The Middle Paleolithic occupations of Üçağızlı II Cave (Hatay, Turkey): Geoarcheological and archeological perspectives

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The Middle Paleolithic occupations of Üçağızlı II Cave (Hatay, Turkey): Geoarcheological and archeological perspectives

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ABSTRACT

The site of Üçağızlı II is located in a partially collapsed cave on the Mediterranean coast of the Hatay region, South Central Turkey. A small intact chamber (chamber D) preserves a sequence of Middle Paleolithic deposits nearly 2 m thick. Test excavations at the site in 2005 and 2007 produced large assemblages of artifacts, vertebrate and shellfish remains. The entire sequence formed during the Upper Pleistocene, subsequent to MIS 5a. Faunal and lithic assemblages are comparatively homogeneous, consistent with the inference that the deposits formed under relatively constant environmental conditions. Micromorphological analyses reveal an abundance of combustion features and products, although the visibility of the features is locally compromised by local, small-scale bioturbation. There is evidence that the ways fires were created and maintained changed along with the intensity of occupation. Lithic assemblages most closely resemble other Middle Paleolithic assemblages from the northern Levant but there are inconsistencies with the accepted pattern of technological change over time in the Levantine Mousterian more broadly. Faunal and lithic evidence indicate that the intensity and duration of occupational events declined over time at Üçağızlı II. While there are many parallels in raw material economy with the early Upper Paleolithic of the nearby Üçağızlı I site, the Middle Paleolithic hominins may have used the coastal landscape in a different way from later Upper Paleolithic groups.

1. Introduction

The Middle Paleolithic of the Levant is central to understanding culture change and interactions of hominin populations during the Middle and late Pleistocene. Generalized changes over time in Levallois technology seem to map onto different hominin taxa (Bar-Yosef, 1998), and changes in lithic industries have been linked to the movement of human populations into and out of the Levant, perhaps in response to changing climates (Shea, 2008). Some genetic evidence even suggests that the first admixture between Neanderthals and modern humans occurred in the eastern Mediterranean region (Green et al., 2010). This hypothetical movement of populations from the south (modern humans) and the north (Neanderthals) begs a series of questions about the sources of the different groups of hominins that contributed to the Middle Paleolithic archeological record of the Levant. Unfortunately, we know much less about the prehistory of hypothetical source areas for these populations than we do about the central and southern Levant.

This paper presents results from small-scale excavations of Üçağızlı II, a Middle Paleolithic site located in south-central Turkey (Fig. 1), at the northern limit of the Levantine coastal zone. It is one of a very small number of excavated Pleistocene sites in the region, and the only Middle Paleolithic site to have been investigated systematically in more than 50 years. Although the excavation area was limited, the deposits are rich, yielding substantial samples of stone artifacts, animal bones and marine mollusk remains. The artifact assemblages of Üçağızlı II present both parallels and contrasts with the better-known evidence from the central and southern Levant. The deposits also document changing use of the coastal landscape which shows both parallels and contrasts with early Upper Paleolithic land use at the nearby site of Üçağızlı I.

2. Location and Geology

Üçağızlı II is situated along the northeastern coast of the Mediterranean Sea a few kilometers north of the modern-day border between Turkey and Syria (Fig. 1). Ecologically and topographically, this region represents the northernmost extent of the Levantine coastal lowlands, south of where they meet the Taurus Mountains and the Anatolian Plateau. The local bedrock consists of interbedded ophiolite with chert and serpentinized perodotite, overlain by a thick platform of Cretaceous, Paleocene and Eocene limestones (Al-Riyami and Robertson, 2002). The underlying ophiolote and serpentinite are exposed to the north of the

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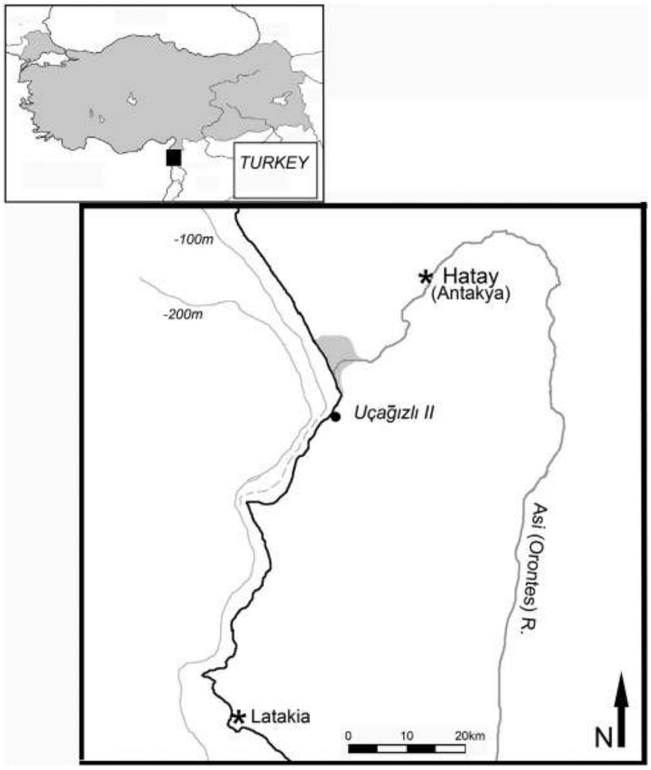

Fig. 1. Location of Üçağızlı II. Gray shaded area shows approximate boundaries of the contemporary Asi (Orontes) river delta.

cave. Typical karstic dissolution augmented in places by coastal karst processes has produced hundreds of small and large caves along the coast. Quite a few of the larger chambers visible today are collapsed, including the main chambers at both the Üçağızlı I (early Upper Paleolithic) and Üçağızlı II sites. The area around the sites is neotectonically active (Pirazzoli, 2005; Rukieh et al., 2005; Doğan et al., 2012; Florentin et al., 2014), clearly evident from the many uplifted marine terraces and sea caves along the coastline. A series of short, very steep drainages run perpendicular to the coastline.

The Üçağızlı II site is situated at the juncture of two very different sorts of landscape. The site itself is located within a steep "rock coast". The topography plunges from an elevation of 1709 m at the summit of Mt. Aqraa (Kel Dağ) to sea level over a horizontal distance of only 3.2 km. A short distance to the north, the delta at the mouth of the Orontes (Asi) river has produced a low coastal plain roughly 7 km long and up to 3 km deep (Fig. 1). The delta plain would of course have been more extensive during periods of low sea level. The boundary between the delta and the rocky coast is 1–2 km north of the site. These diverse topographic zones would have given prehistoric foragers ready access to a wide range of habitats and environments, from the littoral and coastal marshes, dunes and plains to steeply eroded mountain slopes and the irregular plateau formed atop the limestone platform to the east and north, all within a radius of 10 km.

Üçağızlı II occupies the south edge of a 45 m-wide cove situated on a limestone wave-cut shore platform that is slightly less than 7 m above current sea level (Fig. 2). Most intact archeological sediments are preserved within a small (~56m^2) narrow karstic chamber (D) that is presently about 11 m above sea level. Immediately adjacent to this chamber are the remains of a much larger collapsed cave system, including two large collapsed chambers (A and B) as well as a smaller active chamber (C) that is nearly buried by colluvium from the slopes above. Reddish sediments containing bones and flint adhere to the lower parts of the walls of the collapsed chambers indicating that archeological sediments once extended over a much larger area: no more than 10% of the area originally available for occupation is preserved today. At its base the cemented terrestrial sequence grades into a sequence of beach deposits consisting of coarse sands and cobbles. This beach layer once extended across the entire width of the wave-cut platform although only patches of it remain today. Archeological deposits were protected from erosion only in the small lateral chamber (D) where excavation took place. Interbedded archeological materials and flowstones along the walls of chamber A show that the karst was active during at least the later part of the hominin occupations.

Chamber D at Üçağızlı II is less than 5 m wide at its broadest point and approximately 14 m long. The chamber opens to the NNW, where a steeply eroded slope just outside the current dripline and an artificial rock wall truncate the deposits. The chamber narrows sharply at its southern end, continuing as a narrow tunnel, much too small to enter, for some distance. Although Chamber D is narrow, a sequence of archeological deposits almost 2 m deep is preserved within it. Horizontal flowstones adhering to the wall on the west side of the chamber above the present ground surface indicate that the upper part of the sequence has been lost to erosion.

3. Excavation and stratigraphy of Üçağızlı II

Dr. A. Minzoni-Deroche discovered and named the site of Üçağızlı II during a survey of coastal caves in the Hatay region in the 1980s. It is less than 0.5 km from the Üçağızlı I Upper Paleolithic site (Kuhn, 2004; Kuhn et al., 2009) but is not part of the same karstic system. We relocated the site in the course of excavations of Üçağızlı I. Until 2005 local shepherds were using chamber D as a seasonal goat pen, and the surface was covered with a thick layer of compacted dung. The only archeological deposits evident at the time consisted of the rim of cemented sediments adhering to the walls of collapsed chambers A and B. However, sometime in 2004/2005 clandestine excavators dug a large pit deep in the back of chamber D. The presence of numerous animal bones and flake tools in the heaped-up sediments, and lenses of what appeared to be ash and charcoal in the walls of the pits showed that the site contained rich subsurface archeological deposits. Test excavations were initiated in order to document the stratigraphic and archeological sequence in the site before it could be destroyed completely by illegal excavators.

We initially excavated a 1×2 m test trench near the middle of chamber D at Üçağızlı II to evaluate the condition of the deposits and the depth of the archeological sequence. This trench was subsequently backfilled. In 2007 the trench was re-exposed, and enlarged to just over 2×2 m. The second phase of test excavation was necessary to increase sample sizes of archeological materials and collect samples for dating and geological studies.

Because this was an exploratory rescue excavation, rapid and efficient excavation was the highest priority. During the excavations sediments were collected from within quarter squares (0.5×0.5 m) and arbitrary 5 cm cuts excavated within geological or anthropogenic layers. It was easier to follow layers in the second phase of the project once there was already a profile to work from. All sediments were carefully dry-sieved through 3–4 mm mesh. As a result of these methods we feel confident that larger artifacts and bone fragments (>0.5 cm) are well sampled, but very small fragments and remains of microfauna are certainly under-represented.

During excavation the archeological deposits were divided into four main layers, A–D, based on differences in soil color and texture (Fig. 3).

Layer D consists of coarse sand with rounded limestone cobbles and occasional wave-worn shells. The sand is strongly cemented with carbonate in places, and the degree of cementation increases with depth. Layer D appears to correlate with the beach rock exposed outside the mouth of the chamber, and so may be several meters thick.

Layer C is a deposit of dark brown, silty-clay loam 30–40 cm thick. It is sandier just above the contact with layer D, probably a result of reworking of sediment from the underlying deposits. The boundary between layers C and D is sharp but undulating.

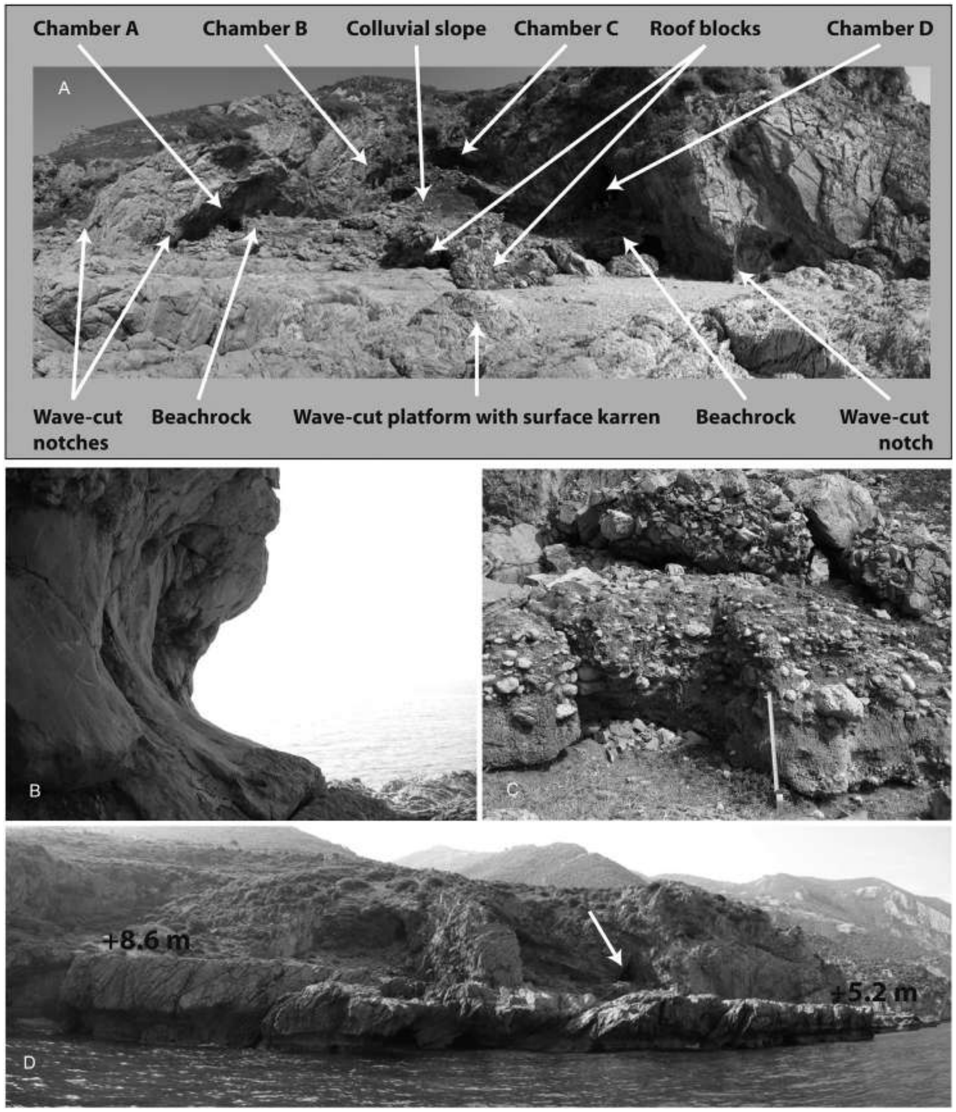

Fig. 2. Geomorphic features in and around Üçağızlı Cave II. A) View of the site looking southeast. Üçağızlı Cave II is a remnant of a collapsed cave system comprised of at least four chambers. Portions of the vaults of chambers A and B are visible along the east wall of the site. Chamber C is still active today, but is almost entirely buried by a locally brecciated colluvial deposit that post-dates the collapse of chambers A and B. Large roof blocks are also present. Archeological materials are preserved in cemented deposits along the east wall of Chamber A, within chamber D, and on top of beachrock just outside of the entrance of chamber D. Geomorphic features associated with a former high and stable sea level include wave-cut notches, beachrock (cemented beach deposits), and a wave-cut platform with surface karren and dissolution pans on its surface. B) Detail of a wave-cut notch, approximately 50 cm in vertical height, located on the east side of the site. The elevation of this feature is 6.9 m a.s.l. The elevation of the notch on the west side of the site is 5.3 m a.s.l. C) Photograph of a remnant of the beachrock that filled chambers A and D. The elevations of the upper surface of this deposit range from 9.7–9.5 m a.s.l. on the east wall of the site to 8.1–7.8 m a.s.l on the west wall. The scale is 50 cm. D) Viewed from the sea, it is apparent that neotectonic activity postdated the high and stable sea level. Tectonic movement tilted the formerly horizontal surface of the wave-cut platform (surface elevations indicated) and associated notches and beach deposits. Earthquakes may have contributed to the collapse of the karstic system, facilitating erosion of the majority of the beach deposits and overlying archeological materials. Chamber D is indicated by the arrow. The cavity visible to the east of the site is formed within terrestrial breccia. Sea caves, and several Holocene notches are visible at and above the present sea surface.

Layer B is a deposit of brown silty clay loam approximately 120 cm thick, locally cemented. The contact with layer C is sharp. During the initial testing a sub-layer, named B′, was identified based on changes in the level of cementation and frequency of combustion features. However, the distinction between B and B′ was less apparent in the 2007 excavation. Because it is so thick, layer B was arbitrarily divided into upper (Bu) and lower (Bl) zones at a depth 105 cm below datum.

Layer A consists of the uppermost 10–25 cm of sediment remaining in the chamber today. The sediment is more yellow in color and less thoroughly compacted than the underlying deposits. Where visible the contact between A and B is sharp but irregular, but it has been obliterated over much of the trench by a recent pit which cuts through layer A into layer B.

Layers A–C are quite homogeneous sedimentologically. They differ only in the relative proportions of anthropogenic and geogenic inputs, sediment color and levels of cementation. Layers A–C are all highly anthropogenic, with large quantities of combustion byproducts, bones, flint and shell. The combination of low rates of geogenic deposition and burrowing activity by insects and small vertebrates has served to homogenize the deposits over a vertical scale of centimeters, eliminating most evidence of individual episodes of deposition. Layer D, the marine sand and gravel deposit, is predominantly geogenic in origin. Artifacts and bones from layer D were confined to the zone just below the contact with layer C. They probably represent material reworked into the top of the otherwise archeologically sterile beach sand.

Evidence of fires is abundant in layers B and C in Üçağızlı II (Fig. 3). Combustion features such as hearths and ash layers are best preserved in layer B, where thick, sub-horizontal lenses of ash, charcoal and burned bones are visible in section (Fig. 3). In layer C the evidence for combustion is more diffuse: it is obvious in micromorphology thin

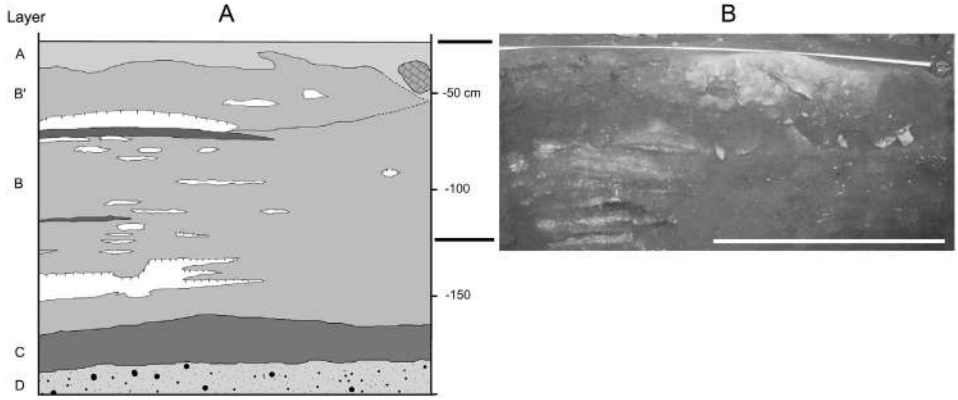

Fig. 3. Stratigraphy Üçağızlı Cave II. A: Schematic profile of south profile of excavation trench. B: photograph of top 1 m of south profile of excavation trench showing pit (upper right) and stacked combustion features (lower left) (white bar = 1 m). Note that profile in photograph (B) is one m north of drawn profile (A): they do not portray exactly the same package of sediments.

sections but is not visible macroscopically except for the abundant fine charcoal particles that make the sediment darker than the overlying units. Even within layer B the visibility of ash layers varies laterally at the scale of decimeters. Ash lenses are preserved toward the middle of the chamber but are not evident closer to the cave walls. Traces of ash, charcoal and burned bones and stones can be observed in thin sections even where distinct features are not apparent in freshly-cleaned stratigraphic profiles. Most of the archeological deposits at Üçağızlı II are relatively dense, so despite the small area of the excavation of just over 4 m^2, substantial assemblages were collected from all major stratigraphic units except layer D. However, densities peak in the lower part of layer Bl and C.

Uranium series dates (Table 1, Fig. 4) provide rough chronological constraints for the occupations of Üçağızlı II. Sample U2-S2 was collected from a flowstone formed directly on top of beach rock along the eastern wall of the collapsed chamber A. The age, 75,287 +/− 461 years BP suggests that the beach deposit underlying the archeological deposits was formed near the end of the MIS 5a high sea stand. A roughly projected elevation of this high-stand, accounting for local uplift rates (Bridgland et al., 2003, Demir et al. 2004) is close to modern sea level, which is consistent with similar features in other parts of the central and western Mediterranean (e.g., Ambrosetti et al., 1972, Butzer and Cuerda, 1962, Dorale et al. 2010), but higher than the global value (Dumas et al., 2006, Schellmann and Radtke, 2004).

Two other U/Th dates were obtained from flowstones situated above the beach deposit and intercalated with cemented archeological deposits (U2-S1, U2-S4) on the eastern wall of collapsed chamber A. The ages of these samples indicate that the cave was occupied until at least 42,091 +/− 1689 years BP. The U/Th ages for these two samples overlap with calibrated radiocarbon ages for the earliest Upper Paleolithic occupations of Üçağızlı I cave (Kuhn et al., 2009). Unfortunately, the archeological materials contained within associated brecciated deposits are too sparse to attribute them to either a Middle or Upper Paleolithic occupation.

Two speleothem carbonate samples were also collected from within the excavated chamber D (U2-S0, U2-S3). Both came from a thin, horizontal flowstone adhering to the west wall of the chamber. The U/Th ages place the formation of this flowstone, which is situated ca. 11 cm above the top of the Middle Paleolithic deposits, between 21.5 and 24.2 ka, well after the end of the Middle Paleolithic in Eurasia. These results suggest that some thickness of deposit has eroded from the top of chamber D.

4. Archeological findings

4.1. Faunal evidence

Remains of vertebrates and marine mollusks are common throughout the layers A–C in Üçağızlı II (Stiner, 2010). As is typical of the Middle Paleolithic in the Mediterranean, remains of terrestrial ungulates dominate the fauna (Table 2; Supplemental Table 1). Out of a total of more than 8050 identified specimens (NISP), 6084 specimens are attributable to small, medium and large ungulates (Tables 2, 3). The sample also includes remains of both small and large carnivores, small vertebrates (mammals, birds and reptiles) and abundant fragments of large mollusk shells. The Üçağızlı II fauna is exclusively anthropogenic. Remains of carnivores are scarce, and evidence for gnawing is practically nonexistent. Cut-marked bones are quite numerous by contrast, as has been previously documented (Stiner et al., 2009).

The spectrum of taxa represented is fairly consistent across the stratigraphic sequence in Üçağızlı II. The range of ungulate species is comparatively broad, with seven genera represented. In all layers, the three most common ungulates are fallow deer (*Dama mesopotamica*), wild goat (*Capra aegagrus*), and roe deer (*Capreolus capreolus*). By themselves, *Capra* and *Dama* account for between 52% and 68% of the ungulate remains in every layer. Larger ungulates such as red deer (*Cervus elaphus*) and aurochs (*Bos primigenius*) are also present in every level but in much smaller numbers. There is a single rhinoceros tooth from layer B′. Carnivore remains are present in small numbers throughout the sequence, with fox being the most abundant carnivore in terms of NISP, followed by bear (both *U. arctos* and *U. spaelaeus*), wolf, lynx and

Table 1
Uranium series dates from Üçağızlı II.[1]Samples processed by Dr. J. Rink, N. Robinson and J. Thompson at Macmaster University. Isotopic measurements by Dr. Brieuc le Fevre at the GEOTOP Laboratory, University of Quebec, Montreal. [2]Sample processing and isotopic measurements by Dr. Y. Asmerom and V. Polyak, University of New Mexico.

Sample	Elevation above beach	^{238}U ppb	^{232}U ppt	$^{230}Th/^{238}Th$ activity ratio	$^{230}Th/^{238}U$ activity ratio	Measured $\delta^{234}U$ ($^{0}/_{00}$)	Initial $\delta^{234}U$ ($^{0}/_{00}$)	Uncorrected age (years BP)	Corrected age (years BP)
U2-S0[1]	>200 cm	165 ± 0.2	246 ± 1.4	409.774 ± 8.251	0.200 ± 0.004	Not reported	Not reported	24,212 ± 532	Not reported
U2-S1[2]	40 cm	471 ± 1	71,063 ± 181	7.86 ± 0.04	0.388 ± 0.002	41.4 ± 0.7	47.0 ± 0.9	50,756 ± 342	46,478 ± 2144
U2-S2[2]	10 cm	556 ± 1	5424 ± 66	155.94 ± 1.97	0.498 ± 0.002	−3.1 ± 0.8	−3.8 ± 1.0	75,572 ± 440	75,287 ± 461
U2-S3[2]	213 cm	321 ± 1	16,837 ± 145	10.80 ± 0.13	185 ± 0.002	36.3 ± 1.3	38.4 ± 1.3	21,477 ± 200	19,998 ± 763
U2-S4[2]	2–25 cm	590 ± 1	69,258 ± 202	9.13 ± 0.05	0.350 ± 0.002	27.3 ± 0.9	27.3 ± 0.9	45,454 ± 268	42,091 ± 1689

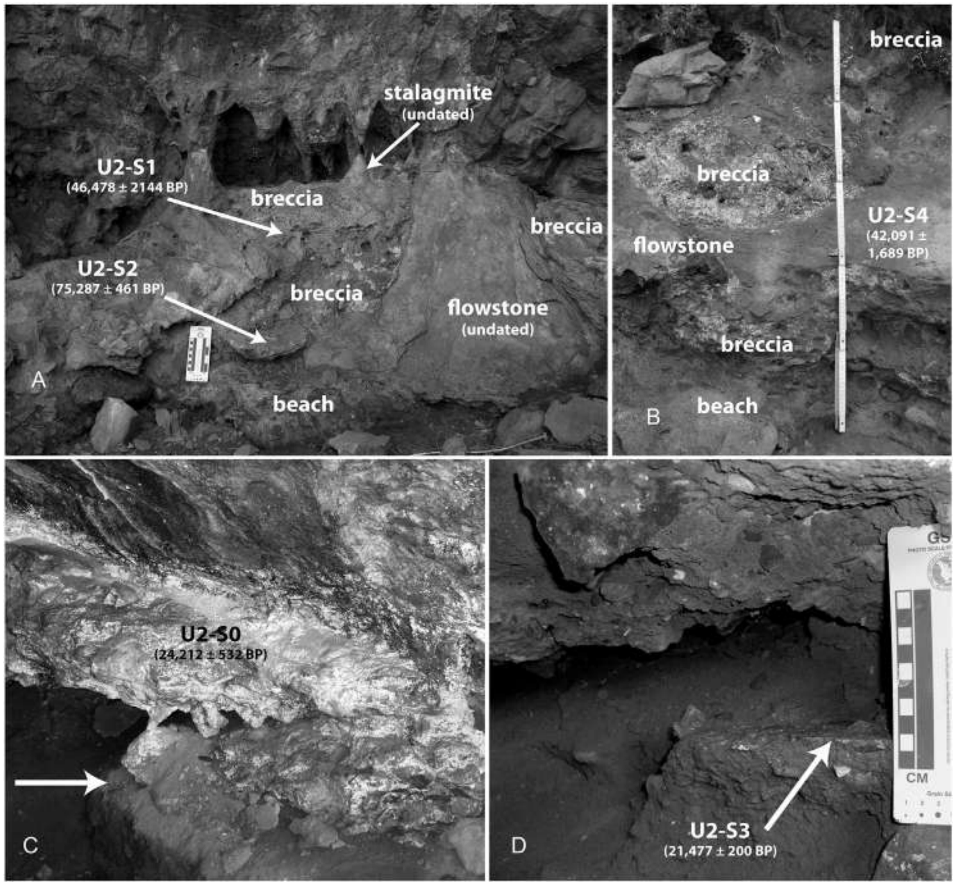

Fig. 4. Locations and situations of speleothems sampled for uranium-series dating. A) A sequence of beach deposits, flowstones, stalagmites, and archeological materials embedded in terrestrial breccia is present along the east wall of chamber A. Two of the dated flowstones are visible in this photograph. Flowstone U2-S2 provides a minimum age for the archeological materials in chamber A, and a maximum age for the beach deposit. Additional flowstones and a capping stalagmite remain undated. B) In this locality, terrestrial sediments containing archeological materials are directly on top of the beach deposit. An overlying flowstone (U2-S4) provides a minimum age for these materials, and a maximum age for brecciated sediments above. C) Horizontal flowstones are present along the west wall of chamber D. These horizontal features formed during the last glacial maximum on top of one or more former sediment surfaces, as evidenced by archeological materials embedded in their bases. Although these features postdate the archeological deposits, they do provide maximum ages for one or more phases of erosion that removed at least 10 cm of sediment from the site. The 2005 ground surface is indicated by an arrow. The 2005 and 2007 trench did not extend beneath the flowstones due to cementation of the sediment. Future excavations targeting this area could expose earlier phases of flowstone formation. D) Flowstone U2-S3 is stratigraphically beneath both flowstone U2-S0 and archeological materials embedded in cemented sediment. This relationship suggests that a phase of erosion postdates flowstone U2-S0, and that U2-S3 formed on top of an erosional surface.

hyena (Tables 2 and 3). Cut marks, breakage patterns and burning damage indicate that the small carnivores were hominin prey.

There are some minor fluctuations in the abundance of ungulates species through the stratigraphic sequence (Table 7). *Dama* is more common than *Capra* in A, B′ and Bu, whereas these species occur in nearly equal proportions in Bl and C-D (Table 4). Note that the two earliest layers are combined due to small sample sizes. Frequencies of *Capreolus* are consistent except for layers C–D, where they are lower. The most conspicuous anomaly in species abundance concerns the suid remains in layers C–D. About 27% of the identifiable bones in the lowermost layers belong to *Sus*, whereas this species accounts for less than 9% in subsequent assemblages. The fact that both suids and caprids are most abundant in layers C-D is interesting in that the former are generally associated with forested conditions whereas the latter prefer more open and possibly upland slopes. However, the sample of specimens identifiable to a species in layers C–D is only 187, so it is possible that the elevated abundances of caprid and suid remains are simply artifacts of sampling.

The assemblages of small vertebrate prey from Üçağızlı II are dominated by tortoise bones (*Testudo graeca*). Identified small mammals are limited to a few bones of hedgehog (*Erinaceus* sp.), hare (*Lepus capensis*) and porcupine (*Hystrix* sp.). Bird bones are very rare, highly fragmented and impossible to assign to genus or species.

As in many other Mousterian sites situated near the Mediterranean littoral, the inhabitants of Üçağızlı II collected marine mollusks as food. The abundance of shellfish parallels the abundance of bone and lithics over the stratigraphic sequence. The most common mollusk species include edible turban or top shells (*Monodonta turbinata* and *M. lineata*) and limpets (*Patella* spp.). The same species are found in early Upper Paleolithic faunas at Üçağızlı I cave (Stiner, 2010). The whole *Patella* shells from the Middle Paleolithic layers at Üçağızlı II are much larger than the shells from the neighboring Upper Paleolithic sequence at Üçağızlı I. A taxonomic shift is unlikely, and so the explanation must lie with changes to the marine environment and/or an increased intensity exploitation by humans in the later period.

Overall the array and proportions of prey species are much more consistent among Mousterian layers at Üçağızlı II than they are across the Upper Paleolithic sequence at Üçağızlı I cave (Kuhn et al., 2009; Stiner, 2010). In the early Upper Paleolithic at Üçağızlı I the relative abundances of caprids and fallow deer vary in a cyclical, complementary manner, perhaps tracking changes in local temperature and rainfall associated with Heinrich events 3 and 4. The more consistent array of species at Üçağızlı II suggests that the entire sequence of deposits under consistent environmental conditions. The archeological layers at Üçağızlı II began accumulating on top of a reworked marine beach that formed before 75 ka, based on the date of the flowstone capping

Table 2
Taxonomic representation of faunal remains at Üçağızlı II. Vertebrate counts are NISP. Shellfish remains are tabulated as MNI for comparability. Categories such as "large ungulate" or "Cervidae" refer to specimens that can be assigned to size class or general taxonomic grouping only.

Taxon	A	B′	Bu	Bl	C–D
Slow small game					
Shellfish	159	380	489	626	123
Testudo graeca	10	16	25	66	11
Quick small game					
Lepus capensis	1	1	0	0	0
Erinaceus sp.	0	1	0	2	1
Small mammal	1	1	0	10	0
Birds (large)	1	0	3	0	0
Histrix cristata	0	0	0	1	1
Ungulates					
Dicerorhinus hemitoechus?	0	1	0	0	0
Bos primigenius	2	13	5	13	3
Large ungulate	2	7	18	23	10
Cervus elaphus	3	5	9	68	4
Cervidae	5	7	15	56	13
Dama mesopotamica	85	258	295	458	49
Sus scrofa	22	36	67	122	51
Capra aegagrus	67	120	218	473	49
Medium ungulate	75	360	519	1128	145
Capreolus capreolus	67	127	213	402	31
Small ungulate	13	31	62	207	26
Carnivores					
Small carnivore (indet.)	0	0	1	3	0
Vulpes vulpes	2	2	4	13	0
Lynx lynx	0	1	4	1	0
Hyaenidae	0	0	1	0	1
Canis lupus	0	1	0	6	0
Ursus arctos	1	5	6	6	0
Ursus spelaeus	0	0	0	0	1
Large carnivore (indet.)	1	0	2	0	0
Total	517	1373	1956	3684	519

the beach. The rich array of ungulate species and the moderate abundance of both fallow and roe deer throughout further suggest that local environments were at least partly wooded, while the presence of caprids throughout indicates that the foraging radius of the Middle Paleolithic inhabitants also incorporated steeper, more sparsely-vegetated terrain. Tentatively we would place the Mousterian occupation in the comparatively temperate, early part of MIS 3, sometime between 60 ka and 50 ka.

The fact that shellfish are common throughout the sequence suggests that the coastline was never far from Üçağızlı II. It is difficult to reconstruct Pleistocene shorelines in the area surrounding the site. Estimated rates of coastal uplift in the area vary widely, perhaps reflecting differential uplift of individual fault blocks (e.g., Bekaroğlu, 2012, Doğan et al., 2012, Florentin et al., 2014). However, on a modern bathymetric map (Hall, 1981) the 100 m sea-floor contour is about 0.75 km from the present-day shore-line in front of the cave, and the 200 m contour is between 1.5 and 1.9 km away (see Fig. 1). Add to that estimated rates of uplift ranging between 0.34 and 1.19 mm/yr. in different sections of the coastline (Doğan et al., 2012, Florentin et al., 2014) and it is clear that Üçağızlı II would always have been within one km or so of the sea during even the coldest parts of MIS4 and 3, and therefore a convenient location for marine foraging.

Table 3
Proportions of major classes of faunal remains. Vertebrate counts are NISP. Shellfish remains are tabulated as MNI for comparability.

Faunal group	A	B′	Bu	Bl	C-D
Shellfish	0.308	0.277	0.250	0.170	0.237
Tortoise	0.019	0.012	0.013	0.018	0.021
Birds & small mammals	0.006	0.002	0.002	0.004	0.004
Large ungulates	0.008	0.015	0.012	0.010	0.025
Medium ungulates	0.498	0.573	0.574	0.626	0.599
Small ungulates	0.155	0.115	0.141	0.165	0.110
Small carnivores	0.004	0.002	0.005	0.005	0.000
Large carnivores	0.002	0.004	0.005	0.003	0.004
N	516	1372	1956	3684	519

Table 4
Proportions of ungulate taxa, NISP. Only specimens identifiable to the specific level are included.

Taxon	A	B′	Bu	Bl	C–D
Bos primigenius	0.008	0.023	0.006	0.008	0.016
Cervus elaphus	0.012	0.009	0.011	0.044	0.021
Dama mesopotamica	0.346	0.462	0.366	0.298	0.262
Sus scrofa	0.089	0.064	0.083	0.079	0.273
Capra aegagrus	0.272	0.215	0.270	0.308	0.262
Capreolus capreolus	0.272	0.227	0.264	0.262	0.166
N	246	559	807	1536	187

4.2. Lithic assemblages

Nearly 20,000 lithic artifacts were collected from the small excavation trench at Üçağızlı II. This total includes 1814 retouched tools and Levallois flakes, 370 cores and core fragments, 2726 large flakes (>25 mm) and 14,803 chips, chunks and fragments (Table 5). Almost all artifacts recovered were manufactured from flint. Middle Paleolithic tool makers exploited several different varieties of flint, which vary in color, texture, grain-size and flaking quality. Many of the common varieties of flint could be collected both from primary outcrops located 10–15 km away on the plateau north and east of the site and from fossil or active beaches located closer to the coast (see Kuhn, 2004). Active beaches around the site today contain only calcareous rocks, but fossil beaches on uplifted terraces also contain flint pebbles. We have no way of knowing whether a particular specimen was obtained from a primary or secondary source unless it preserves cortex on its dorsal surface. Where cortex is present it is simple to distinguish the chalky rinds of cobbles from primary outcrops from the distinctive frosted, pitted outer surfaces of beach pebbles. Chert nodules are also present in the limestone exposed in the vicinity of Üçağızlı II, but the chert has very unpredictable fracture and this material was not exploited systematically.

Overall there is considerable technological homogeneity among the assemblages from layers A-C at Üçağızlı II cave: the assemblage from layer D is too small to characterize, and it probably derives from the earliest part of layer C anyway. All of the large assemblages contain a range of core forms, but blank production is predominantly Levallois in character (Fig. 5). Roughly 2/3 of cores which were complete enough to

Table 5
Basic composition of lithic assemblages by layer. Type of cortex (pebble, non-pebble) indicated.

Layers		Retouched tools	Utilized pieces >2.5 cm	Core	Debris <2.5 cm
A	Total	280	311	42	1287
	Pebble	44	105	25	192
	Non pebble	13	25	4	69
B′	Total	357	370	46	2318
	Pebble	50	122	22	250
	Non pebble	24	30	8	113
Bu	Total	434	514	45	3215
	Pebble	63	216	27	348
	Non pebble	24	37	3	141
Bl	Total	550	1109	163	5238
	Pebble	79	465	108	994
	Non pebble	27	75	19	251
C	Total	185	403	72	2649
	Pebble	9	81	21	197
	Non pebble	14	65	23	225
D	Total	8	19	2	96
	Pebble	1	4	0	6
	Non pebble	1	2	0	11

identify are Levallois cores, and between 29% and 52% of retouched tools are made on Levallois blanks. Non-Levallois cores are also present in all assemblages. The most common non-Levallois specimens are unifacial centripetal cores: these resemble Levallois cores but lack the full array of attributes such as platform preparation or intentional control of lateral and distal convexities. True discoid cores, with steeply-inclined faces and flakes removed tangentially, are uncommon in the assemblages.

Strategies for core preparation and exploitation are also fairly consistent throughout the Üçağızlı II sequence. Table 6 shows the ranges of core forms in the Üçağızlı II assemblages. Multiple patterns of core exploitation are represented in each assemblage. When classified in terms of the last Levallois face exploited, unidirectional exploitation (Fig. 6) is the most common in all layers, followed by centripetal (Fig. 7) and bidirectional. Except in layer Bu, centripetally-exploited cores make up between 21% and 28% of Levallois cores in all assemblages. Patterns of exploitation of non-Levallois cores contrast with those of Levallois cores. Prismatic or pseudo-prismatic cores with one or two striking platforms are comparatively scarce throughout the sequence.

Although Levallois production is common throughout the sequence, Levallois products *sensu lato* are somewhat more abundant in the lower part of the sequence. A larger proportion of tools are made on Levallois blanks in layers C and D than in layers A and B. Likewise, the proportion of Levallois cores within the total core assemblage increases with depth. Although uni- and bi-directional Levallois cores are common, products are only moderately elongated. Morphological blades (L = >2 W) are always less than half as abundant as flakes, whether Levallois or non-Levallois. Levallois points and pointed flakes are abundant in some layers, though typical Levallois point cores are rare.

Interestingly, while dorsal scar patterns on flakes do show a similar level of consistency across layers, the proportion of unidirectional and multi-directional scar patterns are reversed from the cores. In all layers, the largest plurality if not the outright majority of flakes, Levallois and non-Levallois, show orthogonal or multi-directional dorsal scars, more

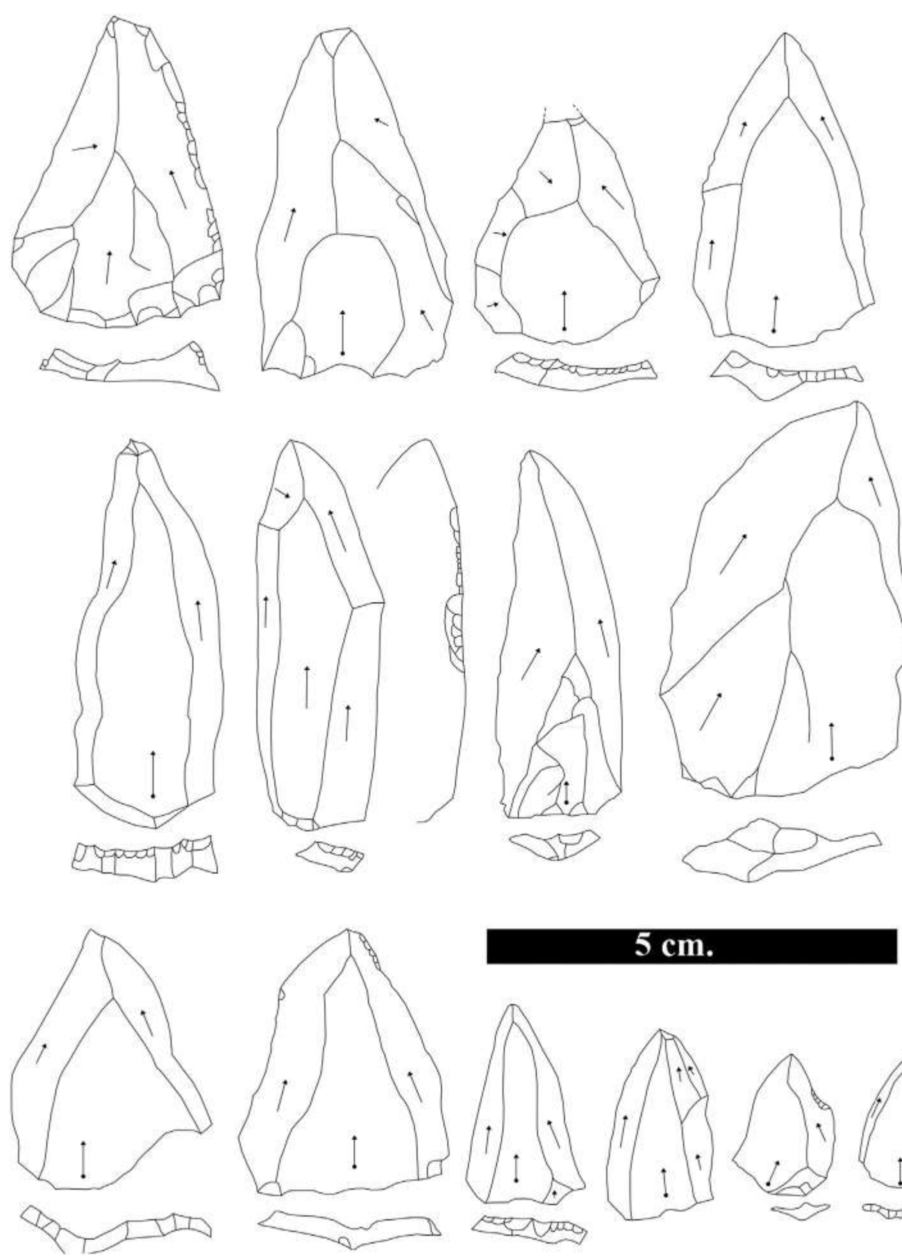

Fig. 5. Levallois flakes, blades and points.

Table 6
Core forms.

	Layer A		Layer B′		Layer Bu		Layer Bl		Layer C		Layer D	
	N	%	N	%	N	%	N	%	N	%	N	%
Levallois cores												
Bidirectional	2	11.1	3	23.1	3	13.6	20	19.4	11	25.6	1	100
Unidirectional	11	61.1	7	53.8	13	59.1	56	54.4	22	51.2		
Unidirectional preferential					5	22.7			1	2.3		
Centripetal	5	27.8	2	15.4	1	4.5	24	23.3	9	20.9		
Centripetal preferential			1	7.7			2	1.9				
Point core							1	1.0				
Total	18		13		22		103		43		1	100
Non-Levallois cores												
Tested	5	38.5	5	27.8	3	21.4	7	20.0	6	50.0		
Unifacial	4	30.8	8	44.4	5	35.7	9	25.7				
Discoid	2	15.4	2	11.1	1	7.1	2	5.7	1	8.3		
Bifacial							2	5.7				
Single prismatic	1	7.7			2	14.3	8	22.9	1	8.3		
Bipolar							1	2.9	1	8.3		
Amorphous			1	5.6			3	8.6	3	25.0		
Polyhedron	1	7.7			1	7.1	2	5.7				
Konbewa			2	11.1	2	14.3	1	2.9				
Total	13		18		14		35		12			
Fragment cores	11		15		9		25		17		1	
General total	42		46		45		163		72		2	

typical of centripetal core preparation. Flakes with parallel dorsal scars, more typical products of uni- or bi-directional cores, are always in the minority.

One possible explanation for the discrepancy between Levallois cores and products is that there was a consistent pattern in the transformation of core morphologies as reduction progressed. We can observe only final Levallois surface, but it is well established that patterns of exploitation can change over the lifetime of a core (Baumler, 1988; Dibble, 1995; Peresani, 1995–1996). The fact that most Levallois cores show unidirectional or bidirectional preparation but most flakes and blanks preserve multi-directional dorsal scars could be explained if centripetal preparation was typically used for most core exploitation, and if knappers shifted to uni- or bidirectional strategies late in the life histories of core. However, metric data (Table 7) are not consistent with a scenario of *consistent* transformation in core morphologies with reduction. In all layers but Bu, the average dimensions of Levallois cores showing unidirectional exploitation are about as large as or larger than centripetally-worked Levallois cores. There is no consistency at all in thickness measurements. In sum, while individual cores probably were transformed from unidirectional to centripetal exploitation this was not a consistent practice. Note that we have separated out cores with overpassed final removals since these are unusually small anyway.

There are several alternative explanations for the apparent discrepancies between flake production and core exploitation in the Üçağızlı II sequence. On one hand the inconsistency may be more apparent than real. Many flakes and blades with orthogonal flake scars may have come from unipolar or bipolar cores rather than centripetal cores. Such pieces could have been removed immediately after lateral convexities were adjusted by flaking from the core edges. It is also possible that certain kinds of pieces, especially longer products of unidirectional Levallois cores, were systematically removed from chamber D, either to another part of the site or to another part of the landscape. The small area of intact sediments preserved at Üçağızlı II and the small size of the excavation trench could amplify the effects of any systematic biases in the location of activities or in the movement and disposition of artifacts. Unfortunately, we are unable to sample the majority of the site's original occupation area, most of which has been lost to erosion.

The assemblages of retouched tools are also quite homogenous throughout the Middle Paleolithic sequence at Üçağızlı II (Tables 8a, 8b). Sidescrapers (Fig. 8) and retouched points (Fig. 9) account for between 43% and 50% of retouched tools in all levels. Simple sidescrapers are always the most abundant varieties, followed by the category of points/convergent scrapers. Denticulates and notches make up between 10% and 21% of retouched pieces in the various assemblages, while "Upper Paleolithic" tool types account for between 8% and 11% of the total. Dejeté and transverse sidescrapers are scarce throughout, probably reflecting the tendency toward slightly elongated blanks. Note that a number of retouched points show inverse (ventral) basal thinning, possibly to facilitate hafting (Fig. 9).

Exploitation of artifacts and raw materials in the upper layers at Üçağızlı II was somewhat more thorough than in the lower layers. Frequencies of retouch are relatively high compared to other Levantine Mousterian assemblages, with between 17% and 40% of blanks over 25 mm in maximum dimension showing some evidence of retouch. The frequency of retouched pieces is highest in the upper part of the sequence. In layers A, B′, and Bu, between 33% and 40% of large blanks are retouched. The ratio drops off sharply, to between 17% and 20%, in the lower part of layer B (Bl) and layers C and D. The frequency of sidescrapers with multiple retouched edges varies within a narrow range (43%–49%) except in layer C where it drops to 28.8%. The frequencies of cores are also consistently higher in layers C (10.9%) and Bl (8.9%) than in layers A (6.6), B′ (6.0%) and Bu (4.5%), suggesting that there was more in situ reduction in the lower part of the sequence, more importation of large blanks in the upper layers, or both.

The use of primary and secondary sources of raw materials also varied over time at Üçağızlı II. Here the strongest contrasts are between layer C and all other layers. The proportions of nodular cortex on artifacts, which indicates the abundance of raw material obtained from primary sources located on the inland plateau, are fairly constant in layer A and in all subdivisions of layer B, varying from 20% to 32% of all specimens. Moreover, cortex characteristic of pebbles from secondary sources is more common than nodular cortex in all classes of artifact. Not surprisingly, the proportion of non-pebble cortex is lowest on cores, the sorts of artifacts least likely to have been transported substantial distances, and highest on retouched pieces, the artifacts most likely to have been carried to the site. By contrast, in layer C nodular cortex is more abundant overall, being observed on more than 53% of all cortical artifacts. Moreover, cortex from the primary sources is as abundant as or more abundant than pebble cortex in all artifact classes. The clear implication is that more raw material from the primary sources on the plateau above the site was being imported in the basal layer C.

The combined evidence from rates of retouch, frequencies of different classes of artifact, and raw material exploitation, indicates that the

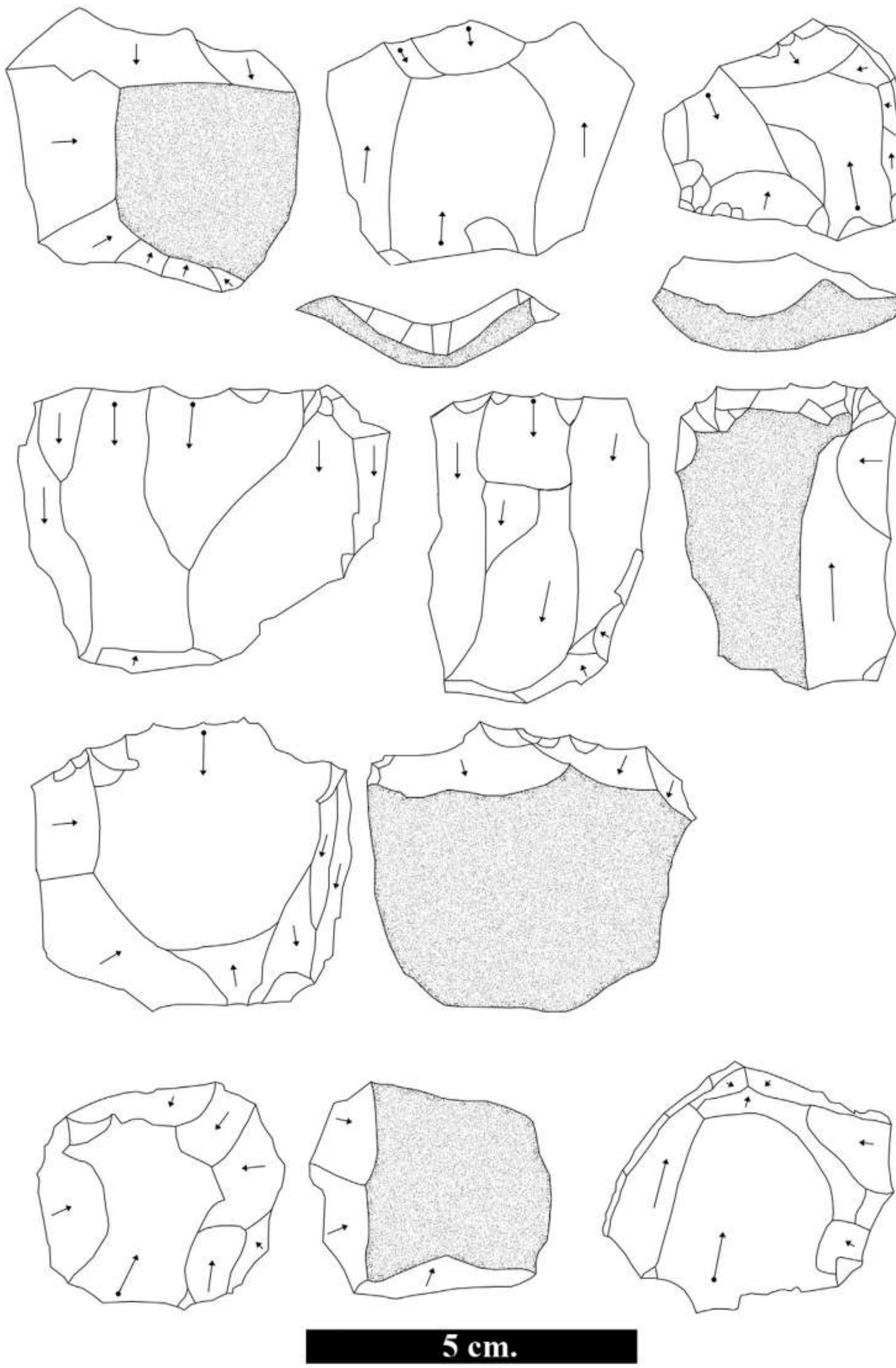

Fig. 6. Uni-, bidirectional and centripetal Levallois cores.

duration or intensity of occupations of Üçağızlı II changed over time. In layers A, B′ and Bu, high proportions of retouched pieces and relatively scarce cores suggest that more artifacts arrived in the cave as blanks or shaped tools. Conversely, higher proportions of cores and more unretouched large flakes in the lower levels suggest a greater contribution of in situ flint working to the assemblages. Meanwhile the changing frequencies of different cortex types indicate a decline over time in the amounts of flint from more distant primary sources being carried to the cave, and particularly in the amount of material entering the cave in an unworked or partially-worked state. These two sources of evidence point to a decline in the intensity or duration of occupation at Üçağızlı II. More intensive occupations of layer C, and perhaps extending into Bl, were provisioned with good flint from inland sources, which was worked in place into a variety of implements. The upper layers suggest that human occupations were more sporadic or shorter in duration, so that the site was less often supplied with raw materials from distant sources. Instead, the assemblages contain greater proportions of artifacts, mainly tools and large flakes that people carried along with them, while in situ manufacture involved mainly lint from secondary sources. Interestingly, these changes in the intensity of raw material use correspond with changes in overall density of artifacts within the deposits. As mentioned above, artifact densities peak in layer C. We emphasize that these contrasts in the length or intensity of occupations are quantitative rather than qualitative—we are not proposing

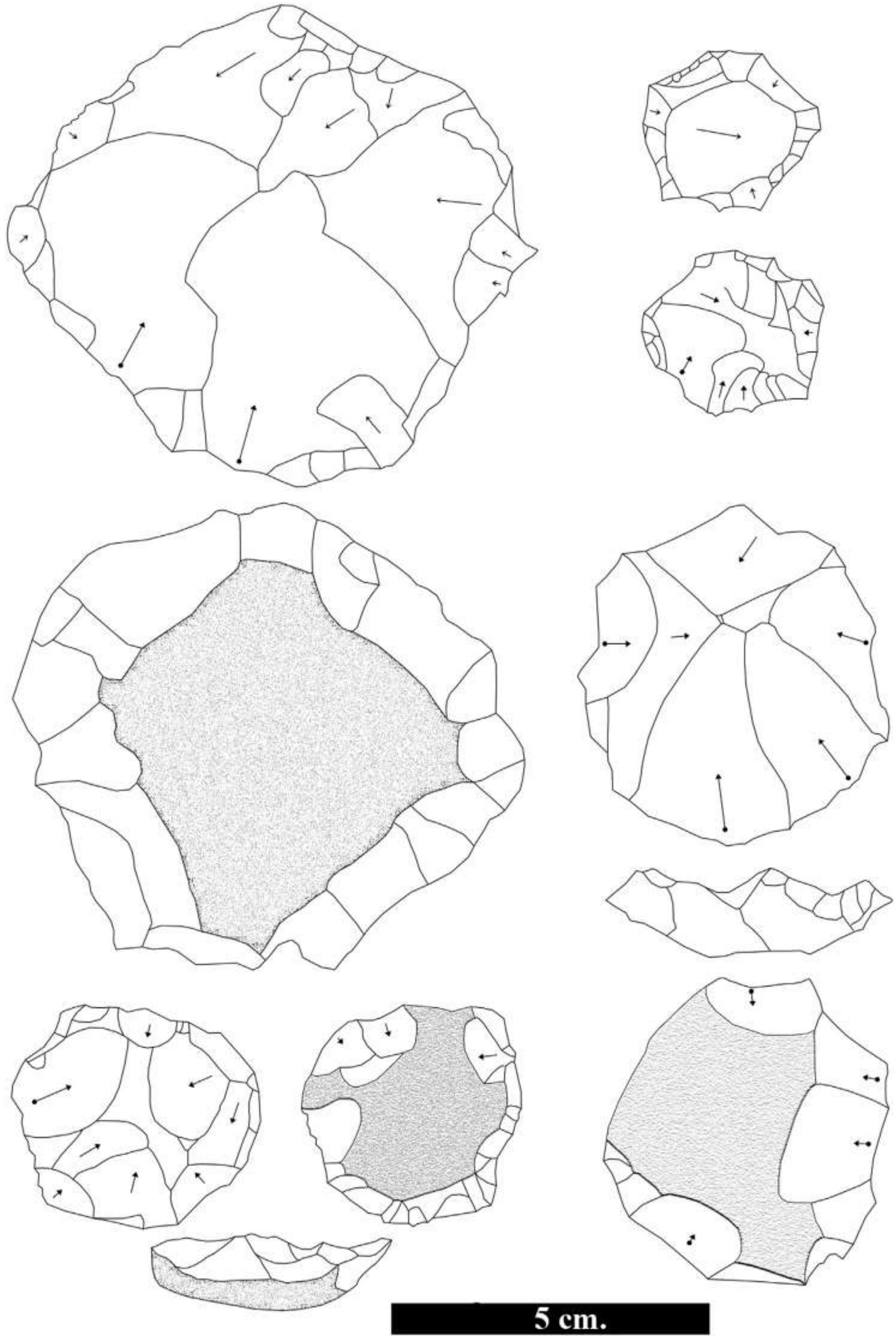

Fig. 7. Centripetal Levallois Cores.

fundamentally different types of occupations, just shorter or longer residential stays. Unfortunately, small-scale homogenization of sediments by burrowing animals makes it impossible to isolate individual occupational or depositional episodes within the sedimentary sequence and so to provide detailed observations about them.

4.3. Combustion products and features

Part of our initial interest in Üçağızlı II stemmed from visible combustion byproducts exposed by a looters' trench at the back of the chamber in 2005. During the subsequent 2005 and 2007 excavations, remains of numerous combustion features and burned materials were identified. From a macroscopic perspective, evidence of fires is most abundant in layers B and C. Discrete features, comprised of lenticular, sub-horizontal accumulations of charcoal, burned bone and ash, or lenses of what appeared to be cemented ashes are best preserved in layer B, where the thickest sequence of stacked features is visible in the western half of the north section (Fig. 3). Elsewhere within the layer, the visibility of ash lenses is laterally variable. In layer C the evidence for combustion is more diffuse, visible macroscopically only in the concentration of fine charcoal that makes the sediment darker than the overlying units.

In order to investigate the burned materials and probable hearths we collected micromorphological samples from the Üçağızlı II sequence

Table 7
Measurements of whole Levallois cores according to exploitation pattern.

		A		B′		Bu		Bl		C	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Length	Bidirectional	**38.0**	2.1	**35.2**	1.3	**36.3**	8.6	**42.2**	6.4	**37.9**	3.7
	Centripetal	**37.4**	5.8	**42.5**	13.4	**24.0**	–	**40.4**	7.7	**43.0**	6.9
	Centripetal + overpass			**34.5**				**37.3**	6.7		
	Unidirectional	**40.1**	9.1	**42.3**	10.5	**43.3**	6.8	**40.6**	7.1	**38.8**	9.4
	Unidirectional + overpass					**43.6**	3.3			**33.5**	
Width	Bidirectional	**30.3**	11.0	**32.8**	2.5	**32.3**	7.1	**38.2**	5.3	**31.1**	2.7
	Centripetal	**32.9**	7.3	**31.7**	1.1	**25.0**	–	**35.7**	6.4	**37.5**	6.1
	Centripetal + overpass			**30.0**				**34.0**	4.2		
	Unidirectional	**35.4**	6.7	**32.3**	6.0	**33.7**	9.7	**34.1**	6.6	**32.3**	7.0
	Unidirectional + overpass					**39.5**	4.7			**28.5**	
Thickness	Bidirectional	**12.3**	0.4	**15.8**	5.4	**15.0**	2.3	**14.8**	4.7	**13.3**	3.9
	Centripetal	**15.7**	4.0	**14.5**	3.5	**11.0**		**18.3**	23.0	**14.7**	5.7
	Centripetal + overpass			**12.5**				**12.5**	2.1		
	Unidirectional	**13.9**	5.4	**18.1**	7.1	**16.9**	5.1	**15.9**	4.7	**13.3**	4.2
	Unidirectional + overpass					**15.6**	3.0			**12.0**	

for high resolution analysis. Oriented blocks of archeological sediment were carved from exposed excavation profiles using a knife. The blocks were stabilized in the field using packing tape or plaster bandages, and transported to the University of Arizona, where they were dried and impregnated with a mixture of polyester resin and styrene, catalyzed with MEKP. Once hardened and cured, the blocks were sliced vertically to expose the internal stratigraphy, and key areas were trimmed to be processed into oversized petrographic thin sections (5 × 7 cm). The uncovered thin sections were prepared and ground to a standard thickness of 30 μm by Quality Thin Section (Tucson, AZ). The thin sections were studied at a variety of magnifications under plane-polarized (PPL), cross-polarized (XPL), oblique incident, and fluorescent light, as well as dark field illumination. Nineteen of the blocks that were collected during the 2005 and 2007 seasons came from the main excavation area. An additional two samples targeted brecciated sediments located outside of the excavated chamber. Of the blocks collected from excavation profiles, six specifically targeted combustion features that were visible in the field.

Thin section descriptions, identification of the main sedimentary components, and observation of microscopic attributes such as structure, fabric and pedofeatures followed guidelines provided by Stoops (2003). Interpretation of the depositional sequence, including identification of sedimentary components and features derived from human activities was facilitated by a microfacies approach. Courty (2001) first applied microfacies analysis to archeological samples following principles developed for sedimentary petrography (e.g. Flügel, 2009, Bertran and Texier, 1999. This approach was employed at Üçağızlı II because micromorphological samples contained numerous microstratigraphic units and sedimentary domains and many units exhibited similar characteristics, and thus were likely to have shared depositional and post-depositional histories.

Characteristics used to define the four main microfacies types include a) the sedimentary components, which can be anthropogenic, geogenic or biogenic, b) fabric, and c) microstructure. Anthropogenic sedimentary components, such as calcareous ashes, and fragments of bone, chert and charcoal are abundant throughout the sequence. Geogenic components include aggregates of reddish clay and quartz silt, fragments of limestone and speleothem, and calcitic sands. Secondary calcite is an additional geogenic component, present as infillings in voids and bone pores as well as zones of recrystallization and cementation of ashes. Biogenic components include rare fragments of shell and phosphatic coprolites. Microfacies types I, II, and III (Fig. 10; Fig. S1) are dominated by anthropogenic materials and are present in samples collected from layers A, B and C. Microfacies type IV is characterized by sand-sized fragments of limestone and is present only in the sample from the contact between layers C and D.

Microfacies II and its subtypes contain abundant anthropogenic materials derived from combustion, and exhibited fabrics and structure indicative of in situ burning. For example, some microstratigraphic units are composed of nearly pure laminated ashes and contain clay

Table 8a
Typological composition of Üçağızlı II assemblages.

	A		B′		Bu		Bl		C		D	
	n	%	n	%	n	%	n	%	n	%	n	%
Levallois flake	40	14.29	43	12.04	58	13.36	94	17.1	36	19.46	2	25
Levallois blade	12	4.29	8	2.24	30	6.91	43	7.82	11	5.95	0	0
Levallois point	22	7.86	19	5.32	19	4.38	94	17.1	15	8.11	1	12.5
Retouched Levallois point	0	0	6	1.68	4	0.92	10	1.82	0	0	0	0
Pseudo-Levallois point	5	1.79	7	1.96	12	2.76	27	4.91	8	4.32	0	0
Mousterian point	33	11.79	47	13.17	57	13.13	51	9.27	12	6.49	3	37.5
Limace limace	0	0	1	0.28	0	0	0	0	0	0	0	0
Single side scraper	40	14.29	61	17.09	68	15.67	62	11.3	26	14.05	2	25
Double side scraper	5	1.79	9	2.52	10	2.3	6	1.09	5	2.7	0	0
Convergent side scraper	3	1.07	7	1.96	8	1.84	6	1.09	2	1.08	0	0
Déjeté scraper	2	0.71	2	0.56	5	1.15	1	0.18	1	0.54	0	0
Transverse side scraper	5	1.79	6	1.68	9	2.07	4	0.73	5	2.7	0	0
Scrapers (25–29)	0	0	5	1.4	3	0.69	8	1.45	6	3.24	0	0
Upper paleolithic tools	17	6.07	30	8.4	36	8.29	29	5.27	12	6.49	0	0
Notch	21	7.5	17	4.76	24	5.53	33	6	18	9.73	0	0
Denticulate	17	6.07	18	5.04	9	2.07	25	4.55	8	4.32	0	0
Mixed tools	6	2.14	8	2.24	6	1.38	0	0		0	0	0
Broken retouched tools	52	18.57	63	17.65	76	17.51	57	10.4	20	10.81	0	0
Total	280	100	357	100	434	100	550	100	185	100	8	100

Table 8b
Typological and Technological Indices for Üçağızlı II assemblages.

	I	II	III	IV	Ilty	IR	IAU	IL	IF	Ifs	Ilam
A	26.4	33.2	1.4	13.6	26.4	19.6	0.7	16.4	36.9	31.3	18.8
B′	21.3	40.6	3.9	9.8	21.3	25.2	1.1	14.2	34.5	29.0	20.6
Bu	25.6	39.6	3.0	7.6	25.6	23.7	0.5	16.2	33.4	28.2	19.6
Bl	42.3	28.9	2.5	10.2	42.3	15.3	0.2	17.4	38.1	32.5	24.5
C	33.5	35.1	1.6	14.1	33.5	24.3	–	13.3	40.5	33.5	23.0
D	37.5	62.5	–	–	37.5	25.0	–	18.5	40.7	29.6	14.8

intercalations, and individual ash aggregates or plant structures in their original positions. These latter features, termed "articulated ashes" (Sherwood, 2001), in combination with partially carbonized tissues (Mentzer, 2012), have been reported from other archeological sites and ethnographic contexts (Karkanas et al., 2007; Mallol et al., 2007; Shahak-Gross et al., 2008; Karkanas, 2010) including nearby Üçağızlı Cave I (Goldberg, 2003, see Mentzer, 2011 for a full geoarcheological analysis of both sites). Both clay intercalations and articulated ashes are fragile and suggest that the ashes have not been strongly impacted by high-energy post-depositional mixing processes such as bioturbation, or human activities such as sweeping and dumping. These microstratigraphic units exhibit variable post-depositional recrystallization and cementation, and are most abundant in the sequence of stacked combustion features identified visually during excavation of layer B.

Microfacies types I and III contain abundant anthropogenic materials derived from combustion, but these are mixed with geogenic components and exhibit fabrics and structures that are indicative of post-depositional reworking. The numerous channel and chamber voids, and sand-sized ellipsoidal pellets composed of mixtures of calcareous ashes and other fine materials are consistent with post-depositional bioturbation by insects (Kooistra and Pulleman, 2010, Stoops, 2003), and possibly rodents (P. Goldberg, personal communication). Microfacies type I, which is enriched in ashes, is most common in samples from layer A and in layer B in the eastern portion of the site. Reworked sediments are variably cemented by secondary carbonate, although to a lesser degree than samples containing in situ burned materials. Samples from layer C (microfacies type III) also exhibit fabrics and structures consistent with bioturbation, but are enriched in microscopic fragments of charcoal, as well as bone and geogenic fine sediment, which collectively contribute to the dark color of the sedimentary fine fraction. Ashes are less abundant in this layer, although other primary carbonates, such as limestone and speleothem, and secondary carbonates are present. The fourth microfacies type is composed of variably cemented calcareous beach sand.

We emphasize that microfacies are not layers or depositional units. They represent small packages of sediment with similar sedimentary and post-depositional histories, as revealed by micromorphology. Microfacies I and II might be present in different parts of the same layer, even within the same micromorphology block (Figs. 10 and 11): the only difference would be the extent to which anthropogenic or biogenic forces re-arranged the combustion products. The vertical and lateral distribution of the different microfacies types reflect differences in primary modes of deposition, including hominin activities, combined with post-depositional processes. Anthropogenic materials are a minor component only microfacies type IV, which is present only in layer D and the base of layer C. Micromorphological analyses therefore support the interpretation that archeological materials associated with layer D were likely introduced as a result of occupation on top of the exposed beach surface, or post-depositional mixing of occupation debris downward from layer C. Layer C is enriched in micro-charcoal relative to other layers. Although ashes and burned bones are present, intact combustion features were not present in any of the samples from this layer. In contrast, samples from layer B contain microfacies types that are dominated by ashes, either in situ or reworked. The compositional difference between layers C and B could be due to burning activities of different intensities or duration contributing to deposition. Typically, fires that burn to completion under well-ventilated conditions produce more ashes than charcoal, while fires that are extinguished or maintained under reducing conditions produce more charcoal than ash (Braadbart and Poole, 2008; Wattez, 1988).

Intact combustion features are only present in samples from layer B (Fig. 11; Fig. S2). Profiles of the eastern half of the excavation area, which is situated beneath the highest point in the cave ceiling, contained numerous ash lenses interbedded with lenses of what appeared to be charcoal and burned bone. Open hearths constructed on top of a minimally-prepared substrate will produce a typical sequence of heat-altered sediment overlain by charcoal and ash (Meignen et al., 2001, Mentzer, 2012). At high magnification, however, the sequence of combustion features in layer B is comprised of in situ lenses of ash interbedded with thin accumulations of anthropogenic occupation debris rich in fragments of bone (see Fig. 11a–c). Some coarse bone fragments within this sequence are fragmented in place, which suggests that this area of the site was used for a variety of activities which included burning but also discard of lithic and bone fragments. What were identified as charcoal layers in the field are therefore actually thin occupation surfaces unrelated to the process of combustion (cf. Mallol et al., 2013, Mallol and Mentzer, in press: Figs. 10–11). A continuous sample column collected from the eastern area of the site contains 26 horizontal units, of which 16 are intact or partially intact lenses of ash. At high magnification, some ash lenses exhibit internal stratigraphy and thus represent multiple burning events. Only two horizontal units contain notable quantities of charcoal (see Fig. 11b–c), which suggests that the majority of burning events in these simple hearths continued until all of the fuel was converted to ash. Some areas within this sequence are locally bioturbated – in particular the accumulations of occupation debris between ash lenses – however, evidence of post-depositional cementation is present throughout and increases with depth such that excavations in this area were not continued into layer C.

Throughout most of layer B the anthropogenic materials, although equally abundant, are homogenized through localized bioturbation. Concentrations of intact ashes are present, but lenses are discontinuous due to localized cementation (see Fig. 11d, e). Reworked aggregates of cemented ashes are also present. These observations suggest that burning activities likely took place in all areas of the site, but that secondary processes have obliterated traces of in situ burning in large parts of the excavated area. It is also possible that some of the abundant burned materials in the Western Area were redeposited by hominins, such as "rake-out" from hearths located beneath the high point of the cave ceiling. However, bioturbation has obscured any primary depositional fabrics that could be used to support this interpretation. Layer A contains only reworked burned materials, suggesting that combustion activities continued throughout the history of occupation of the chamber, but the primary features are not preserved today.

In sum, the micromorphological analyses indicate that the apparent localization of evidence of fire visible in profile today is partially, perhaps even predominantly, a result of post-depositional processes. Beneath the highest point in the chamber, hearths in layer B are preserved due to cementation by dripping water. Today, water enters the site in this area along prominent joints in the vault. Elsewhere,

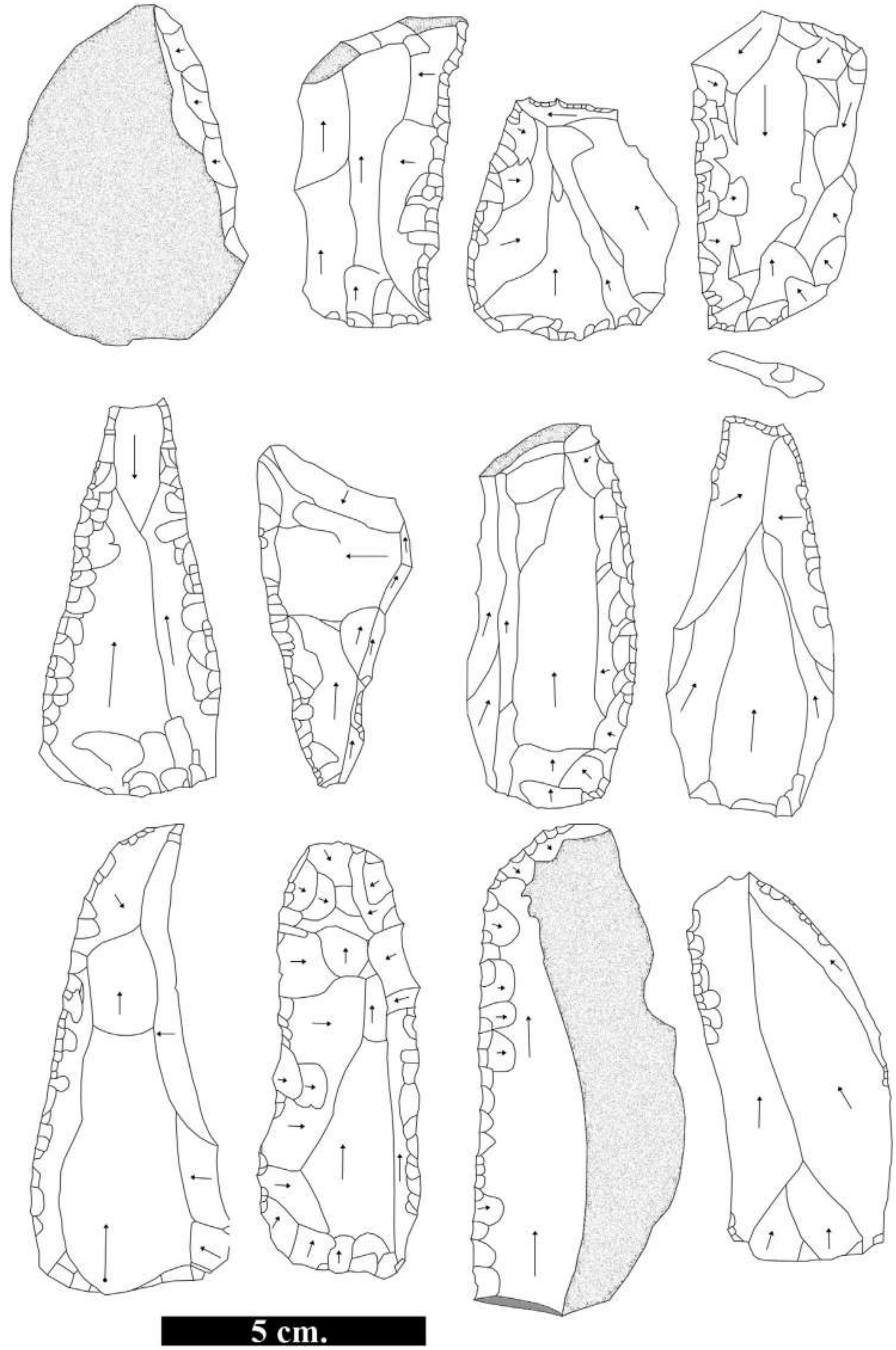

Fig. 8. Sidescrapers.

burrowing creatures reworked the sediment and obliterated much of the evidence for burning in place, except on mm- to cm-scales where portions of ash lenses are locally preserved. These traces of ash, charcoal and burned bones can be observed in micromorphological thin sections even where distinct features are not apparent in freshly-cleaned stratigraphic profiles. The high resolution observations suggest that sometimes-intensive burning activities occurred at Üçağızlı II throughout the duration of its use, and that combustion features contributed a significant volume of anthropogenic sediment to the site, even in locations where they are not evident in the field.

5. Discussion and conclusions

Faunal and geological evidence suggest that the cultural deposits remaining within chamber D at Üçağızlı II formed predominantly through anthropogenic sedimentation under relatively constant conditions. Based on the uranium-series date from a flowstone capping the beach deposit in chamber A, in combination with the archeological materials on top of beach sands within chamber D, we surmise that the entire sequence formed after ~75 ka. Unfortunately, we do not have good age constraints for the upper part of the sequence, in particular the potential

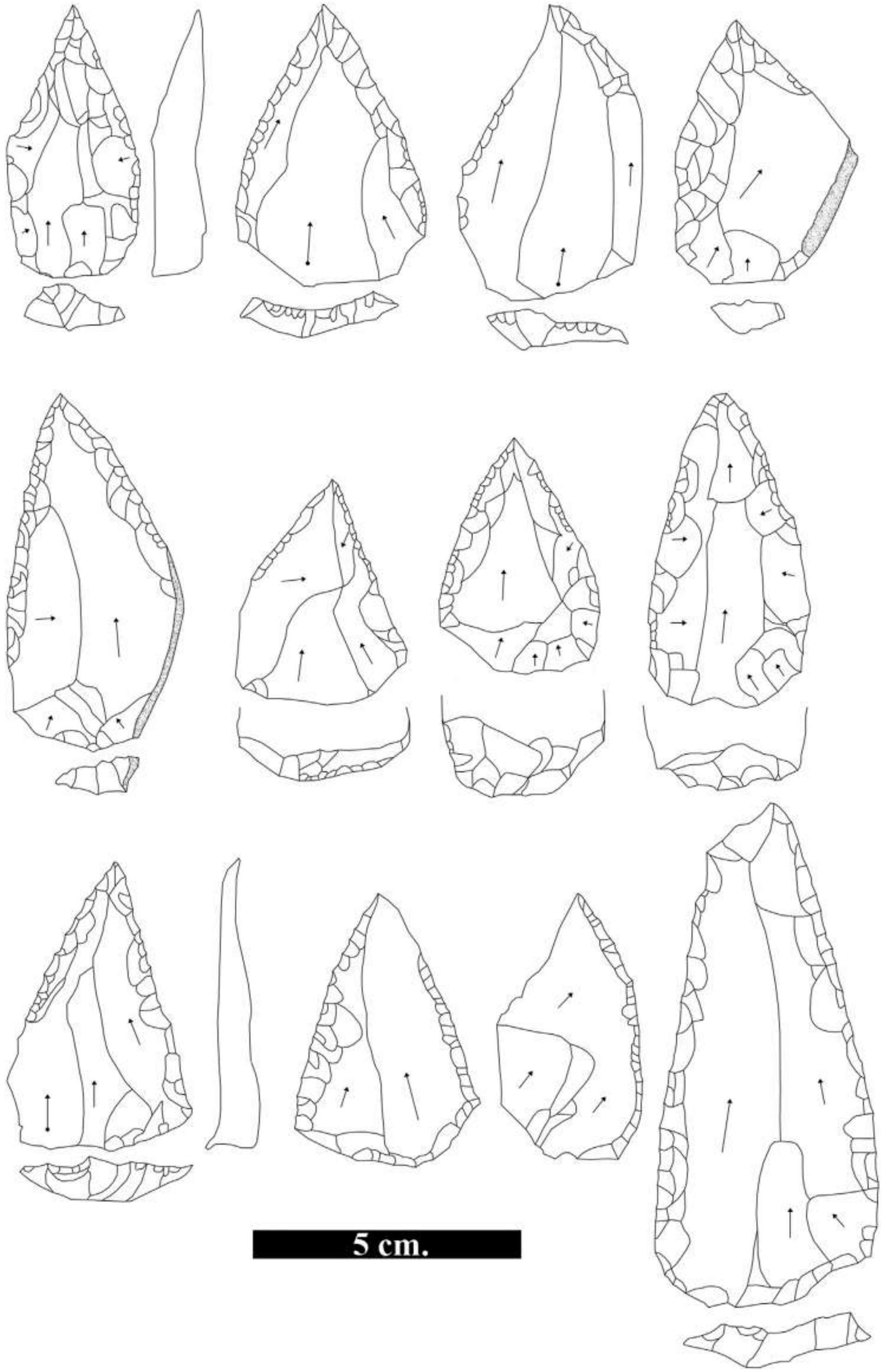

Fig. 9. Mousterian points and convergent scrapers.

for overlap in the occupations of Üçağızlı Caves I and II. It is possible that future excavations could help resolve the chronology of the site. For example, targeted excavation beneath the horizontal flowstones and brecciated deposits along the western wall of chamber D could uncover earlier phases of speleogenesis within the archeological sequence.

There are a few local comparators for the Üçağızlı II Mousterian lithic assemblages. The best one is the site of Merdivenli, situated in the Çevlik/Mağaracık area around 10 km north, across the mouth of the Asi river. Merdivenli was one of a small group of sites excavated in the late 1950s and early 1960s by Şenyürek and Bostancı (1958a,b). The excavators divided the deep sedimentary sequence at Merdinvenli into five units (I–V). Lithic assemblages from Merdivenli were recently restudied by İ. Baykara (Baykara et al., nd). Although the assemblages were selectively curated, enough material was retained to obtain a good technological profile. As at Üçağızlı II, Levallois production dominates. Levallois cores with parallel or convergent removals slightly outnumber cores with centripetal removals at Merdivenli. Unlike the situation at Üçağızlı II, however, there is no contrast between scar patterns on cores and flakes at Merdivenli: parallel and convergent scar patterns always outnumber centripetal ones on Levallois pieces. Overall,

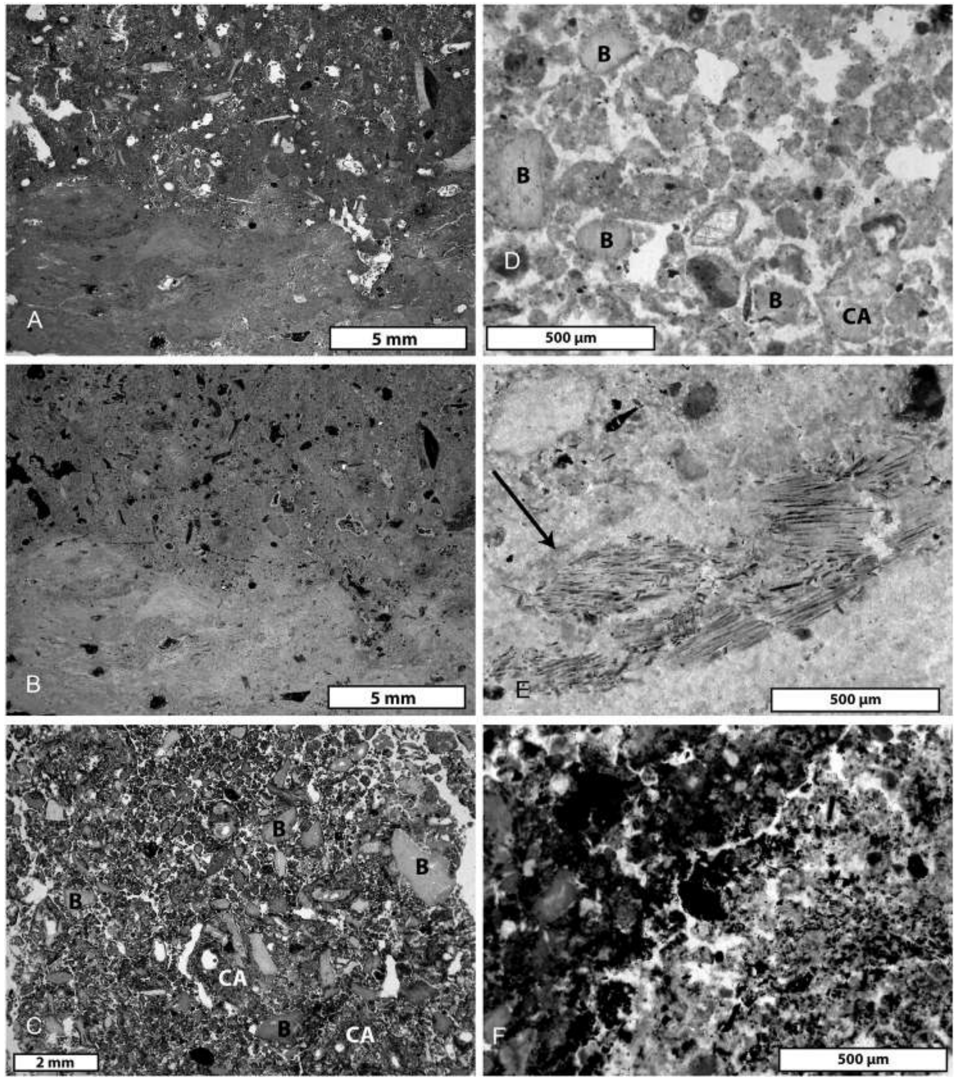

Fig. 10. Anthropogenic microfacies types in the Üçağızlı II deposits. A) Two microstratigraphic units in layer B exhibiting microfacies types I (upper half) and II (lower half). The two microfacies types are rich in ashes but differ in their fabric and structure. Microfacies type I has high porosity due to the presence of numerous channels and chambers. Microfacies type II has low porosity and laminated fabric. Microfacies type II therefore preserved the original depositional fabric, while microfacies type I exhibits fabric and structure that are indicative of post-depositional bioturbation. Geogenic sediment and other anthropogenic materials, such as fragments of bone and chert are more abundant in microfacies type I. PPL. B) Same view as (A), XPL. The striking difference in birefringence between the two units is due to the presence of geogenic sediment in microfacies I. The parent material for microfacies type I is therefore a combination of ashes, sourced either from primary combustion features or rake-out, anthropogenic occupation debris, and terrestrial fine sediment. Both microfacies types I and II contain secondary carbonate. C) Microfacies type III in layer C. This microfacies type is rich in microcharcoal, fragments of bone (B), and geogenic sediment. Ashes are present within aggregates of cemented sediment (CA). These aggregates indicate that the sediment was locally cemented by secondary carbonate prior to a later phase of bioturbation. Channels, chambers, and granular aggregates are typical of bioturbated sediment and are abundant in this sample. PPL. D) High magnification view of the granular microstructure that is typical of microfacies type I. Sand-sized fragments of bone (B) and cemented ashes (CA) are visible. PPL. E) High magnification view of clay intercalations (arrow), articulated ashes, and partially-carbonized tissues that are typical of microfacies type II. XPL. F) High magnification view of the abundant microcharcoal that contributes to the dark color of microfacies type III, and layer C overall. Microcharcoal is abundant in both the ashy cemented aggregates (right) and the granular matrix (left). The parent material of this microfacies type was likely a combination of charcoal-rich combustion features, anthropogenic debris, and terrestrial fine sediment. PPL.

the technological and typological indexes for the Merdivenli assemblages most resemble Qafzeh (Hovers, 2009) and Ksar 'Akil XXVIa and XXVIb (Marks and Volkman, 1986).

Mousterian assemblages from more distant sites in Turkey bear less resemblance to the Üçağızlı II material. The assemblages from the Upper Pleistocene levels at Karain Cave (layer I), on the Aegean coast near Antalya, are characterized by small artifact size, heavy retouch and reduction, and centripetal blank production. They resemble industries from the Zagros or the Balkans but differ from the contemporaneous Levantine Mousterian (Otte et al., 1995). Survey and limited excavations around obsidian sources on Göllü Dağ in central Anatolia have yielded large samples of Middle Paleolithic artifacts (Kuhn et al., 2015). Because the Göllü Dağ sites are all located within 1–2 km of a raw material outcrop there is abundant evidence for artifact production but few retouched pieces. As is the case with the assemblages from Üçağızlı II and Merdivenli, the materials collected on Göllü Dağ are dominated by Levallois production. However, centripetal production predominates in the central Anatolian assemblages. Moreover, Levallois points or point cores are essentially absent. As Levallois points are one common feature of the Mousterian throughout the Levant, their absence from the Göllü Dağ collections suggest cultural discontinuity between the Anatolian plateau and the Mediterranean coastal zone.

Looking more broadly, the lithic assemblages from Üçağızlı II resemble the Levantine Mousterian due to the reliance on Levallois production and the high frequency of points (retouched and unretouched). On the other hand, given the likely time range (<75 ka), the dominance of unipolar and centripetal Levallois production is also inconsistent with the best-known part of the Levantine record: based on the sequences

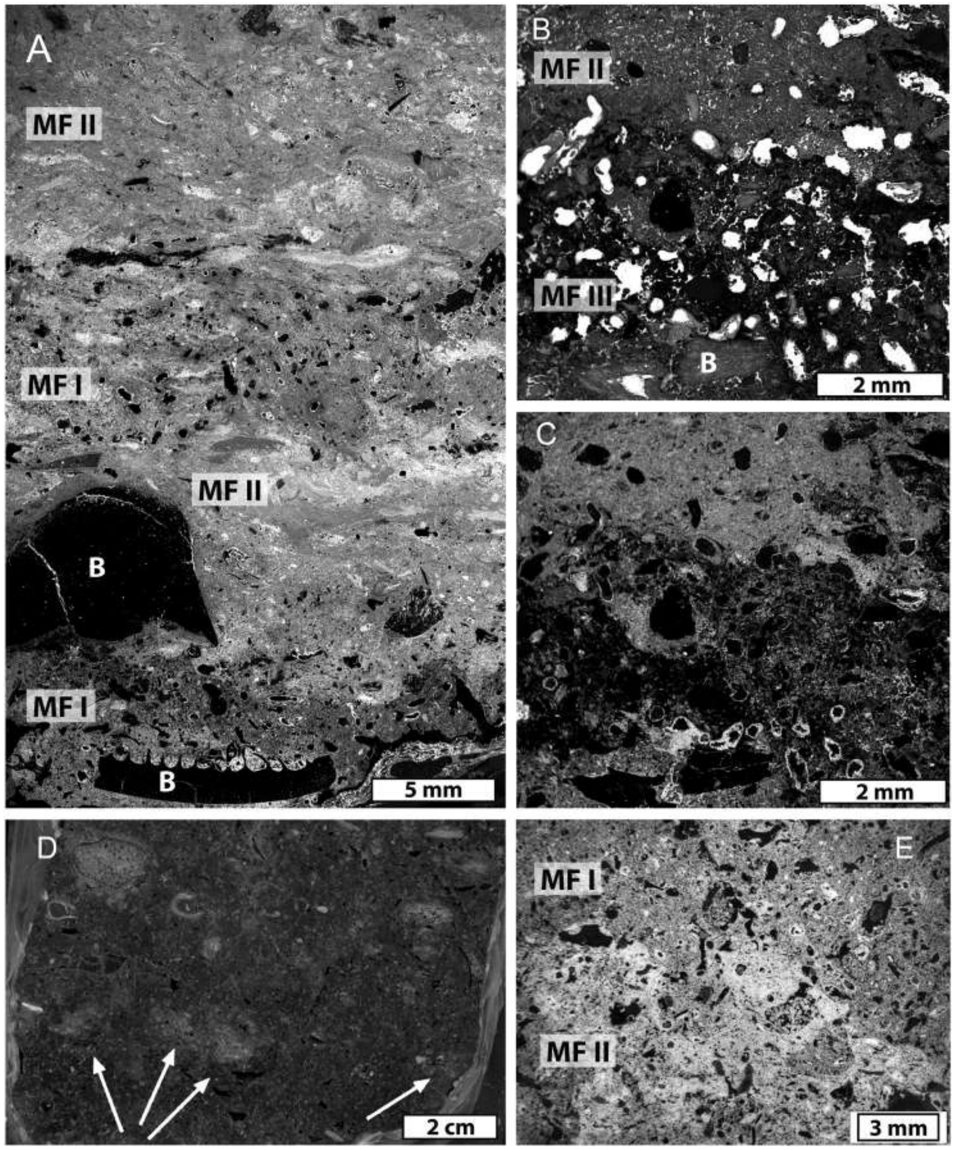

Fig. 11. Hearths in layer B. A) The sequence of stacked combustion features visible in the eastern portion of layer B contains numerous microstratigraphic units of variable microfacies type. Here, four units alternate between microfacies types I and II, interpreted as locally reworked ashy sediment interbedded with *in situ* ashy hearths. Fragments of bone (B) are present within the lowest unit, suggesting that other materials were discarded in this area during the phases of surface exposure. XPL. B) Microstratigraphic units containing charcoal are rare in this sequence, however, this unit of microfacies type II is underlain by a unit of microfacies type III. This relationship may indicate that a hearth containing a couplet of charcoal and ash was originally present here, with later reworking of the charcoal layer into the anthropogenic substrate beneath. Note the fragments of bone (B) that refit within the field of view, suggestive of trampling. PPL. C) Same view as (B), XPL. D) In the western portion of layer B, visible combustion features are rare to absent, however aggregates of cemented ashes are encountered during excavation. In this incident light scan of an impregnated sediment block, several aggregates of cemented ashes are visible within a horizontal concentration (arrows). E) At higher magnification, the aggregates of cemented ashes exhibit features typical of microfacies type II, which indicates that these may be remnants of an intact ashy hearth that has since been nearly obliterated by bioturbation. Darkfield illumination and XPL.

from Tabun and Kebara and other sites we would expect to find more convergent Levallois production during this time period in the southern and central Levant. The early Upper Paleolithic sequence of Üçağızlı I shows strong parallels with the layer XXII–XVI at the site of Ksar 'Akil (Leabanon) (Kuhn et al., 2009: 109), and it is not surprising that the Mousterian at Üçağızlı II is also similar to that from Ksar ‘Akil. Based on the frequencies of Levallois points, blades and flakes, layers A, B′ and Bu from Üçağızlı II most closely resemble layers XXVIIa and XVIIb at Ksar ‘Akil, whereas the assemblage from layer C is more similar to layers XXVIIIa and XXVIIIb (Marks and Volkman, 1986: 9). However, Marks and Volkman (1986) attributed layers XXVIIIa and b to “Phase 1″ or the early Levantine Mousterian, whereas Üçağızlı II is clearly too recent for this. Perhaps the lesson to be learned is variability within the northern Levantine sequence does not fit so neatly within the three-stage model developed for the central and southern Levant. There is certainly a good deal more diversity within the later phases of the Mousterian than the simple tripartite system developed for Tabun Cave leads us to expect (Hovers, 2009).

One of the most striking features of the Middle Paleolithic of the eastern Mediterranean is the consistent reliance on Levallois methods of blank manufacture. From the southern Levant to coastal Anatolia, Middle Paleolithic assemblages can be characterized as Levallois Mousterian. In the early Levantine Mousterian non-Levallois methods of production sometimes co-existed with Levallois (Meignen, 2007; Wojtczak et al., 2014), but between about 150,000 and 50,000 years ago one form or another of Levallois production is dominant across the region. Experimental and theoretical research shows that Levallois technology is a very efficient method for converting raw material into a range of large, sharp, usable blanks (Brantingham and Kuhn, 2001; Eren and Lycett, 2012; Lycett and Eren, 2013; Shimelmitz and Kuhn, 2013).

However, the global distribution of Levallois technology and its presence at a single site such as Üçağızlı II are phenomena of a vastly different scales (Kuhn, 2013). The former, an emergent pattern of choices made by countless individuals over tens of thousands of years across the eastern Mediterranean rim, may well be attributable to the general economic and functional advantages of Levallois. The latter, an outcome of decisions made by people at a single place over a comparatively restricted interval of time, is just as likely to reflect habitual patterns of learning and cultural transmission (Kuhn, 2013).

Although the lithic industry of Üçağızlı II is relatively homogeneous from both a technological and a typological perspective, we do see some changes in the nature of the occupations. Most notably the site saw a declining intensity of occupation with time, as expressed in the frequency of retouch and the intensity of raw material exploitation and density of archeological finds. Hypothesized changes in the duration of occupations at Üçağızlı II find interesting parallels in the long early Upper Paleolithic sequence at Üçağızlı I (Kuhn, 2004, Kuhn et al., 2009). Occupants of the two sites used basically the same array of local pebble and more distant nodular flints. They also showed a similar level of flexibility in exploiting different raw material sources to maintain a supply of useable artifacts. At Üçağızlı I there is an increase (rather than a decrease) over time in the intensity or duration of occupations. More prolonged occupations are marked by provisioning of the site with greater quantities of "costly" raw materials from the primary sources on the plateau. More sporadic occupations in the early layers at Üçağızlı I are marked by more exploitation of local pebble raw materials, and more extensive exploitation of blanks (Kuhn, 2004, Kuhn et al., 2009). In other words, the Middle Paleolithic inhabitants of Üçağızlı II and the Upper Paleolithic people using Üçağızlı I employed the same general strategies of technological provisioning. Similar observations have been made based on other datasets (e.g., Barton et al., 2011; Kuhn and Clark, 2015).

While the structure of variation in the two sites is similar, there are also real differences between Middle and Upper Paleolithic raw material economies at Üçağızlı I and II. Most obviously, nodular cortex is almost always more common in the Upper Paleolithic assemblages, and especially so in the densest, most prolonged occupations (layers B1–B3). In the Upper Paleolithic sequence, the proportion of cortical pieces coming from primary sources varies from a low of 23% in some of the more ephemerally occupied layers (D) to a high of 88% in the stratum with evidence for the most intensive occupation (layer B) (Kuhn, 2004). The range of variation in the Mousterian levels at Üçağızlı II is more limited, ranging from a low of 18% in Bl to a high of 51.5% in layer C (the sample from layer D is too small for a reliable estimate). Again this difference appears to be a matter of degree rather than kind. Basically, Upper Paleolithic artisans almost always made greater use of the best quality primary flints than did their Middle Paleolithic counterparts.

There are several ways we might account for the contrasts between Middle and Upper Paleolithic raw material use in the study area. The contrasts are certainly not indicative of differences in capacities for planning ahead. Both populations used the same raw material sources, none of which (that we currently know of) is more than a long day's march from the sites. The contrasts in raw material exploitation are much more likely to be the products of different sets of short-term economic decisions.

One possibility is that Middle and Upper Paleolithic sequences simply sample different points on a spectrum of occupational duration/intensity. The most prolonged Middle Paleolithic occupations may be similar in scale to moderately intensive Upper Paleolithic occupations of these sites. Patterns of small game exploitation would tend to support this hypothesis. The Upper Paleolithic inhabitants of Üçağızlı I used a somewhat broader range of small game resources, including quick-flight taxa such as birds and lagomorphs (Kuhn et al., 2009; Stiner, 2010). As is typical across the Mediterranean basin, the Middle Paleolithic occupants of Üçağızlı II exploited only easy-to-collect small animals such as shellfish and tortoises. Although this seems to be a pan-regional pattern reflecting economic reorganization, the broadened exploitation of small game in the Upper Paleolithic could also be associated with more intensive and prolonged use of places resulting in local depression of medium- and large game populations. Unfortunately, geological conditions and particularly rates of geogenic sediment input vary markedly in the two sites making it is impractical to compare absolute values for artifact density or other indicators of occupational intensity. Likewise, small scale homogenizing of sediments in Üçağızlı II by burrowing insects obscures individual occupational or depositional episodes within the sedimentary sequence, so that intensity of occupation is not as clearly expressed in features such as fireplaces.

A second possible explanation for the contrasts between the two sites and periods is that Middle Paleolithic hominins exploited the coastal landscape differently than later Upper Paleolithic people. If Middle Paleolithic foragers were primarily focused on the coastal lowlands, if the dominant direction of residential movement was parallel to the coast rather than perpendicular to it, they may have had less regular access to raw materials on the inland plateau. By that same token, if Upper Paleolithic groups regularly moved from the coast to the inland plateau, the primary sources would have been more regularly accessible to them. In this regard it is interesting, though not definitive, that marine resources (shellfish) occur throughout the Middle Paleolithic occupations at Üçağızlı II, but are absent from the middle and lower part of the Upper Paleolithic sequence at Üçağızlı I.

Despite locally poor preservation, micromorphological studies provide a wealth of information on use of fire within chamber D at Üçağızlı II. By-products of combustion are abundant throughout the sequence, but the relative quantities of charcoal and ash, as well as the magnitudes of post-depositional bioturbation and cementation, vary. When preserved, the combustion features in Üçağızlı II are generally similar to those documented in the Upper Paleolithic layers at Üçağızlı Cave I, with little evidence for substrate preparation prior to burning (Mentzer, 2011). The differential visibility of combustion features within and among layers in Üçağızlı II appears largely to be a function of variable preservation, rather than a reflection of activity localization. Secondary cementation of hearths, which helps preserve them, and post-depositional bioturbation, which obscures them, are spatially variable within the cave, especially within layer Bl, where it likely reflects an increased intensity of dripping water in the center of the chamber at this time. Finally, the declining intensity of occupation evidenced by the macro-artifacts correlates with a shift from charcoal-rich to ash-rich sediments. One intriguing possibility is that this shift was accompanied by a change in the type of burning and the completeness of combustion that took place within hearths at the site, with fires in the upper layers being allowed to burn to pure ash, while fuel in the lower layers was extinguished before it had burned completely. Unfortunately, in the absence of preserved hearths in the lower part of the sequence this remains speculative. In either case, it is clear that fire was an integral and constant element in the behavioral repertoire of the Middle Paleolithic hominins at Üçağızlı II, even in those levels where the traces of fires are not readily apparent into the naked eye.

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.jasrep.2015.09.022.

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