THE UPPERMOST MIDDLE PLEISTOCENE-HOLOCENE ALLUVIAL DEPOSITS OF THE UPPER TIBER BASIN (NORTHERN APENNINES, CENTRAL ITALY): CHRONOLOGICAL CONSTRAINTS FROM ARCHAEOLOGICAL DATA

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ABSTRACT: The paper reports the results of a geomorphologic and stratigraphic study of the NW portion of the Upper Tiber Basin (Central Italy), and focuses on the terraced alluvial deposits which are grouped into late Middle-Upper Pleistocene (MUP) and Holocene (HOL) units. The drainage development in the basin was deeply influenced by an active tectonic setting characterized by orthogonal faults, which forced river deviations and attracted alluvial deposition in the subaerial portions of the basin. The occupation of this intermountain territory by ancient human communities is recorded by late Prehistoric-Protohistoric archaeological findings collected within or on the surfaces delimiting these units. This archaeological dataset allowed an indicative dating of the major stages of the fluvial evolution between the end of the Middle Pleistocene and the late Holocene. The chronological constraint indicates that the morpho-stratigraphic events recorded in the MUP and HOL units, have reasonably occurred within the two last glacial-interglacial cycles. Rapid climate changes, affecting the surface hydrology and the sediment supply to the river systems, and the active tectonic setting, thus, may account for the gaps in the local archaeological record, including most of the late Paleolithic, the Mesolithic and the early Neolithic. Late Pleistocene and the early Holocene stages of relevant alluvial deposition in a subsiding basin may have caused the burial of the missing cultural stages or may have prevented the human occupation of hydraulically unsafe valley floors.

Keywords: Alluvial terraced deposits, Intermontane basin, Archaeology, Middle Pleistocene-Holocene, Central Italy.

1. INTRODUCTION

Despite several techniques are suitable for the geomorphologic calibration of the Quaternary successions (Walker, 2005), a major problem in the study of terraced alluvial deposits is frequently represented by their dating. Nevertheless, temporary or stable human settlements have occupied alluvial plains, especially during the Late Quaternary. This is testified by archaeological remains spanning the late prehistorical-historical cultural stages. The Geoaarchaeology of alluvial plains (Brown, 1997; Woodward & Huckleberry, 2011), thus, may provide suitable tools for analysing the dynamics of these environments induced by concurrent natural and anthropic processes. In the Northern Apennines (Central Italy) terraced fluvial deposits occurring in several intermountain basins (Fig. 1a), are ascribed to the late Quaternary on the basis of the distribution and dating of archaeological remains.

In this paper we present the spatial and stratigraphic distribution of terraced alluvial deposits in the intermountain Upper Tiber Basin (NE Tuscany, Central Italy) referred to the latest Middle Pleistocene-Holocene on the base of the distribution and dating of archaeological materials collected in the last decades.

2. REGIONAL SETTING

The study area is located in the upper reach of the Tiber River, barred by the Montedoglio Dam and including the tributaries Singerna, Sovara, Tignana and Afra creeks. This is a portion of the Upper Tiber River basin (UTB, Figs. 1, 2), a NW-SE trending intermountain depression about 21 km long and 10 km wide, flanked by steep hills composed of Miocene turbiditic sandstones (Tuscan and Umbro-Marchean units respectively) to the NNE and SSW and Jurassic-Eocene ophiolites, limestone and marls (Ligurid units) to the NNW. The basin is bounded by the Alto Tiberina Fault along the SW shoulder (ATF, Figs. 1b, 2) and by the antithetic Sansepolcro Fault on the opposite side (SaF in Fig. 2; Baroni & Ciacci, 2004). The NW-SE elongated Anghiari-Citera hills are delimited toward the Tiber plain by the ATF-synthetic Anghiari Fault and cross-cut by NE-SW trending faults (Fig. 2). A portion of a basin fill about 1,000 meters thick (Sani et al., 2009), is exposed on the flanks of these hills (Benvenuti, 1989; Cattuto et al., 1995; Pialli & Plesi, 2009), consisting of 150 m thick Lower-Middle Pleistocene alluvial gravels, sands and subordinated...
muds subdivided in this study into four main units (Fig. 2; Tab. 1). The older, Monterchi-Citerna-Fighille unit (MCF, Fig. 2), includes final lower Pleistocene floodplain-palustrine sands and muds (MCF1) (Ciangherotti & Esu, 2000; Argenti, 2003-2004) erosively overlain by early Middle Pleistocene fluvial arenaceous-calcareous gravels, sands and muds (MCF2) (Benvenuti, 1989). The MCF unit is tilted against the ATF (cross section in Fig. 2; Sani et al., 2009) and unconformably overlain by the Anghiari unit (ANG), made of Middle Pleistocene fluvial calcareous gravels (ANG1) unconformably overlain by deeply weathered fine conglomerate and sand (ANG2) (Van Waveren, 1986). The Tiber River plain is characterized by alluvial and colluvial deposits (MUP and HOL units, Fig. 2) that are described and discussed in more detail in section 4.

3. ARCHAEOLOGICAL RECORDS

Since Prehistory and Protohistory the Upper Tiber Valley has represented a strategic connection route across the Northern Apennines divide as documented by extensive archaeological surveys (Moroni Lanfredini & Benvenuti, 2010; Fig. 2). The Middle Palaeolithic is the earliest period recorded. This is represented by stone tools collected southwest of Anghiari on the surfaces of the ANG2 unit and in the paleo-Sovara terraced deposits (MUP2 at Castel di Sorci and nearby sites, site 1 in Fig. 2; Crocchi et al., 1978; Borgia & Moroni Lanfredini, 2004, Moroni et al., 2011) attesting to the presence of Neanderthal groups for seasonal hunting and gathering. The lithic assemblages are characterized by Levallois and, subordinately, discoid production systems and include mainly side scrapers, points, denticulates (Fig. 3a-c) and rare handaxes.

The Early Upper Paleolithic is documented on the NW slopes of the basin by an Aurignacian lithic industry, very rich in burins des Vachons (Fig. 3d-e), recovered near Caprese Michelangelo (Fig. 1b) (Moroni Lanfredini & Ronchitelli, 2001), which dates back around 30 ka ago (Arrighi et al., 2006). The floodplain occupation is recorded from the Final Upper Paleolithic in the Consuma 2 site (site 2 in Fig. 2; Moroni, 1990), presently flooded by the Montedoglio lake, by a Final Epigravettian lithic assemblage dating back to around 12 ka ago, characterized by microlithic backed tools. Evidence of the human presence on the valley floor during the early Holocene is fragmentary with a missing Mesolithic stage and only few Early Neolithic findings discovered in the Tiber plain (Consuma, site 2 in Fig. 2). The Neolithic to Eneolithic (Copper Age) transition is recorded near the Tiber River (Consuma 1 and Moresco; sites 2 and 3 in Fig. 2; Castelletti et al., 1992; Moroni Lanfredini, 1995-1996), by two open-air sites which yielded pottery decorated with the Late Neolithic Chassey style and pot-shapes and handles typical of the Early Eneolithic of Central Italy. The Middle Eneolithic is currently attested by sporadic material, while the late Eneolithic/Early Bronze Age period (Vaso Campaniforme stage) is represented by the Consuma 2 and Salsastrino delle Lole sites (Fig. 3f-i) (sites 2 and 4 in Fig. 2; Moroni, 1990; Guidi & Moroni Lanfredini, 2001). The Bronze Age, particularly its middle stage, marks a period of wider occupation in the plain close to the Tiber River banks or in the narrow valleys of its tributaries. Almost the whole of the Early Middle Bronze Age sites is on the Tiber floodplain (Salsastrino delle Lole upper layer, Consuma 4, Gragnano; sites 2, 4, 5 in Fig. 2; Moroni Lanfredini & Ronchitelli, 1997; Guidi & Moroni Lanfredini, 2001). The Middle Bronze Age (Apennine phase) recorded at Gorgo del Ciliegio (site 6 in Fig. 2; Fig. 3l-m; Arrighi & Moroni Lanfredini, 2004) and around Caprese Michelangelo, points to settlements on the higher slopes. A significant
Late Quaternary Upper Tiber Basin

Fig. 2 - Detailed geological map and cross section of the study area with the location of selected archaeological sites discussed in the text: 1: Castel di Sorci; 2: Consuma 1-4; 3: Moresco; 4: Salcastrino delle Lole; 5: Gragnano; 6: Gorgo del Ciliegio; 7: Trebbio. ATF: Alto Tiberina Fault; AF: Anghiarì Fault; Ssf: Sansepolcro Fault.
Fig. 3 - Archaeological materials from the UTB: a-c) Middle Paleolithic stone tools from Castel di Sorci: a) Levallois core; b) sidescraper; c) point; d-e) Aurignacian Burins de Vachons; f-i) Late Eneolithic/Early Bronze Age flint arrowheads from various sites. The division of the graduate bar for a) to i) is 1 cm; j) the Gorgo del Ciliegio site excavated in the late summer of 2011: the semi-circular ditch and some postholes (white arrows) attests to dwelling remains, persons for scale; m) a selection of pottery from the Gorgo del Ciliegio site, the rod for scale is 20 cm long; n) an oven from the Iron Age Trebbio site, reused as a dustbin for pottery and other materials. Rod for scale is 20 cm long.
occupation of the floodplain during the Iron Age is re-
corded south of Sansepolcro by a 20-hectares wide pro-
to-urban settlement (Trebbio, site 7 in Fig. 2; Iaia & Mo-
roni Lanfredini, 2009), characterized by well-developed
handicraft activities mostly related to pottery production
(Fig. 3n).

When plotted against time, the Prehistoric-
Protohistoric archaeological record of the UTB, thus,
shows a pattern of documented cultural stages separat-
ed by quite long periods of missing or occasionally rep-
resented cultures (Fig. 4a). The calibration of artefact
assemblages mostly collected within the deposit of the
different units described below has been obtained by a
variety of methods, reported in the papers cited above,
including comparison with well-dated archaeological
materials from other Italian localities, and radiocarbon
dating of charcoal derived from the human activity.

4. GEOMORPHOLOGY AND STRATIGRAPHY OF
THE LATEST MIDDLE PLEISTOCENE-HOLOCENE
SUCCESSION

The landforms and the underlying sediments re-
furred to units MUP and HOL (Fig. 2) are briefly de-
scribed in this section providing a geomorphologic pic-
ture quite different from those represented in the exist-
gen geological maps (Jacobacci & Malatesta, 1969; Pialli
& Plesi, 2009).

4.1. MUP Unit

Landforms and deposits referred to this unit (Fig. 2)
are further subdivided in sub-units MUP1-3 on the base of
geomorphic and stratigraphic lines of evidence.

4.1.1. MPU1 sub-unit

Arenaceous-ophiolitic boulder to pebble-sized
gravels (MUP1) is exposed for few meters at a road cut
NW of Anghiari. The gravels are poorly stratified and
show a clast-supported texture with abundant sandy-
silty interstitial matrix. Clasts are rounded to well-
rounded showing an embrication hinting to paleocur-
rents from NW. This outcrop is at the base of a fan-
shaped, relief considered the evidence of a small alluvi-
al fan fed by the paleoSovara Creek that flowed from
NW to SE. A SW-NE trending fault (Carmine fault in Fig.
2) that places the ophiolites of the Ligurid Units in con-
tact with these and older Quaternary deposits of the
Anghiari hill, suggests a tectonic control on a possible
diversion of the Sovara Creek, today flowing to SW.

4.1.2 MPU2 sub-unit

Remnants of a fluvial terraced surface occur on
the right of the Sovara Creek with a wider patch near
Castel di Sorci, a few kilometers SE of Anghiari. At this
location, the terrace, standing about ten meters above
the modern valley floor, contains gravel, sand and mud
referred to the MUP2 sub-units. These deposits are af-
fected by a deep yellowish-reddish paleosol bearing
Middle Paleolithic stone implements (Fig. 3a-c; Cocchi
et al., 1978; Moroni Lanfredini & Benvenuti, 2010; Mo-
roni et al., 2011).

4.1.3. MPU3 sub-unit

The Tiber River plain between Montedoglio Dam
and Santa Fiora village is a large NW-SE trending fan-
shaped surface topographically outlined by contour lines
oriented transversally to the basin (Fig. 2). Such mor-
phology indicates an abandoned large alluvial fan pos-
sibly fed by the Tiber and/or Singerna rivers. The latter
behaved as distributive fluvial systems (Hartley et al.,
2010), that is, axial rivers flowing into a subsiding basin
that expand into terminal alluvial fans. Notably, the oc-
currence of such a large relict fan in the Tiber plain is
not detectable in the existing geological maps (Jacob-
acci & Malatesta, 1969; Pialli & Plesi, 2009), which
represent it as the active floodplain of the Tiber River
(Tab. 1). The deposits subtended by this fan-shaped
plain are referred to sub-unit MUP3 and have been par-
tially observed in a 2.5 meters deep excavation (Fig. 5a,
location on Fig. 2). From the base, the deposits consist
of about 2 meters thick clast-supported and well-
rounded arenaceous pebble-sized gravels and sand af-
fected on top by a well-developed reddish paleosol. This
is buried by medium-fine yellowish sand, 0.5 meters
thick. The buried soil suggests that the fan remained
morphologically stable for a relatively long time, later on
covered by the toe of a small alluvial fan (HOL 1 sub-
unit, see below) fed by a local stream and not by the
main Tiber River. The soil development, thus, indicates
that the fan was abandoned due to a possible feeder
deviation. The NW-SE trend of the MUP3 fan does not

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<th>Geological Map of Italy, 1:100,000 sheet 115 “Città di Castello”</th>
<th>Geological Map of Italy, 1:50,000 sheet 289 “Città di Castello”</th>
<th>This study</th>
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<td>d1 (slope talus)</td>
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<td>HOL1-3 sub-units</td>
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<td>q1 (&quot;old&quot; terraced alluvial deposits)</td>
<td>bn (teraced alluvial deposits)</td>
<td>MUP3 sub-unit</td>
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<td>q2 (terraced alluvial deposits)</td>
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<td>QT2 (fluvio-lacustrine clay, sand and gravel)</td>
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<td>MUP1-2 sub-units</td>
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Tab. 1 - Comparative scheme of the stratigraphic subdivisions adopted in this study and in the existing geological maps (Jacobacci & Malatesta, 1969; Pialli & Plesi, 2009) of the study area.
match the WSW-ENE orientation of the present Tiber valley upstream the Montedoglio Dam fitting on the contrary the proximal valley reaches of the Singerna and Tiber rivers which may represent the original fan feeders, then displaced by a NE-SW dextral fault (Montedoglio Fault in Fig. 2; see Sani et al., 2009). A few km east of San Pietro in Villa (Fig. 2), a further N-S trending fan-shaped hill faces the NW corner of the Tiber plain. Despite the lack of outcrops, the surface sediments are arenaceous and subordinate calcareous gravels indicating a thin clastic sedimentary cover on the Ligurian limestone and marlstone bedrock. This landform and the related clastic deposits are ascribed to MUP3 sub-unit and interpreted as the evidence of a further small alluvial fan originally prograding in the Tiber plain and then headed from its original fluvial feeder. The latter was the precursor of the Tignana Creek whose entrenched valley is characterized by a proximal N-S trending reach, coaxial with the San Pietro in Villa fan. In proximity of the NW prosecution of the Sansepolcro fault, the valley turns in a NE-SW trend reach. This evidence suggests that also the Tignana Creek may have diverted as the consequence of active faulting.

4.2. HOL unit

Landforms and deposits ascribed to the HOL unit (Fig. 2), occur in the lowermost and partly still active alluvial plains. This unit is further subdivided in the HOL1-3 sub-units coinciding with three distinct alluvial surfaces.

4.2.1. HOL1 sub-unit

The HOL1 alluvial plain is entrenched in the MUP and older units. The distribution of this landform in the Tiber River valley as well as in the valleys of its tributaries, testifies to the development of stream channels and adjacent floodplains upstream from the bridge between Santa Fiora village and Sansepolcro town (Fig. 2). Downstream, the HOL1, though dissected by the HOL2 and the modern river network (HOL3), widens in a surface that hints to a further Tiber alluvial fan. A lobed morphology, with a main NE-SW oriented axis, ascribed to this sub-unit characterizes also the plain of the adjacent Afra Creek, suggesting the possible coalescence of the tributary HOL1 Afra fan. The deposits subtended by these surfaces are not exposed and a partial view of the HOL1 stratigraphy derives from the excavation of the Consuma 2 site before the valley flooding upstream the Montedoglio dam (Fig. 2; Moroni, 1990). In a 3-meter deep trench excavated in deposits morphologically correlated to the HOL1 sub-unit, the lower part consisted of brownish pebble-size and clast-supported conglomerate (Fig.5b), overlain by mottled sandy mudstone with pebbly lenses on top.

Fig. 4 - Archaeology and Chronology of the UTB: a) the archaeological stages documented in the UTB and the approximate duration of the morpho-stratigraphic units. Hatched intervals refer to missed cultural stages possibly due to: 1) still not discovered materials, 2) prevented occupation of unsafe alluvial plains, 3) materials eventually buried by alluvial deposition; b) the basin stratigraphy compared with the chronostatigraphy, magnetostratigraphy and marine isotope stages of the late Quaternary.
Late Quaternary Upper Tiber Basin

Final Epigravettian stone tools (Moroni, 1990) have been found in the middle of these deposits together with isolated arenaceous cobbles. The upper part was characterized by a lag of pebble-sized conglomerate overlain by massive dark mudstone bearing late Eneolithic-Early Bronze age stone tools indicating a middle Holocene reoccupation of this river bank. At the SW margins of the Tiber plain, slope deposits and small alluvial fans developed at the foot of the Anghiari hills represent the HOL1 sub-unit. These fans, fed by the gravel-rich ANG1-2 units, evidently graded at a base level different from that of the main river network. The inferred activity of the Anghiari fault (Delle Donne et al., 2007) and the confinement of the MUP3 fan lobe, concurrently determined a local topographic low for the fan deposition fed by the short and steep creeks draining the Anghiari hill.

4.2.2 HOL2-3 sub-units

In the Tiber plain the landforms and deposits ascribed to HOL2 unit point to a geomorphic development similar to that recorded by the HOL1. A river channel entrenchment widens downstream in a relatively larger plain attesting to a progressive telescopic shift toward SE of the Tiber fluvial-fan complex. Similarly to the previous unit, small alluvial fans graded to a higher base level with respect to the HOL2 plain. Notably, the alluvial fans ascribed to HOL2 sub-unit occur only SE of Santa Fiora on the left of the Tiber River. The HOL2 Afra fan is the largest one. Unit HOL3 represents the recent fluvial landforms in the plain. These are related to the narrow (and up to 5 meters deep) river valleys incised in the older units and by small alluvial fans that aggraded onto the fans of the HOL2 unit. The related deposits have been investigated in a trench excavated on the left of the modern Afra channel, about 0.9 km NE of the Trebbio site (Figs.5c; 2 site 7). The alluvial succession is composed of about 1.30 meters of mottled muddy sand with land snail shells referred to the distal portion of the HOL1 Afra fan. These deposits are overlain by 0.8 m thick lenticular gravel bed that records a HOL3 palaeoAfra channel, in turn overlain by 0.4 meter thick muddy sand representing the overbank deposits of the nearby active Afra channel.

5. THE ARCHAEOLOGICAL CONTRIBUTION TO A CHRONOLOGICAL CONSTRAINT OF MUP AND HOL UNITS

The ancient human occupation of the UTB is considered largely controlled by the alluvial dynamics recorded by the MUP and HOL units, which in turn resulted from a balance between active tectonics and climate variations. From one side the material evidence of occupation of alluvial plains is considered a proof of local reduced alluvial sedimentation and attitude to flooding, conditions that made safe the temporary and/or stable settling of human communities on these surfaces. From the other side the gaps in the archaeological record of the UTB, beside indicating still undiscovered cultural stages, may reflect: 1) sporadic and/or absent occupation of areas of active alluvial deposition such as the documented large alluvial fans or 2) sediment deposition that buried any material evidence of possible land occupation.
Under these assumptions the archaeological record, included its hiatus, may be considered for dating the depositional stages represented by the units and sub-units described above (Fig. 3a).

1) The Middle Paleolithic stone tool assemblage found within the MUP2 deposit of the Castel dei Soci terrace indicates that possibly around 130-100 ka ago Neanderthal populations moved on the Anghiarì hills flanked to SW by a terraced paleoSovara valley. The fault-controlled deactivation of the MUP1 Sovara fan was followed by the incision of a MUP2 Sovara valley trending as the present one.

2) From the Anghiarì hills Neanderthals could have seen the MUP3 fans in the plain, which were active up to the latest Pleistocene. This chronologic reference is suggested by the final Epigravettian tools, collected in the stratified Consuma 2 site, upstream the Montedoglio dam, and confidently referred to about 12 ka ago. The latest Paleolithic people occupied the left bank of the WSW-ESE trending Tiber valley evidently when the MUP3 fans would have been inactive due to the fault-controlled devi-
ation of the Singerna-Tiber and Tignana rivers. The long span of time, characterized by the missing of most of the late Paleolithic during the late Pleistocene, coincided with huge sedimentation on the Tiber alluvial fan that may have prevented a stable human occupation of the plain and/or may have buried any artefact.

3) Similarly, the missing/sporadic Mesolithic and Neolithic stages suggest that the Tiber valley floor was unsuitable for stable human occupation also during the early Holocene. The HOL1 sub-unit developed during this span of time.

4) The geomorphic setting related to less intense fluvial processes evidently determined favourable condition for a safe settling on the valley floor since the Ene-
olithnic and particularly in the mid-late Holocene when the alluvial plains were occupied by Bronze-Iron ages people. HOL 2 unit testifies to a period of renewed allu-
vial-fan development particularly in the Afa Creek plain. Here the human occupation shows a gap from the Mid-
dle Eneolithic (Moresco site) to the Iron Age (Trebbio site) which is considered an approximate duration of the HOL2 Afa fan development.

5) Finally, the large Trebbio settlement in the Afa plain is indicative of the human presence during the de-
velopment of the HOL3 sub-unit. The latter marks a pe-
riod of generalised fluvial incision in the basin and de-
finitive deactivation of the large alluvial fans, which es-
established safe hydraulic conditions on the terraced allu-
vial plains.

Despite the active tectonic setting may have re-
presented a primary factor controlling the alluvial dynam-
ics, autogenic processes of alluvial-fan deposition (Schumm et al., 1987; De Celles et al., 1991) may be not ruled out. The progressive south-eastward migration of MUP3-HOL2 alluvial fans in the Tiber plain may have also determined by channel entrenchment in response to local modification of base level induced by the fan lobes.

When compared with the Marine Isotope Stratig-
raphy (Fig. 3b), the latest Middle Pleistocene-Holocene alluvial deposits and landforms of the UTB reasonably encompass at least two major glacial-interglacial cycles including the marine isotopic stages (MIS) 7-1. The ef-
facts of these climatic changes on water discharge, sed-
iment production and transfer may have affected the geographic dynamics recorded by the MUP and HOL units. An analysis of the fluvial response to climate change during the last 200 ka in the Mediterranean Ba-

sin (Macklin et al., 2002), indicates that, despite differ-
ences related to local morpho-tectonic settings, alluvial deposition occurred particularly during glacial stages (i.e MIS6 and between the late MIS5 and MIS2). In the studied case this seems confirmed by the large MUP3 Tiber fan whose development reasonably encompasses the MIS 4-2 interval. Due to an uncertain dating of MUP1-2 sub-units, older than 130 ka, at the moment clear rela-
tions with glacial/interglacial stages cannot be estab-
lished and a partial correlation to MIS 7 and 6 is only hypothetic.

6. CONCLUSIONS

A portion of the alluvial intermontane Upper Tiber Basin and its occupation by ancient human communities have been investigated through the integration of geo-
omorphology, stratigraphy and archaeology. Not exclud-
ing intrinsic factors, alluvial deposition, recorded by the MUP and HOL units, was primarily influenced by an ac-
tive tectonic setting characterized by orthogonal NW-SE and NE-SW trending fault systems which created sedi-
ment accommodation through differential subsidence and forced river deviations through vertical and lateral displacement of faulted blocks. The spatial and chrono-

tological distribution of late Prehistoric-Protohistoric ar-
chaological findings, collected on and within these units, has allowed an indicative dating of the major stages of fluvial network modification occurred between the end of the middle Pleistocene and the late Ho-

cene. This chronologic calibration indicates that, be-
sides the active tectonic setting, the morpho-

stratigraphic events recorded in the described units have occurred within two major glacial-interglacial cy-

cles. The latter may have controlled the local surface hydrology and the sediment supply to the fluvial sys-
tems. Accordingly, gaps in the archaeological record, including most of the late Paleolithic, the Mesolithic and the early Neolithic, attest to stages of huge alluvial de-
position in a highly subsiding basin. This may have de-
termined the burial of the missing cultural stages or may have prevented any occasional or stable occupation in lowlands during the development of large alluvial fans. From a methodological point of view the integration of geological and archaeological data, adopted in this study, demonstrate the potentiality of cooperation be-
tween physical and human sciences in revealing the complex interaction of Man and Environment.

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