceous with interbeds of thinly bedded clay limestone			0 - 22.2	very low		very low
		Dolomite or calcareous dolomite with thin marlstone interbeds			0 - 14.28	low		very low
Magrouba area P22 (Onshore)	Outer platform to basin	Limestone, micritic, argillaceous, with thin interbeds of a dark claystone			3.8 - 7	9 - 12 11.13	intergranular	<0.01

Table 1 : Relation-ship between sedimentary characters, log signature and reservoir potential within the Bireno Member in El Jem - Sfax area

Sedimentary characters				Eectrical log	Reservoir characters				
Area	Environments	Lithology	Log	GR 0 100	Volume of Shales	Porosity (Φ %)	Fracture Intensity	Fracture types	K (md)
Sidi El Kilani P-14 et P-15 (Onshore)	Outer -shelf	A (7 m -10 m) Chalky limestone, Mudstone to Wackestone B (0.8 m - 4 m) Argillaceous chalky limestone, mudstone		A B A	0, 4 - 2,7 % 4 - 8 %	19 -27 (22,7)	(+) (-)	Open (1 to 2 cm)	Good ↓ Drainage
El Hdadja P-18 (Onshore)	Outer-shelf	Argillaceous chalky limestone, mudstone with interbeds of thinly bedded clay limestone			20 - 30 %	> 5 % (13 %)	(+)	Filling by calcite or by other mineralisa-tion	Low to Moderate ↓ Low Drainage
Selekta P-24 (Offshore)	proximal Outer-shelf	Campact chalky limestone			0 - 0,3 %	Very low	(-)		Very low ↓ Low drainage
Chorbane P-12 (Onshore)		Dolomitised limestone				10,1 - 13,2	0,1 fracture/ m	Open to partially open	0,74 - 0,76 (< 1 md)

Table 2: Relation-ships between sedimentary characters and reservoir potential within the Abiod Formation

VI – FACIES EVOLUTION THROUGH THE UPPER CRETACEOUS AND SUBSIDENCE ANALYSES:

VI-1- Well –log correlation

The correlation of well logs with outcrops have provided a means of better visualization and understanding the extension of reservoirs in subsident basins. For this reason, many cross well –correlations through the Upper Cretaceous facies was undertaken in many directions in our study area.

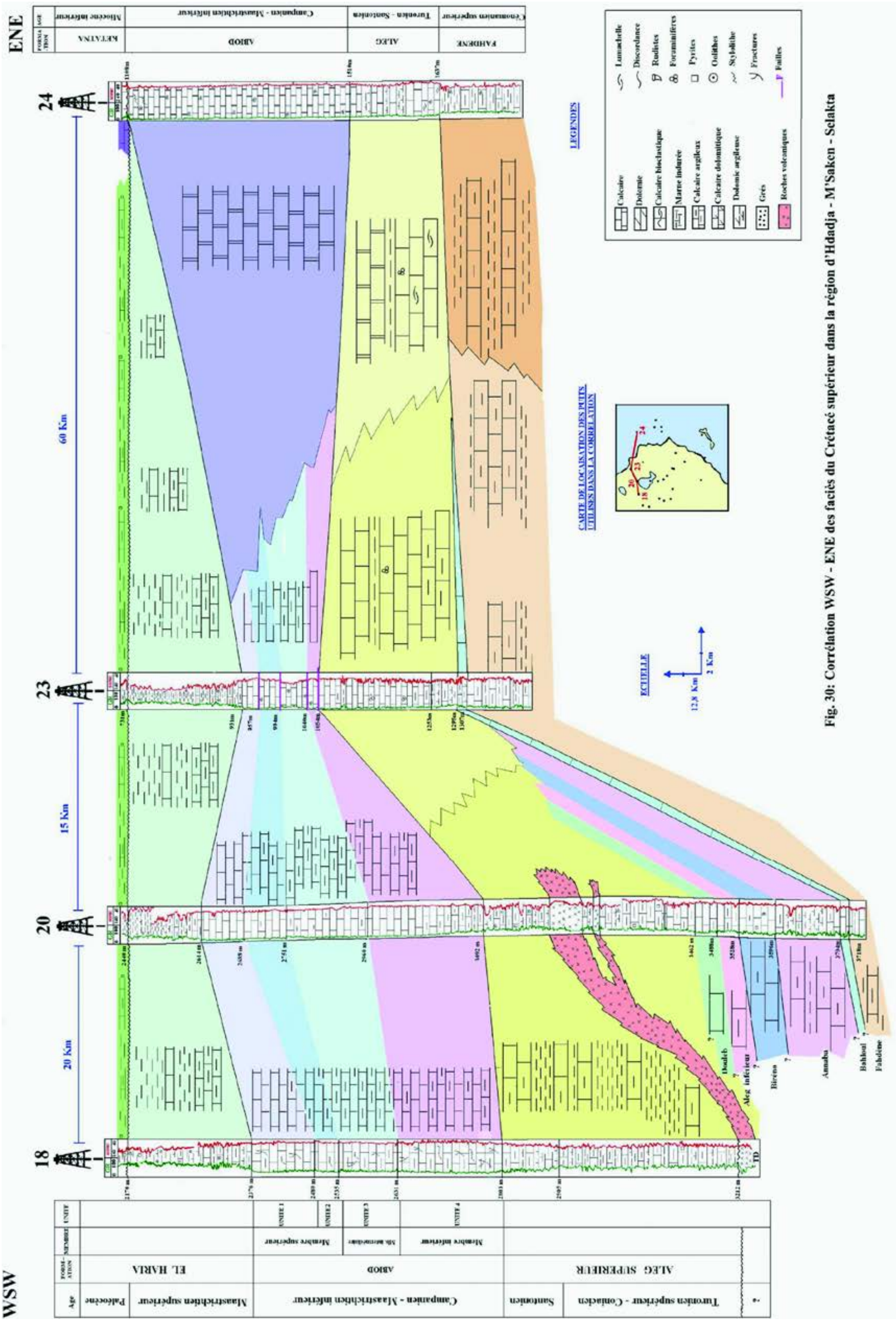


Figure 19 : Well-log correlation through the Upper Cretaceous facies in the El Hdadja-Sousse area

The well log E-W cross section in the El Hdadja- Sousse area shows the following facts: (Fig. 19):

- The Aleg formation thickness considerably increases from the East in Selekta well (127 m) toward the West in El Hdadja well (626 m). This thickening could be in relation with a deepening of the deposition environment. Indeed, the Aleg formation which is constituted by a blocky limestone in Selekta area laterally changes, toward El Hdadja, to marls (results confirmed by increase in GR values).
- The Abiod formation is very thick through all sections excepted in M'Saken area. In fact, toward El Hdadja, limestones are characterized by a relatively high content in clays. In addition, volcanic material evidence, could confirm the depressed character of this area which appear to act as a subsiding trough during the Late Cretaceous. However, toward the East (Offshore), facies are clearly shallower.

Data collected from the Selekta well confirm an uplifting within this area.

VI-2- Isopach map of the Abiod formation:

The isopach map of the Abiod Formation provides the following interpretations: (Fig.20):

- Two depressed areas, oriented North-South respectively occupy the Sidi El Kilani area and the Maamoura area. The main depocenter is identified around the Sidi EL Kilani field (Sidi El Kilani -1 well) where more than 600 m of pelagic sediments are deposited. This area is considered as a subsiding trough oriented E-W and related to the main fault of Sidi El Kilani, oriented N140 and also showing numerous multidirectional ramifications.
- Toward the North (Gulf of Hammamet) numerous emerged areas reflect an irregular topography which is mainly expressed by highs and subsident basins. However, the Southern part (Sfax –Kerkennah area), is characterized by thinner series and less subsident sectors. Locally, emergence and volcanic activities are obvious. Volcanic activities appear to occur preferentially along E-W, N-S and NW-SE accidents.

VII- CONCLUSIONS:

The main conclusions drawn from the study of the Upper Cretaceous carbonatic facies in Central –Eastern Tunisia are summarized as follows:

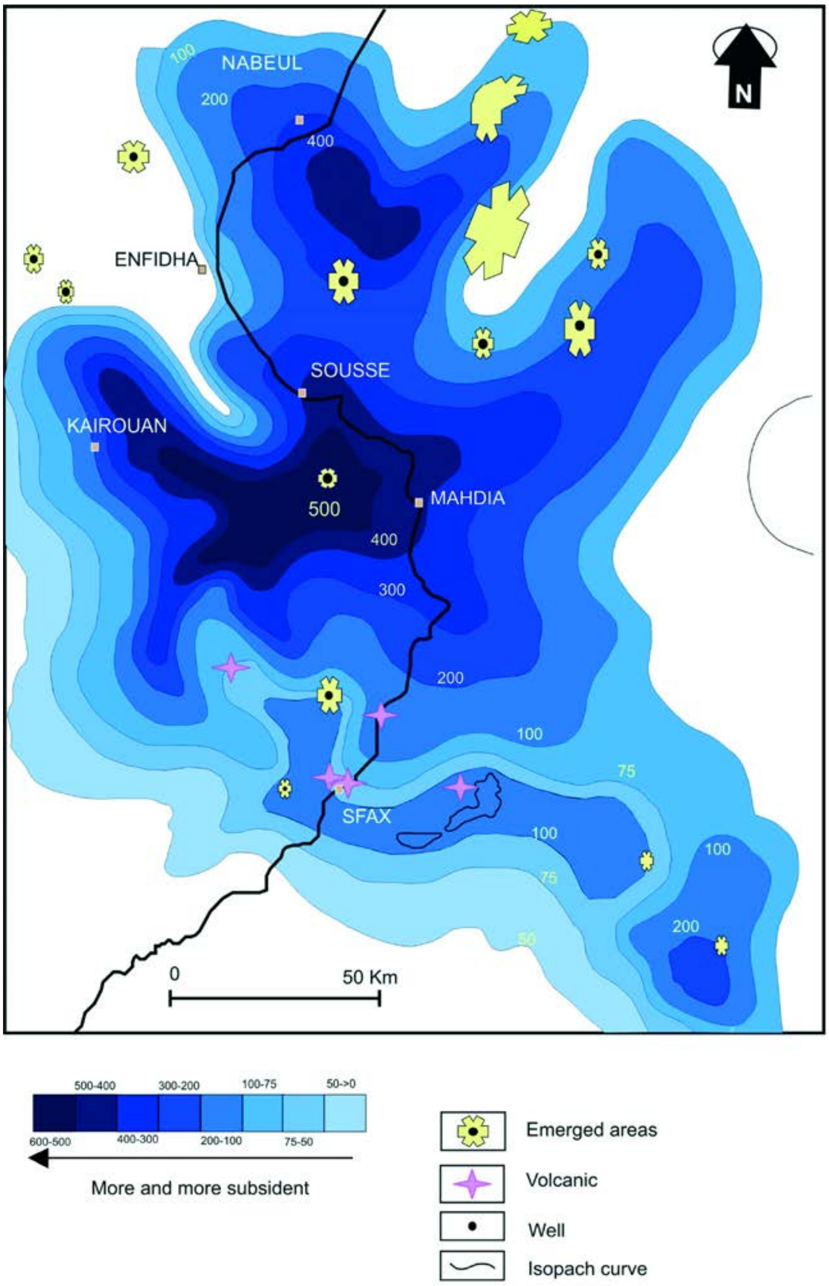


Figure 20: Isopach map of Abiod Formation in Eastern Tunisia

1. Within the Bireno Member, three units (B1), (B2) and (B3) are identified. Laterally, facies are globally homogenous, excepting a variation concerning their diagenesis, especially dolomitisation.

2. The Douleb Member appears more homogenous in facies than the Bireno Member. In fact, facies are rich in oolites and bioclasts in El Jem –Sfax area. However, in North Kairouan area facies change to deeper facies corresponding to argillaceous chalky limestone.

3. within the Abiod Formation, the Lower Member and the Upper Member appear deposited on a clearly irregular topography mainly expressed by numerous highs (such as

horsts) separated by basins (such as grabens, half-grabens)). However, the Upper Abiod, relatively more homogeneous in facies appears deposited on a relatively regular palaeotopography, probably during the deposition of the Middle Abiod marls.

Certain areas, such as Sidi El Kilani-Souassi-El Jem area, seems relatively subsiding. This subsidence could be related to synsedimentary tectonic movements. These areas offer a particular interest in terms of hydrocarbon plays, in relation with the existence of thick reservoir rocks. However, in Ktitir area, for example, facies thicking is probably in relation with a deepening of the deposition environment.

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