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Survey archaeology and regional analysis: A conceptual model on the selection of past dynamics during the Holocene in Wadi Abiod, Aures, Eastern Algeria.

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Abstract: This paper inserted within a geoarchaeological study, provides a model for the investigation and the support of past dynamics of a mountainous landscape in the Aures region (Algeria) during the Holocene. It introduces the first analysis based on the detailed mapping of morphological features of the study area in relation with a typo-morphology theoretical model that was confronted with data from archaeological research. Our results suggest that the choice of the prehistorical movement processes has been driven by the outcrop of some deposits and the presence of specific landforms, such as high and low-relief areas. This approach was applied to a sector with controversial archaeological evidences (the valley of Wadi Abiod), where geological and morphological analyses support archaeological research in the reconstruction of the ancient pathways during the Holocene. This integrated approach can help archaeologists to understand and then discover ancient courses crossing complex in impervious landscapes such as the intramountain Lands.

Key Word: Geoarchaeology, Typo-morphology, North Africa, Aures, Mobility, Holocene..

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I. INTRODUCTION

The reconstruction of past human movement's dynamics is an important issue that is often related to the morphology of a given territory, as well as, conversely, is necessarily connected to a pathway network due to its important role on past behavioral processes. These past dynamics were strongly influenced by geological, geomorphological and topographical attributes such as rock deposits, spatial extensions of watercourses, drainage networks, and slope profiles. Thus, a comprehensive evaluation of the past movement circuit should include a multidisciplinary approach, in which lithological, morphological, and hydrological study should be confronted with the archaeological analysis (Ramazzotti, 2013, 2014 a & b).

Our work aims to investigate the multiple influences of geological and morphological features on the selection of past human movements during the Holocene in an intermountain landscape. A territory constituted by a massif hardly offering north / south passages, but partially crossed by a north-east / south-west syncline depression at the bottom of which flows the river. The behavioral perspective of this study being dependent on a decisive environmental context, although unstable and little known, wishes to draw attention to the Holocene potential of the Aures region and more specifically in the Wadi Abiod valley in the Saharan Atlas.

A preliminary geological and geomorphological analysis of the region were performed in order to investigate the possible lithological, morphological, and hydrological influence on the selection of past movements' circuit in the region. These factors were analyzed at a regional (Aures) and at a local scale (Wadi Abiod valley) in parallel with a broad study of the scientific literature. Therefore, a deep investigation based on a detailed geological mapping was performed in order to verify the relations between the different stratigraphic features of rocks and the distribution of deposits.

Then, a hypothetical model of what was applied using the typo-morphology method, a widely shared and a reliable principle of landscape processual analysis, which consists in the decomposition of landscape into its elementary components and the subsequent identification of the structures and their relationships. This method is based essentially on the diachronic reconstruction of the human settlement sequences and look into the comprehension of the logic in their organization, to shed light on the location preferences and settlement strategy of communities.

In order to highlight the principal landforms during the Holocene of the studied area and their possible influence on the path system, a geomorphological analysis has been realized, from which a 3D schematic geological cross-section highlighting the valley geometry and the surrounding landscape was derived.

Topographic data have been extracted from a Digital Elevation Model (DEM) with a spatial resolution of 30 m. The information obtained was essential for the investigation of the possible factors for settlement preferences.

The above obtained data were then confronted, with parallel fieldwalking surveys of the whole territory of the studied area, to gather information on Holocene chrono-cultural ensembles. These were preserved in sheltered sites and open-air campsites, with numerous traces related to funeral tombs. The multi-millennia occupations that they attest will help to clarify the motivations of the populations to settle near rivers, springs and lagoons, notably in a geographical sector marked by a climatic disturbance and periods of drought and which had a strong impact across the Mediterranean basin without sparing the Saharan Atlas territories.

II. HISTORY OF FIELDWORK AND RESEARCH CONTEXT

The research in Aures (Figure1) was almost completely interrupted after the 80's, creating an important gap in our knowledge of recent prehistory. The region suffers from fragmented prehistoric research and a full picture of the richness and diversity of local developments is still lacking (Mulazzani et al., 2016). In many cases a thorough revision at the light of new methods need to be done. Even so, the few existing data point to an important anthropic frequentation between the 9th and 3rd millennia BC during the Holocene (Alimen et al., 1979; Arlette et al., 1997; Aumassip,1986; Balout, 1955; Camps, 1963, 1966, 1975; Cote, 1991; Grebenart, 1971; Roubet, 1966, 1968, 1969, 1971, 1979, 1985, 2003).

The most known deposit since the beginning of the 21th century that has been the subject of a modern excavation is situated on the northern slope of the Aures and which is identified as the Capeletti cave. It has revealed Neolithic facies of Capsian tradition dated to 5929-4928 BCE (Roubet, 1979). However, in regards to the particular nature of the Aures, the overall occupation of the massif is not limited only to this cave or to this period. In fact, other surveys carried out by J.-L. Ballais have revealed 43 sites (Ballais&Roubet, 1981, 1982).

The data indicates an undifferentiated Epipaleolithic with abundant lamellae is more evenly distributed in the large valleys. while The Capsian was recognized in the vicinity of Mchouneche, but is much better represented in the north, in relation to the massive occupation of the High Plains by this culture. Whereas the Neolithic, outside the major site of Capeletti cave, remains poorly represented. The uninterrupted occupation of caves since this period does not facilitate prospecting and it is therefore difficult to draw any conclusions from the currently known distribution of the deposits.

Wherefore, for the comprehension of these past dynamics we have started by investigating the south region of the Aures through a prospection along the Wadi Abiod in order to gather as much data as possible related to archaeological founds from which we count seven funeral monuments of a circular or elliptical aspect, these monuments can be quite easily confused with the tumuli provided with a circle of stones at their base (Camps, 1991). Nevertheless, the difficulty of doing a proper field survey due to the escarpments, and the constant occupation of the area constitute another reason for opting for geospatial analysis for a more thorough sediments and landforms analysis that could reveal new insights on past settlements and formation processes in the versant.

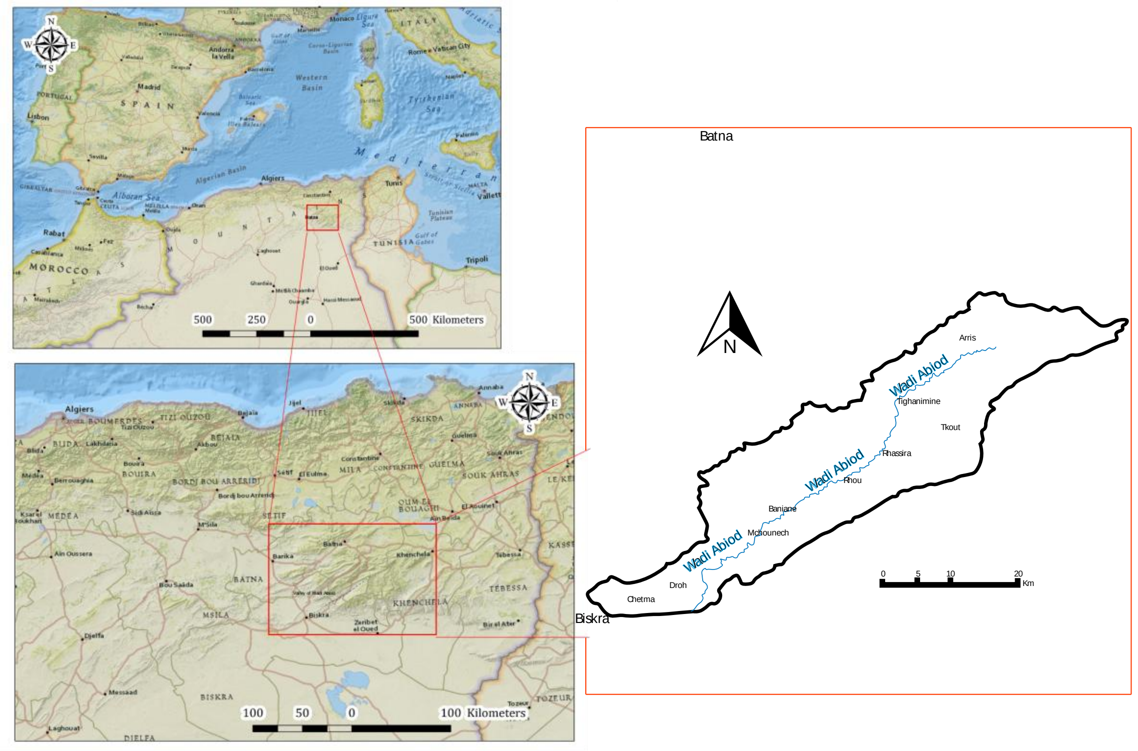

Figure 1.QGisbasemap illustrating the position of the studied area and its delimitation.

III. REGIONAL GEOLOGICAL AND GEOMORPHOLOGICAL CONTEXT

Backed to the north to high plateaus which often exceed 1,000 m above sea level (a.s.l), the massif of the Aures (Figure2) literally plunges into steep and rugged waterfalls and escarpments, towards the south-east and south-west, that is to say towards the Saharan depression which does not reach 150 m.a.s.l.

The Massif is an eastern continuation of the Atlas Mountain System and is placed at the hinge of two large ensembles that constitute the Algero-Tunisian Saharan Atlas in northeastern Algeria (Figure.1). It is made up of a set of chains with very contrasting relief (Benmessaoud et al., 2009). It is composed of a series of tight folds which draw long rectilinear edges, made of narrow ridges and separated by deep valleys. The highest peak in this massif is located at Chelia Mtn. and exactly at " Irfen'Keltoume " with an altitude of 2326 m. The region has undergone different orogenic phases that gave rise to synclinal and anticlinal structures. The most important are the Atlasic (Upper Lutetian) phase and the Upper post-Miocene phase.

The Atlas Mountains are made up by a Meso-Cenozoic sedimentary sequence that, from Trias to Quaternary has went through a series of deformational events (folds and faults) related to tectonic stress which resulted in the development of the mountain range (Bracéne et al., 1998; Askri et al. 1995). This long tectonic history has drawn a geological limit corresponding to a multi-kilometer tectonic accident, marking the end of the North Saharan Pliocene (Marmi&Guireaud, 2006). This flexure gives the entire territory a general south-west / north-east direction serving as a major benchmark (Frizon de Lamothe et al., 1990). It generated the main morphological features (e. g. ridges, saddles, valleys, paths river) and influenced the natural landscape and environment of the area, and also these features were, probably, used as a natural pathway for moving people toward comfortable places.

The region of Wadi Abiod, that constitutes our case study, is one of the valleys of this massif, located just north of the southern Atlasic Fault, in the transitional region with the High Plateaus. It belongs to the large hydrological basin of ChottMelghir, and is formed by the union of torrents descending from the steep slopes of the highest point in the Aures of which is Chelia Mtn. and Ichemoul Mtn.(2100m). After crossing Tighanimine, it cashes in the canyons of Rhoufi and the gorges of Mchouneche, then opens a path towards the Saharan plain to the gorges of Foum el Gherza.

The geological formations consist of detrital deposits of the Lower Cretaceous; argilo-carbonate deposits of the Upper Cretaceous and Jurassic; the Tertiary sediments are predominantly carbonate from the Paleocene to the

Middle Eocene, while the Neogene is essentially detrital. Lateral variations in facies are very frequent and concern all levels. While the Plio-Quaternary is characterized by the persistence of Tertiary sedimentation with the development of ablation forms, presence of crusts and the formation of a lacustrine system (Ballais, 1984).

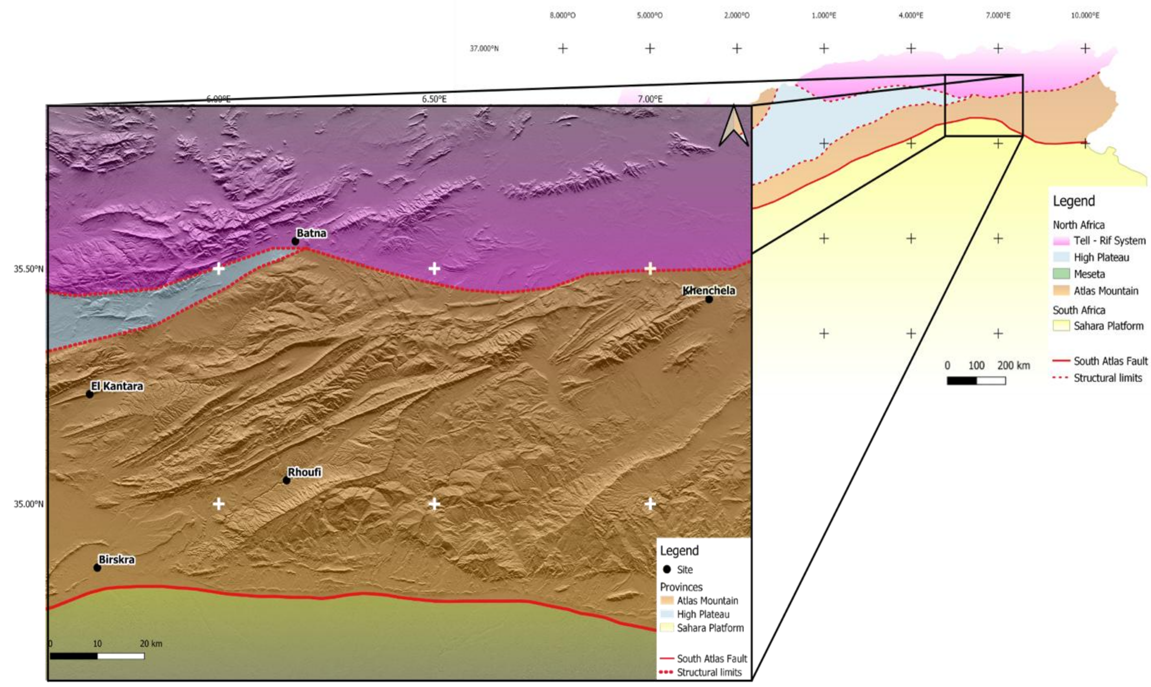

Figure 2. Overview of the position of the Aures in the Saharan Atlas of eastern Algeria

IV. SLOPE CONTEXT

In order to better understand the morphology of the area, we have realized the topographic map, reported in (Figure 3). The area is characterized by a wide range of altitudes, with the highest point above the 2000 m.a.s.l., and the lowest below the 0 m.a.s.l. We focused our attention on the Wadi Abiod valley by plotting a total of five transects (Figure 3) crossing along and through the valley: three 2D profiles (AA'; CC'; DD'); and two 3D sections (BB'; EE'). The 2D profiles were realized by using QGIS Software through a QGIS Profile Tool which extracts profiles starting from a raster layer with an elevation field; whereas the 3D sections were realized using ENVI software.

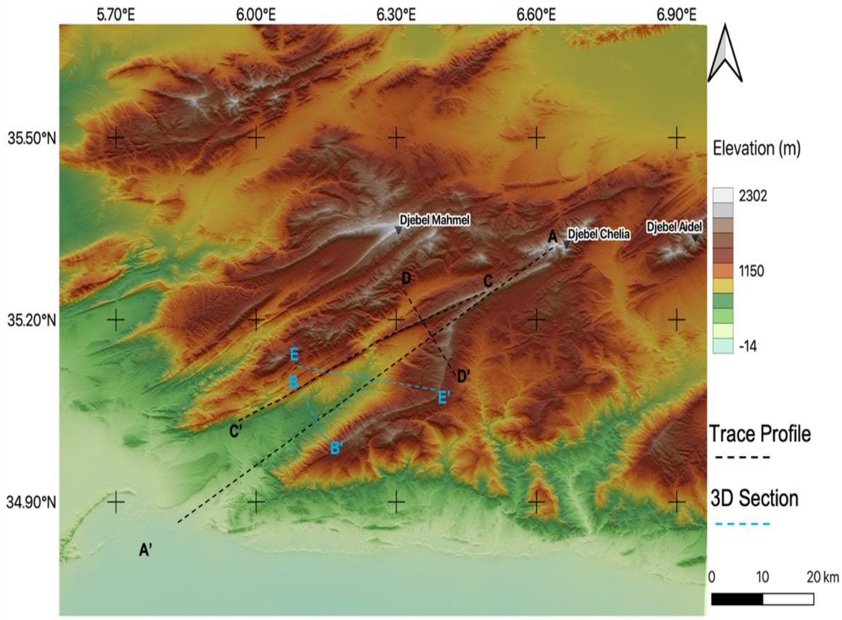

Figure 3. Topographic map showing the location of the five transects.

By analyzing the profile trending NE-SW (AA') and running parallelly to the entire valley (Figure 4), it is possible to divide the section into seven different parts: the first one "a", is the higher most area, Chelia Mtn which exceeds the 2000 m.a.s.l.; the second sector "b" is a little depression that connects the Chelia to the second higher zone of the area, the third sector "c", is prevalently flat region with an almost constant altitude of about 1700m. The limit to the sector "c" is located at the edge of the flat region and it represents the entrance to the valley, the sector "d", characterized by a constant downslope to SW until the end of AA'. With a focus on the bottom part of the profile, from the sector "d" to the end, we can see some distinctive traits: the sector "e", characterized by a very undulatory segment because of the river meandering in this sector; the sector "f", that represents a high structure related to the Eastern edge of the valley; the sector "g", where the profile is very low and flat because it reaches the Sahara Platform limit.

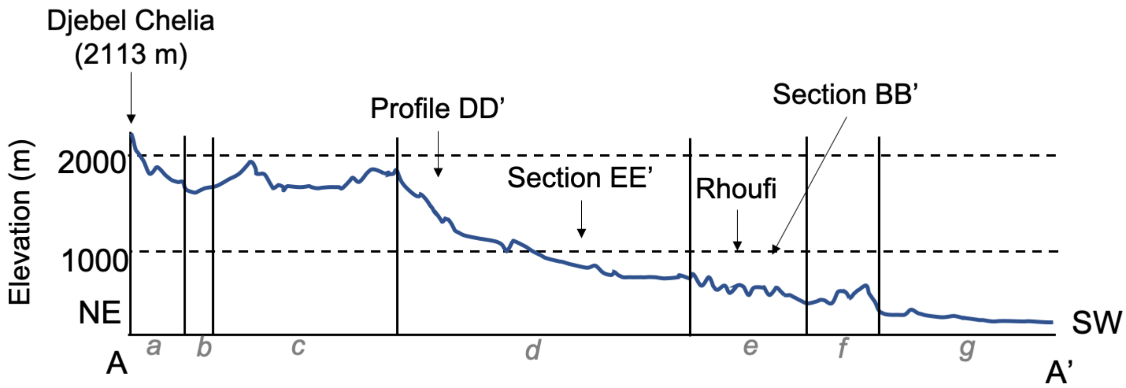

Figure 4. Topographic profile A-A' with a NE-SW trend running parallel to the valley. it's subdivided in seven sectors, form "a" to "g".

From D-D' profile (Figure 5) and from the 3D section (Figure6) it is possible to observe how the valley of the Wadi Abiod is a large valley characterized by a steep and narrow ridge, to the left side and a high wide ridge to the right side.

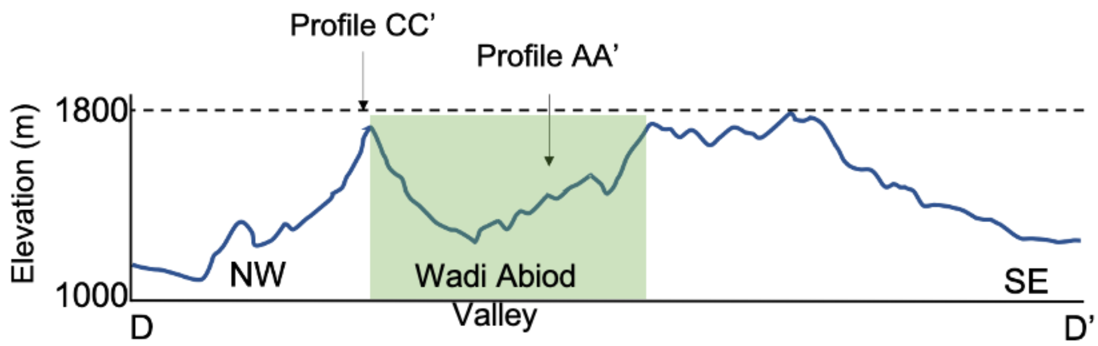

Figure 5. Topographic profile D-D' with a NW-SE trend that cut the valley. The valley of Wadi Abiod has been highlighted in green.

Furthermore, considering a NW – SE 3D section we emphasize the transversal geometry of the Wadi Abiod valley (Figure 6) where we report a 3D schematic geological cross-section highlighting the valley geometry and the surrounding landscape.

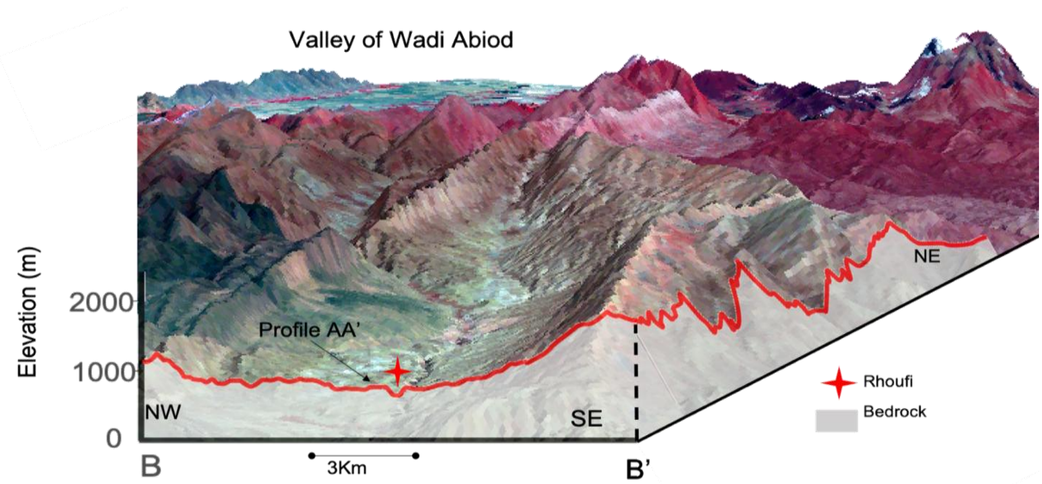

Figure 6. 3D view of the Wadi Abiod valley with a topographic profile (B-B' fig 1)

We focused on the orthogonal section with respect to the main axes of Wadi Abiod valley (B-B'). The river flows and cuts the bedrock. According to the geological map (Lafitte, 1939) and to the topographic profile, the valley is characterized mainly by a carbonate series with an age ranging from the Trias up to the Miocene, that include a large variation of calcareous rocks, from limestone to marl. From Lafitte (1939), the valley outcrops minor continental deposits (debris slope) on the NW side of the valley.

V. FLUVIAL CONTEXT

The Wadi Abiod river basin has been analyzed by a multiscale approach: a first general regional overview of the network and then a focus on the Wadi Abiod valley. These two studies are carried out based on the

definition of the drainage network by Deffontaines and Chorowicz (1991): they defined the drainage network as a set of topographic surfaces which are bordered by uphill slope on all sides except for the direction of the water flux.

By using such statement, we have recognized and extracted the drainage network starting from a DEM (with a 30 meters resolution derived by the Shuttle Radar Topography Mission - SRTM) by the use of QGIS software.

To extract the main rivers and their tributaries, a parameter suitable to define the network density has to be set (Figure 7). We have chosen two values identifying the regional and local scale rivers pattern: for a regional scale we have used the parameter suggested by the QGIS User Guide, but we have changed the parameter reducing it into the local scale in order to have more information about the tributaries.

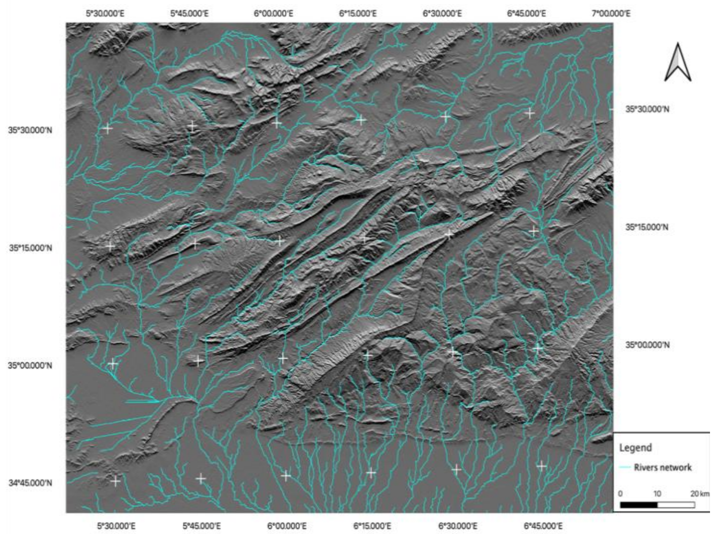

Figure 7. Channel network map at a regional scale with a DEM as base map.

Comparing (Figure 7) with the topographic map (Figure 3) it is possible to derive that the upper limit of the drainage network corresponds to the most elevated zone and it trends towards North – North-East and South – South-West zones respectively.

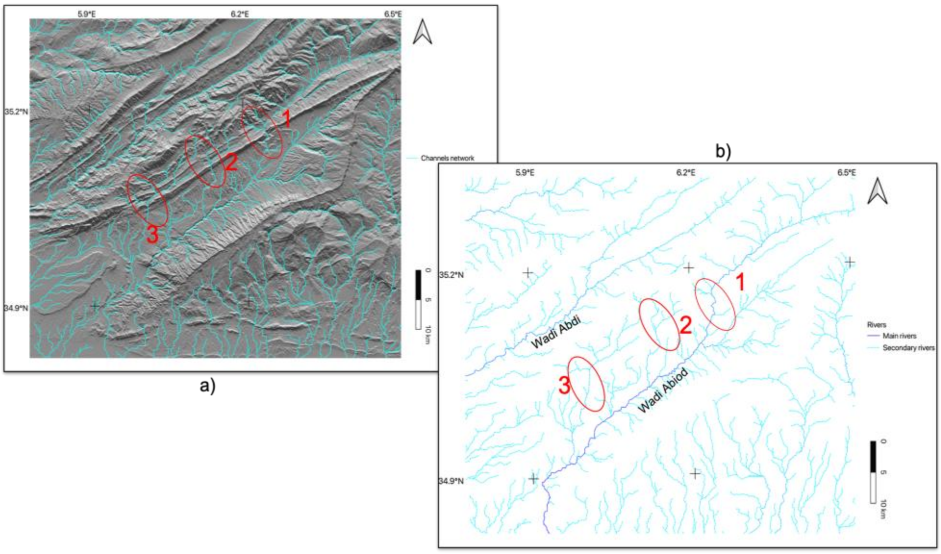

Figure 8. Channel network map focused on the Wadi Abiod valley. The three red circles shoe the main N-S deviations.

At a smaller scale (Figure 8) we have also identified the NE-SW trend of the main rivers (Wadi Abdi and Wadi Abiod) with a number of tributaries orthogonal to them.

The analysis performed highlights that the tributaries are characterized by longer paths and their orientation depends on the transversal tectonic elements which drives the topography in this region.

A particular N-S deviation of the Wadi Abiod river has to be highlighted (red circle in Figure 8). By a closer observation (Figure 9), we may see how the previous mentioned deviation is not the only one in the valley of Wadi Abiod.

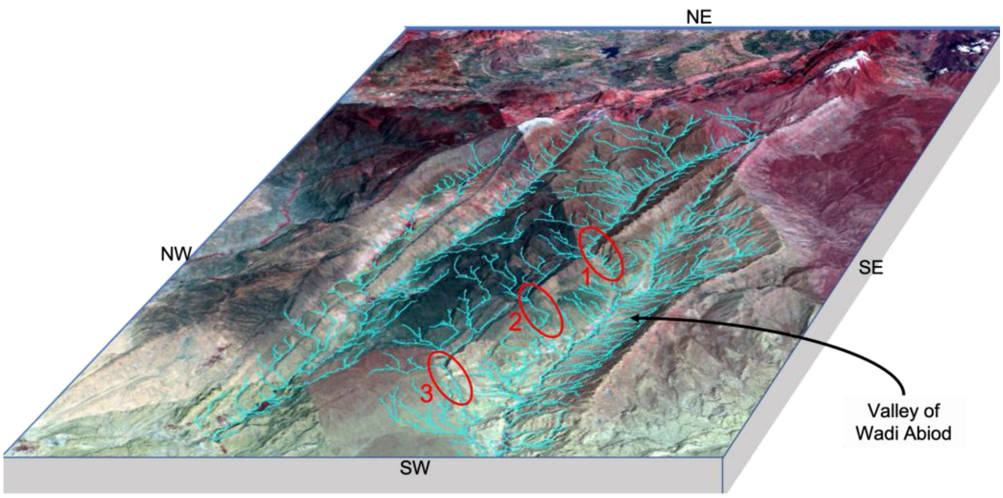

Figure 9. 3D view of the Wadi Abiod valley with the overlay of the drainage network (in red the three N-S trend deviations of the main river Wadi Abiod).

In (Figure 9) we overlay the shapefile of the drainage network on an ASTER image in a 3D view. This figure shows three main N-S deviations of the river Wadi Abiod that depend on the tectonic element.
These N-S deviations are recognizable tracing a NE-SW topographic profile (trace C-C' on (Figure 3) along the crest that borders the valley on the left side (Figure10) cut by the three deviations previously mentioned.

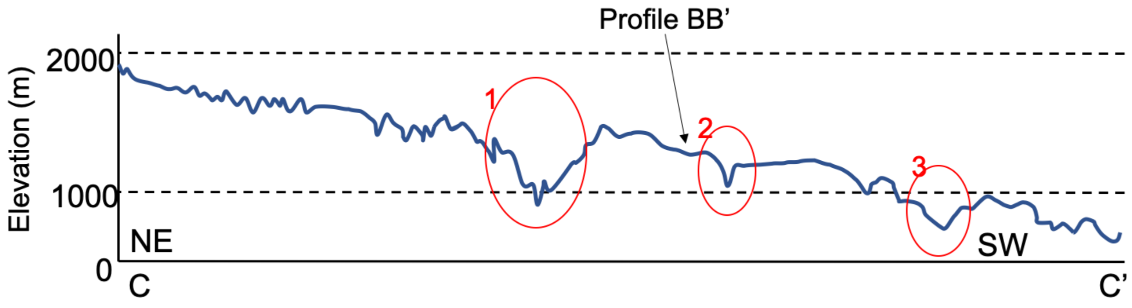

Figure 10. Topographic profile C-C' with a NE-SW trend running along the crest that border the valley on the left side. Circled in red are shown the three valleys formed by the river.

It is useful to focus the attention on the northern one (red circle 1 in Figure 8, Figure 9 and Figure 10). Up to us it is the most important because conversely for the others (circles 2 and 3) it connects two rivers of the Wadi Abiod (Figure 11).

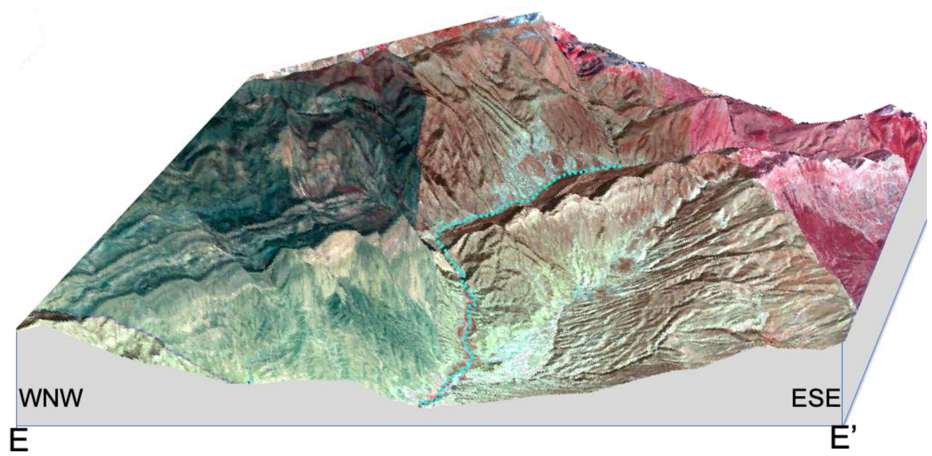

Figure 11. 3D view of the Wadi Abiod valley (section E-E' in' Figure 3) with a focus on the most important N-S deviation of the Wadi Abiod River

In order to extract the drainage network, we applied the Fill Sinks tool available on QGIS release "3.8" on DEM obtained by "dwtkns.com": this procedure allows to clean up the DEM by removing sinks and peaks that are usually related to the noise relevant to the used DEM, and that would capture the flow of water. A second step foresees the application of hydrogeological analysis procedure included in the QGIS used release (https://docs.qgis.org/3.10/en/docs/user_manual/).

VI. TYPO-MORPHOLOGICAL MODEL OF THE HUMAN OCCUPATION

Several authors have emphasized the influence of the ridgeway for modeling the movement and it is what we apply in this study to track down the itineraries followed during prehistoric times. Indeed, the territory corresponds to the superposition of the anthropic structure (the built and non-built settings, the system of their formations and their connections which are the itineraries) on the natural structure that conditions the formation and transformation of the first. The latter is defined as a set of morphological and climatic characteristics assembled by the oro-hydrography produced using GIS tools and DEM representing the individualization of each territorial segment.

In fact, for the conceptualization of past mobility hypothesis, an initial work for the determination of the principal crest line has been performed in the region of Wadi Abiod based on the typo-morphological approach of the territory. This crest line corresponds to the watershed line between two basins (it is the most continuous and prolonged line) more significantly depending on the consistency of the underlying basins since the course along the watershed allows access to an area. This initial phase is correlated with the itinerary that past population has followed in order to better control the environment and to better understand the natural structure of the territory (Caniggia& Maffei, 2000). It corresponds to the period when man lived from gathering and hunting, moving on the main crest line dominating the territory, which makes of it the path of the first anthropic occupation of the landscape.

A second task was performed to reveal the secondary crest line, and which is located on the watershed branching off from the main crest course. It delimits tributary or sub-tributary basins within a larger river basin (Caniggia& Maffei, 2000). What characterizes this phase is the sedentary lifestyle of man, that also corresponds to the emergence of the high promontory settlements. They are implanted on hilltops; at the lowest level are the water sources. It is a system of direct connections between the relevant establishments in the same altimeter band and which also offers the possibility of access to promontories at lower altitude (Caniggia& Maffei, 2000).

In our case, for the study of the territory we had to refer to the already processed models of orography and hydrography (Figure3;7; 9) in order to have a clear idea on the possible location of the different itineraries such as the course of the crest line and the course of the secondary crest using the typo-morphological method of the territory (Caniggia&Malfroy, 1986) as well as GIS tools.

Two main phases were depicted from the typo-morphological analysis: a first phase that corresponds to the main ridgeway which is that of Chelia Mtn. ; from this main route, two crest routes emerge, one on the chain of Takroumt Mtn. and Krouma Mtn. in the north-west and the other on the Ahmar Khadou Mtn. in the south-east. A second phase follows and which corresponds to the settlements, where there is an emergence of structures on the secondary crests and on high promontories and which are strictly connected with the source of water (the river Abiod) that is located at lower levels (Figure 12).

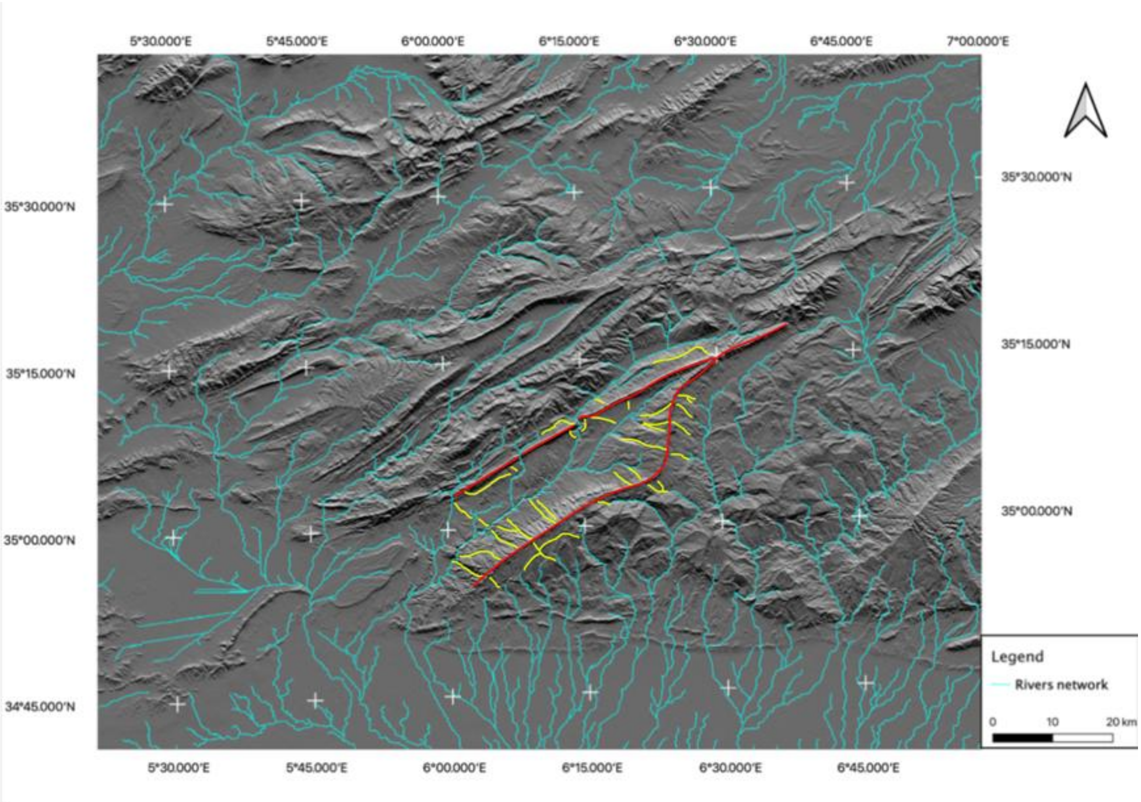

Figure12. An oro-hydrographical map illustrating the main ridgeways (in red) and secondary crest paths (in yellow) of the studied area.

Consequently, by overlapping the natural and anthropic layers we observe the distribution of patterns along the area (Figure 13)

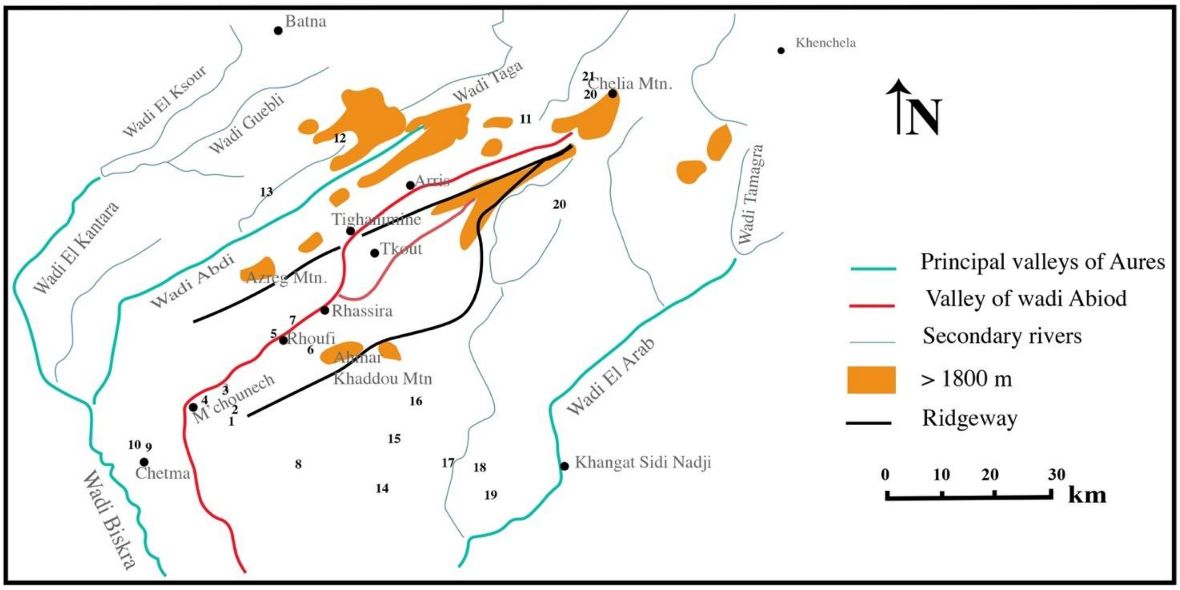

Figure 13. Prehistorical sites discovered within the valley of Wadi Abiod and its surroundings: Lamellae industry: 1; Epipaleolithic: 3,4, 9,11, 12,13,15,16,20,22; Capsian: 2,14,21; Neolithic: 8,19; Funeral monuments: 5,6, 7.

VII. VALLEYS, TERRACES AND ALLUVIAL PLAINS

Changes in lacustrine levels during the Quaternary are related to paleoclimatic variations (Petit-Maire et al., 1991; Damnati, 2000; Damnati&Taieb, 2003). Methods for reconstructing these changes are based on stratigraphic, sedimentological, geochemical and palaeoecological studies. In fact, in semi-arid regions, high lacustrine levels are frequently recorded by terraces, or by exposures of lake sediments around watershed margins (Fekri, 2007). Changes in the nature of sediments (facies) and sedimentation rates also provide an important source of information on past water levels. The presence of erosion surfaces or drying slits is correlated with low or very low water levels. Laminated deposits in some lakes reflect water stratification and high lake levels (Damnati, 1993).

To highlight the originality (Riser, 1979) of the Quaternary hinge and the role of climatic variations in Quaternary evolution, we have relied on works performed in the Aures piedmont: the passage is generally from levelling forms to accumulation forms. Indeed, covered ablation glacis or less frequently, pediments are replaced by terraces, alluvial fans and spills.

The Lower Pleistocene after the major tectonic phase, is characterized by an alternation of glacis and mudflows. The covered ablation glacis-fan changes locally into a glacis accumulation or fan. Mudflows of several kilometers long and several tens of meters are subsequently emplaced. The second glacis is generally an ablation glacis-fan covered by blocks and pebbles sometimes strongly consolidated by a calcareous cement. A second generation of mudflows is emplaced with the same characteristics as the first (Ballais, 1984). During the middle Pleistocene, the glacis achieve their maximum prolongation. The accumulation forms (accumulation glacis in the Aures) begin to replace ablation forms (covered ablation glacis) (Ballais et al., 1985). In the Upper Pleistocene-Holocene, this trend becomes generalized (terrace, alluvial cone and spreading) (Coque&Gachelin, 1975). Furthermore, the granulometry of the deposits, coarse in the lower and middle Pleistocene, become fine in the upper Pleistocene and predominantly fine in the Holocene.

Finally, this evolution highlights the existence of a fundamental climatic break at the end of the middle Pleistocene (Lacustrine phase) and other less important ones at the beginning of the lower Pleistocene and at the end of the upper Pleistocene (Ballais, 1991).

VIII. The main features of the Holocene

Between 9500-2000 BP, multidisciplinary studies (Ballais, 1991; Mulazzani, et al., 2016; Roubet& Amara, 2015) have highlighted a series of at least four climatic episodes. A first one during the early Holocene, with a first significant arid phase (Gastropods dating gives 9500-6320 cal BP) marked by eolian sandy deposits (Ballais et al., 1979). The second record is marked by a humid Neolithic phase (6320 ± 120 cal BP) (Roubet, 1979) of a slow and regular river flow and a Mediterranean vegetation. At the same time for the Eastern Chotts, the rise of their less saline waters could rise and approach the Aures foothills, also watered, making it difficult to go around the massifs (Aures) . The third episode is marked by a dry phase starting from (4320 ± 120 cal BP) (Ballais, 1979) where eolian deposits reappear accompanied with a mechanical weathering. Finally, a sub humid phase (2700 ± 120 cal BP) (Ballais, 1979) marked this episode with a fine, brownish deposit on the slopes where it constitutes most of the silt in Wadi Abiod, followed by erosion of soils and emergence of tilbutaries due to anthropic activities. This doesn't exclude other phases of Eolian depositions in the last centuries (Barades, 1949).

IX. CONCLUSION

The combination of human activities and climate factors in Wadi Abiod had notable consequences for the distribution and dynamics of communities and landscapes. In fact, within the data presumably relating to the prehistorical period, there appear to be morphological differences in types of sites and settlement patterns.

The different ridgeways so far recognized are linked to cultural choices involving successful adaptation phenomena to local environmental diversity and Holocene climatic fluctuations, and suggests that the settlement was probably not a permanent one: in the early periods, humans in the region were mobile. Therefore the settlement was not habitable, but more likely practical.

The Wadi Abiod, a major river artery of the southern pre-Saharan territories of eastern Algeria, played a decisive role during the upper Pleistocene and Holocene. Tectonic activity transformed the landscape, giving an orientation to this river, which continues to feed the western chotts. This waterway has remained a traffic route linking the foothills and valleys of the South Atlas Mountains to the southern grassy plains. It has facilitated and directed the movements of men and fauna towards the interior and exterior of the massifs. The archaeological evidence that has been recovered from previous studies and from the field consist of visible surviving and recorded materials (Lithic industry, Sepultures). Current data show an important prehistoric variability. The prehistoric sites are located downstream and on the mountains, a long term trend, with special emphases on preferred locations becomes comprehensive with the climate fluctuations. The culturally identified context show that these displacements date back to the end of the Lower Pleistocene (Acheulian), and that they continued to vivify these territories during the Holocene. Thanks to dated settlements, a strong anthropic presence was noted during the Holocene phases. The presence of abundant and varied lithic testimonies that these societies has left are excellent indirect evidences of varied and abundant local resources. Finally, we underline the paucity of our knowledge of the periods after the 2nd millennium BC. This period is relative to the development of high promontories and the settlement of man: The presence of numerous funerary monuments bears witness to human presence, but the traces of their daily life and those of their chosen camps remain to be discovered in order to confirm a continuity of occupation during protohistoric and historic times of the territory of the Aures that is not disputable.

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