RESEARCH ARTICLE

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PALEOENVIRONMENT AND STRATIGRAPHY OF THE QUATERNARY FORMATIONS LOCATED IN OUED BOUSSEMANE SITE, AIN ZERGA LOCALITY, TEBESSA, NE ALGERIA: SEDIMENTOLOGICAL AND GEOCHEMICAL ANALYSIS

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SUMMARY

The present work carried out at the Oued Boussemane, Ain Zerga locality, is the first of its kind in terms of paleoenvironmental reconstitution aimed at highlighting the prehistoric man's way of life in this region. In this perspective, we proceeded with the digging works which allowed us to release a 180 cm thick section, in which we uncovered 8 different sedimentological levels. More than 500 archaeological objects have been discovered (flint tools, bone, ceramic pieces), as well as 27 samples have been collected and intended for several types of analysis (sedimentological, magnetic, faunistic, geochemical, micromorphological,...).

Sedimentological and geochemical analyses, as well as in situ observations, reveal the presence of two distinct strato-sedimentological units:

- The first being located in the upper part of the section, rich in pottery and lithic industry, is attributed to the Holocene and the upper Pleistocene. It is relatively rich in organic matter and shiny blunted quartz grains, reflecting a period of humid weather.
- The second is characterized by the presence of limestone crusts and shiny blunted quartz grains; it is older (dating from Pleistocene).

This unit is set up under a hydrodynamic regime during a wet period as well. According to the data, the lithic industry can be attributed culturally, to the middle Paleolithic (Atéro - Mousterian), corresponding in North Africa at the interval 140000 - 20000 years BP.

Key words: Ain Zerga, paleoenvironmental reconstitution, Holocene, upper Pleistocene, humid weather, middle Paleolithic.

1. INTRODUCTION

The Oued Boussemane rock - shelter is located about twenty kilometers northeastern Tébessa, Algeria. In this rock - shelter, trace of ancient human occupation have been discovered. Therefore, in order to make a paleoenvironmental reconstitution highlighting the way of prehistoric man lived in this area; we proceeded to a geological digging. The stratigraphic section then studied, 180 cm thick, revealed more than 500 archaeological objects (flint tools, bones, ceramic pieces). Throughout this section, we collected 27

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samples of sediments for several types of analysis (sedimentological, geochemical...).

2. GEOGRAPHICAL AND GEOLOGICAL FRAME-WORKS

The Oued Boussemane rock - shelter is located about twenty kilometers northeastern Tébessa and a few kilometers in the south of Ain Zerga locality (Fig. 1). Located in one of the Jebel Dyr gorge, this vast shelter about one hundred meters long wasformed in limestone rocks of Cenozoic age (Ph.1). As part of the northeastern Saharan Atlas, Jebel Dyr is a perched syncline including Cenozoic rocks in its summit. The shelter itself is dug into Nummulitic limestones dated Ypresian-Lutetian (Vivière, 1985; Djerrab and al., 2012) (Fig. 2)

3. SITE SELECTION AND STAGES OF THE GEOLOGICAL SURVEY

Generally, rock - shelters allow a good preservation of sediments which are deposited there; these last are protected against the action of the atmospheric agents (Djerrab and Camps, 2011). This type of site is particularly sought after in the study of Quaternary formations. In contrast, the study of terraces (fluvial, alluvial) remains dependent on the effect of meteoric weathering, which must be taken into account in any interpretation (Djerrab and Aïfa, 2010; Djerrab and Camps, 2011). In addition to its intrinsic characteristics, the Boussemane shelter is relatively large (important thickness of sediments), easily accessible and close to a water point (wet sieving). The realization of survey was undertaken in September 2011 on a 3 m^2 surface:

- Cleaning of the surface site (presence of a visibly reworked level).
- removal of sediments with a brush.

Fig. 1. Geographical location of the study area (site represented by a red dial).

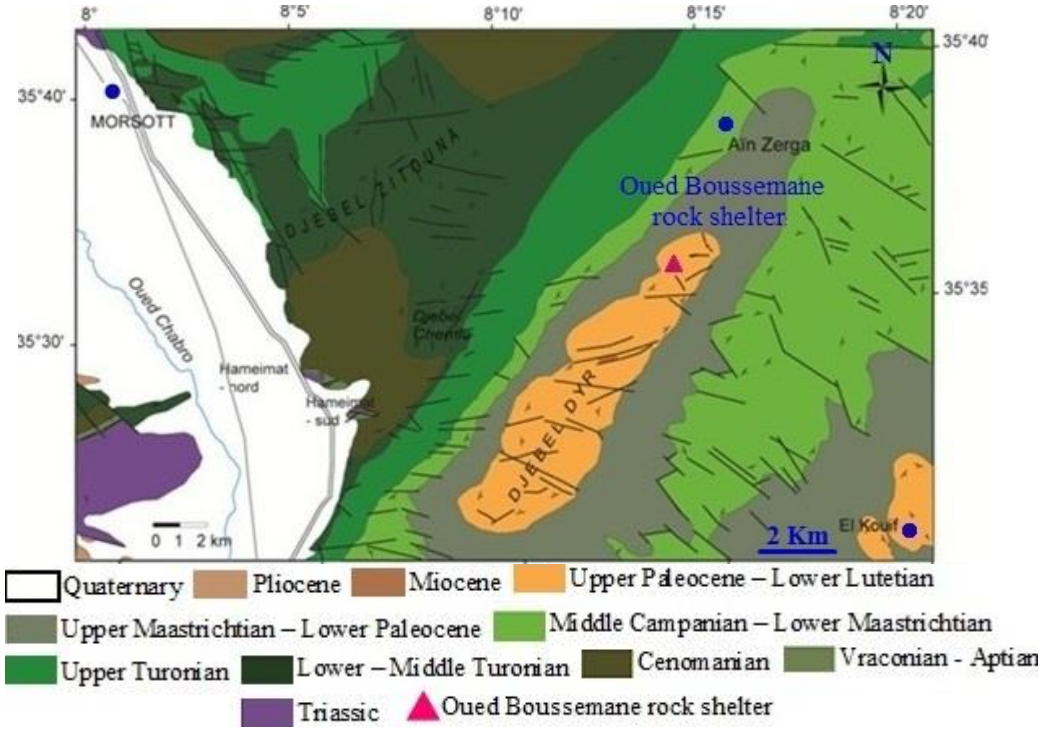

Fig. 2. Geological map of djebel Dyr (Extracted from the Morsott geological map, 1956).

Photo 1. Overview of the Oued Boussemane site located in a gorge of djebel Dyr.

In mid-November 2011, 174 objects were discovered (pottery fragments, bones, archeological flint tools), four sedimentological levels fully cleared and a fifth in part only. These levels are distinguished by their color and content. At the end of January 2012, excavations revealed 5 distinct levels with a partially cleared sixth, in which we collected 380 objects. In February 2012, a 180 cm thick deposit was excavated, with:

- 8 stratigraphic levels, identified on the basis of color or content differences.
- More than 550 objects distributed as follows :
  - 130 bone fragments, including some teeth,
  - 400 archaeological tools in flint,
  - 10 pottery fragments (only in the superficial levels),
  - Some pieces of coal.

4. SEDIMENTOLOGICAL STUDY

The sedimentological study was carried out at the National Museum of Natural History, Paris (Prehistory Laboratory, Institute of Human Paleon tology).

4.1. Morphoscopy of quartz grains

The morphoscopy of quartz grains was performed on cold decarbonated sediments. The quartz grains are sorted with a binocular magnifying glass and then classified according to their shape and surface appearance reflecting different environments (Cailleux and Tricart, 1963). They must be large enough to be able to record their last mode of transport (diameter > 0.25mm) (Cailleux and Tricart, 1963; Miskovsky and Debard, 2002). Grains are classified into four main categories:

- Unused grains: do not show any clear signs of mechanical wear and have an angular, sharp-edged appearance. The crystal faces are original or resulting from breakage.
- Blunted or used grains: generally angular in shape with blunt tops and edges. Their appearance shows significant changes before the final deposit.
- Blunted and shiny grains: blunted, sometimes rounded and smooth with a shiny and transparent appearance. They result from a long mechanical wear in the water.
- Round and matte grains: rounded, marked with small impact of shock. These grains are totally opaque; they come from a shaping of shocks with other particles during a wind transport (Le Ribault, 1977; Legigan, 2002).

Our study revealed the presence of different categories of grains (Ph. 2), especially the shiny blunt grains, ubiquitous throughout the observed section (63.03%). Unused grains represent 24.09%, the round mattes are observed in all levels (12.88%). Note the presence of rare bipyramidic quartz (levels 2 and 8).

4.2. Particle size analysis

This analysis was performed using a laser granulometer at the National Museum of Natural History in Paris. Laser granulometry is a technique based on the diffraction and diffusion of a laser beam hitting a particle. This technique makes it possible to obtain more reliable results than conventional sieving; it is interested also in studying the grain size distribution of sediments; in order to reconstruct their transport and deposition conditions (Geiss and al., 2004; Djerrab and al., 2013a).

In reality, sediments of the superficial formations result from the combined action of various factors, such as the bedrock type, the climate or the anthropogenic factors (Miskovsky and Debard, 2002). The particle size study aims to trace the sediment history and sorting it into granulometric classes (blocks, pebbles, gravel, coarse sand, fine sand, silt, clay). The type of dominant elements and the evolution of their concentration make it

possible to estimate climate and transport agent intensities (Hunt and al., 1995; Miskovsky and Debard, 2002; Geiss and al., 2004).

The results obtained in the context of this study show the dominance of fine sands and silts. The presence of calcareous concretions argues in favor of a humid climate. The granulometric curves of the raw and decalcified sediments are almost identical. The percentage of limestone elements is substantially the same all along the section (Fig. 3). These carbonated particles have probably infiltrated through the limestone wall, they can also be derived from the disaggregation of the blocks fallen in the shelter (Stockhausen and Zolitschka, 1999; Weston, 2004).

5. GEOCHEMICAL STUDY

This study was carried out at the Tunis Science Faculty laboratory; its objective is to determine the content of certain elements in the sediment:

- carbonate content (calcimetry),
- organic matter rate,
- rate and type of clays (X-ray diffractometry).

The presence of these elements, their concentration and their absence can give indications on the origin of the sediments, the climate (temperature, rate of precipitation) and the post-depositional evolution (infiltration, dissolution ...) (Banerjee and al., 1981; Djerrab and Aïfa, 2010; Djerrab and al., 2013a).

5.1. Calcimetry measurement

This is a measurement using Bernard's calcimeter, which determines the amount of $CaCO_3$ contained in a sample by comparing the volume of CO_2 produced by this sample to that released by a given amount of pure calcite. This method has an uncertainty of 5 to 10% (Maher, 1986).

In this section, the rate of carbonates varies between 25% and 54%. There is a very significant variation and a positive correlation with the particle size fractions: sand, silts and clay. Carbonates tend to rise from the top to the median portion of the section (intense limestone wall leaching phenomenon), but from -215 cm, a further decrease followed by a sharp rise at the base is recorded (Fig. 4).

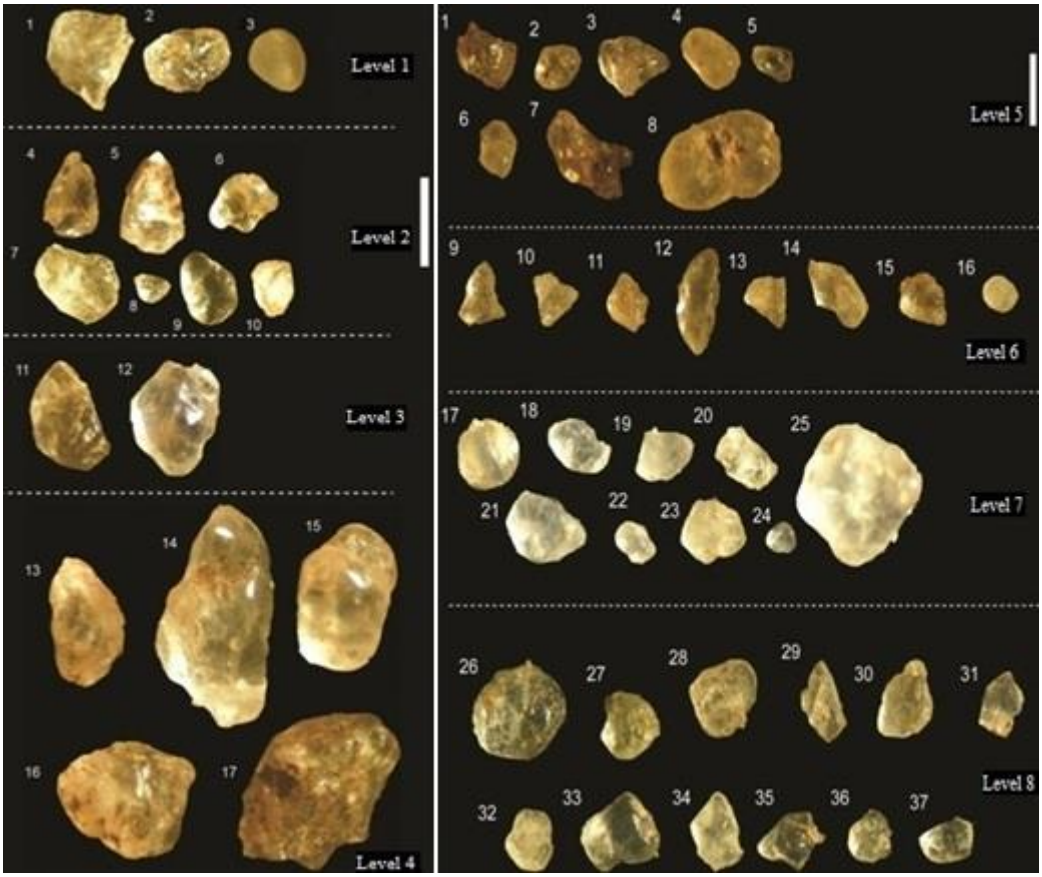

Fig. 3. Overall grain size: 1.Before decalcification, 2.After decalcification

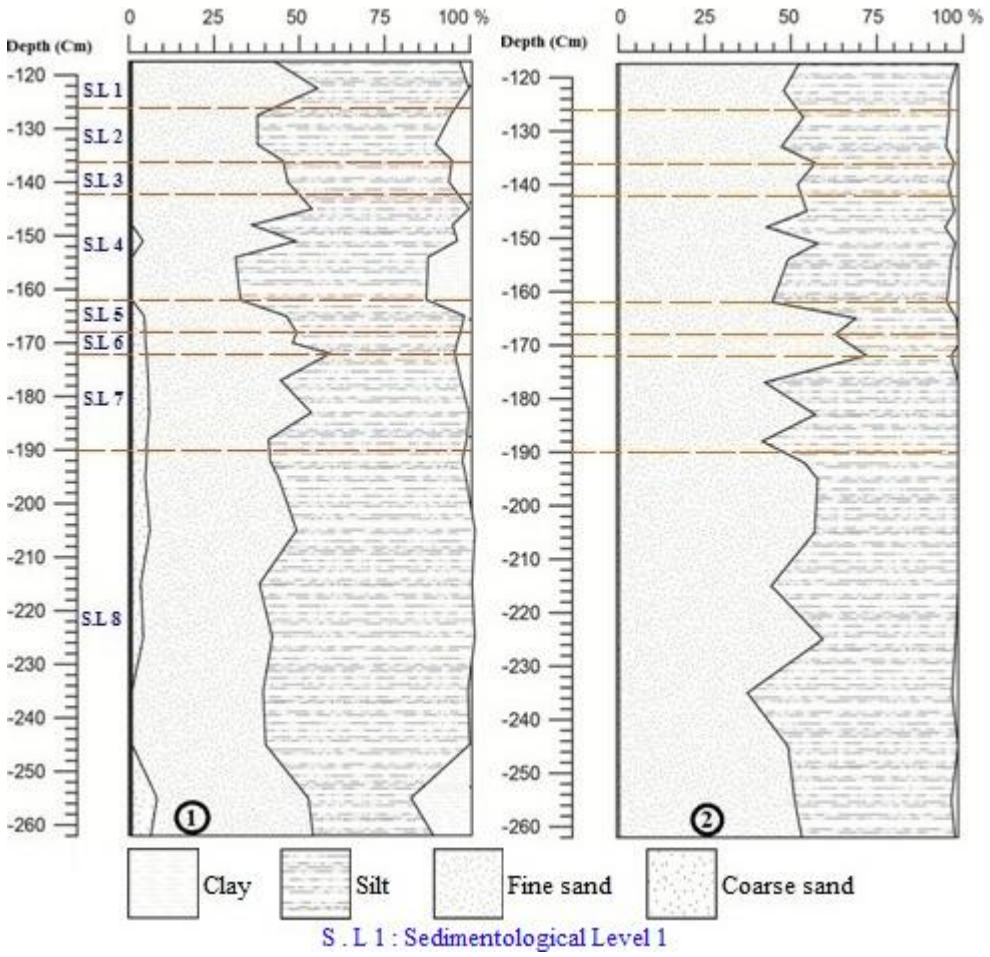

Fig. 4. Evolution of the $CaCO_3$ rate.

5.2. Measurement of organic matter content

The maximum concentration of organic matter remains spread over the first 80 cm of the section; notably sedimentological levels 2, 3, 4 and 5. Level 2 has an average rate of 22 ‰, levels 3 and 4 are the richest with a content of 36‰, while level 5 shows a rate of about 30 ‰ (Tables 1.1 and 1.2). We note the presence of traces of dusty "hearths", formed by black grey ashes, of decimetric dimensions, in levels 3 and 4.

5.3. X-ray diffractometry

X-ray diffractometry refers to the clay fraction of sediment with an average diameter of less than 2 µm. The clay minerals inherited or formed on site need specific conditions to form (bedrock type, temperature, precipitation) (Deng, 2000; Maher, 2011). The analysis proved the presence of the following clay minerals:

- Illite: structure similar to muscovite (more water).
- Smectite: Calcium, rarely sodium, formed in poorly drained soils.
- Chlorite: Formed during sediment digenesis.
- Kaolinite: formed in well-drained soils in acid pH.
- Vermiculite: close to illite and chlorite, with swelling properties.

We analyzed 27 samples distributed over the 8 sedimentological levels. The results obtained are recorded in the following table (Table 2).

6. DISCUSSION

From the sedimentological point of view, the morphoscopy of quartz grains reveals that the shining blunted grains are ubiquitous at the level of the whole cut with a rate of 63.03%. They translate a long transport by water. Other types of grains remain less abundant at lower rates. Granulometric analysis shows the dominance of fine sands and silts. The percentage of limestone elements (sands and silts) is the same all along the section. The presence of calcareous concretions argues in favor of a humid climate.

From a geochemical standpoint, the measurement of calcimetry shows that the rate of carbonates varies between 25% and 54%. These compounds are positively correlated with the particle size fractions: sand, silts, and clay. Measurements of the organic matter content indicate that the maximum concentration remains confined in the first 80 cm of the section (sedimentological levels 2, 3, 4 and 5), with presence of dusty "foci" and "Fireplaces" formed of blackish ash.

X-ray diffractometry analysis informs us about the specific paleoclimatic conditions of genesis of the inherited or locally formed clay minerals. Each clay mineral reveals its own characteristics and geochemical formation conditions. This analysis showed the presence of illite, Smectite, Chlorite, Kaolinite and Vermiculite.

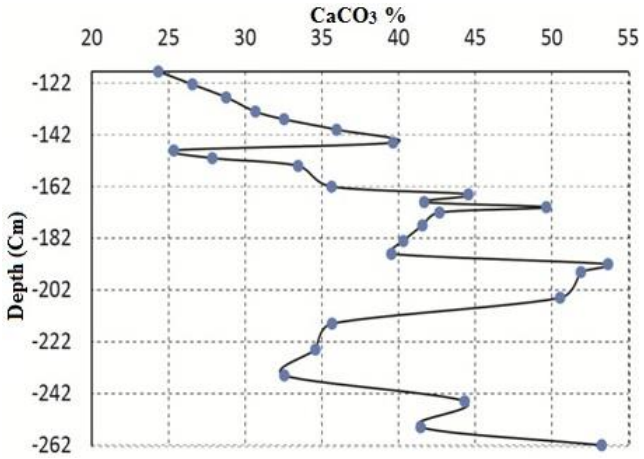

Table 1.1. Measurements of the rate of organic matter (Levels 1, 2, 3, 4, 5).

sample numbers	1	2	3	4	5	6	7	8	9	10	11	12	13
Organic matter (‰)	16	20	24	32	40	36	40	38	36	34	32	32	28
Sedimento – logical Levels	I	II		III			VI				V		
Depth (Cm)	120 – 126	126 –136		136 –142			142 –162				162 –168		
Average content / Level (‰)	16	22		**36**			**36**				30		

Table 1.2. Measurements of the rate of organic matter (Levels 6, 7, 8).

Sample numbers	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Organic matter (‰)	24	16	15	13	14	14	13	12	12	13	10	11	12	13
Sedimento-logical Levels	IV		IIV				IIIV							
Depth (Cm)	168 –172		172 –190				190 –260							
Average content / Level (‰)	20		14				**12**							

Table 2. X-ray diffractometry results.

Levels	Clay minerals (%)					Other components
	Illite	Smectite	Chlorite	Kaolinite	Vermiculite	
I	19.67	12.36	9.43	5.17	3.21	Iron hydroxides(hematite, goethite)+ quartz and calcite
II	16.37	13.25	5.79	10.12	3.52	Rare fibrous clay minerals (Attapulgite) + quartz, iron oxides
III	15.34	11.27	5.35	9.52	/	Fibrous clay minerals (Sepiolite, Palygorskite) + quartz, iron oxides
VI	19.39	12.67	4.90	7.45	2.12	Very rare fibrous clay minerals (Palygorskite) + quartz, iron oxides
V	15.36	12.56	9.68	5.45	4.23	Fibrous clay minerals (Sepiolite, Palygorskite) + quartz, iron oxides
IV	18.63	13.16	6.68	7.54	2.32	Rare clay minerals (Sepiolite, Palygorskite) + quartz, iron oxides
IIV	16.65	13.58	6.86	3.57	1.48	Fibrous clay minerals (Sepiolite, Palygorskite) + quartz, iron oxides
IIIV	20.58	10.73	6.47	5.36	2.52	Some clay minerals (Palygorskite, Sepiolite) + Iron hydroxides

The sedimentological and geochemical data obtained indicate the nature of the conditions of transport, deposition and formation of the different types of particles. They retrace the history of palaeoenvironments and the conditions under which these quaternary formations were set up.

7. CONCLUSION

The survey conducted in the locality of Aïn Zerga (Oued Boussemane) allowed the release of 8 sedimentological levels distinguished by their color, texture and content in archaeological material. The samples collected were subjected to sedimentological and geochemical analyzes, the results of which were summarized and previously exposed. *In situ* observation reveals the presence of two distinct strato-sedimentological units:

- The first strato-sedimentological unit located in the upper part of the section, is rich in pottery (Neolithic) and lithic industry (levels 4, 5 and 6) hence its chronological attribution to the Holocene and the upper Pleistocene. This unit is relatively rich in organic matter and shiny blunt quartz grains, thing which testifies a humid climate. In the absence of archaeological material other than the ceramic modeled in level 3, we tend to attribute this unit to the Neolithic without asserting it, however (Deng, 2000; Mooney and al., 2002; Djerrab and al., 2012).
- The second strato-sedimentological unit, characterized by the presence of calcareous crusts and shiny blunt quartz grains, is older (dating from the Pleistocene). It has been established under a hydrodynamic regime during a wet period. In large part, the uncovered tooling is represented by scrapers (lateral, transverse, discarded and double) and pieces with check marks.

These data place the lithic industry of levels 4, 5 and 6, culturally, in the Middle Paleolithic (Atero-Mousterian) which corresponds in North Africa to the interval 140000 - 20000 years BP (Djerrab and Aïfa, 2010; Djerrab and Camps, 2011; Djerrab and al., 2012; Djerrab and al., 2013a).

In fact, previous work in the region has already revealed the environmental humidity during the Holocene (2000, 7000 and 8000 years BP) and also during certain Pleistocene periods (Djerrab and al., 2013).

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