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Bernard Geyer, Jacques Besançon. Environmental and land-use evolution in the Euphrates valley during the Neolithic and Chalcolithic periods. *The Syrian Jezira, Cultural Heritage and Interrelations*, Apr 1996, Deir ez-Zor, Syria. p.61-68. halshs-01285347

HAL Id: halshs-01285347

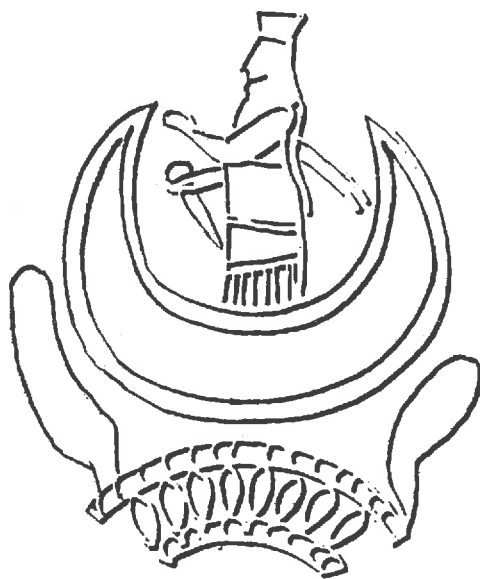
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DOCUMENTS D'ARCHÉOLOGIE SYRIENNE
I
THE SYRIAN JEZIRA
CULTURAL HERITAGE AND INTERRELATIONS



Proceedings of the International
conference held in Deir ez-Zor april 22nd - 25th, 1996

2002

Edited by
Michel Al-Maqdissi, Maamoun Abdul Karim, Amr Al-Azm, Moussa Dib Al-Khoury

MINISTÈRE DE LA CULTURE
DIRECTION GÉNÉRALE
DES ANTIQUITÉS ET DES MUSÉES
RÉPUBLIQUE ARABE SYRIENNE

ENVIRONMENTAL AND LAND-USE EVOLUTION IN THE SYRIAN EUPHRATES VALLEY DURING THE NEOLITHIC AND CHALCOLITHIC PERIODS

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Introduction:

Humans were at a very early stage attracted to the Syrian part of the Euphrates basin, a powerfully flowing allogeous river. From the pre-pottery Neolithic⁽¹⁾ onwards, permanent habitation sites appear, related to the presence of perennial water. But the density of the occupation sites as well as the conditions of soil use, the limitations to which man had to adapt, often changed according to cycles, which have deeply affected the recent geological history of the valley. These often recurring modifications were diverse in nature: covering by alluvial sediments or on the contrary, reincision of the talweg, climatic oscillations, historical recompositions or impacts of human intervention. These different factors were often tightly interwoven. It is difficult to detect causal relationships and to measure their influence, as this certainly varied strongly, as much in space⁽²⁾ as in time. The instability of the environmental constraints required adaptation; different strategies must have been invented to insure the continuity of occupation and development. This appears very clearly in the case of the Neolithic and the Chalcolithic, periods during which the Euphrates valley was profoundly changed.

The Euphrates in Syria: the river-basin and the valley:

In all transitional regions between the Mediterranean zone and the Arabian desert, the conditions of human occupation remain highly dependent on the bioclimatic environment. Taking into account the extension of the basin slope of the Euphrates, even only within Syria, it is obvious that there are considerable variations in climate; mean

annual precipitation is more than 330 mm upriver (Jerablus), less than 140 mm downriver (Abu Kemal). However, the quantity of rain, highly variable from one year to another, remains everywhere below the potential evapotranspiration (ETP). This bioclimatic diversity prevents us from defining an unbroken sequence of human occupation. We shall take as an example here the region between Deir ez-Zor and Abu Kemal, climatically homogenous and very arid.

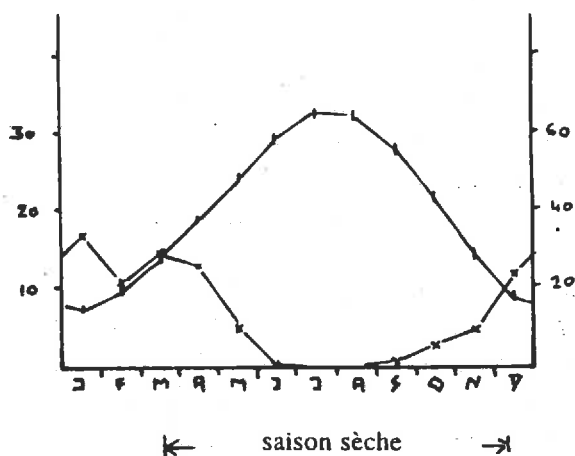
a- Climatic aridity:

In this sector, the mean annual precipitation varies between 159 mm (Deir ez-Zor) and 133 mm (Abu Kemal),⁽³⁾ while the potential evapotranspiration is evaluated at 1800 mm.⁽⁴⁾ The moisture deficit is thus considerable, so much so that the precipitation is affected by an annual variability of almost 50 %. Thus the biologically dry season lasts for 9 or 10 months (fig. 1) during

Fig. 1: Ombrothermical diagrams of the climatological measuring stations of Deir ez-Zor and Abou Kémal (based on M. Alex 1985).

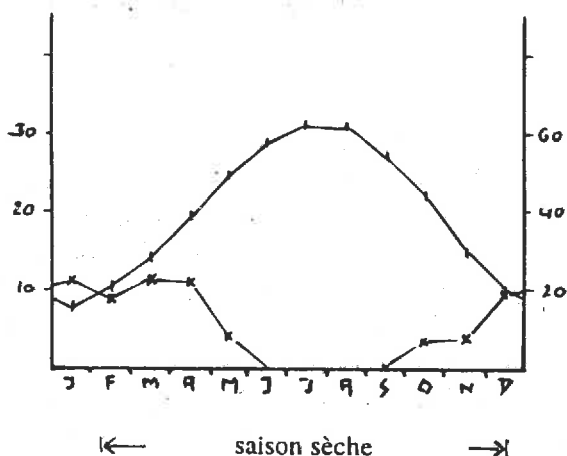
Deir ez-Zor (203 m)

T moy.an. 19,9° P moy. an. 155 mm



Abou Kémal (182 m)

T moy.an. 20,0° P moy. an. 123 mm



which high temperatures combine with little or no rain from April to November. In winter rainfall is short and intense, and infrequent. It follows that, in spite of a generally flat topography, pluvial run-off is extensive. Infiltration is thus very limited, which means that useful reserves are not retained in the soil. These violent run-offs lead to flash floods in the wadi beds, which cause considerable erosion.

The soils, which absorb only rainwater, are affected by a humidity system which may be termed arid, and by an extremely arid temperature system (Van Vambeke 1985, cited by Boerma 1989-90). Their rate of humidity is practically zero for nine months of the year; they are only partially saturated during the other three months. Subject to such limitations, the natural vegetation is particularly fragile and crops can rarely be grown without irrigation. Thus there is a contrast between the valley floor and the surrounding plateaus.

b- The adjacent plateaus:

On both sides of the wide alluvial corridor (fig. 2) in which water is always accessible in one way or another, the plateaus of the left and right banks present a topography barely marked by shallow valleys and more or less closed depressions.

Certainly the plant associations which develop on these relatively high⁽⁵⁾ surfaces have all the characteristics of desert steppe vegetation (Boerma 1989-90), being open formations which offered less cover, as they were highly degraded by exploitation of woody species and by grazing. The natural potential is relatively weak, as the soils are little evolved (entisoils) and often gypseous (gypsiorthyds) (Boerma 1979-80). They have suffered from erosion (wind and water) leading to the creation of a superficial *reg*. Below, the plateau is crowned on the right bank by a compact, very hard calcite crust, and on the left bank by a gypseous crust. In both cases, this type of superficial substratum, eventually cleared, is another limitation because it aggravates the edaphic aridity by limiting the depth and permeability of the soils.

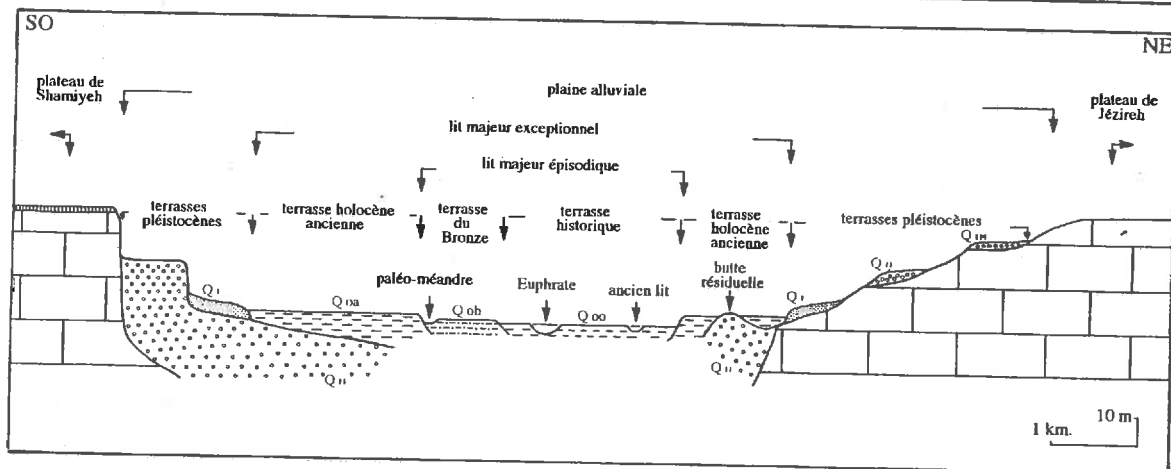


Fig. 2: Schematic section of the Euphrates Valley

The territories affected by this phenomenon, which represent nearly 80 % of the surface of the plateaus of Shamiyah and Djezireh, are really unsuitable for cultivation, even with irrigation. Only the depressions, closed or semi-closed, are usable, as they are slightly concave at the surface of the two plateaus. Fine colluvial particles collect in these depressions. Run-off water also finished here. Thus these depressions offer thicker soils, with a water retention capacity which is relatively high. These are then the only areas on the plateaus which have real agronomic potential. Normally precipitation is insufficient to guarantee regular crops, but these are possible in "good years". In the past, it is possible that when a pluviometric system was more favorable, somewhat more systematic sowing could have taken place.

This situation may also have occurred in the wadi valleys which join the Euphrates. The wadi beds offer alluvial soils, certainly little evolved but much deeper than those of the plateau. They are, importantly, relatively poor in gypsum as they are well washed and drained. Their agronomic potential is not negligible, all the more so as the roof of the water table is not far from the surface and even exceeds it at times, at least when the season is humid. However, it should be remembered that in autumn and spring violent floods can rush through the *tahwegs*. The circulation of water in the water table, in a downstream direction, has the virtue of limiting salt concentration but brings on a rapid lowering of

the level of the underflow when supply from upstream runs dry. Man did seek to overcome this problem; on some of these wadis, he erected dams in order to block the flow of flood waters and keep them infiltrating into the alluvium, thus lengthening the growing time for cultivated plants (Calvet and Geyer 1992). We shall see below that, in the Neolithic, particular conditions led to a development of the sections downstream from these wadis without special constructions being necessary.

c- The valley of the Euphrates: advantages and limitations:

The contact between the plateau and the river plain often consists of a series of terraces, successively fashioned by the Euphrates during the Quaternary and formed from accumulation or erosion. In other sectors, the levels of terraces are replaced by a single glacis. In any case these edges are hardly favorable to agricultural use by dry farming. Only on the most recent terrace (Q₁, which corresponds to the last morphodynamic pleistocene phase)⁽⁶⁾, or more generally on the gentle slopes at the bottom of the main slope, was agricultural development possible, though in general with irrigation.

The alluvial plain (fig. 2) presents very different problems. Its bed is made up of alluvial sediments laid down after the end of the last pluvial. While the successive Pleistocene cycles left preserved ranges of terraces along the edges of the Shamiyah

and the Djézireh, the alluvial floor dates from the Holocene, except for the low mounds, numerous but small, consisting of "Rissian" pebbles (QII).⁽⁷⁾ These just barely emerge from the alluvial floor (Qoa) which occupies most of the wide fluvial corridor and which was shaped during the lower Holocene; in fact no site earlier than pottery Neolithic is to be found. Consisting mainly of fine sediments (silt), this formation probably took place at about 10,000 BP, certainly for climatic reasons (Geyer and Sanlaville 1991). The occupation of this vast ancient Holocene plain did not become permanent, nor even seasonal (see below), until after it was cut again by the bed of the Euphrates. We attribute this to a relatively humid climate between 7,600 and 6,000 BP (Sanlaville, 1981), which modified the direction of the fluvial morphodynamic. This tendency for linear erosion appears contemporary to the beginning of the Ubaid period (end of the 6th millennium) or something earlier (Halaf period?). It could have occurred a little earlier in the valleys of the tributary wadis (7th millennium? on the Wadi Menbij, cf. Geyer and Sanlaville 1991). Afterward, that is around the end of the Bronze Age, a new reversal of the tendency occurred.⁽⁸⁾ This resulted in a second filling in (Qob), much less voluminous than the preceding one as it remains interlocked with it from 0.5 to 1 m. The deposits of the Qob are essentially sandy-silty to silty-clayey. Observations made in the Syrian Euphrates valley at Jurdi esh-Sharqi (Geyer and Sanlaville 1991) and Emar-Meskene (Geyer 1990), on the Iraqi Euphrates (Geyer 1992) as well as at Wadi Manbij (Geyer and Sanlaville, 1991) and on the Syrian coast (Sanlaville *et al.* 1995) have led to the dating of this formation; it corresponds to the end of the middle Bronze Age or to the late Bronze Age.

Since then, several similar cycles, though less effective, have also made their mark on the evolution of the valley floor.

It may be concluded that human occupation had to adapt to numerous modifications of the environment. During the filling-in phases, episodes of submersion during high water multiplied the risks: seasonal submersion within the limits of the

floor during its raising, temporary but doubtless frequent submersion on the level immediately above. The occupation of these spaces and the working of the land were very uncertain from January to May, a period during which the river, because of its pluvio-nival system, was at its highest level. On the other hand, during the periods when the Euphrates recut its bed, the risk was less great though still present; the occurrence and extension of flooding were in any case notably reduced on the Qoa surface.

A more insidious and permanent constraint had a strong influence on the occupation of the valley: the high saline level of water in the water table situated in the sediments, which carpet the alluvial floor. This renders the water unusable for consumption or for irrigation. This meant above all that the river was the only source of suitable water throughout the year. It was therefore vital to settle near the river to be able to take advantage of its water for domestic use as well as for irrigation. At the same time it was necessary to be cautious, as during flooding the waters were more destructive the closer one was to the riverbed. These are then the two apparently contradictory requirements, which dictated the way in which the Euphrates valley was occupied.

The first phases of occupation:

a- The Neolithic: occupation on the edges of the valley:

During the first sedentary settlements, whether at Mureybet and Abu Hureyra or farther downriver, the Qoa formation was in the process of being created. The river flowed in a system of interlacing channels, constantly changing, and not in a single bed with bending meanders as we know it today (fig. 3). The valley floor was not then the site of stable occupation of a sedentary type, because of the frequent risk of changing waters and of submersion. Occupation could only occur on the edge of the alluvial floor, for example on one or another of the Pleistocene terraces, which provide relatively flat spaces, salubrious on account of the soil having a generally large grain size. The most developed formation, on which were founded,

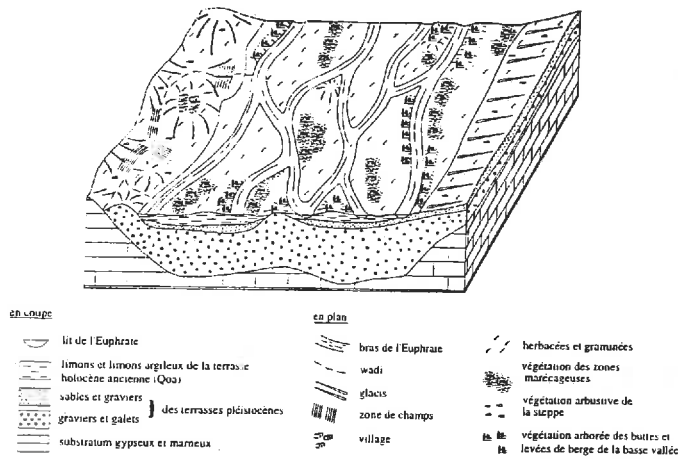


Fig. 3: Schematic reconstruction of the environment of the Euphrates valley in Neolithic times (P.P.N.B).

among others, the settlements of Bouqras and Tell es-Sinn, is that of Q_{II} (fig.5). This makes up also the base of scattered mounds, which emerge, today from the Holocene floor. However these mounds, certainly beyond the reach of the water, were hardly occupied from this period onward as they were too often isolated by flooding. Bouqras and Tell es-Sinn are thus located on the edge of the Holocene floor, as close as possible to the only useful water source but safe from flooding. On both sites a tributary wadi, of average size, flows into the river near the site. This leads us to question the role of side wadis could in the agricultural economy. We know thanks to excavation (Akkermans *et al.* 1981 for Bouqras, Roodenberg 1979-80 for Tell es-Sinn) that subsistence was based on herding, hunting and gathering, and only secondarily or partially on agriculture. The activities of herding, hunting and gathering were suited to a region with complementary potential: on one hand the steppe of herbaceous plants⁽⁹⁾, already affected by aridity but richer than today, which covered the plateau and the Quaternary terraces, and on the other hand the gallery forests related to the river, dominated by poplars, willows and tamarisks (Boerma 1979-80). The possibility of an agricultural economy, incipient as it was, raised more problems because of the already arid climate. However we see unirrigated crops occurring regularly even today.

Thus two possibilities for subsistence present themselves:

First are simply the post-flood crops. These are planted on the wide stretches of silt, freed of flood water during the first two weeks of June, offering "a strong probability of success" (D'hont, 1994). The sowing being late, the crops consist of summer cereals, legumes and various *cucurbitaceae*.

The second process, with more uncertain results, concerns dry cultivation, essentially of cereals. These crops are attempted either in the closed (or semi-closed) depressions of the plateau, or downstream from certain fans or glacis upon which there is a diffuse rainwater flow, or on the floor of terminal sections of certain tributary wadis. With mean annual precipitation between 130 and 160 mm and a rate of annual variability of about 50 %, only in the "good years" (during which the rains are more abundant and occur at the right time) will there be a harvest. It should be pointed out here that the maximum precipitation in spring, though secondary (fig. 1), counts for little unless the rains of autumn and winter are sufficient to ensure germination.

Thus, dry cultivation is not impossible, but remains uncertain, and post-flood cultivation is always possible but concerns only summer crops.

What could have been the situation at the time of the Neolithic villages of Bouqras and Tell es Sinn?

The occurrence of post-flood cultivation deserves consideration. With a river circulation in interlacing channels, the drop in flow liberates large areas of suitable moisturized silt. But we cannot hope to determine the extent of the spaces made usable. In fact, the topography as it exists today, with its levees and depressions, no longer corresponds to that which existed in the Neolithic; between 0,5 and 1 m of silt overflow now mask the earlier relief, besides the later human activities which have changed it. It is obvious that, if the type of farming is still practiced today, technically simple

as it is, it could also have occurred in the Neolithic. The possibility of dry cereal farming, outside flood zones and in winter, is questionable. Remains of cultivated cereals have been recovered at Bouqras (Akkermans *et al.*, 1981) as well as at Tell es-Sinn (van Zeist 1979-80). An obvious hypothesis is that the climate was somewhat more humid than today; in this case purely rain-fed crops would have been less uncertain, particularly in the closed depressions of the plateau or on the low slopes of the glaci-fans subject to diffused run-off. But it is perhaps on the bottom of the tributary wadis that the situation would have been more favorable than today. J. Boerma (1979-80, p. 65) observes correctly that "the soils of the wadi bottoms may provide, at irregular times, a quantity of water available to plants sufficient to practice rained arable farming". The edaphic conditions for agriculture were then necessarily more favorable than today, as in a somewhat more humid climate, favoring a more protective plant cover, run-off water would have flowed less quickly, ground water at the wadi bottom would then have accumulated better and for a longer time (particularly in spring). Above all, the high flood waters, which occupied the floor of the main valley almost until the beginning of the summer, slowed the draining of these small ground water deposits in the *talwegs* of the tributaries. The latter benefited in their end segments from edaphic humidity, which unfortunately they no longer have today.

At the end of the Neolithic and in the Chalcolithic (a careful appropriation of the alluvial floor):

The conditions of land occupation were profoundly changed by the evolution of the morphodynamic activity of the river (fig. 4). From the beginning of the Ubaid period, possibly already during the Halaf period, the river began cutting the valley floor more intensively, all the effects of this being developed in the Uruk period. This change is reflected gradually in the choice of protohistoric settlement sites (fig. 5). Baghouz, of the Samarra period (Du Mesnil du Buisson, 1948) as well as es-Susa 3, of the Ubaid period (dates given by J.-Y. Monchambert), do not yet differ in regard to their

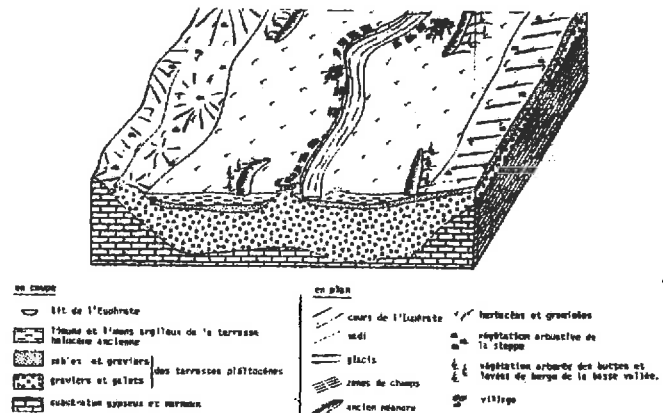


Fig. 4: Schematic reconstruction of the environment during the Chalcolithic period.

location from PPNB sites. In the Ubaid period itself we have only a single site situated at the edge of the river, on the valley floor: that of Tell Graiye (Kelly Buccellati, pers. comm.). This is then clearly a transition phase. During the Uruk period, all the sites known to us in this region are situated immediately next to the Euphrates, which flowed only along one bed. The latter is marked by bending meanders, except where resistant outcrops, consisting of Q_{II} pebbles, prove unassailable - this is true, for example, of Tell Graiye and Tell Ramadi, where the river is literally channeled (Geyer and Monchambert, 1987). The outcrops of these ancient "Rissian" deposits, of which the grain size resists the erosive ability of the Holocene river (and which are sometimes cemented), are quite frequent and play an important role in the evolution of the valley floor during the Holocene. In fact, during the change in the dynamics of the Euphrates discussed above, and from the beginning of the cutting of the Qoa formation, it is these hard areas of resistance, being quite numerous, which when near, have fixed the course of the river. Trapped by these unyielding outcrops, the river could only continue to modify its course in the intervals between, according to the dynamics of free meanders: exaggeration of curves, recutting, creation of crescent lakes, etc. The establishment of sites (Tell Graiye, Tell Ramadi...) on these resistant areas was certainly not accidental. The river being the only water source, it was necessary to be near it but also necessary to avoid its excesses: the violence of exceptional flooding,

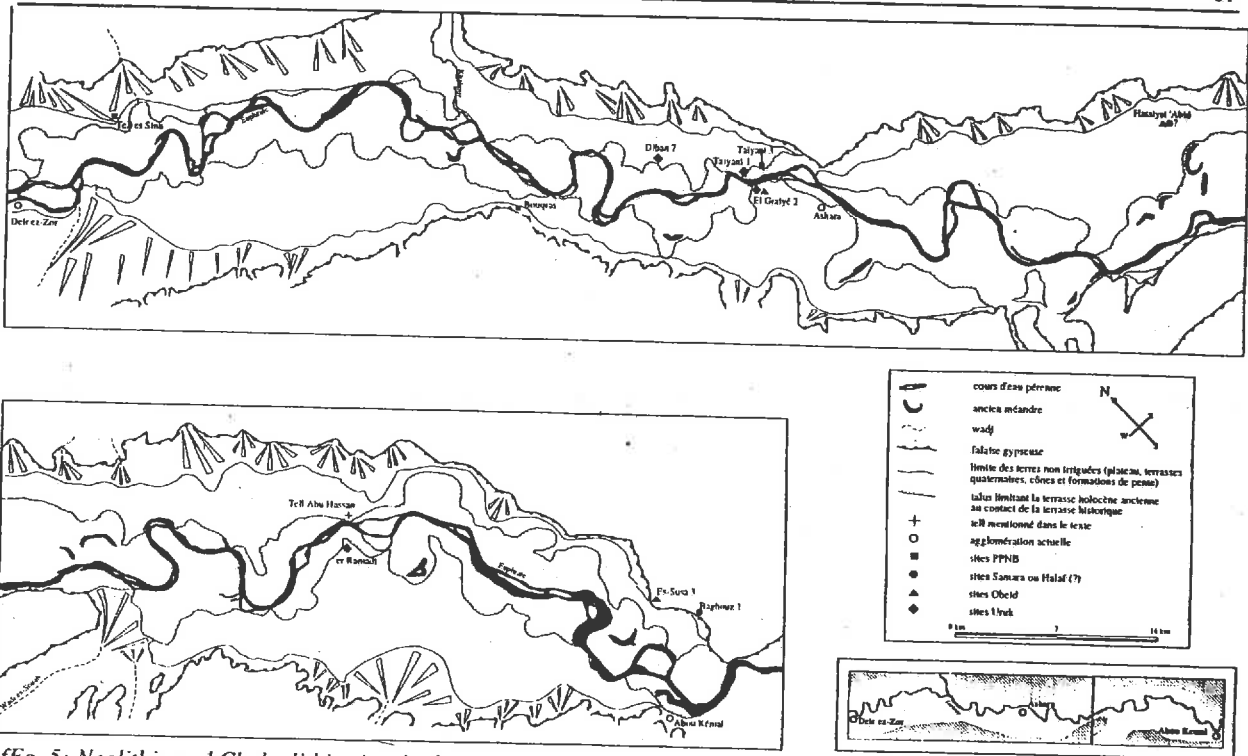


Fig. 5: Neolithic and Chalcolithic sites in the middle Euphrates valley.

the destructions caused by its changing course. The normal flow was contained in the cutting of the Qoa formation, but as this was recent and still little developed, it was insufficient to contain the powerful floods which occurred regularly. Furthermore, the destructive effects of these floods were maximum at the height of the banks of the meanwater channel, on the edge of the cutting where settlement was desirable. This major though infrequent risk was to be added to the permanent one related to the lateral undermining of the banks of the meanwater channel on account of the normal shifting of the meanders. Thus the only reliable locations were these mounds, consisting of a relatively resistant material. As for the development of the alluvial plain, it seems that this was made healthier by the improvement of drainage, thanks to the tapping effect created by the recut bed of the Euphrates. The spaces occupied by the Qoa terrace were thus continually cultivable. The land near the river could benefit from indispensable irrigation and reach its high fertility potential. Inversely, the low valleys of the tributary wadis ceased to offer productive land, because of the rapid exhaustion of their water tables. Finally floodwater cultivation

noticeably decreased, as it was confined to the meander belt, marshy in parts.

Conclusion:

The region was subject to fundamental change during the period from the Neolithic to the Chalcolithic. In the Neolithic, humans settled on the edges of a valley, which was inhospitable, at least seasonally. But the very particular conditions of the environment did allow, though only in limited areas, an agriculture which does not need artificial irrigation in spite of the arid climate. In the Chalcolithic, the environmental conditions changed. The alluvial floor became permanently accessible in spite of certain recurrent risks. But agricultural development of the land became much more directly dependent on irrigation, which then became a necessity in this region.

It is necessary to stress that the establishment of sites and the conditions of agricultural development in this basically arid region were not only in response to changes in the nature of the climate, but to the dynamic behavior of the Euphrates, which itself had been subjected to modifications.

Notes:

1. For example at Mureybet and Abu Hureyra, where levels dating to the 2nd half of the 9th millennium were discovered.
2. The basin-slope of the Euphrates is 350,000 km² (70,000 km² in Syria); its course 2350 km (602 km in Syria) in length.
3. Unless otherwise indicated, the climatic data is taken from Traboulsi 1991.
4. From Boerma 1989-90. This figure seems underestimated.
5. The difference in level from the valley floor is almost 40 m, which excludes all traditional irrigation, other than motorized.
6. It could correspond to the isotopic stages 2 to 4.
7. It could correspond to the isotopic stages 8 to 10.
8. In fact, the beginnings of this fill perhaps occurred in a somewhat earlier period as, on the Syrian coast, beach formations and a alluvial terrace are evidence of a phase of degradation corresponding to the second half of the 5th and the beginning of the 4th millennia (Sanlaville *et al.* 1995).
9. According to Boerma 1989-90, this is a steppe with *Helianthemum*, *Heliotropum*, *Plantago*, *Astragalus*, *Arnebia* and *Trigonella*; locally, in favored zones, open formations of pistachio should grow.

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