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MORPHO-PEDOLOGY VARIATIONS IN A PRE-SAHARAN REGION CASE ZIBAN SOILS

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Abstract: During this study, we tried to highlight the main lines of the spatial evolution of the morpho-pedological characters of certain soils, on a sequence established from the geomorphological map in the region. Biskra is an Oasis located in the North-Eastern Sahara of Algeria. After a long prospection, we have established two sequences of soils which have different morphological characteristics. These variations are mainly due to the geomorphological position of the terrain and the favorable hydrological aspect in the first sequence to the formation of gypsum soils compared to the second.

Key words: Saharan soils, gypsum, morpho-pedology, salinity, groundwater

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INTRODUCTION

In arid regions, rainfall, low and occasional, induces a markedly deficient climatic drainage for most of the year. Flows, superficial (oueds, backwaters) or hypodermic, are most often temporary. They reach areas of concentration which are the privileged places of saline manifestations in water and soil.

The processes of valorization of the grounds used, do not take into account all the factors (climatic, edaphic, hydrological etc.) which ensure and perpetuate this production. On the other hand,

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developing the land means above all taking into account all the factors cited above in order to assess the current capacities and meet the maximum requirements for increasing the intrinsic quality of the land and ensuring, in a sustainable manner, a yield qualitative and quantitative (Benadji, 1998).

In the same perspective, for us pedologists, it is essential to remember that the genetic characterization of soils in the Saharan environment requires knowledge of the geomorphological context in which these soils are located. It is also established that we cannot explain in an isolated way, according to the only vertical migration of the matter and only of the interdependencies with what surrounds it. The notion of topo-sequence, resulting solely from topographical considerations, is insufficient because it could lead to a comparison of soils of different ages (Boumaraf, Saadi, & Marre, 2016). Thus, a new morpho-pedological approach to soils is adopted by Bétard in 2006, (Bétard & Bourgeon, 2009) to create a new approach to land evaluation in the Saharan region of Ziban one of the most productive agricultural with 4.3 million date palm trees (Faci & Benziouche, 2021), in association with greenhouse cultivation (Ouendeno, Daoudi, & Colin, 2015).

MATERIAL AND METHODS

Geography of the Ziban region

Biskra region is located in southeastern Algeria at 425 Km of the capital (Algiers) (Figure 1). It is bounded in the north by the Saharan Atlas, which represents a SW – NE directional relief. It extends to the Chott Melghir area in the southeast and to the Eastern erg in the southwest. Biskra region constitutes a transition zone between two different morpho-structural domains, the folded domains in the north and the flat and desert expanses of the Sahara in the south.

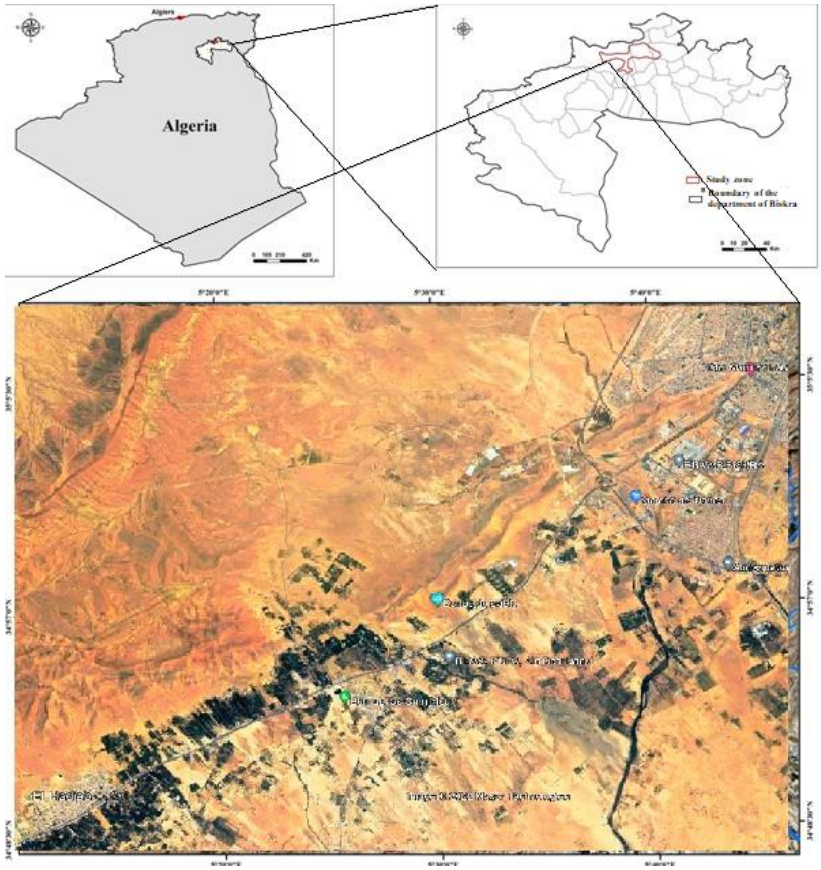

Figure 1. Geographical location of the study region (Boudhibi, 2021)

Geology and hydrogeology of the Ziban region

The Biskra region is part of the transition between the folded Atlas domain of the North (Saharan Atlas), and the flat and desert expanses of the Sahara. The latter characterized in particular by the very flat regions corresponding to the great western and eastern Erg, to the plateau of Mzab, Tadmait, Tinrheret as well as to the relatively depressed region of Gourara, Touat, Tridklet, south-Tihert (Boumaraf, Bensaid, & Marre, 2014b). The northern part of the region is in the form of a chain, roughly,oriented North-East - South-West of the Jura type and to the south, the Saharan plain is presented by a whole series of erosion glaze shaped by runoff and where oases are located (figure 2) (Chebbah, 2007). The region is characterized by sedimentary terrains ranging from the Barremian at the base to the calcaro-gypsum Quaternary with sandy and clayey alluvium, while the Tertiary is formed by sandstone beds, sandy clays and carbonate formations (Abdennour, et al., 2021). It is an environment very marked by mechanical and water erosion. The hydrographic network is dense. The Biskra region has several aquifer reservoirs that belong to the Quaternary, Miopliocene, Lower Eocene and Upper Senonian (Maastrichtian) and Albian (Bouziane & Labadi, 2009).

The quaternary water table: It is located in alluvial accumulations and is characterized by very salty water. It has a great influence on the pedogenetic process of the southern piedmont, particularly in the formation of gypsum accumulations.

The Mio-Pliocene sand aquifer: This aquifer consists essentially of an alternation of sands, gravels and clays. It is heavily exploited, especially in the Biskra area, by a very large number of boreholes intended mainly for the irrigation of agricultural land.

The Eocene and Senonian limestone water table: The reservoir of this aquifer consists essentially of limestone. Its depth varies from approximately 150 to 400 m. The waters have an alkaline sulphate and alkaline-earth facies

The CI Continental Intercalary aquifer The Albian aquifer: It is made up of sandstone and clay. The waters are variously deep according to the Atlas flexure (1500 to 2500 m) and very hot (60°C). They are also the least salty.

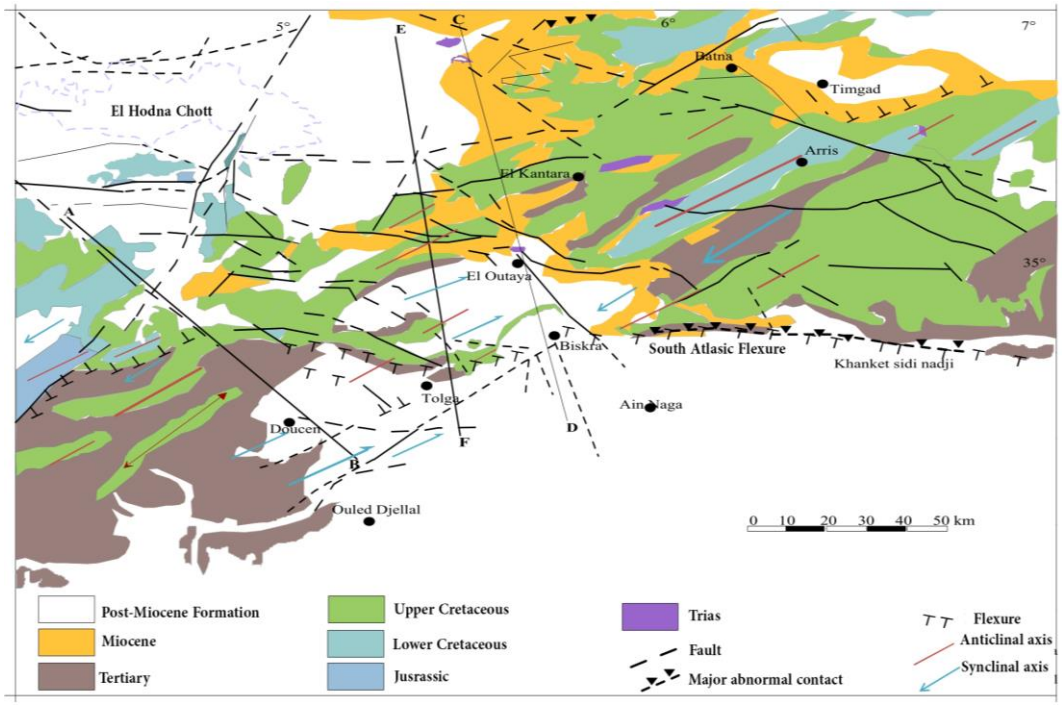

Figure 2. Tectonic sketch (Extracted from the hydrogeological map of Biskra (Boudhibi, 2021))

Climate of the Ziban region

The observation of relative to the ombrothermic diagram; shows that the climate of the region of Biskra is characterized by a single dry season extending throughout the year (Figure 2). This is one of the parameters for the climate of arid zones, in addition to the high evaporation and irregularity in the rainfall regime. The mean annual temperature is 22°C. July is the warmest month of the year, while January is the coolest. The average annual precipitation is 148 mm. There is almost no precipitation during the summer months. Potential evapotranspiration is high and can reach 10 to 20 times the amount of water falling (Saadi, Debabech, & Traore, 2021).

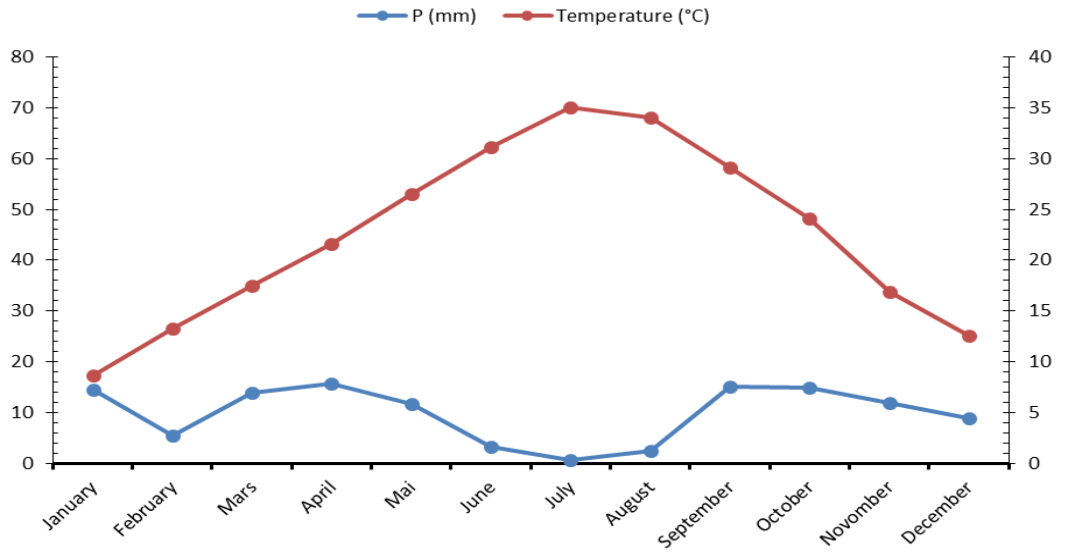

Figure 3. Ombrothermic diagram of Biskra region (period of 2000-2018) (ONMT, 2020)

GEOMORPHOLOGICAL MAPPING

The prospecting methods

After a general reconnaissance of the Biskra Valley, using basic documents (topographic, geological map and aerial images), it was in the southern part that we focused the field surveys, because it offered the bottom of the Chott Oumach, many forms of landscapes that contemplate a distribution of varied and multiple soil types (Boumaraf, Saadi, & Marre, 2016).

The geomorphological study is based on systematic mapping (Gueremy & Marre, 1996; Marre, 2007; Boumaraf, Bensaid, & Marre, 2014; Boumaraf, Saadi, & Marre, 2016). It made it possible to show the existence of two series of geomorphological levels:

- The first starts from level zero the bottom of the Chott Oumache at the Ziban Mountains (Benadji, 1998) with five morpho-pedological levels;
- The second begins from Jebel Delouate to Jebel Bourhzel with four distinct levels defining the southern and northern limit of the Faidjet El Hammam valley located northwest of the city of Biskra which has dug on the anticline since the Miocene (Figure 3).

SEQUENCE A

The bottom of the sebkha of oumache the lower level A0

This level corresponds to the current settling pit with pseudogley soils. Characteristic of the covered white salant, with an absolute absence of vegetation, it offers a remarkably flat topography (altitude-20 to 45 m). Its is characterized by a carpet of white salt crystals, of different types (sulfate and chloride). In certain areas, the surface consistency becomes a viscous and crispy crust (Figure 4).

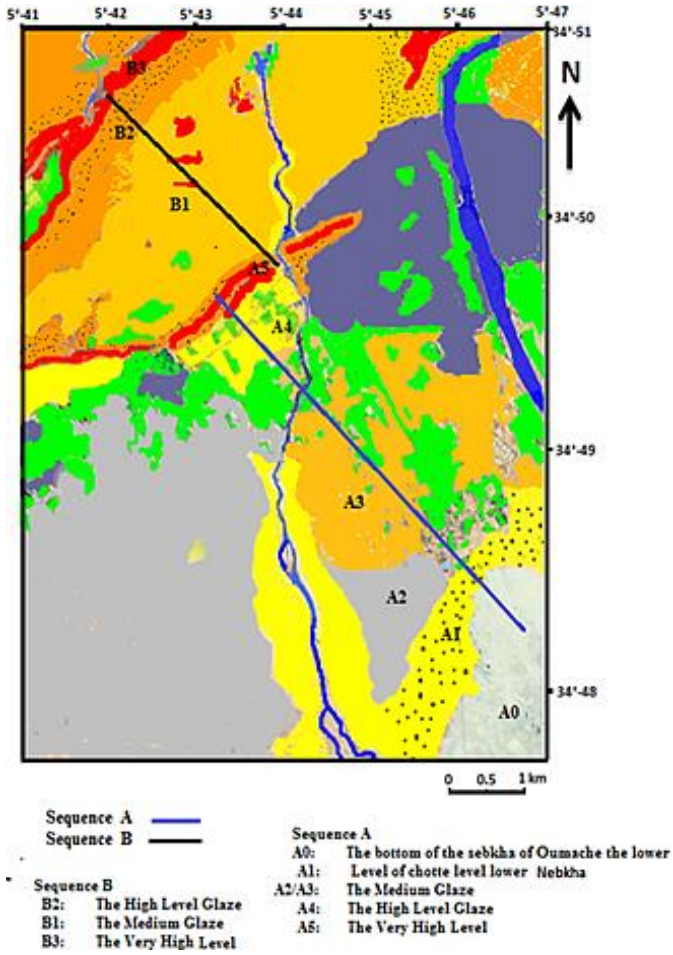

Figure 4. Morpho-pedological map of the study area

Figure 5. Gypsum crust surmounted by a veil of sand. The OumachSebkha (Laouar, 2022)

Level of chotte level lower A1

It is remarkable by a passage to a higher threshold, with a transition that is sometimes not very visible, an extremely short concavity, and where the density of halophilic plants in the form of nebkha become more numerous. It is located in a silt saturated with salts, and which marks the passage to the chott. It is characterized by silty-sandy soils sometimes dune it is a fringe of the sebkha.

The Medium Glaze A2

The surface of this level has a greater area than that of the neighboring levels. This level appears a few meters equipped with the previous one. It is presented as a glacis with a greater extension towards the southwest, with a very slight slope. It is characterized by soils with gypsum accumulation, characterized by crusts and encrustations of gypsum at varying depths. Invaded by the nebkas, there are favorable conditions for their formation due to their proximity to groundwater (the water table) (Mostephaoui, Saker, & Bensaid, 2013) which is too salty and loaded with sulphates (Table 1). This sheet varies between 0.80M and 1.5M depending on its piezometric position and the season. These chemical characteristics, particularly its content of soluble salts, are accentuated largely due to irrigation and the excessive use of chemical fertilizers. The drainage water from the palm groves upstream and occasional floods are the principal sources of water table maintenance (Abdelhafid, Rechachi, & Halitim, 2019).

Table 1. Analytical results of groundwater In the Oumache Region

Prof M	CE dS/C	PH	Cl-- PPM	So4-- PPM	HCo3 PPM	Na+ PPM	K+ PPM	Mg++ PPM	Ca++ PPM	Σ- / Σ+	ES g/l	SAR	Cl-- / So4--
>1.5	47.8	8.2	626.2	142.4	6.5	466.13	33.2	109.19	184.6	0.97	37.2	4.51	4.39

The Medium Glaze A3

This level appears to the northwest of the Oumache depression, towards the Aurès Mountains and the plain of the Faidjet El Hammam valley. It is characterized by alluvial-colluvial clay-silty soils with high total limestone content (from 30% to 45%). These are unstructured soils with a very diffuse transition between the underground horizons. Located on the foothills of the Aurès mountain range, our landscape is presented as an accumulation of glaçi entangled with the last level with pronounced erosion escarpments, sometimes giving rise to moors degraded in its upper part by more active watercourses. The surface appearance of this level presents characters of vertisms with very characteristic shrinkage slots.

The High Level A4 Glaze

It is an erosion glaze defined by certain inclined surfaces and others very sandy. The presence of sands on this level is due to the dominant wind current in this region and which blows from the Nod West to the South East. This flow of sands and gypseous dusts existed several times during the Upper Pleistocene and the Holocene. It is materialized by veneers of dunes and more or less indurated gypsum accumulations on the side of the Ziban reliefs. Deposits from arid periods alternate with deposits from wet periods (paleosols, alluvium) (Figure 5).

A variable slope of 5% to 15% for the swallow with a reduced spatial extension, very variable compared to the previous level. The piedmont becomes slightly concave giving the appearance of a perched glacier. Hydrographic network and more pronounced downstream by ravines 20 to 40 cm deep, more pronounced downstream. On the surface, breccia is very regularly observed, probably developed on Miopliocene materials (Ballais, 2010).

The Very High Level A5

This level is represented by an immense glacier dominating the northern part of sequence A defined by the mount of Jebel Delouate by a drop of several tens of meters. These formations are

upper crusts (figure 6) made up of crumbly clods and nodules stuck to a harder layer of gypso-limestone. At its base, a consolidated marly substrate. The vitreous structure in crusts and encrustations marries the topography. Observed on surface debris in holes of varying sizes. Covered with a veil of sandy and loose cover composed of xerophytes rarely reaching 50 cm. This level bears some traces of flow reduced to a few tens of centimeters of hack.

Figure 6. Gypsum crust surmounted by a veil of sand (Laouar, 2022)

SEQUENCE B

This sequence begins from the mount of DJebel Delouate described in the previous section A5 towards the mount of Jebel Bourehezal which delimits the valley of Faidjet El Hammame (Figure 7).

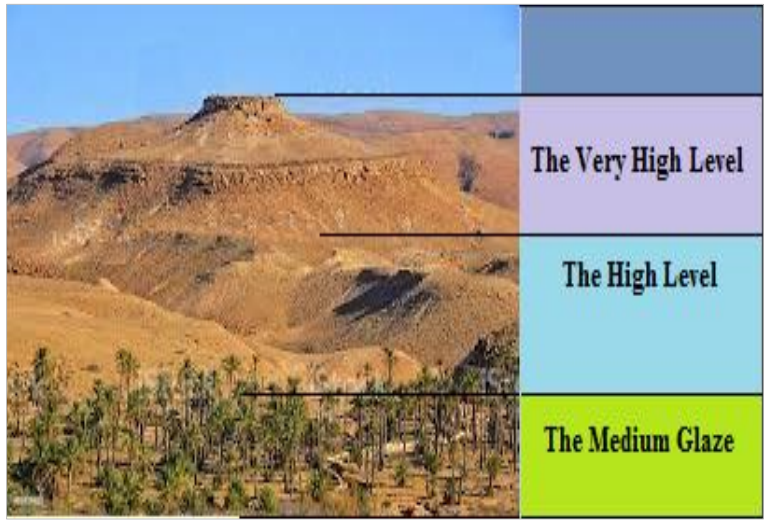

Figure 7. The variation in glaze levels observed in the Biskra region

The High B2 Level

This level is presented at the same time by Djebel Delouate in the south and Djebel Bourehezal in the north with altitudes between 200 and 250 meters the first and from the Upper

Cretaceous: represented by crystalline and dolomitic limestones in very thick layers, marly and gypsum lagoon intercalations many in the west.

The second that of Jebel Bourehezal is from the Lower Cenomanian: Its power is 300 to 400 m of gray or white limestone regularly alternating with greyish, sometimes gypsum marls.

The Medium Glaze B1

They appear as slightly inclined surfaces with a slope generally at 3%. One observes there in a very regular way exclusively colluvial deposits represented by clays; gypsum in thick layers, anhydrites and dolomitic limestones. In the form of breccias from the Villafranchiene period developed on large-scale Mio-Pliocen gypsum fluvio-lacustrine materials. Residual reliefs which are observed especially in the northern region, from the geological point of view they are relic formations of the Cenomanian and the ancient Quaternary.

These reliefs appear in the landscape as witness mounds characterized by the presence of gypsum encrustations on the surface (associated with the Marls) and marly gypsum at their base. These formations are more or less tabular and generally sandy. The slope of the land is generally steep (3-7%) with often undulating micro-relief undergoing more or less active erosion sometimes giving bad land to the north.

The Very High Level B3

This level is represented by a huge glaze, dominating the northern part of the Valley by a steep of several tens of meters. These formations are top crusts (Figure 7) and consist of crumblyclumps and glued nodules layer harder gypso-limestone. At its base, a consolidated marl substrate. The scabbing and crusting, glassy structure marry topography. Observed on the surface of debris from breccias of varying sizes. They are covered with a veil of sandy cover and loose wind input. This landscape is also characterized by sparse xerophytic plants rarely reaching 50 cm. This level bears some traces of flow reduced to a few tens of centimetres hack.

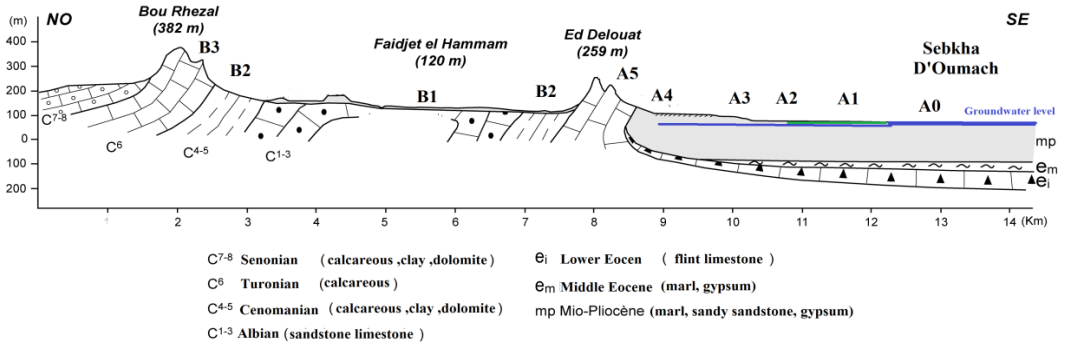

Figure 8. The spatial distribution of morpho-pedological units in the Biskra region

CONCLUSION

All the factors that preside over the formation and evolution of soils induce a double differentiation in the vertical organization of the profiles and in their lateral distribution. By analyzing the variations of the analytical and morphological results obtained from the sebkha of Oumach towards the upper level of Jebel Delouat, and from the towards Djeble Boughezal, it clearly appears to us that the landscape of the Biskra region is part of a region that evolves as part of the endorheic system.

The evolution of the landscape of this region depends for the structural part on the conditions defined by the lithology and the tectonics and also on the systems of erosion subjected to paleoclimatic aspects inherited from the Quaternary, of which the crusts are the testimonies in the first section.

the series of soils located on the sequence going from the Djebel Bourehezal to the depression of Oumache, the sulphated layers, contribute to the accumulations of gypsum in the form of cuirasses and encrustations. This sequence is largely subject to the progressive accumulation of sulphates in the colluvial material, this is the domain of gyso-morphy. This precipitation results from the upward movements of the saline solutions of the water table very close to the surface (Bouselsal & Hakim, 2022). This aquifer is fed by rainfall, floods, diffuse flows, drainage water from agricultural activities in this region.

In addition, on the northwest slope of the Ziban valley, precisely on the southern slope, of the Aurès anticlines (figure 8) a series of soils are distinguished by finer accumulations of clayey silt from alluvium and colluvium and gypsum rates are much lower, in the absence of shallow aquifer dynamics.

The alternation of wet and dry recent Quaternary climatic phases operated in this region, allowed the construction by mechanical erosion observed through surfaces interrupted by incisions and embankments. And similarly also on the second section of the northern flank of Djebel Bourehezal at Djebel Delouate sequence B. The soils formed on sequence B and that located to the North East of sequence A define similar morphological properties on the structural and textural level and do not offer their own pedogenetic evolutionary characteristics observed on sequence A where the formation of soils with gypsum accumulation is characteristic.

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