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Earthquakes and Tectonic Dynamics Favouring Late Pleistocene Human Settlements in the Jebel Gharbi, Libya

Introduction

The Jebel Gharbi (also known as Jebel Nafusah) is located in the northern part of the Tripolitanian plateau, 60 km from the Mediterranean coast at Gharyan to the east, and 135 km at Nalut to the west. A series of water courses drain from the jebel toward the Jefara plain to the north. The two largest ones are the Wadi Ghan to the east, and the Wadi Ain Zargha in the middle part of the jebel.

Some information on the archaeology on the mountain range is available since the 1940s, thanks to the archaeo-geological investigations by McBurney and Hey (1955), who concentrated their fieldwork in the Wadi Ghan. Since the early 1990s, the Italian-Libyan Archaeological Project, has started a new research plan aiming at reconstructing sedimentary and anthropic sequences, and studying their interrelations (Barich 1995; Barich et al. 1995; 1996; 2003a; 2003b; in press a; in press b; Barich and Giraudi in press). Among the various members of the project, one of the present authors, Elena Garcea, is responsible of the early prehistory, and the other, Carlo Giraudi, is in charge of the geomorphology and geoarchaeology of the study area.

Our fieldwork combines geoarchaeological and site surveys with systematic artefact collections and test excavations. Research has concentrated on the eastern and central parts of the mountain range, in the Wadi Ghan and Wadi Ain Zargha respectively, and has recently extended to the foot of the northern scarp of the mountain, around the area of the modern village of Shakshuk and its

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surroundings, where a series of water springs appear. The Shakshuk area proved to be particularly rich in prehistoric sites and Upper Pleistocene geomorphological features (cf. Barich et al. in press a; Garcea 2004; in press). Furthermore, we identified clear sets of evidence of active tectonic faults capable to produce ground displacement during earthquakes; the faults and related fracture field also act as a preferential underground drainage network and feed some water springs which can still sustain the human settlement system of the area. This allowed us to extend the geomorphological framework of Shakshuk to other parts of the mountain range, where evidence of faults and water springs exists, but could not be interpreted within such a detailed scheme connecting geological events and human adaptations.

This paper aims at presenting two major results of our research. The first is to demonstrate that there were strong earthquakes and serious tectonic dynamics during the late Upper Pleistocene in the Jebel Gharbi, and the second is to show how these events created the conditions that favoured human occupation by Aterian and Later Stone Age/Upper Palaeolithic populations.

1. Wadi Ghan

1a. Geology

The first study area was located in the upper Wadi Ghan valley, in the central-eastern side of the jebel, around 550 m a.s.l., east of the modern town of Gharyan (Figs. 1, 2).

Some very clear alluvial terraces, covered by loess, appear at different heights from the bottom of the valley (McBurney & Hey 1955; Giraudi 1995; Barich et al. 1996). MSA artefacts were found on the higher alluvial terrace, formed by boulders and gravel in a sandy matrix (Fig. 3a). Therefore the terrace predates such artefacts. The second terrace is mainly formed by alluvial boulders and gravel in a silty sandy matrix containing MSA artefacts, and is covered by a thick calcrete horizon, also containing MSA artefacts. A series of aeolian sediments, heteropic with the alluvial ones, lie on the calcrete: the sequence starts with a reddish aeolian sand covered by loess formed by silt, containing Aterian and LSA artefacts. A thin, discontinuous calcrete layer is interbedded.

A second aeolian sandy layer, light-pink in colour, overlies the loess and is covered by a later loess deposit containing Epipalaeolithic/Iberomaurusian artefacts.

A lower terrace consists of alluvial silty sand and includes a thin grey charcoal-bearing layer. The charcoal has been radiocarbon dated to 11,110±40 (Beta-157690/13,180 to 12,980 and 12,940 to 12,910 Cal BP).

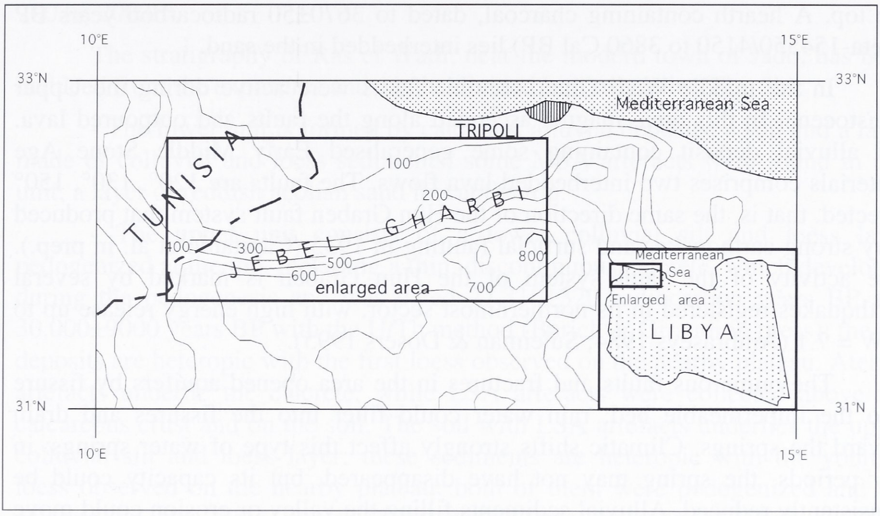

Fig. 1. Map of the study area.

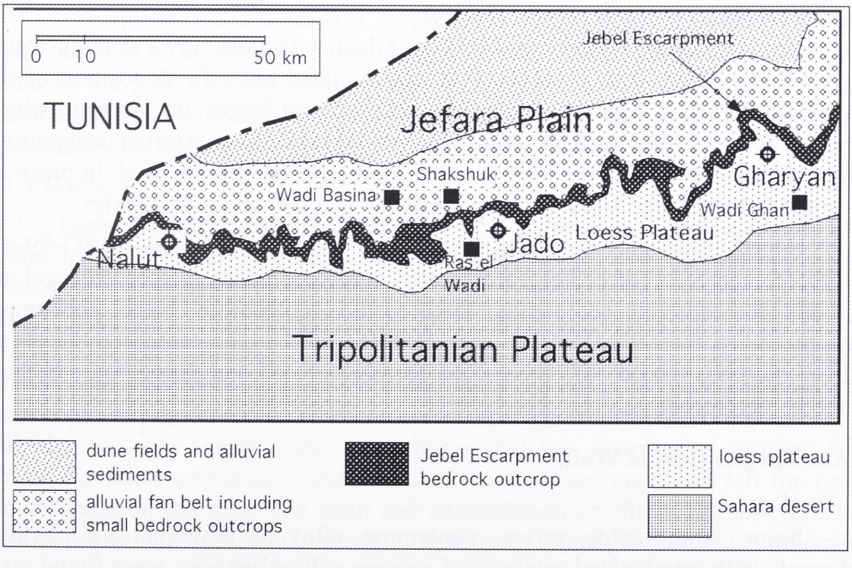

Fig. 2. Main morphological and geological features of the Jebel Gharbi.

The lowermost terrace is made of alluvial sandy gravel becoming sandy at the top. A hearth containing charcoal, dated to 3670±50 radiocarbon years BP (Beta-154550/4150 to 3860 Cal BP) lies interbedded in the sand.

In the middle Wadi Ghan, tectonic faults were active during the Upper Pleistocene. In this area, magma ascended along the faults and outpoured lava. An alluvial deposit containing some generalised Early Middle Stone Age materials comprises two interbedded lava flows. The faults are 120°, 130°, 150° directed, that is, the same direction of the Hun Graben fault system that produced very strong earthquakes and surficial faulting in 1935 (Capitanio et al. in prep.). The activity of the fault system of the Hun Graben is marked by several earthquakes registered in its northernmost sector, with high energy release up to MW = 7.1 (Ambraseys 1984; Suleiman & Dosers 1995).

The numerous faults and fractures in the area opened aquifers by fissure into the impermeable bed: rain water could filter into the fissures and drain toward the springs. Climatic shifts strongly affect this type of water springs: in dry periods, the spring may not have disappeared, but its capacity could be consistently reduced. Alluvial sediments filling the valley or erosion could move upstream or downstream the position or the water outsprings between a few tens and a few hundreds of metres. Human settlements are situated both upstream and downstream of the present location of the springs.

1b. Prehistory

As the deposit in the middle Wadi Ghan with lava flows contain rolled Early Middle Stone Age artefacts, they accumulated after the deposition of the Early Middle Stone Age archaeological material and before the Aterian, which appears on top of the sediments with interbedded lava flows. Aterian occupations can be dated to an age <100,000 years (cf. Garcea 2004; Barich et al. in press a). As noted before, Later Stone Age materials lay in a soil above this series.

Four Aterian sites were identified in the Wadi Ghan, SG-99-40, SG-99-41, SG-99-46, and SG-00-61. They are located along the banks of the wadi and are included in colluvial sediments. Two surface collections were performed, respectively at Site SG-99-41 (32°03'23"N/13°04'41.1"E) and Site SG-00-61 (32°04'25.7"N/13°05'43.6"E). Near the former, a few Later Stone Age artefacts could be recognised.

2. Ain Zargha (Ras el Wadi)

2a. Geology

Some stratigraphic series, containing alluvial, colluvial and aeolian sediments with interbedded artefacts of various cultural phases, were found on a slope incised by gullies near Ain Zargha (Giraudi 1995; Barich et al. 1996; 2003a; 2003b).

The stratigraphy of Ras el Wadi, near the modern town of Jado, has been deduced from the exposures and can be divided into two units (Fig. 3b):

- The lower unit is formed by calcretes, alluvial deposits, a soil and a layer made of colluvial and loess sediments: some MSA artefacts were found in this unit; a layer of reddish aeolian sand lies at the top.

- The upper unit consists of a lower colluvial silt and loess layer pedogenized at the top, including a thin, discontinuous calcrete, which developed during the pedogenesis and was dated 27,310±320 radiocarbon years BP and 30,000±9000 years BP with the U/Th method (Barich & Giraudi in press); the silt deposits are heteropic with the first loess observed on the nearby plateau. Aterian artefacts underlie the calcrete, while LSA artefacts were collected above the calcareous crust and on the soil. The soil with LSA artefacts underlies the upper colluvial silt and loess layer; these sediments are heteropic with the younger loess observed on the nearby plateau: both of them were pedogenized and the calcrete on the loess, which developed during pedogenesis, was dated to 18,020±190 years BP by the radiocarbon method (Beta-154575/21,610 to 20,090 Cal BP). The younger aeolian reddish sand layer, which is the last sediment exposed by later gulling, lies on this soil.

The spring of the Wadi Ain Zargha, near Ras el Wadi, is connected with a weak outlet of an aquifer layer included in the bed. The aquifer was fed far away, south of the jebel. As percolation rates were quite slow and regular, it is very much likely that climatic changes did not affect this spring flow. The human settlements are located just upstream of the spring of the wadi.

2b. Prehistory

Early Middle Stone Age, Aterian and Later Stone Age artefacts were found inside the Ras el Wadi sedimentary sequence. Five Aterian sites were located in this area which surrounds the water spring of Ras el Wadi (Barich et al. in press b). Surface collections were made at two of them, SJ-98-27A (31°55'03.6"N/12°00'08.1"E) (cf. Barich et al. 2003a; 2003b; Garcea 2004) and SJ-98-28 (31°55'08"N/12°00'10"E). The latter evidenced a remarkable concentration of Aterian artefacts. The density of artefacts indicated an average of 10 flaked pieces per square metre. It is likely that this distribution resulted from strong deflation activities, which removed the fine sediment and left the heavy stone pieces on the spot. The fresh and unweathered condition suggested that no post-depositional rolling occurred. Therefore, although vertical movements repositioned the artefacts, no important horizontal displacement must have taken place.

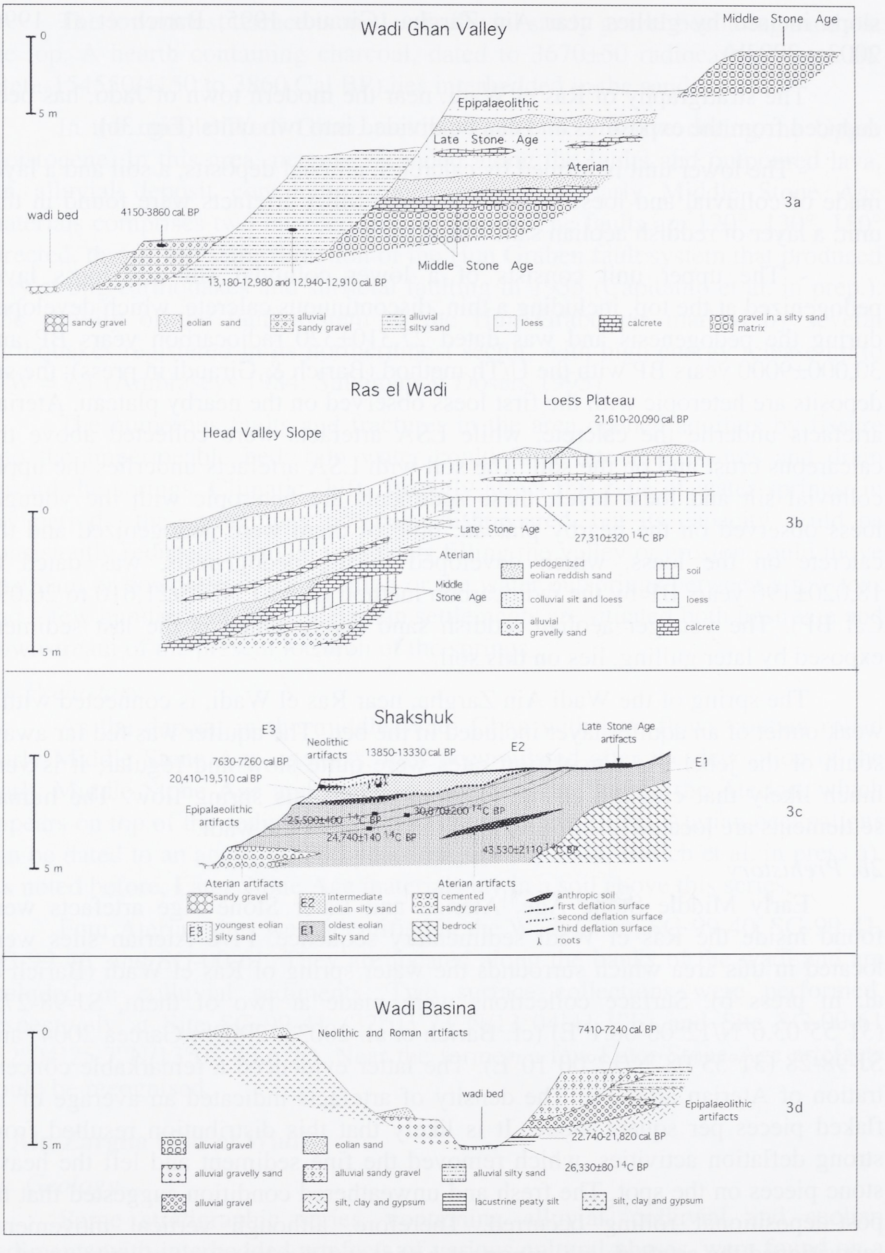

Fig. 3. Quaternary stratigraphies at the Wadi Ghan, Ras el Wadi, Shakshuk, and Wadi Basina.

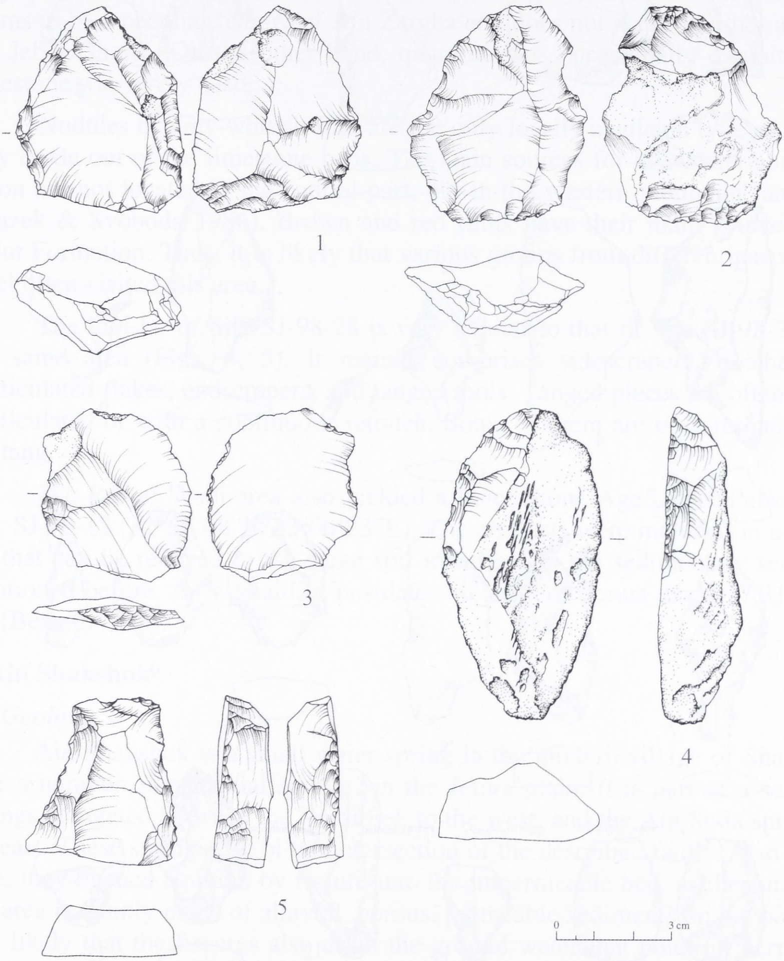

Fig. 4. Retouched tools from Site SJ-98-27A: 1-2. Levallois cores; 3. Retouched Levallois flake; 4. Limace; 5. Tranchet.

Fig. 5: 1. Retouched tools from Site SJ-98-27A: Truncation; 2. Simple straight sidescraper; 3. Convergent sidescraper; 4. Denticulated flake; 5. Tanged sidescraper on a Levallois flake; 6. Tanged retouched Levallois flake; 7. Tanged denticulate on a Levallois flake; 8. Tanged denticulated flake; 9. Tanged flake; 10-11. Broken tanged points; 12. Tanged denticulate on a Levallois blade; 13. Tanged point.

Most of the assemblage was made of different types of flint (grey-whitish, grey, pale yellow, red, banded, translucent brown-grey). Such a variety of flints seems to be a peculiar feature of Ain Zargha and does not occur in other areas of the Jebel Gharbi. On the other hand, quartzite was occasionally exploited and limestone was rarely used.

Nodules of grey-whitish flint are the only locally available type of flint as they erode out of the limestone beds. The main sources for raw material exploitation are not located in the central part, but in the western mountain range (cf. Mrazek & Svoboda 1986). Brown and red flints have their main source in the Nalut Formation. Thus, it is likely that various groups from different parts of the jebel often visited this area.

The tool-kit of Site SJ-98-28 is very similar to that of Site SJ-98-27A, in the same area (Figs. 4, 5). It mainly comprises sidescrapers, notched and denticulated flakes, endscrapers, and tanged tools. Tanged pieces are often small, denticulated or with a continuous retouch. Some of them are only retouched on the tang.

The Ras el Wadi area also yielded a Later Stone Age/Upper Palaeolithic site, SJ-90-12 (31°55'08"N/12°00'23"E). The artefacts were included in a paleosol that can be referred to the same soil identified in the sedimentary sequence mentioned before. As we said, it postdates a calcareous crust dated 27,310±320 BP (Beta-154576).

3. Ain Shakshuk

3a. Geology

Ain Shakshuk is a small water spring in the modern village of Shakshuk, near a number of perennial springs, in the Jefara plain. It is part of a series of springs elongated between the Wadi Sel, to the west, and the Ain Soda spring, to the east. These springs rise at the intersection of the described faults. Also in this case, they opened aquifers by fissure into the impermeable bed, as the surrounding area is mainly made of alluvial, porous, permeable sediments on the bedrock, it is likely that the fissures also drain the ground water that pours in permeable sediments during precipitations. Climatic shifts may influence the capacity of these springs, even though it is unlikely that they can dry during arid times; the intersections between the faults that drain water from quite extended underground areas are able to guarantee a certain input of water.

The Wadi Sel is a small wadi draining from the Jebel Gharbi into the Jefara, a few hundred meters from Ain Shakshuk. An exposure on the right bank of this wadi shows aeolian sediments with interbedded archaeological materials.

Because of the presence of water table and capillary flow, the sediments are moist up to a few centimeters below ground level and deflation is not active.

We could observe three stratigraphic units in this area (Fig. 3c). The oldest one is of silty sand, aeolian in origin, heteropic at the bottom with cemented sandy gravel and alluvial sediments containing Aterian artefacts. A dark-grey anthropic soil with Aterian artefacts is interbedded in this unit. A number of thin charcoal-bearing aeolian layers appear towards the top. The soil was dated 43,530±2,110 radiocarbon years BP (Beta-167098) while the charcoal horizons with a Later Stone Age artifact are 24,740±140, 30,870±200, and 25,500±400 radiocarbon years old (Beta-157687; Beta-157688; Beta-167099).

The top of the first unit is formed by a nearly flat or undulating surface also evidenced by stone lines and remnants of an archaeological soil containing Epipalaeolithic artefacts dated to 16,750±60 years BP (Beta-157689; 20,140-19,510 cal BP). This surface is very similar to the present one and was produced by deflation after 24,740±140 years BP.

The intermediate unit is formed by silty sand, aeolian in origin, which covers the deflation surface and is younger than 16,750±60 radiocarbon years BP. The youngest unit is also formed of silty sand, and covers an archaeological soil containing Neolithic artefacts.

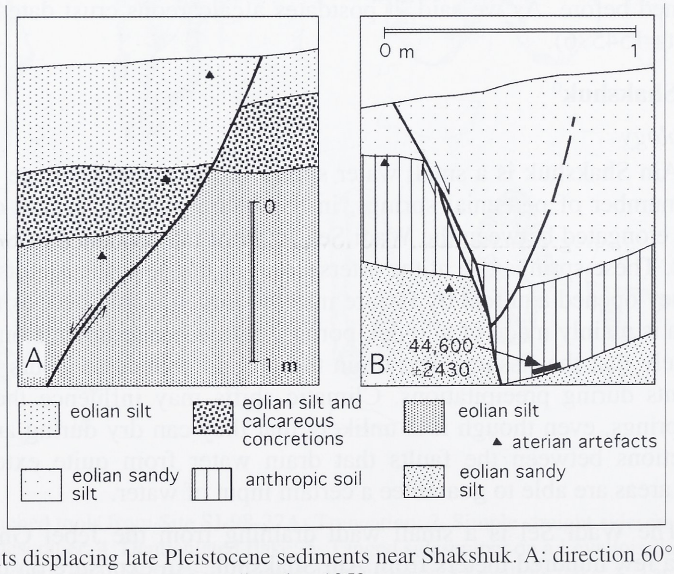

Fig. 6. Faults displacing late Pleistocene sediments near Shakshuk. A: direction 60°; B: direction 125°.

At the Wadi Sel, some faults appear with directions 68° and 125° (Fig. 6). The faults were active during the late Upper Pleistocene as they displaced a paleosol dated 43,530±2,110 and 44,600±2,430 years BP. The displacement of the soil occurred during one or more high magnitude earthquakes linked to the north-western boundary of the Hun Graben fault system (Capitanio et al. in prep.). The activity of the fault system of the Hun Graben is marked by several earthquakes registered in its northernmost sector, with high energy release up to MW = 7.1 (Ambraseys 1984; Suleiman & Dosers 1995).

3b. Prehistory

A test excavation was dug on the right bank of the Wadi Sel, at about 5 m from the bottom of the wadi, at Site SJ-02-68 (32°00'55"N/11°57'07"E). It brought to light a sequence with: (1) a layer with charcoal, corresponding to the Epipalaeolithic site (SJ-00-56) excavated near-by (Barich & Lucarini, this volume), (2) a sandy layer with an endscraper reworked on a Mousterian core and a crested bladelet, (3) a layer with charcoal and ashes, which included a Levallois flake, and (4) a sandy layer with several artefacts, including a denticulated truncation. Layer 3 evidenced a fault caused by the seismic activity mentioned above (Fig. 6b). It was dated to 44,600±2,430 BP (Beta-167097). The artefacts in Layers 3 and 4 can be attributed to the Aterian. They correspond to two different phases of occupation of the site within the Aterian horizon, which preceded the faulting and tectonic activities. Layer 2 may be associated with a Later Stone Age/Upper Palaeolithic settlement of the site.

The Shakshuk deposit with archaeological artefacts consists of a sequence with Early Middle Stone Age, Aterian, and Later Stone Age artefacts, respectively in the lower, middle, and upper parts of an aeolian deposit.

Another test pit was excavated at Ain Shakshuk West, Site SJ-00-55 Test 2 (32°01'05.9"N/11°57'10.7"E). The upper part (0/-50 cm) of the deposit comprised a sequence of alternating aeolian and ashy layers with some charcoal and no archaeological artefacts. The lower part of the sequence (-50/-90 cm) was formed by layers of light brown clay, alternated to thin ashy lenses. One elongated blade appeared 55 cm below the present surface. An AMS dating analysis gave a radiocarbon age for this layer at 30,870±200 years BP (Beta-157688), but it is possible that the blade is in secondary position. In fact, the regular series of alternating aeolian and ashy layers with a very fine matrix and no archaeological artefacts or coarse gravel suggest that deflation redeposited only fine and light sediments. A younger age of 24,740±140 years BP (AMS analysis: Beta-157687) for the lowest part of the formation supports this hypothesis. Even though there is a inversion in the chronological sequence with older sediments above earlier ones, we can still infer that the Later Stone Age developed from the period between 30,000 and 24,000 years ago.

A further sondage was excavated in the area of Ain Shakshuk West, at Site SJ-00-56 Extension 2 (32°00'59"N/11°57'07"E). It uncovered a stratigraphic sequence with a Pleistocene formation including, on top, some intrusive Epipalaeolithic industry, and, at -150 cm below the surface, a few late Aterian artefacts, including a backed cortical flake and a Levallois flake. This sequence is similar to the previous one excavated in the Wadi Sel, near Shakshuk, although it is less characterised.

4. Wadi Basina

4a. Geology

The Wadi Basina is located about 10 km west from Shakshuk. Three terraces have been found along the Wadi Basina banks, in the Jefara alluvial plain (Figs. 2, 3d). The exposure produced by lateral erosions of the wadi shows a series of sediments pertaining to a small playa. The older ones are formed by silt, clay and gypsum, evaporitic in origin, and form the first terrace. A lacustrine peaty silt lies at the base of the deposit on the second terrace. It was radiocarbon dated 26,330±80 years BP (Beta-154555) at the bottom and 18,760±50 BP BP (Beta-154554/22,740-21,820 Cal BP) near the top. These deposits underlie sandy silt, clay and gypsum sediments in which a body of alluvial gravel, containing Epipalaeolithic artefacts, is interbedded. The younger deposits forming the terraces are made of alluvial sandy gravel.

The third terrace is made of alluvial gravelly sand. Small dunes covering Neolithic and Roman (I - III centuries AD) pottery lie at the top of both the older and the younger terraces.

The Wadi Basina has small springs connected with the outlet of water from phreatic zones where the permeable sediments of the alluvial fans become thin and overlap with impermeable, evaporitic sediments. As the alternating fresh water and evaporitic sediments show in the adjacent playa, the shift in the carrying capacity of the springs must have been quite considerable in the course of the time. The drainage basin of the phreatic zone corresponds to the catchment of the Wadi Basina. Therefore, the precipitations on the Jebel Gharbi and on its northern side have strongly affected the spring flows.

4b. Prehistory

A water spring appears in the upper course of the Wadi Basina. There are some Aterian artefacts in the area surrounding the spring. They are scattered on a stone pavement formed by strong deflation on the higher terrace.

Concluding remarks

To conclude, we can note that the seismic activity attested to in the Upper Pleistocene is still related to present-day events. In fact, during the 1930s and before, there were strong earthquakes in the desert, a few tens of kilometres south-east of Gharyan, in the eastern part of the Jebel Gharbi, which produced a faulting activity along the faults that are part of the same tectonic system that we described for the late Upper Pleistocene. Near Gharyan, two water springs with drinkable water had been located at Caf-Tobbi and at Mimun, as early as the first archaeological explorations (Fabbri & Winorath-Scott 1965).

A particularly interesting and unique aspect regarding the adaptational dynamics to the environment of the Jebel Gharbi came to light during our recent fieldwork. Beginning from the late Upper Pleistocene, tectonic faults produced a number of earthquakes of high magnitude. The geomorphology of this mountain range attracted human populations and favoured their settlements, as it could offer a series of fresh water springs. Outlets of underground aquifers could flow through the fissures created by tectonic faults.

To sum up, in the Wadi Ghan, the existence of lava flows with rolled Early Middle Stone Age materials below the deposit with Aterian industries indicates that a chronological hiatus separated the two cultural complexes. Precipitations still feed water springs through the fissures and, consequently, depend on the local climatic conditions that can increase the springs in humid periods and reduce them in dry times. Therefore, it is not surprising that Aterian, and even more so, Later Stone Age sites are not as frequent as in the central part of the Jebel Gharbi.

By contrast, at Ras el Wadi in the Wadi Ain Zargha, an aquifer, located south of the jebel, regularly fed the outlet of the water spring, assuring water resources even during dry times. Human settlements are concentrated upstream of the spring and the variety of flints used for lithic industries suggests that various groups from different parts of the jebel visited and settled in the area.

Moving down the jebel, in the Jefara, the series of water springs comprised between Wadi Sel and Ain Soda, in the Shakshuk area, shows that precipitations may have increased their flows, but the numerous intersections of the fault system guaranteed the outlet of underground water even in arid periods. Aterian sites are numerous and well-documented in this area. They exhibit two stratigraphically different horizons that precede a Later Stone Age phase, including typical Aterian and later, still Aterian, complexes.

The geomorphology of the Wadi Basina was not favourable to human settlements in the Upper Pleistocene. There are small water springs that depend on rainfall and probably dried during arid times, until the final Pleistocene, when a lacustrine sediment formed between 26,000 and 18,000 years ago. Few Aterian artefacts are scattered on a stone pavement indicating deflation activities before the formation of the lacustrine horizon.

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