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A NEW CHRONOLOGY OF UPPER HOLOCENE AEOLIAN SANDS IN THE ZIBANS RANGE, ALGERIA

ABSTRACT: BENAZZOUZ M.T., *A new chronology of upper Holocene aeolian sands in the Zibans range, Algeria.* (IT ISSN 1724-4757, 2003).

The existence of a transatlasic acolian system through the eastern Saharian Atlas point out massive migrations of mobile sands from the High Plains in the North, to the Sahara desert to the South and confirm that in Algeria, there is not a progression of desertification from the Sahara toward the North. The age of these sand displacements is ancient and dates back to the upper Pleistocene and the Holocene. A new chronology of upper Holocene, supported by 12 new datings ^{14}C indicates variations of arid periods and humid periods. This new chronology caracterise an evolution stage since 4000 BP marked by the rapidity of paleoenvironments instabilities during the upper Holocene period through the Zibans range with the development of four sequences: a humid phase during 3300-3000 ^{14}C yr BP; an arid phase during 2900-2500 ^{14}C yr BP; a humid phase during 2400-2200 ^{14}C yr BP; an arid period between 2200 and 1650 ^{14}C yr BP dominated by incision of rivers where man's role became more and more higher. The present day remobilisation of sands doesn't justify an aridification of the climate.

KEY WORDS: Aeolian morphogenesis, Desertification, Upper Holocene, Eastern Algeria.

INTRODUCTION

The originality of landscapes of the algerian eastern saharian Atlas take piace here in the presence of dune fields within the chain, on reliefs and on all sides of the Saharien Atlas. The research of the origin and the age of these dunes, of their progression, will give us a better lighting for the understanding of mechanisms of the desertification that affects the Hodna basin and the Zibans range in north Algeria.

The discovery of an transatlasic aeolian system through the eastern saharian atlas shows massive migrations of sands from the High Plains in the North to the Sahara in the South and confirm that there is not in Algeria progress of desertification from the Sahara toward the North (Benazzouz, 2000).

The reconstitution of an evolution stage after 4000 yr BP confirms the speed of paleoenvironments instabilities through the eastern Algerian Saharian Atlas during Upper Holocène.

The aeolian transatlasic system or the Zahrez-Hodna - Zibans system

The large spatial extension of aeolian forms is integrated in an aeolian system which can transgress several reliefs, from the High Plains at the North to the Sahara crossing away the atlasic mountains (fig. 1).

The Zahrez aeolian system

In the High Plains of the west (fig. 1), the wind system is centered in the basin of the Zahrez, while developing a very long dunefield of 100 kms length and 3 to 5 kms large. This dunefield framed the Zahrez Rharbi and Zabrez Chergui to the East until the high valley of the oued Temsa situated at the westside of Bou Saada town.

The aeolian system of the Zahrez could have existed because the role piayed by the imposing Mountains of the Ouled Nail which develops 90 kms width in the North-south axis and culminated to more of 1000 meters of altitude. This imposing mountain facilitated the stopping of sands against northern slope while forbidding any kind of sand transit on tops and transfert of sand toward the South by the clearing of these reliefs (Trayssac, 1981; 1983).

The outflow of important volumes of these sands from the system of the Zahrez takes place at the East as impressive sand falls which cover completely the southern flank of the djebel Kenfoud (fig. 2).

So, these sand falls operate as a transfert of sand from the aeolian system of the Zahrez toward the Hodna-Zibans

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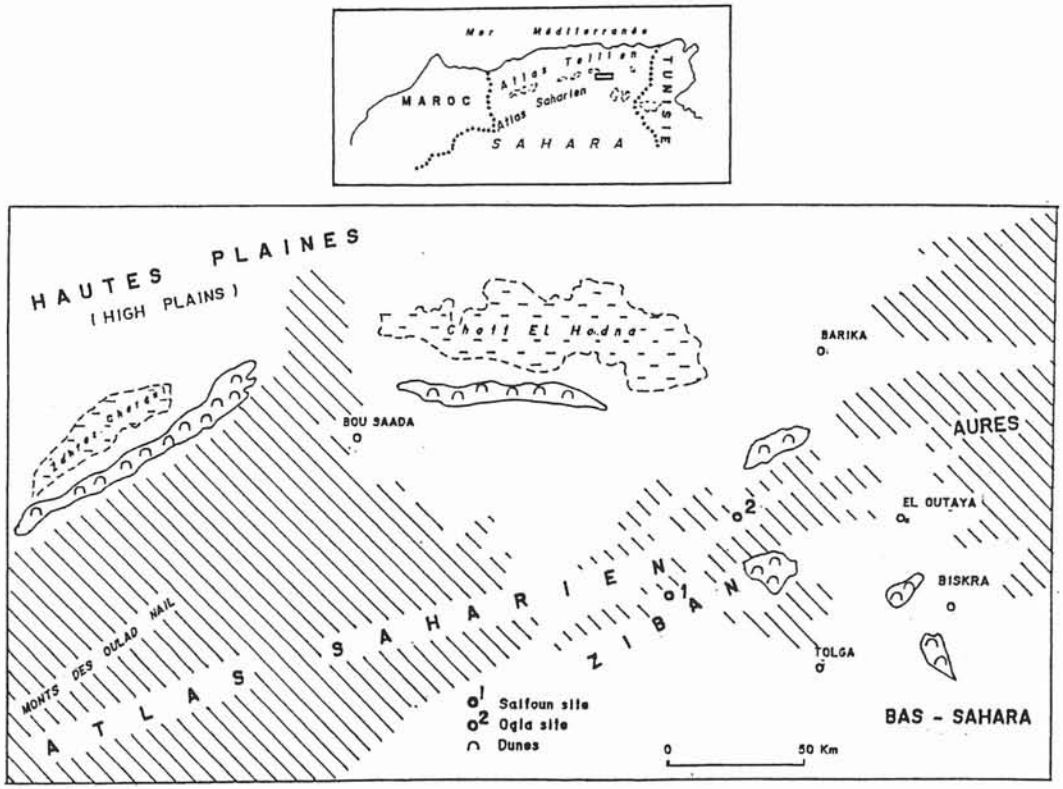


FIG. 1 - Location map.

system by the mobilization of these sands to the high valley of the oued Maiter to the East (Benazzouz, 2000).

The Hodna-Zibans aeolian system

In the Hodna basin, it exists two types of dunefields (Benazzouz, 2000):

- The erg of oued Maiter is organized in parabolic dunes which are oriented West-East and are covering a large band South-North of 20 kms longer and a width of 1 km.
- The dunefield system of the djebel Meharga lies down on 40 kms from west and develop a width of 2 to 4 kms.

While in the Zibans range, the impact of the aeolian flux represents on the surface of soil a zone lying down the

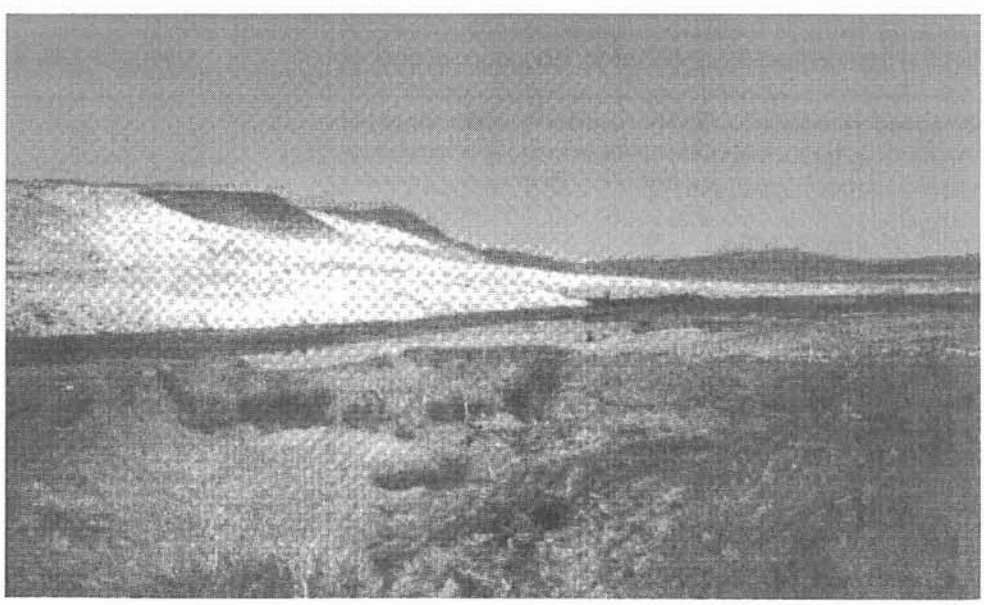


FIG. 2 - Sand falls as falling dunes, covering djebel Kenfound at the West of Bou Saada showing the emergency of sand from Zahrez aeolian system to the Hodna aeolian system.

Northwest toward the Southeast and that covers a length of 100 kms for a width of 50 kms (Benazzouz, 1996). Actually, one can follow on field the impact on the surface of this wind system to the South, towards the chott Merouane (Rebillard & Ballais, 1984).

The major differences between the two wind systems of the Zahrez and the Hodna appear through the following particular characteristics:

- The absence of the sand sheets in the Zahrez system inside the Ouled Nail'mountains whereas they dominate in the Zibans range.
- The widespread geomorphological imprints and advanced partition of the aeolian forms through the Zibans shows the absence of massive blockage effects on the atlasic mountain facing the direction of sand displacements.
- The presence of internal relay (sebkhas, depressions, aeolian plugs, oueds,) assuring the permanent supply in sands of the Zibans wind system (Benazzouz, 1993); these relays are necessary to the process of the transatlasic aeolian flux because they permit and facilitate the mobilization of sands from the North border of atlasic mountains to its southern margins, on the Saharian piemont.
- The absence of wind currents deviation in the Zibans:

Contrary to the Ouled Nail'mountains, the Zibans range are characterized by the existence of a perfect correspondence between the dominant wind direction, those of the Northwest and the general orientation of dunes according to the axis Northwest-Southeast.

At the end of this analysis, it appears that we are, in fact, in presence of two very distinct wind systems:

- The aeolian system of the Zahrez process under the influence of a *linear type obstacle,*
- The aeolian system of the Zibans is an *open sytem.*

The evidence of sand displacements first toward the East concerning the Zahrez, then in direction of the Southeast to the Zibans, don't mean the presence of long transatlasic aeolian migration toward the Bas-Sahara.

The age of wind sand displacements in the Zibans and the Hodna

The wind flow pattem are ancient enough and has occured many times in the past in the Zibans and the Hodna because one can reconstitute movements of sands and dusts at least since the beginning of Middle Pleistocene.

The formation 6 of red quartzy sands with chalky nodules is assigned to the Upper Pleistocene (Ballais, 1991).

Otherwise, these deposits with chalky nodules define, the general rupture in eastern Maghreb between the Middle Pleistocene and the Upper Pleistocene (Ballais & Ben Ouezdou, 1992).

THE SPEED OF PALAEOENVIRONRNENTS INSTABILITIES DURING THE UPPER HOLOCENE IN THE ZIBANS RANGE

The systematic investigatings on field through the Zibans range and the Hodna have leads to the discovery of new sites whose isotopics dates obtained reveal the existence of an evolution stage after 4000 BP in the Zibans range (Benazzouz, 1997) that will be specified by the analysis of sites of djebel Saifoun (fig. 3) and Oued el Ogla, situated in the plain at the south of the chott el Hodna (fig. 4).

The analysis of the sand ramp of the djebel Saifoun

The djebel Saifoun (788 m) is located to the west of Biskra town, in the central part of the Zibans range (fig. 1).

This intramountainous sand ramp is constituted by the superposition of three generations of fossil aeolian sands separated by two palaesols. The most complete stratigraphic log of sand ramp studied in djebel Saifoun (fig. 3) shows first, at the bottom the clear beige sand (7.5 YR 6/6) poor consolitated, one to 2 meters thick; these sands are strongly homogeneous by their grains size parameters (tab. 1) that confirm the presence of a fine sand and well sorted sand (fig. 4).

The geochimical analyses translate weak concentrations in Fe_2O_3, MgO, CaO, Na_2, K_2O, and a weak percent in Phosphorus. The mineralogical composition is balanced between the Kaolinite and the smectite in the respective proportions of 41,7% and 40,3%, the Illite only represents 17%.

The second sequence, central part of the trench, which are 0.70 to 1.20 m thick constitute the palaeosol which is dated to 3100 ± 55 years BP. This fossil soil is formed by sands greatly oxydized (5YR 4/5) and consolidated with small pebbles, fire stones and helix.

At the surface, morphogenesis seems to intensify over the upper windblown sands where a phase of breaching and erosion lightly degraded by the accumulation of pebbles on which the present mobile sands are accumulated.

This upper sequence seems to characterize the morphological evolution of the whole region despite the lack of the definitive and direct chronological criterias.

The paludal formations of oued Ogla

The choice of this site is justified by the conservation here of the terminal sequence of the aeolian plugs filling of all bottoms of valleys and plains of the Zibans range; these aeolian plugs are edificated by the paralyzed run-off in the Hodna from the North toward the Southeast in direction of the Bas-Sahara at the end of the Upper Pleistocène.

A set of sketch sections along oued el Ogla (fig. 5) and through small lateral ravines permit us to propose the following formations:

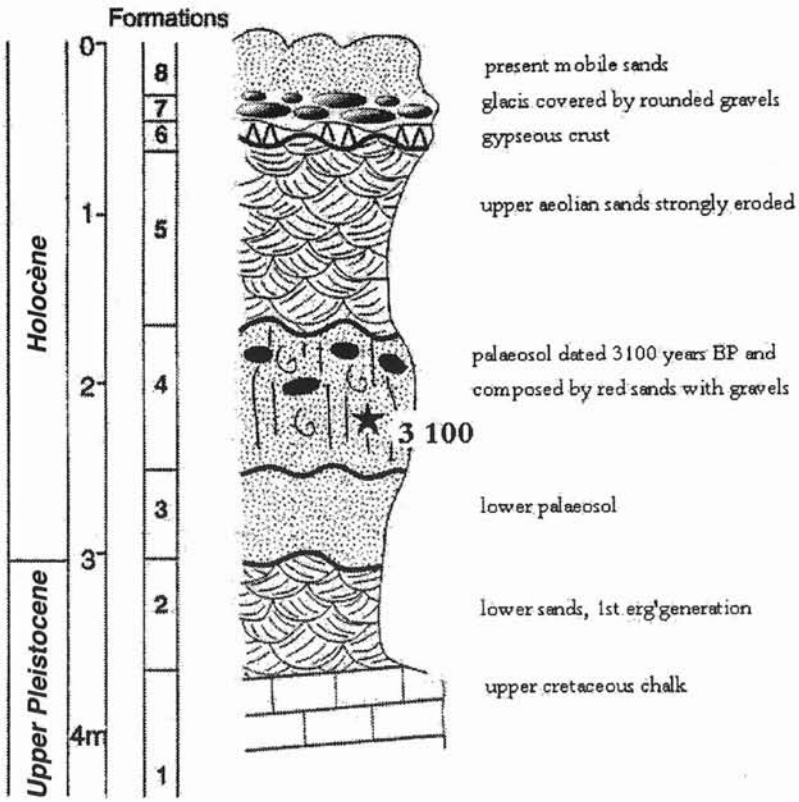
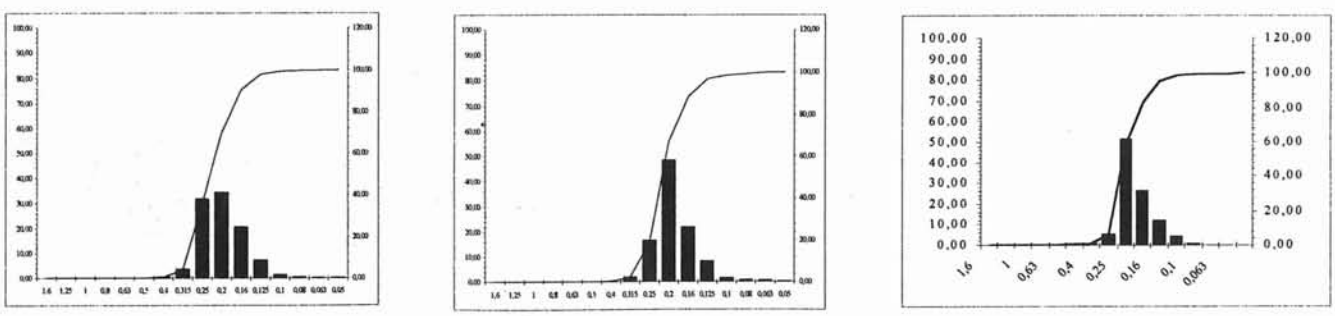


FIG. 3 - Stratigraphic log of djebel Saifoun'sand ramp.

- The base is formed by clays sandy gypsous with gley (7.5 YRS 6/5), and prismatic structure, 1.60 m thick, assigned to the ancient bottom of sebkha;
- The formation 4, with chalky nodules is covered by a gypsum crust well developed in trench at the terrace of oued el Ogla; in several points, we could have localized the outcrop in surface of brown clayey-sandy silts with chalky concretions nominated as: *formation 6* (in Ballais & *alii*, 1979).
- Over this gypsum crust the upper sequence of the oued Ogla represented the Holocene from the formation six with blackish paludal sands (10 YRS 4/3) and which contains *Helix*. The grain size parameters (tab. 2) show the presence of a well sorted and fine sand (leptokurtic). The grain size cumulative curve and histogram frequency confirm the presence of aeolian sand (fig. 6).
- The formation 7, with reddish sands occured at 2290 ± 60 y BP (Gif. 9871), datation done on land gasteropoda (shells of *Melanostoma helix*).
- On the surface and top of the sketch we can observe the deposition of pebbles and gravels as alluvium and colluvium attesting the presence of a glacis (Benazzouz, 2000).
- On the surface of the glacis, the mobile present sands are still in progress.



Lower sands (1st erg) - formation 2 | *Palaeosol dated 3100 BP - formation 4* | *Upper sands (2nd erg) - formation 5*

FIG. 4 - The particle-size distribution of the djebel Saifoun aeolian sand ramp as histogram and cumulative frequency.

TABLE 1 - Sedimentological analysis of the djebel Saifoun aeolian ramp sands

Indices samples	Median grain size mm	Mode mm	Mean grain size Mz	Sorting index So	Skew-ness	Kurto-sis	Coarse sand mm	Medium sand mm	Fine sand mm	Munsell color	Formations
					Modern sands						
4 a	0,257	0,250	2,02	0,30	0,35	0,92	0	82,40	17,60	10 YR 7/5	8
					Upper sands, 2nd generation						
3 b	0,244	0,250	2,09	0,35	0,30	0,95	0	76,40	23,60	7.5 YR 5/5	5 high
3a	0,259	0,250	2,00	0,31	0,30	1,00	0,20	83,20	16,20	7.5 YR 6/5	5 bottom
					Palaeosol dated 3100 BP						
2c	0,227	0,200	2,17	0,38	0,18	0,95	0	68,50	31,50		4 high
Saf 1 - 2b	0,217	0,200	2,24	0,34	0,19	1,24	0	66,8	33,20		4 center
2 a	0,217	0,200	2,22	0,38	0,12	1,00	0	62,02	37,98		4 bottom
					Lower palaeosol						
Saf. 1 - 2	0,240	0,250	2,13	0,45	0,22	0,97	0	68,67	31,33	7.5 YR 5/5	3
					Lower sands, erg of the first generation						
1 c	0,233	0,250	2,14	0,36	0,22	0,95	0	72	28	7.5 YR 6/6	2 bigh
1 b	0,245	0,250	2,09	0,36	0,32	0,96	0	75,40	24,60	10 YR 7/5	2 center
1 a	0,229	0,200	2,15	0,37	0,16	0,93	0	70,02	29,98		2 bottom

A NEW CHRONOLOGY OF AEOLIAN MORPHOGENESIS THROUGH THE ZIBANS RANGE AND THE HODNA BASIN DURING THE UPPER HOLOCENE

To the light of these analyses, we think to be in measure to propose a synthesis which detailed the holocene morphoclimatic evolution through the Zibans range and the Hodna basin. It exists very few datings in this space covering the Hodna and the Zibans range and among the rare, we reply the 2 main datings on helix published in the Zibans and indicating a humid phase between 6320 ± 120 yr BP and 4830 ± 120 yr BP (Ballais & *alii*, 1979).

Since, no new date avalaible nor published in the region; opportunitely, our research complete and precise more the morphoclimatic chronology of the region, this new chronology is argumentated by not less than 11 new local radiocarbon datings obtained on the ^{14}C by M. Fontugne in the Center of Weak radioactivities of the Laboratory mixed CNRS-CEA to Gif sur Yvette (France).

These datings are unpublished, because and for the first time, we could have dated some dry phases; the reasoning that we will use here is supported by datings ^{14}C no calibrated.

The interest of these results resides on the one hand, in the stake in evidence of transit zones where the recent phase development is strongly marked but also, to the unpublished discovery of news sketches in the Hodna and in the Zibans range.

Contribution of new isotopiques datings

A first group of five datings situated morphogenic events that stand in the period between 3300 BP to 2260 BP, whereas the different formulations of morphoclimatic evolution worked out by Ballais (1991) for the Zibans, don't include dates corresponding to this interval of the prehistoric Upper Holocene. This period is unknown because of the absence of aeolian forms or deposits in this area but also, the absence of published datings.

The evidence of a humid phase occured at 3300 BP - 3000 BP

It's about the stake in evidence of a humid phase that occured at approximatively 3300 BP-3000 BP through the Hodna and the Zibans range.

TABLE 2 - Sedimentological characteristics of the Oued el Ogla paludal formations

Indices formations	Median grain size mm	Mode mm	Mean grain size Mz	Sorting index So	Skewness Ski	Kurtosis K	Coarse sand mm	Medium sand mm	Fine sand mm	Munsell color
					Paludal black sands (Ogla 2)					
Formt. 6	0,181	0,160	2,49	0,59	0,01	1,36	1,65	33,81	64,54	10 YR - 4/3
					Red silty sands dated 2290 BP (Ogla 4)					
Formt. 7	0,194	0,160	2,36	0,62	– 0,04	1,21	1,26	44,77	53,97	5 YR - 6/5

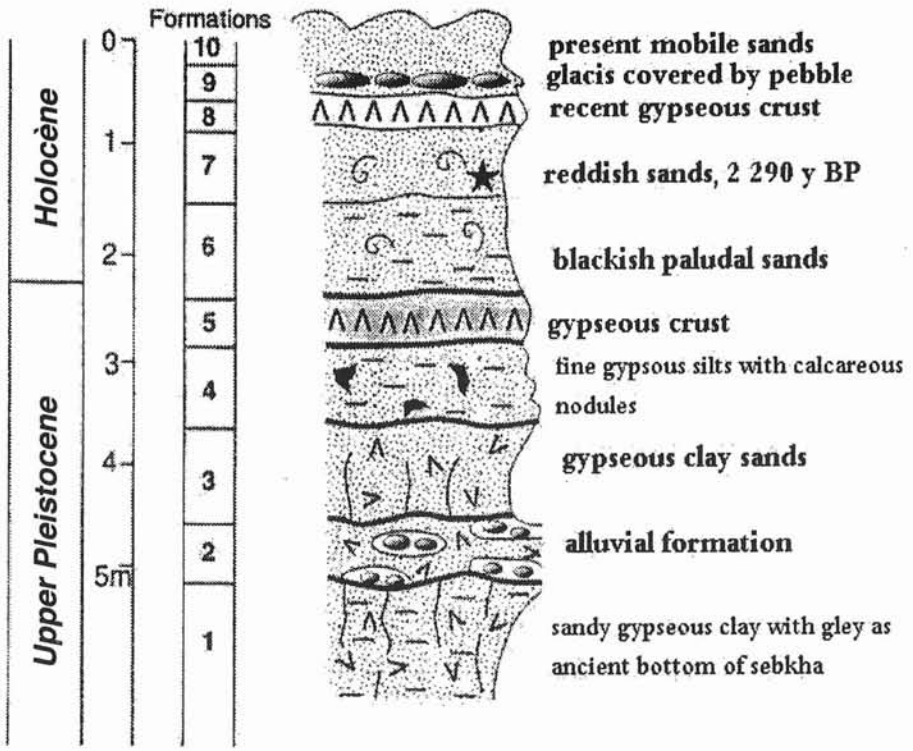


FIG. 5 - Sketch section of the paludal formation of Oued el Ogla.

In two different sites, one could bave dated 2 palaeosols, the first is formed at 3100 BP in the sand ramp of the djebel Saifoun, at the west part of the Zibans and the second, located at the East is occured at 3300 BP in the terrace of oued Selga Seghir (fig. 1) situated at the southern limit of the plain of El Outaya.

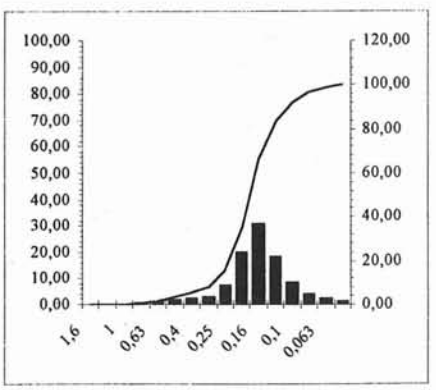
In fact, the beginning of the aridification is well admitted toward 4500-4000, and the last date (4000 BP) generally situate in time the extension of aridity in North Africa (Rans-Jurgen Bolle, 1996), but with some contradictions.

In the Zibans, it was a favorable period to pedogenesis attested by the palaeosol in the sand ramp of djebel Saifoun which occured at 3100±100 yr BP and of the accumulation of the terrace of the oued Selga-Seghir at 3300±70 yr BP.

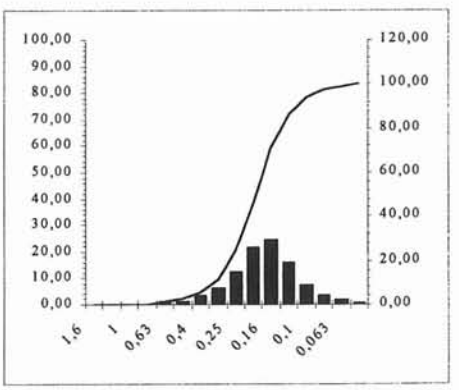
However this humid phase which we just detected in the Zibans and dated at 3300-3000 BP is important, because it confirms our hypotheses (Ballais & Benazzouz, 1994, p. 68) concerning a strongly fluviatile morphogenesis phase affecting alluvium depositions of the main lower terrace in the valley of oued Chéria-Mézeraa (Némemcha).

A dry phase toward 2900 BP - 2500 BP

A second group of three radiocarbon datings on the fossil windblown sands produce an identical age:



Formation (6) black sands, Ogla 2



Formation (7) red sands à 3100 BP, Ogla 4

FIG. 6 - Grain size cumulative curve and histogram frequency of the Oued el Ogla paludal sands.

- 2840 ± 40 yr BP: in fossil erg of djebel Sahbana, dated by radiocarbon on fragments of ostrich eggs
- 2790 ± S 95 yr BP: in fossil sand ramp of djebel Fozna, dated by radiocarbon on land gasteropoda (*Helix*)
- 2660 ± S 45 yr BP: in fossil erg of Fennd Baroud, dated by radiocarbon on fragments of ostrich eggs.

The interest of these direct chronological criterias reveal first the possibility of identification of the progressive drying of the climate at the prehistoric upper Holocene occured at 2900 BP - 2500 BP, then, and confirm here, the reconstitution of the holocene morphoclimatic evolution of the eastem Maghreb (Ballais, 1995, p. 332) with proposing some complements.

This dry phase is dominated by defiation but especially by the mobilization of windblown sands that announce the aridification of the climate.

The originality of the humid phase at 2400 BP - 2200 BP in the Zibans range

The existenee of a humid climatic phase is caracterised by:

- the deposit of sands at Helicella streamed between dunes of Grand Erg Oriental at Ksar Rhilane (Tunisia);
- by the accumulation of gyttja in the chott Rharsa in Tunisia (Ballais, 1992);
- by the fine alluviums along the Némemchas range (Ballais & Benazzouz, 1994).

The field geoindicators of this phase in the Zibans, bave been localized and dated in the site of Foum Zgag at the East of M'Doukal (Benazzouz, 2000), in upper part of the sand ramp that is gullyed strongly and covered by a glacis with pebbles and gravels.

This spreading glacis is well developped through the Zibans and the Hodna and marks the interruption of the previous arid period.

While, the end of this humid period seems more precocious here, with the deposition of reddish sand occured in 2290 ± 60 yr BP (Gif. 9871) which trenched paludar formations of oued el Ogla and could indicate a drier environment, premises of a period dominated by incision downstream and developped by 2200 BP to about 1650 BP, until 2nd-3nd century ap.J.C., where no deposit has been recognized (Ballais, 1995, p. 335).

Dating radiocarbone results, indicate here 2450 ± 40 yr BP (Gif. 9474) and corresponds to the minimum age of this humid phase identified in the Zibans and the Hodna (Benazzouz, 2000) and belongs to the historical late holocene characterised by the deposition of the lower low terrace body and its dissection as well as by desertification which particularly process at the 20th century by the remobilization of aeolian sands.

THE IDENTIFICATION OF MORPHOGENIC SUCCESSIONS

The Holocene and in particular, the Upper Holocene is characterized by the speed of the palacoenvironments instability.

The research of tendency from some rare palaeoenvironments criterias would be very useful to a better understanding of the present evolution in these regions of the Hodna and the Zibans.

So, our demonstration take in account, at the first place, the present period that is submitted to a phase of incision downstream.

Then, we search for in the holocene chronological succession of the similar holocene morphological phenomenon and try to characterize the type of evolution that they probably followed.

We could have put currently in evidence a morphogenic succession similar to the succession in progress, and we can situated approximatively 3500 BP - 2500 BP, which succession was applied to the context of the site of the Fourn ez Zgag sand ramp on the upper sequence of the sketch.

The analysis of this phase shows that this one starts by the stabilization of sands of the sand ramp and their fixing with the development of a glacis; followed by an episode of treanching the formation of glacis and the sequence finished by an intense deflation with accumulation of windblown sands.

Those morphogenics actions constitute a morphogenic succession that appears in the beginning by an increase of the humidity as intense and concentrated rains and finished in a dry ambiance of aridification of the climate.

If one considers the present period, it seems to start by the accumulation of the historic terrace: 1350 BP - 1470 BP or 610 BP (Ballais, 1992) followed by the cutting of this historic terrace and since some decades, the present remobilisation of sands with a strong defiation.

We have just proven that the present period writes down itself in a morphogenic succession that had taken place effectivety by the past no far, we are able therefore to consider conditions of evolution of the present morphogenesis provided that to integrate consequences of the anthropogenic geosystems.

The interest of morphogenic succession, stake in evidence in the Zibans confirms:

- The present remobilisation of windblown sands writes down itself in a normal morphogenic succession;
- The present remobilisation of sands doesn't write down itself in an aridification of the climate;
- The processes of desertification appears recently in the 20th century.

In a general way, one considers in North Africa, that until the Roman colonization, the environment evolves on natural climatic conditions. Since, the anthropogenic actions become more and more prevailing with the fluctu-

ations of the soil occupation during the historic times (Benazzouz, 1996) that could be a decisive factor in the understanding of the development of the desertification.

CONCLUSION

This research confirms a fact unrecognized since a long time in Algeria or often contested by certain technicians on the sense of sand displacements in intra-atiasic depressions: the sand comes from the Northwest and the west (Benazzouz, 2000) that is to say from the High Plains and not from the South, this is not the Sahara that threatens the Hodna or the Zibans. This study leads to point consequences relative to modern desertification trough the northern marges of the Sahara which consists on a progress of environment' degradation from the High Plains to the South, towards the Sahara.

These displacements of sands take place in the setting of a wind system that consists in a transfert of High Plain sands toward the Sahara by crossing the Atlasic mountain.

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