

# THE ORIGINS AND DEVELOPMENT OF AGRICULTURE IN THE WĀDĪ AL-ḤASĀ REGION: 2006 TEST EXCAVATIONS AT KHIRBAT AL-ḤAMMĀM (WHS149), TBAS 102, AND TBAS 212

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## Introduction

This is a report of the results of the first field season of the Origins and Development of Agriculture in Jordan (ODAJ) project. The project's primary goal is to examine the periods on either side of the transition to agriculture in the Wadi al-Hasa catchment in order to shed light on the biocultural changes associated with the shift from hunting and gathering to domestication economies. Test excavations at two Late Epipaleolithic sites and one Pre-Pottery Neolithic site were carried out during May and June 2006. ODAJ is one of the many excavation projects that was spawned by the archaeological surveys carried out in and around the Wadi al-Hasa catchment (Clark *et al.* 1994; MacDonald 1988, MacDonald *et al.* 2004) ODAJ project findings, to date, indicate that Natufian and Neolithic groups in the Wadi al-Hasa catchment devised local strategies and local identities, while simultaneously retaining meaningful cultural connections with other groups in the southern Levant. This work demonstrates that west-central Jordan is a productive setting for further investigations into both sides of the transition to agriculture.

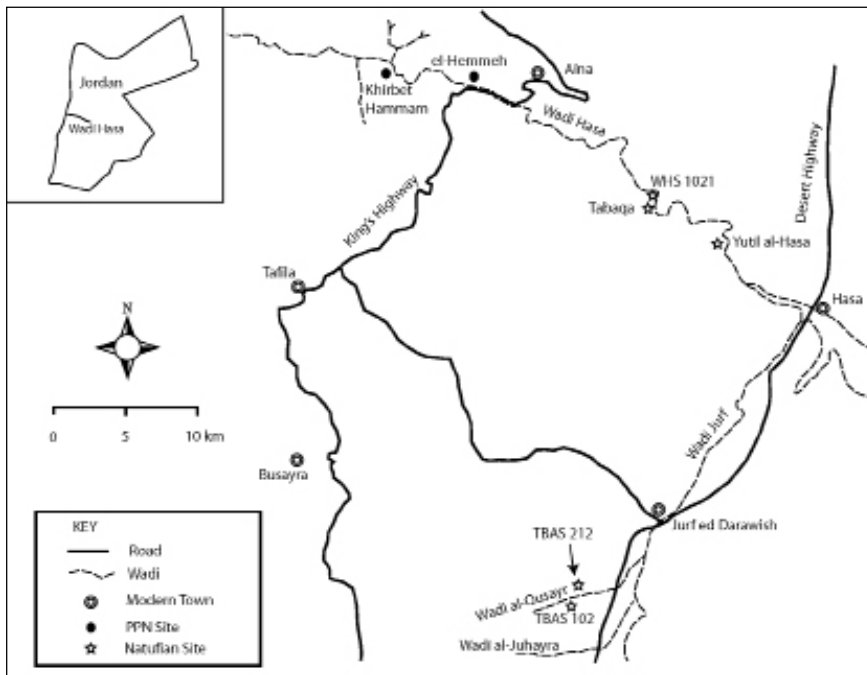
## Sites

The Wādī al-Ḥasā is the southernmost major drainage into the Dead Sea depression. Beginning in the desert/steppe environment of west-central Jordan, the wādī traverses a number of different environmental zones before it empties into the Dead Sea plain near aṣ-Ṣāfi. Archaeological surveys of the wādī have recorded nearly 1600 archaeological sites (Clark *et al.* 1992, 1994; MacDonald 1988) attesting to the importance of the Wādī al-Ḥasā, in terms of resources and geography, to prehistoric and historic populations. Within the larger Wādī al-Ḥasā catch-

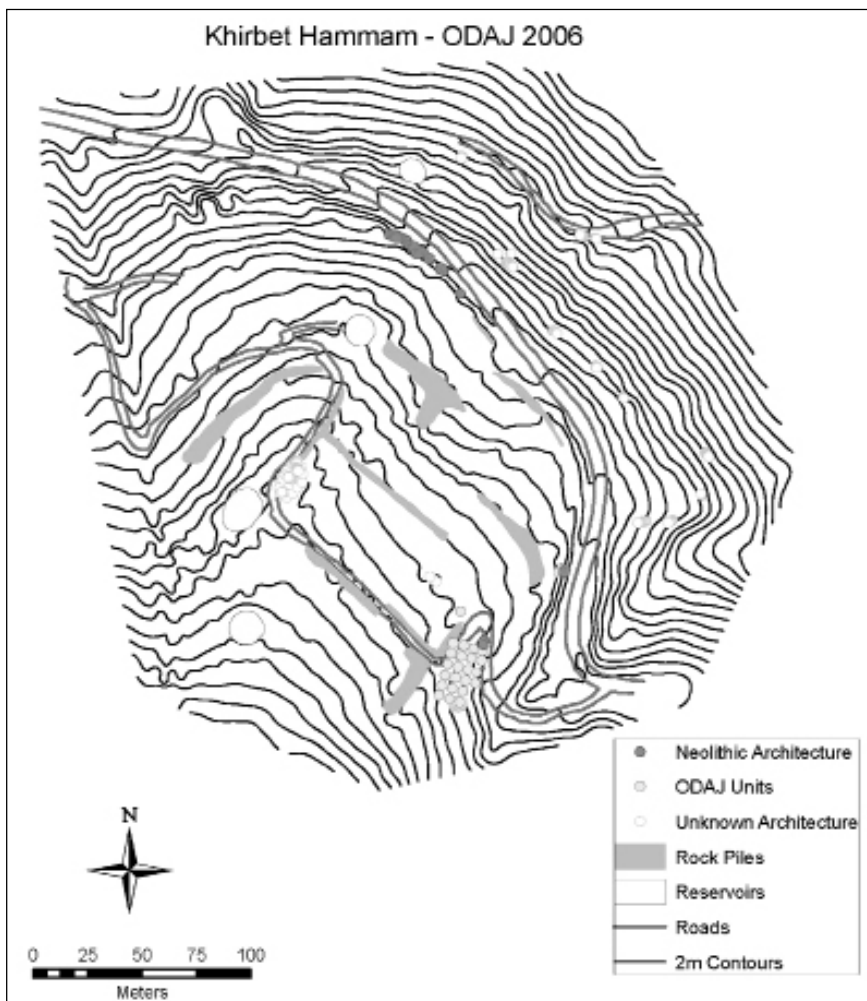
ment, the smaller wadis to the south (e.g., Wādī al-Jurf and Wādī Burma) contain numerous small drainages (e.g., the Wadis Juhayra and al-Quṣayr), all of which flow into the upper end of the Wādī al-Ḥasā. Thus, the regions investigated by the ODAJ project are linked by virtue of the continuity of the larger catchment region.

A cluster of ten Natufian sites was identified along the Wādī al-Quṣayr, a small, shallow wādī approximately 25km southeast of the Wādī al-Ḥasā during MacDonald's Tafila-Busayra survey (TBAS) in 1999-2000 (MacDonald *et al.* 2004; Neeley 2004, 2006). Two of these sites, TBAS 102 and TBAS 212 (**Fig. 1**), were selected for test excavations based on the density (greater than 200 pieces within a 1m diameter) and techno-typological characteristics (bladelet cores and small, abruptly backed lunates) of the surface remains. Following the 2000 survey, one of these sites (TBAS 212) was tested in 2004 by Fujii (2005) and identified as a Late Natufian camp. Previous publications (e.g., MacDonald *et al.* 2000, 2001, 2004; Neeley 2004, 2006; Neeley and Peterson 2007) have referred to the sites being located in the Wādī Juhayra. However, they are more appropriately considered to be part of the Wādī al-Quṣayr, a small wādī located north of the Wādī Juhayra.

Khirbat al-Ḥammām's location on the south side of the Wādī al-Ḥasā was noted in surveys by Glueck (1939) and MacDonald (1988) (**Fig. 1**). The Pre-Pottery Neolithic occupation was later confirmed by surface inspection (Rollefson and Kafafi 1985) and a test excavation trench along the roadcut (Peterson 2004). Khirbat al-Ḥammām covers approximately 7 hectares and rests on a sloped terrace 290 masl (**Fig. 2**). It has been spared the substantial erosion that has drastically truncated other Neolithic sites in the



1. Location of ODAJ Project Sites and Other Pertinent Sites in West-Central Jordan.



2. Topographic Map of Khirbat al-Hammām.

region. This enhances the research potential of the site, especially in combination with numerous architectural remnants, well-preserved organics, and over 2m of cultural deposits. Recognizing this potential, the Jordanian government purchased the site and now employs security personnel to protect it. Their presence has substantially diminished disturbances at Khirbat al-Ḥammām from cultivation, bulldozing, and vandalism.

Our rationale for expanding investigations of the agricultural transition outside the Wādī al-Ḥasā proper – and into the wider catchment zone – was grounded in previous research. Survey and excavation projects within the Wādī al-Ḥasā have identified several Early Natufian sites such as Ṭabaqa, Yutil al-Ḥasā, and WHS 1021, but no Late Natufian sites (Byrd and Colledge 1991; Olszewski *et al.* 1994; Olszewski and Hill 1997). Typo-technological analyses of the materials from the Wādī al-Quṣayr region suggested the possibility for Late Natufian occupation. Therefore we chose to expand the research area in hope of catching the terminal Epipaleolithic habitation which segued into the earliest manifestations of the Pre-Pottery Neolithic.

### Chronology

The chronological sequence of the combined three sites spans much of the transitional Late Epipaleolithic and Early Neolithic sequence. AMS dates provide the anchors for the sequence, but are supplemented by typotechnological assessments of the lithic assemblage. The AMS dates are presented here, while the relative dating from stone tools will be discussed in the section devoted to artifact descriptions.

#### *Late Epipaleolithic Sequence*

The initial expectations regarding the chro-

nology at TBAS 102 and 212 were colored by the survey results in 1999-2000 (MacDonald *et al.* 2000, 2001) and previous work in the Wādī al-Ḥasā (Olszewski 2000). In the former, the local setting was identified as a lacustrine environment (Moumani *et al.* 2003) with the presence of some Helwan retouched lunates. Similar combinations found in the Wādī al-Ḥasā indicated an Early Natufian occupation. Thus, it was expected that an Early Natufian occupation would characterize the Wādī al-Quṣayr materials as well. However, two radiocarbon dates from TBAS 102, both around 11,000 bp (uncalibrated) (**Table 1**), indicate an early Late Natufian occupation (Neeley in press). These dates fit well with the calibrated dates for the Natufian found in Bar-Yosef (2000) and Aurenche *et al.* (2001). Furthermore, the typotechnological characteristics of both assemblages are consistent with the expectations for a Late Natufian occupation. In the larger picture of west-central Jordan, these two sites appear to be the first Late Natufian occupations identified within the Wadi Hasa catchment and their presence indicates that hunter-gatherers continued to occupy this region, at least initially, in the face of the environmental changes associated with the onset of the Younger Dryas about 11,000 bp.

#### *Neolithic Sequence*

Analysis of the 2006 materials suggests that Khirbat al-Ḥammām has a more complex, multiphase occupational history than previously thought. Originally, two AMS dates from the 1999 excavations documented a Late Pre-Pottery Neolithic B occupation (Peterson 2004). However, two additional AMS dates from the 2006 season suggest the need to re-evaluate that chronological interpretation (**Table 1**). Both conventional and calibrated dates fit within the

**Table 1:** Radiocarbon Dates from TBAS 102 and Khirbat al-Ḥammām (WHS 149).

Site	Sample No.	Unit/Level	Conventional Age	Two Sigma Calibrated Results
TBAS 102	Beta 221179	3/3	11170±70 BP	13410-12980 BP and 12940-12910 BP
TBAS 102	Beta 229411	4/2	11040±60 BP	13100-12860 BP
WHS 149	Beta 221347	2/3	8310±40 BP	9450-9240 BP
WHS 149	Beta 221348	2/4	8440±40 BP	9520-9420 BP

Middle PPN sequence using the chronology proposed by Kuijt and Goring-Morris (2002: 366). The calibrated dates straddle the MPPNB/LPPNB boundary using the Aurenche *et al.* (2001) chronology. Furthermore, projectile point styles hint at a PPNA/EPPNB component at the site. Overall, current data from Khirbat al-Ḥammām suggest that the cultural remains may stretch back further towards the inception of agricultural origins, and span a significant portion of the Pre-Pottery Neolithic. Finally, excavations did not reach the bottom of cultural deposits in either field season.

The 2006 field season resulted in a re-evaluation of the time periods represented at these sites. Most importantly, the new dates indicate a shift toward the time of the transition to agriculture with the identification of a Late Natufian component and the expansion of the PPN from Late into the Middle PPN and possibly including a PPNA/EPPNB component. Given the small scale of excavation to date, the presentation of these dates suggests that west-central Jordan merits more work in these crucial time periods.

### Geomorphology

Today, the Wadi al-Hasa catchment is a region of rugged topography and distinctive geology and landforms. Ongoing work in this area highlights the need for finer-grained environmental reconstructions supported by geological data. Not only were the prehistoric environments during the transitional periods vastly different from present, but changes in local landforms due to climatic and anthropogenic factors have affected our ability to find sites and generate comprehensive models of the agricultural transition. Our environmental reconstructions rely heavily on the work of Hill, who relocated sites in the Ḥasā area and analyzed landscape change using settlement data and paleoenvironmental indicators in the region (Hill 2006). Continued geoarchaeological survey in and around the Wādī al-Quṣayr region and the Wādī al-Ḥasā were integrated into the 2006 ODAJ field season.

### Natufian Landscapes

The present day landscape of the Wādī al-Quṣayr consists of a sparsely vegetated, rocky, arid environment. Nearly all the vegetation oc-

curs in the wadi bed which is broad and flat and shows little evidence of downcutting. Modern use of the area for agricultural or pastoral activities is rare due to the scarcity of water and foliage. These present conditions can be contrasted with the prehistoric environment of the Wādī al-Quṣayr which appears to have been much more conducive to human habitation.

During the Paleolithic, the dominant feature of the Wādī al-Quṣayr was the presence of water in the form of springs, ponds, and marshes. Support for this wetter environment is derived from the presence of marl deposits (Moumani *et al.* 2003). This landscape was probably part of a series or chain of marsh habitats extending north to Jurf ad-Darāwīsh and ultimately toward the Wādī al-Ḥasā. Indirect support for this greater resource base is the large number of archaeological sites clustered along these pond/marsh environments stretching from the Lower Paleolithic through the Late Epipaleolithic (Neeley 2006). For the Wādī al-Quṣayr, it is suggested that these marsh/pond environments were fed by a series of spring deposits that were active during wetter phases of the Late Pleistocene. A likely change in the environment occurs with the onset of the Younger Dryas (11,000 bp uncalibrated, 12,900 cal BP) in which climatic conditions became warmer and drier, effectively signaling the end of the pond/marsh environments. The archaeological record in the Wādī al-Quṣayr supports this climatically induced hiatus as the prehistoric occupation terminates with the Late Epipaleolithic (the first part of the Late Natufian about 11,200 bp) and is only sporadically represented during the Chalcolithic and Bronze Age with an absence of early Neolithic sites (though see Fujii 2002 for the identification of a PPNB site on the slopes of Tall Juhayra). This gap in the archaeological record is consistent with the occupational history from both Jurf ad-Darāwīsh and the eastern end of the Wādī al-Ḥasā as Late Natufian materials are absent as the marsh environments recede. Furthermore, those areas outside of these Late Pleistocene marsh/pond settings appear to contain little evidence of a Late Paleolithic (Upper and Epipaleolithic) settlement (e.g., the TBAS region), suggesting that these marsh/ponds were primary settlement locations in an otherwise marginal environmental setting (Neeley 2006).

### *Neolithic Landscapes*

A database of sites in the Wādī al-Ḥasā compiled from the MacDonald (1988) south bank surveys and the Clark (Clark *et al.* 1992, 1994) north bank surveys documents that Neolithic and Chalcolithic sites are often perched on steep, sometimes unstable slopes with awkward access to agricultural lands either in the floodplain below or plateau above (Hill 2006: 77-78). Did people choose to settle in these awkward settings because they were the only options in an environment with few attractive options for farming? A more likely explanation, is that the Ḥasā of today looks drastically different than the Ḥasā of 8-10,000 years ago.

Specifically, substantial channel incision, due to both climactic and anthropogenic changes, can be inferred from settlement distribution, Dead Sea sedimentation records, and isotopic studies of speleotherms. Preliminary geoarchaeological survey during 2006 reinforces a hypothesis that the Neolithic Wādī al-Ḥasā was dominated by a wide, slow moving waterway – one that built up rich, alluvial soil rather than scouring it away. In this scenario, the wadi valley would have provided large expanses of arable land in a broad, flat floodplain. A landform in the Wādī al-La‘bān, a tributary of the Wādī al-Ḥasā, may represent a preserved remnant of the ancient wadi channel that remains intact at an elevation of 30m above the current wadi bed. Coring this landform should provide materials that can be dated to support to this hypothesis. High agricultural productivity at Khirbat al-Ḥammām is supported by indirect, artifactual evidence. The site’s surface is littered with hundreds of handstones and large querns. This view of the Ḥasā, as providing a landscape of sustained agricultural productivity, if further supported by recent discoveries at al-Ḥimmah, a Neolithic site that lies less than 10km from Khirbat al-Ḥammām on the north bank of the wadi (**Fig. 1**). Recent excavations document the presence of PPNA, LPPNB, PPNC, and possible PPN occupations at el-Hemmeh (Makarewicz and Austin 2006; Makarewicz *et al.* 2006).

Reconstructions of local environmental conditions are beginning to portray both the Wādī al-Ḥasā and its catchment zone on the plateau to the south as well-watered and economically productive locales capable of supporting thriving

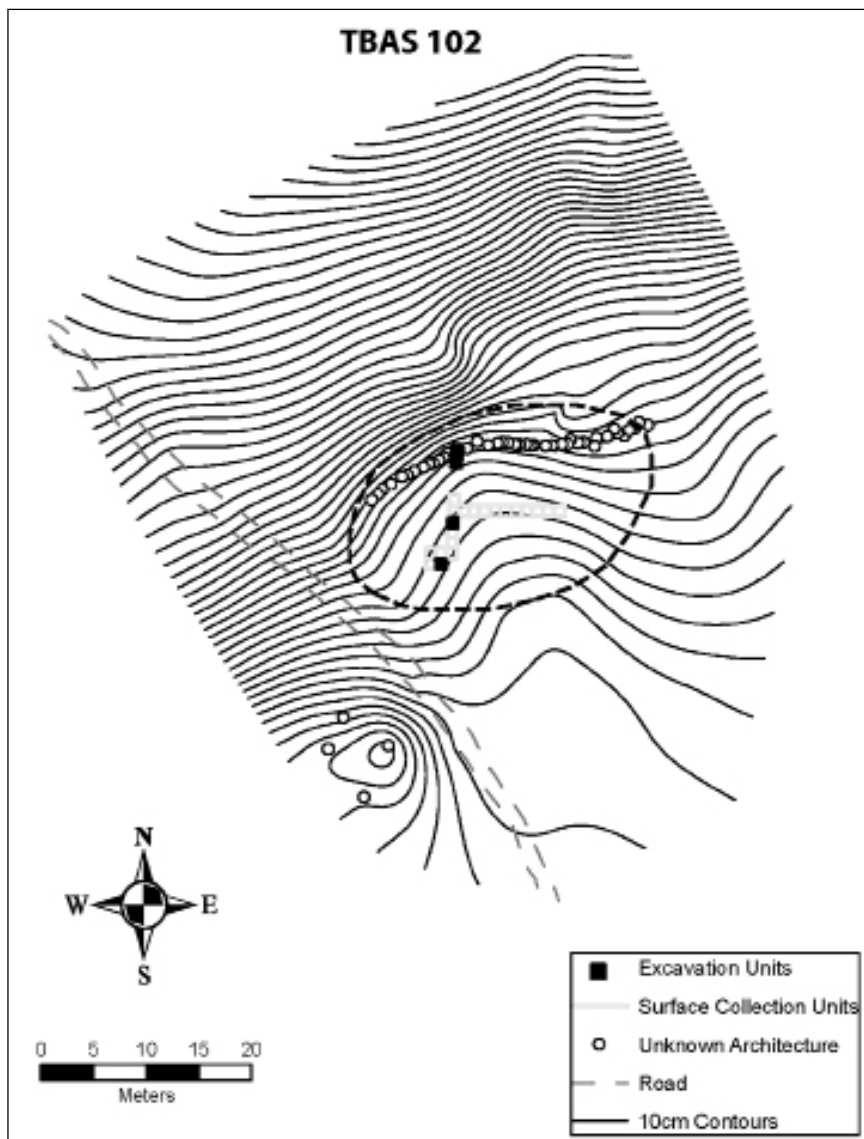
communities. The available chronological data indicate long, multi-phase, occupational histories at these sites which suggest a chronological convergence between the areas. Artifacts and economic data sets from these sites further add to our knowledge of Natufian and Neolithic environments and lifeways in the Wādī al-Ḥasā region.

### **Field Methods**

Our first season of fieldwork involved mapping, surface collection, and test excavation. Both of the Late Epipaleolithic sites (TBAS 102 and 212) were subject to limited surface collections. The rationale behind this was the uncertainty that there would be substantial subsurface deposits. However, subsequent test units revealed that both sites had sufficiently intact subsurface deposits and were not solely surface manifestations. At TBAS 102, twenty 1 x 1m units were surface collected. Each of these was subdivided into four 50 x 50cm quadrants. In addition to the surface collections, four 1 x 1m units were excavated. Two of these, Units 1 and 2, bisected the 17m long stone alignment on the north side of the site (**Fig. 3**). The remaining two units, Units 3 and 4, were placed in the center of the site where the depth of deposits was expected to be greatest. All of the test units were excavated in 10cm levels and screened through .33cm mesh.

TBAS 212 was significantly larger than TBAS 102, as surface materials were scattered along the north side of the wadi. Only ten 1 x 1m surface units were collected, all of them in the immediate vicinity of the two test excavation units (**Fig. 4**). Again, the excavation proceeded in 10cm levels and all materials were sieved through a .33cm mesh.

At Khirbat al-Ḥammām, team members surveyed the site surface in 10m transect intervals, mapping exposed architectural elements and artifact distributions. Based on survey results, the site size was estimated at 7 hectares. Limited surface collections were conducted at twelve 5 x 5m units (300m<sup>2</sup>) that contained high surface densities and/or exposed walls of presumed Neolithic origin. Based on survey and surface collection, three test units (8m<sup>2</sup> in total) were excavated in the East Field. A top layer of disturbed soil containing modern rubbish was removed from all units before systematic excavation began. Below this, units were exca-



3. Topographic Map of TBAS 102 indicating Site Boundaries and Areas of Investigation.

vated in 10cm. arbitrary levels and all soil was sieved through .33cm mesh. A limited program of soil sampling was undertaken to test for the preservation of macrobotanical, phytolith, and spherulite remains. Test Unit 1 (1 x 2m) was abandoned after 10cm of vertical excavation showed that the deposits were largely devoid of artifacts and the wall alignment was only one course deep. Test Units 2 (2 x 2m) and 3 (1 x 2m) proved more productive and are discussed in further detail below.

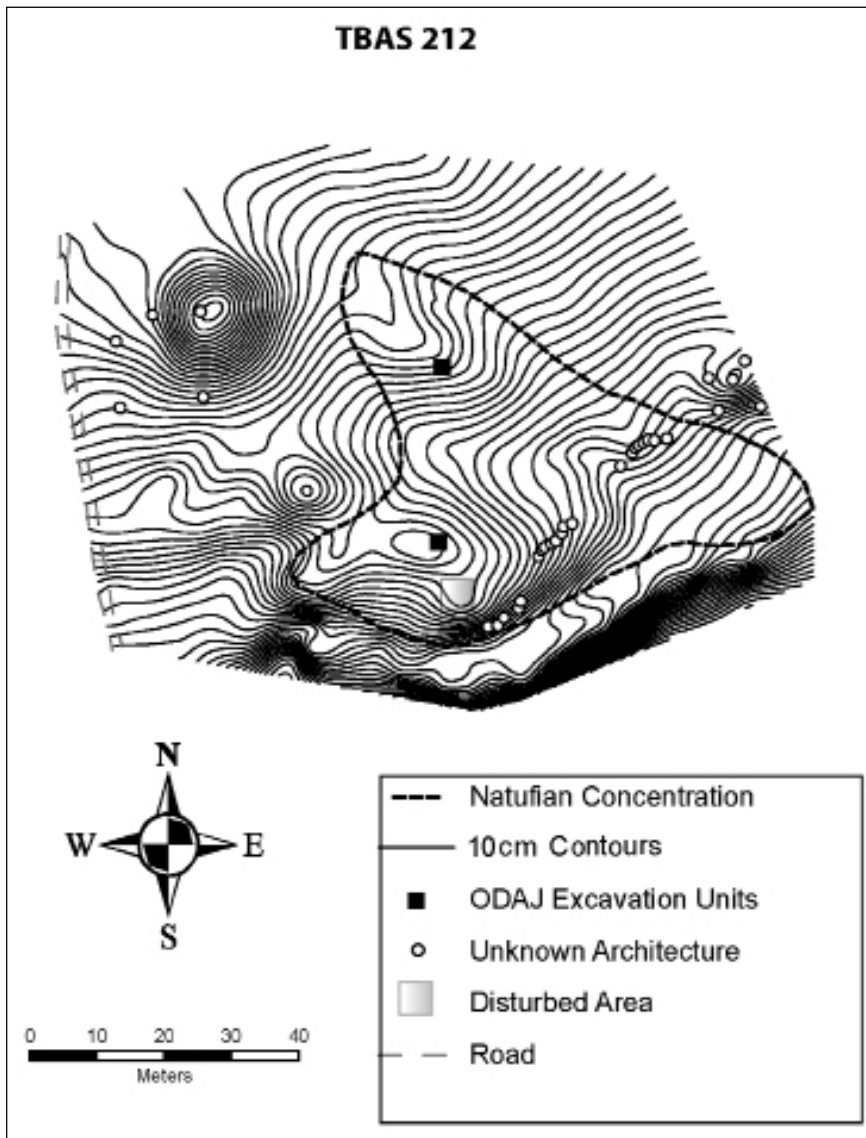
### Stratigraphy/Architecture

#### *Wādī al-Quṣayr—TBAS 102 and 212*

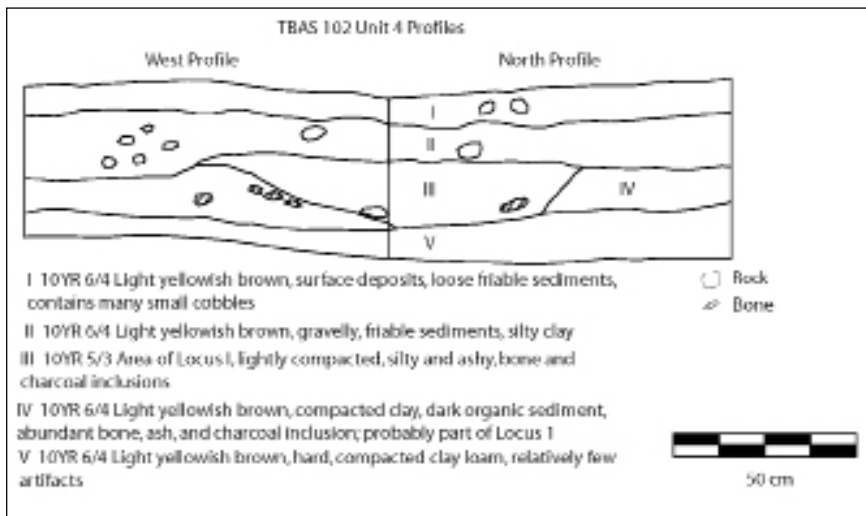
The test units at TBAS 102 contained a light yellowish brown (10YR 6/4) clay loam with oc-

casional inclusions of silts and sands. The lower levels of the four units contained small inclusions of calcium carbonate. Formal hearth features were absent but an area of darker soil (10YR 5/3 brown) containing fragmented burned bone, freshwater shell, and charred organics for dating occurred in the northwest quadrant of Unit 4 in levels 2 and 3 (20-30cm below the surface) (Fig. 5). Although the organic content was higher in this area, the edges were poorly defined and it is undetermined whether this constitutes a feature in the formal sense or whether it reflects activities related to disposal and post-occupational disturbance.

More enigmatic at TBAS 102 was the 17m long alignment of stones on the northern edge



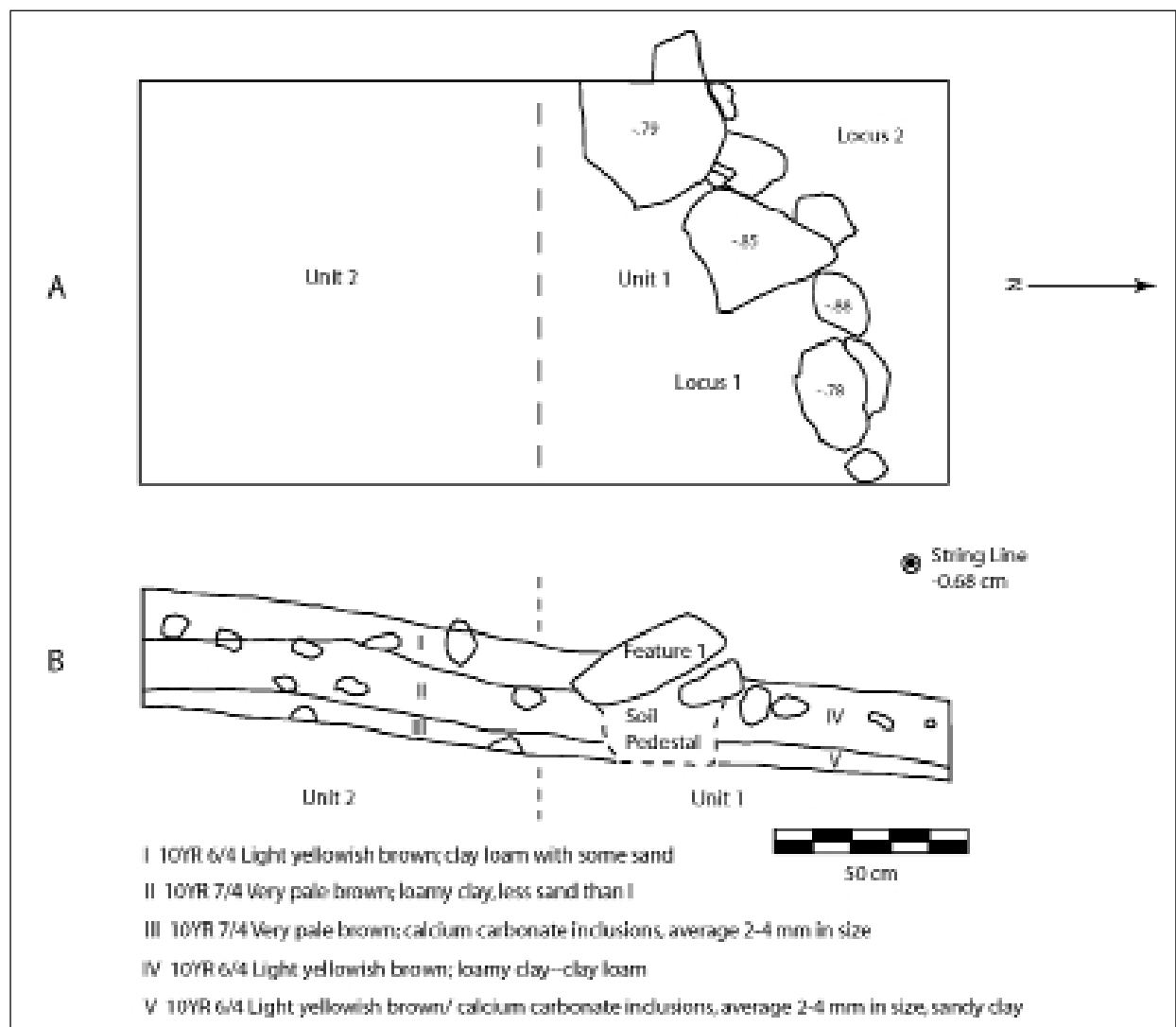
4. Topographic Map of TBAS 212 indicating Site Boundaries and Areas of Investigation.



5. West and North Profiles of TBAS 102 Unit 4.

of the site. The alignment is situated downslope from the site center and consists of a roughly linear alignment of unevenly spaced stones. Test Units 1 and 2 bisected this feature in order to determine its depth and possible cultural affiliation (**Fig. 6**). The larger stones, visible on the site surface, were supported by a series of smaller stones. Gaps were present between the stones suggesting that it did not function as a terrace or retaining wall. Furthermore, the depth of the sediment on the uphill side is not significantly different from that on the downhill side. A possible function for the alignment could be as a windbreak, especially since the gaps between the stones could be filled in with organic construction materials to create an ephemeral

barrier. This assumes that the prevailing winds were coming from a northerly or northwest direction. A potential problem with this explanation is the location of the alignment on the down-slope of the site. Unless individuals were directly against the windbreak, it would offer little wind protection on the upslope side of the site. Finally, it is worth noting that the lithic materials from Units 1 and 2 were least similar to materials in Units 3, 4, and the site surface. The materials from Units 1 and 2 were comprised of more coarse-grained, heterogeneous cherts that were larger and less well-made than the other Natufian materials. This suggests differences in activity locations or the presence of another cultural component, likely post-dating the Natufian



6. Planview (A) and West Profile view (B) of TBAS 102 Units 1 & 2.



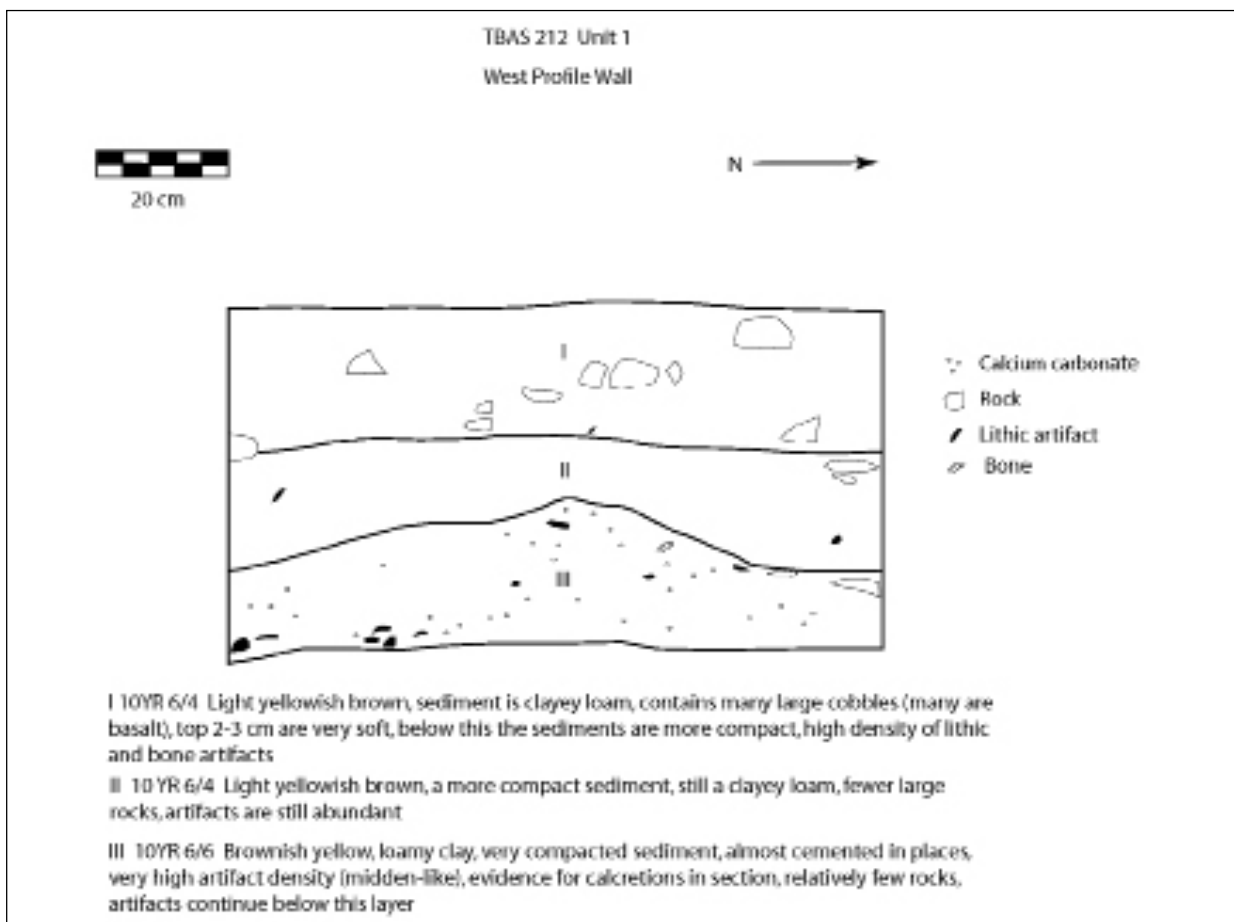
materials that dominate the site. In this case, we might be able to assign the stone alignment to this later site component and segregate it from the Natufian occupation. It should be noted that ceramics, which are associated with Holocene sites along the wadi, were not recovered from any of the excavated or surface collected units.

The two test units at TBAS 212 were characterized by loamy sediment, with variations in clay and silt inclusions that were light yellowish brown in color (10YR 6/4). Sterile sediments were reached in Unit 2 at a depth of 40cm below the surface while in Unit 1 the lower strata contain numerous inclusions of calcium carbonate and cultural materials increased in frequency (Fig. 7). Sterile deposits were not reached in the latter unit and there is potential for additional buried materials. Formal features were not observed, however, given the size of the site and the presence of subsurface materials, there is a high probability for features.

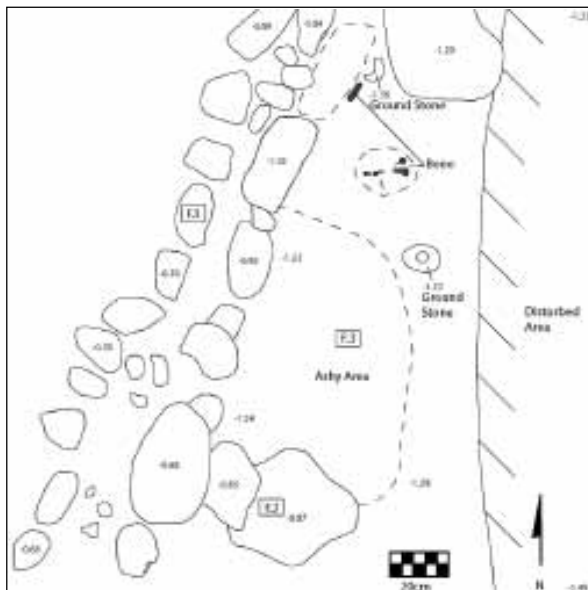
*Khirbat al-Hammām*

The ground surface of Units 2 and 3 was uneven due to the natural contour of the terrace as well as modern surface disturbances. The average depth of excavation across the units was 70cm. The fill from Units 2 and 3 consisted of homogeneous, loose, silt loam of grayish brown (10YR 5/2) or light grayish brown (10YR 6/2) color. The consistency and color suggested high ash content. Cobbles were frequent inclusions, and probably represent wall fall. The first four levels of excavated fill did not contain changes in color or texture indicative of natural strata. The homogenous fill may represent 1) trash deposits, with the abandoned structure serving as a midden for neighboring households, 2) slope wash, 3) or some combination.

Natural stratigraphic changes were first encountered in Level 5, as we came down on an irregular floor surface at between 60-65cm below ground surface (Figure 8, Feature 3). The



7. West Profile of TBAS 212 Unit 1.



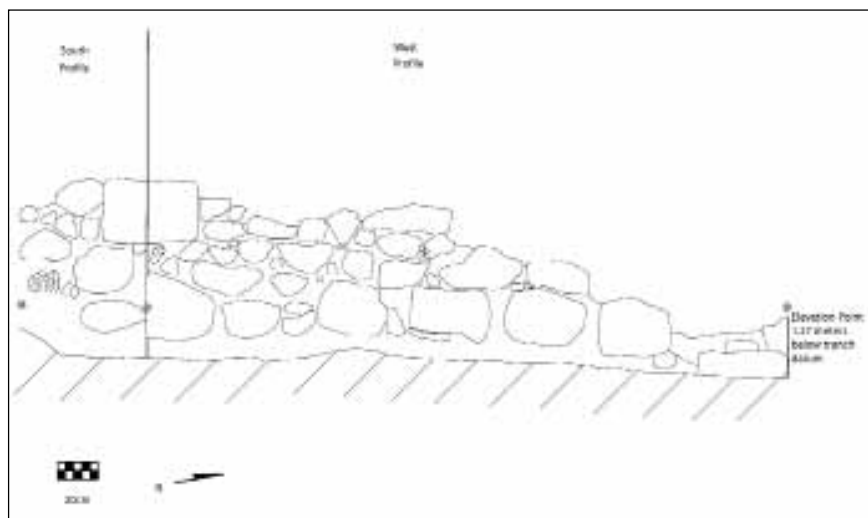
8. Plan View of Khirbat al-Hammām Units 2 & 3, Level 5.

surface was identified by a slight color change (10YR 5/4-yellowish brown), increased compaction, numerous flecks and small chunks of charcoal, and irregular patches of plaster. The course of stones sitting on this surface was noticeably larger than those in other courses, and presumably served as the wall's foundation (Fig. 9). This *huwwar* floor contrasts with the well-prepared, decorated plaster floor uncovered during the 1999 testing (Peterson 2004). Temporal or functional differences between architectural features uncovered in 1999 and 2006 may be significant. Furthermore, the East Field stone walls were preserved to a maximum of 4 courses

measuring 75cm, compared to the over 2m walls preserved in the earlier, roadcut test excavations. Time permitted us to excavate a partial subfloor level in Unit 2 and 3 (Level 6). Excavations below the floor contained artifacts as well.

Resting slightly above this *huwwar* floor in Unit 2 were 2 large pierced ground stone items. Directly under these pierced stones, resting on the floor, were numerous intact faunal elements and a tight cluster of human bones and teeth. The human remains represent a child's skull, which appears to have been placed on the floor surface, perhaps in an organic container. There was no evidence that it was buried in a subfloor pit feature. We hypothesize that the ground stone artifacts served to mark to the location of the buried human remains. Additional bioarchaeological details of the human remains are provided later in this report.

Architecturally, throughout the excavation of Unit 2, Feature 1 was assumed to be a single wall formed double row of rectangular limestone blocks (Fig. 8). However, when we moved southwards and opened Unit 3, the two rows diverged suggesting that they defined walls of separate structures that ran alongside each other. There is also evidence that individual structures went through cycles of internal modification. For example, an internal dividing wall (Figure 8, Feature 2) within the structure does not extend to the floor, suggesting that it was a later addition. The 2006 excavations provide additional support for the agglutinated, shared wall architectural tradition that is becoming well-



9. South and West Profiles of Khirbat al-Hammām Units 2 & 3.

represented across southern and central Levantine PPN sites.

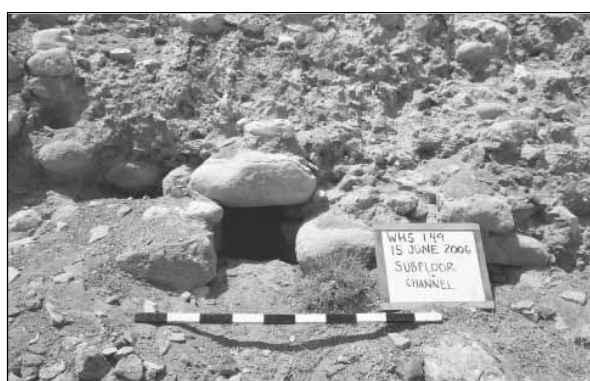
Lastly, three probable subfloor, stone channel constructions were identified during a visual survey of the exposed roadcut (**Fig. 10**). These are evocative of similar features at Baṣṭa (Nissen *et al.* 1987, 1991).

### Artifacts

All three of the 2006 ODAJ sites contained numerous artifacts. The following presents preliminary analysis results of the lithic, shell, human, faunal, and botanical materials at the sites.

### Lithics

Chipped and ground stone specimens were



10. Subfloor Channel in Roadcut at Khirbat al-Ḥammām.

washed and catalogued in the field. Detailed analyses of the Natufian materials were carried out under the direction of Dr. Neeley at his laboratory at Montana State University. Analyses of the Khirbat al-Ḥammām finds were carried out by Dr. Peterson and her students at Marquette University's Archaeology Laboratory.

*TBAS 102 and TBAS 212.* The 2006 field season yielded 32,507 pieces of chipped stone from the testing of these two sites. As presented in **Table 2**, the debitage percentages between the two sites are very similar. The main difference between the two sites is in the proportion of fragmentary and complete flakes. Another area of difference can be found in the density of materials (**Table 3**). When standardized by units of excavation ( $m^2$ ), the lithic materials at TBAS 212 are over four times more dense than TBAS 102. A possible explanation for this difference in artifact density might be due to variations in the length of occupation or the frequency of reoccupation. In light of the small-scale of the present excavation, we feel that the frequency of occupation is a more plausible case. Our reasoning for this is based on (1) the nearly identical proportions of the different debitage classes, suggesting that the same sorts of reduction activities were in place at both locations, and (2) the more widely

**Table 2:** Debitage Counts and Percentages from TBAS 102 and TBAS 212.

	<b>TBAS 102</b>	% <sup>1</sup>	% <sup>2</sup>	<b>TBAS 212</b>	% <sup>1</sup>	% <sup>2</sup>
Cores	113	1.1	1.8	211	0.9	1.5
Core Trimming Elements	66	0.7	1.0	170	0.8	1.2
Blades (complete)	324	3.3	5.1	594	2.6	4.3
Blade fragments	1421	14.4	22.6	3149	13.9	22.8
Flakes (complete)	1001	10.2	15.9	1404	6.2	10.2
Flake fragments	2706	27.4	43.0	7127	31.5	51.6
Tools	446	4.5	7.1	870	3.8	6.3
Microburins	223	2.3	3.5	274	1.2	2.0
Chips (< 10 mm)	1854	18.8	-	5417	23.9	-
Chunks	1704	17.3	-	3433	15.2	-
<b>Total</b>	<b>9858</b>		6300	22649		<b>13799</b>
<sup>1</sup> percentages for all debitage categories.						
<sup>2</sup> percentages excluding chips and chunks.						

**Table 3:** Lithic density per m<sup>3</sup> at TBAS 102 and TBAS 212.

	TBAS 102		TBAS 212	
	Units 1 & 2	Units 3 & 4	Unit 1	Unit 2
Volume of dirt (m <sup>3</sup> )	.60	.90	.50	.40
Artifact density	2013	7855	15,048	7482
Standardized density per 1m <sup>3</sup>	3355 (.11)	8727 (.28)	30096 (1.0)	18705 (.62)

scattered lithic materials at TBAS 212 relative to TBAS 102. At the latter site, occupation is constrained and localized, while in the former, site materials extend 60-70m along the north side of the wadi in varying densities. Such a pattern might emerge if populations returned to this location repeatedly.

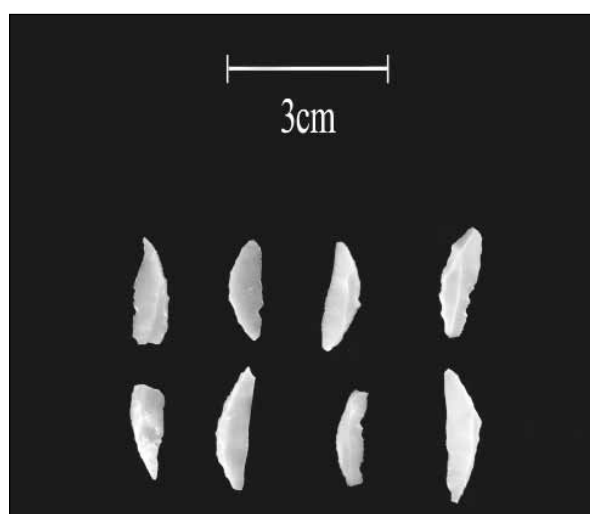
Raw materials are predominantly fine-grained flints. These range in color from light brown to gray, however, some of the color differences might be due to chemical weathering as most of the surface material was gray yet the subsurface material was more variable in color. There are also some heterogeneous cherts in the assemblage. These are characterized by differences in color, grain-size, cortex, and size from the other materials. The latter is of particular note, as the heterogeneous chert cores are significantly longer and heavier than the fine-grained materials (**Table 4**). While chert materials are

locally abundant and available, as evident by the use of these materials at nearby Paleolithic sites, the fine-grained flint appears to be selected for by the Natufian occupants. These raw materials are smaller than their chert counterparts as evident by the small-size of the discarded cores (many still retaining up to 50% of the surface covered with cortex), and the presence of a few tested cores that are roughly egg-size and shape. This suggests a pattern of raw material procurement that is unique to the Natufian as these raw materials do not appear in other local assemblages and the locally abundant cherts used during much of the Paleolithic are a minor component of the Natufian assemblages.

Retouched pieces consist largely of partially retouched edges of flakes and blades. Diagnostic elements are comprised of microlithic tools, primarily lunates (**Fig. 11**). Samples of complete lunates from both sites were examined

**Table 4:** Comparison of Core size (length and weight) between cherts and flints at TBAS 102 and TBAS 212.

	TBAS 102		TBAS 212	
	All Cores (Complete + Fragments)		All Cores (Complete + Fragments)	
	Chert <sup>1</sup>	Flint <sup>2</sup>	Chert <sup>1</sup>	Flint <sup>2</sup>
<b>Length</b>	47.29 mm	34.27 mm	49.33 mm	29.35 mm
<b>Weight</b>	92.1 g	23.49 g	77.8 g	14.7 g
<b>N</b>	19	69	12	195
	Complete Cores		Complete Cores	
	Chert <sup>1</sup>	Flint <sup>2</sup>	Chert <sup>1</sup>	Flint <sup>2</sup>
<b>Length</b>	49.98 mm	35.98 mm	61.10 mm	30.69 mm
<b>Weight</b>	105.6 g	28.9 g	135.55 g	17.1 g
<b>N</b>	15	39	6	118
<sup>1</sup> Course-grained, heterogeneous material.				
<sup>2</sup> Fine-grained, homogeneous material.				



11. Lunates from TBAS 102.

(Table 5). Lunates from TBAS 102 tend to be larger in terms of length, width, and thickness than TBAS 212. However, a size comparison with Early Natufian assemblages at Ṭabaqa and Bayḍa (Byrd 1991; Byrd and Colledge 1991) indicates that the TBAS assemblages are significantly smaller, conforming to the general notion that Early Natufian lunates are larger than those from the Late Natufian. An exception to this trend is observed with the Wādī Judayid lunates which are very small for an Early Natufian occupation (Sellars 1991). Perhaps more importantly for diagnostic purposes is the type of retouch on the lunates. It is generally recognized that Helwan (bifacial) retouch is a hallmark of Early Natufian industries (e.g., Bar-Yosef 1998; Belfer-Cohen 1991; Edwards 1991). This type of retouch is absent from the TBAS lunates where the dominant retouch type is abrupt retouch. This suggests that the assemblage is not typologically Early Natufian in age and is best

assigned to the Late Natufian. These typological patterns fit with the radiocarbon dates as well.

*Khirbat al-Ḥammām.* The chipped stone assemblage from 2006 contained 3982 artifacts. Khirbat al-Ḥammām demonstrates broad technological similarities with widespread, PPNB lithic patterns. The ranges of tool and debitage classes are consistent with Early Neolithic sites elsewhere (Tables 6 and 7). Most of the projectile points bear a typological resemblance to Byblos points, exhibiting unifacial retouch, rounded

Table 6: Tool Classes from the 2006 Excavations at Khirbat al-Ḥammām.

Class	n	%	% <sup>1</sup>
Projectile points	17	13	30
Perforators	10	8	17
Glossed blades	14	11	25
Scrapers	4	3	7
Burins	6	4	10
Notches	5	4	9
Adzes	1	1	2
Retouched blades	18	14	-
Retouched flakes	11	8	-
Utilized blades	39	30	-
Utilized flakes	6	4	-
<b>Total</b>	<b>131</b>	<b>100</b>	<b>100</b>

<sup>1</sup> Includes only formal tool classes (n=57) leaving out unclassified, retouched, and utilized pieces.

Table 5: Lunate dimensions of Complete Pieces from TBAS 102, 212, and other selected Jordanian sites.

	TBAS 102	TBAS 212	Ṭabaqa <sup>1</sup>	Bayḍā <sup>2</sup>	Wādī Judayid <sup>3</sup>
N	13	25	31	-	286
Length	19.39 mm	15.10 mm	21.19 mm	26.95 mm	15.20 mm
Width	5.72 mm	4.35 mm	6.84 mm	-	4.87 mm
Thickness	2.42 mm	2.00 mm	2.35 mm	-	-
Weight	0.25 g	0.12 g	-	-	-

<sup>1</sup> Byrd and Colledge 1991.  
<sup>2</sup> Byrd 1991.  
<sup>3</sup> Sellars 1991.

**Table 7:** Chipped Stone Counts and Percentages from the 2006 Excavations at Khirbat al-Ḥammām.

Category	n	%	% <sup>1</sup>
Cores	69	2	5
Core trimming element	6	>1	>1
Blades	254	6	20
Flakes	813	20	64
Tools	131	3	10
Chips, chunks	2709	68	-
TOTAL	3982	100	100

<sup>1</sup> Excludes chip, chunks (n=1273).

shoulders and retouched tangs (**Fig. 12**). Informal tools, such as retouched and utilized flakes/blades, are also well-represented.

Several observations are of chronological interest because they suggest pre-LPPNB occupation. Several projectile points match descriptions of earlier, EPPNB or PPNA, point styles. Specimen #25 (far right in **Fig. 12**) was found on the surface of Test Trench 2 before excavations began. The small point, produced on a blade, has bilateral notching. Morphologically the point shows similarities to el Khiam points. Specimen #60 (not illustrated) is the base of a similar point, with the lateral notches preserved. The artifact was found in the first 10cm of fill in Test Trench 2, a layer which had been greatly disturbed from both natural and cultural causes. These point types are widely regarded as *types fossiles* of the PPNA and EPPNB (Banning 1998; Gopher 1994). Erosion of the sloped site terrace, as well as a range of modern subsurface



12. Projectile Points from Khirbat al-Ḥammām.

disturbances may be responsible for the stratigraphic inversion of earlier points on top of later, *in situ* deposits.

Strategic exploitation of high quality raw materials in conjunction with naviform core-and-blade technology are hallmarks of MPPNB lithic production. The shift away from blade production has been correlated with LPPNB/PPNC manifestations at a number of sites, including ‘Ayn Ghazāl (Gebel and Beinert 1997: 242; Nissen *et al.* 1987: 98-100; Quintero 1998; Rollefson 2003). However, local variation in the timing of the shift away from naviform blade and tool production is beginning to be documented as well (Barzilai and Garfinkel 2006; Galili *et al.* 1993). Two patterns from Khirbat al-Ḥammām are worth mentioning in this context, albeit with the caveat that our sample size is quite small. First, the flake:blade ratios in Units 2 and 3 show a marked decrease at/near the floor contact level (**Table 8**). Second, corresponding with the increase in blade production in the lower levels is an increase in the use of high quality flint raw materials. Cortical surfaces were examined to differentiate between high quality flint and wadi cobble material. Cortical pieces of high quality material – fine grained, few internal inconsistencies – typically had weathered cortex, indicative of having been quarried from bedded deposits. Cortical pieces with mechanically weathered cortex were assumed to be derived from local wadi cobbles. This material is more coarse-grained and has many more internal flaws visible that hamper standardized blade production. In Level 5, 89% of the pieces with identifiable cortex, appear to have originated from bedded deposits (Koska 2008).

Glossed blades make up 25% of the formal

**Table 8:** Blade and Flake Counts and Ratios by Level at Khirbat al-Ḥammām – Units 2 & 3

Level	Blade	Flake	Flake/Blade
1	44	89	2.02
2	23	77	3.35
3	19	64	3.37
4	17	59	3.47
5 <sup>1</sup>	49	52	1.06

<sup>1</sup> The bottom of Level 5 corresponds to floor contact.

tool assemblage. A preliminary functional analysis of the fourteen tools was conducted. The majority of specimens show no retouch and unilateral usewear. Exceptions are one denticulated specimen (far right in **Fig. 13**) and one steeply backed, more massive specimen (far left in **Fig. 13**). Tool metrics combined with location and invasiveness of gloss suggest that most of these tools were hafted and suitable for harvesting cereals. The Khirbat al-Ḥammām assemblage shows strong similarities with the ‘Ayn Ghazāl glossed blades with respect to a number of metric attributes and breakage patterns (Olszewski 1994; Vande Walle 2008). Vande Walle asked whether some of the retouched and utilized blades might have been harvesting implements on which gloss had not yet formed. However, the unglossed specimens tend to exhibit distinctive patterns of retouch and/or wear suggesting different functions. For example, wear and retouch are often discontinuous, bilateral, or both.

A sample of the ground stone was analyzed and reported from the 1999 fieldwork (Peterson 2004). A noteworthy addition from 2006, are the three large ‘pierced stones’ found on the floor of the main room we excavated (**Fig. 14**). Several broken specimens had previously been de-

scribed from the surface assemblage analyzed in 1999. In the relatively unstandardized terminology applied to ground stone, these are variously described as mace heads, digging stick weights, loom weights, etc. without much in the way of formal description. These specimens are relatively large compared to other Neolithic specimens described by Wright (1992). They weigh, on average, 4 kilograms and measure 17cm in diameter. A child’s skull lay directly under two of these large pierced stones, which were resting on a rough *ḥuwwar* floor.

#### Shell/Ornaments

Preliminary work on the shell from the sites has been completed by Aldona Kurzawska of the Polish Academy of Sciences (**Table 9**). The two Epipaleolithic sites yielded a total of 460 pieces of shell from both freshwater and marine contexts. The marine shell is indicative of Mediterranean and Red Sea origins, suggesting the trade of materials from these sources to the occupants in the Wādī al-Quṣayr. All of these have been modified and probably functioned as personal adornments. The bulk of the shell material (n=445) is freshwater in origin. These are not culturally modified like the marine shell, but are important to reconstructing the prehistoric environment as they suggest the nearby presence of spring deposits, an environment significantly different from the present desert conditions.

Khirbat Ḥammām’s 2006 shell inventory includes both freshwater and marine shell specimens (n=46), and both types are culturally modified. Marine shell from both the Mediterranean and Red Seas are present. The shell assemblage mirrors general patterns found at Yiftahel, Abu Gosh, and Jericho. The shell data are relevant because they document that the site’s residents were actively involved in fairly widespread economic and social networks on par with other large, well-documented PPNB sites. The fill directly associated with the child skull contained a glycymeris shell bead. So it seems likely that shell artifacts were incorporated into ritual practice at Khirbat al-Ḥammām, as well.

#### Biological Specimens

##### *Human Skeletal Material at Khirbat al-Ḥammām*

The skull found on the floor of Unit 2 was



13. Glossed Blades from Khirbat al-Ḥammām.



14. Pierced Stone Objects from Khirbat al-Ḥammām.

**Table 9:** Shell Species and Frequencies from TBAS 102, 212 (Natufian), and Khirbat al-Ḥammām (PPNB).

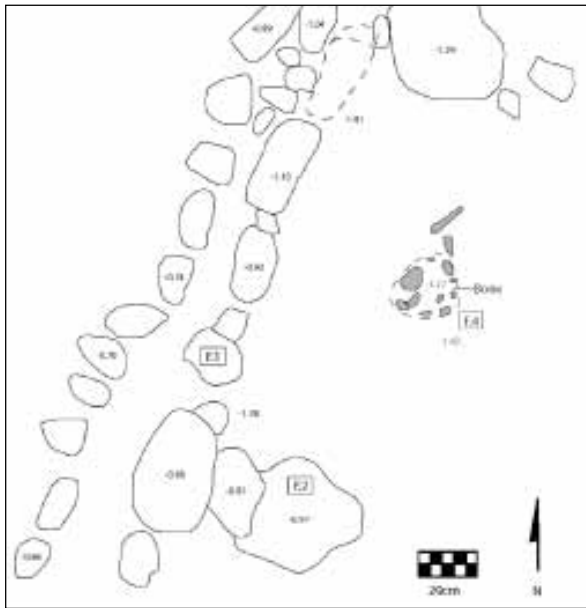
Species	Origin	TBAS 102	TBAS 212	Khirbat al-Ḥammām
<i>Melanoides tuberculata</i>	Freshwater	424	1	3
<i>Melanopsis buccinoidea</i>	Freshwater	13	6	18
<i>Bulinus truncatus</i>	Freshwater	1	-	-
<i>Theodoxus jordani</i>	Freshwater	-	-	1
<i>Xerocrassa sp.</i>	Land	2	-	-
<i>Sphincterohila zonata</i>	Land	-	-	8
<i>Nassarius gibbosulus</i>	Mediterranean Sea	2	-	1
<i>Acanthocardia tuberculata</i>	Mediterranean Sea	-	-	2
<i>Cerastoderma glaucum</i>	Mediterranean Sea	-	-	1
<i>Nerita polita</i>	Red Sea	-	-	1
<i>Euplica turturina</i>	Red Sea	-	1	-
<i>Cypraea isabella</i>	Red Sea	-	-	1
<i>Cypraea sp.</i>	Mediterranean and Red Sea	-	-	2
<i>Dentalium shells</i>	Mediterranean and Red Sea	9	1	-
Gastropod	Mediterranean and Red Sea	-	-	1
<i>Glycymeris sp.</i>	Mediterranean and Red Sea	-	-	4
<i>Donax sp.</i>	Mediterranean and Red Sea	-	-	1
Fossil bivalve	Fossil deposit	-	-	1
<b>Total</b>		<b>451</b>	<b>9</b>	<b>45</b>

highly fragmented, due in part from the weight of the ground stone artifacts lying directly above it. The skull appeared to be resting on the floor of the structure, as there was no indication of a pit feature. The fragile pieces had remained tightly clustered, as if they had been placed in a container that subsequently disintegrated (Fig 15). Excavators noted numerous well preserved caprine limb elements resting on the floor in proximity to the skull fragments. One might interpret these as offerings associated with the human materials, perhaps as part of a ritual associated with the abandonment of the structure, or some

other culturally significant event. However, the lack of a well-defined pit feature as well as the numerous faunal remains found throughout the excavation levels makes this association less than certain. The method of skull removal is not clear from the remains. The cranium and mandible are complete, but no cut marks are present. Neither are there vertebral fragments present.

Based on root development of the first premolar, the individual died at age 3 or 4 (Moorrees *et al.* 1963). Infants and juveniles are represented at other PPN sites. The assemblage of plastered skulls, for example, includes some





15. Plan View of Burial at Khirbat al-Ḥammām, Level 5.

juveniles (Bonogofsky 2003). And at MPPNB ‘Ayn Ghazāl infants were found in subfloor pits and foundation deposits (Rollefson *et al.* 1992). The number of infant and child remains has been increasing with new examples from several sites in southern Jordan: e.g., Ghwair I (Simmons and Najjar 2006) and Ba’ja (Gebel *et al.* 2006).

The central and lateral permanent incisors, that were still been developing beneath the gum-lines, show evidence of multiple hypoplastic bands. These bands are hallmarks of events that disrupt normal growth patterns (laying down the enamel) in teeth. The presence of multiple enamel hypoplasias on multiple teeth is indicative of systemic stress that affected the child over a significant period of his/her short life, as opposed to localized trauma to a specific tooth or teeth. The placement of the bands can be used as a rough estimation of the timing of stress events and suggests critical problems beginning around

age 2. Hypoplasias were common among adolescents and adults from MPPNB burials at ‘Ayn Ghazāl, Baṣṭa, and Wādī Shu‘ayb (al-Abassi and Sarie 1997; Rollefson *et al.* 1992; Schultz 1987; Schultz and Scherer 1991).

The tradition of skull caching and intramural burial is a hallmark of the PPN. And the residents at Khirbat al-Ḥammām appear to be participating in this ritual practice. But placing a child’s skull in a container on the floor of a structure is less well-documented. The variation may reflect the interplay between local and regional forces in forging mortuary practices. Other cases of local variation in PPNB mortuary practices reinforce this interpretation and include the collective burials at Ba’ja (Gebel *et al.* 2006), the unusually rich grave good assemblage associated with the burial at al-Ḥimmah (Makarewicz and Austin 2006), and the cultic, mortuary site of Kfar HaHoresh (Goring-Morris (2000).

*Fauna*

A total of 2,480g of animal bone was recorded from the three sites. Of this 610 g or 24.6% by weight was identified (Tables 10-13), represented by 173 fragments. The greater part of this material, 51.9% of the total weight and 67.6% of the identified fragments, unsurprisingly came from the larger and more intensively occupied Khirbat al-Ḥammām. The difference in state of preservation between the Natufian and Pre-Pottery Neolithic B assemblages was striking. The Natufian material from TBAS 102 and 212 was significantly more fragmented, pitted and abraded than that from Khirbat al-Ḥammām, and the proportion that could be identified was consequently very much lower: respectively 14.2 and 12.4% by weight, as opposed to 35%.

It should be noted that small samples sizes place profound limitations on the interpretation

**Table 10:** TBAS 102 and 212: Identified and Unidentified Animal Bone by Number of Fragments and Weight.

Category	TBAS 102				TBAS 212			
	N	%	Wt(g)	% Wt	N	%	Wt(g)	% Wt
Unidentified	844	97.3	566.1	85.8	612	94.9	467.0	87.6
Identified	23	2.7	93.5	14.2	33	5.1	66.0	12.4
<b>Total</b>	<b>867</b>	<b>100.0</b>	<b>659.6</b>	<b>100.0</b>	<b>645</b>	<b>100.0</b>	<b>533.0</b>	<b>100.0</b>

of these data. Identification was attempted for almost all fragments, excluding vertebrae other than the atlas and axis, as well as ribs. Teeth which comprised less than half of a complete tooth crown were also excluded. Measurements were taken following the guidelines of Driesch (1976) and Davis (1992); burned specimens were excluded. These measurements have not been examined in detail owing to the small sample sizes and preliminary nature of this report.

*TBAS 102 and 212*

A total of 659.6 g of animal bone was recorded from TBAS 102. Of this 93.5g or 14.2% by weight was identifiable (**Tables 10-11**), represented by 23 fragments. The remains of gazelle accounted for 16 fragments, or 69.6%. Three cattle bones and two bones each of equid and caprine were also identified. Of the latter, one specimen — a substantial astragalus — could be attributed to goat as opposed to sheep, but whether this specimen represents Persian wild goat or Nubian ibex is impossible to say on morphological grounds. As it was recovered from Unit 4 Level 1, the possibility that it may be a modern intrusion should also be considered.

A potential pit was identified within Unit 4 Levels 3 and 4, yielding six identifiable fragments, three of which could be attributed to gazelle. In addition, this feature also contained both of the equid and one of the caprine specimens identified in the assemblage. The unidentified material from this potential pit also yielded numerous equid-sized but otherwise unidentifiable scapula fragments, in all probability derived from the same bone as the identified equid scapula fragment. This suggests that the material

recovered from within this feature may, though fragmented, be more or less *in situ*.

A total of 533 g of animal bone was recorded from TBAS 212. Of this 66 g. or 12.4% by weight was identifiable (**Tables 10-11**), represented by 33 fragments. The remains of gazelle accounted for 30 fragments, or 90.9%. Three cattle bones were also identified.

The faunal remains from Unit 1 Level 2 were unusual in that they contributed no less than 21 identifiable fragments, or 63.6% of the total from the site. All but one of these could be attributed to gazelle, with the other being of cattle. The 20 gazelle bones were dominated by non meat-bearing lower limb elements, with 15 fragments coming from this part of the skeleton; these included 8 distal metapodial fragments. Split lengthways, gazelle distal metapodials were frequently used as bone tool blanks in the southern Levantine late Epipalaeolithic and Neolithic, most commonly for awls.

Although small, the faunal assemblages from TBAS 102 and 212 appear typical of open-air Natufian sites in the southern Levant, both in the range of taxa represented and the generally poor state of preservation of the remains. Minority of bones was burned, with a handful displaying cutmarks consistent with skinning, disarticulation and defleshing (Rixon 1988). The faunal remains from TBAS 102 appeared to be in a slightly worse state of preservation than those from TBAS 212.

There is little reason, at this stage of the late Pleistocene, to assume that the faunal remains from either site represent anything other than free-living animals subjected to greater or lesser degrees of controlled predation. A high degree of dependence on gazelle characterized most Natufian sites, though perhaps to a lesser extent to the east of the Jordan Valley than in the Palestinian woodland zone to the west (Martin 1994; Wasse 2000: 90-95). The sample of gazelle remains from TBAS 102 and 212 is unfortunately too small and badly preserved to permit specific identification with any degree of confidence. The relatively large size of some of the gazelle remains is however more reminiscent of mountain or goitered gazelle than of dorcas gazelle, a conclusion supported by the limited biogeographical evidence available (Uerpmann 1987: 90-110; Harrison and Bates 1991: 193-204; Tch-

**Table 11:** TBAS 102 and 212: Total Number of Identified Animal Bone Fragments.

Taxon	TBAS 102		TBAS 212	
	N	%	N	%
Gazelle	16	69.6	30	90.1
Cattle	3	13.0	3	9.9
Equus	2	8.7	-	-
Caprine	2	8.7	-	-
<b>Total</b>	<b>23</b>	<b>100.0</b>	<b>33</b>	<b>100.0</b>

ernov *et al.* 1987).

The presence at TBAS 102 of equid — most probably onager, but perhaps also wild ass (Uerpmann 1987: 19-32; Driesch and Wodtke 1997: 530-533) — and apparent absence at both TBAS 102 and 212 of woodland and/or mesic taxa such as deer and wild boar suggests that the Late Natufian environment may have been open, lacking in high vegetation and probably quite steppic. In this regard, the presence at both sites of cattle — almost certainly aurochs — is significant in view of the requirement of this taxon for drinking water at least every second day (Uerpmann 1987: 72). Though likely steppe, the local environment is therefore unlikely to have been so arid as to preclude the presence of at least small seasonal springs and, perhaps, a larger body of water in the general vicinity of the sites at the time they were occupied.

*Khirbat al-Ḥammām*

A total of 1,287.3g of animal bone was recorded from Khirbat al-Ḥammām. Of this 450.4 g or 35.0% by weight was identifiable (**Table 12**), represented by 117 fragments. A minority of bones were burned, with a handful displaying cutmarks consistent with skinning, disarticulation and defleshing (Rixon 1988). Of the 117 identifiable fragments, the remains of caprines account for 109 fragments (**Table 13**), or 90.9%. A total of 31 caprine post-cranial and horncore fragments could be attributed to goat with varying degrees of confidence. The identified horncore fragments were of goat rather than Nubian ibex, but the possibility remains that a few specimens of the latter are included in the post-cranial material. Sheep were not identified in the assemblage. In addition, there were three cattle bones, one of gazelle, and two bones each of fox and a medium (duck-sized) bird; one of

**Table 12:** Khirbat al-Ḥammām: Identified and Unidentified Animal Bone by Number of Fragments and Weight.

Category	N	%	Wt(g)	% Wt
Identified	117	10.0	450.4	35.0
Unidentified	1,050	90.0	836.9	65.0
<b>Total Sample</b>	<b>1,167</b>	<b>100.0</b>	<b>1,287.3</b>	<b>100.0</b>

**Table 13:** Khirbat al-Ḥammām: Total Numbers of Identified Animal Bone Fragments.

Taxon	N	%
Caprine	109	93.1
(Goat)	(31)	(26.5)
Cattle	3	2.6
Fox	2	1.7
Bird	2	1.7
Gazelle	1	0.9
<b>Total</b>	<b>117</b>	<b>100.0</b>

NOTE: Brackets indicate caprine specimens identified as goat.

the bird bones was a complete proximal posterior phalanx.

Khirbat al-Ḥammām is thought to date to the later phases of the PPNB period, by which time village-based herding economies based on domestic caprines had become firmly established in the southern Levant (Horwitz *et al.* 2000). Data from ‘Ayn Ghazāl (Wasse 2002) suggest that caprine-herding, based initially on goats rather than sheep, was making the major contribution to village-based faunal economies on the Jordanian plateau by the beginning of the Middle PPNB, if not earlier. It is however important to note that the first appearance in the region of domestic goats (whether by introduction or autochthonous domestication continues to be a matter for debate, e.g. Horwitz *et al.* 2000; Wasse 2001, 2007 and references therein) did not lead to the overnight replacement of earlier economic strategies based on hunting. At ‘Ayn Ghazāl, for example, although almost 2,000 caprine bones were identified from Middle PPNB contexts, more than 800 gazelle bones were found alongside them. (Wasse 2002: table 1). There is general agreement that domestic sheep were first introduced to the southern Levant from the north in small numbers some hundreds of years later, perhaps around the Middle to Late PPNB transition, but that they did not become economically significant until well into the Late PPNB and Pre-Pottery Neolithic C (PPNC) (Driesch and Wodtke 1997; Horwitz *et al.* 2000; Wasse 2002, 2007).

Notwithstanding the generally accepted existence of considerable grey areas in the middle ground between hunting on the one hand and herding on the other, it was deemed appropriate to attempt to assess the Khirbat al-Ḥammām goats against five criteria commonly used to distinguish the bones of a domestic animal from its wild progenitor, *viz.* (1) presence of a foreign species, (2) size reduction, (3) change in population structure, (4) morphological change and (5) increase in species frequency (Davis 1987; Meadow 1989; Legge 1996).

With regard to the first criterion, biogeographical considerations (Wasse 2001 and references therein) and the presence of at least one and possibly two caprine bones in the Late Natufian TBAS 102 assemblage suggests that it is highly improbable that this part of west — central Jordan lay outside the natural biogeographic range of Persian wild goat or, indeed, of Nubian ibex. On this basis alone, the Khirbat al-Ḥammām goats could represent free-living, hunted animals.

Systematic assessment of the second, third and fourth criteria would require much larger samples than those at our disposal here. However, on cursory inspection, the great majority of the Khirbat al-Ḥammām goat remains appear to derive from relatively small animals, broadly comparable in size with those from PPNB ‘Ayn Ghazāl, which the present author has interpreted as domestic (Wasse 2000, 2002). As at Middle PPNB ‘Ayn Ghazāl, Khirbat al-Ḥammām also yielded a minority of extremely large goat specimens, which could equally well represent hunted Persian wild goat or Nubian ibex as large domestic males.

Assessment of the Khirbat al-Ḥammām goats against the fifth criterion provides much more convincing evidence for domestication. As already noted, the great majority of Natufian and, indeed, Pre-Pottery Neolithic A (PPNA) faunal assemblages from the southern Levant are dominated by gazelle (e.g. Davis 1987, fig. 6.15), with exception of sites in the dry steppe and sub-desert zones of southern and eastern Jordan and the Negev, where caprines were more frequently exploited (Davis *et al.* 1982; Hecker 1989; Henry and Turnbull 1985; Martin 1994). Although small, the faunal assemblages from TBAS 102 and 212 suggest that this part

of west-central Jordan was one of the areas in which gazelle was the prey animal of choice for Natufian hunting communities. It therefore seems likely that the absolute predominance of goat at Khirbat al-Ḥammām post-dates the more general shift from gazelle to goat (Davis 1987, fig. 6.15) that had occurred in many parts of the southern Levant by the beginning of the Middle PPNB, which is thought by many to reflect the change from hunting to herding.

The faunal assemblage from Khirbat al-Ḥammām appears typical of PPNB village sites on the Jordanian plateau. Caprines were the most common taxon during this period at ‘Ayn Ghazāl (Driesch and Wodtke 1997; Wasse 2002), Baṣṭa (Horwitz *et al.* 2000), Bayḍa (Hecker 1975) and as-Sifiyah (Mahasneh 1997). It is generally accepted that the great majority of caprine remains from PPNB village sites on the Jordanian plateau represent herded domesticates, and there is little reason — at present — to assume that this was not also the case at Khirbat al-Ḥammām. It should not, however, be assumed that all caprine remains from the site necessarily represent herded domesticates; it is possible, even likely, that a small minority still derived from hunted Persian wild goat or Nubian ibex.

Similarly, the presence of a minority of cattle bones is a near ubiquitous feature of PPNB faunal assemblages from the southern Levant, although whether or not these were hunted or herded during the earlier part of this period continues to be a matter for debate. The presence of cattle in the faunal assemblages from TBAS 102 and 212 indicates that this taxon was hunted by the Late Natufian inhabitants of the area, and it is conceivable that their PPNB descendants may have done likewise.

The two fox bones in the assemblage are of particular interest, as both display cutmarks consistent with skinning, suggesting that these animals may have been exploited as much for their fur as for their meat; “in the early phases of the PPN in the Levant, we can see an intensive hunt for fur-bearing animals” (Driesch and Wodtke 1997: 534). The first fox bone was a relatively large distal femur fragment, almost certainly of red fox, with cutmarks on the lateral epicondyle. The second was a much smaller proximal radius fragment, tentatively attributed to sand fox, sliced all the way through some-

what below the proximal end. In this respect it should be noted that Driesch and Wodtke (1997: 534) have identified both red fox and sand fox at 'Ayn Ghazāl.

In sum, the predominance of goat, scarcity of gazelle and absence so far of sheep in the faunal assemblage from Khirbat al-Ḥammām suggests, to the extent that data from sites elsewhere may be considered representative of this particular corner of west-central Jordan, that the site post-dates the earliest Middle PPNB phases of village-based caprine herding in the region, during which hunting continued to play a significant role, but pre-dates the widespread introduction of sheep from the Late PPNB onwards. In this respect, the 2006 faunal assemblage would sit comfortably within a transitional Middle to Late PPNB timeframe, as currently understood.

The faunal assemblage recovered in 2006 from Khirbat al-Ḥammām has demonstrated that this site has the potential to deliver an enormous assemblage of adequately preserved, well-dated and demonstrably *in situ* faunal remains dating to a key period in southern Levantine prehistory. The abundant caprine remains potentially represent early Neolithic goat-based animal husbandry in its most fully developed form. The recovery of larger samples of material upon which to base a systematic zooarchaeological analysis would therefore be highly desirable. It will be recalled that intensive herding of goats - in the manner most likely practiced at Khirbat al-Ḥammām — has been implicated in severe environmental degradation around a number of early Neolithic villages (e.g. Rollefson 1996), which may in turn have paved the way for the development of more mobile sheep-based forms of pastoral economy in the PPNC (Rollefson and Köhler-Rollefson 1993; Wasse 1997). It should, however, be cautioned that analysis of the large samples of faunal material that would undoubtedly be recovered from more extensive work at Khirbat al-Ḥammām would be both time-consuming and expensive.

#### *Botanical Remains*

The flotation program did not yield any macrobotanical remains in the five samples processed from Khirbat al-Ḥammām. However, good preservation of both seeds and wood at nearby al-Ḥimmah encourage us to search for

features which might provide more productive samples (Makarewicz *et al.* 2006).

To complement geoarchaeological and macrobotanical investigations, five sediment samples were collected to examine spherulite and phytolith concentrations at Khirbat al-Ḥammām (Canti 1998; Henry *et al.* 2003; Piperno 2006). Studies of these microscopic formations have yielded significant information about local paleoenvironmental conditions, agricultural practices, and pastoral activities at other Neolithic sites in the southern Levant (Albert and Henry 2004; Cummings 2003; Henry *et al.* 2003; Jenkins and Rosen 2007).

Samples were processed at the Geoarchaeology Laboratory of Boston University. Each sample was sieved through a 250 micron geological sieve, and five milligrams was mounted on a microscope slide using Entellen New. The slides were then examined with a Nikon Labophot 2 polarizing microscope utilizing crossed polarized light at 200x. Identification of spherulites was carried out using pertinent literature (Canti 1997, 1998, 1999) and thin-section references. Phytoliths were observed on these slides only at the presence/absence level and compared with the relevant literature (Kaplan *et al.* 1992) and the phytolith reference collection.

Spherulites, while present, did not occur in high enough concentrations to indicate herbivore dung deposits (e.g., goat or sheep penning deposits). Low concentrations of spherulites could represent background noise from the local environment, including runoff from nearby grazed fields (Albert and Henry 2004), or could indicate faecal remains of humans, birds and dogs (Canti 1999). Various phytolith forms were also observed on the slides, even though the slides were not formally processed for phytolith extraction. Phytoliths observed include simple sheet elements and various trapezoids indicative of the Poaceae family (Kaplan *et al.* 1992). These forms are coming found in a variety of grass species.

These initial investigations establish the presence of both faecal spherulites and phytoliths at Khirbat al-Ḥammām. Future phytolith and spherulite research will integrate additional micromorphological and microartifact analyses to address a range of taphonomic and behavioral questions.

### Summary

Two decades of survey, excavation and geoarchaeological study in the Wādī al-Ḥasā have produced a wealth of information. Preliminary work at the Natufian sites has added to our knowledge of late Pleistocene adaptations in west-central Jordan in several ways. First, it is apparent from marl deposits and potential springs that marsh/wetland environments were more numerous in this area during the late Pleistocene. Second, it appears that Natufian settlement in the area was closely tied to these resource areas. This is apparent from the Wādī al-Quṣayr as well as the Wādī al-Ḥasā. It remains to be determined whether these were seasonally productive areas resulting in repeated short-term occupation or more sedentary occupations. We presently lack the architectural components that characterize other parts of the Southern Levant. Third, the typological and radiocarbon evidence point to a Late Natufian occupation in the Wādī al-Quṣayr, which makes these the first sites of this period in west-central Jordan. A Late Natufian presence is potentially significant for addressing local influences on the subsequent development of agricultural communities.

Test excavations at Khirbat al-Ḥammām shed light on Neolithic occupation in the area. Geoarchaeological investigations suggest that the Hasa environs may well have provided a stable and productive foundation supporting developments in farming and animal husbandry. From the vantage of Khirbat al-Ḥammām's multi-phase occupation, we suggest that certain locales within the Wādī al-Ḥasā sustained repeated, and perhaps continuous occupations dating to the PPNA/EPPNB, MPPNB, and LPPNB. At Khirbat al-Ḥammām, continuity between the MPPNB and LPPNB is manifest across a range of behavioral correlates including masonry construction techniques, shell acquisition, and faunal exploitation patterns and may suggest an *in situ* transition. Our results also show that the residents at Khirbat al-Ḥammām were inextricably linked to a larger PPNB world via ritual practice, symbolism, trade relationships, and shared technological repertoires (plaster production, chipped stone styles, etc.).

The results from 2006 provide further evidence that the Wadi al-Hasa catchment provided a well-watered, sustainable landscape for

groups on either side of the agricultural transition. Productive test excavations confirmed the presence of both Late Natufian and PPN groups. Accumulating absolute dates and typological evidence, narrows the temporal gap between the last foragers and first farmers in this area.

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