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► **To cite this version:**

Catherine Kuzucuoğlu, Michel Fontugne, Damase Mouralis. Holocene terraces in the Middle Euphrates Valley, between Halfeti and Karkemish (Gaziantep, Turkey). *Quaternaire*, 2004, Fluvial Archives Group. Clermond-Ferrant 2002., 15 (1-2), pp.195-206. 10.3406/quate.2004.1767. hal-02470841

HAL Id: hal-02470841

<https://hal.science/hal-02470841v1>

Submitted on 19 Oct 2020

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HOLOCENE TERRACES IN THE MIDDLE EUPHRATES VALLEY, BETWEEN HALFETI AND KARKEMISH (Gaziantep, Turkey)

■
Catherine KUZUCUOGLU*, Michel FONTUGNE** and Damase MOURALIS*

ABSTRACT

The Holocene fluvial and archaeological records in the valleys draining the south-eastern piedmont of the Taurus range present several contrasted phases, interrupted by transition and/or rupture periods. The low terrace records identified in the Middle Euphrates valley between Halfeti and Karkemish give the following results: 1) a pre-Holocene incised topography is dated Upper or Late Pleistocene; 2) Late Pleistocene/Early Holocene alluviation deposited sands and silts forming a "high terrace" (+8-10 m) fossilising the previous incision; 3) at mid-Holocene the valley was forested and the landscape stable; 4) at the end of the 5th mill. BC, erosion and incision preceded the instalment of new settlements on the valley floor; 5) high floods followed this incision; 6) during the 2nd mill. BC or only in its second half, the river deposited a +4 m terrace, which was followed by incision during the first centuries of the 1st mill. BC.

The comparison with previous works realised within the Turkish and Syrian Middle Euphrates basin shows similarities and differences in the chronology of events and in the interpretation of the possible climatic significance of the changes observed. Discussion then tries to take into account 1) the records of global and regional climatic changes, 2) the sizes and geographic characters of the watersheds studied, 3) their position in the whole Euphrates basin, 4) the specific history of man's occupation of the land.

Key-words: Middle Euphrates, Holocene terraces, Floods, Archaeology.

RÉSUMÉ

TERRASSES HOLOCÈNES DANS LA MOYENNE VALLÉE DE L'EUPHRATE ENTRE HALFETI ET KARKEMISH (Gaziantep, Turquie)

Les enregistrements sédimentaires et archéologiques holocènes dans les vallées drainant le piedmont sud-oriental de la chaîne taurique présentent plusieurs phases contrastées, interrompues par des périodes de transition et/ou de ruptures. Ainsi, les dépôts formant les basses terrasses entre Halfeti et Karkemish dans la vallée moyenne de l'Euphrate turc présentent la succession suivante : 1) une topographie d'incision est d'âge Pléistocène supérieur (en relation avec le dernier Glaciaire ?) ; 2) des sables puis des limons sont déposés pendant l'Holocène inférieur, qui forment une «haute terrasse» (+ 8-10 m) fossilisant l'incision antérieure ; 3) à la mi-Holocène, la vallée est végétalisée et les paysages sont stables ; 4) A la fin du 5e mill. BC, une phase d'érosion et d'incision précède l'installation de populations chalcolithiques dans la vallée ; 5) de fortes inondations surviennent au tournant des 4e-3e mill. BC ; 6) pendant le 2e mill. BC, ou seulement pendant la 2e moitié du 2e mill. BC, une nouvelle phase de sédimentation conduit à la construction de la terrasse de +4 m, suivie d'une nouvelle incision pendant les premiers siècles du 1er mill. BC.

La comparaison avec les données fournies par les travaux antérieurs dans le bassin du Moyen Euphrate turc et syrien montre que la chronologie et des changements de dynamique fluviale, ainsi que l'interprétation des mécanismes climatiques éventuellement sous-jacents, présentent des similitudes et des différences selon les parties du bassin étudiées. Une discussion est donc engagée, qui prend en compte 1) l'enregistrement des changements climatiques globaux et régionaux, 2) la taille et les caractéristiques géographiques des bassins versants concernés, 3) leur localisation par rapport à l'Euphrate, drain principal, 4) l'histoire locale et régionale de l'occupation des territoires concernés par l'homme.

Mots-clés : Euphrates Moyen, terrasses, Holocène, crues, archéologie.

I - INTRODUCTION

Archaeological surveys organised in the frame of the damming of the Euphrates (for example: Algaze *et al.*, 1994) led to the realisation of salvage excavation and

research programmes, the latest of which in south-eastern Turkey being the Zeugma (Abadie-Reynal *et al.*, 2001) and Taçdam projects (Tuna and Velibeyoglu, 2002). In the mean time, several geomorphology researches have

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been realised in the Middle-Euphrates valley¹, focusing on the river terraces and Holocene alluvial records in Syria (Besançon and Sanlaville, 1981; Geyer and Sanlaville, 1991; Geyer and Besançon 1997; Geyer and Monchambert, in press) as well as in Turkey (Minzoni-Deroche and Sanlaville, 1988; Rosen, 1998; Wilkinson, 1990, 1999).

Results provide comparative terrace sequences dated from Late Pleistocene to Medieval Ages, identifying a succession of stabilisation, alluviation and erosion phases. Because of the scarcity of ¹⁴C datable matter in the alluvial fills, the dating of the Holocene evolution of the valley is mostly based on 1) correlation with archaeological layers at sites and/or by archaeological objects present in the fills and 2) comparison with climatic records provided by palynological studies from distant areas (lake Van, eastern Mediterranean sea, Ghab valley) (fig. 1). In this context, the climatic interpretation and the dating of the latest Euphrates sequences seem to vary between authors and study locations. Indeed, when comparing chronological schemes of river valley and slope dynamics, other factors than a direct response to global climate changes (mostly evidenced in marine and ice records) on regional climate changes (mostly evidenced in lake records) and on local environmental changes (mostly evidenced also in lakes and river watersheds) do intervene. In case of a river environment, some of these factors are 1) the geographic specificity of the environmental system studied, 2) its size and location within a larger drainage area also influenced by its own position in and its relations with a broader system; 3) the possible impact and relationships with man's activities.

The comparison of results obtained at various places within the Middle Euphrates basin, must thus take into account, not only the records of global and regional climatic changes, but also the sizes of the watersheds studied, the geographic (climatic, relief) location of the

watersheds and their position within the whole Euphrates basin, as well as the specific history of man's occupation of the land.

In this frame, the object of this paper is to provide additive results and interpretation regarding sedimentologic and geomorphologic records of Holocene river dynamics in the Middle Euphrates valley out of sections studied between Halfeti and Karkemish (fig. 2 and 3).

Our study of the Euphrates river dynamics has been based on two complementary approaches: 1) the stratigraphic and sedimentologic study of the sediment fills within the valley and 2) the correlation between river deposits and archaeological stratigraphy/chronology at sites. Terrace geomorphology, sediment fill characteristics, unconformities in the sequences (erosion, stepped terraces, fossilization), and changes in river beds allow us to set up a relative chronology of phases in the evolution of the river dynamics. The origin of the changes observed is discussed in the light of the available data on the evolution of climate in the region and adjacent areas and of possible changes in land cover. In addition, the relationships between man and his environment in the valley are discussed using archaeological site stratigraphy as well as data on settlement distribution and continuity, and cultural history (either on the site spots or in the valley corridor). Regarding archaeological records at site, the study presented in this paper is mainly based on data from four sites recently excavated or still under excavation. From upstream southwards to Karkemish, these sites are: Horum Höyük (Marro, in press), Saraga Höyük (Sertok and Kulakoglu, 2002), Zeytinlibahçe Höyük (Frangipane *et al.*, 2002), Savi Höyük (Dittmann *et al.*, 2002)². Information from other sites located in adjacent watersheds as well as in the Middle Euphrates valley north and south of the part of the valley studied, is used for comparison and interpretation (fig. 2 and 3).

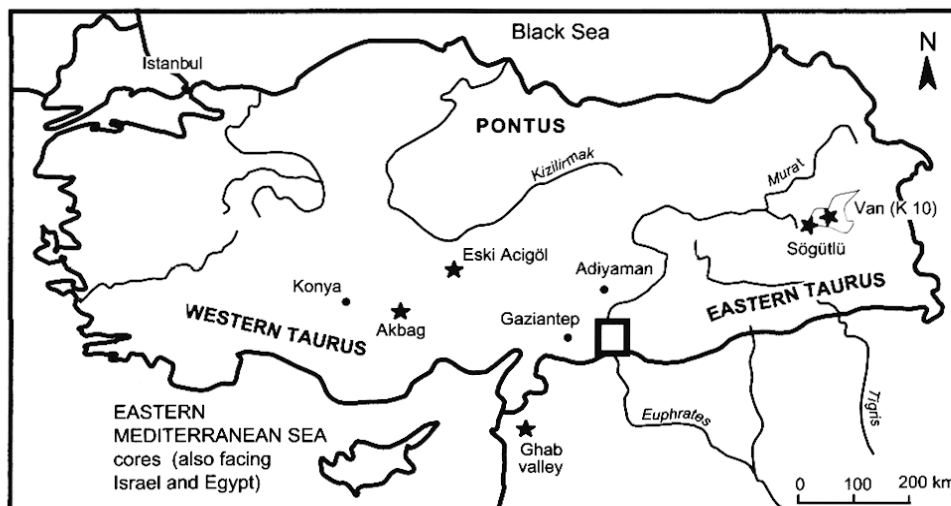


Fig. 1: Location of cores providing pollen references (black stars on the map) for Late Glacial and Holocene in the area studied. Small rectangle shows location of the area studied.

Fig. 1 : Localisation des séquences palynologiques de référence (étoiles noires sur la carte) pour le Tardiglaciaire et l'Holocène dans la région étudiée. Le rectangle sur la vallée de l'Euphrate correspond à la région étudiée.

¹ The definition of the "Middle Euphrates valley" varies according to authors. When studies are focussed on Syria, the "Middle Euphrates valley" is perceived as the valley between Mari to ca. the Turkish border, while in Turkey, it corresponds to the part of the valley from the Adiyaman region to the Syrian border. Geographically, we may consider that the "Middle Euphrates valley" extends from the Adiyaman region where the river enters the southernmost Taurus ranges down South to the confluence with the Khabur in eastern Syria (see fig. 1).

² The Turkish word «höyük» is the equivalent of the Arabic word «tell», meaning an isolated mound corresponding to human settlements. In the following pages, the word «höyük» will be omitted from the name of the sites cited.

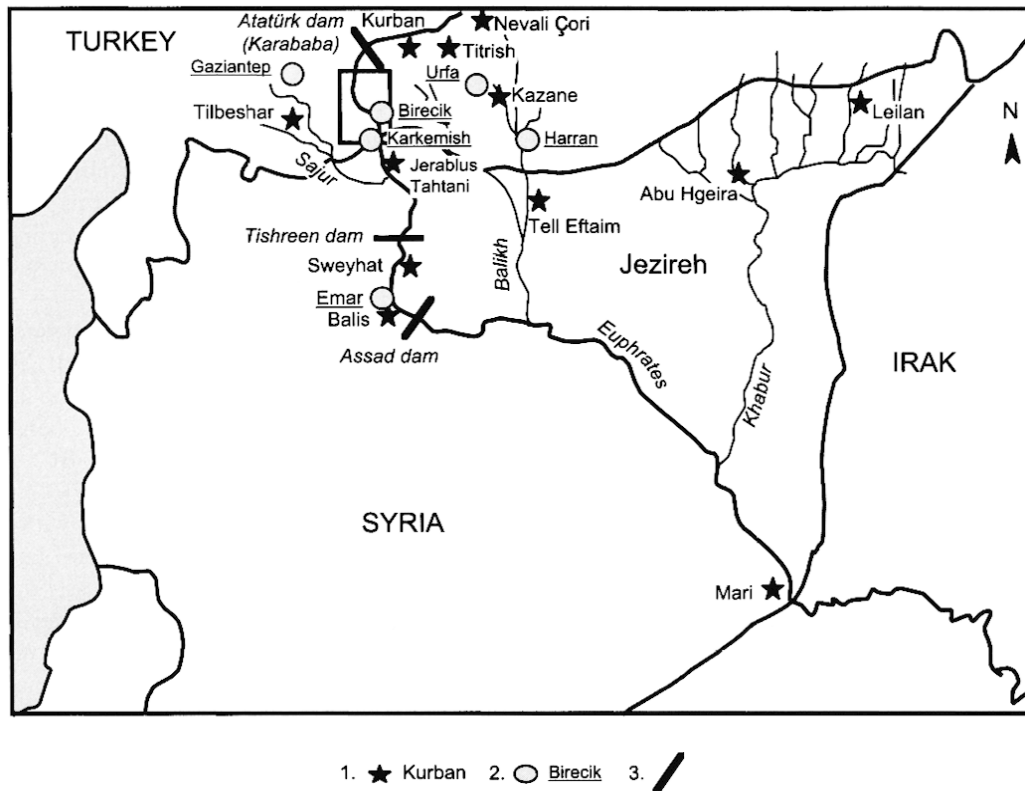


Fig. 2: Location of archaeological sites and towns cited in text (the inside rectangle shows location of map in figure 3). 1. Archaeological sites; 2. Main towns; 3. Dams.

Fig. 2 : Localisation des villes et sites archéologiques cités dans le texte (le rectangle indique la localisation de la figure 3). 1. Sites archéologiques ; 2. Villes ; 3. Barrages.

II - HUMAN OCCUPATION OF THE MIDDLE EUPHRATES VALLEY IN TURKEY: AN OVERVIEW OF THE ARCHAEOLOGICAL RECORD

From 1) the quantity of Palaeolithic artefacts collected on the plateaux and terraces along the Middle Euphrates valley (Minzoni-Deroche and Sanlaville, 1988; Bourguignon and Kuzucuoglu, 1999; Taskiran, 2002) and 2) the density of Chalcolithic to Iron Age archaeological sites located within and above the valley, the Middle Euphrates valley appears to have been, during history, an economically active region and a potential route for the exchange patterns connecting the southern (Mesopotamia, Jezireh, Levant) and the northern (Eastern and Central Anatolia, Caucasus) regions on both sides of the southern Taurus ranges.

THE EARLY HOLOCENE: PRE-POTTERY NEOLITHIC (PPN) AND POTTERY-NEOLITHIC (PN) CULTURES IN SOUTH-EASTERN ANATOLIA

The history of agricultural practices and settlements in the area from the Levant to South-East Anatolia on either sides of the external Taurus ranges is a very long one, starting before the beginning of the Holocene. Here, sedentarisation appears at ca. 10000 BC while plant and

animal domestication are completed at ca. 8000 cal. BC³ (Özdoğan & Başgelen, 1999).

In this region, the earliest Neolithic cultures belong to aceramic Neolithic, equivalent to the Levant and northern syrian pre-pottery Neolithic PPN A and PPN B. Excavated aceramic Neolithic «reference-sites» in the Euphrates and Tigris valleys in Turkey are (Harmankaya and Tanindi, 1999; Canew, 2002): Hallan Çemi (10200-9200 BC); Çayönü (10000-6800 BC); Göbekli Tepe (> 9100-8750 BC); Nevali Çori (8600-8000 BC); Gritille (8400-6600 BC); Cafer (8300-7300 BC); Gürcü (8000-7000 BC); Hayaz (7500-7300 BC). North of Karkemish, two Neolithic sites (the only ones identified in the area), Akarçay and Teleilat, are under excavation. In both sites, PPN settlements are much more extensive than the following PN periods (Balkan-Atli *et al.*, 2002; Karul *et al.*, 2002).

THE 6TH TO 4TH MILL. BC IN THE BIRECIK-KARKEMISH AREA

In this region, cultures previous to the Bronze Ages are named according to the following terminology: Halaf (6th mill. BC); Ubeid (5th mill. BC); Uruk (4000-3100 BC)⁴. According to the survey realised by Algaze *et al.* (1994), settlements belonging to Halaf, Ubeid and Early

³ Dates in this paper are given in BC years. When cited from papers where they are published in uncal.¹⁴C BP years, they are translated here in cal. BC years according to Stuiver & Reimer (1993). When published in cal. BP years or in varve years, they are also presented in cal. BC, in order for the time frame to be coherent through the whole paper.

⁴ As far as the chronology used by archaeologists is concerned, the starting and ending dates of each period previous to the Middle Bronze Age in the area will, by precaution, remain unprecise (Marro & Hauptmann, 2000).

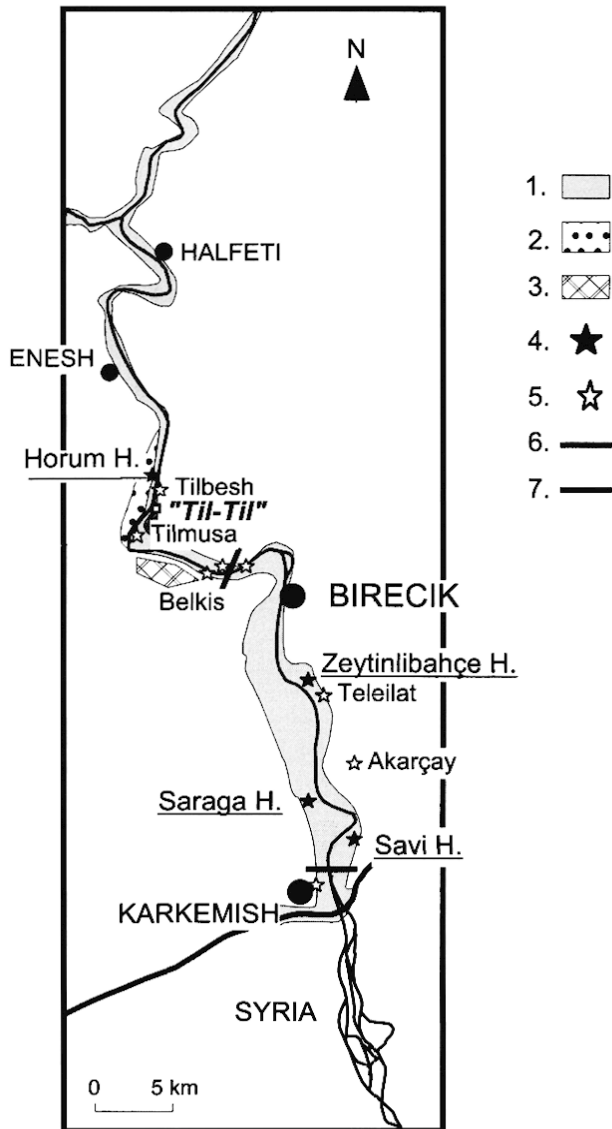


Fig. 3: The Euphrates valley between Halfeti and Karkemish. 1. Euphrates Holocene valley; 2. Upper Pleistocene terrace in the Horum plain; 3. Zeugma Roman city; 4. Archaeological site studied; 5. Other archaeological site cited in text; 6. Dam; 7. Border line.

Fig. 3 : La vallée de l'Euphrate entre Halfeti et Karkemish. 1. Vallée holocène de l'Euphrate ; 2. Terrasse du Pléistocène supérieur dans la plaine d'Horum ; 3. Zeugma, ville romaine ; 4. Site archéologique étudié ; 5. Autre site archéologique cité dans le texte ; 6. Barrage ; 7. Frontière.

Uruk (ca. 4000-3700 BC) are rare in this part of the valley where the sites locations are distinct from one another. In contrast, Middle and Late Uruk (3700-3100/3000 BC) settlements, characterised by the introduction of Mesopotamian wares and probable arrival of new populations, account for an important increase of sites during the second half of the 4th mill. BC. Such an expansion during which cultural material shows intensive contacts between pre-existing and expanding cultures is unparalleled elsewhere in the northern Mesopotamia periphery (Algaze *et al.*, 1994).

THE 3RD AND 2ND MILL. BC (THE BRONZE AGES) IN THE BIRECIK-KARKEMISH AREA

The Bronze Age covers the 3rd and 2nd mill. BC. It is divided into three periods: Early, Middle and Late. Each successive phase and sub-phase of the Bronze Ages is

defined by the disappearance and/or appearance of some specific archaeological material (mainly ceramic types). During the whole period, archaeological evidence shows the ever-lasting importance of local traditions together with the growth and decrease of influences from neighbour states (Babylonian, Assyrian, Hittite...). The cultural history of the area studied here and its local chronology still being in the process of being defined (Marro & Hauptmann, 2000), the chronology to which this article refers to is the following:

- The Early Bronze Age (EBA) corresponds to the 3rd mill. BC and is divided in 4 periods, I, II, III and IV, each of them lasting roughly between 200 and 250 years;

- The Middle Bronze Age (MBA) is divided into two periods: MBA I (2100/2000-1800 BC) and MBA II (1800-1600 BC);

- The Late Bronze Age (LBA) ends with the fall of the Hittite Empire in Anatolia and of local kingdoms at ca. 1200/1100 BC.

In this part of the Euphrates valley, the archaeological evidence from recent excavations (Tuna & Velibeyoglu, 2002) shows that the Early to Middle Bronze Age levels present a remarkable occupation continuity throughout the 3rd and the first quarter of the 2nd mill. BC (Kepinski-Lecomte, 1995; Marro, in press). Some settlements may have been abandoned during the 3rd mill. BC (Zeytinlibahçe was unoccupied during the 2nd quarter of the 3rd mill.). The second half of the 3rd mill. BC and the first half of the 2nd mill. BC show a town expansion also concerning low levels in the valley. During the 3rd and 2nd mill. BC, the Birecik-Karkemish area is part of the main commercial routes linking Mesopotamia to Central Anatolia, which were also crossing the Euphrates up North at Tuttul or down South at Karkemish. The absence or paucity of the following LBA sites (i.e. 1600-1200/1100 BC) deduced from first surveys (Algaze *et al.*, 1994) is now denied by results from recent excavations (Tuna & Velibeyoglu, 2002). All these new results now lead to a more constrained dating of the changes noticed in river dynamics during the 4th, 3rd and 2nd mill. BC.

III - HOLOCENE ENVIRONMENTAL CHANGES: AN OVERVIEW OF RECORDS FROM SOUTH-EAST ANATOLIA AND NEIGHBORING AREAS

References for the regional climate evolution and changes since Late Glacial are provided in Eastern Anatolia by Lake Van (Landmann and Reimer, 1996; Lemcke and Sturm, 1997; Wick *et al.*, 2003) and Söğütü marsh (Bottema, 1995), in NW Syria by the Ghab valley (Niklewski and van Zeist, 1970) in spite of some uncertain dating (Yasuda *et al.*, 2000), and in the eastern Mediterranean sea by marine cores (Rossignol-Strick, 1995, 1999). Other lake records are available from central Anatolia (Cappadocia: Roberts *et al.*, 2001; Woldring and Bottema, in press; Konya plain: Bottema and Woldring, 1984; Fontugne *et al.*, 1999; Kuzucuoglu *et al.*, 1999). River and soil environments have been studied in Syria (Courty, 1994; Geyer and Sanlaville, 1991; Geyer and Besançon, 1997; Wilkinson, 1999) and in Turkey (Minzoni-Deroche and Sanlaville, 1988; Wilkinson, 1990;

Rosen, 1998). All the palaeoenvironmental records from the eastern Mediterranean sea and from central Anatolia agree to place at ca. 4500–4000 BC a climatic alteration separating the Holocene in two phases. However, in the latest cores studied in Lake Van, where all dates are varve-based, such a climatically diphased Holocene is not evidenced at ca. 4500 BC but at 2100 BC in the $\delta^{18}O$ record and at 1400 BC in the Mg/Ca record (Landmann and Reimer, 1996; Lemcke and Sturm, 1997; Wick *et al.*, 2003). In the $\delta^{18}O$ record of these cores, the relative humidity increase starting at the end of the Younger Dryas (8460 BC) remains high until 2100 BC when aridity starts, lasting until 100 BC; the Mg/Ca ratio signals a humidity equivalent to today from 8460 to 6190 BC, increasing from 6190 BC to 1400 BC, with minor recessions at 4400 BC and 2900 BC. According to Mg/Ca ratio, lake level decreases and evaporation increases at 1400 BC, quickly reaching today's values after an ultimate recession in lake level at 1100 BC (Landmann and Reimer, 1996).

It thus appears that, in the eastern Mediterranean region, the Holocene is divided into two main climatic phases (Kuzucuoglu and Roberts, 1998). During an early phase (the Early Holocene, ending with the “climatic optimum”), the climate is warm and increasingly humid. The later phase starts at ca. 4500–4000 BC, with humidity decrease and strengthening evaporation impacts (eastern Mediterranean cores; Sögütlü marsh; Eski Acigöl; Konya plain). Holocene “brutal events” recorded in the North Atlantic and ice cores (at 6500–6100 BC, 4700 BC, 2200–2000 BC: Gasse, 2000) correspond, when identified in the eastern Mediterranean region, to dry spells.

THE EARLY HOLOCENE AND THE TRANSITION TO LATE HOLOCENE IN THE MIDDLE EUPHRATES REGION

In the Syrian Euphrates, the warm and humid Early Holocene is marked by the deposition of a silty terrace (Geyer and Sanlaville, 1991; Geyer and Besançon, 1997), the sedimentary characteristics of which indicate a braided flood plain (Geyer and Monchambert, in press). Rosen (1998) in the Urfa plain and in the Euphrates valley near the site of Titrish, also notices an Early Holocene hydrological regime responding to moist conditions, in agreement with Courty's observation (1994) in north-eastern Syria where silt aggradation previous to the 6th mill. BC is related to high floods.

All authors agree to place the Euphrates incision and contraction in river bed during the 6th mill. BC (Halaf). In Syria, pre-Ubeid (Halaf) incision thus allows the valley to be durably occupied at the beginning of Ubeid. Geyer & Monchambert (in press) relate this incision to a late humid phase of the Holocene optimum during the 6th mill. BC evidenced in the eastern Mediterranean marine cores (Rossignol-Strick, 1995) and in the continental sequences of the Levant (Sanlaville, 1996).

However, Rosen (1998) explains the 6th mill. BC incision by a “dry” episode evidenced in the upper Khabur by Courty (1994) whose interpretation identifies a “two-step” climatic change: 1) during the 6th mill. BC, both precipitation and temperature decrease; 2) during the 5th and 4th mill. BC, increase in river discharge and violence

of seasonal rains induce the renewal of flood occurrences locally destroying sites. Floods during the 5th mill. BC are also noticed in the Middle Euphrates valley near the Turkish border in Syria where they reach a + 12 m height (Oguchi and Oguchi, 1998). Such events in small catchments mean not only that local rain gained in irregularity and stormy character, but also that local precipitation increased, which would also sustain the growth of vegetation cover implied by 5th mill. BC soils in the Urfa region and Balikh valley (Rosen, 1998).

In contrast, in other parts of the Middle Euphrates valley as well as in the Balikh valley in Syria, the Early Holocene moderately stable landscapes (soils, forest cover) and perennial channel flows come to an end, not during the 6th or 5th mill. BC, but later, between the end of the 4th-beginning of the 3rd mill. BC or during the first half of the 3rd mill. BC (Titrish, Kurban: Wilkinson, 1999) or even during late 3rd mill. BC (Kazane: Rosen, 1997; Syrian Middle Euphrates valley: Wilkinson, 1999).

During the 4th and beginning of the 3rd mill. BC, vegetation growth and runoff inhibition induces steadier perennial flows, stable alluvial environments and rise of groundwater tables (Kurban). Sustained moderate flow deposits well-sorted and rounded gravel fills (Kurban, Tell Eftaim: Wilkinson, 1999). In the smaller catchments however, the valley fill is continuously reworked during the 4th mill. BC. Thus, in the upper Khabur where the 5th mill. BC soil erosion, strong discharges and incision also prevail through the 4th mill. BC, increased silt-clay input from eroded slopes by more erratic flow regimes encouraged a shift from braided to more meandering silt load river channels at the end of the 4th mill. BC (Courty, 1994).

These results present contrasted chronology and interpretation of climatic and environmental changes evidenced during the 5th and 4th mill. BC (i.e. the end of the Climatic Optimum and the following millenium), which vary according to regions along the southern and northern piedmonts of the external Taurus ranges. This variety probably represents differences introduced by the geographic characters, location and size of the drainage areas studied, as well as probable differences in land and resource exploitation systems through history.

THE BEGINNING OF LATE HOLOCENE: THE 3RD AND 2ND MILL. BC IN THE MIDDLE EUPHRATES AREA

The 3rd mill. BC

During the 3rd mill. BC, an environmental change occurred in the Turkish (Kurban, Titrish) and northern Syrian (Jerablus-Tahtani, Tell es-Sweyhat) Middle Euphrates, as well as in its tributaries in Turkey (Sajur), and in Syria (Balikh, Khabur). This change is marked by an increase of flood magnitude and of soil erosion which had diverse geomorphologic and dynamic effects according to the size and location of the drainage system.

At Titrish, the mid-3rd mill. BC is marked by episodic high energy flow (extreme flood events) occurring in a channel larger than before (Wilkinson, 1999). According to the author, coarse sediment transport in the area is possibly caused by stripping of vegetation from the hills

or (more likely), by a more erratic rainfall pattern with increased droughts and heavier storms. When compared with the previous stable period, flow regime becomes unsteady and flow peaks increase, as at Kurban further downstream.

At Jerablus-Tahtani in the north-syrian Euphrates valley, flood inundation occurs at least at ca. + 5 m in the later 3rd mill. BC (Peltenburg *et al.*, 1997). Further south (Tell es-Sweyhat), aggradation of alluvial fans shows, after early 3rd mill. BC, a gradual accretion associated with an essentially stable Euphrates channel. In small catchments aside, in contrast, channels shift continuously, scouring away the floodplain and trimming bluffs, as well as presumably any associated sites that were originally present. In these small catchments, during the later 3rd millenium or early 2nd mill. BC, aggradation infills across the entire width of valleys with ploughwash containing sherds (Wilkinson, 1999).

In the Balikh valley, through the 3rd mill. and attaining a peak during the early 2nd mill. BC, erratic flow and channel incision in smaller catchments coincided, or followed by a short time, the growth of sites to their maximum size which, in turn, were responsible for an increase in water demand which exacerbated climate-originated water depletion (Wilkinson, 1999). At Kazane (Rosen, 1997), inflow changed at late 3rd mill. BC when flows became seasonal and water tables lowered. This change was followed by erosion dissecting the former mid-Holocene fill. In the Khabur (Courty, 1994), the 3rd mill. BC is characterised by a marked seasonality with long dry periods alternating with short humid ones, rainfall being lower and more irregular than during the 5th and 4th mill. BC.

The 2nd mill. BC

In South-East Anatolia the transition 3rd-2nd mill. BC is marked by an environmental degradation possibly modifying the environmental constraints of land occupation and water availability.

In the Middle Euphrates valley (Titriş, Kurban: Wilkinson, 1999), the beginning of the 2nd mill. BC is marked by a narrowing of channels and the aggradation of colluvium and small alluvial fans. Similar incision and erosion are noticed by Rosen (1998) during the 2nd half of the 2nd mill. BC in the Balikh valley. According to Wilkinson (1990), increased delivery of fine sediments from neighbouring fields and slopes indicates that both runoff and slope erosion increases are related to human influence in the form of vegetation removal due to intensive land use during both the 3rd and 2nd mill. BC.

IV - THE ENVIRONMENT OF THE EUPHRATES VALLEY DURING HOLOCENE, FROM THE HALFETI GORGES TO THE TURKISH-SYRIAN BORDER (KARKEMISH)

THE EUPHRATES VALLEY AT ITS ENTRANCE IN THE NORTHERN SYRIAN PLATEAUX

In the eastern anatolian mountains, two rivers, the Karasu coming from the Erzurum area and the Murat Su coming from the lake Van region, meet to form the Euphrates (fig. 1). The river flows then southwards, in

a series of trenches and plains across the south-eastern Taurus ranges, towards the Jezireh in Syria and Mesopotamia further South.

At Karkemish on the Syrian border, the drainage area of the Euphrates river covers 110,000 km². Before the first large dam was set in operation at Keban in 1974, the discharge of the Euphrates at Birecik was ca. 1000 m³/sec, with a 0.2 % river slope. Every spring, flood peaks (in April and May) commonly reached 5000-7000 m³/sec, while summer-autumn discharges remained lower than 500 m³/sec (Birecik Company, 1994). Such discharge distribution profiles clearly illustrate the winter snow melt-related origin of the floods, generated in the eastern anatolian mountains. While annual precipitation reaches >1000 mm/yr in some mountains of eastern Anatolia, annual rainfall on the south-eastern Taurus piedmont accounts only for 400-450 mm/yr, allowing however rain-fed crop cultivation. Before the flooding of the valley by the dams, the main agricultural activity was focused on fruit production, especially pistachio (also growing on hill slopes), olives, figs and grapes. Residual oak trees from open forests can still be observed on the limestone and basaltic plateaux aside, where extensive sheep husbandry occurs.

The part of the valley studied presents two distinct geomorphological sectors, the upper plain (Enesh-Belkis) and the lower plain (Birecik-Karkemish), delivering different and complementary Late Pleistocene and Holocene fluvial terrace records (fig. 3).

1) After leaving its last gorges in the Eocene limestone at Enesh some 10 km South of Halfeti, the valley widens to form a plain reaching 2 km in width and 10 km in length (called the "Horum" plain in this paper). At Belkis the valley narrows again and is bordered on both sides by cliffs cut into Lower Miocene marly limestone. This plain is filled by two embedded silty terraces in which today's floodplain and river bed are incised. Their altitude relative to the river bed reaches +8-10 m for the lowest, and +13-15 m for the highest (fig. 3 and 4). In the floodplain, a +2 m sandy terrace bordering the main 50 m wide channel marks the recent regular occurrence of spring floods (Bourguignon and Kuzucuoglu, 1999). Several archaeological sites occur in this part of the valley: Tilbesh, Tilmusa and Sürtepe on the left bank; Horum and Belkis on the right bank (fig. 3). Of these, only the base of the Horum tell is based on the +8 m terrace, while the others lie in or over a younger alluvial deposit reaching +3-4 m in relative height (fig. 6).

2) Downstream from the Birecik cliffs, the valley widens again: 4 km at Birecik and 5 km near Karkemish (fig. 3). This width increase produces lesser constraints to the flows and their load, so that the high terrace deposits are not as thick as in the Horum plain, and are also more dismantled while the remains of the +4 m terrace, commonly embedded in older formations, are more numerous.

The Horum plain

The reason for the construction and conservation of high recent terraces in the Horum plain is the presence of both gorges in and out of the plain, leading to the trap-

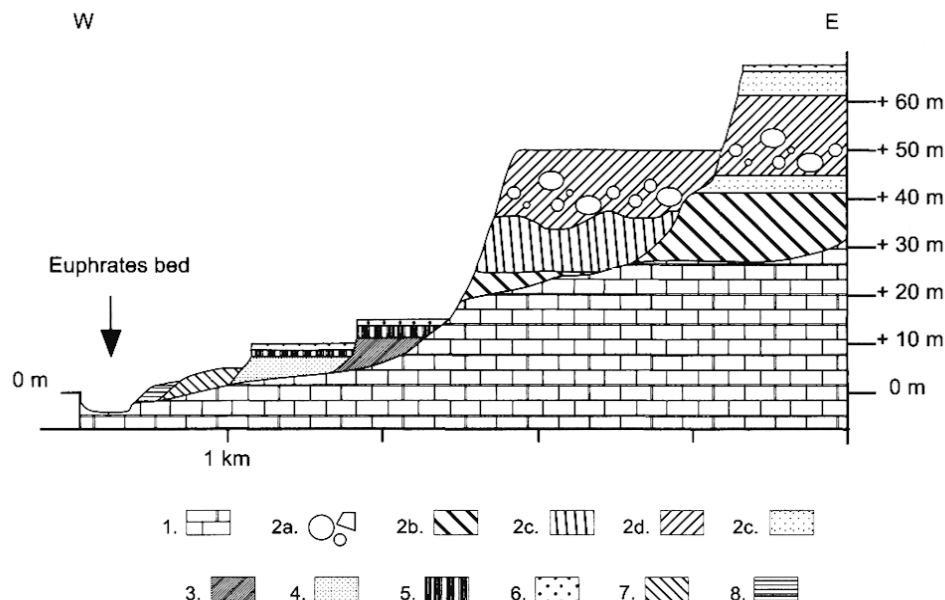


Fig. 4: Schematic cross-section of alluvial terraces succession upstream from and in the vicinity of Birecik dam. 1. Oligocene marly limestone; 2a. Middle to Upper Pleistocene fluvial bedload deposits; 2b and 2c. Middle to Upper Pleistocene fluvial coarse and sand deposits (two units in lower old terrace); 2d. Boulders; 3. +14-15 m = Upper Pleistocene terrace (bedload covered with sand-based limy silts); 4. +8-10 m Pleniglacial-Late Glacial-Early Holocene terrace (bedload covered with sand-based limy silts); 5. Mid-Holocene soil; 6. 4th mill. BC flood silts; 7. Bronze Age terrace (+4 m); 8. Recent flood deposits (+2 m terrace).

Fig. 4 : Coupe schématique des terrasses alluviales de la vallée de l'Euphrate en amont et autour du barrage de Birecik. 1. Calcaires marneux oligocènes ; 2a. Charge de fond des hautes terrasses du Pléistocène moyen à supérieur ; 2b et 2c. Dépôts fluviaux graveleux et sableux des terrasses du Pléistocène moyen à supérieur (deux unités dans la terrasse inférieure) ; 2d. Blocs roulés ; 3. Terrasse du Pléistocène supérieur (+14-15 m = charge de fond surmontée de limons calcaires sableux à la base) ; 4. Terrasse du dernier Pléniglaciaire-Tardiglaciaire-Holocène inférieur (+8-10 m = charge de fond et limons calcaires, sableux à la base) ; 5. Sol mi-holocène ; 6. Limons de débordement (4^e mill. BC) ; 7. Terrasse de l'Age du Bronze (+4 m) ; 8. Dépôts actuels (terrasse de +2 m).

ping of thicker sediment deposits in a first phase, and to more efficient incision in a second phase. Also, nearby slopes provided much more colluvial sediments transiting from alluvial fans feeding the terrace by the sides.

Two main cycles are registered in the terrace succession in the Horum plain (fig. 4 and 5). Such successions have also been noticed by Algaze *et al.* (1994). In the Harran area (Rosen, 1998), soils covering silt deposits capping bed loads are commonly truncated and are dated by Paleolithic artefacts. According to these observation and comparison, the cycles composing both terraces in the Horum plain can be expected to be Upper Pleistocene in age, although precise dating is lacking.

The summit of the upper recent terrace in the Horum plain reaches +14.5-15 m at Til-Til, a cliff dominating the left bank of the Euphrates between Tilbesh and Tilmusa. Units are composed of a series of sand layers covered by whitish silts of ca. 6 m thickness, overlying a bed load deposit (coarse gravel of Taurus origin) topping an incision level in the limestone bedrock positioned at +2 m above the Euphrates main channel. The relative altitude of this incision surface is stable throughout the valley from Horum to Saraga, indicating that, at time of the formation of this older terrace, active channels were flowing +2 m over today's river level (Mouralis, 1999). A soil is developed on the top of this series, showing vegetation development at +11.70 m (fig. 3 and 5). This soil is covered in conformity by 1 m red silts over which another, darker, soil is developed. Organic matter from this later soil has been ¹⁴C dated 4468 cal. BC (5660 ± 70 BP: Gif 101054) (fig. 5). This mid-Holocene soil is buried under 2 m of younger whitish silts. The soil and its ¹⁴C date

point out to a stable landscape and an incised river bed at the end of the Holocene Climatic Optimum, with the development of a substantial vegetation cover. The deposit over which this soil developed, i.e. 1 m thick silts, appears then to be Early Holocene in age. The uppermost 2 m thick whitish silts burying the soil above +12.8 m must thus have been deposited by Late Holocene high floods.

Under the Horum chalcolithic settlement installed on the +8 m terrace on the right bank, a reddish soil is truncated at ca. +7.5 m, as shown by the stratigraphic study of the sides of a well dug by Early Uruk people (fig. 5). Only the base of this soil, eluviated and associated with carbonate nodules, is preserved under some alluvial deposits covering it unconformably. The soil developed over a series similar to that observed at Til-Til: bed-load followed by sands covered by whitish and orange-coloured silts. However, the incision fossilised by the bed-load deposit reached a level lower than that of today's river bed. The Horum series is thus embedded within the Til-Til older cycle (fig. 5). Having been extracted from an eluviated horizon, the sample given for ¹⁴C dating did not contain enough organic matter to produce any date. However, due to the embedding of the Horum cycle within the Til-Til terrace and the presence of a mid-Holocene soil on top of the silts covering the Til-Til Upper Pleistocene cycle, both Horum truncated soil and Til-Til dated soil should be of the same age, indicating that the deposition of the Horum +8 m terrace occurred during Early Holocene or before (end of Last Glacial?).

According to this observation, chronological hypotheses for the succession of events recorded in the younger terrace system in the Horum plain may be the following.

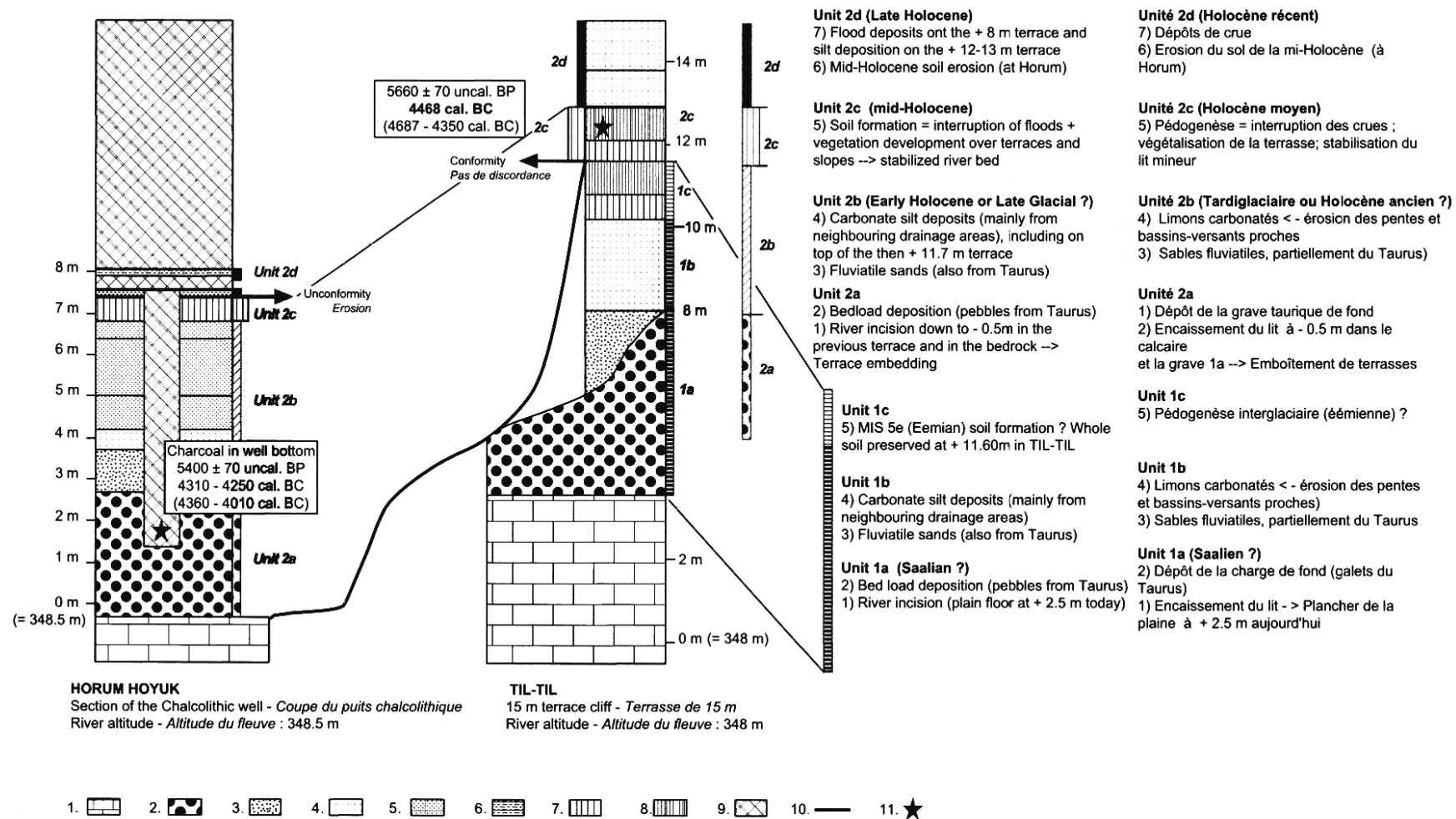


Fig. 5: Stratigraphy of the lowest terrace at Horum (+8 m) compared to that of the Til-Til terrace (+14-15 m). 1. Limestone bedrock; 2. Bedload (rounded pebbles and gravels transported from the Taurus); 3. Fluvialite sandy deposits; 4. Light coloured carbonate silts; 5. Yellow to orange coloured carbonate silts; 6. Bedded fine fluvialite sands; 7. Reddish silts with carbonate nodules; 8. Soil (red silts); 9. Archaeological layers; 10. Main unconformities (erosion); 11. Dated samples.

Fig. 5 : Analyse stratigraphique des dépôts formant la terrasse inférieure (+8 m) à Horum comparée à la série formant la terrasse de Til-Til (+14-15 m). 1. Substratum calcaire ; 2. Charge de fond (galets et graviers roulés provenant du Taurus) ; 3. Sables fluviaux ; 4. Limons carbonatés couleur crème ; 5. Limons carbonatés, jaunes à orangés ; 6. Sables fluviaux fins lités ; 7. Limons rougeâtres à nodules de carbonate ; 8. Sol (limons rubéfiés) ; 9. Couches archéologiques ; 10. Discordances principales (érosion) ; 11. Echantillons datés.

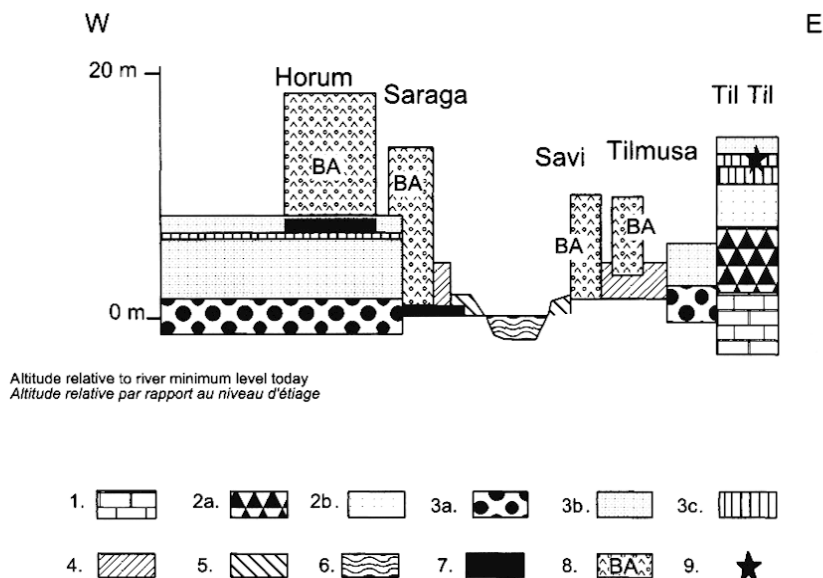


Fig. 6: Synthetic presentation of stratigraphic relationships between Upper Pleistocene river deposits and post 5th mill. BC archaeological sites in the flood valley of the Euphrates river between Horum Höyük and Karkemish. 1. Oligocene limestone basement; 2a. Upper Pleistocene +12-15 m terrace: basal unit (base load); 2b. Upper Pleistocene +12-15 m terrace unit: upper sands and carbonated silts; 3a. Upper Pleistocene +8-10 m terrace: basal unit (base load); 3b. Upper Pleistocene +8-10 m terrace: upper sands and carbonated silts; 3c. Mid-Holocene palaeosol; 4. Bronze Age terrace (+4 m); 5. Recent river deposits (+2 m terrace); 6. River bed; 7. Chalcolithic layers (Horum and Saraga); 8. Bronze Age and more recent archaeological layers; 9. ^{14}C date.

Fig. 6 : Présentation synthétique des relations stratigraphiques entre dépôts fluviaux du Pléistocène Supérieur et niveaux archéologiques postérieurs au 5^e mill. BC dans la vallée de l'Euphrate, entre Horum Höyük et Karkemish. 1. Substratum calcaire oligocène ; 2a. Terrasse +12-15 m (Pléistocène Supérieur) : unité de base (charge de fond) ; 2b. Terrasse +12-15 m (Pléistocène Supérieur) : dépôts sableux et limoneux terminaux ; 3a. Terrasse +8-10 m : unité de base (charge de fond) ; 3b. Terrasse +8-10 m : dépôts sableux et limoneux terminaux ; 3c. Paléosol mi-Holocène ; 4. Terrasse de l'Age du Bronze (+4 m) ; 5. Dépôts fluviaux subactuels (terrasse de +2 m) ; 6. Lit du fleuve ; 7. Niveaux chalcolithiques (Horum et Saraga) ; 8. Niveaux archéologiques de l'Age du Bronze et postérieurs ; 9. date C^{14} .

The river down-cutting previous to the +8 m terrace deposition incised the Upper Pleistocene +12 m terrace down below the base of the Upper Pleistocene sediments, within the bedrock. Deposition of the +8 m terrace sediments occurred afterwards. Since the youngest palaeosol at Til-Til is dated mid-Holocene, the deposition of the +8 m terrace also bearing this soil, may be assigned to a period extending from the Last Glacial (Pleniglacial? Lateglacial?) to Early Holocene. A second phase of incision cut the +8 m terrace. It was deep and rapid enough to keep later meanders of the river from eroding most of the +8 m terrace. In the mean time, gullies also deeply incised the terrace confirming the rapidity of change in base level in the plain. The depth and age of this later incision are given by the presence of "pre-Uruk" layers at Saraga at -1 m below today's river bed (Sertok and Kulakoglu, 2002), and by the relative altitude (+1.4 m) of the oldest EBA layers (continuing below +1.4 m) excavated in a sounding at Savi (Dittman *et al.*, 2002). According to these dates, the erosion leading to the truncation of the soil at Horum as well as the incision shown by the very low altitude of the Middle Chalcolithic settlement in Saraga, must have occurred during the 2nd half of the 5th mill. BC.

The 4th mill. and 3rd mill. BC between Halfeti and Karkemish

The continuity of occupation of the Late Chalcolithic and Bronze Age settlements in the valley reflect partly the relationships between the location of the sites and the incision-flooding occurrences during the beginning

of the Late Holocene. Thus, the settlement of a site may partly be dependant of its location within the valley, i.e. of its altitude relatively to the present level of the river bed. Accordingly, a distinction is made between «high» and «low» sites (fig. 6) :

- «high» sites, where Late Chalcolithic and Age Bronze villages settled on the +8 m terrace; they were almost continuously occupied from the mid-4th to the mid-2nd mill. BC (Horum and Zeytinlibahçe);
- «low» sites, where pre-Uruk and Middle EBA population (Saraga, Savi) settled below today's river level; in these sites, hiatus may occur in the stratigraphy.

Some data concerning the dynamics of the river during Late Holocene are thus provided by the stratigraphy of high and low sites.

At the beginning of the 3rd mill. BC, silts and thin sands interstratified at a +10 m height at Zeytinlibahçe, signal the occurrence of high magnitude floods which did not cause any rupture in the occupation of the settlement. At mid-3rd mill. BC, the low parts of the valley are reoccupied (Saraga, Savi). In Saraga, the Iron Age settlement being built over eroded Late Bronze Age structures, the meander move and the incision responsible for the partial destruction of the höyük is thus constrained to a period covering the end of the 2nd mill. BC (LBA) and the first centuries of the 1st mill. BC. Such a partial destruction concerned at least Horum, Tilmusa, Zeytinlibahçe, Saraga and Savi.

In parallel, in the Birecik-Karkemish area, the +4 m terrace was found to contain Bronze Age ceramic sherds, the type of which was not clear enough to allow a precise dating. Deposition of the terrace sediment must thus

have occurred either during the late 3rd and/or the 2nd mill. BC. A more precise dating of this aggradation period is possible using comparison with results in neighbouring regions. In the Syrian Euphrates valley, Geyer & Sanlaville (1991) studying this terrace, similarly reported sherds of all Bronze Ages, but no Iron Age ones. Consequently, the authors date the fill of a transition period between LBA and Iron Age, Near Kurban, aggradation of 3 m fining upward gravel and loam deposited by high energy episodic flow is dated early 2nd mill. BC or later, because of the presence in the fill of EBA IV-MBA I sherds (Wilkinson, 1999). In the Urfa region, no MBA or LBA sherds were found in the sediment, the age of which is proposed by Rosen (1998) to be Early Bronze Age, i.e. 3rd mill. BC. According to these various findings and conclusions, it is proposed here to date the Late Holocene aggradation leading to the formation of the +4 m terrace in the Halfeti-karkemish part of the Euphrates valley, of the late 3rd – early 2nd mill. BC, or (most probably) of the end of the 2nd mill. BC.

The origin of the aggradation processes does not yet seem to be climatic; rather are its construction and incision to be considered as an effect of land use practices by man (Wilkinson, 1999). However, the progressively drying phase of the early 2nd mill. BC, signalled in the isotopic record of Lake Van, exacerbated most probably the man-originated stress on the water supply and environmental systems.

V - CONCLUSION

Comparison with results from neighbouring areas leads us to propose the following Upper Pleistocene-Holocene succession: 1) a +11.7 m high terrace consists of Upper Pleistocene deposits topped by an Upper Pleistocene soil; 2) incision follows, down-cutting the bedrock below the Upper Pleistocene sediments; 3) sedimentation fills the incised valley with first, a bed-load (last Pleniglacial?), second, sand and silt series (Lateglacial?) with some latest silt deposition overlapping the +11.7 m terrace up to +12.8 m; 4) a soil develops on top of both terraces, dated mid-Holocene; 3) the truncation of this soil occurs afterwards, while the river and its side-gullies incise the +8 m terrace down to inside its bed-load unit; 5) Chalcolithic population settle in the valley floor and on the +8 m terrace during a period of low floods; 7) High floods occur after mid-Holocene, depositing silts on top of the +12.8 m terrace up to 14.5 m, and sands interstratified in the Late Chalcolithic and first Early Bronze Age archaeological layers of sites located at +8 m (Horum Höyük and Zeytinlibahçe).

At the boundary between mid and late Holocene (6th-5th-4th mill. BC), several sedimentary discontinuities occur in alluvial sequences studied in the south-eastern Taurus piedmont, whether in the Euphrates basin (south-eastern Anatolia, northern Syria) or north-eastern Syria (Balikh and Khabur valleys). These discontinuities do not appear to have been contemporaneous and show somewhat contrasted scenarios when compared from a region to another. Such variety in time-records may represent delayed responses to a regional climatic change unevenly

distributed in time on contrasted topographies inland which influence the amount of precipitation received. Also, the size of the stream (whether the Euphrates river or one of its tributaries) and the location of the sections studied within the whole drainage basin influence the dynamic processes recorded in the valley fills.

The mid-Holocene climatic change seems to start locally earlier (6th mill. BC) on the today more rain-poor part of the Syrian plateaux (the Jezireh), occurring later (4th mill. BC) northwards on the Taurus piedmont (the Karkemish-Birecik region), reaching eastern Anatolian highlands (lake Van) at the end of the 4th or during the 3rd mill. BC. This change is characterised by decreasing humidity and more erratic and stormy precipitation. Such a change could be produced by a southwards shift of the influence of the monsoon rains producing drought in Syria, while Mediterranean air masses bring regular precipitation on the Taurus heights (Rossignol-Strick, 1999). Observed differences in climate and stream flow characteristics between neighbouring regions during the 6th, 5th and 4th mill. BC may thus reflect delayed responses which can be partly enlightened by the geographic distribution of records studied along a North-South transect: changes occur at earlier dates in the South (6th-5th mill. BC) to later dates in the North (4th mill. BC), while Anatolian uplands receive higher and more regular precipitation during the 5th and 4th mill. BC.

Parts of the regime of the Euphrates river on the Taurus southern piedmont during the late 3rd and 2nd mill. BC (aggradation, floods, incision) may thus be a response, to some extent, to cumulative impacts of climatic progressive change and land use practices. Higher flow variations at all BA periods in the Euphrates valley, increased erosion, or accelerated aggradation in smaller catchments, are thus related partly to the Late Holocene climatic desiccation, but also to the increasing impact of human activities on landscape during the 3rd and 2nd mill. BC.

ACKNOWLEDGEMENTS

This study started in the frame of the Zeugma Archaeological Salvage project and the Horum höyük excavation (C. Marro & A. Tibet). The author thanks all teams working in this project, the French Ministry of Foreign Affairs, the French Institute of Anatolian Studies (IFEA, Istanbul) and the CNRS (UMR 8591; PeH and PEVS Programmes) for supporting the study. Support was also provided by the Birecik Dam project. This work was made possible by the enthusiastic collaborations established with the archaeological teams and directors of the excavations at Horum höyük, Zeytinlibahçe höyük, Saraga höyük, Savi höyük and Tilbeshar höyük. The Gaziantep Museum, the Turkish Ministry of Culture (Ankara) and its local officials always did their best for facilitating field work and access to sites. May every one, as well as B. Geyer, C. Kepinski-Lecomte, K. Köroglu, C. Marro and T. Wilkinson who kindly accepted to comment on this paper, be thanked for their support, contribution and interest in this research.

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