Geogr. Fis. Dinam. Quat.
36 (2013), 95-105, 6 figg.

DOI 10.4461/GFDQ.2013.36.7

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GEOMORPHOLOGY OF THE MELENDIZ RIVER IN CAPPADOCIA (TURKEY): SETTING OF PRE-POTTERY NEOLITHIC SITES OF AŞIKLI AND MUSULAR, AND CLIMATE RECONSTRUCTION DURING THE ONSET OF THE HOLOCENE

ABSTRACT: KUZUCUOĞLU C., *Geomorphology of the Melendiz River in Cappadocia (Turkey): Setting of Pre-Pottery Neolithic sites of Aşıklı and Musular, and climate reconstruction during the onset of the Holocene*. (IT ISSN 0391-9838, 2013).

The reconstruction of the river dynamics in the Melendiz valley (Cappadocia, Turkey) is studied on the basis of geomorphology and archaeological data acquired from two Pre-Pottery Neolithic (PPN) sites, *i.e*. dated c.a. 8300 to 7000 BC. Together with the study of terraces in the vicinity of the sites and the results of 3 cores retrieved from the alluvial fill of the floodplain, data enlighten climatic trends and changes as well as river environmental responses during a period spanning from the end of Late Glacial to 7000 BC (*i.e*., 9000 cal. BP). During the Last Glacial a gravel deposit accumulated in the valley, and this deposit was incised before the turn of the Late Glacial / Holocene. The incision of hydro-climatic origin was probably accentuated by tectonic uplift. When the PPN population arrived on the shores of the Melendiz River at the beginning of the Holocene, the valley was wide open between incised Last Glacial terraces, and the settlement occurred on a bed-load blanketing the valley floor (braided river). The relationships between archaeological layers and river deposition, conservation and erosion during the occupation of Aşıklı and Musular sites (*ca.* 8300 to 7000 BC) indicate depletion of precipitation during the first two millennia of the Holocene. Like in other regions located at the foot of mountainous ranges in central Anatolia, humidity rose together with runoff from upper basins, which was triggered by higher precipitations (rain and snow) on highlands.

KEY WORDS: Pre-Pottery Neolithic, Early Holocene climate, Central Anatolia, Aşıklı, Melendiz, Musular.

INTRODUCTION

The Pre-Pottery Neolithic (PPN) sites of Aşıklı and Musular face each other on each side of the Melendiz river valley in western Cappadocia. ^{14}C dates from Aşıklı settlement range from 8300 to *ca*. 7500 BC, while dates from Musular overlap the end of Aşıklı occupation, continuing until *ca*. 7000 BC. Archaeological findings in Aşıklı allow the study of the domestication practices while those of Musular allow the study of the off-site activities and rituals of the Aşıklı community based on cattle hunting. Both sites contribute to the understanding of the spatial distribution of early sedentary communities and the local neolithisation process, favouring the hypothesis of multi-regional centres and successive stages of plant and animal domestication practices development in the Eastern Mediterranean. In this context, the study of the geomorphological setting of the sites and the reconstruction of their dynamic relationships to the river and the water resources provide information on several important matters: (i) the environmental conditions of the instalment of the first PPN populations *ca*. 8500 BC, of the growth of the Aşıklı village during 1000 years (until 7500 BC), of the appearance and development of Musular settlement (7600-7000 BC), and of the abandonment of Aşıklı *ca*. 7500 BC; (ii)

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The author's deep thanks are first addressed to the successive directors of the Aşıklı excavation, for their support in all matters. These are namely, from the Prehistory Department of Istanbul University: U. Esin who invited me to join the Aşıklı team in 1995 and 1996, S. Harmankaya, N. Balkan-Atlı with whom I worked in Aşıklı in 2003, and M. Özbaşaran with whom a research project continues since 2010. Thanks are also addressed to the Cultural Affairs Directorship of the Ministry of Culture of the Turkish Republic for delivering the necessary authorizations. I am also much grateful to all the Aşıklı teams I worked with, whether assistants, Master and Ph.D students, drivers and villagers who assisted me in collecting data in field geomorphological surveys and coring. My gratitude also goes to T. Yılmaz and the Jemas Ltd. soil mechanics enterprise for their contribution to the 1995 coring. This work was financed for the Turkish side by the Aşıklı excavation project (mainly the Istanbul University funding and the Tübitak projects), and for the French side by the PICS of the CNRS in 1995, the Paléo2 CNRS program in 2010, completed by the PaléoMex INSU-CNRS (Mistrals) program in 2011 and 2012. The author is also grateful to the anonymous and helpful reviewers of the manuscript, whose efficiency and rapidity have been much appreciated. Through this article, the author sincerely acknowledges Monique Fort's contribution to such geomorphological approaches as the one applied in the research herewith published, and thanks her for friendly souvenirs born from collaboration and common field work in another region of Anatolia, that of Lake Van.

whether relationships exist between these cultural events and the climatic conditions.

THE MELENDIZ VALLEY IN WESTERN CAPPADOCIA

The most important river in Cappadocia is the Melendiz, which flows northwards in a trough of Plio-Pleistocene age (fig. 1). The source is located in the 1 Ma old Melendiz dağ (*ca.* 2900 m asl), a massif composed of a variety of calcalcaline lava flows (basalts and andesites). Northwards the Melendiz River drains the Çiftlik plain (*ca.* 1520 m asl), which is filled with lacustrine, torrential and reworked volcanism-generated sediments. Outflowing through gorges cut in andesites and basalts, the river drains Upper Quaternary volcanic deposits emitted by the Hasan dağ. At the

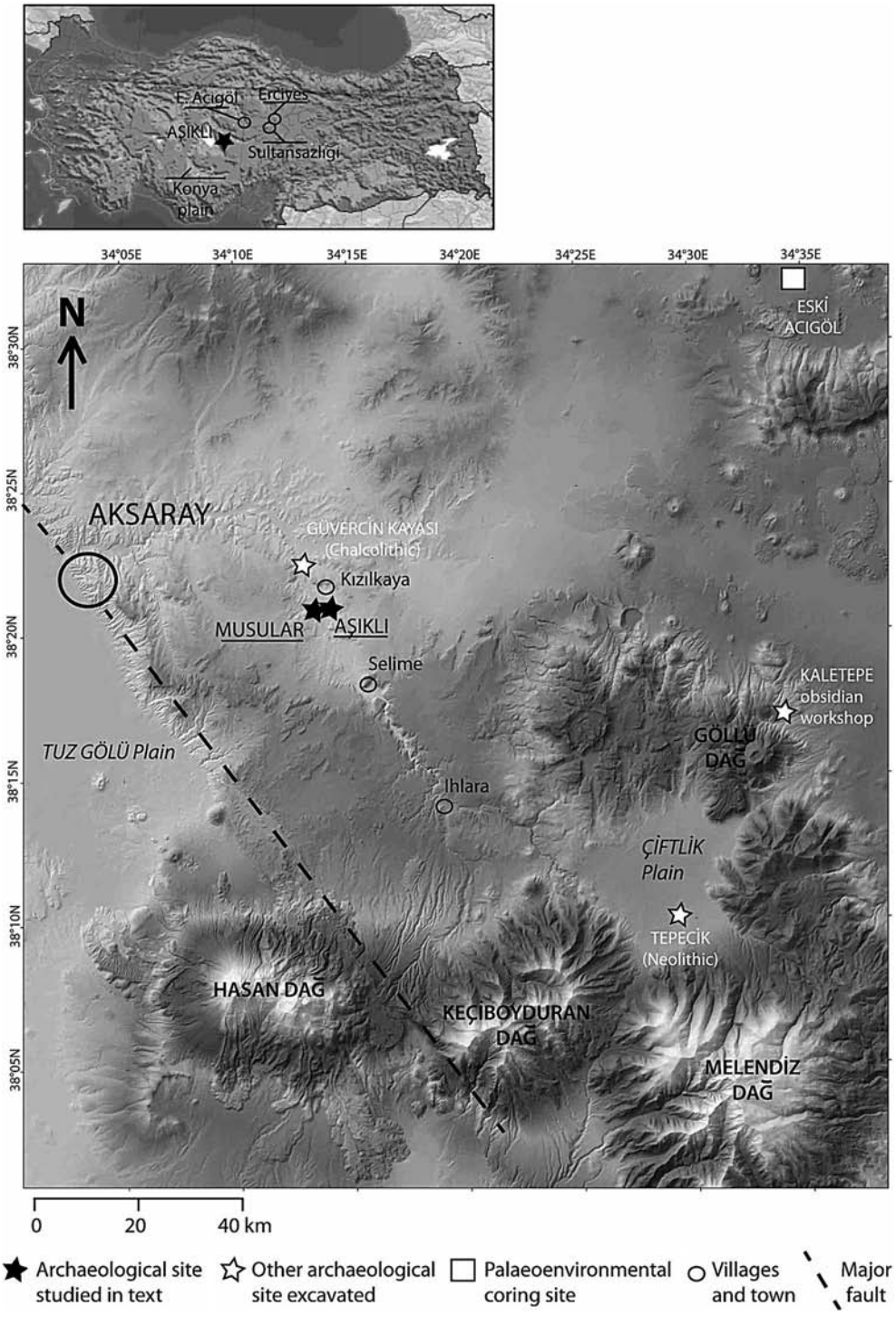

FIG. 1 - Location of sites presented in the text.

entrance of the Ihlara village, the valley becomes deep, narrow and steep, incising Upper Pliocene red and hard *Kızılkaya* Cappadocian ignimbrite (Le Pennec & *alii*, 1994). From Selime village downstream (fig. 2), the river incises the following succession: a lower grey-coloured and rather soft ignimbrite called *Cemilköy* by Le Pennec & *alii* (1994), topped by the *Kızılkaya* ignimbrite flow. When leaving the Cappadocian ignimbritic plateau (1400 m asl) after the village of Kızılkaya (*ca.* 1200 m asl), the river turns west through the pre-ignimbrite basement (granite, marble, diabase, ophiolite, marine clay and carbonates, conglomerates, etc.) towards Aksaray town and the Tuz Gölü plain (*ca.* 950 m asl) where its course finally ends (fig. 1).

These ignimbrites, which form the Cappadocian plateau drained by the Melendiz River, are good geomorphological archives and relative chronological markers of the formation and geological evolution of the Melendiz valley. Indeed, the morphologies below and above the ignimbrites show that (i) the south-north direction of the valley is constant since the Pliocene, (ii) two thirds of the valley incision occurred during the Pleistocene, and (iii) all the Pleistocene incision constraining current Melendiz valley was very rapid. Both the magnitude and rapidity of this incision can be explained by:

– a Plio-Pleistocene tectonic uplift of the Cappadocian plateaus accompanied by the formation of both the Sultansazlığı pull-apart basin (east of Cappadocia: 1000 m) and the Tuz Gölü depression (west of Cappadocia: 950 m);

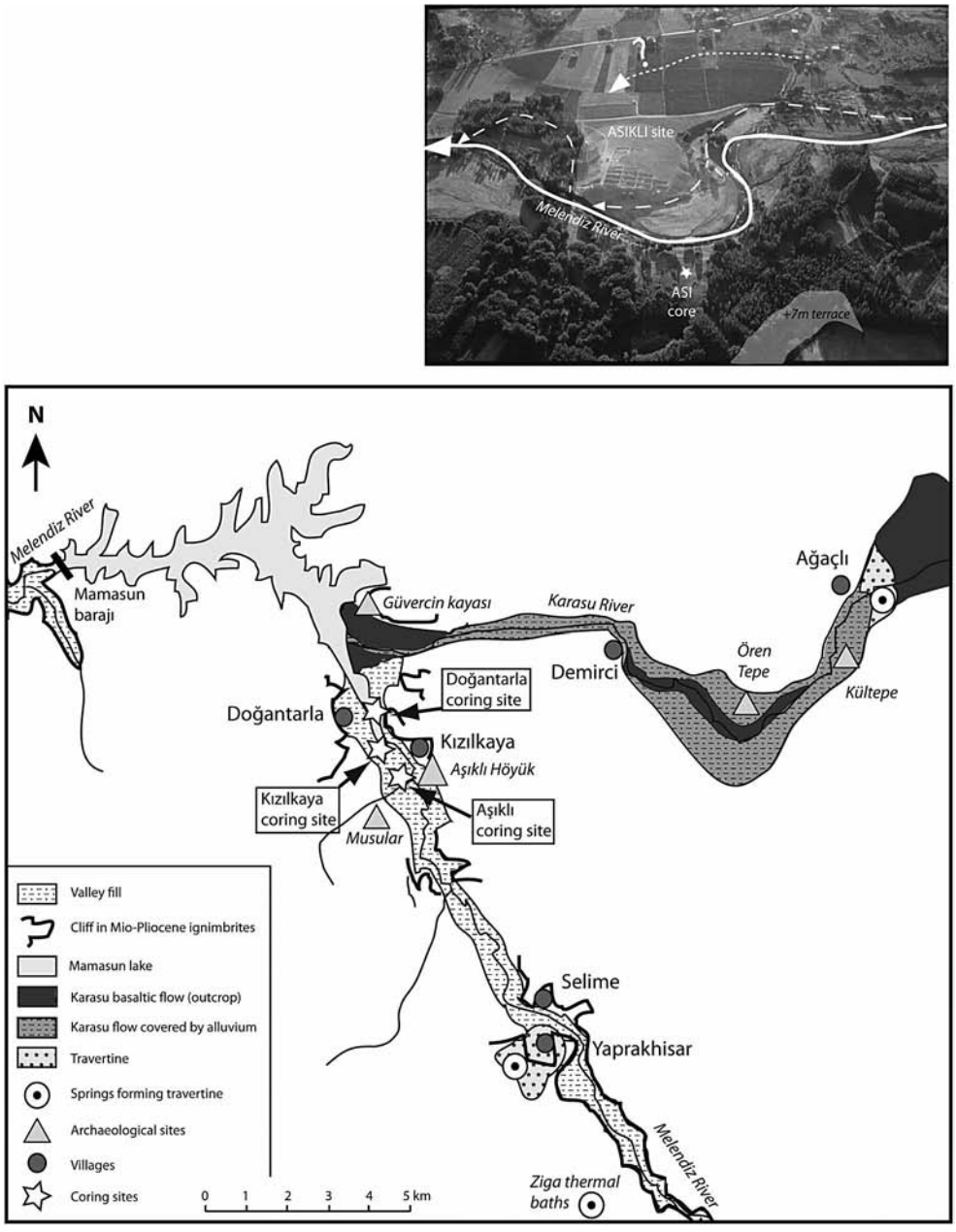

FIG. 2 - The setting of the cores in the Melendiz floodplain near Aşıklı Höyük.

– the activity of a Pleistocene S-N oriented faulted network as shown by the Melendiz valley between the points in and out the deep and narrow incision in the thickest part of the Kızılkaya plateau (Ihlara and Selime villages), which corresponds to a fault-line spotted by travertines fed by warm hydrothermal springs on the sides and at the bottom of the valley;
– the growth of the Hasan dağ volcano (3268 m) which increased the declivity of the river drainage and the consequent incision rate of the river.

Archaeological data from Aşıklı and Musular sites in the Melendiz valley: an overview

Prehistoric sites excavated in Cappadocia expand from Paleolithic (Kaletepe-Dere3) and Pre-Pottery Neolithic (PPN; Aşıklı, Musular, Kaletepe) to Ceramic Neolithic and Chalcolitic (Kaletepe, Tepecik-Çiftlik, Köşk Höyük, Güvercin Kayası, etc.; for a review see Özdoğan & *alii*, 2012). Among these sites, Aşıklı and Musular are located in the Melendiz valley *ca.* 30 km east from the city of Aksaray. Not only are both these sites very rich in fauna and flora remains, but also an impressive amount of *chipped obsidian industry* is directly related to the proximity of the Göllüdağ obsidian outcrops and prehistoric workshops (Balkan-Atlı & Binder, 2012; fig. 1).

The oldest site, *Aşıklı Höyük* («höyük» = mound), is a well-known Pre-Pottery Neolithic settlement (Özbaşaran, 2012). The site was occupied continuously from *ca.* 8300-7950 BC (Level 4), *ca.* 7900-7800 BC (Level 3), and *ca.* 7800-7500 BC (Level 2). It is the oldest PPN settlement excavated in Anatolia west of the Euphrates region. Excavations were conducted, from 1989 to 2004 by Ufuk Esin, Savaş Harmankaya and Nur Balkan-Atlı, and since 2010 by Mihriban Özbaşaran. Results exhibit four phases of occupation, from Level 4 at the base (yet under excavation) to the late Pre-Pottery Neolithic Level 1 on the summit of the mound (heavily eroded and reworked by ploughing, thus not excavated). Occupied by PPN populations from ≥8300 to *ca.* 7500 BC the site concentrated activities from plant and animal collecting and hunting, to pre-domestication and domestication (Buitenhuis, 1997; Willcox, 2012). The oldest dated layers reached in 2011 are radiocarbon aged 8300 BC (Level 4; Özbaşaran, 2012), and the youngest ones from Level 2 are aged 7500/7400 BC. PPN Levels 3 and 2 which cover the 7900-7500/7400 BC time span (Esin & Harmankaya, 1999; Özbaşaran, 2012) constitute the upper two thirds of the mound above +4.75 m ATR (above today's riverbed).

The *Musular site* faces Aşıklı on the other side of the 400 m wide Melendiz river valley (fig. 2). Excavations were conducted from 1996 to 2004 under the direction of Mihriban Özbaşaran. They evidence one PPN occupation phase characterised by specialised activities focused on wild cattle hunting and butchery, dated *ca.* 7600 to 7000 BC. The site is thus contemporary with and posterior to the very last period of Level 2 in Aşıklı (Özbaşaran & *alii,* 2012). Above PPN layers, eroded materiel contains Pottery Neolithic material dated beginning of 6th millennium BC, signalling a much younger occupation of the site after the PPN abandonment.

The geomorphological setting of Aşıklı and Musular sites in the Melendiz valley

Immediately south of the Kızılkaya village where both sites are located, the valley is incised between two cliffs formed by the Cemilköy-Kızılkaya ignimbrite succession. On the right bank (east) the Kızılkaya (youngest) ignimbrite is thicker, and the steep cliff is impressive. On the left bank where the Kızılkaya ignimbrite is thinner or absent; the cliff is smooth and its summit is much lower above the valley.

Paralleling this morphological contrast, the relations of the Aşıklı and Musular sites with the valley and its river are also very different: (i) Resting over the river valley bottom, *Aşıklı* site is a 15.35 m high mound rising above the current right bank of the Melendiz River (fig. 2). The altitude of the summit is 1119.45 m asl (+15.35 m ATR). A meander circles around the western side of the mound where a *ca.* 10 m-high cliff cuts archaeological layers. The erosion of the site by the river corresponds to a loss of about a third of the mound. (ii) On the other side of the valley (south), the *Musular site* overlooks the current riverbed from a *ca.* 12 m height. In full opposition to Aşıklı mound, it rests above the widely open and eroded surface of *Cemilköy* ignimbrite. This position keeps it out of reach of the river floods. Below the site toward the river, a +7 m terrace forms a noticeable step towards today's floodplain (fig. 4).

North of Aşıklı site, an elongated depression separates the mound from the ignimbrite cliff bordering the valley (fig. 2). Eastwards, this depression is humid, with a slope down to the root of the meander circling around the mound. Westwards, the floor of this depression remains rather high above the present valley floor (*ca.* 12 m), ending abruptly because of a cut by a palae-meander positioned *ca.* +3-4 m ATR. Whatever the age of this terraced meander, the elongated depression questions the possible existence of an old channel of the Melendiz River on the northeastern side of the mound. Considering the 12 m height (ATR) of the depression, such an old channel would signify (i) a landscape at the onset of the Holocene, *i.e.* at the time of the first PPN settlement, very different from the present one, and consequently (ii) a complex evolution of the valley during the first millennia of the Early Holocene.

GEOMORPHOLOGICAL SURVEY IN THE AREA OF THE AŞIKLI AND MUSULAR SITES IN THE MELENDIZ VALLEY

In order to reconstruct the local environment of the first settlers of central Anatolia in the Melendiz valley, two types of approaches were conducted: coring in the valley fill, and field investigation of fluvial deposits forming terraces and old fluvial landforms.

Data from the coring of the alluvial fill in the Melendiz valley

Three spots in the lowest terrace (+2-3 m) were cored in 1995 (fig. 2, 3), from upstream in the vicinity of the

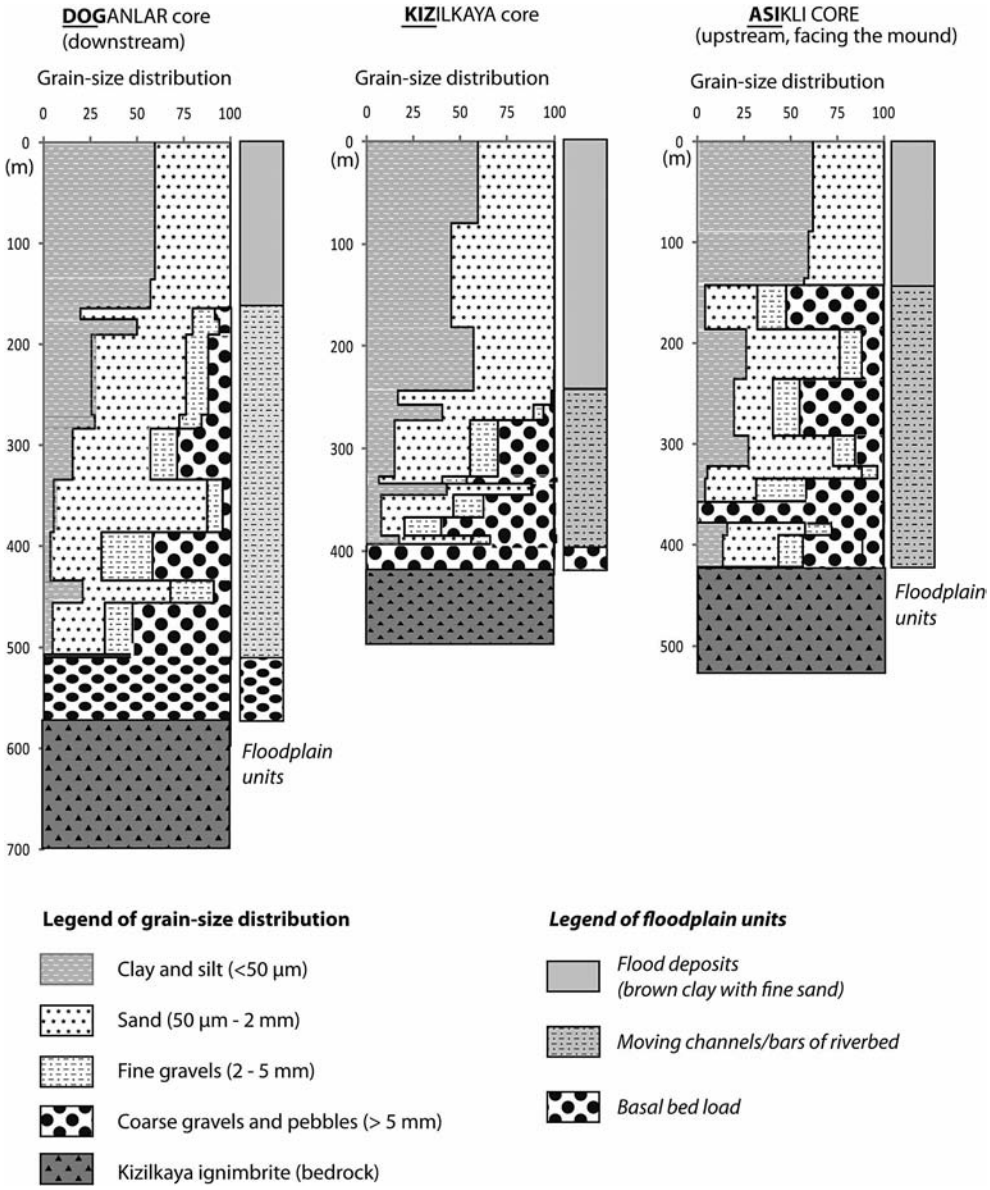

FIG. 3 - Aşıklı cores: grain-size analyses and interpretation of depositional environment.

Aşıklı mound downstream to the Doğanlar village facing Kızılkaya village. The 64 mm diameter cores were extracted using a rotary and hydraulic Craelius XC-SH truck mounted drill. Cores were sub-sampled at the coring spots, with intervals based on the facies and estimated grain size of the stratigraphic units identified during the coring process. Samples were sent to Laboratoire de Géographie Physique (LGP) in Meudon (France) for analyses.

Two sites were located (fig. 2) on the left bank of the river. The first one faced the mound and was labelled «Aşıklı core» (ASI spot: N 38° 20'53; E 34° 13'41). It reached the ignimbrite at -425 cm below the surface of the +1 to 2 m terrace. The second one faced the Kızılkaya village, and was labelled «Kızılkaya core» (KIZ spot: N 38° 21'39; E 34° 15'17). It reached the ignimbrite at –385 cm below the surface of the +2 to 1 m flood terrace.

On the right bank of the river at the foot of the Kızılkaya cliff and close to the bridge leading to the Doğanlar village, the «Doğanlar core» (DOG spot: N 38° 22'18; E 34° 13'04) reached the ignimbrite at -578 cm below the surface of the +1 m river bank.

The ignimbrite basement was reached at a variety of depths (–425 cm in ASI, –422 cm in KIZ and –570 cm in DOG). These values express the locations of the spots within the meandering dynamics of the river: the DOG sequence represents an ancient-meander which once was deeply incising the foot of the Kızılkaya cliff; the other two sequences, record places aside from the main active bed of the river within the floodplain system.

Above the ignimbrite, the sequence is composed of three units with, from bottom to top (fig. 3):

– A Unit 3 present in KIZ (between –422 and 393 cm) and DOG (between –570 and 510 cm) cores. Composed of

rounded pebbles of various lithology, this unit corresponds to a base load forming the base of the alluvial accumulation. In both these cores, the contact between Units 3 and Unit 2 is underlined by a hard red and white formation formed of cemented rounded gravels. This layer is 8 cm-thick in KIZ (385-393 cm) and 3 cm in DOG (507-510 cm).

– In the three cores, Unit 2 is composed of alternations of coarse sand and gravel layers, with incursions of pebble layers. This succession records wandering channels incising the floodplain. In all layers, the sand is grey-coloured instead of ochre as in Unit 1. In ASI, Unit 2 fills most of the core below the fine-grained Unit 1. In the other two cores, Unit 2 develops from –393 to 242 cm in KIZ, –507 to 165 cm in DOG, and between –425 and 143 cm in ASI. At the ASI location, obsidian chips found in the sediment indicates that Unit 2 was deposited either during or after the occupation of the mound.
– The last unit, Unit 1, corresponds to flood deposits over which a soil developed. The sediment is composed of brown to ochre-coloured clay mixed with fine sand. The total thickness of this upper unit is 143 cm in ASI, 242 cm in KIZ, and 165 cm in DOG.

The river terraces along the Melendiz river valley in the surroundings of Aşıklı

Transversal profiles of the river valley between Musular and Aşıklı (fig. 4, 5, 6) record several episodes of lateral erosion and incision steps followed by sediment accumulation. These episodes can be reconstructed out of the formation of three alluvial terraces reaching relative altitudes of +7 to 8.5 m, +3 to 4 m and +1 to 2 m ATR, the lowest one being also the widest.

The uppermost alluvial terrace and the topography previous to the first settlement at Aşıklı

Remnants of the uppermost alluvial terrace (+7 to 8.5 m ATR) are topographically disconnected from the archaeological sites. They are preserved at two locations:

– on the left bank below the Cemilköy cliff (fig. 4), it is formed by an old gravel and block alluvial sediment outcropping in the 3 m-high upper part of the scarp. It is dominated by the ignimbrite cliff on the summit of which lays the Musular site 12 m above the valley.
– on the right bank of the river, the terrace reaches a +8.5 m ATR altitude. It extends between the Aşıklı mound and the Kızılkaya ignimbrite cliff bordering the valley. Topographically connected to the mound slopes, it is covered by colluvium produced both by the cliff and the mound (fig. 5).

A geomorphological cross section through the surface formations between both locations suggests a Pleniglacial/Late Glacial age for the sedimentation and succeeding incision of this +7 to 8.5 m terrace. The main arguments are provided by the geometry of the terraces in the valley and by the stratigraphic connections of the Aşıklı archaeological layers with the alluvial sediment fill (fig. 5) showing that:

(i) The incision that formed the scarp of the terrace destroyed parts of it and also attacked the ignimbrite bedrock (fig. 3). This incision in the bedrock is prior to the alluvial plain formation (Units 3 and 2, fig. 3). It can be explained either by a tectonic uplift of the Aksaray block above the Tuz Gölu plain, or by a climatically-triggered change in the water discharge *vs.* sediment load in the river.

(ii) This incision is prior to the oldest excavated layers of the Aşıklı mound (Level 4: 8300-8000 BC, presently ex-

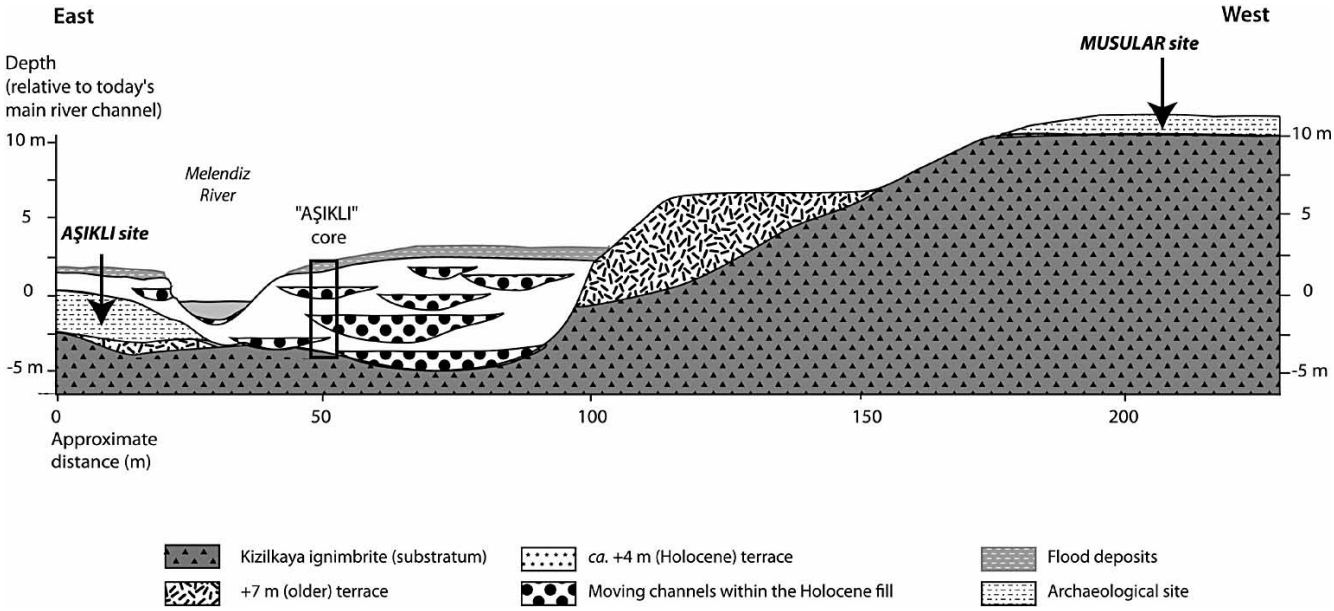

FIG. 4 - The geomorphological setting of Musular site on the left (south) bank of the Melendiz river valley.

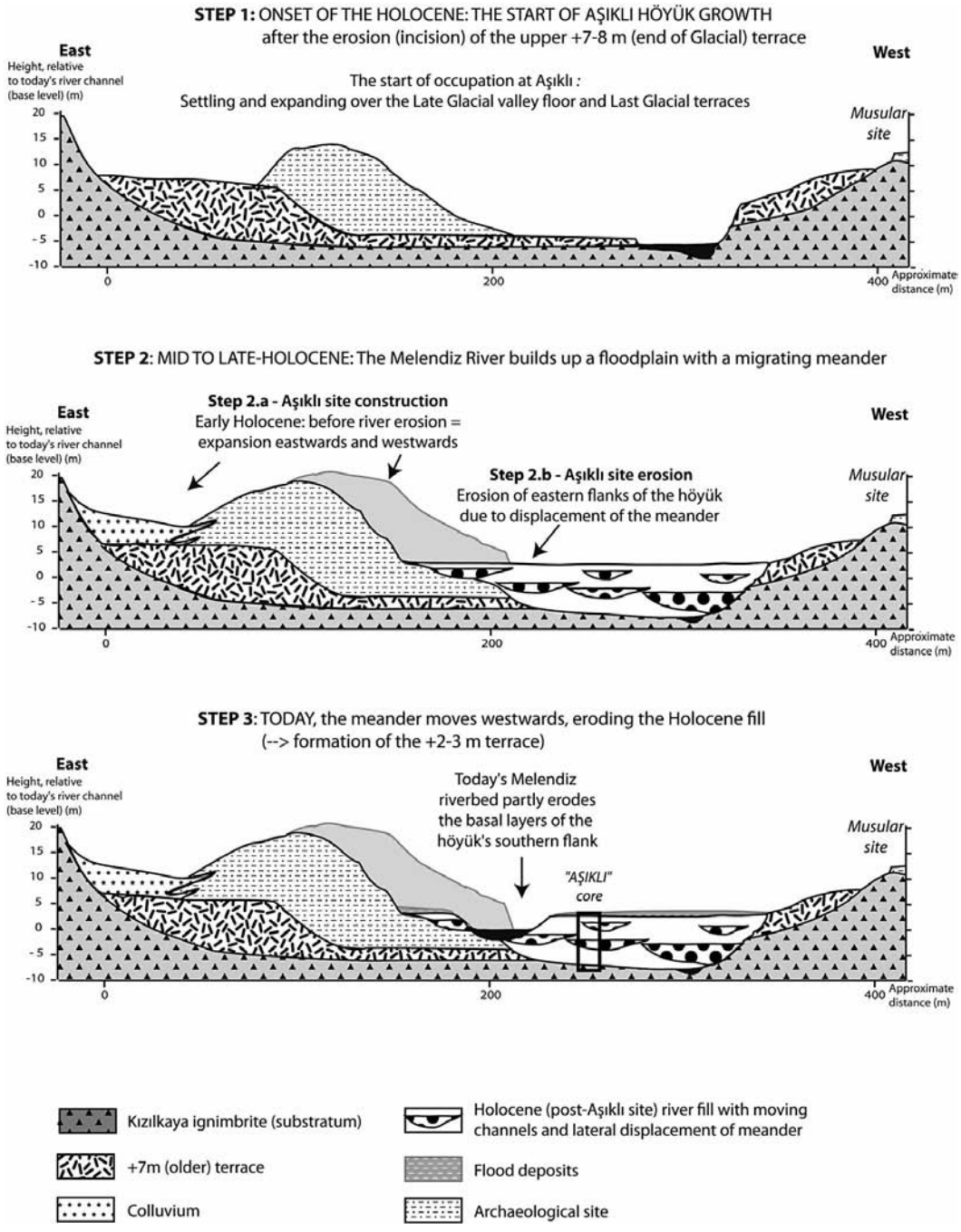

FIG. 5 - The setting of Aşıklı Höyük in relation to the Melendiz River: Hypothesis 1.

cavated down to +4 m ATR). Below these layers, the virgin soil has not yet been reached by the excavation, but could be expected down to *ca*. –1 m ATR. With an age of the first occupation at Aşıklı mound spot estimated anytime between 9000 and 8300 BC, the incision of the +7 m terrace is pre-Holocene.

(iii) A test trench, excavated in a +3 m terrace at the southeastern foot of the Aşıklı mound, exposed a reddish weathered bed load (G. Duru, oral communication). Buried by the mound colluvium, the relative altitude of the contact between this reddish formation and the Aşıklı archaeological layers above it, is not known. Nevertheless, the pre-Holocene age of this weathered alluvium seems evident and this reddish pebble deposit is most probably the same material as the one forming the +7 m terrace below Musular.

As a result, the reconstruction of the topography at the time of the earliest occupation of the Aşıklı site (fig. 5, 6) presents a wide and slightly undulating flat valley bottom drained by a river incised in the substratum at the foot of cliffs cut into a pebble formation dating Last Glacial (MIS 2, LGM? end of LGM?). At the onset of the Holocene,

this old pebble accumulation was also present at the bottom of the valley (as shown by the trench excavated by G. Duru) where it possibly formed islands between meandering river channels.

The PPN settlements and the river dynamics between 9000 and 7000 BC

During the occupation of the Aşıklı site by the Pre-Pottery Neolithic population (*ca.* 8300-7500 BC), a succession of sedimentation/incision/sedimentation phases occurred, the chrono-stratigraphy of which is based on:

– the results of the 1995 cores, which show that the first (≥8300 BC) PPN human occupation forming the base of the 15.35 m high Aşıklı mound is contemporaneous with the start of the construction of the river floodplain, since the ignimbrite roof in the valley is covered by fluvial sediments reworking archaeological layers, as shown by obsidian chips collected in the basal unit of ASI core (fig 3);
– the accidental cut of the right bank of the river during a flood in 1997. At this occasion, remains of Aşıklı Level 2 buildings (*ca.* 7900-7500 BC) appeared in the riverbed. At that spot, these buildings were buried below flood deposits forming the +2 m floodplain. These well-preserved but fragile mud-brick walls were washed out by running water after a few months. The eroded surface of this archaeological layer dips from –0.5 m in the riverbed up to +2 m ATR below the surface of a +3 m terrace in the direction of the mound. Besides, Level 2 layers being present in the current riverbed, we assume that (i) Level 2 settlement occupied here a low position close to the river; (ii) the river was flowing at a lower altitude than today.

Consequently, the stratigraphic transversal section through the low terraces burying the basal parts of the Aşıklı mound (fig. 4) shows that:

– the current +2 m terrace around the mound is partly formed by *in situ* archaeological layers pertaining to the latest phase of Aşıklı Pre-Pottery Neolithic (Level 2);
– while the 95 cores show that the bottom of pre-Holocene incision is –4 m below the current flood plain surface, some Level 2 archaeological layers are –1 m below the current floodplain surface, *i.e.* 2 m (at the most) above the ignimbrite basement eroded by the river;
– in the cliff scar cutting the mound riverwards, Levels 3 and 2 outcrop respectively between 4.05 to 6.15 m (Level 3) and between 8.65 m to 14.45 m (Level 2) ATR. This means that previous to Level 2 an old cliff eroded Level 4 and possibly Level 3. At the end of Level 4 or 3, the mound was reaching a *ca.* 10.5 m height above the river, before Level 2 occupation layers blanketed the cliff eroded in previous archaeological layers. As a matter of fact, a riverward dipping «street» (Esin & Harmankaya, 1999) joins the highest Level 2 layers down to a «low-town» positioned next to a riverbed lower than today. According to the approximate end dates of Level 4 (*ca.* 8000 BC) and Level 3 (*ca.* 7900 BC), and according to the approximate beginning date of Level 2 (*ca.* 7900 BC), the destruction of a large part of the Level 4 mound must have taken place between 8000 and 7900 BC.

THE EARLY HOLOCENE ENVIRONMENT AT TIME OF AŞIKLI AND MUSULAR PPN OCCUPATION

The environmental context of the instalment of the first settlers at Aşıklı is here deduced from terrace construction and preservation as well as from the stratigraphic record of the alluvial valley fill.

Ca. 10,500-9500/9000 BC: The end of Late Glacial (Younger Dryas)

The Melendiz valley in which early PPN populations settled was *ca.* 400 m wide and incised in the +7 m high terrace formed during the Last Glacial, partly destroyed during the end phases of the MIS 2 (Marine Isotopic Stage 2, *i.e.* the LGM). In the process of destruction, and before accumulation dynamics started with the climate change at the start of the early Holocene, the river also cut into the ignimbrite bedrock. This incision in the bedrock was most probably triggered by a tectonic uplift related to the activity of the Aksaray fault (fig. 1) or of that of the fault constraining the Melendiz valley in this area.

9000-8000 BC: The onset of the Holocene and the arrival of the first PPN populations

According to the remains of an old pebble formation preserved at the bottom of the Late Glacial valley, the landscape at time of arrival of the first PPN settlers must have been that of a river flowing in channels partly incised in the bedrock, and partly reworking a pebble formation resulting from the reworking of the Glacial +7 m terrace. Such an environment evokes a fluvial environment characterised by a wandering-meander pattern (Easterbrook, 1999) as recorded in the cores (Unit 3).

In such an environment, it is possible that one of the braids of the river or even a main river branch may have flown on the other (northern) side of today's mound. If that is the case, remains of the old pebble formation were also incised down to the ignimbrite roof on the other side of today's mound. Meaning that the Holocene accumulation of sediments north of the mound, whether natural (alluvium, colluvium) or archaeological is at least 12 m-thick between PPN mound and Kızılkaya ignimbrite cliff (fig. 6).

As shown by Woldring cited by Esin (in Özbaşaran, 2012), the settlement level of the first populations was some 61 to 2 m below the present riverbed. This confirms that the river was flowing at a level lower than today in a landscape where the flood plain construction had not yet started. This context shows that the proximity of the riverbed(s) was not a problem for the population occupy-

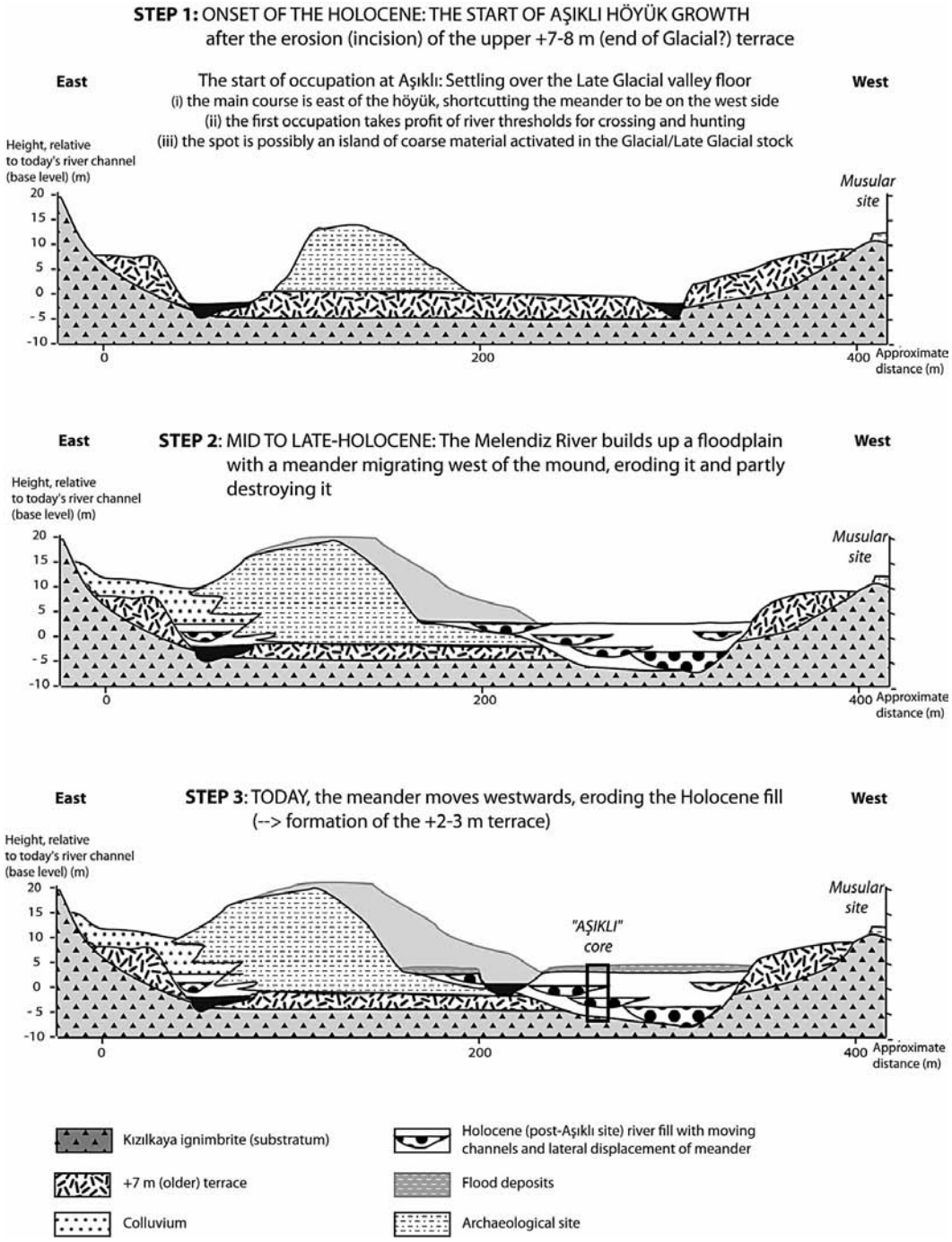

FIG. 6 - The setting of Aşıklı Höyük in relation to the Melendiz River: Hypothesis 2.

ing the site, *i.e.* the floods were not reaching the rising Level 4 mound. In total, the archaeological activities during Level 4 generated a ≥4 to 6 m-high mound rising above the pebble formation. During the growth of this mound, the river definitively settled on the south and west of the human settlement, like today. These observations mean that: (i) the erosion of the Glacial terrace and the incision in the ignimbrite bedrock stopped with the onset of the Holocene; (ii) rather low floods were occurring in a channelised river environment.

8000-7900 BC (post-Level 4 and pre-Level 2): A rapid and high magnitude change in river regime?

At the end of Levels 4 or 3, *ca.* 8000 or 7900 BC, irregular and brutal floods occurred, which caused overbank flooding of the valley, with moving meanders eroding the mound. This change may have been short in time for this event and possible other changes in the river dynamics were both short enough and not risk-bearing enough to provoke the abandonment of the Aşıklı site.

7900-7600/7500 BC: Environment during Aşıklı Level 2

The fact that Level 2 mud-bricked walls outcrop below today's riverbed signifies that during Level 2 (7900-7500 BC) the river was still lower than today. The good preservation of the mud-brick walls at the depth of today's riverbed strongly suggests that the climate was dry enough to keep earth houses from flood threat, meaning that floods were neither high nor destructive during the 1st half of the 8th millennium BC (*ca.* 9900-9500 cal. BP). The dryness of the first part of the Holocene may have caused the formation of the hard red and white formation cementing rounded gravels at the contact line of Units 3 and 2 in the alluvial fill.

7600/7500 to 7000 BC (Musular occupation period): An increase in flood occurrences and magnitudes?

At the base of the mound, the lowest parts of Aşıklı Level 2 are both partially covered by Holocene flood deposits and incised by the current riverbed. The flood-plain accumulation burying Level 2 layers may have started during the last century of Level 2 occupation (*ca.* 7600-7500 BC) when the site of Musular is occupied on the other side of the river. The newly founded Musular site on the summit of the Cemilköy cliff concentrated activities devoted to animal hunting, husbandry and butchering. The contrast between activities in Musular and Aşıklı may have accompanied some cultural change related to cattle and sheep domestication practices. In parallel, it also responds to an environmental change recorded by increasingly high-magnitude discharges and flood occurrences of the river during the second half of the 8th millennium BC. Such an increase in flood occurrences may have led the population to continue life and production activities in areas yearlong safe from too high a risk of flood hazards.

At present

Incision of archaeological layers belonging to Aşıklı Level 2 by the Melendiz River in 1997 means that:

– the current valley floor is higher than during the 9th and 8th millennia BC. This rise in altitude is due to the generally positive budget of the river accumulation forming the Holocene floodplain after the abandonment of Aşıklı Level 2.
– today's bank erosion is not due to a reactivation of incision but to meander mobility. Today, incision does not provoke a deepening of the channel, and the dynamics is mainly characterised by overbank deposition and meander migration.

Presently, no data are available for measuring the possible impacts of: (i) global change (the definite melting of permanent snow in the upper parts of the drainage basin, increasingly irregular precipitation and spring temperatures, rain amount decrease); (ii) land-use trends (overexploitation of pasture land, forest clearance for fuel wood, etc.).

DISCUSSION

The study of the geomorphological setting of the Aşıklı and Musular sites in the Melendiz valley in western Cappadocia informs about the environmental context of the Late Glacial/Holocene transition and of the Early Holocene. The results exposed here can be compared with palaeoenvironmental sequences from Cappadocia in Eski Acıgöl maar (Roberts & *alii*, 2001; Woldring & Bottema, 2001; Jones & *alii*, 2007) and Erciyes volcano (Sarıkaya & *alii*, 2009; Zreda & *alii*, 2011), as well as from the Konya plain (Fontugne & *alii*, 1999; Kuzucuoğlu & *alii*, 1999 a and b; Roberts & *alii*, 1999; Kuzucuoğlu, 2002) and the Tuz Gölü plain (Kashima, 2002).

The dry climatic conditions recorded by the Melendiz fluvial system at the beginning of the Holocene during the occupation of the Aşıklı site (≥8300 to 7500 BC) can also be discussed in the light of papers by van Zeist & Bottema (1991) and Bottema (1999). These authors identified in Anatolia a westward-growing time-delay in the Early Holocene precipitation increase (up to 2000-3000 years in the central Anatolian plateaus). The mineralogical record in the Eski Acıgöl sediment fill also responds to a precipitation depletion paralleling temperature increase during the two first millennia of the Early Holocene. In the Erciyes a glacier advance, *i.e.* a rise in precipitation, is recorded *ca*. 7200 BC (Sarıkaya & *alii*, 2009). In the semi-arid Konya plain, this early Holocene humidity depletion has been evidenced on the basis of hydrographical data recording the start of local-scaled precipitation increase only *ca.* 6000 BC (Kuzucuoğlu & *alii*, 1999 a and b; Kuzucuoğlu, 2002).

Thus, the increasingly warm temperatures during the first millennia of the Holocene in central Anatolia were not accompanied by a rise in precipitation. This climatic context generated a dryness, which lasted most probably until *ca.* 6000 BC (*i.e.*, 8200/8000 cal. BP) in the Konya Plain. However, the humidity depletion stopped earlier in the mountainous areas where Mediterranean-originated precipitation increased *ca.* 7500 BC (*i.e.*, 9500 cal. BP; see records from the Çarşamba alluvial fan, the Eski Acıgöl lake sediments, and the Erciyes moraines). Due to increasing rain and snow, this humidity rise fed run-off systems watering Anatolian territories located at the foot of highland ranges or volcanoes. Consequently, river valleys collecting water from highlands (*e.g.*, the Melendiz River in Cappadocia) escaped local dryness but were submitted to seasonal discharge responses to thaw. It is such a discharge which caused the dramatic erosion of the Aşıklı mound at the turn of the occupation Levels 4 to 2 *ca.* 8000-7900 BC. After 7500 BC, river discharge as well as precipitation increased enough as to accelerated the start of the floodplain construction.

CONCLUSION

The results of this geomorphological study of terraces and river deposits in relation to the instalment of early settlers of the most important PPN site of Central Anatolia

enlightens the environmental context of this installation. They confirm that in Central Anatolia (i) the LGM was marked in river valleys by thick coarse deposits later deeply incised (most probably during Late Glacial), and (ii) the Early Holocene humidity rise occurred with a *ca*. 2000 years delay after the onset of the Holocene. This late occurrence occurred in two steps. The first step, clearly recorded in the Melendiz River valley in the area of Aşıklı and Musular, corresponds to a precipitation increase in the highlands forming barriers to the Mediterranean humidity across the central Anatolian plateaus, such as mountainous ranges (Taurus) and volcanic massifs (Hasan dağ, Melendiz dağ, Erciyes dağ, etc.). The climatic signal of this first humidity rise, contemporaneous with high temperatures (more frequent abundant snow melting) is the construction of alluvial fans at the foot of the mountains (*e.g.*, Konya plain) and of floodplain further downstream in large valleys (*e.g.*, Melendiz River). The change in river dynamics from very Early Holocene low river discharge (dry context) to alluvial fill aggradation (more humid and temperate context) occurred *ca*. 7500 BC, *i.e.* 9500 cal. BP. It provoked a rise in flood occurrences and magnitudes. Later, as shown by previous work in the Konya plain (Kuzucuoğlu & *alii*, 1999b; Roberts & *alii*, 1999; Kuzucuoğlu, 2002), precipitation also increased in the Central Plateaus where depressions were filled with water *ca*. 8200/8000 cal. BP.

REFERENCES

BALKAN-ATLI N. & BINDER D. (2012) - *Neolithic obsidian workshop at Kömürcü-Kaletepe (Central Anatolia)*. In: Özdoğan M., Başgelen N., Kuniholm P. (Eds.), «The Neolithic in Turkey, Central Turkey Vol., Archaeology and Art Publications», Istanbul, 71-88.

BOTTEMA S. (1999) - *Landscape archaeology and reconstruction of the Mediterranean environment based on palynology*. In: Leveau P., Trement F., Walsh K. & Barker G. (Eds.), «Environmental Reconstruction in Mediterranean Landscape Archaeology». Oxbow Books, Oxford, 9-16.

BUITENHUIS H. (1997) - *Aşıklı Höyük: a predomestication site.* Anthropozoologica, 25-26, 655-662.

SARIKAYA M.A., ZREDA M. & ÇINER, A. (2009) - *Glaciations and paleoclimatic variations on Mount Erciyes, central Turkey, since Last Glacial Maximum, inferred from 36Cl cosmogenic dating and glacier modeling.* Quaternary Science Reviews, 28, 23-24, 2326-2341.

EASTERBROOK D.J. (1999) - *Surface Processes and Landforms*. Prentice Hall, London.

ESIN U. & HARMANKAYA S. (1999) - *Aşıklı*. In: Özdoğan M. & Başgelen N. (Eds.), «Neolithic in Turkey. The Cradle of Civilization, New Discoveries, Archaeology and Art Publications», Istanbul, 115-132 (text), 87-100 (plates).

FONTUGNE M., KUZUCUOĞLU C., KARABIYIKOĞLU M., HATTE C. & PASTRE J.-F. (1999) - *From Pleniglacial to Holocene: a ^{14}C chronostratigraphy of environmental changes in the Konya Plain, Turkey.* Quaternary Science Reviews, 18, 573-591.

JONES M.D., ROBERTS C.N. & LENG M.J. (2007) - *Quantifying climatic change through the last glacial-interglacial transition based on lake isotope palaeohydrology from central Turkey*. Quaternary Research, 67, 463-473.

KASHIMA K. (2002) - *Environmental and climatic changes during the last 20,000 years at Lake Tuz, central Turkey.* Catena, 48, 3-20.

KUZUCUOĞLU C., BERTAUX J., BLACK S., DENEFLE M., FONTUGNE M., KARABIYIKOĞLU M., KASHIMA K., LIMONDIN-LOZOUET N., MOURALIS D. & ORTH P. (1999a) - *Reconstruction of climate changes during the Late Pleistocene, based on sediment records from the Konya Basin (Central Anatolia, Turkey).* Geology, 34, 175-198.

KUZUCUOĞLU C., FONTUGNE M., KARABIYIKOĞLU M. & HATTÉ C. (1999b) - *Evolution de l'environnement dans la plaine de Konya (Turquie) pendant l'Holocène.* In: Otte M. (Ed.), «Anatolian Prehistory. At the Crossroads of Two Worlds». Liège Univ., Liège, 605-624.

KUZUCUOĞLU C. (2002) - *The environmental frame in Central Anatolia from the 9th to 6th millennia BC*. In: Gerard F. & Thissen L. (Eds.), «The Neolithic of Central Anatolia», Istanbul. BIAA-IFEA-LANED, Ege Yayınları, 33-58.

LE PENNEC J.-L., BOURDIER J.-L., FROGER J.-L., TEMEL A., CAMUS G. & GOURGAUD A. (1994) - *Neogene ignimbrites of the Nevşehir plateau, central Turkey: stratigraphy, distribution and source constraints*. Journal of Volcanology and Geothermal Research, 63, 59-87.

ÖZBAŞARAN M. (2012) - *Aşıklı*. In: Özdoğan M., Başgelen N. & Kuniholm P. (Eds.), «The Neolithic in Turkey, Central Anatolia». Ege Yayınları, Istanbul, 135-158.

ÖZBAŞARAN M., DURU G., KAYACAN N., ERDOĞU B. & BUITENHUIS H. (2012) - *Musular, the 8th Millennium cal. BC site of Aşıklı*. In: Özdogan M., Basgelen N. & Kuniholm P. (Eds.), «The Neolithic in Turkey, Central Anatolia». Ege Yayinlari, Istanbul, 159-180.

ÖZDOGAN M., BASGELEN N. & KUNIHOLM P. (2012) - *The Neolithic in Turkey. Central Turkey.* Archaeology & Art Publications, Istanbul, 279 p.

ROBERTS N., BLACK S., BOYER P., EASTWOOD W.J., GRIFFITHS H.I., LAMB H.F., LENG M.J., PARISH R., REED J.M., TWIGG D. & YIĞITBAŞOĞLU H. (1999) - *Chronology and stratigraphy of Late Quaternary sediments in the Konya Basin, Turkey: results from the KOPAL Project*. Quaternary Science Reviews, 18, 611-630.

ROBERTS N., REED J., LENG M., KUZUCUOĞLU C., FONTUGNE M., BERTAUX J., WOLDRING H., BOTTEMA S., BLACK S., HUNT E. & KARABIYIKOGLU M. (2001) - *The tempo of Holocene climatic change in the Eastern Mediterranean region: new high-resolution crater-lake sediment data from central Turkey*. The Holocene, 11, 721-736.

VAN ZEIST W. & BOTTEMA S. (1991) - *Late Quaternary vegetation of the Near East*. Beihefte zum Tübinger Atlas des Vorderen Orients, Reihe A, Nr. 18., Wiesbaden.

WILLCOX G. (2012) - *The beginnings of cereal cultivation and domestication in Southwest Asia*. In: Potts D.T. (Ed.), «A Companion to the Archaeology of the Ancient Near East». Blackwell, London, 163-179.

WOLDRING H. & BOTTEMA S. (2001) - *The vegetation history of East-Central Anatolia in relation to archaeology: the Eski Acigöl pollen evidence compared with the Near Eastern environment*. Palaeohistoria, 43-44, 1-34.

ZREDA M., CINER A., SARIKAYA M.A., ZWECK C. & BAYARI S. (2011) - *Remarkably extensive glaciation and fast deglaciation and climate change in Turkey near the Pleistocene Holocene boundary.* Geology, 39, 11, 1051-1054.

(Ms. received 1 December 2012; accepted 1 March 2013)