Sedimentological and sequential analysis of the deposits of upper tortonian within the basin of el ma labiad, tebessa (algero-tunisian borders)

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Abstract

The authors' works concern the sediments of the upper part of Tortonian within the basin of El Ma Labiad located at the southern part of Tebessa city, belonging to the eastern saharian Atlas mountains chain on the Algero-Tunisian borders.

The sedimentological analysis, carried out on 120 samples, has confirmed a downlap development structures towards the West of the basin. These analyses have also proved the presence of a detrital continental sedimentation of four environments characterized by the river, delta, lake and marsh materials.

The petrographic and morphological analysis reveal a clastic sediments essentially quartz-bearing interbedded by some argillaceous intercalations, and a far-off water transport of an origin probably saharian.

Key words: El Ma Labiad basin, Tortonian, sequential analysis, Sedimentology, NE of Algeria.

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التحليل الرسوبي والمتوالي لتوضعات التورتونيان الأعلى في حوض الماء الأبيض، تبسَة (الحدود الجزائرية – التونسية)

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الملخص

يعنى هذا البحث بدراسة التحليل الرسوبي والمتوالي لتوضعات طابق التورتونيان الأعلى (upper Tortonian) العائد إلى عصر الميوسين في منطقة حوض الماء الأبيض الواقعة جنوب مدينة تبسة في الشرق الجزائري التابعة لسلسلة جبال الأطلس الصحراوي الشرقية على الحدود الجزائرية التونسية.

بيّنت الدراسة الرسوبية التي أجريت على 120 عينة مختارة تطور النمط الرسوبي التنازلي (down lap structures) في اتجاه الناحية الغربية من الحوض. كما بيّنت التحاليل المخبرية وجود رسوبيات حطامية قارية موزعة ضمن أربعة أنماط رسوبية متمثلة في البيئات النهرية والدلتاوية ثم الشاطئية المغلقة لتنتهي بالبيئات المستنقعية.

هذا وقد أوضحت التحاليل البتروغرافية والمورفولوجية للرسوبات سيطرة فلز المرو (الكوارتز) مع وجود قليل من الفلزات الغضارية المتزايدة في نسبتها نحو الأعلى، كما أكد ت كذلك أنها قد تعرضت لنقل مائي مسافات طويلة، وأنها ذات مصدر صحراوي محتمل.

الكلمات المفتاحية: حوض الماء الأبيض، التورتونيان، التحليل المتوالي، الترسيب، شمال شرق الجزائر.

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1- Introduction:

The area of study (Fig. 1) is located between 8° 12' - 8° 15' of longitude East and 35° 12' - 35° 18' of latitude North (Durozoy, 1956). It corresponds to the higher part of Tortonian of El Ma Labiad basin, within the algero-tunisian borders (fig1). The sediments of detrital origin are deposited in angular unconformity on the Cretaceous formations and are on the top of a ferro-siliceous crust of continental weathering which separates them from the older miocene sediments.

The Tortonian age of the azoic sediments in question, was allotted by analogy of lithological position with the Miocene's sediments of Mechta Remila and Koudiat Naga in the north of Tebessa, where the micropaleontologic analysis, determined by N Van Ngoc (1995), has proved an age of Langhian-Serravalian to the lower part of the ferruginous crust of continental weathering and Tortonian to the top of this one.

2- Materials and methods:

The work was applied on approximately 120 samples, distributed on two profiles of which one is in the named eastern part –Tenoukla Bordj- (table N°1) and the other in the named western part -Tenoukla Col- (table N°2). The sedimentological and sequential analyses repose mainly on the observation in the field (in particular sedimentary structures and limits between sequences), the detailed grain size analysis at the laboratory (Vischer 1969), the environments of sedimentation and the sedimentological coefficients. The observations in the field for macrofauna and the micropalaeontological analyses at the laboratory were also taken for study, however the results have proved an azoic field.

3- Previous works on the Miocene's series:

The first observations established on the Miocene's sediments of the surroundings of Tebessa were given by A. Gaudry (1897), which described, close to Khenchela in the south of Hammam Salihine, a layer of conglomerate with *Moerithernium trigonon ANDEWS*, which confirms the age of lower Miocene. This conglomerate, with large and rounded elements of rollers, is deposited on the folded sediments of the Cretaceous.

A. Brives (1919, 1920) on the lucky find of a tooth of *Dinotherium*, allotted to Miocene, found in the sand pit of El Kouif. More recently, C. Arambourg (1952) (*in Dubourdieu, 1956*) allotted these series to lower Miocene.

G. Durozoy (1956) had determined, in the geological map of Tebessa, without any palaeontological evidence, The lower (Burdigalian) and middle (Vindobonian) sandy Miocene, followed by the marly higher Miocene (Pontian).

F. Morel (1957) has found the print of *Ostrea crassissima LMK* within the carbonated rollers-conglomerates of the Djebel Derries located in the west of Djebel Belkfif at the north of Tebessa.

G. Dubourdieu (1956), has described, in a geological investigation of the Ouenza' area, the Miocene formations situated approximately at 8km in the North-East of the famous mine of iron layer. By macrofauna datation, this author summarized the Miocene sediments of this region in three series of Burdigalian, Helvetian, and Tortonian.

G. Dubourdieu and L Hottinger (1959) announced the presence of Miocene *Neoaveolina* in the Miocene Mesloula at Djebel Bardo.

J. L. Bles and J. J. Fleury (1970) have discovered, below the Miocene sand of El Kouif, a conglomerate composed of large rollers of the Eocene carbonated rocks (local material), which they regarded as lower Miocene.

J. M. Vila (1977) described, within the surroundings of Koudiat Mami, Argoub Zitoun and Koudiat er Rahia above the conglomerates of lower Miocene or the Cretaceous, the russet-red sandy limestones with algae. According to this author, it is about of the series of the sandy, glauconitic and intraclastic biomicrites. These limestones are of a nodulous aspect and often in big benches with remains of Melobesiaes, Bryozoaes, Pectinidaes and Barnacles, containing a microfossils allotted to lower or middle Miocene.

This same author has also supposed as the puddings, described by A.Gaudry (1897) (*in Vila, 1977 b*) close to Khenchela in the south of Hammam Salihine, are of an aquitano-burdigalian age.

W. M. Kowalski and al. (1995 a & b), have prearranged, instead of the macroscopic observations on the miocene sediments, the first sedimentological work on the area, which contributed, in spite of their insufficiency, to the development a comprehension of the miocene sediments within certain localities of the area.

Table n°1: Bordj Tortonian profile Sedimentological characteristics of the samples of the Tenoukla

N° Sp	Posit (m)	Dip	Md (µm)	Class	Rol %	Salt %	Susp %	Sed Env	N° Sp	Posit (m)	Dip	Md (µm)	Class	Rol. %	Salt %	Susp %	Sed Env
01	0.0	75°	200	B	2.0	70.0	28.0	D	36	130.0	"	260	M	0.2	59.8	40.0	D
02	1.0	"	300	B	0.6	75.1	24.3	D	37	140.0	55°	350	B	0.1	74.4	25.5	D
03	5.0	"	350	B	0.2	88.0	11.8	D	38	147.0	"	450	B	0.5	81.0	18.5	D
04	14.0	"	270	B	0.2	69.8	30.0	R	39	150.0	"	550	VB	0.3	88.0	11.7	D
05	18.5	"	–	–	0.0	0.0	100.0	Ma	40	150.0	"	380	VB	10.0	65.0	25.0	R
06	19.5	"	800	B	0.7	90.3	9.0	R	41	158.5	"	300	B	6.2	56.8	37.0	R
07	21.0	"	600	M	0.5	89.0	10.5	R	42	167.0	"	300	B	2.3	57.7	40.0	R
08	23.0	"	–	–	0.0	0.0	100.0	Ma	43	169.5	"	140	M	0.0	48.0	52.0	R
09	25.0	"	240	RG	0.4	57.6	32.0	R	44	172.0	"	320	B	0.5	69.5	30.0	D
10	26.0	"	–	–	0.0	0.0	100.0	Ma	45	182.0	"	500	B	0.1	81.0	18.9	D
11	27.0	70°	250	B	5.2	64.8	30.0	D	46	182.0	"	120	B	0.4	58.0	41.6	D
12	36.0	"	500	B	0.8	74.2	25.0	D	47	186.0	51°	410	B	0.3	79.0	20.7	D
13	37.5	"	270	B	0.1	71.9	28.0	D	48	194.0	"	470	B	0.7	84.0	15.3	D
13A	47.0	"	400	B	1.0	74.0	25.0	D	49	194.0	"	120	B	0.3	59.0	40.7	D
14	47.0	"	300	B	0.7	69.3	30.0	R	50	196.5	"	350	VB	17.0	64.0	19.0	D
15	55.5	"	180	B	0.2	64.8	35.0	R	51	200.0	"	490	B	0.2	81.0	18.8	D
16	57.0	"	140	B	0.3	57.0	42.3	R	51A	205.0		520	B	4.2	79.0	16.8	D
17	58.0	"	510	RG	1.1	92.0	6.9	R	52	205.0	"	390	B	3.0	57.0	40.0	L
18	61.0	67°	160	M	0.1	67.0	32.9	R	53	212.5	"	350	B	0.3	40.0	59.7	L
19	62.0	"	250	B	0.5	70.0	29.5	R	54	220.0	"	260	M	2.1	36.9	61.0	L
20	68.5	"	240	B	0.2	60.0	39.8	R	55	230.0	45°	–	–	0.0	0.0	100.0	Ma
20A	75.0	"	–	–	0.0	0.0	100.0	Ma	56	232.0	"	270	B	0.2	69.8	30.0	D
21	76.5	"	330	B	0.2	73.0	26.8	R	57	233.0	"	330	B	0.4	70.6	29.0	D
22	79.0	"	330	M	0.5	74.0	25.5	R	57A	245.0		420	B	0.5	78.0	21.5	D
23	80.0	"	330	B	0.4	75.0	24.6	R	58	245.0	"	360	M	0.1	54.0	45.9	L
24	81.0	"	300	B	0.1	76.0	23.9	R	59	256.0	"	210	B	0.4	39.0	60.6	L
25	82.0	"	380	B	0.4	68.0	31.6	R	60	259.0	36°	110	RG	0.4	31.0	68.6	L
26	89.0	60°	350	B	0.5	64.5	35.0	R	61	263.0	"	240	B	0.4	55.6	46.0	L
27	98.0	"	250	B	3.4	56.6	40.0	R	62	268.0	"	230	B	0.5	33.0	66.5	L
28	100.0	"	200	VB	3.0	57.2	42.8	R	63	273.0	"	140	B	0.4	51.0	48.6	L
29	102.0	"	250	AB	0.7	75.3	24.0	R	64	276.5	26°	300	B	0.4	38.6	61.0	L
30	108.0	"	200	M	1.6	70.0	28.4	R	65	278.0	"	160	B	0.0	0.0	100.0	L
31	108.0	"	200	M	0.1	76.0	23.9	D	66	278.0	"	–	–	0.0	0.0	100.0	Ma
32	114.5	"	320	B	0.2	81.8	18.0	D	67	289.0	"	–	–	0.0	0.0	100.0	Ma
33	119.0	"	400	B	1.1	82.0	16.9	D	68	303.0	"	–	–	0.0	0.0	100.0	Ma
34	121.0	"	–	–	0.0	0.0	100.0	Ma	69	316.0	"	–	–	0.0	0.0	100.0	Ma
35	123.0	"	260	M	0.7	54.3	45.0	D	70	329.0	"	–	–	0.0	0.0	100.0	Ma

Legend : B.- Bad, Class.- Classification, D.- delta, L.- Lake, M.- Medium, Ma.- Marsh, Md.- Median, Posit.- Position, R.- River, R.G.- Rather good, Rol.- Rolling, Salt.- Saltation, Sed. Env.- Sedimentary environment, Sp. - Sample, Susp.- Suspension, V.B.- Very bad.

Table n°2: Sedimentological characteristics of the samples of the Tenoukla Col Tortonian profile

N° Sp	Posit (m)	Dip	Md (µm)	Class	Rol %	Salt %	Susp %	Sed Env	N° Sp	Posit (m)	Dip	Md (µm)	Class	Rol. %	Salt %	Susp %	Sed Env
01	0.0	75°	400	B	0.9	73.1	26.0	D	26	33.5	"	500	M	0.1	76.0	23.9	D
02	3.0	"	700	B	4.2	70.0	25.8	D	27	34.5	"	140	B	1.6	69.2	29.2	D
03	4.0	"	310	B	0.2	70.8	29.0	D	28	36.5	"	320	B	0.4	33.0	66.6	L
04	4.5	"	800	VB	15.5	69.3	15.2	D	29	45.0	"	250	B	0.4	27.3	72.3	L
05	5.5	"	300	B	1.4	71.0	27.6	D	30	51.0	"	200	B	0.3	32.9	76.8	L
06	7.0	"	480	B	4.4	80.6	15.0	D	31	51.5	"	–	–	0.0	0.0	100.0	Ma
07	8.0	"	500	B	2.1	75.9	22.0	D	32	55.0	68°	320	B	0.9	86.1	13.0	D
08	9.5	"	310	B	0.2	69.0	30.8	D	33	58.0	"	320	B	0.2	86.7	13.1	D
09	11.0	"	390	B	0.1	68.1	29.8	D	34	65.0	"	400	B	0.4	87.7	11.9	D
10	12.0	"	600	B	8.5	71.3	20.2	D	35	70.0	"	420	B	0.1	89.0	10.9	D
11	13.5	72°	610	B	1.7	83.9	14.4	D	36	71.5	"	480	B	0.5	61.5	38.0	L
12	14.0	"	910	B	7.3	80.6	12.1	D	37	91.0	"	330	B	0.9	49.0	50.1	L
13	14.5	"	200	M	0.5	75.2	24.3	D	38	92.0	"	320	B	0.1	42.9	57.0	L
14	17.0	"	420	B	4.0	78.8	17.2	D	39	96.0	"	250	B	0.4	21.6	78.0	L
15	18.5	"	500	B	0.2	83.7	16.1	D	40	105.0	"	–	–	0.0	0.0	100.0	Ma
16	20.0	"	310	B	0.2	70.0	29.8	D	41	109.0	"	320	B	1.4	43.6	55.0	L
17	23.0	"	400	B	0.4	74.1	25.5	D	42	114.0	"	250	B	0.1	37.9	62.0	L
18	23.5	"	280	B	0.8	78.8	21.4	D	43	117.0	65°	–	–	0.0	0.0	100.0	Ma
19	25.0	"	400	B	1.2	79.7	19.1	D	44	126.0	"	320	B	0.7	46.9	52.4	L
20	26.0	"	260	B	0.4	74.0	25.6	D	45	131.0	"	–	–	0.0	0.0	100.0	Ma
21	27.5	70°	420	B	0.3	78.8	20.9	D	46	150.0	"	380	B	0.2	48.3	51.5	L
22	29.0	"	480	B	0.4	81.3	18.3	D	47	166.5	"	220	B	0.1	25.4	74.5	L
23	29.5	"	600	B	0.3	82.9	16.8	D	48	180.0	"	–	–	0.0	0.0	100.0	Ma
24	30.5	"	700	VB	9.2	75.0	15.8	D	49	200.0	"	–	–	0.0	0.0	100.0	Ma
25	31.5	"	260	RG	0.9	72.0	27.1	D	50	225.0	"	–	–	0.0	0.0	100.0	Ma

Legend : B.- Bad, Class.- Classification, D.- delta, L.- Lake, M.- Medium, Ma.- Marsh, Md.- Median, Posit.- Position, R.- River, R.G.- Rather good, Rol.- Rolling, Salt.- Saltation, Sed. Env.- Sedimentary environment, Sp. - Sample, Susp.- Suspension, V.B.- Very bad.

4- Results and discussions:

The sedimentological analyses, carried out on two profiles of upper Tortonian of the El Ma Labiod basin, confirmed a downlap structures mode deposits towards the west of the basin. This higher part of the Tortonian basin includes four types of sedimentary environments formed of detritus continental material which developed in riverwashes, deltaic, lake and marshy deposits.

The sequential analysis of the two profiles made it possible to define five elementary cycles. The lower part the profile reveals passages between river and delta sediments, which pass in higher part to those of lake and finally in marshy sediments. The sedimentary sequences with recurrence of several rhythms, and with hardened, perforated or gullied surfaces are primarily of order 3 (mesosequences).

A sequential correlation between the two profiles (Fig. 2), made it possible to prove the dynamism and the mode of the basin development, and also giving its lateral variation in sedimentary volume from the eastern to the western zones. This sequential correlation, inside the same basin, is of a paramount importance for the recognition of its geological history and consequently of its comparison to other adjacent basins (Kowalski *et al.*, 1995a and 1995b; Hamimed *et al.*, 2001) of the same or different age in order to give the various developments and sedimentological aspects of the study area.

The first two cycles, alternate in river and delta sediments (approximately 150m of thickness), are entirely developed in the Tenoukla Bordj profile, being located within the eastern part of the study area. At the base of the profile, appears a deltaic segment connecting with the summit part of the lower Tortonian sediments, therefore, there is always a downlap structures development towards the western direction of the basin.

The third cycle (50m) begins with a fining-up sequence of river sediments, only expressed in the Tenoukla Bordj profile, and then surmounted by a coarsening-up sequence of deltaic sediments, which make the base of the second profile located in the Tenoukla Col towards the west. Within this latter profile the deltaic sediments rest in angular discordance on the marly Emscherian sediments, therefore one note a development of downlap structures towards the west.

The forth cycle (40 m), which appears in lake sediments at the base and deltaic ones at the top is presented at the same time within the two profiles (Tenoukla Bordj and Tenoukla Col), however, it is with more important lake sediments in the first profile, and with those of deltaic sediments relatively developed in the second profile. Therefore, it is clear that the old sediments are always developed in the east than in the west where the recent sediments cover the old ones and exceed them.

The fifth cycle begins by the lake sediments and passes gradually to those of marsh. It is expressed in the two cited profiles above, however, it is much more developed in that located in the west where the lake sequences of the base are more important and the marshy deposit covers and exceeds greatly the eastern sediments of the Tenoukla Bordj profile, therefore a downlap development is repeated even in the upper part of the formation.

The petrographic and morphoscopic analyses show a silico-clastic sediment with rare argillaceous intercalations, and blunted and shining components. At the upper part the formation passes to a marshy facies with the mean intercalations of crystalline gypsum. One notes the sporadic presence of silicified wood, the rare spangles of muscovite, but, a total absence of feldspars, therefore a presumably far-off river transport of an origin probably saharian.

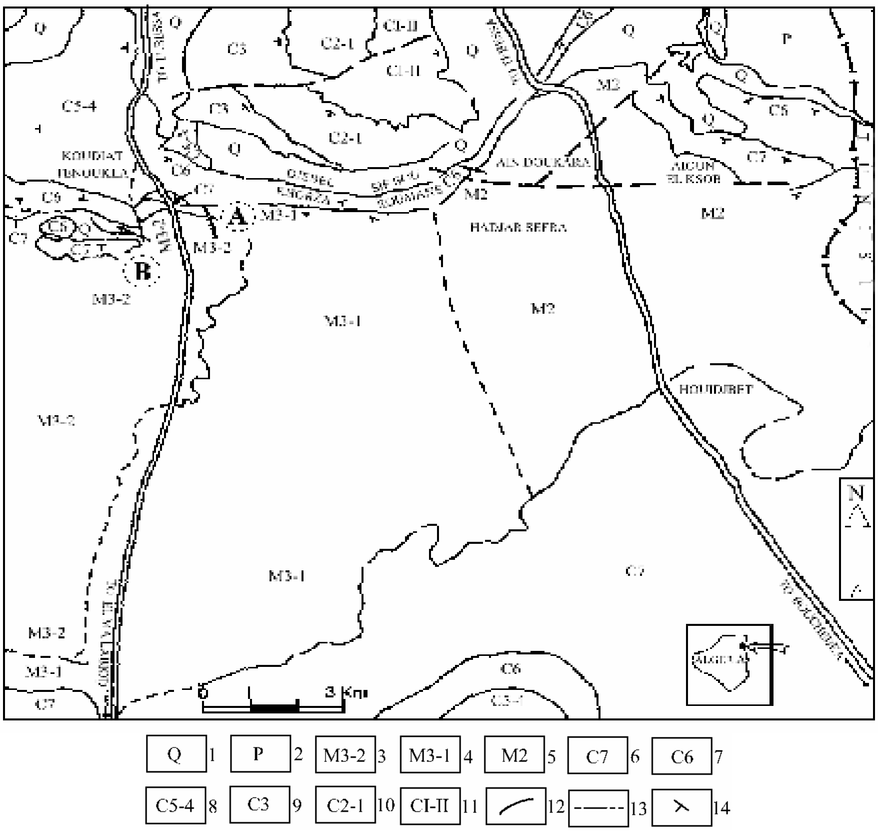

Fig.1: Geological draft of the area of El Ma Labiod (G Durozoy 1949 and 1956), Reinterpreted by the authors, and the position of the two profiles A and B

Legend: A-Profile of the Tenoukla Bordj; B-Profile of the Tenoukla col; 1-Quaternary (Q); 2-Pliocene (P); 3-Upper Tortonian: multi-coloured clays (M3-2); 4-Lower Tortonian (M3-1): sandstone with argillaceous intercalations; 5-Langhian-Serravalian (M2): sandstone; 6-Emscherian (C7): lumachella marls; 7-Turonian (C6): limestone (base) and marls (summit); 8-Cenomanian (C5-4): lumachella marls; 9-Vraconian (C3): black and marly limestone; 10-Albian (C2-1): grey limestone; 11-Aptian (CI-II): limestone (summit) and dolomitic limestone (base); 12- Geological contours; 13-Faults; 14-Dips.

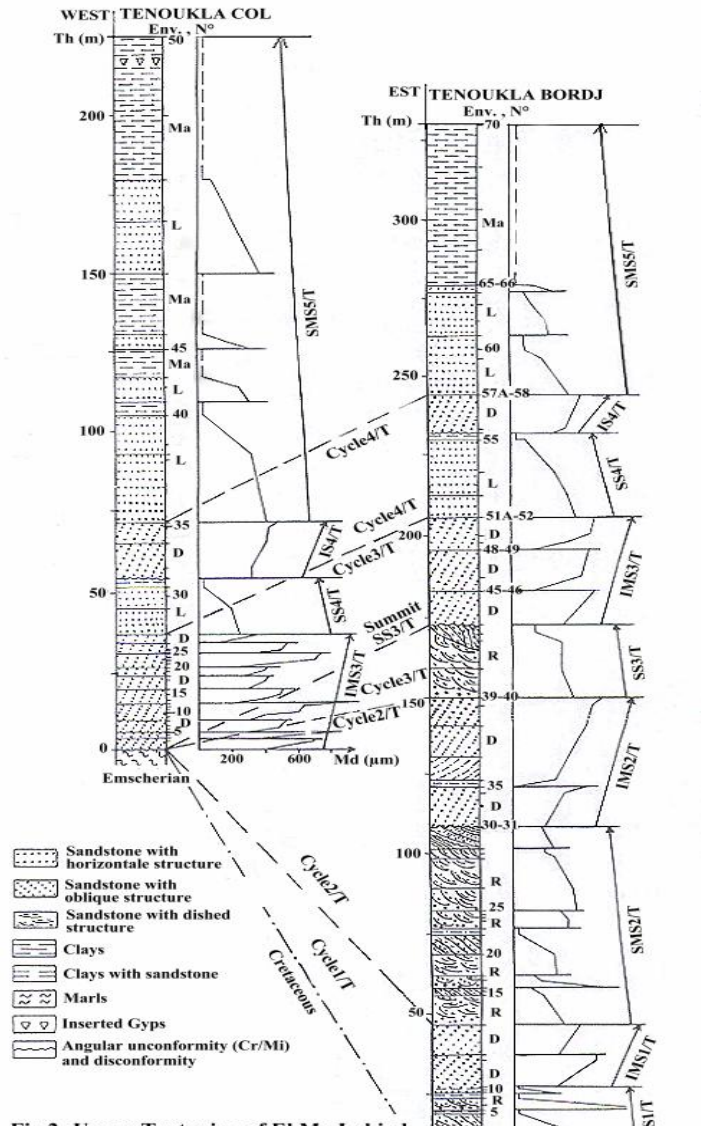

Fig.2- Upper Tortonian of El Ma Labiod basin (geological and sedimentological profiles, sequences and megasequences, and the sedimentation environments).

Legend: Cr- Cretaceous; D- Delta; Env- Environment; IMS- Inverse Megasequence; IS- Inverse Sequence; L- Lake; M a - Marsh; Md- Median in micron meters; Mi- Miocène; N°- Sample Number; R- River; SMS- Simple Megasequence; SS- Simple Sequence; T- Tortonian; Th- Thickness in meters.

5- Conclusion:

In conclusion, the sedimentological and sequential analyses have proved that the oldest sediments of the Tortonian basin are always more and more replaced by the more recent sediments which cover and exceed them towards the west, therefore a downlap development from the Eastern to the Western zones of the basin. The sequential analysis has also proved that the Tortonian basin subjected mainly to a sandy continental sedimentation passing to marshy one in the summit part of the profile towards the west of the basin. According to the recorded thicknesses and without counting the erosion phenomenon of this higher part of the basin, one notes that a continuous subsidence, becoming weaker towards the summit (marshy sedimentation), that subjected to this Tortonian basin exceeds largely that of the Langhian-Serravalian basin which is located towards the east until the algero-tunisian borders. The petrographic and morphoscopic analyses of the sediments confirmed a fluvial transport and a very distant origin, presumed saharan of the detritus material.

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