THE MORPHO-PEDOLOGIES OF SAHARAN SOILS, A PHYSICO-CHEMICAL AND MINERALOGICAL APPROACH. (CASE OF THE SAHARAN SOILS OF OUM THIOUR, ALGERIAN NORTH EASTERN SAHARA).

Belkacem BOUMARAF[1] **(*)**, Ines SAADI[2]

1- Laboratory of promoting innovation in agriculture in arid regions, University of Mohamed Kheider, Biskra, Algeria .E mail belkacem.boumaraf@univ-biskra.dz . ORCID: https://orcid.org/0000-0001-8897-1140

2- [2-] Laboratory of promoting innovation in agriculture in arid regions, University of Mohamed Kheider, Biskra,
Algeria .Email inesse.saadi@univ-biskra.dz ORCID / https://orcid.org/0000-0003-4658-3902

Abstract

This study highlights on the geochemical level the evolution of the pedogenic characters of morpho-pedological units characterized in a setotrional region of the Algerian Sahara that of the Oum Thiour region. Mineralogical and pedological analyzes carried out on several soil surveys for each geomorphological entity, demonstrated the specificities of the specific soils (salinity, presence of crusts, etc.), which reflect the landscape without this region

Keywords: Sahara, difactometry, salinity, crust, geomorphology

1.INTRODUCTION

In the majority of cases, people interested in the development of new agricultural areas in Saharan edapho-climatic conditions confuse cultivation and land development. To cultivate land, it is necessary to carry out a set of works in order to produce plants. Thus the processes used do not take into account all the factors (climatic, edaphic, hydrological, etc.) which ensure and sustain this production. On the other hand, developing land means above all taking into account all the factors previously mentioned in order to assess current potential and bring together the maximum conditions necessary to increase the intrinsic quality of this land and ensure, in a sustainable manner, qualitative and quantitative production

[1].In this same perspective, for us soil scientists, it is essential to remember that the genetic characterization of soils in the Saharan environment requires knowledge of the geomorphological framework in which these soils fit. It is also established that they cannot be explained in isolation, relying solely on the vertical migrations of matter and only on the interdependencies with what surrounds them. In geology and geomorphology, we have long made the distinction between surface formations and soils. The first are the product, in situ or reworked, of geomorphological processes (physical disintegration and chemical alteration), the second is the alteration of the mineral fraction and its evolution which is considered as a prerequisite for pedogenesis.

Thus, by identifying the share of heritage in the landscape, by their distribution into different generations according to reliable criteria, geomorphology contributes to the interpretation of polyphase soils associated with the oldest of them. Likewise, it intervenes in the determination of their polygenic character and specifies, where applicable, the aspects of the morpho-dynamic sequences of the mineral material and the corresponding morpho-climatic. Overall, mineralogy makes a significant contribution to soil mapping. [2],[3] and[4]The current orientation of pedology towards their study at the level of bio-geodynamic units involves multidisciplinary research where morpho-pedology finds its place. These conclusions remain valid for its close relative, geochemistry which deals with the nature of the distribution and migration of the chemical elements constituting soils.

Our work consists, through a mineralogical inventory and morpho-pedolological mapping, of establishing the main pedogenic traits of the soils of a Saharan region.

2.MATERIAL AND METHODS

2.1 GEOGRAPHY AND GEOLOGY OF THE STUDY AREA

Our study area is located in the upper part of the Oued Righ valley is located in the northeast of the Algerian Sahara, along the large eastern Erg and south of the Aurès massif (Figure: 1). It is a kind of very flattened gutter 15 to 30 km wide and extends over 150 km, on a south-north axis between latitudes 32° 45' - 34° 30' and longitudes 5° 45 and 6 °15 East. It is included in a set called Bas Sahara. It's a bowl

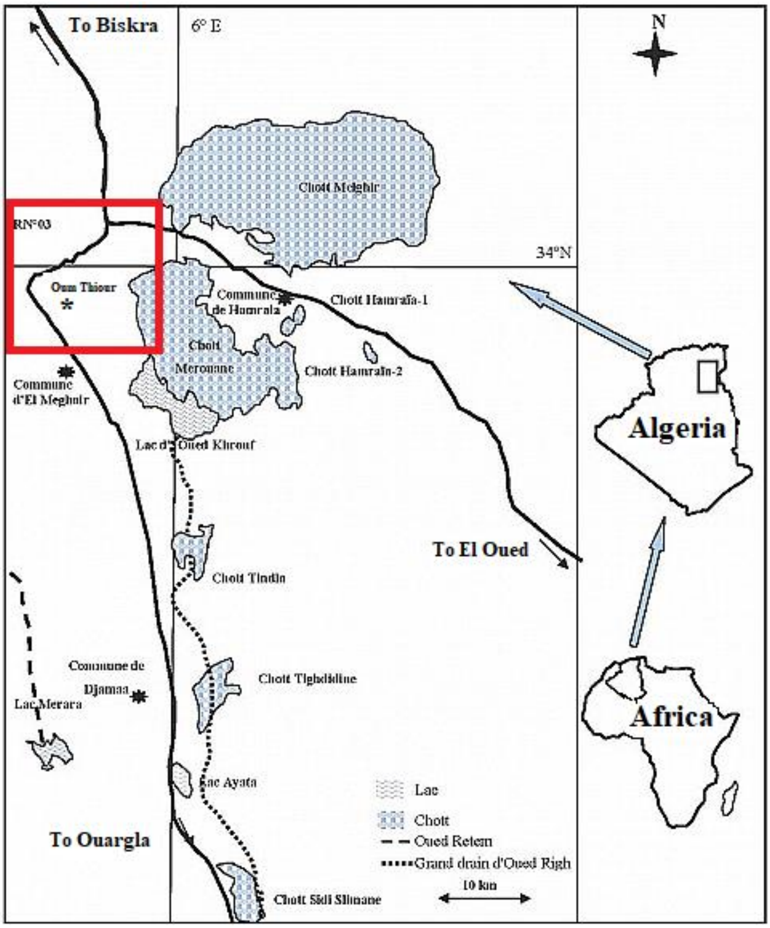

Figure 1. The geographic location of the region of Oum Thyour

vast of more than 400,000 km² which rises slowly towards 200-300 m altitude on the slightly inclined plateaus of M'Zab to the west, Tademait and Hamada of Tinghert to the south and the Tunisian Dahar to the East. To the north, the Ranges of Aures and Nemenchas dominate this basin. It is a Cretaceous halo that constitutes the plateaus that surround the central depression. Tertiary and Quaternary formations occupy the central part. [5](Figures 2 and 3)

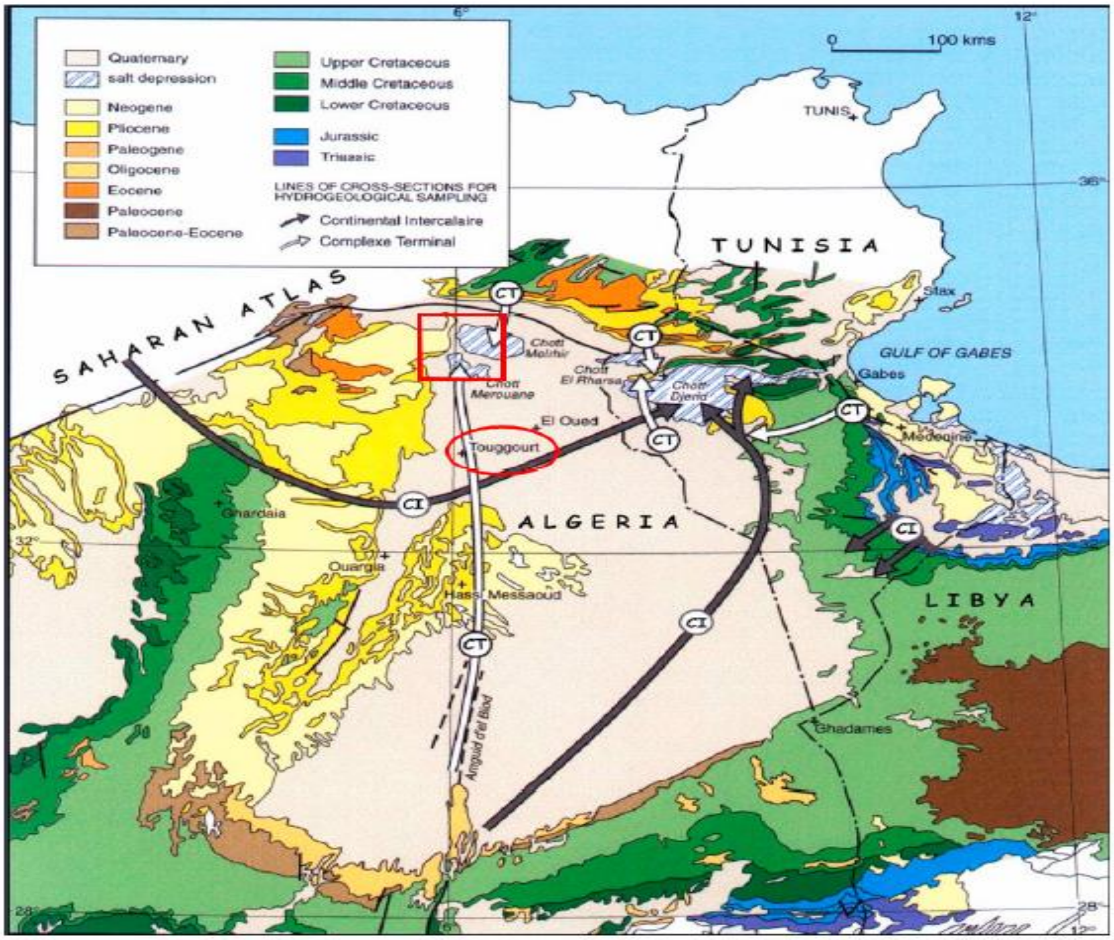

Figure 2. Geological levelling to Northern Sahara[6]

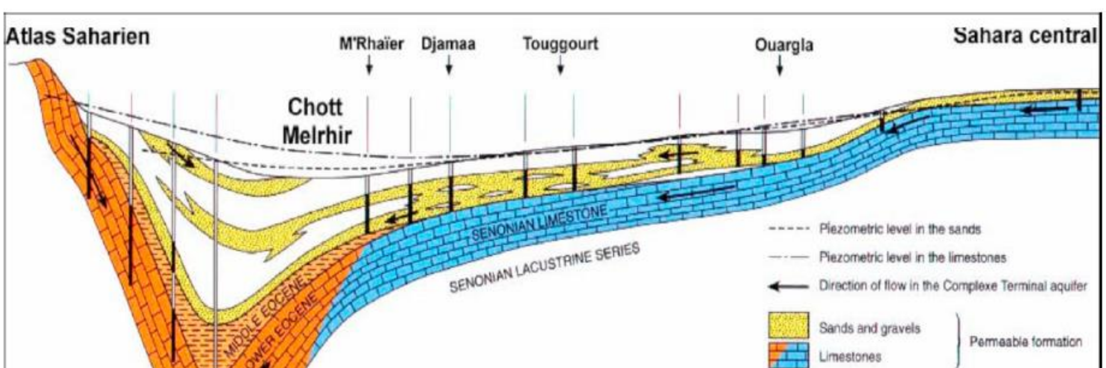

Figure 3. Cross-section the hydrogeology framework in the regional Cup crosses in section in the web of highlighting the Terminal Complex in Algeria [6]

2.2 CLIMATE OF THE WADI RIGH VALLEY

The dry period extends throughout the year.The average annual rainfall is 66.44 mm (period 2003-2023).The driest months remain June, July and August with an average of 1 mm of rain. The wettestmonth is January with a maximum of 17.23 mm .The average annual temperature is 22.37°C with the highest temperatures during the month of July with an average of 34.33°C.The lowest temperatures are recorded during the month of January (10.79°C on average). During the period from April to July, the winds of the sirocco blow very strong. [7]

2. 3 GEOMORPHOLOGICAL MAPPING:

2.3.1 Field prospecting methods

After a general reconnaissance of the valley ofThe Oued Righ, executed thanks to the basic documents, topographical, geological maps [6] and satellite images(Digital Elevation Model (DTM)). It is in its northern part that we concentrated the land prospections, because it offered from the plateau of Still to the bottom of the Chott Mérouane many forms of land that suggested a distribution of soil varied and numerous.

2.3.2 Geomorphological mapping.

The geomorphological study is based on a methodical cartographic survey [8] [9]. It showed the existence of five geomorphological levels tiered with the bottom of the Chott Mérouane and four glacis (Figure. 4).

a) The bottom of the Mérouane Chott ,The level N°0
b) The lower glaze of level N°1
c) The average glaze of level N°2
d) The high glaze of level N°3
e) The very high glaze level N°4

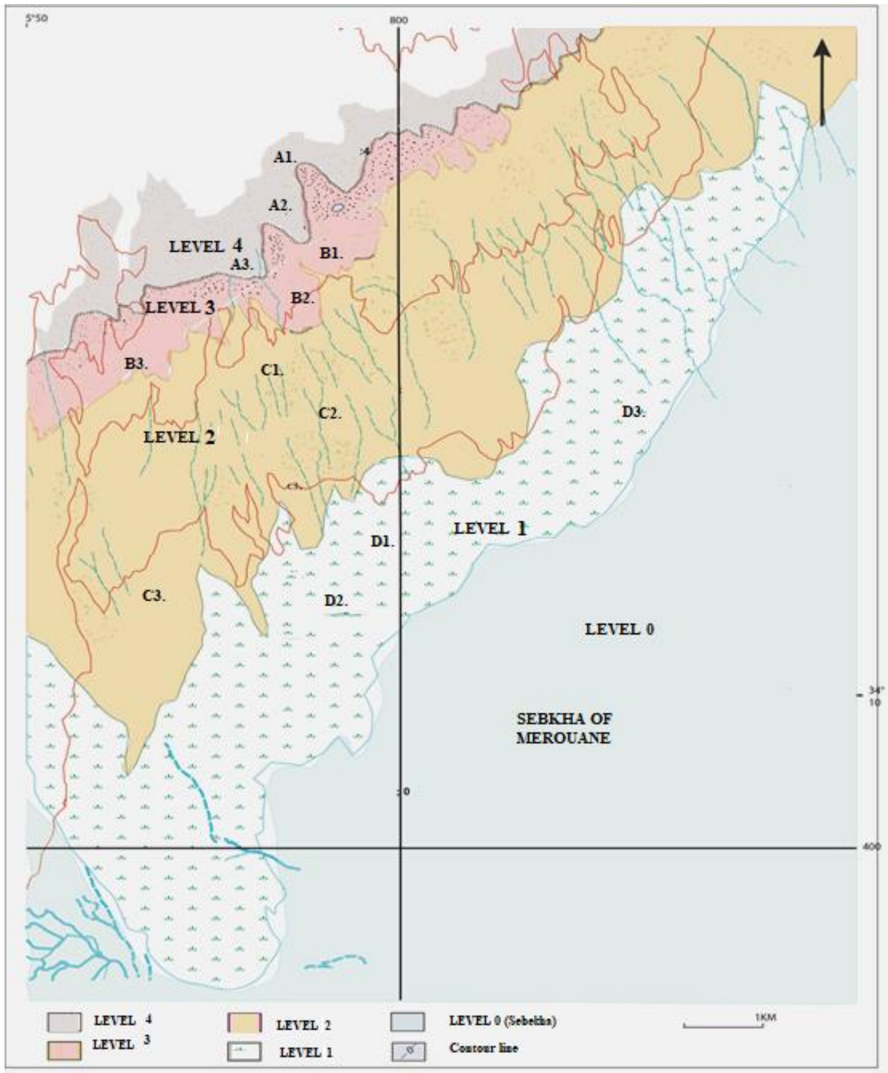

Figure 4. Geomorphological map of the area

2.4 Soil Sampling and Analysis Methods

Soil samples are taken according to geomorphological levels, from the lowest level towards the bottom. We respectively have four levels 1,2,3, and 4 (figure. 4) level zero could not be taken into consideration; It coincides with the level of the great chotts, with the almost permanent presence of the superficial salt layer. For each level studied, several soil surveys were carried out on the ground. Thus we were able to bring out three typical profiles. Soil analyzes are carried out on the clay content, total limestone, pH (1/2.5), electrical conductivity (EC 1/5), CEC, gypsum and finally difractometric analyzes on the fraction less than 2 microns

3.Results and discussion

Table :1 Physico-chemical results of profiles from each geomorphological level

The results of level 1 (physicochemical analyzes)															
Profils	Depth Cm	Clay %	pH H_2O	CEC Cmol /Kg	CE dS/Cm	$CaSo_4$ $2H_2O$ %	$CaCo_3$ %	Soluble salts ppm							
								Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	$So4^{--}$	$Hco3^-$
D1	0 - 30	10.11	8	2.8	14.1	44.2	2.6	60.3	22.7	57.2	7.8	64.62	41.1	2.8
	30 - 60	19.4	8.1	5.1	8.2	51.6	1.8	43.8	18.11	50.5	7.2	71.45	38.8	2.8
D2	0 - 25	7.8	7.9	3.4	16.21	58.1	1.7	37.91	21.44	48.72	4.82	73.22	35.44	2.4
	25 – 55	19.5	7.9	4.6	9.12	63.8	1.5	44.81	18.38	40.8	7.91	72.21	55.60	2.8
D3	0 - 15	5.4	7.8	2.4	18.12	34.88	2.8	63.61	19.45	75.52	10.76	59.12	41.18	3.2
	15 - 45	24.4	8.2	10.5	12.51	66.4	1.3	75	18.91	91.8	17.92	55.22	46.44	3.4
The results of level 2(physicochemical analyzes)															
C1	0 – 15	22.8	7.9	4.8	5.2	59.6	2.2	32.2	6.2	10.1	8.8	30.2	22.8	2.4
	15 - 33	7.4	8.2	3.1	9.72	74.3	2.2	58.26	5.4	30.6	16.86	69.14	37.55	2.8
	33- 75	21.2	8.1	5.1	7.3	44.6	2.6	30.45	6.5	29.5	6.22	35.6	30.5	2.8
C2	0 - 45	8.2	7.9	2.8	8.1	34.5	1.8	40.4	5.41	22.81	8.61	47.8	27.2	2.6
	45 -70	17.3	8.1	5.9	8.54	66.9	7.6	54.31	9.71	28.81	10.4	50.7	53.6	2.4
	70 - 120	26.2	8.1	9.5	14.7	49.84	16.2	75.11	10.71	49.5	15.91	79.2	61.8	3.4
C3	0 - 20	8.4	8.1	2.6	9.8	21.2	2.2	78.2	7.8	40.1	15.6	94.1	36.4	2.4
	20 – 75	12.4	8.1	3.2	8.84	51.1	2.4	80.1	6.4	42.4	17.2	96.8	38.7	2.4

	75 – 100	24.4	8.2	4.8	6.5	65.5	2.2	40.8	5.2	11.84	6.82	41.55	20.4	2.8
The results of level 3(physicochemical analyzes)														
B1	0 - 40	5.5	7.8	2.6	8.1	57.41	1.6	41.2	3. 41	22.11	7.92	52.3	24.81	2.6
	40 - 65	21.60	7.9	12.1	9.34	51.88	7.32	61.35	6.26	25.8	14.4	76.2	30.6	2.4
	65 - 120	12.4	8.1	4.8	10.7	71.15	8.1	72.32	8.7	32.54	18.62	86.2	33.4	3.6
B2	0 - 35	8	7.9	2.4	8.3	29.38	3.1	48.2	5.26	24	8.44	50.1	28.18	2.4
	35 - 90	15.7	7.9	4.2	7.9	77.2	9.9	41.76	5.38	23.09	8.87	44.6	26.74	3.2
	90 – 150	22.5	8.1	9.8	10.2	25.6	11.6	42.1	6.11	21.4	9.12	42.23	28.2	3.2
B3	2 - 45	5.1	7.9	2.2	10.1	69.6	0.86	58.22	8.15	30.4	9.45	75.45	33.16	3.4
	45 - 110	27.2	8.2	11.7	12.2	23.8	21.8	75.1	9.81	50.17	16.1	86.1	20.50	3.6
The results of level 4(physicochemical analyzes)														
A1	2 - 45	6.8	8	2.4	10.2	35.5	35.5	80.7	6.95	37.6	17.4	90.1	40.4	2.2
	45 – 90	21.4	7.9	4.1	6.3	58.3	58.3	30.91	4.1	10.7	5.2	31.11	19.9	2.8
A2	2 - 55	8.1	7.9	2.8	11.81	28.36	28.36	60.09	3.1	28.4	18.6	75.4	31.5	3.1
	55 - 110	19.3	7.9	3.8	8.1	56.8	56.8	38.34	4.85	21.83	8.58	42.3	23.2	2.8
A3	2 - 45	7.82	8	3.2	11.1	35.22	22.2	88.6	8.25	32.6	17.5	108.8	30.8	2.6
	45 - 95	12.8	7.9	6.4	8.58	61.15	35.22	47.8	5.1	16.6	8.4	98.2	24.1	2.8
	95 - 155	26.4	7.8	7.1	6.52	24.8	51.2	41.11	5.44	32.18	4.6	28.6	25.1	2.6

A. THE LOWER GLAZE OF LEVEL N°1

The results obtained in this level (Table:1and 2), demonstrate the strong presence of gypsum especially at depth (from 485.49 to 1437.38 cps). This is linked to the proximity of a water table (approximately 60 cm) whose waters very laden with salts (ES=12.4 g/l) increase the solubility of the gypsum [8][9]. Indeed, the solubility of gypsum is generally influenced by the presence of soluble salts because gypsum is a weak electrolyte its solubility is modified when the solution contains strong electrolytes having or not common ions [10].

Calcite which is present in small quantities on all profiles (15.34 and 31.43 cps) remains low compared to dolomite which reaches the maximum value of 233.84 cps. According to the local stratigraphic analysis of the lower Sahara, dolomite is mainly present at the Turonian level. The presence of this mineral in recent formations could be explained by its detrital origin due either to water erosion and runoff responsible for supplying dolomite to the regions located below [11], or to wind action. recent [12]. The hypothesis of neoformation before saline accumulation, by the retention, at the level of sub-surface horizons, by the rootlets of dense vegetation, of excess carbonates would be very improbable in this bioclimatic context [13]. Attapulgite is clearly present in the profiles. This is linked to the geochemical stability, rich in basic ions, necessary for its conservation that this level offers. However, these conditions remain far from those favorable to its possible neoformation. According to [14], the observed absence of attapulgite observed at the level of the chottes and sebkhas of El Hodna could be explained by the non-existent contribution of high concentrations of soluble salts in the genesis of this fibrous mineral characteristic of these regions.[15]. In a climatic context different from this one (semi-arid), the disappearance of attapulgite in certain horizons is linked to the very low or absent limestone content and to their increased humidity [16] has raised the vulnerability and the absence of this fibrous mineral in subhumid and humid regions. But it remains to be seen whether the quasi structural permeability in this level would be responsible for a possible destruction of the attapulgite. However, we note its absence at the level of the epipedon.

Masked by the gypsum peak, kaolinite (7.2Å) is also present in this profile at low intensities from 5.95 to 16.75 cps. It is commonly accepted that kaolinite is a clay mineral which is built in environments where there is rigorous leaching and a strong desaturation of the solutions which takes place from the surface horizon towards the depth where the environment is rich in silicates of aluminum and allows the neoformation of this mineral. As the saline profile in this level does not present this pattern (hyperpedonic), the kaolinite comes from an inheritance.

Once present in this environment, it remains the most stable phyllite mineral. The high presence of illite is probably linked to the high K^+ content in the ground water (18.11 and 22.7 ppm)[14]. On the other hand, chlorite finds a better intensity of its peak in this level, which reflects a perfect crystallinity of its crystal lattice caused by the richness of this medium in basic cations, particularly that of Mg^{++}. The heating and swelling tests carried out on sample d 25-55 allowed us to see that it would rather be a smectite–chlorite stratification.

B. THE AVERAGE GLAZE OF LEVEL N°2

X-ray analysis of samples taken from level 2 revealed the very particular manifestation of attapulgite only at depth for profiles C2 and C3. This could be explained by the influence of a surface layer loaded with Mg^{++} and Si^{+++} very present in this level nourishing the formation of this fibrous mineral [14].and [17]. Notes that the attapulgite content decreases more or less rapidly when going from depth to the surface on soils developed on marl in Senegal and he concludes that this mineral is inherited from the parent rock.

The presence of detrital attapulgite in the current sediments as is the case in the surface horizon of profile c1 (0-15cm) has already been observed by [18], [19] and [20]. This fibrous mineral is exported in the form of dust to desert regions by the wind. like the previous level, we note a strong presence of gypsum which destroys the quartz material hence the release of silica likely to contribute to the neoformation of attapulgite by creating covalent bonds with Mg^{++}. However, the horizons where we noted the absence of this mineral are characterized by the presence of a gypsum crust. However, given the extent of the wind contributions observed through the morpho-analytical examination in this level we can think that this attapulgite is deposited by the wind in the case of profile C1. This process was reported by [20]in the erg of Mali and [18] in the Saudi desert, where on site, the attapulgite subjected to a temporary hydromorphy, quite permeable in a calcimagnesic environment, is well preserved [21]. However, its absence in petrogypsic horizons is linked to the mechanical effects of gypsum crystallization.

Chlorite, which presents itself in this level in a manner different from that of attapulgite, is present on all the treated samples. (C1, C2 and C3) and finds better crystallinity at depth (382.59 cps) which could suggest a transformation by in situ aggradation in a salty environment caused by the surface layer.The illites show a more intense presence in the underground horizons than on the surface. The surface illites are of detrital origin resulting from wind inputs. The illites act as precursors in the transformation towards the smectites present in the C3 profile (58.78 and 78.15 cps), as a possible consequent proof of this transformation. The presence of kaolinite in the profiles studied either on the surface or at depth alongside smectite and illite reflects a heritage due to the differential alteration of the source rock. This is not a neoformation of kaolinite because we cannot reach the simple stage of transformation from illite to montmorillonite.

A. THE HIGH GLAZE OF LEVEL N°3

The diffractometric examination carried out on the samples taken in level 3 very clearly reveals the predominance of quartz (154.38 and 1336.96 cps) and gypsum (238.36 and 1045.02) over all the primary and secondary minerals, particularly in its upper part. Next to gypsum, the proportion of anhydrite remains relatively variable with values oscillating between 7.30 and 38.31cps. Its absence is noted in profile b1 at depths between 65 and 120cm (Table 2). Calcite is predominant in all samples, followed by dolomite which has a strong presence in profile b2 (233.80 cps) and by apatite (between 40.56 and 190.23 cps). We also look at anatase in depth.

Fibrous minerals are represented in this profile by palygorscrit present only at depth in profile B1. Illite and kaolinite are detected on all profiles of this level 3, with the exception of profile b1 at depths between 40 and 65cm, where we note the absence of kaolin. In this Saharan climatic context, these minerals are inherited. Once established, they can undergo transformations by aggradation especially for illite given the ionic concentration of the soil solution, the simultaneous presence of chlorite or smectite would be a consequence of this evolution. Considered as a clay resulting from a neoformation of attapulgite [15], its presence in recent formations would be inherited from transport in the form of aeolian dust. [20]. However, the presence of attapulgite at depth and in the encrusted horizon and its absence on the surface, suggests that this crust is of detrital origin and not a sheet, especially since its position in this level is not constant. The presence of anhydrite ($CaSO_4$) in the mineral procession alongside gypsum leads us to the same reasoning. Indeed, the formation of anhydrite is different from that of gypsum because the deposition temperature of anhydrite (200°C) is higher than that of gypsum. which is frequently encountered in limestone and dolomitic formations.

B. THE VERY HIGH GLAZE LEVEL N°4

From the diffractometric results we can observe the predominance of gypsum and quartz in the mineralogical procession. This results in gypsum percentages which vary between 28.6% and 60.27%. These results show constant values of the gypsum content in the surface horizon on the three profiles (between (300.67 cps and 391.69 cps). In profile A1, the gypsum content decreases, in depth, at the level of the green marls where it takes the value of 24.8% (132.43 cps). exclusively from wind contribution [13]and

[12]. In the carbonate family, calcite and dolomite are relatively stable in the surface horizon but at depth calcite is distinguished by the value of 155.87 cps (a3 profile horizon: 45-95cm) unlike dolomite (13.84 cps table 2). According to [22] and [23], the presence of these minerals in the crusts and post-Villafranchian encrustation are a legacy from older formations

The presence of Illite in this level would probably be due to a heritage This mineral usually appears in alluvial micaceous sandstones and sands [24]. However, the intensity of this mineral is stronger at depth (profile A3). According to [15] the variation in the illite content within a profile can be a consequence of its transformation into swelling structures such as montmorillonite. This mechanism cannot take place given the climatic conditions prevailing in the study region where it would require hydrolysis and progressive leaching of ions [14], especially since we did not detect the presence of montmorillonite. [25]

thinks that to the extent that the original material does not contain montmorillonite, clay minerals of the 2-1-1 type like chlorite evolve by transformation (degradation) in the direction of montmorillonite, this remains strong improbable because it would require the existence of an intermediate stage in the mineralogical procession, that of the presence of chlorite-Smectite stratifications [15],and the almost absence of these stratifications in the diffractograms confirms that there was no of geochemical evolution.

Table :2 Diffractometric results expressed in counts per second (CPS)

THE RESULTS OF LEVEL 1 (DIFFRACTOMETRIC ANALYZES)											
		Intensity (counts per second) of the main minerals (fraction < 2µm)									
Profils	**Depth (cm)**	**Calcite**	**Dolomite**	**Anhydrite**	**Gypse**	**Quartz**	**Attapulgite**	**Kaolinite**	**Illite**	**Chlorite/**	**smectite**
D1	**30 - 60**	**31.43**	**49.56**	**25.53**	**485.49**	**168.38**	**45.55**	**5.95**	**120.62**	**142.40**	
D2	**0 – 25**	**15.34**	**137.40**	**13.51**	**509.60**	**309.60**	**-**	**-**	**113.11**	**104.17**	
	25 - 55	**16.25**	**233.84**	**10.02**	**1277.78**	**985.22**	**39.46**	**7.22**	**158.36**	**282.37**	
D3	**15 - 45**	**19.41**	**17.59**	**19.41**	**1437.38**	**86.05**	**19.51**	**16.75**	**84.28**	**348.73**	
THE RESULTS OF LEVEL 2(DIFFRACTOMETRIC ANALYZES)											
	0 – 15	**9.66**	**40.44**	**23.27**	**340.83**	**468.36**	**11.15**	**13.42**	**25.25**	**8.15**	**-**
C1	**15 - 33**	**13.51**	**47.65**	**6.01**	**933.46**	**299.66**	**21.98**	**14.44**	**247.42**	**57.65**	**-**
	33 - 75	**8.06**	**49.49**	**38.33**	**289.64**	**144.48**	**28.98**	**24.42**	**149.92**	**69.92**	
C2	**45 – 70**	**95.30**	**57.56**	**36.69**	**485.49**	**193.10**	**-**	**19.69**	**123.52**	**110.98**	**-**
	70 – 120	**17.99**	**13.84**	**28.91**	**136.04**	**298.88**	**92.11**	**32.21**	**153.59**	**181.93**	**-**
C3	**20 – 70**	**188.38**	**-**	**5.88**	**945.92**	**1737.77**	**-**	**158.58**	**88.18**	**168.68**	**58.78**
	70 – 120	**125.29**	**-**	**17.47**	**545.55**	**169.27**	**93.90**	**25.29**	**135.82**	**382.59**	**78.15**
THE RESULTS OF LEVEL 3 (DIFFRACTOMETRIC ANALYZES)											
B1	**0 - 40**	**105.79**	**142.68**	**19.23**	**340.59**	**449.27**	**-**	**40.44**	**244.29**	**-**	
	40 - 65	**62.80**	**37.58**	**28.53**	**381.64**	**154.38**	**13.38**	**-**	**79.90**	**-**	
	65 - 120	**183.19**	**19.19**	**-**	**502.20**	**1336.96**	**5.15**	**9.98**	**57.55**	**19.23**	
B2	**35-90**	**136.86**	**233.80**	**7.30**	**1045.02**	**1239.79**	**-**	**69.94**	**89.80**	**22.97**	
B3	**45– 110**	**145.43**	**10.04**	**38.31**	**238.36**	**298.86**	**-**	**14.74**	**83.30**	**-**	
THE RESULTS OF LEVEL 4 (DIFFRACTOMETRIC ANALYZES)											
A1	**45 -90**	**61.96**	**86.00**	**26.30**	**391.69**	**475.07**	**76.70**	**-**	**88.08**	**-**	**-**

A2	**55 – 110**	**61.73**	**68.06**	**-**	**329.09**	**106.21**	**16.45**	**25.59**	**86.86**	**-**	**-**
A3	**2 –45**	**117.59**	**45.60**	**21.79**	**300.16**	**249.30**	**4.64**	**15.86**	**7.25**	**6.88**	**15.86**
	45 – 95	**155.87**	**13.84**	**53.87**	**298.86**	**103.59**	**52.94**	**-**	**80.08**	**-**	**159.22**
	95 - 155	**11.39**	**21.35**	**17.17**	**132.34**	**1463.66**	**-**	**83.51**	**192.35**	**-**	**274.21**

4. CONCLUSION

Covered by a veil of aeolian sand, the general texture of the soils studied is almost uniform on the surface (except for the fringe of the chott). On the other hand, for the sub-surface horizons become finer towards the bottom of the sequence, and the transition between the horizons sharper. The soil solution is almost dominated by sodium and offers a slightly alkaline to alkaline pH.

The saline profiles vary from one level to another and sometimes in the same level (case of level 2), it is oriented with a maximum of salinity towards the top of the profile as is the case of levels 1 and 4, and for level 3, the electrical conductivity is greater than in the sub-surface horizons. This variation indicates to us that the salinity is ascending under the effect of climatic aspiration from the ground water or following an accumulation on the surface of salt grains that can be evaporated from the large chotts. The effect of the salt-laden groundwateris mainly manifested in levels 1 and 2 by various forms of gypsum accumulations, on the other hand for levels 3 and 4 they are exclusively of wind origin. In level 2, the saline profile offers certain variations observed: ascending in the case of profile C3, and descending in the case of profiles c1 and c2. Despite the proximity of the groundwaterl, this variation is due to the presence of a gypsum crust which hinders the rise of salts towards the surface.

The results of the mineralogical analyzes show that the identified minerals come from a heritage. However, we must make a distinction between the upstream and downstream of the Wadi Righ valley. Upstream, the current Saharan climatic context with a deficit significant rainfall, does not offer favorable conditions for the possible reorganization of silicate minerals initially degraded. Only the wind is the particle mobilization agent capable of creating a spatial distribution of secondary minerals beyond the limits of the lower Sahara. Furthermore, downstream, seasonal fluctuations in the ground water level allow silicate minerals to find environments rich in basic ions which offer conditions for conservation or even transformation by aggradation of their crystalline networks (case of illites and chlorites). However, the fact remains that the gypsum identified on all levels destroys certain minerals during its precipitation by the force of pressure it exerts. [14]. showed that gypsum invades, destroys and blocks the evolution of limestone accumulations because the crystallization pressure of gypsum (1100 km/cm²) destroys the carbonate aggregates. [26], make the same observation for quartz and other secondary minerals. Another observation that we have retained is that the mineralogical procession of crusts and crusts in levels 1 and 2 (except attapulgite) are relatively the same for the horizons located below. Which suggests that this consolidation occurred after the formation of these glacis

Acknowledgments:

I would like to thank my colleagues from the laboratory: Ecosystem diversity and dynamics of agricultural production systems in arid zones “DEDSPAZA” at the University of Biskra, Algeria for allowing me to finalize the soil analyzes

References

[1] (Bennadji, 1998 Création d'Oasis dans le Sahara Algérien :Le projet de Gassi-Touil . *Sécheresse*, N°4, pp289-298

[2] Laour, S, Boumaraf, B, & Saadi, I. (2023), Morpho-pedology Variations in Pre-Saharan Region Case Ziban Soils. Analele Universităţii din Oradea, Seria Geografie, 33(1), 43-53.https://doi.org/10.30892/auog.331104-899+.

[3] Boumaraf B ,, Saadi I , Marre A, Bensaid .B 2016 The Spatial Distribution of Pedogenetics of Soil Processes in the Valley of Oued Righ.Algeria (Sahara North East) A Geomorpho-Pedological Approach, International Journal of Advances in Science, Engineering and Technology(IJASEAT),V:4,,pp:156-159

[4] Bétard ,2009 : Cartographie morphopédologique : de l'évaluation des terres à la recherche en géomorphologie , Géomorphologie : relief, processus, environnement, vol. 15 - n° 3 |

[5] Gouskov.N , 1964: : Notice explicative de la carte géologique de Biskra au 1/200000 . Publication de la série géologique .Algérie . 13p

[6] Bettahar.A, Nezli.I.E,Kechiched.R,2017: Evolution and Mineralization of Water Chemistry in the Aquifer systems of the Terminal Complex of the Wadi Righ Valley,Energy Procedia,Volume 119,2017,Pages 318-324,ISSN 1876-6102, https://doi.org/10.1016/j.egypro.2017.07.115.

[7] (ONMT, 2023) Synthèse de données climatiques de la willaya de Méghaier: Office National de la Météorologie.

[8] Gueremy.P., Marre.A. (1996). Une nouvelle méthode de cartographie géomorphologique applicable aux aléas naturels. Travaux de l'Institut de Géographie de Reims,pp 5-40.

[9] Marre.A, 2007: Cartographie géomorphologique et cartographie des risques. Bulletin de l'Association des Géographes Français, n° 1 ("Géographies"), p. 3-21.

[10] Pouget.M ,1968: Contribution à l'étude des croûtes et encroutements gypseuses de nappe dans le sud tunisien. Cahier ORSTOM .Série pédologie. Vol n°3-4 pp309.

[11] Charle.M, 1975 : Remarque sur la genèse et l'âge des croutes carbonatées méditerranéenne. Annales INA, Alger.Vol n°1,année 1976, pp 159-162

[12] (Coque.R 1962 La Tunisie présaharienne, étude géomorphologique. Ed colin, Paris .Thèse d'état, 488 p

[13] Boulain.J, 1961: Sur le rôle de la végétation dans la formation des carbonates calcaires méditerranéennes. *C.R. Acad, Sci*, Paris, t. 253, n° 22, pp. 2568-2570

[14] Halitim.A,1988, Les sols des régions arides de l'Algérie. Edition OPU. Alger 386 p

[15] Paquet.H 1969: Evolution géochimique des minéraux argileux dans les altérations et les sols des climats méditerranéens et tropicaux à saisons contrastées. Thèse Sci. Strasbourg et Mém. Ser. Carte géol. Als. Lorr., 30, (1970), 212 p.

[16] Schone.C, 1969: Contribution à la connaissance des minéraux argileux dans les sols marocains. Cahiers Rech. Agro. INRA. n°34 ,18-24pp

[17] Magnie.P ,1964: Les argiles des sols des régions subhumides d'Afrique occidentale .Bull.Serv..Carte.Geol.Alsa-Lorr. n014,pp111-128-

[18] Viani.B, Al-Mashhady.A.S ,Dixon J.B. ,1983: Mineralogy of Saudi Arabian soils: Central alluvial basins. Soil Sci. Soc. Am. J. 47, 149-157

[19] Callen.RE (1984) Clay of the Palygorskyte –Sepiolite dispositional environoment,age and distrubution. dévloppement in sedimentologie . 37 Elsevier ,Amsterdam, pp 1-37 / 256 p

[20] Coude–Gaussen .G ,1987 Observation au MEB de fibres de palygorskyte transporteés en grains par le vent. Micromorphologie du sol ,686 p, pp199-205

[21] Dutil.P,1971: Contribution à l'étude des sols et des paléosols de Sahara. Thèse doc. D'état, Faculté des sciences de l'université de Strasbourg. 346p,

[22] Durand.J (1963), Les croutes calcaires et gypseuses en Algérie, formation et age . Bull .Soc. Géol de France, Vol n° V ,pp959-963.

[23] Conrad.G, 1969: L'évolution continentale post-hercynienne du Sahara Algérien. Éditions du CNRS Paris, - 527 pages

[24] Aubert.G, Guillemin.C Pierrot.R. 1978 : Précis de minéralogie. Paris : Masson, 1978, 332 p.AUBERT and al, 1978

[25] Wilbert.J,1965 Tirs et sols tirsifiés au Maroc .Annales de L'.INRA, Maroc ,N°20,pp 23-85

[26] Halitim.A,Robert.M. 1987: Interaction du gypse avec les autres constituants du sol : analyse microscopique de sols gypseux en zone aride (Algérie) et études expérimentales. In Fedoroff et all. (ED) : soil micromorphology, AFES.pp 179-186