The Gypsum in The Soils of the Valley of Oued Righ (Northeast of Sahara – Algeria)

Boumaraf Belkacem, Saadi Inesse and Bensaid Rabah

***Abstract* - Gypsum is the most abundant mineral in soils of arid regions, it is formed when the concentration of Ca $^{+2}$ and SO4-^{2} are considerable in the soil. 04profiles representative of the Oued Righ valley (south-east of Algeria) were studied. . The results obtained indicate that several forms of gypsum are distributed according to the physicochemical characteristics of the soils; .Gypsum formation is geological in levels 3 and 4 and neoformation in the lower part of the plain (0, 1 and 2 this is due to the proximity of the aquifer.**

***Keywords*— Sahara, gypsum, morphopedology, gypsum soils. salinity**

I. Introduction

The arid zones are characterized by the presence of gypsum, limestone and soluble salts with very variable forms. Gypsum can accumulate in the soil when evapotranspiration becomes greater than precipitation. However, where gypsum particles are present in the soil, their type, amount, and degree of crystallization, these factors have a profound impact on physical and physico-chemical properties of soil as a medium for plant growth (Fedoroff and Courty, 1989).

Gypsum formation is generally associated with gypsiferous rocks and sediments of different origins (Hashemi et al, 2011). When present in small amounts, gypsum has a positive effect on soil properties and may play a role of amendment and fertilizer because it brings Ca ++ and SO4 ions - necessary for the growth of plants. On the other hand, at high levels, it affects the behavior and functioning of soils and plants (Pouget, 1995).

It is essential for us to recall that the genetic characterization of soils in a Saharan context leads the soil scientist to a systematic knowledge of the geomorphological framework in which these soils are inscribed, it is also now established that we can not explain in isolation, according to the only vertical migrations of the mineral matter, their interdependence with those around them especially that the notion of topo-sequence results from this consideration based on the only topographic

II. Material and Methods

A. Geography and Geology of the OUED RIGH Valley

The OUED RIGH valley is located in the North-East of the Sahara Algeria, along the large eastern Erg and south of the Aurès massif (map: 3). It presents itself as a kind of 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. She is included in a set called Bas Sahara. It is a vast basin of more than 400.000 km ² which is slowly rising towards 200-300 m of altitude on the slightly inclined plateaus of M'ZAB in the west, TADEMAIT and HAMADA of TINGHERT in the south and from the Tunisian DAHAR to the east. To the north, the Chaines des AURES and NEMENCHAS dominate this basin. It is a Cretaceous halo which constitutes the plateaux which surround the central depression. Tertiary and Quaternary formations occupy the central part (GOUSKOV, 1964)

B. Climate of the OUED RIGH Valley

The dry period extends throughout the year. The average annual rainfall is 66.44 mm (2003-2012 period). The driest months are June, July and August with an average of 1 mm of rain. The wettest month 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 hard. (ONMT, 2012)

C. The geomorphological cartography:

1. Field prospecting methods

After a general recognition of the valley of the OUED RIGH, executed thanks to the basic documents, topographic maps, geological (CASTANY, 1952) and satellite images (Digital Elevation Model (DTM)). It is in its northern part that we concentrated the field surveys, because it offered from the plateau of STILL to the bottom of Chott MEROUANE many forms of ground which allowed to consider a distribution of varied and many types of soils.

2 Geomorphological mapping.

The geomorphological study is based on a methodical cartographic survey (GUEREMY AND MARRE, 1996, MARRE, 2007). It has shown the existence of five storied geomorphic levels with the bottom of the Chott Merouane and four glacis (Fig. 1).

3 Methods of sampling and soil analysis:

Soil sampling is done according to the geomorphological levels from the swallow to the lover we have four levels 1, 2, 3, and 4 respectively (Fig. 2) the level zero could not be taken in

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consideration; it coincides with the level of the big chott and the almost permanent presence of the salt water table.

For each level studied, nearly 24 holes are surveyed, and at least three representative soil profiles have been analyzed. Each level studied is represented by its typical soil profile, with, in all, four representative profiles described and analyzed . The soil analyzes are based on the rate of gypsum, clay, total limestone, pH (1 / 2.5), electrical conductivity (EC 1/5), and analyzes and microscopic treatments were carried out using a diffractometer. x-ray at the geology laboratory of the University of REIMS (FRANCE)

5. Results and discussion

Fig 1 - Geomorphological map of the study area with location of the profiles

A. Level 0:

This level corresponds to the current decantation basin with pseudogley soils. Covered with characteristic white salt, (the great chott) with an almost absolute absence of vegetation It offers a remarkably flat topography. (Altitude from -10 to -35m) Characterized by a carpet of whitish saline crystals, of different types, (sulphated and chlorinated). In some places, on the surface, becomes by its consistency a crust viscous and crisp (BRIERE, 2000)

B. Level 1:

Perceptible by a passage towards a higher threshold, with a transition sometimes not very obvious, an extremely short concavity, and where the density of the halophyte plants become more numerous. Implanted in silts saturated by the salts, and which marks the passage to the chott. It is characterized by silty-sandy loam soils. This is the fringe of the big chott.

The shape of the gypsum in this level is powdery. it was characterized by WATSON (1985) as an unconsolidated surface (> 2 mm) gypsum deposit, which can be accentuated by the proximity of a saline solution from the water table, due to fractures generated in the structure when it is desiccated during dry periods. The rate of gypsum, which is lower in surface area than in depth, remains high (between 34.88% and 66.4%). However, according to TIMPSON ET AL (1986), the precipitation of the salts occurs in a vertical sequence from the level of the water table to the surface in the following order: $CaCo_3$-$CaSO_4$-$NaCl$-$MgSO_4$-$MgCl_2$-$CaCl_2$ (Fig 2 .). This can be explained by the high electrical conductivity at the surface which causes the partial dissolution of the gypsum crystals.

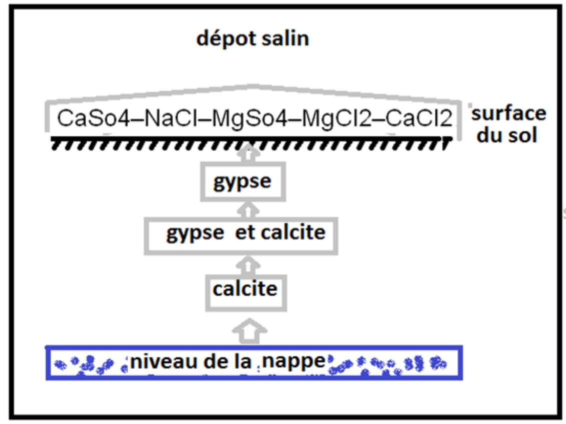

Fig 2 - Precipitation of soluble salts from a loaded slick according to TIMPSON and AL 1986

The Cl- / SO4- ratio is sometimes greater than 2, which reflects the high mobility of the Cl- ion relative to SO4-especially when the groundwater geochemical facies is of the sulphated chloride type (BOUMARAF, 2004). The presence of gypsum gives low Cl- / SO4-- ratios because of the dissolution of this salt under such circumstances of ionic concentration in the aqueous extract (electrical conductivity between 8.2 and 18.12 dS / cm).

C. Level 2:

This level appears a few meters nested with the previous one. It presents itself like a huge glacis, with very weak slope. It is characterized by gypsum accumulation soils, is characterized by gypseous crusts and encrouting at varying depths. Invaded by the nebkas who find there favorable conditions for their formation, (the proximity of the water table) and confers on the general landscape a bumpy appearance. The surface of this level has a greater surface area than that of the boundary levels

In this level, the general structure of the soils is loose with a sandy to loamy texture. The pedogenetic evolution of these soils is globally weak. This character is due to climatic conditions that cause wind deflation. The landscape is invaded by nebkas. The grounds are covered with a more or less important wind veil which limits their evolution. This veil is made of sand grains, which are associated with many very fine forms of gypsum crystals. (fig 3)

According to WANG, (1998) crystal formation is large when the Ca ++ content in the soil solution is greater than 10-3 mol / l. However, the accuracy of the localization of the various forms is unknown because they are subject to continuous solubilization and crystallization phenomena which are caused by the highly contrasted seasonal variation of the water table level (dominance of the per-assensum or per-descalum movements).) and also the ionic nature of it.

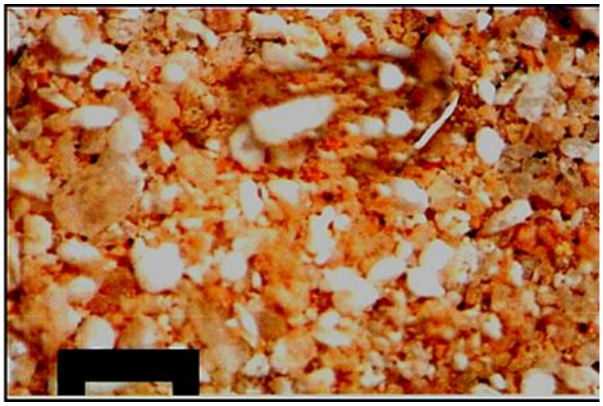

Fig 3 Strong presence of gypsum associated with the grains of the covering sands, profile: c2, horizon (0 - 45cm). (Photos, BOUMARAF, 2012)

He microscopic observations of the samples collected in the field we could distinguish on the surface of lenticular crystal forms and very rarely acicular. In depths, they are sub-angular to ovoid in shape (Photos III.5 and III.6)

We could observe in the horizons of the profile nodules of various sizes (between 2 and 20 cm) and dense. Sometimes they are confused with reddish-yellow sands. More deeply (profile c2), we observe crusts that overcome gypsum crusts. In this case, the lamellar structural tendency of encrusting does not seem sufficient to distinguish them from each other.

According to ROBERT et al (1987) the hardening of the gypsum encrustation is due to the interpenetrating coating of gypsum crystals without the intervention of cement, where the various constituents of the soils (quartz, clay, limestone) are trapped in a sort framing formed from gypsum lenses bonded together with other smaller size crystals.

The content of the gypsum in the profiles represents, in this level, varied values between (21.2 and 74.3%). On the other hand, total limestone has obviously very low values in all treated samples (Table III.6). According to VIELLEFON (1976), gypsum and limestone in the soil are not independent of each other. When the amount of limestone decreases, that of gypsum increases. HALITIM AND AL. (1987) show that gypsum invades, destroys and blocks the evolution of limestone accumulations. They think that this phenomenon is due to the crystallization pressure of gypsum (1100 kg / cm²) which destroys limestone individualizations as a result of the continuous arrival of sulphate solutions and their precipitation. (fig 4).

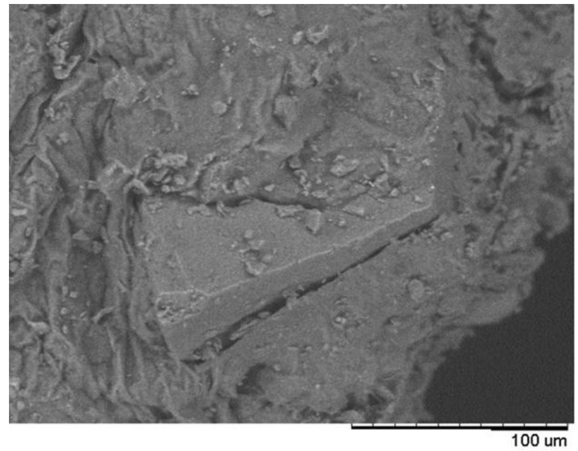

Fig 4 Crystals of calcite agglutinated by gypsum (Photos:, BOUMARAF, 2012)

Generally the structure is finer in depth. However, sometimes it becomes massive, with the presence of a gypsum crust of light yellow to tanned brown.

D. Level 3:

These are spreading glazes defined by inclined surfaces. A slope varying from 5% to 15% downstream, with a reduced spatial extension, and very variable compared to the previous level. The piedmont becomes slightly concave offering the appearance of a perched formation. The hydrographic network and more pronounced upstream by deep ravine from 20 to 40cm, and downstream of rare channels. On the surface, we observe very regularly, thick gypseous crusts, probably of Villafranchian epoch developed on Miopliocene materials (BALLAIS, 2010)

The soils are generally little evolved because of the discontent, at varying depths, crusts, gypsum crusts and conglomeratic elements (fig 5) On the whole of this level, the gypseous crusts are exposed on the surface. downstream. The percentage of gypsum varies between 25.6 and 72.2%.

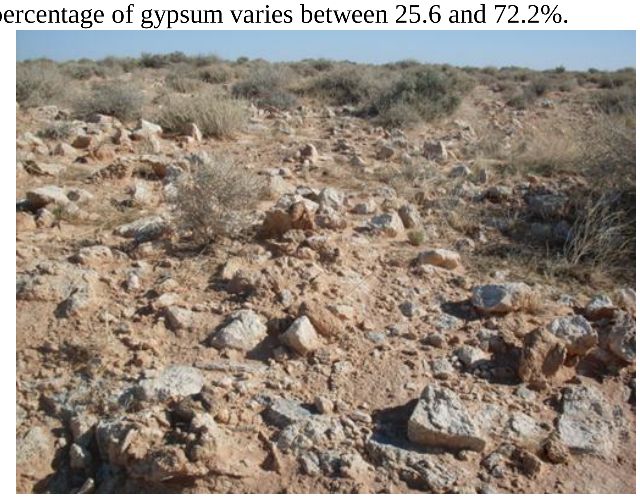

Fig 5 State of Level 3 Surface (Photo, BOUMARAF, 2012)

CONRAD estimates, in 1969, that this type of formation is due to a circulation of water on the old deposits of Piedmont. During the regressive periods of the climate, the Quaternary. Other authors consider these slopes as relic terraces reworked by a dynamic slope with old colluvial deposits resting on a marly and gypsum waterproof bedrock. They take their spatial evolution only to the decrease of the runoff and not of the sulphate precipitation caused by the fluctuation of a charged sheet.

The lacustrine deposits of the early Upper Quaternary Pliocene (Mio-Pliocene of some authors (Nesson 1971)) consist of more or less gypseous clays without coarse inputs. The Middle Pleistocene deposits are only coarse on the north shore of the Chott Mérouane, proof of the increased contribution by the wadis which come down from the Saharan Atlas and which transport today only silt, whereas on the southern and western banks are observed only rare sandy beaches

Calcium carbonate and soil gypsum are not independent of each other: when the calcium carbonate content decreases that of the gypsum increases. According to Boyadgiev, 1974 and Vieillefon, 1976, the link between limestone and gypsum depends on their form of accumulation and the level of soluble salts. : The more their structure is fine and powdery in a salty environment the more the ratio is significant Gold this is not the case here, except in the case of the profile b3 with the subterranean horizon (45-110 cm) where the rate of clay is 27.2%

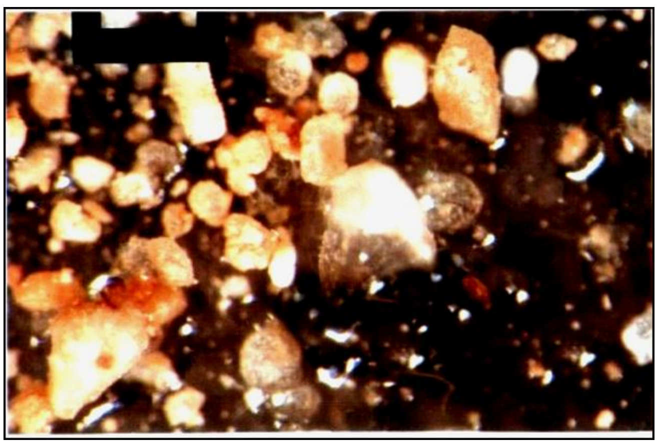

Fig 6 Quartz crystals agglutinated with gypsum (G) (X10) (Photo BOUMARAF, 2012)

Gypsum particles have no negative charges and therefore the exchange capacity of gypsum soils is expected to decrease as the gypsum content increases, especially in low organic matter soil. the CEC varies between 2.4 and 12.1 Cmol / kg

D. Level 4

This level is represented by an immense glacis, dominating the northern part of the valley by a steepness of several tens of meters. These formations present at the top ribbon film crusts (Fig 7) consisting of friable clusters and nodules glued to a hard layer gypso-limestone. At its base a marly consolidated substrate. The crusts and encrouting, with a glassy structure, follow the topography. Surface debris is observed in gaps of variable size. Covered by a sandy veil and a loose vegetal cover composed of xerophytes rarely reaching 50cm. This level carries some traces of flow reduced to ravines of a few tens of centimeters

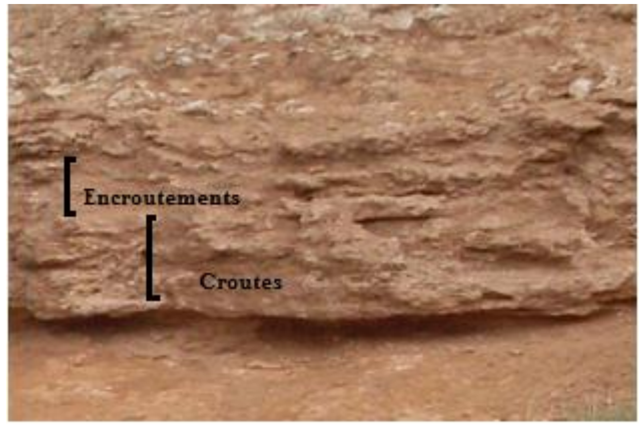

Fig 7: Laminated Morphology of Level 4 Crusts and Encrustations

However, this gypseous crust covers almost all level 4, sometimes it is dislocated in some places., Fragmented and remodeled during paleoclimates According to the UNDP, (1971) this formation can be related to the villafranchian. However, it should be emphasized that the gypsum horizons develop even on the dunes where there is no groundwater or sheet flow (MATHIEU AND TOREZ, 1976) as a result of lateral inflow caused by the wind . Currently all these formations outcrop in this level are covered with fine sand of aeolian contribution and on the piedmont and the embankment of this formation.

CONCLUSION

From the elements collected through the geomorphological and pedological studies, the characteristic genetic traits of soils in our study area are spread over two distinct territories. The former is not subject to the current influence of the water table. The second, situated below the first towards the sebkha is, or on the contrary, under the continual influence of this sheet and of these saline accumulations that it generates this sheet (Fig. 4). Its effects are accentuated by the absence of a vegetal cover especially at the level of sebkhas where the entrainment of the salty particles éolisables causes a secondary salinization on the surfaces studied and even beyond. This explains the presence of gypsum crusts and other forms of gypsum depending on the nature of the existing soil at the upper levels. The current effect of the water table is non-existent.

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