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Fluvial environmental contexts for archaeological sites in the Upper Khabur basin (northeastern Syria)

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Abstract

Today the eastern tributaries of the Upper Khabur run dry during the summer and the landscape is devoid of trees. This picture is misleading when we try to understand archaeological sites within their former environmental context. Interdisciplinary geomorphological, archaeobotanical and ostracod research on a sequence from the Wadi Jaghjagh indicates that relatively stable, perennial flow velocities occurred during the mid 4th to mid-3rd millennium BC. Evidence was found for a gallery forest and swamp belt along the Jaghjagh during the mid-4th millennium BC. Oak park woodland was present within the region in the 3rd millennium BC and probably up to at least the 3rd century AD. Shortly after 2500 BC, Jaghjagh stream velocities probably decreased or the stream bed had changed its location. Later deposits, possibly dating to the 5th century BC, indicate similar, rather stable flow of the Jaghjagh. More recently however, about ca. AD 900 or afterwards, a flashflood-like regime occurred, which may relate to deforestation. The Wadi Khanzir sediment archives reflect the flashy intermittent regime of this stream, like it still is today, with flashflood evidence dating to the first half of the Holocene and probably dating to approximately AD 400 or later. Along the Jarrah, topsoil was eroded and redeposited by the wadi sometime between 1300 and 600 BC. This may have been caused by the intensive resettlement program of this region around 800 BC. Between about 600 and 300 BC 1.5 m of clay was deposited on the plain.

Keywords: Fluvial geomorphology; Syria; Botanical remains; Ostracods; Geoarchaeology; Upper Khabur; Jaghjagh; Khanzir; Jarrah

Introduction

A fluvial geomorphological field survey was undertaken in the Upper Khabur basin of northeastern Syria to gain understanding in fluvial and environmental setting of archaeological sites (Fig. 1). The project focuses on several north–south flowing tributaries of the Wadi-el Radd, which has its mouth in the Khabur. The Khabur is an important tributary of the Euphrates. During the late Quaternary, the Jebel Sinjar experienced uplift, causing the Wadi-el Radd zone to subside. This uplift might have blocked the south-flowing streams and diverted them westward to the Jaghjagh and the Euphrates (Kolars and Mitchell, 1991). Although the Jaghjagh would be a perennial stream in the absence of damming and irrigation, it presently runs dry during the summer from Qamishli onwards. The Jarrah and Khanzir only flow during the height of the rainy season. Evaporation in the Wadi-el Radd is so great that only in times of flood does water find its way in any quantity west to the Khabur (Kolars and Mitchell, 1991).

Summers in the area are very hot and dry, while all rain falls between October and April when snowfall also can be expected. Rainfall varies from more than 450 mm in the north to 250 mm in the south. Today, the northern part of this area is intensively used for grain cultivation, whereas the southern part is more steppe-like. Hardly any trees grow today within the area, although Hillman (in Moore et al., 2000; Fig. 3.7) reconstructed the area to form a deciduous oak park woodland under modern climatic conditions in the absence of deforestation, grazing and cultivation. Because of the rather dry climate streams, wadis (dry water courses) played an important role for human societies within this area and many archaeological sites—often tells (settlement mounds)—are located along them. Therefore, gaining insight into the fluvial history will deliver information on the location of former stream courses and their relation to

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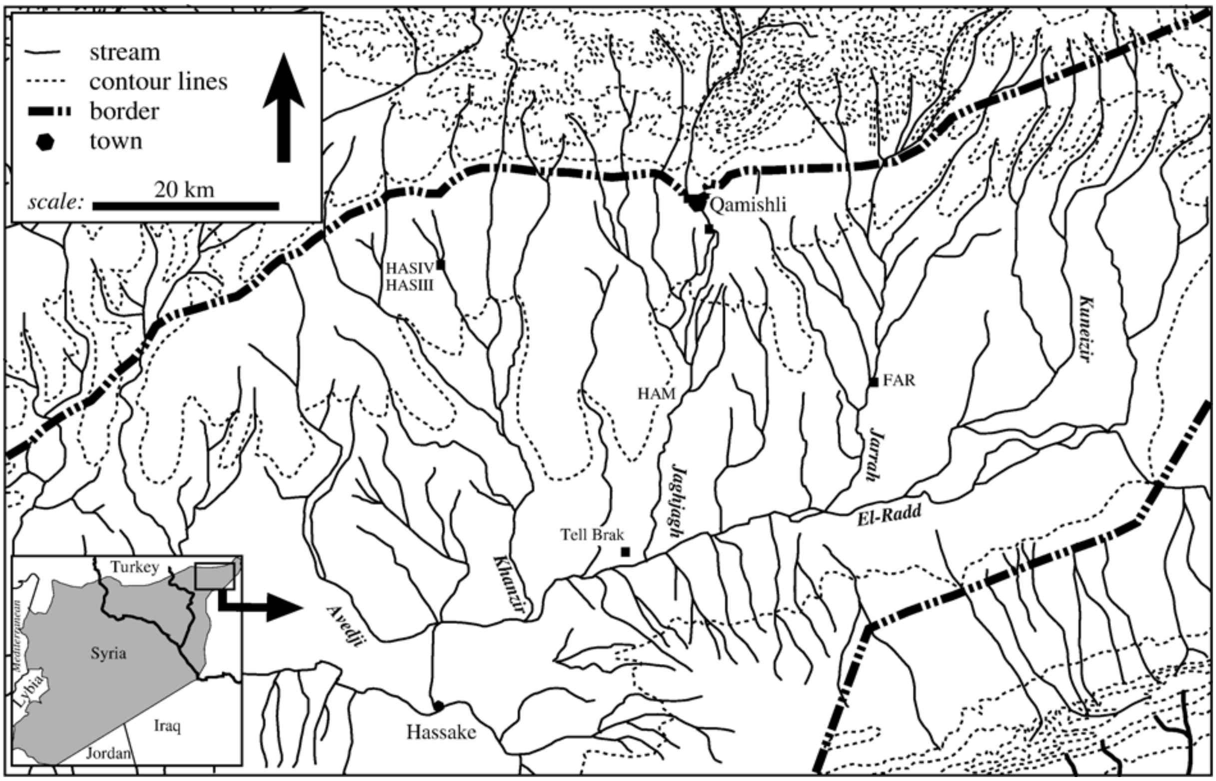

Figure 1. Map of the Upper Khabur Basin showing the sequences. Contour interval 100 m.

archaeological sites, on stream regimes with implications for site setting and subsistence economy, on the palaeoclimate which had implications for the subsistence economy and general settlement history, and on the impact of former societies on the landscape through, e.g., irrigation, deforestation and erosion. The regions settlement history is relatively well known from intensive archaeological survey and excavation (e.g., Meijer, 1986; Wilkinson and Tucker, 1995; Lyonnet, 1996, 1997, 1998, 2000; Wilkinson, 2000b, 2002; Wilkinson and Barbanes, 2000). Several geoarchaeological field projects also have been initiated within this area (e.g., Courty, 1994; Rösner, 1995; Wilkinson, 2000a, 2002; Besonen and Cremaschi, 2002; French, 2003). A chronological understanding of the regional landscape evolution still needs much refinement to correlate the better known settlement history of this region with the fluvial history. Within this article several well-dated fluvial sequences will be discussed together with their incorporated botanical, ostracod and mollusc remains, making it possible to understand the riverine environmental history with relevance for archaeological sites. Up to now, the region has not been well covered by conventional lake, palynological, and other types of proxy records.

Methodology

During the summer of 2002, about 70 fluvial exposures were studied in the field and about 500 sediment samples and 72 sherds were exported for laboratory analysis. In order to gain preliminary insight into the fluvial chronology, sherds were collected from fluvial deposits where present. They were unfortunately mostly typologically undatable, making it necessary to apply thermoluminescence (TL) screening to gain approximate ages of the sherds, which was undertaken in the course of 2003 (see Deckers et al., 2005). The TL screening approach deviates from standard TL dating in several aspects. The most important difference is that rather than measuring dose rates, an estimated rate of 3 mGy/yr is used. This value was obtained by averaging dose rates measured in 157 HF-treated quartz samples from 3 widely separate locations and calculating for additional dose rates, since polymineral samples are used. The regeneration method, used here in simplified form, can sometimes introduce further problems related to sensitivity changes. A further difference of the method is the lack of any supralinearity assessment, fading, and additional uncertainties in dose rate due to the possible presence of low concentrations of zircon grains in some polymineral samples (Deckers et al., 2005). Therefore, in addition to the standard error an additional 25% uncertainty was adopted to calculate the overall error on the ages. Based on these TL screening results on sherds, some areas were selected for further geomorphological and chronological study during the summer of 2003. The locations that were chosen exposed sediments older than ca. AD 1500, thus including sequences that contain older sherds and/or stronger developed soils. The chronology of sequences with recent off-site sherds is better known than those with old sherds. Therefore, our objective was to gain a better insight into the age of the older sediments.

Further insight into the fluvial chronology has been obtained through eight Single Aliquot Regenerative (SAR) Optically Stimulated Luminescence (OSL) dates on sediments. Moreover, several radiocarbon dates were obtained: two on in situ organic material, one on humic acid, two on snails from in situ snail layers and one on charcoal flecks, the provenience of which was questionable. The dates have been calibrated with the online calibration program CALPAL.

At two locations, in situ botanical material was found and identified. Near Tell Hamidi, a water-saturated in situ organic-rich layer, unique for the Near East, has been found 4 m under the present plain, intercalated with fluvial deposits. Flotation was performed on sediment from this layer and the botanical and ostracod remains identified. Near Abu Dhuwil a charcoal layer overlain by fluvial deposits was found from which the fragments have been identified and dated. Additionally, in situ snails and mollusks were found and identified in several fluvial deposits. Moreover, several georeferenced Corona satellite images were analyzed in order to gain further insight into the fluvial evolution in the neighborhood of the studied sequences. Declassified Corona satellite images from the 1960's contain important information on former river courses, presently inactive streams, and archaeological sites, which sometimes are not easily visible in the field.

Descriptions of the sequences

Sections from the Wadi Jaghjagh

The river evolution of the Wadi Jaghjagh was studied in detail at several sections exposed by modern river incision. Four of them will be discussed in detail below.

About 2 km south of Qamishli (37°0′58.9"N, 41°15′19.3"E), section QAM2 was investigated (Fig. 1) that contained several gravel layers alternating with fine-grained deposits (Fig. 2 and Table 2). The larger exposure contains Jaghjagh paleochannel gravel deposits, which correlate with units 1, 2, 3, 4, 5 and 6 of section QAM2. Clayey sand unit 3 and gravel units 6 and 8 contain dozens of *Melanopsis* spec. (probably *buccinoidea*) snails. *Melanopsis buccinoidea* occurs in a wide variety of freshwater habitats. Usually, it occupies gravel, sometimes also silty mud (Heller et al., 1999; 49). They probably died en masse after a flood when they were subsequently buried by the overlying fine-grained deposits. The shells from gravel units 3 and 6 were dated at 2380±30 ^{14}C yr BP (KIA24910) and 2325±25 ^{14}C yr BP (KIA24909), respectively. However, these dates should be considered as maximum dates because the snails might have taken up older carbon from dissolved chalk (Wagner, 1995; 98). Overlying the gravel channel is a fine-grained channel deposit with clayey overbank deposits in QAM2 (Fig. 2 and Table 2).

About 400 m north of QAM2, at 37°1′13.4"N, 41°15′5.5"E, another exposed section (QAM) was studied (Figs. 1 and 3; Table 2). Here, coarse gravel channel deposits, post-dating 1.1±0.4 ka (TL screened sherd), have been found at 1.8 to 0.6 m below the plain. The massive, poorly sorted gravels contain a relatively large amount of organic matter, suggesting that these layers were deposited by flashfloods that washed off organic-rich topsoil. The great number of snails within these gravel units also suggests that the snails were buried after the flood. Soil formation on the present-day surface is weakly developed (only A-horizon formation) and suggests that the sediments have been deposited relatively recently or have been eroded. Currently, the river is incising.

8.5 km south from QAM2 along the Wadi Jaghjagh (36°57′ 24.5"N, 41°11′34.4"E), a naturally exposed section ABO near Abu Dhuwil was studied (Figs. 1 and 4 and Table 2). The section (Fig. 4) was exposed through the present-day Jaghjagh 150 m southeast from Tell Abu Dhuwil, an Early Bronze Age

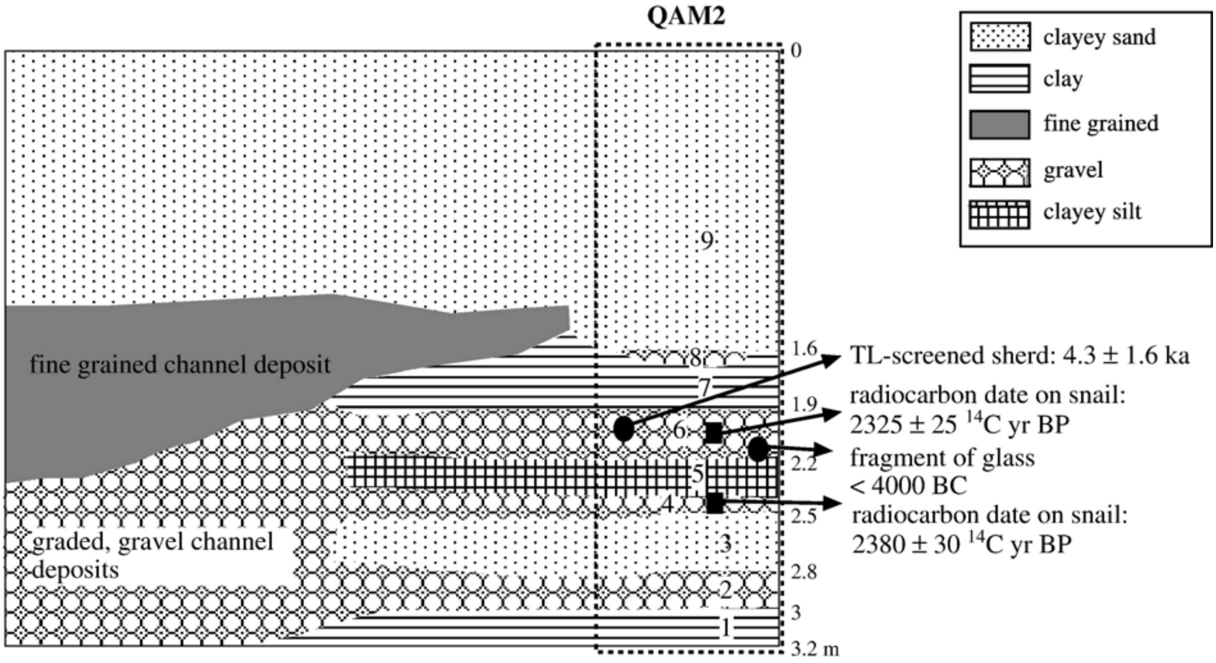

Figure 2. Section QAM2 along the Wadi Jaghjagh.

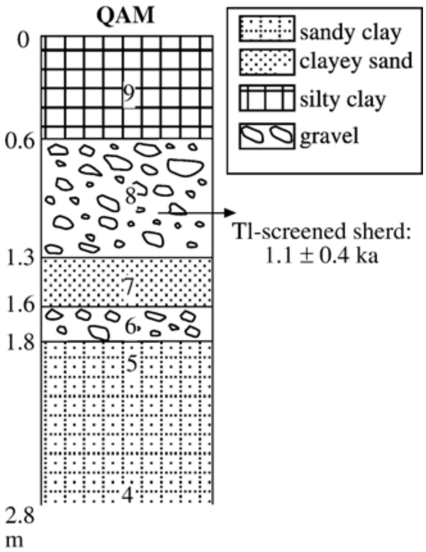

Figure 3. Section QAM along the Wadi Jaghjagh.

and Byzantine period settlement mound (Meijer, 1986; 21). Here, medium-sized fluvial sand was superposed by an in situ charcoal-rich layer from which one fragment has been radiocarbon dated at 1780±30 ^{14}C yr BP (AD 244±62). Forty-four fragments have been identified, all of which are deciduous *Quercus* (oak). Overlying the charcoal-rich layer is 1.7 m of clayey sand that contains a significant amount of fine charcoal. Within this layer a sheep and dog bone were found about 1 m below the present surface and a snail ca. 0.8 m below the surface. Based on observations and sediment analysis, soil formation has occurred. An A-horizon has formed, indicated by the higher organic matter content and a magnetic susceptibility enhancement typical for A-horizons. Moreover, some incipient B-horizon formation probably has occurred as well, indicated by the prismatic soil structure between 0.3 and 1.5 m and a slightly higher amount of $CaCO_3$ at about 1 m. The great amount of archaeological material in the fluvial sediments, and the proximity of the tell, suggest that this material has not been transported a long way.

A third area of interest along the Jaghjagh is near Tell Hamidi, a well-known excavated archaeological settlement mound with lower town located along the Wadi Jaghjagh (Wäfler, 1990, 2001) (Figs. 1 and 5 and Table 2). The investigated occupation levels span from the 2nd millennium BC to recent times. About 650 m north of the tell (Fig. 5a), just outside the town wall, two sections (HAMIII and HAMIV), naturally incised by the Wadi Jaghjagh were studied and three boreholes (HAMB1, HAMB2 and HAMB3) were taken to document the river deposition history. At a level of ca. 4 m below the plain in two of the cores, an in situ organic-rich and water-saturated layer overlying fluvial gravels was found and radiocarbon dated at 4665±25 ^{14}C yr BP (3449±49 cal BC) (Fig. 5b and Table 2). A small portion of this layer (HAM B3.12) was floated and the carpological, charcoal and ostracod remains identified. Additional samples below (HAM B3.14) and above the organic-rich layer were analyzed. Sample number HAMB3.14 was taken from ca. 4.45 m below the surface and consisted of silty sand with some organic material included. Sample number HAMB3.11 is from a clay layer and contained some ostracods but lacked identifiable plant remains. Table 1 shows all identified taxa and their environmental context.

Because these layers were waterlogged, carbonized and uncarbonized plant remains were preserved. Despite the small sample size, the concentration of botanical remains was considerably high. The carbonized remains most likely represent a deposition of crop processing by-product derived from Late Chalcolithic agricultural activities at Tell Hamidi. Most of the uncarbonized plant remains derive from natural habitats, mainly indicating fresh and moist conditions. Remains of water plants (e.g., chara) were found as well as vegetation typical of swamps, streamsides, muddy river banks and ditches (e.g., galingale). The single tree species that was discovered in the remains is willow (*Salix* sp.), which was represented by bud and wood remains. *Salix* probably grew along the river banks together with other hydrophilous species, such as dewberry. Other species of this genus belong to the blackberry group. Beside these, some ruderals (e.g., vervain) and probable crop weeds (e.g., purslane and common fumitory) were also found amongst the uncarbonized remains, reflecting the presence of open agriculturally used ground in the closer surroundings of the *Salix* stands. Further sampling would be necessary to quantify these results on the composition of the riverine flora.

Ostracods were collected from the 180-µm sieve residues and classified with the keys by Griffiths and Holmes (2000), van Morkhoven (1963), and Hartmann (1989). Due to small sample size, only single and sometimes fragmented valves of the ostracods were preserved. The inner sides of the valves were often encrusted with sediment, thus covering the muscle scars and complicating the identification.

Amongst the four different types identified, the most common belonged to *Ilyocypris* cf. *inermis* Kaufmann and *Candona* sp. One individual shell of *Ilyocypris* species was identified (cf. *Ilyocypris decipiens* Masi). A single valve of a probable *Cytheroidea* species was found in the uppermost sampled horizon. All these are freshwater taxa and are regularly

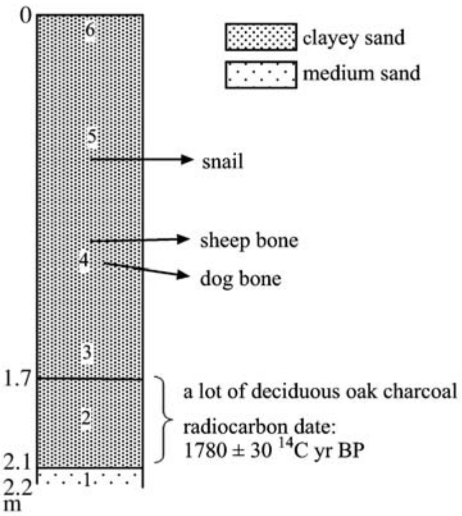

Figure 4. Section ABO along the Jaghjagh.

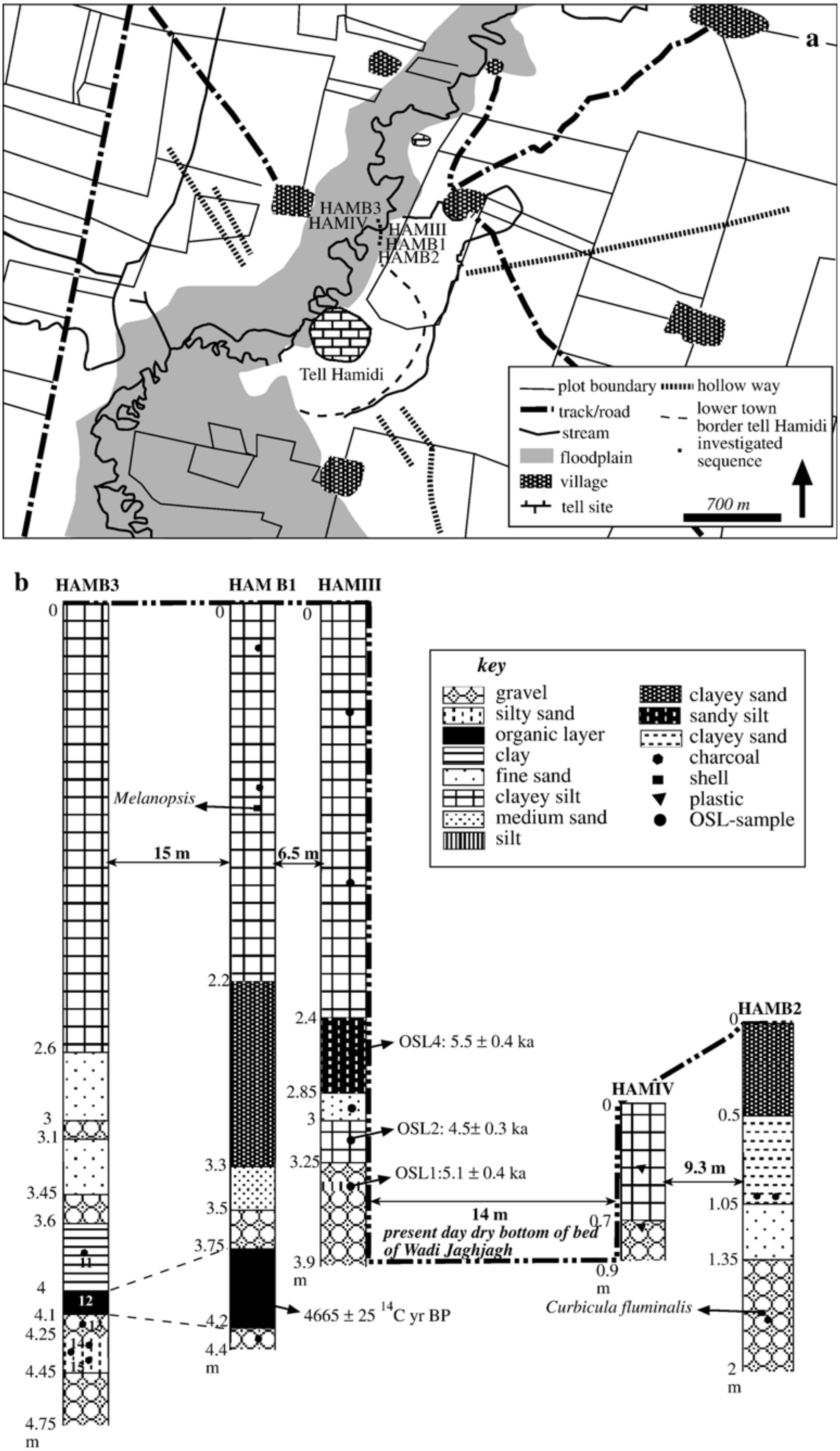

Figure 5. (a) Detailed location map of the Hamidi transect along the Wadi Jaghjagh based on georeferenced Corona satellite image D025–055 1105-1FWD, 5 Nov 68. (b) Hamidi transect along the Wadi Jaghjagh.

mentioned in Near Eastern ostracod studies (e.g., Altınsaçlı and Griffiths, 2002). *Ilyocypris* is predominantly found in freshwater (Martens and Ortal, 1999). Ecological characterization of *I. inermis* Kaufman is cold stenothermal (linked to permanently “cold” water) and mesorheophilic (frequently found in flowing waters with various velocities) (Meisch, 2000). *I. decipiens* Masi is ecologically characterized as probably polythermophilic (species found in “warm” waters) and rheoeuryplastic (found in both flowing and stagnant waters) (Meisch, 2000). In contrast to *I. inermis* Kaufman, it can tolerate slightly higher salinity degrees. Although tempting, at this stage of our research it is not possible to draw any conclusion on the development of the mentioned factors (i.e., depth, velocity, permanence of the waterbody, and paleosalinity) from the sampled sequence around 3450 BC. For this to happen, further sampling of ostracods and dating would be necessary.

The analyzed organic-rich layer corresponds to the level just below the exposed section HAMIII. Several SAR OSL dates have been obtained from section HAMIII that should be younger than the radiocarbon date. The date obtained for the silty unit at ca 3.5 m below the plain is 5.1±0.4 ka (GLL040101) and corresponds well with the radiocarbon date. The dated clayey silt at 3.15 m below the plain and above HAMIII OSL1 has been SAR OSL-dated at 4.5±0.3 ka (GLL040102). The sandy silt at ca. 2.6 m below the present plain, however, provided a slightly older date of 5.5±0.4 ka (GLL040106). The uncertainty value of the date suggests this date is still consistent with the other dates. The SAR OSL ages should be considered as maximum ages. Thus, the lower half of HAMB3, HAMB1 and HAMIII represent mid-4th to ca. mid-3rd millennium BC coarse grained deposits.

The clayey silt deposits of the upper 2 m of HAMB3, HAMB1 and HAMIII post-date 2500 BC and indicate a different fluvial environment. HAMIV, on the other bench of the present-day Jaghjagh, is a recent deposit as indicated by the plastic piece occurring in it. Within HAMB2 several *Corbicula fluminalis* shells were found. *Corbicula* shells can live both in fluvial sands and gravels in relatively high-energy environments, and in silts and muds in quieter habitats (Meijer and Preece, 2000; 243).

Table 1
Table with identified taxons from the waterlogged organic-rich sediments from the Hamidi transect with their habitat indicated

Taxon	HAM B3.11	HAM B3.12	HAM B3.14	Ecology
Ostracods				
Ilyocypris cf. *inermis* Kaufmann	1	6	1	Freshwater, rarely slightly brackish
Ilyocypris decipiens Masi		1		Predominantly in fresh waters
Candona spp.	1	2	3	Often associated with fine, organic-rich muds
Cyprididae	1			Mainly brackish to haline waters
Carbonized plant remains				
Centaurea sp.		1		Crop weed
Cyperus longus L.		1		Phragmites-swamps, river shore, muddy river shore, sea coast, ditches
Bromus sp. (long caryopsis)		1		Crop weed
Triticum dicoccum Schrank, glume base fragment		1	2	Crop
Triticum diccocum/monococcum, glume base fragment		1		Crop
Galium cf. *aparine*		1		Crop weed
Galium sp.		1	1	Crop weed
Vitis sp. (fragment)			1	Food plant
Salix sp., wood		5		Riverine woods
Uncarbonized plant remains				
Asteraceae		3		–
Heliotropium sp.		1	1	Disturbed habitats, ruderal and in fields
Chara sp., oopore		1		Freshwater lakes, stagnant but oligotroph waters (submerged)
Chara sp., oogonium		1	1	Freshwater lakes, stagnant but oligotroph waters (submerged)
Cyperus longus L.		2		Phragmites-swamps, river shore, muddy river shore, sea coast, ditches
Carex spp.		3		–
Euphorbia sp.		1		–
Cicer arietinum L.		1		Crop
Fumaria officinalis L.		1	1	Crop weed
Ajuga/Teucrium		1		–
Lamiaceae		1		–
Portulaca oleracea L.		1		Cultivated soil, desert places, waste places near sea-level
Rubus fruticosus L. agg.		4	3	Forests to open shrubs, and waste places
Rubus sp., thorns		3		–
Rubus caesius L.		2		Mainly by streams and rivers in sun or shade
Salix sp., bud		1	1	River banks
Verbena officinalis L.		1		Ruderal, disturbed places, rocky slopes, dry river beds, embankments, walls, sand dunes, wood, bushes

Section from the Wadi Jarrah

Section FAR, near Farsuk Kabir (Figs. 1 and 6) along the Wadi Jarrah, was exposed by the present-day Jarrah River (36°51′31”N, 41°28′50.9”E). It is located ca. 230 m southeast of the archaeological site Tell Farsuk Kabir where artifacts have been found dating from the 6th to 2nd millennium BC (Meijer, 1986; 15). At a depth of ca. 4 m below the present plain, a SAR OSL date on the 4- to 11-μm polymineral fraction from clayey silt sediment provided the age of 3.3 ±0.2 ka (GLL040103) (Fig. 6 and Table 2). A slightly higher fine-grained OSL sample on a polymineral fraction from clay (GLL040104) and TL screened sherd also provided similar dates. Between 3.55 and 3.70 m a redder color of 7.5YR/3/3 occurs, corresponding to a higher organic-matter content in sample 5 (Fig. 6) as established through loss-on-ignition and by spectrophotometry. It might represent an A-horizon of a paleosol, however, it more likely represents the remains of redeposited soil sediments because the boundary appears to be rather abrupt. Moreover, the date of 4791±38 ^{14}C yr BP (KIA24912) (3584±68 BC) on humic acids from this layer supports this as well. The OSL date on a fine-grained polymineral fraction of the clay just above this organic-richer layer is 2.6±0.4 ka (GLL040105). Between 2.6±0.4 ka and 2.3 ka±0.2 ka (GLL040107), 1.5 m of clay was deposited. A sherd TL screened to approximately 2.2±0.6 ka is consistent with this, considering the minimum uncertainty on this date. Moreover, incipient soil formation on the present-day surface indicates that some time has passed since the uppermost 1.7 m of silty clay sediments have been deposited. More precisely, an A-horizon developed and carbonate accumulation took place to a depth of ca. 50 cm. Soil formation studies within this area suggest that this degree of soil formation represents about 2000 yr of soil formation (Wilkinson, 1990). A borehole transect perpendicular to the wadi over ca. 50 m revealed similar fine-grained sequences.

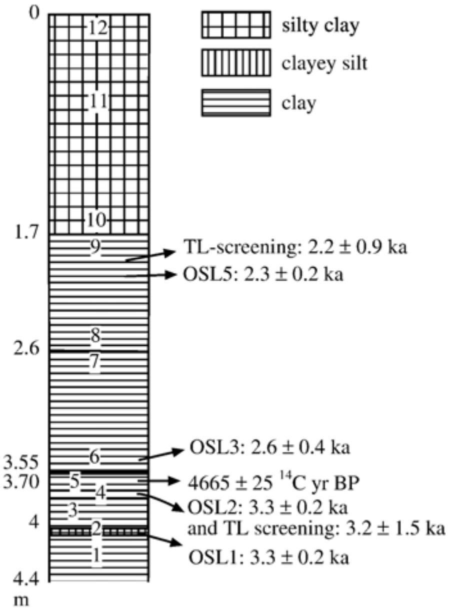

Figure 6. Section FAR along the Wadi Jarrah with sample numbers indicated.

Studied locations along the Wadi Khanzir

Tell Mozan is a major archaeological site in the piedmont area of northern Syria that has been excavated since 1984, with occupation levels from ca. 5000 to 1500 BC. Although it is often mentioned that Tell Mozan is not located along a wadi, analysis of the declassified Corona satellite image D025 055 1105-1 FWD (5 of November 1968) indicates that still in the 1960’s a tributary of the Wadi Khanzir had its course through the lower town of Mozan and the present-day village (Figs. 1 and 7). Today, this tributary is hardly visible across the landscape. The satellite images also suggest that before its location through the lower city of Mozan, the relict watercourse possibly went through the tell (Fig. 7). About one km southeast of the outer city a dentritic pattern of inactive paleochannels with archaeological tell sites along their course have been identified on the declassified satellite image, indicating that the area was well-watered in the past.

Just south of Tell Has at a distance of 6 m from the present-day Wadi Khanzir, a 3.8-m-deep waterpit, HASIV, was investigated (37°4′43.4”N, 40°50′33.5”E) (Figs. 1 and 8 and Table 2). At a depth between 3.8 and 3.6 m under the present plain, coarse-grained, poorly sorted gravel deposits consisting of limestones and related rocks from the Tur Abd Din represent the remains of an ancient streambed, tentatively SAR OSL-dated at 21.1 ±1.6 ka (GLL040108) (Fig. 8). Since this age estimate was obtained using only a single aliquot of quartz grains, its reliability is low. The presence of sherd-like artefacts within the gravel, also indicates that this date is too old. Above the gravel unit, a charcoal fleck from a clay overbank deposit was radiocarbon dated at 9377±44 ^{14}C yr BP (KIA24913) (8648±58 BC). It is unsure whether this fleck is in-situ or represents redeposited organic material. From about a depth of 3 to 0.9 m within the HASIV section, in-situ occupation levels were found, containing sherd-like artefacts. TL screening of these sherds yielded age estimates in the range of 6.5±1.7 to 4.6±1.2 ka (approximately 4500 to 2600 BC). Thus the flashflood deposits predate 4500 BC. The upper 0.9 m consists of fine-grained fluvial sediments that post-date the occupation deposits.

Just north of Tell Has along the Wadi Khanzir another section HASIII was exposed through bulldozing in the present-day river bed (37°4′49.2”N, 40°50′37.6”E) (Figs. 1 and 9; Table 2). Here, the remains of a former shallow, high-energy channel have been found between 2.3 and 1.55 m below the plain and post-date 1.6±0.5 ka. The channel was ca. 3 m wide and its fill consists of massive, poorly sorted gravel with clasts up to 20 cm in a clayey silt matrix. Sherds within the gravel were TL screened to the Late Chalcolithic and Early Bronze Age. In the clayey silt deposits a possibly Early Iron Age sherd occurred. The sherds probably derived from the tell nearby. After the flashflood, 1.55 m of fine-grained sediments were deposited. Some soil formation has occurred within these sediments, including A-horizon formation (a higher organic matter content of sample 7 and magnetic enhancement) and slight $CaCO_3$ accumulation at the height of

Table 2
Descriptions of sequences

HAMIII	
0–1.6 m	Clayey sand, color: 10YR/5/4, clasts: very few, rounded to sub-rounded, medium
Gravel lense	Gravel in clay matrix, color: 10YR/5/3, matrix supported, clasts: moderate, very small, rounded to sub-rounded, limestones and related rocks from Tur Abd Din hills
1.6–1.9 m	Clay, color: 10YR/5/4, clasts: moderate, very small, angular to sub-angular, matrix supported, $CaCO_3$ accumulation
1.9–2.2 m	Gravel in silty sand matrix, color: 10YR/6/3, clasts: abundant, rounded to sub-rounded, small, limestones and related rocks from Tur Abd Din hills, matrix supported, some grading, no imbrication, many *Melanopsis* snails, $CaCO_3$ accumulation
2.2–2.4 m	Clayey silt, color: 10YR/6/3, no clasts
2.4–2.5 m	Gravel in clayey sand matrix, color: 10YR/6/3, matrix supported, a lot of Melanopsis snails, clasts: abundant, rounded-sub-rounded-angular, medium to small, limestones and related rocks from Tur Abd Din hills
2.5–2.8 m	Clayey sand, color: 10YR/6/4, weak consistency, matrix supported, clasts: moderate, rounded–sub-rounded—angular, medium to small
2.8–3 m	Gravel in clayey sand matrix, no imbrication, clasts: abundant, sub-rounded to rounded, medium to small, limestones and related rocks from Tur Abd Din hills, $CaCO_3$ accumulation
3–3.2 m	Clay, color: 10YR/6/4, manganese flecks, $CaCO_3$ accumulation, no clasts
QAM	
0–0.6 m	Silty clay, color: 10YR/6/4, clasts: very few, very small
0.6–1.3 m	Gravel in silty sand matrix, color: 10YR/6/3, no grading, poorly sorted, no imbrication, clasts: large to small, sub-angular to sub-rounded, limestones and related rocks from Tur Abd Din hills
1.3–1.6 m	Clayey sand, color: 10YR/6/4, matrix supported, clasts: some, large, angular to sub-angular, $CaCO_3$ concretions
1.6–1.8 m	Gravel in clayey silt matrix, color: 10YR/6/4, clast supported, clasts: many, large to very small, angular to sub-rounded, limestones and related rocks from Tur Abd Din Hills
1.8–2.8 m	Sandy clay, color: 10YR/8/2, clasts: moderate, small to large, angular, manganese flecks, $CaCO_3$ accumulation
ABO	
0–1.7 m	Clayey sand, color: 10YR/6/3, clasts: few, large and rounded, limestones and related rocks from Tur Abd Din hills
1.7–2.1 m	Clayey sand, color: 2.5YR/3/2, no clasts, some $CaCO_3$ accumulation
2.1–2.2 m	Medium sand, color: 10YR/5/4, no clasts
HAMIII	
0–2.4 m	Clayey silt, color: 10YR/5/4 to 10YR/6/4, no clasts, $CaCO_3$ accumulation between 1.8 and 2.4
2.4–2.85 m	Sandy silt, color: 10YR/6/4, matrix supported, clasts: few, <0.4 cm
2.85–3 m	Medium sand, color: 2.5Y/6/4, clasts: few, rounded, <0.5 cm
3–3.25 m	Clayey silt, color: 2.5Y/7/3, no clasts, oxidation stains
3.25–3.40 m	Gravel in sand matrix, color: 10YR/5/6, clast supported, orientation S-ward, imbrication, clasts: small, abundant, rounded to sub-rounded, limestones and related rocks from Tur Abd Din
3.40–3.45 m	Silt without clasts, 2.5Y/6/4
3.45–3.9 m	Gravel in sand matrix, color: from 10YR/6/8 (upper portion) to 2.5/6/4 (lower portion), clast supported, S-ward orientation, imbrication, clasts: small, abundant, rounded to sub-rounded, limestones and related rocks from Tur Abd Din
FAR	
0–1.7 m	Silty clay, color: 7.5YR/5/4, no clasts, moderate consistency
1.7–2.6 m	Clay, color: 7.5YR/5/3, no clasts, firm consistency
2.6–3.55 m	Clay, color: 7.5YR/5/4, manganese flecks, $CaCO_3$ wires, no clasts
3.55–3.70 m	Clay, color: 7.5YR/5/4, firm consistency, manganese flecks, $CaCO_3$ accumulation
3.70–3.80 m	Clay, firm consistence, color: 7.5 YR/5/4, no clasts, manganese flecks
3.80–4 m	Compacted clay, color: 7.5 YR/3/3, $CaCO_3$ wires, no clasts
4–4.05 m	Clayey silt, color: 10YR/6/4, no clasts, manganese flecks
4.05–4.4 m	Clay, color: 5YR/3/3 (moist), firm consistency, no clasts, $CaCO_3$ accumulation, manganese flecks
HASIV	
0–0.9 m	Sandy clay, color: 10YR/6/3, weak consistency, clasts: rare and rounded
0.9–2.7 m	Archaeological in situ layers in clayey silt matrix, 10YR/5/3
2.7–2.98 m	Silty clay, color: 10YR/6/3, clasts: moderate, small, sub-rounded to sub-angular, many artifacts
2.98–3 m	Ashy layer, clayey silt, color: 5YR/6/1, clasts: some, angular to sub-angular
3–3.24 m	Silty clay, color: 10YR/6/3, moderate consistency, clasts: moderate, angular to sub-angular, many sherd-like artifacts
3.24–3.26 m	Ashy layer, clayey silt, color: 2.5Y/3/1, firm consistency, clasts: few
3.26–3.3 m	Sterile clay, color: 10YR/6/3, firm consistency, clasts: rare
3.3–3.32 m	Ashy layer, clayey silt, color: 10YR/5/2, clasts: few, large to small
3.32–3.6 m	Clay, color: 10YR/6/3, rigid consistency, clasts: rare but present
3.6–3.8 m	Gravel in silty sand matrix, clast supported, clasts: abundant, rounded to sub-rounded, between 20 cm and some mm, limestones and related rocks from Tur Abd Din, poorly sorted, no imbrication, S-ward orientation
HASIII	
0–1.55 m	Clayey silt, color: 10YR/5/2 near sample 7, 10YR/6/2 near sample 3, clasts: few, sub-angular–rounded–sub-rounded, small
1.55–2.3 m	Massive gravel in clayey silt matrix, color: 2.5Y/5/2 color of matrix, clast supported, clasts: rounded to sub-rounded, from less than 1 to 20 cm, limestones and related rocks from Tur Abd Din, poorly sorted, some imbrication

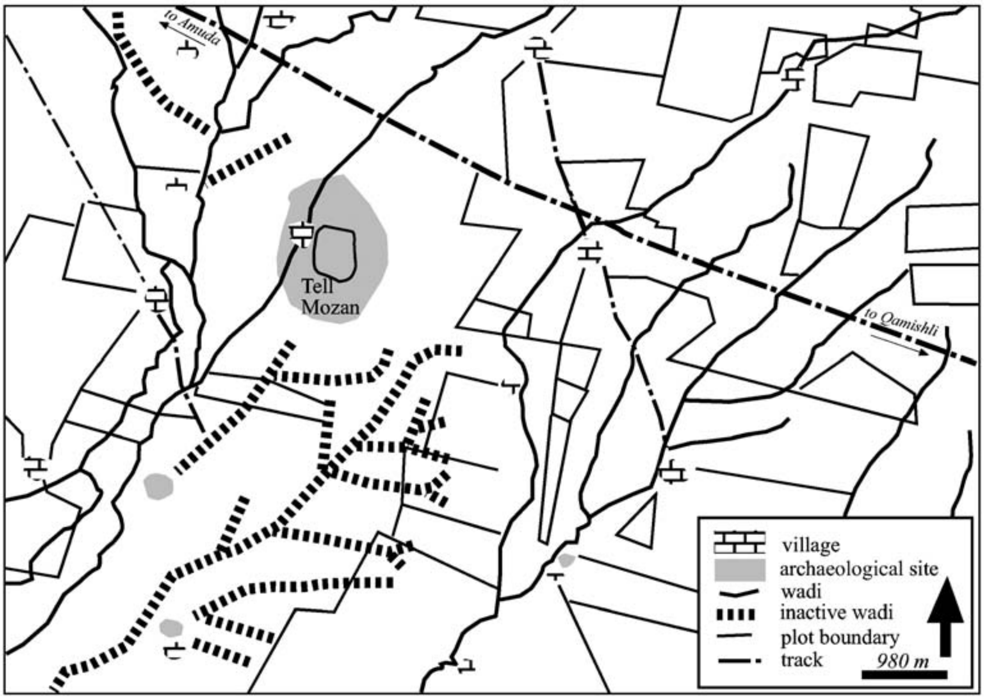

Figure 7. Map of the Tell Mozan surroundings based on satellite image interpretation of D025-055 1105-1 FWD from the 5 Nov 68.

samples 6 and 5. The soil formation within these sediments indicates that more than a thousand years probably passed since their deposition (compare with the chronosequence by Wilkinson, 1990).

Discussion

The studied sequences make it possible to gain insight into the fluvial history through the Holocene and place the archaeological sites within their landscape context. However, we must be careful in comparing sediments from the perennial Jaghjagh with those of the intermittent Jarrah and Khanzir. In the latter two, the sediments should reflect more highly fluctuating stream velocities.

In the early Holocene evidence is limited for this region. The only references are provided from the southern Wadi Avedji, where Courty (1994) found evidence of torrential river behavior dating to the early Holocene between the archaeological sites Kachkachok 2 and 1 (Fig. 1). The poorly sorted gravel at the bottom of HASIV pre-dates ca. 4560 BC and also indicates flash-flood like conditions.

During the mid-4th to mid-3rd millennium BC, the Jaghjagh had a vigorous, relatively steady flow as evidenced in the Hamidi transect. The exceptional archaeobotanical assemblage in between the fluvial deposits there suggests the presence of a *Salix* (willow) riverine gallery forest and an extended swamp belt with *Cyperus* along the Jaghjagh. Dillemann (1962;

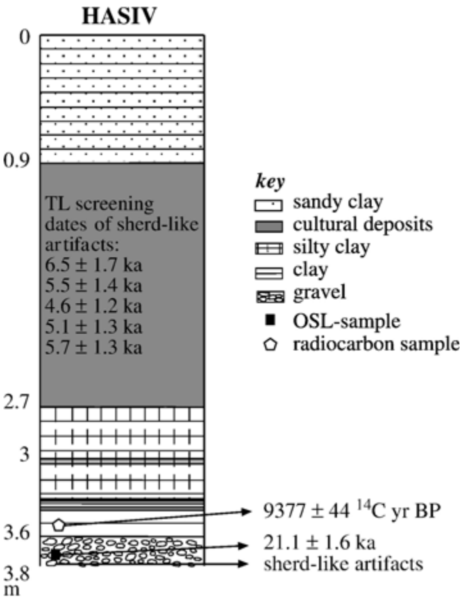

Figure 8. Section HASIV along the Wadi Khanzir.

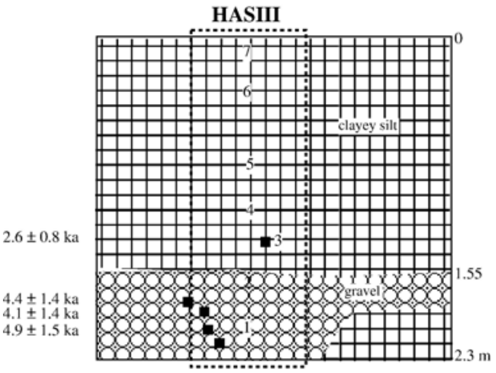

Figure 9. Section HASIII along the Wadi Khanzir. Samples taken throughout the section as indicated. Dates within section derive from redeposited TL screened sherds.

Plate V) has documented that a riverine gallery forest was found along the Jaghjagh in the historical past at certain places. Moreover, the mid-4th millennium BC botanical remains from the Hamidi boreholes suggest the presence of woodland vegetation in the area, which might have consisted of a deciduous oak park woodland as indicated by the analysis of charcoal from 3rd millennium BC Tell Mozan (Deckers and Riehl, 2004; Deckers, 2005) and through potential vegetation reconstruction by Hillman (in Moore et al., 2000; Fig. 3.7). A denser tree cover, by increasing rainfall interception and inhibiting runoff, may have resulted in steadier perennial flow and elevated groundwater tables. In the Tell Hamidi area, however, agricultural activities also took place as indicated by the plant remains from HAMB1 and HAMB3. Evidence of open vegetation was found as well. Tell Mozan, a major third millennium BC site, was also probably better watered than is often assumed today. Satellite images not only indicate the presence of a channel that flowed through the tell and that later altered its course through the lower town, but also show the presence of an inactive, dentritic channel system only a few km southeast of Mozan with some accompanying tell sites.

After 4.5±0.3 ka, fine-grained clayey silt sediments were deposited at the location HAM along the Wadi Jaghjagh, which suggest either that the stream bed had changed its location or that stream velocities had decreased. The extraction of water for irrigation may have played a role in diminution of stream flow within this rather modest-size river. Wilkinson (1999) documented this for the neighboring Balikh. Moreover, Ergenzinger and Kühne (1991) found indications of a possible canal system that stretched from the lower Jaghjagh along the left Khabur and Euphrates bench until the height of Mari. Remains of a canal were found on aerial photographs along the Wadi Jaghjagh near Tell Bab. The channel perhaps continued to Tall al-Hosn parallel to the Wadi-el-Radd and continued to Tell Brak and Awan along the Jaghjagh. Near both locations, possible canal remains were found (Ergenzinger and Kühne, 1991; 171). Some care is necessary with this interpretation, however, because no fieldwork was undertaken and Van Liere and Lauffray and Oates instead believe it to be a Roman road (Ergenzinger and Kühne, 1991). Historically, it seems that the first regional canal was built by the Middle Assyrians in the 13th century BC on the eastern bank of the Wadi Jaghjagh. The whole system was installed and used by the Neo-Assyrians between the 9th and the 7th century BC. The eastern canal was then joining the Nahr Daurin along the northern bank of the Euphrates, thus providing a throughgoing system from the Jaghjagh to Mari (Ergenzinger and Kühne, 1991).

Other human activities also might have contributed significantly to aggradation of the floodplain, such as intensive landuse with reduction of the woody vegetation resulting in increased erosion vulnerability. During the mid-3rd millennium BC, the plain was intensively inhabited (Lyonnet, 1998; 368). Another possible cause for the deposition of fine-grained sediments at HAM post-dating 4.5±0.3 ka might relate to drier climatic conditions at the end of the 3rd millennium BC, which may have caused reduced stream-flow (Courty, 1994; Bar-Matthews and Kaufman, 1998; 211).

Although no geomorphological evidence can be confidently assigned to the earlier 2nd millennium BC, 25 letters to Zimri-lim report heavy rains and high floods in the Euphrates and the Khabur (Cole and Gasche, 1998, p. 9). They report, for example, that the dikes of the region were reinforced from top to bottom with bitumen in anticipation that the rivers would flood after two heavy rains; that the wadis near Mari filled with floodwaters and inundated fields near the palace; and that other wadi floods caused breaks in barrages, damaged a bridge and destroyed canal works. They also mention a high flood in the Khabur and urgently called for reinforcements at Terqa to attend to the barrages, over the top of which water was said to have been continually pouring. Moreover, they report that the Khabur rose to a height of two m above flood stage and that after it had broken through the dikes and inundated the surrounding countryside, the entire labor force had to be engaged to shore up the banks, and still more men were needed. Finally, a flood of the Khabur caused parts of the outer wall of the citadel of Saggaratum to collapse (Cole and Gasche, 1998, p. 9). This evidence suggests that the first half of the 2nd millennium BC was characterized by higher than average precipitation and runoff. The Van palaeoenvironmental evidence underlines moister climatic conditions in the very early 2nd millennium BC, which was followed shortly after by drier conditions (Wick et al., 2003).

Along the Wadi Jarrah at Farsuk Kabir, the late 2nd and early first millennium depositional history has been well-dated. Clayey sediments dating to the late second and first millennium BC have been found there. Similar to the Hamidi sequence and the fine-grained sediments at Farsuk Kabir, Wilkinson (2000a) found a clay-rich fill dating to 1300 or 1000 BC at the southern Wadi Jaghjagh near Tell Brak (Fig. 1). He concluded that the Jaghjagh developed a deeper and more meandering course. There still was water within the Wadi Jaghjagh and Jarrah during the early Iron Age, but probably less vigorously than during the Bronze Age. Although this reduced streamflow may have resulted from climatic drying during the first millennium BC, as indicated by isotopic research at stalactites from Soreq Cave in Israel (Bar-Matthews and Kaufman, 1998; 208), it may alternatively have resulted from the development of large-scale irrigation systems or a combination of both. Of special interest is the possible redeposited topsoil from section FAR which dates between 3.3±0.2 ka and 2.6±0.4 ka. This erosion of topsoil upon rainfall may have been related to the intensive resettlement of the area about 800 BC (Page, 1968; Wilkinson and Barbanes, 2000: 404). Between 2.6±0.4 ka and 2.3±0.2 ka 1.5 m of clay sediments were deposited by the Jarrah, which may have been caused by intensive landuse. Although it is often stated that the region was deserted during this period (e.g., Lyonnet, 1996), improved understanding of the pottery sequence recently indicated that there were a lot of settlements in the Tell Brak area during this period (Joan Oates, pers. comm., 2006). The possible mid-5th century BC graded sediments from the Jaghjagh near Qamishli (QAM2) suggest a relatively steady and vigorous flow of the Jaghjagh and indicate more humid climatic conditions, supported by the isotopic evidence from Soreq in Israel (Bar-Matthews and

Kaufman, 1998; Fig. 9.5). Sometime later, the channel fill became sandy, indicating lower velocities.

The 2nd to 5th century AD was a dry, stable climatic period as indicated by isotopic research from Soreq cave (Bar-Matthews and Kaufman, 1998; Fig. 9.5). The fine-grained fluvial deposits from ABO along the Jaghjagh dating to the mid-3rd century AD indicate rather low velocities, however, probably represent overbank deposits. The in situ remains of oak charcoal indicate that oak park woodland was still present at that time.

It is interesting to note that although dry climatic conditions prevailed during the mid-4th century AD, the Jaghjagh still must have contained a considerable amount of water in the Qamishli region, since its water was used in the siege of Nisibis in AD 350. Although the five sources about the battle differ markedly in detail, they all agree that Jaghjagh River (then named Mygdonius) was involved and was made to cause some kind of flood, which led to the collapse of part of the city wall of Nisibis (Lightfoot, 1988). In the 5th century AD or perhaps later, a flashflood occurred along the Khanzir, as is documented in the poorly sorted, 3-m-wide massive channel fill at HASIII.

At the Wadi Jaghjagh, a coarse massive channel deposit post-dating approximately the 9th century AD has been found. The poorly sorted gravel suggests flashflood-like conditions, unlike the graded and better sorted channel deposits from the possibly 5th century BC that suggest a more steady flow. The high organic matter content of the gravels also suggests that topsoil had been eroded and was incorporated within the gravel deposit.

Interestingly, historical sources mention that the Jaghjagh was no longer navigable in the 13th century AD (Le Strange, 1895; 60). According to the Soreq Cave isotopic record, the 13th century was not an especially dry period (Bar-Matthews and Kaufman, 1998; Fig. 9.5). Perhaps the Jaghjagh water level was reduced through irrigation. Satellite images from the Nisibis (Qamishli) area show many irrigation canals; however, their age is at present undetermined. It is known, however, that in the 16th century rice was cultivated using irrigation (Cöyünç and Hütteroth, 1997).

Conclusion

This investigation of Holocene valley fills of several small streams of the Upper Khabur Basin makes it possible to gain increased insight into the complex Holocene river and environmental history, improving our knowledge of the environmental context of archaeological sites. Although the region is devoid of trees today, botanical remains from this area (see also Deckers and Riehl, 2004; Deckers, 2005) suggest that oak park woodland was present within this area until the 3rd century AD (e.g., ABO) and that streams like the Jaghjagh were possibly accompanied by a riverine gallery forest in the mid-4th millennium BC (e.g., HAM sequence). The more recent flashflood-like deposits from the Jaghjagh (e.g., section QAM) may relate to deforestation.

The landscape and streams as we observe them today are not representative of the past. The present absence of water in the Jaghjagh during the summer is probably caused by damming and extensive use of water for irrigation. Small stream channels have been recently leveled due to intensive land use. During the mid-4th to mid-3rd millennium BC (e.g., HAM sequence), and possibly during the mid-5th century BC (e.g., QAM2), the Jaghjagh had a vigorous and relatively steady flow. The Jaghjagh stream flow might have been reduced after 2500 BC, either related to climatic changes or extraction of water for irrigation.

The intermittent, poorly sorted, massive gravel sediments of the Wadi Khanzir at Tell Has near the anti-Taurus foothills are sporadic high-energy deposits associated with flashfloods and exceptional rains, with one deposit possibly dating to the earlier half of the Holocene and another approximately at or post-dating about AD 400 (HASIII). Along the Jarrah, organic-rich topsoil sediments have been deposited between 1300 and 600 BC which may be related to intensive resettlement of the area at about 800 BC (FAR). Between about 600 and 300 BC, clay was deposited at Farsouk Kabir.

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