Geology and geomorphology of the Cheria region

Jean-Louis Ballais

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J.-L. Ballais

General Geomorphological Setting.

The region of Chéria is characterized by the juxtaposition of large SW-NE oriented depressions bounded by low narrow djebel systems of uplifted Eocene limestones. A series of five such depressions constitute the region of contact between the High Constantine Plains and the Nemenchas *sensu stricto*. From west to east they are : the Ounrhal depression, the Outa Guert-Outa Gassès depression, the Outa Zora-Outa Guibeur depression, the Chéria depression and the Télidjène depression. Our work has been confined to the latter two.

The Chéria depression is the largest (40 x 22 km) and most complex of the series. It is a large lobed syncline rising steeply to the north (Djebel Dokkane, 1 712 m) where the northern bounding ridges dominate the marshy Tébessa plain. The lobed outline of the depression is due to a succession of two synclinal undulations (Dj. Dokkane in the east and Dj. Treubia in the west) which are separated by the southern flank of an eroded anticline and traversed by the Chéria-Hammamet road. In the southern portion of the syncline the dips increase, forming the anticlines of Outa Guibeur to the southwest and Télidjène to the southeast. These anticlines are separated by a narrow syncline complicated by anticlinal folds near Aïn Babouche. Wadi Chéria-Mezeraa drains south through this syncline and disappears several kilometers downstream (fig. 2).

The Télidjène depression (28 x 8 km) is rich in Capsian sites (fig. 2), and has been the focus of our research. The basin is bounded by an escarpment of jointed Eocene limestone which rises to 1 380 m at Dj. Bou Kammech. In the center of the depression is an isolated assymetric *mont derivé*, the Hamimat Souda (1 183 m) formed of Lower Cretaceous sandstones and quartzites which dip gently to the east and more steeply to the west where they are affected by several faults. To the south of this the extensive zone of transversal faults of Outa Zora-Outa Guibeur is replaced by the diapiric zone of Draa Foum Debbane which is formed of conic hills with steep slopes eroded in Triassic salt-bearing clays and overlain by highly jointed dolomitic limestones with a brown patina. In the center of the depression, Wadi Télidjène has cut its bed into greyish-green marly clays of Upper Cretaceous-Paleocene age.

The origin of this relief is not yet fully understood. The hydrographic network and the formation of large depressions appears closely related to the anticlinal-synclinal alternation and the soft, thick Cretaceous marls capped by thin (25 m maximum) and very resistant Londinian limestones. It is also possible the modern topography results from fluvial downcutting of an older erosional surface. The hydrographic network agrees with the tectonic style and the general dip to the south. However, some streams show aberrant patterns, especially in faulted zones. The regularity in the altitudes of the djebels is also indicative of a former erosion surface. No definitive interpretation is possible at present for the geology of the Nemenchas is poorly known. The deposition of Miocene marine sediments to the west in the Aurès recorded by Lafitte (1) certainly does not agree with a transgression over a pre-Miocene surface.

(1) LAFITTE (R.). — *Les plissements post-nummulithiques dans l'Atlas Saharien.* Bull. Soc. Géol. France, 5e série, t. 19, 1939, pp. 135-159.

Pleistocene Landforms and Deposits.

No geomorphological or stratigraphic evidence for pre-Middle Pleistocene deposits (1) have been observed in the Chéria or Télidjène depressions As elsewhere in the Maghreb, the Middle Pleistocene appears to have been a period of intense morphogenetic change which destroyed earlier Quaternary deposits, and the absence of subsequent downcutting inhibited superposition of later deposits.

(1) We have used Middle Pleistocene and Upper Pleistocene instead of Tensiftian and Soltanian respectively. The latter two were originally proposed for Morocco by CHOUBERT & *al.*, C.R. Acad. Sci., t. 243, 1956, p. 504, but are no longer accepted by many workers because the type sections were poorly chosen : cf. BEAUDET & *al.*, Rev. Géogr. Phys. Géol. Dyn., t. 9, 1967, p. 269.

Therefore, the Middle Pleistocene pediment forms the main relief element in the depressions and can sometimes be traced almost to the center of the basins as an alignment of dissymetric cuesta-like heights. Upslope, a short and marked scarp between 30 and 50 meters high dominates the younger landforms and deposits (e.g. at Henchir Zoura in the southwestern part of the Télidjène Depression where the pediment truncates an anticlinal fold of Eocene limestone, fig. 2). Away from the scarp the surface slopes gently downwards and passes beneath Holocene deposits. Sometimes the Middle Pleistocene pediment is reduced to an isolated hillock (e. g. Koudia Mechouar immediately northwest of Chéria). It is always recognizable by its thin detritic cover of large rounded pebbles in a white calcareous crust which is powdery at the base but sometimes consolidated at the top.

The Middle Pleistocene pediment covers the greatest surface in the piedmonts. Near Aïn Misteheyia it forms a broad plain covered with *Stipa tenacissima.* The average slope is 5-6° but this increases to 10-12° at the contact with the base of the escarpment. The detritic cover is thin, consisting of 20 to 30 cm of flat unstratified pebbles in a hard calcareous matrix which is beige colored when freshly exposed.

Upslope, the Middle Pleistocene pediment passes into encrusted slope talus which masks the base of the escarpment, giving a regularized slope profile. A second and local type of breccia is found near the faulted anticlinal fold which is responsible for both the form of Garat el-Misteheyia and for the spring. This breccia is composed of limestone blocks in which fracture planes follow joints. The blocks are cemented onto the Eocene limestone.

The morphology of pebbles from the Middle Pleistocene detritic cover as well as from the slope talus deposits, indicate intense gelifraction during the formation of these landforms. Additional observations suggest a minor phase of tectonic activity contemporaneous with the Middle Pleistocene pediment. In the piedmont of Djebel Radama, we have observed folded deposits on the right bank of Wadi Hamaja about 200 meters downstream from a small quarry. These beds are between 2 and 3 meters thick. They are formed of well-stratified limestone gelifracts a few centimeters long, which dip upslope and are packed in a very consolidated calcareous matrix. The downstream dip is 30° to the east. Fifty meters upstream the deposit butts against the base of the escarpment at an angle of 10-15°. These beds are truncated by Middle Pleistocene detritic deposits which show evidence for cryoturbation at the base.

The lower deposits were, therefore, deformed by a folding phase which rejuvenated the syncline separating the small faulted anticline of Garat el-Misteheyia from Djebel Radama. It is impossible to accurately date this tectonic phase or the Pleistocene deposits affected by it. The folding may be intra-Middle Pleistocene following a period of dry climate which favored encrustation. The folding was followed by a phase of active frost weathering which furnished the clastics for the rill and sheet wash which truncated the earlier deposits. Alternatively, a long period of consolidation may have preceded the folding, in which case the folded deposits would be pre-Middle Pleistocene. Comparable Quaternary tectonic events are known. These include the Gafsa fault (1), the subsidence of the el-Outaya Plain (2), the tilting of the « Saletian » or « Amirian » pediment at Darza Arma southeast of el-Kantara due to rejuvenation of a post-Eocene fault (3), and the north flexure of the Aurès which affected all the Middle Pleistocene and pre-Middle Pleistocene deposits (4).

The Upper Pleistocene pediment is normally found downslope from the Middle Pleistocene pediment. Near the center of the depressions it usually passes beneath Holocene deposits. About 200 to 300 meters upslope from Aïn Misteheyia its contact with the Middle Pleistocene pediment is marked by a break in slope of 10-12° and a change in vegetation from *Stipa tenacissima* to *Artemisia herba-alba*. Below the escargotière the slope of the Upper Pleistocene pediment decreases to about 2-3° and is indistinguishable from the Holocene alluvial deposits which have a slope of 3°.

When complete, the Upper Pleistocene pediment is several meters thick and is composed of three units :

Upper unit : a thin bed of subangular pebbles in a fine beige-colored matrix.

Middle unit : a thick bed of light-orange fine silty and with unstratified rounded pebbles 1-2 cm long.

Lower unit : rare large angular pebbles and occasional reworked blocks of the older pediment.

A profile through the upper facies just below the Aïn Misteheyia escargotière in Wadi Hamaja reveals the following sequence :

0-30 cm : Dull orange (7,5 YR 7/4) loamy sand with small gravel and some larger (3 cm) flat angular pebbles.

30-90 cm : Small rounded pebbles in a pale orange (7,5 YR 8/3) sandy matrix encrusted with powdery calcium carbonate.

90-120 cm : Dull orange (7,5 YR 7/4) sandy loam with a few pebbles. The base extends below the present wadi bed.

As with the Middle Pleistocene pediment, the Upper Pleistocene one is associated with slope breccia. These are unencrusted, have an orange matrix, and have slightly eroded the rather regularized slopes.

Holocene Landforms and Deposits.

The Chéria and Télidjène Depressions contain well-developed Holocene deposits. The most important of these is the Chéria formation, consisting of terrace and slope deposits. Deposits of Roman age and later are inconspicuous.

The Chéria formation is complex and variable in extent. Upslope, the terrace and slope deposits are often continuous (even along smaller wadis) and vary from a few decimeters to 20 meters laterally. Deposits of the Chéria formation fill the center of the depressions and it is possible to distinguish several facies which result from differences in both topopgraphic position and lateral extension of the deposits.

The type section of the Chéria formation (fig. 3) is located on the right bank of Wadi Chéria-Mezeraa at the foot of Djebel Mezeraa at a point where the valley is only about 200 m wide. A section of 5,90 m is exposed, which reveals the following sequence from top to bottom. We have divided this into

(1) Vaufrey (R.). — *Les plissements acheuléo-moustériens des alluvions de Gafsa*. Rév. Géog. Phys. Géol. Dyn., t. 5, 1932, PP. 299-321.

(2) Guiraud (R.). — *Evolution post-Triasique de l'avant-pays de la chaîne alpine en Algérie d'après l'étude du bassin du Hodna et des régions voisines*. Nice, 1973.

(3) Ballais (J.-L.) et Guiraud (R.). — *Carte géologique d'El Kantara au 1/50 000*. Alger, 1973.

(4) Ballais (J. - L.). — *Etude comparative des glacis des piémonts nord et sud des Aurès*. Colloque sur les glacis d'ablation, Tours, 1974.

the four members which constitute this formation, and which are overlain by Roman deposits.

Roman Deposits :

— Dull yellow orange (10 YR 6/3) silt with carbonized roots and rare large landsnails : 44 cm.

— Dull yellowish brown (10 YR 5/3) silty lens containing a lens of flat subangular pebbles (5-10 cm), flat pebbles (5-6 cm) and subrounded pebbles (20-40 cm) as well as an irrigation channel with Roman potsherds : 46 cm.

Chéria formation, member 4 :

— Loamy clay (possible paleosol) divided in to a lower dull yellowish brown layer (10 YR 5/3) containing 11, 7 % loam and 38, 8 % clay ; a middle layer dull yellow orange (10 YR 6/4) in hue ; and an upper layer of greyish yellow brown (10 YR 6/2) color containing 27, 9% loam and 40,4 % clay with many large landsnails : 70 cm.

— Lens with flat, subangular, stratified pebbles (3 cm) in a dull yellowish brown (10 YR 4/3) loamy matrix : 10 cm.

— Dull brown (7,5 YR 5/3) loamy sand with non tabular and subangular pebbles (5 cm and 2-3 cm) and large landsnails : 32 cm.

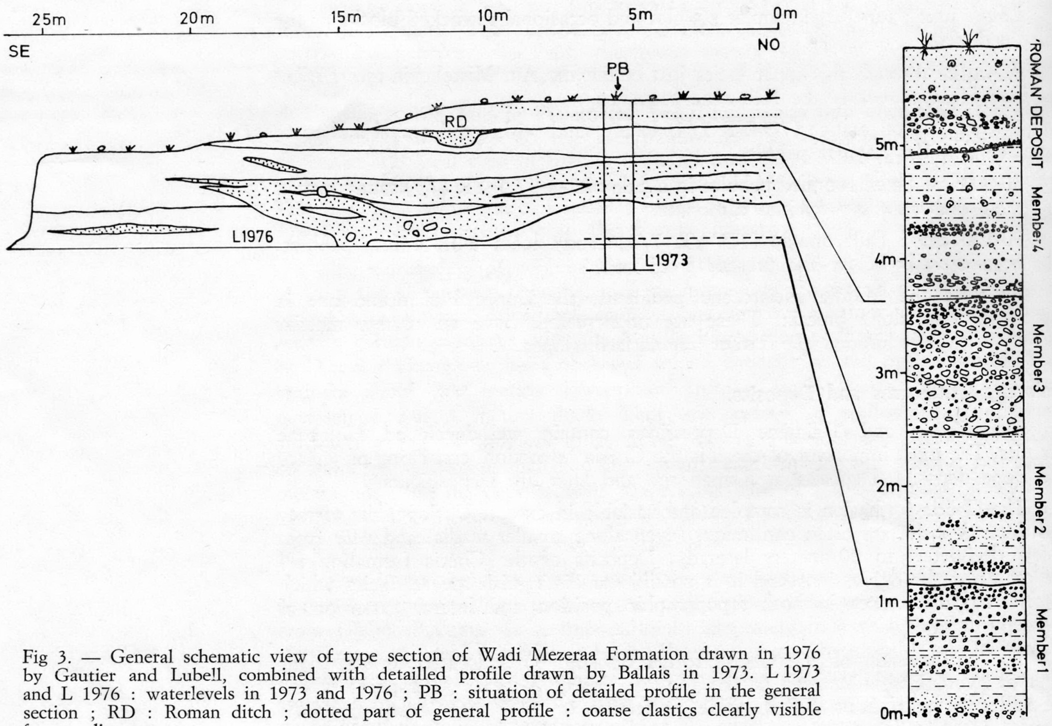

Fig 3. — General schematic view of type section of Wadi Mezeraa Formation drawn in 1976 by Gautier and Lubell, combined with detailled profile drawn by Ballais in 1973. L 1973 and L 1976 : waterlevels in 1973 and 1976 ; PB : situation of detailed profile in the general section ; RD : Roman ditch ; dotted part of general profile : coarse clastics clearly visible from a distance.

Chéria formation, member 3 :

— A lens of flat, subangular pebbles (0,3-5 cm) containing flint, in a dull yellow orange (10 YR 6/3) matrix which stratified but lacking clear orientation and includes small landsnails : 40 cm.

— A lens of subangular and occasional flattened pebbles (10 cm), small flat pebbles, some flint, and a large block (30 cm) in a coarse dull orange (7,5 YR 6/4) loamy matrix : 58 cm.

— A coarse deposit in a loamy dull orange (7,5 YR 6/4) matrix with many flat and rounded pebbles (2 cm) as well as smaller ones, some well-rolled unstratified large pebbles (8 cm) and some flint : 40 cm.

Chéria formation, member 2 :

— A clayey sandy dull orange (5 YR 6/3) deposit with bright brown (2,5 YR 5/8) iron oxide veins and stains of manganese oxide : 6 cm.

— A dull orange (5 YR 6/3) loamy deposit with ferruginous veins and small discontinuous lenses of flat angular pebbles (1-2 cm) at the base : 70 cm.

— A coarse lens of small flat subangular pebbles (1-5 mm), a few larger non tabular and rounded pebbles (2-4 cm), and some flint in a sandy loam matrix with ferruginous dull orange (7,5 YR 6/4) veins : 20 cm.

— A dull yellow orange (10 YR 6/3) deposit of loam, sand and clay with dull orange (5 YR 6/4) ferruginous veins, and a thin layer of 1 cm long gravels : 28 cm.

Chéria formation, member 1 :

— A deposit similar to the underlying one but denser and less coarse in a matrix of loam, clay and sand : 20 cm.

— A deposit of flattened, subangular pebbles (at least 1 cm long), small rolled pebbles and some larger ones, in a dull brown (7,5 YR 6/3) loamy matrix : 38 cm.

— A dull brown (7,5 YR 5/3) clay with ferruginous veins : 4 cm.

— A gravel deposit with small rounded and sometimes flattened pebbles in a sandy matrix with dull orange (5 YR 7/3) stains : 16 cm.

— A dull yellow-orange (10 YR 6/4) clay : 22 cm.

— A gravel deposit with non tabular or subangular pebbles in a sandy matrix with ferruginous stains : visible thickness of 18 cm.

Deposits below this are of unknown depth as they are obscured by the modern wadi bed.

We have obtained a single radiocarbon date from member 2 of 5 839 ± 95 B.P. (I-7 693). The sample consisted of small spiriform land snail shells of an unidentified species found today in moist wadi bank habitats. This date may be too recent because these snails may have incorporated dead carbon (derived from older carbonates and present in the moist soil) during shell building.

Profiles comparable to the type section have also been observed in the piedmonts. The section at Mechta Treïkïa in the Chéria Depression reveals the following sequence (fig. 4).

Roman Deposit :

— Coarse deposit derived from the Upper Pleistocene pediment : 40 cm.

Fig. 4. — Section through the Chéria Formation at Wadi Redif showing escargotière reworked into alluvial sediments.

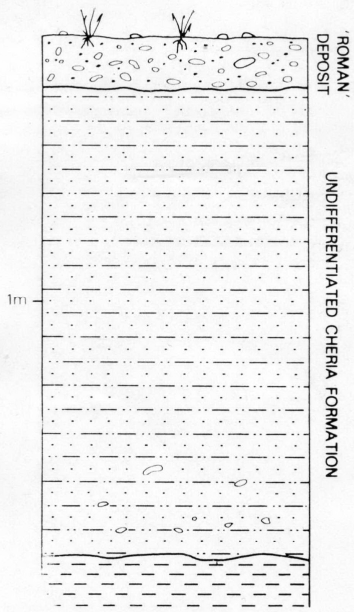

Fig. 5. — Section through the Chéria Formation at Wadi Ebtine.

Chéria formation, member 4 :

— Fine deposits containing loam ; a lens of discontinuous stringers of small pebbles and large snail shells separated by a fine orange lens from a lower lens of flat pebbles (5 cm) and nontabular pebbles (7-10 cm).

Chéria formation, member 3 :

— Coarse deposits with a transitional zone at the base (70 cm) formed by two coarse lenses alternating with two fine lenses with horizontal bedding. These are followed by 70 cm of coarse lenses formed of rolled limestone pebbles (5-10 cm) long, flint, and some apparently reworked quartzite in a matrix which is very encrusted with calcium carbonate.

Chéria formation, member 2 :

— Fine deposits, 30 cm thick, consisting of brownish loam with a few pebbles, many landsnails reworked from escargotière deposits. This overlies a comparable grey deposit.

Other sections in the piedmont have been studied at Wadi Redif, Wadi Ebtine, Mechta Treïkïa, and Wadi Hamaja. The latter will be described in the report on geology and geomorphology of the Aïn Misteheyia locality (see below). At both Mechta Treïkïa and Aïn Misteheyia the sections contain reworked material from Capsian sites. At Wadi Redif, an entire escargotière has been undercut by a former course of the wadi, reworked into the alluvium, and subsequently exposed in section (fig. 4).

The preceeding descriptions suggest that the Chéria formation can be tentatively divided into four members : member 4, an upper deposit of fine clastics which are sometimes mixed ; member 3, a deposit of coarse clastics which overly disconformably ; member 2, a lower deposit of fine clastics containing many landsnail shells and reworked escargotière materials ; and member 1, the basal deposit of coarse clastics which is of unknown depth.

We have been unable to identify these four member at all the localities studied. In those instances where the Holocene alluvial cover is thin, or where only fine deposits occur, a four part division is impossible. For example, at Aïn Misteheyia local factors seem to obscure the general picture. In the depressions, the absence of marked downcutting has inhibited the development of exposures appropriate for study. We have observed only one such section in Wadi Ebtine (fig. 5) where the following sequence recorded :

Roman Deposits :

— Reworked material from the Upper Pleistocene pediment containing abundant small (6-7 mm) rolled subangular pebbles as well as some larger (3 cm) ones and a few flints in a dull brown (7,5 YR 4/4) sandy silt matrix of 16 cm thickness.

Chéria formation, undifferentiated fine facies :

— Highly calcareous orange (7,5 YR 7/6) coarse, angular, blocky deposit of sand (55 %), clay (24, 2 %) and silt (20 %) : 92 cm.

— Dull yellow orange (10 YR 7/4) sands (51,2 %) and clay (33,25 %) with blocky structure : 13 cm.

— Orange sand (7,5 YR 6/6) with silt (12,2 %) and clay (20,7 %) and rare, mostly subangular small pebbles (3 to 5 mm) as well as some larger ones (4 cm) : 40 cm.

Bedrock (Upper Cretaceous) :

— Variegated clays (58,5 % clay, 25,95 % silt) with calcite crystallizations.

Associated with the Chéria formation and terrace are alluvial fans and talus debris. The former are only seen in mountainous areas and are therefore almost absent in the Chéria region. However, well defined alluvial fans can be observed in the tributaries of Wadi Chéria-Mezeraa where, on the left bank facing the type section of the Chéria formation, one such fan overlies member 2 deposits (which contain reworked material from an escargotière) and is interstrafified with member 3 deposits. Another, similar situation was observed a short distance upstream on the right bank.

During the deposition of the Chéria formation and terrace, the mountain slope profiles were affected by only minor changes. However, the type section of the Chéria formation contains, in member 1, large fallen angular blocks derived from the limestone escarpment which are tipped towards the wadi bed. Slightly downstream, on the opposite bank, is a collapsed rockshelter containing Capsian deposits. Comparable blocks can also be seen in member 3 deposits. Further upstream, on the same bank, a high vertical north facing cliff dominates the Chéria terrace. Both downstream and upstream this cliff passes into regularized Late Pleistocene slopes which have hardly been affected by subsequent rill wash. At the foot of the cliff, a stabilized talus cone contains limestone blocks of several cubic meters which are lying flat and are incorporated into the Chéria formation deposits. These blocks have destroyed another Capsian site.

It is clear, therefore, that larger clastics were supplied by both upstream and lateral sources during the deposition of members 1 and 3 of the Chéria formation. It should also be noted that post-Pleistocene calcareous encrustations are exceptional and limited. The terrace is never encrusted, but where an escargotière rests partially on pre-Pleistocene calcareous strata (e. g. the ridge site above Aïn Mistehevia), snail shells, stones and artifacts are cemented into a calcareous matrix of cultural deposits which fill joints in the underlying bedrock limestone.

Recent Terraces (post-Roman) :

Recent terraces are of very limited extent. In the small piedmont wadis, only a discontinuous bench of a few decimeters occurs above the actual wadi channel. It is formed of large subangular gravels with almost no matrix. These recent terraces have been cut into the Chéria formation and form part of the modern floodplain. They are sometimes colonized by vegetation.

Recent terraces are better developed in the major wadis where downcutting has been more extensive. Immediately downstream from the type section in Wadi Chéria-Mezeraa two terraces colonized by willows are visible above the flood plain. The upper terrace begins at water level and rapidly attains an elevation of 2 to 3 m. It is an ablation terrace cut into the fine blackish deposits of member 2 with, perhaps, a thin alluvial cover about 50 cm thick consisting of flat (IF = 2,04) and subangular (IR = 107) limestone pebbles (fig. 8). This deposit is sometimes stained with iron and manganese oxides and contains an intercalated level of fine deposits (1).

The lower terrace, at about 50 cm, is discontinuous and is still functional during floods as indicated by stringers of pebbles without pattern or matrix derived from the major bed.

(1) Cf Cailleux (A.). — *Distinction des galets marins et fluviatiles.* Bull. Soc. Géol. France, 5e série, t. 15, 1945, pp. 374-404.

Holocene morphogenesis :

By the end of the Pleistocene general but irregular downcutting occured. In the upper reaches of the depressions this erosion is sometimes down to the base of the Upper Pleistocene deposits. It is generally accepted that these Upper Pleistocene deposits formed under a cold, humid climate by areal erosion and frost weathering in an open landscape. The downcutting, therefore, indicates a change to warmer and drier climate with reduced mechanical weathering (especially frost heaving) and more concentrated flows of greater erosive power.

The Chéria formation and terrace developed in the downcut areas which formed during this erosional phase. They correspond to a renewed phase of mechanical disintegration which was sufficiently important to inhibit further downcutting and provoke alluviation. This general picture can be refined on the basis of the differences observed in the four members of the Chéria formation.

The deposits of member 1 are poorly known because they are generally below the level of the modern floodplain. They appear to indicate vigorous mechanical disintegration, most probably due to gelifraction.

Member 2 is composed of both coarse and fine deposits. The coarse clastics are characterised by flat limestone pebbles (IF = 2,58). The histogram of flattness (fig. 6) shows a principal maximum (25 %) between 1,5 and 2,0 with a second maximum (15 %) between 2,5 and 3,0 and a third (7 %) between 4, 0 and 4,5. Gelifracts formed by micro-gelivation and mostly of Late Pleistocene age, as well as material derived from macro-gelivation and rock fall (probably also of Late Pleistocene age but possibly earlier) are present. The histogram for indices of rounding (fig. 7) shows only one maximum (33 %) between 50 and 100 with 23 % below 50 and 17 % between 100 and 150. This indicates that the pebbles are mostly reworked from the Upper Pleistocene pediment by very powerful flows.

The fine deposits of member 2 are composed primarily of brownish silty sands and clays which are rich in organic matter, snail shells, bone, aritfacts and fire-cracked rock derived from Capsian sites. Pieces of charcoal from fine deposits of member 2 in Wadi Chéria-Mezeraa have been tentatively identified as *Quercus ilex* and *Cupressus sp.* (Bouzenoune *in litt.*). It appears that fine deposits of member 2 were deposited under conditions of reduced frost weathering by slow and regular flows which transported fine clastics derived from both escargotières and soils forming under an open Mediterranean woodland. The climate was apparently cooler and more humid that at present, especially during the summer.

The downcutting which followed the deposition of member 2 reached 4 meters at Wadi Chéria-Mezeraa and 2 meters at Wadi Redif. As during the post-Pleistocene downcutting, linear incision predominated and was facilitated by the easily eroded fine deposits of member 2. Although less pronounced than the earlier phase, this mid-Holocene period of downcutting certainly indicates a new phase of contracted flows and, therefore, a more arid climate.

A renewal of mechanical weathering marks member 3. This histogram of flatness (fig. 7) has a median comparable to member 2 (IF = 2,52) but the distribution is different. The principal maximum between 1,5 and 2,0 is attenuated 19 % and 18 % of the pebbles fall between 2,0 and 2,5. The second maximum is more pronounced (18 %) and the third about the same with 6 % between 4,0 and 4,5. Apparently frost weathering provided a fresh supply of pebbles. This renewal of mechanical weathering and deposition of coarse materials is confirmed by the presence of alluvial fans and talus deposits.

The above interpretation is confirmed by the histogram of rounding (fig. 7). The median increases (IR = 96) and a unimodal distribution is more pronounced with 39 % between 50 and 100, only 16 % between 0 and 50, and 20 % between 100 and 150. There is, in other words, a shift to greater roundness which suggests a colder climate with more freeze/thaw cycles, decreased evaporation, and stronger flows. Some increase in precipitation may be indicated as well.

Member 4 is marked by a sharp decrease in flattening of limestone pebbles (IF = 2) and a unimodal histogram distinct from the previous ones (fig. 7). Thirty percent of the pebbles are between 1,5 and 2,0 with 20 % between 1 and 1,5 and 21 % between 2 and 2,5. This distribution can be unquestionably interpreted as a result of reduced micro-gelivation. The decrease in roundness

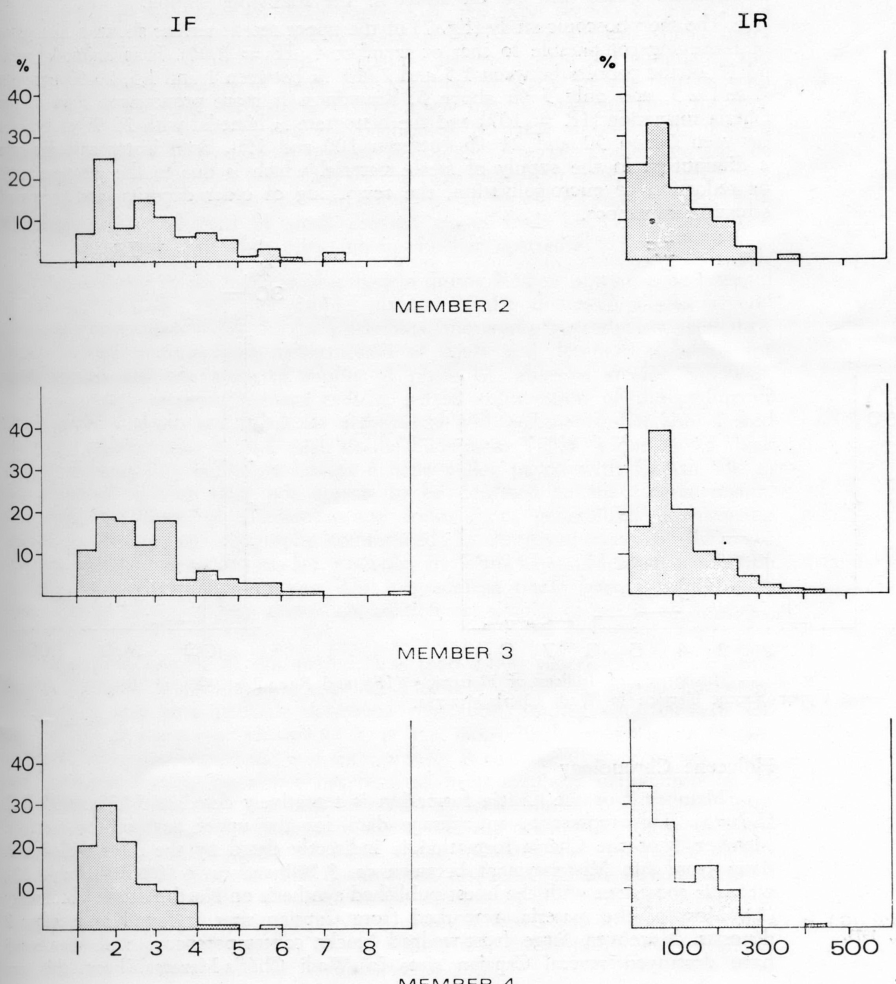

Fig. 6. — Histograms of Indices of Flattening (IF) and Rounding (IR) of Limestone Pebbles from the Chéria Formation, Type Section.

is not as pronounced (IR = 85), but nevertheless, the histogram (fig. 7) becomes bimodal with a marked maximum between 0 and 50 (34 %), with 25 % between 50 and 100 and 15 % between 150 and 200, indicating low capacity flows and micro-gelivation and reworking. As a whole, member 4 is indicative of higher temperature, decreased micro-gelivation, increased evaporation and reduced flows. The climate was, however, drier than during the deposition of member 2.

A downcutting phase follows the Chéria formation and preceeds the deposition of the upper recent terrace. It is more pronounced than the intra-Chéria phase but less than the phase which preceeds the Chéria formation. This post-Chéria downcutting is in all likelihood due primarily to the indirect influence of human interference which will be discussed in the following section.

The morphoscopic study (fig. 7) of the upper recent terrace shows a histogram of flattening comparable to that of member 4 (IF = 2,04). It is unimodal with 33 % of the pebbles between 1,5 and 2, 13 % between 1 and 1,5, 20 % between 2 and 2,5, and only 5 % above 5. Roundness is more pronounced than in the Chéria formation (IR = 107) and the histogram is bimodal with 26 % of pebbles between 0 and 50 and 21 % between 100 and 150. Both histograms indicate a diminution in the supply of fresh material which is due to the disappearance or reduction of micro-gelivation, the reworking of older deposits, and increased stream competence.

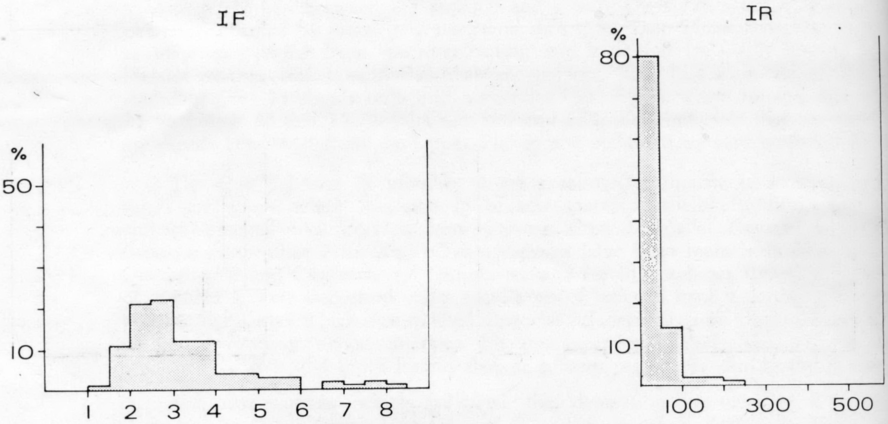

Fig. 7. — Histograms of Indices of Flattening (IF) and Rounding (IR) of the Upper Recent Terrace in Wadi Chéria-Mezeraa.

Holocene Chronology :

Member 2 of the Chéria formation is tentatively dated at 5 839 ± 95 B.P. (I-7693). This represents an average date for the upper part of the member. Member 1 of the Chéria formation is indirectly dated by the three radiocarbon dates from Aïn Misteheyia at between ca. 9 500 and ca. 6 500 B.P. (table 22), which is consistent with the latest published synthesis on North African Chronology (1). Most of the material reworked from Capsian sites is found in member 2 deposits. Moreover, large frost-wedged blocks contemporaneous with member 3 have destroyed several Capsian sites in Wadi Chéria-Mezeraa. From this, we

(1) Camps (G.), Delibrias (G.) et Tommeret (J.) — *l. l.*, 1973.

conclude that deposition of member 1, and the lower part of member 2 were probably contemporaneous with the period of Capsian occupation in this region.

Members 1 and 2 are separated from the upper members of the Chéria formation by a marked erosional disconformity which cannot be dated at present. Member 3 cannot be dated as well, but a terminal (Roman age) date can be inferred for the stabilized surface of member 4 (cf. paleosol in type section ?).

Apparently similar deposits have been observed elsewhere in Algeria. Guiraud (1) has described hydromorphic deposits in the Hodna basin as « Soltanian II ». These appear similar to the deposits of member 2 and the designation « Soltanian II » should be dropped as it refers to Holocene deposits rather than Upper Pleistocene ones.

(1) Guiraud (R.). — *Op l.*, 1973.

The fill of the irrigation ditch exposed in the type section of the Chéria formation (fig. 3) contains potsherds, some of which are typical Roman *terra sigillata.* Other remains of Roman occupation in this region are abundant, and among them are a number of dams still standing in wadis or exposed in wadi banks. One of the latter, exposed in profile a few meters upstream from the type section of the Chéria formation, is constructed of large uncemented, dressed limestone blocks 4 meters above present floodplain. Another crude dam can be seen 1 meter above present floodplain on the right bank of the Wadi Redif a few meters upstream from the section containing the reworked escargotière (fig. 10). A second dam constructed of small dressed stones built on Eocene limestone bedrock is still standing some fifty meters further upstream.

The evolution of the hydrographic system during Roman times can be retraced as follows. Initially, the topographic surface in the depressions was several decimeters lower than today. In the piedmonts, the wadis were shallow, but their regular régime permitted the construction of dams and decantation basins for water storage and regulation of supply. A phase of intensive erosion followed, destroying many escargotières and causing partial colluviation of the pediments which denuded slopes and filled the depressions with sediments that also choked the irrigation channels. At Sidi Aïch in the Soummam Valley, a one meter thick deposit of beige silty colluvium covers a little valley paved with Roman tile so this phase of siltation does not appear to be confined to the Chéria region. Following this phase of alluviation and colluviation, generalized downcutting leading to the modern topography commenced. It destroyed many of the dams and has had marked results as, for example, in Wadi Chéria-Mezeraa where the downcutting has reached 6 meters. This degradation phase been interrupted at least twice by phases of very minor aggradation or, simply, cessation of downcutting.

Despite the brevity of this period (less than 2 000 years), climatic variation may be partially responsible for the late Holocene evolution of the landscape. Aridification may have partially destroyed vegetation, leading to sheetwash soil erosion and downcutting. However, it is far more likely that this evolution is related to human occupation and interference. Roman agriculture in the basins and sheep-goat herding on slopes has resulted in pronounced denudation of the vegetation cover which has not been allowed regenerate during post-Roman times. The density of gullies, the existence of dams, and the density of Roman and pre-Roman sites in localities rarely inhabited today indicates the importance of this human interference, which is well documented elsewhere in the circum-Metiderranean region. Deforestation resulted in the erosion of the thin soil cover, and since neither vegetation nor soils provided effective deterrents to runoff, streams became directly controlled by the pluvial régime and the surplus energy available was, and still is today, used for downcutting.

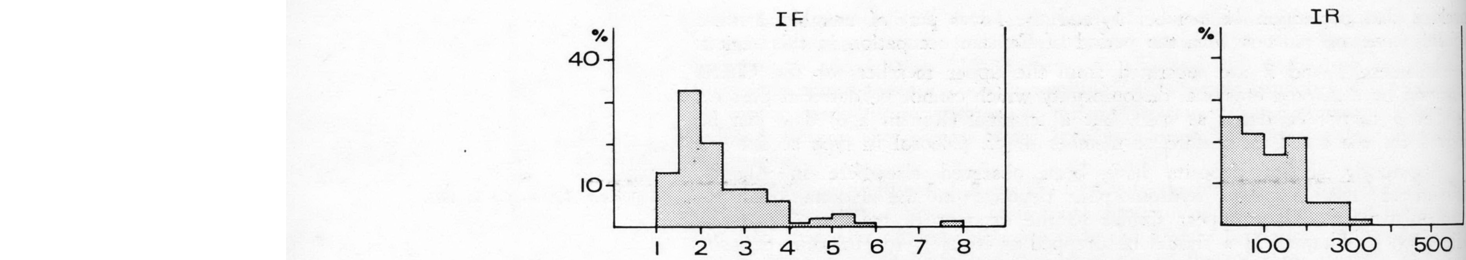

Fig. 8. — Histograms of Indices of Flattening (IF) and Rounding (IR) of recent gelifracts collected in the rockshelter at Relilaï.

The younger terraces indicate two minor episodes during which the supply of clastics was increased due to reworking of older deposits by erosion of wadi banks or, perhaps, short periods of gelifraction. Today, gelifraction is restricted primarily to north-facing cliffs and rock shelters. At Relilaï, for example, a sample of rockfall shows a unimodal distribution for flattening (22 % between 2,5 and 3) and the indices of rounding are between 0 and 50 in 80 % of the specimens measured, with a median of 40 (fig. 8).

The morphogenesis, lithostratigraphy and prehistoric/historic sequence in the Chéria region is summarized in Table 1. At this time it is impossible to draw firm correlations with either the Holocene sequence in Europe or with the tentative climatic curve established for Algeria (1). It should be noted, monetheless, that members 1 and 2 of the Chéria formation suggest a change from drier to more humid climate and that this seems to correspond to a similar trend noted by Couvert which is dated between ca. 9 000 and 8 000 B. P. Furthermore, geochemical, sedimentological and radiometric evidence from Aïn Misteheyia (see below) suggest a similar age for member 1 and contain evidence for an interval of drier climate which may correspond to a similar period noted by Couvert during the same period.

(1) Couvert (M.). — *Variations paléoclimatiques en Algérie : traductions climatique des informations paléobotaniques fournies par les charbons des gisements préhistoriques, note préliminaire.* Libyca, t. 20, 1972, pp. 45-48.

Table I. — Holocene Stratigraphy and Events in the Chéria and Télidjène Depressions.

DATE	LITHOSTRATIGRAPHY			MAJOR EVENTS
Post-Roman				Downcutting
	Recent terraces			Minor alluviation
Roman	Roman deposit			Deforestation, slope erosion, downcutting
				Soil formation ?
	Chéria Formation	Member 4		Fine alluvium and reduced gelifraction
		Member 3		Coarse alluvium and increased gelifraction with formation of alluvial fans and destruction of Capsian sites by rock shelter collapse
				Downcutting
ca. 5800 B.P. ca. 6500 B.P.		Member 2	Capsian occupation	Fine alluvium and reduced gelifraction with destruction of Capsian sites by fluvial erosion
ca. 7000 B.P. ca. 8800 B.P. ca. 9500 B.P.		Member 1		Two periods with coarse alluvium and intensive gelifraction, interrupted by a warmer and drier interval
	?			?
				Downcutting
	?			?
Late Pleistocene	"Soltanian"			Colluviation

Table III-a. — Percentage Frequencies of Pollen in Wadi Mezeraa Deposits.

Stratigraphy	Samples	Sedimentology	pH	Total grains counted	Compositae, liguliflora	Compositae, tubiflora including artemisia	Malvaceae	Gramineae	Pistacia	Quercus	Cheno-am	Acacia	Pinus	Liliaceae	Caryophyllaceae	Salix	Cedrus	Cyperaceae	Unknown	Indeterminate	Ratio of charcoal fragments to identifiable pollen grains
Member 4	3a	clay	7.2	43	7.0	4.6	11.6			4.6	4.6	2.3					9.3		32.4	39.0	2.14:1
	3b	clay	7.0	59		10.2	13.6	3.4	6.8	1.7	3.4	1.7	3.4				6.8		40.7	34.0	2.17:1
	3c	clay	7.2	69		7.2	17.5	15.0		4.3	2.9						2.9	4.3	10.1	29.0	2.29:1
Mbr 3					NOT SAMPLED																
Member 2	IV	sandy loam with abundant shell greasy texture	7.6	149	5.4	27.5	21.0				4.7					8.1	3.4		14.4	58.1	1.59:1
	III	silt with abundant shell	7.0 7.2	6	STERILE																3.80:1
	II	silty clay with some shell	7.2 7.6	120				4.2				9.2	16.7						40.8	24.2	1.19:1
Member 1	I	clay	7.6 8.0	27			7.4	3.7											66.6	30.0	2.74:1

Table III-b. — Percentage Frequencies of Pollen in Wadi Redif Deposits.

Depth in cm from surface	sample number	Sedimentology	pH	total grains counted	Compositae, liguliflora	Compositae, tubiflora including artemisia	Malvaceae	Gramineae	Pistacia	Quercus	Cheno-am	Acacia	Pinus	Liliaceae	Caryophyllaceae	Salix	Cedrus	Cyperaceae	Unknown	Indeterminate	Ratio of charcoal fragments to identifiable pollen grains
105-115	9	silty clay	8.0	PROCESSED BUT NOT COUNTED																	
125-135	8	silty sand	7.6																		
147-157	7	silty sand	6.8																		
175-185	6	clayey silt with angular gravel	7.2																		
200-210	5	clayey silt	7.0	128	6.2	2.3	2.3	3.8	15.7										62.3	91.5	.13:1
225-232	4	silty sand with a little clay	6.8	146	3.4	6.2	19.8	3.4	13.7					0.8	6.9	1.6			24.0	67.0	.44:1
245-253	3	silty sand with bentonitic clay	7.0	244		25.0	13.9	2.9	12.3	1.2			0.4	2.5	1.6				20.9	60.0	.18:1
263-270	2	silty sand with bentonitic clay	7.2	221	4.1	35.3	15.8	0.5		0.9		0.5		0.9					20.8	37.0	.13:1
290-300	1	sandy silt	7.0	237		21.9	10.5	4.6	2.1	2.9	2.5	0.8	0.4	0.8					35.6	60.0	.33:1

Table XXII — Radiocarbon Dates.

Sample No.	Provenience	Sample Composition	Date[1]	
I-7690	Aïn Misteheyia, Square J9 Level 4 (40-45 cm below datum)	*Helix melanostoma* shell	7280±115 B.P.	5330 B.C.
I-8378	Aïn Misteheyia, Square J9 Level 3 (80-90 cm below datum)	*Helix melanostoma* shell	8835±140 B.P.	6885 B.C.
I-7691	Aïn Misteheyia, Square J9 Level 2 (125-135 cm below datum)	*Helix melanostoma* shell	9280±135 B.P.	7330 B.C.
I-7692	Wadi Redif: from escargotière exposed in profile	*Helix melanostoma* shell	7690±120 B.P.	5740 B.C.
I-7694	Wadi Redif: from escargotière exposed in profile	Charcoal	7340±115 B.P.	5390 B.C.
I-7693	Wadi Chéria-Mezeraa: from member 2 deposits	Small spiriform shell of unidentified snail species	5830±95 B.P.	3880 B.C.

(1) All dates are calculated on the Libby half-life and are uncorrected.