The end of the PPNA in southern Jordan: Insights from a preliminary analysis of chipped stone from WF16.

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Abstract

Research on the PPNA of southern Jordan at WF16 suggests that a distinct Late PPNA phase develops at this site. It is visible in changes in lithic assemblages and architecture. Similar changes appear to occur at other sites in southern Jordan dated late in the PPNA. At WF16, the one site that appears to be occupied throughout the PPNA, the chipped stone assemblage appears to evolve during the later stages of the occupation, confirming that the process of transition is locally derived. The main features of the transition visible in the chipped stone at WF16 are a technological change, with an increasing focus on blade manufacture, and some evidence for the development of a bi-directional knapping strategy, and a change in typology. The earlier PPNA material contains both microliths and el-Khiam points. By the Late PPNA both artefact types have completely disappeared from the assemblage. While the difference between early and Late PPNA assemblages are clear, part of the evidence for a local transition is the presence of an assemblage that is intermediary in character, and always stratified between the early and late material. The chipped stone from WF16 has never supported the division of the southern Levantine PPNA into a short Khiamian followed by a long Sultanian phase that is associated with the development of sedentism. At WF16, the early phase appears to encompass the greater part of the PPNA, and to be associated with architecture from its outset, while the Late phase is a relatively short lived. The chipped stone from this Late PPNA phase is sufficiently similar to the preceding PPNA, and dissimilar to the EPPNB elsewhere to continue to describe it as form of PPN. Some of the distinctive traits of this phase, especially in blade production, parallel EPPNB developments elsewhere, and indicate that the southern Jordanian trajectory does not occur in isolation, but is informed by wider processes. We argue that this Late PPNA develops, with influences from elsewhere in the Levant, in particular the incorporation of Naviform technology, into the distinctive MPPNB of southern Jordan and that very early MPPNB dates from Beidha and Shkarat Msaiad support this local trajectory.

Key words: PPNA, EPPNB, WF16, Southern Jordan, cultural diversity.

1.0 Introduction

In the Northern Levant our understanding of the chronological development of PPNA chipped stone, and particularly of the transition from PPNA to PPNB, is well developed. Detailed technological analyses at a range of sites (e.g. Mureybet) have defined a final PPNA industry, based on the removal of predetermined blades from opposed platform cores, that is transitional between the northern region's PPNA and EPPNB industries (Stordeur & Abbès 2002, Abbès 2008). In contrast, the end of the PPNA in the southern Levant has been characterised as a rather abrupt transition from largely unidirectional and rather *ad hoc* PPNA core reduction techniques to the bi-directional Naviform focused MPPNB industries (e.g. Edwards et al 2004). This view has subsequently been moderated by the discovery of a fully-fledged EPPNB at Motza (Khalaily et al 2007), Harrat Juhayra 202 (Fujii this volume) and possibly Mushash 163 (Rokitta-Krumnow this volume), illustrating the complexity of this transition.

Previous attempts to develop a cultural history for the southern Levantine PPNA illustrate the challenges faced when attempting to isolate chronological factors leading to chipped stone assemblage variability in this region (Kaufman and Nadel 2007; Sayej 2004). Early research suggested that the PPNA should be split chronologically into an early Khiamian followed by a later Sultanian phase (Crowfoot Payne 1983, Lechavallier & Ronen 1994). These chronological entities were primarily defined on the presence/absence or relative frequencies of certain tool types; principally microliths, projectile points, bifacials and bitruncations. This chronological schema is no longer acceptable in the southern Levant (Garfinkel & Nadel 1989, Nadel 1990) and is particularly problematic in relation to assemblages from southern Jordan where this subdivision conflates spatial, functional, taphonomic and chronological variability (Edwards et al 2004, Sayej 2004, Kuijt 2001, Pirie 2001).

An alternative approach has recently proposed a 'Late PPNA' (LPPNA) facies within the Southern Levant, which chronologically overlaps with the EPPNB in this region (Finlayson et al 2014). The LPPNA is defined not only on the basis of changing composition of chipped stone assemblages but also on changing architectural styles and animal management strategies (e.g. Edwards et al 2004, Smith et al 2016, Finlayson et al 2014, Finlayson and Makarewicz 2017). Regarding chipped stone, the LPPNA chipped stone assemblage from the site of el-Hemmeh in southern Jordan is marked by a lack of projectile points, increasing use of non-local high quality chert and a greater concern for core maintenance (Smith et al 2016). A similar absence of projectile points has been observed in other

LPPNA assemblages, such as that from ZAD2 (Sayej 2004) and the stratigraphically late assemblage (Trench 3) recovered from test excavations at WF16 (Pirie 2007). This scheme appears promising with regard to comprehending cultural change within the PPNA of southern Jordan, but is currently hampered by a relatively small sample of sites (at the moment only WF16, el-Hemmeh and ZAD2), a limited number of absolute dates and limited technological analyses of relevant assemblages.

In this paper we explore diachronic change in the chipped stone assemblages from WF16, relating this to trends seen in other PPNA assemblages from the region. A detailed description of the assemblages and their stratigraphic placement is presented in Mithen et al (in press). Although our analyses of chipped stone are at a preliminary stage, we show that the material recovered during the 2008-2010 excavation campaigns can be divided into three relatively distinct assemblages; based on technology, typology and raw material procurement. Although a precise absolute chronology for the three assemblages is as yet unavailable (see Wicks et al 2016 for a detailed consideration of the complexities of dating WF16), stratigraphic evidence (see below and Mithen et al in press) firmly suggests that the differences between three assemblages are chronological in nature and reflect local developments in the *chaînes opératoires* of chipped stone production at the site, shedding new light on the diversity of pathways from the PPNA to the PPNB in Southern Jordan.

2.0 Methods & sample

2.1 WF16

The site of WF16 lies in an ecotonal setting in the Wadi Faynan, Southern Jordan. Extensive excavation at the site has been undertaken in two main phases. Following an initial evaluation phase (Finlayson & Mithen 2007), major excavations conducted between 2008 and 2010 exposed a large area (>600m^2) of PPNA deposits, all recorded using the single context methodology (Spence 1990). This revealed an array of mostly semi-subterranean PPNA structures, with complex and variable life histories and stratigraphic interrelationships, alongside a wide range of PPNA material culture and c. 40 human burials (Mithen et al in press, Mithen et al 2015, Finlayson et al 2011b). The base of occupation deposits was not reached. For analytical purposes each structure was assigned an Object (O) number during excavation. Figure 1 shows a plan of WF16 illustrating the key structural elements discussed in this report. With the exception of a few pottery sherds and a burial dating to the Bronze Age there is no clear evidence for any pre or post PPNA prehistoric activity at the site, and a suite of 46 AMS ^{14}C indicate that the excavated layers of the site were occupied between c. 11.84 ka cal BP and 10.24 ka Cal BP, spanning most of, and potentially exceeding, the accepted duration of the PPNA in the southern Levant (Wicks et al 2016, Kuijt & Goring Morris 2002).

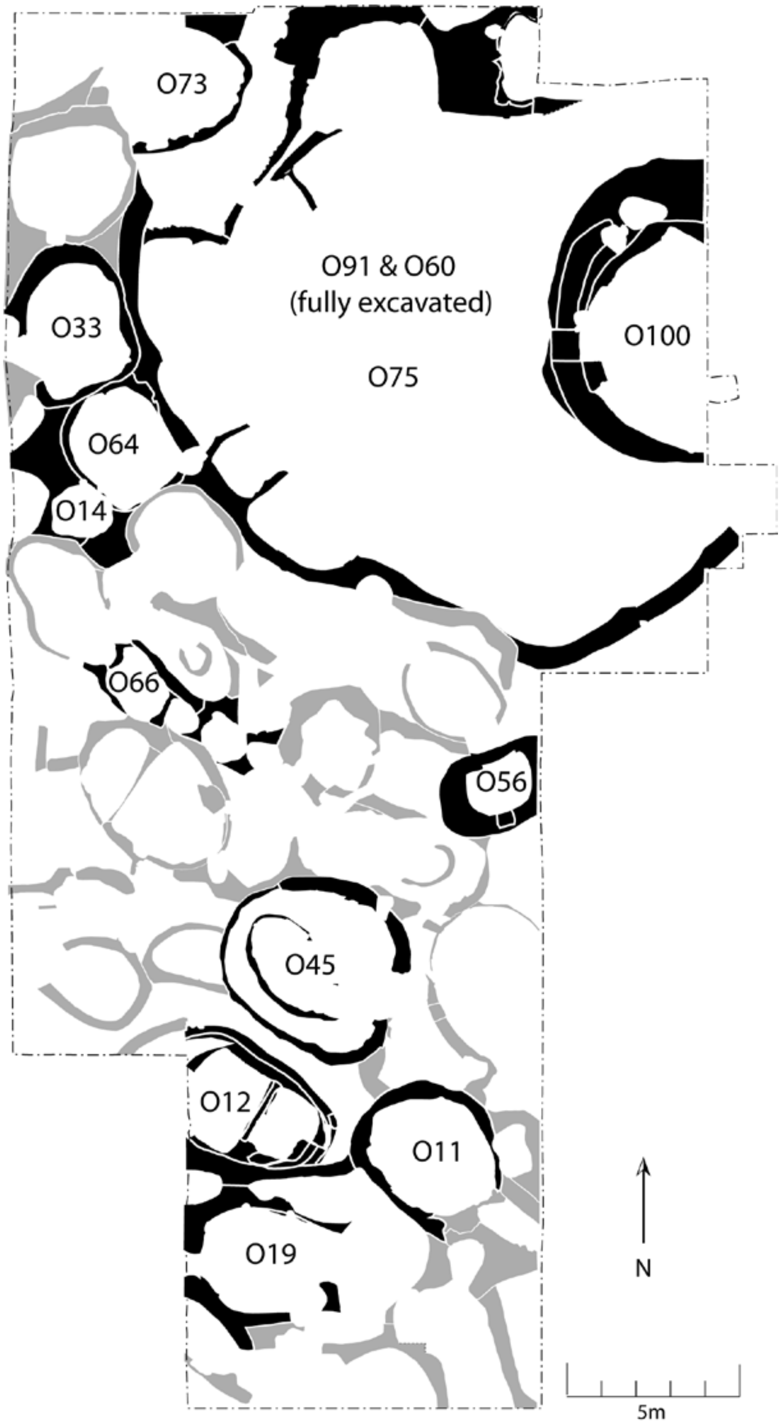

Figure 1: Schematic plan of WF16 showing Objects sampled in the present analysis

2.2 Sample

The present sample of chipped stone consists of 22,923 pieces (119.39Kg), recovered during the 2008-2010 excavation campaign at WF16. This is only 4% by weight of the c. 2,700Kg of chipped stone recovered during the 2008-2010 excavations. The sample was drawn from 14 Objects, representing different proportions of the total recovered from each of those Objects, ranging from c.88% of the small assemblage from Structure O14 to just c.2% of the vast assemblage from Midden O60. Notably, the Midden O60 assemblage comprises c.60% (c.1600kg) of the total chipped stone recovered during the 2008-10 excavation campaign (Table 1). The sample was selected to give a broad coverage of the site, concentrating on Objects that had been most fully explored through excavation. Within sampled Objects, chipped stone was randomly sampled from material collected through dry sieving (2mm) and from hand-picked 'small finds'. Chipped stone collected during flotation was not included in the present sample.

Structure	N pieces	Weight (g)	Percentage (by weight) of chipped stone sampled from Object
O11	1034	3765	33
O12	2244	9475	34
O14	906	3055	88
O19	1012	5590	34
O33	1452	6950	77
O45	3102	12655	24
O56	1237	7052	83
O60	4640	30810	2
O64	403	1292	84
O66	688	3256	66
O73	661	3720	55
O75	1559	3055	4
O91	1489	13620	12
O100	2496	15090	24
All sampled objects	22923	119385	19

Table 1: Provenance, quantity and weight of the chipped stone sample included in the present analysis.

2.2.1 Definitions

The initial cataloguing of chipped stone presented here largely follows the scheme used by Pirie (2007) (itself largely based on the work of Nadel (1997)) in the site evaluation phases, with a few minor modifications to encompass the wider range of material recovered.

Cores were classified on the basis of the dominant removal type (flake, blade, bladelet or mixed), platform (single platform, change of orientation, opposed or multi-platform), shape (pyramidal, prismatic, irregular), and raw material type (cobble, tabular, unknown/other). Items are described as core fragments where further classification is impossible due to breakage. Core Trimming Elements (CTE) are classified on the basis of which part of the core they remove. These comprise core face removals, which are flakes/blades which remove hinge and step fractures from the core face, platform rejuvenation flakes, which remove parts of the striking platform and crested elements, at WF16 these are usually crested only on a single versant.

Flakes are defined as all removals that feature ventral faces and are greater than 10mm in size, where the maximum length is less than twice the maximum width. In the present analysis this also includes flake fragments. Blades are defined metrically, having a length greater than twice their width. Bladelets are defined as blades where length does not exceed 50mm and width does not exceed 12mm. Spalls are removed from an edge of a debitage element and are triangular in cross sectional shape (e.g. burin spall). Products results from use of the microburin technique (MBT) are classified as either proximal or distal. Primary elements are included in the general debitage counts (e.g. flake, blade or bladelet), although an estimate of the number of primary/cortical elements (with >30% cortical covering) was made for each assemblage.

Debris is classified as either chunk or chip. Chips have a maximum dimension of 10mm. It should be noted that this differs from several other PPNA chipped stone reports (e.g. Nadel 1997) where the maximum size of chips was set at 15mm. Chunks are debitage items with no identifiable ventral face.

All retouched pieces are also classified according to debitage element and included in debitage counts. Non-Formal Tools (NFT) include retouched flakes, blades, bladelets which feature retouch but are not classified under any of the formal tool categories. This differs from Pirie (2007) where retouched bladelets were included as microliths. In the present analysis microliths are defined as bladelets which feature backing and/or truncation. Microliths are further classified into simple microlith types based on shape, type and position of retouch (e.g. lunate, Helwan lunate, backed bladelet). Used items include any debitage element with clear, macroscopically visible signs of use, such as edge wear/damage or rounding. The only exceptions to this are items with macroscopically visible polish, or gloss, which are classified as ‘glossed piece’. Glossed pieces are further classified on the basis of blank type and any retouch.

Points are defined as having a generally straight, acutely angled tip, usually formed by convergent retouch of lateral margins. Points also feature basal modification through the removal of the butt and generally feature basal retouch or truncation. Perforators include both borers and awls which are further classified on the basis of blank type and tip morphology. Borers feature elongated, parallel sided tips formed by steep retouch. Awls are a less tightly defined category and include a wide range of pointed tools.

The definition of scrapers, truncations, burins and notch/denticulates, follows Pirie (2007) and these are further classified on the basis of blank type and edge shape as well as the type and location of retouch. Bitruncations include all bladelets with truncation at both distal and proximal ends and are further classified as either Hagdud or Gilgal (which feature basal notches) subtypes. Bifacial pieces include all items with significant bifacial shaping and are further classified according to regularity of form, degree of finishing, shape and by the presence/absence of tranchet sharpening scars.

3.0 Raw materials

The most frequent chert types in the WF16 assemblage have been classified into five raw material types based on visual inspection of colour, grain size, translucency and cortex type (Table 2). This follows Pirie's (2007) system, although some modification was necessary because the use of the different types of brown flint appears to have chronological significance in the present analysis. More specifically, Pirie's 'chocolate brown smooth flint' type has been subdivided into two types, a medium grained opaque brown flint (Type 4) and a fine grained, relatively translucent brown/caramel coloured type (Type 5).

The dominant raw materials in the present sample are Types 2 & 3 (medium-grained, grey/grey-brown, opaque chert). Type 4 material (brown, medium-grained, opaque chert) also occurs, albeit usually in lower proportions, in most of the sampled sequences. Type 1 material (smooth grey, fine grained, translucent chert) occurs in low proportions (<5%) in most of the sampled sequences. These four chert types are currently abundant in the wadi channel and the battered state of cortex on many of the archaeological samples suggests that this was a source of these during the PPNA. Type 5 raw material appears to have been collected from sources beyond the immediate environs of the site. Not only are cobbles of this material absent from the present wadi channel, but the presence of non-battered, chalky cortex on this material shows that it has not been transported by fluvial processes. Whilst the PPNA source of this material has not yet been confirmed, nodules of similar material have been identified eroding from the hillslopes near to the town of Shawbak (c.10km upstream from WF16).

Raw Material Type (this study)	Pirie (2007) type	Description
1	Smooth grey	Fine grained, translucent grey chert. Wadi cobble cortex. White patina. Can occur within cobbles of raw material types 2 and 3.
2	Non-homogeneous	Variable in colour from white to dark grey. Opaque and medium grained. White patina. Battered Wadi cobble cortex. Similar to type 3.
3	Grey brown	Medium grained, grey brown, opaque chert. Battered wadi cobble cortex. White patina. A variable raw material type
4	Chocolate brown	Medium grained dark-mid brown, opaque chert. White patina. Chalky white cortex on cobbles.
5	Chocolate brown	Fine grained caramel brown chert. Varies from moderately opaque to moderately translucent. Cream/yellow patina. Fresh, chalky cortex. Derives from flat (tabular) slabs/cobbles.

Table 2: Classification of chert raw material types.

4.0 Three assemblage types

Analysis of the entire WF16 sample suggests that three stratigraphically distinct assemblages are present (see below and see Mithen et al in press for a detailed description of the entire assemblage). Although these assemblages share some common features; they are distinguishable in terms of raw material use, core reduction strategies and typological composition. The majority of the present sample belongs to what we have designated Assemblage A (total artefacts = 14,699). Assemblage A material was found in all Objects other than O60 and O91. However, some material, including that from outdoor surface O91, together with stratigraphically early material from Midden O60 (contexts (576), (684), (700) and (706)) and Structure O100 (contexts (906) and (907)), contain what appears to be a distinctive assemblage type we have designated as Assemblage B (total artefacts = 3730). A third assemblage, only recovered from Midden O60 (contexts (199), (203), (347), (353), (438) and (571)) and Structure O100 (contexts (801), (896) (897) and (898)) is quite different and has been designated as Assemblage C (total artefacts = 4524). Where present, Assemblage B is always stratigraphically above Assemblage A, and below Assemblage C, while Assemblage C is always above both other assemblages (Tables 3, 4 & 5, Figure 2).

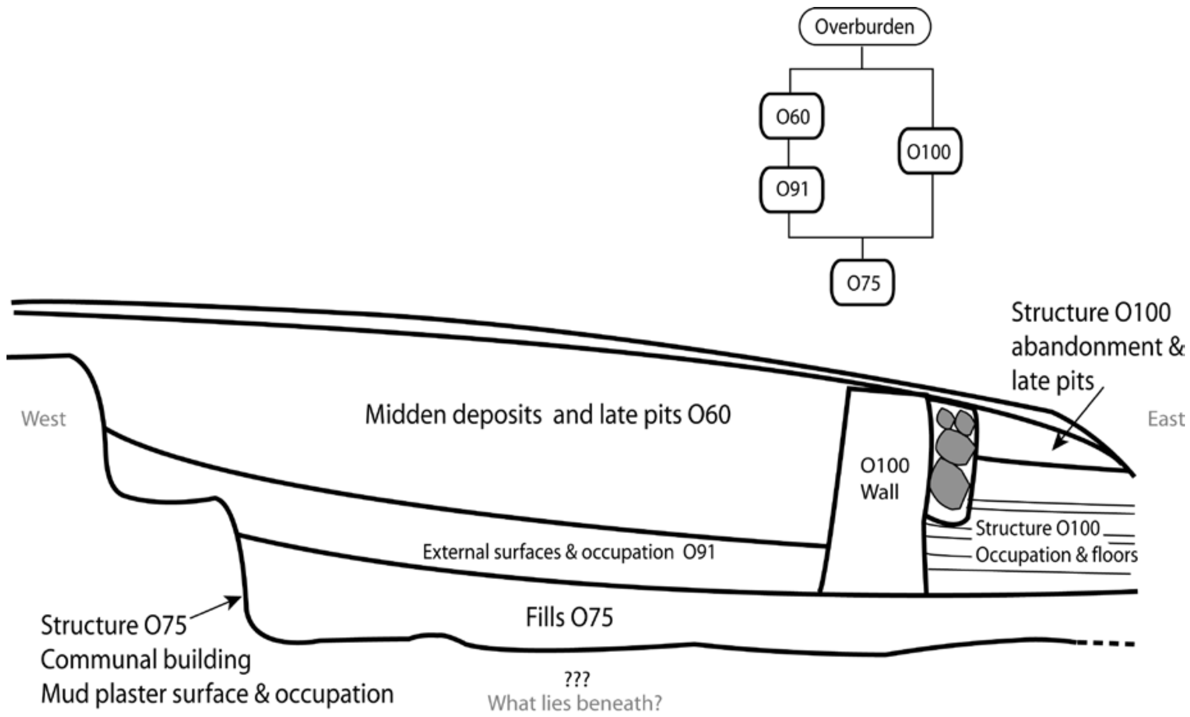

Figure 2: Schematic cross section showing stratigraphic relationships between O75, O91, O60 and O100 in the north-western part of the site

		Assemblage A		Assemblage B		Assemblage C		Total WF16	
		n	%	n	%	n	%	n	%
debitage	cores	147	1	78	2.09	82	1.81	307	1.34
	cte	138	0.94	54	1.45	86	1.9	278	1.21
	flakes	7682	52.37	1791	48.02	2489	55.02	11962	52.18
	blades	686	4.68	171	4.58	282	6.23	1139	4.97
	bladelets	1823	12.43	440	11.8	660	14.59	2923	12.75
	spalls	8	0.05	19	0.51	40	0.88	67	0.29
	mbt	41	0.28	0	0	0	0	41	0.18
	Total debitage (inc. tool blanks)	**10525**	**71.75**	**2553**	**68.45**	**3639**	**80.44**	**16717**	**72.93**
debris	chips	2419	16.49	776	20.8	500	11.05	3695	16.12
	chunks	1725	11.76	401	10.75	385	8.51	2511	10.95
	Total debris (inc. tool blanks)	**4144**	**28.25**	**1177**	**31.55**	**885**	**19.56**	**6206**	**27.07**
	Total	**14669**		**3730**		**4524**		**22923**	

Table 3: Summary of the sampled WF16 assemblages. Note that tools blanks are counted in

debitage and debris statistics.

	Type A		Type B		Type C		Total WF16	
Tool type	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
NFT	513	35.28	87	35.37	199	51.29	799	38.27
Used pieces	117	8.05	26	10.57	35	9.02	178	8.52
points	153	10.52	13	5.28	0	0	166	7.95
perforators	217	14.92	30	12.2	28	7.22	275	13.17
scrapers	47	3.23	10	4.07	22	5.67	79	3.78
bitruncations	31	2.13	0	0	0	0	31	1.48
truncations	25	1.72	3	1.22	4	1.03	32	1.53
bifacials	7	0.48	2	0.81	3	0.77	12	0.57
glossed pieces	19	1.31	5	2.03	3	0.77	27	1.29
burins	14	0.96	12	4.88	34	8.76	60	2.87
notch/denticulates	97	6.67	20	8.13	14	3.61	131	6.27
microliths	59	4.06	1	0.41	1	0.26	61	2.92
backed blades	8	0.55	0	0	1	0.26	9	0.43
retouched frags	105	7.22	19	7.72	30	7.73	154	7.38
varia	42	2.89	18	7.32	14	3.61	74	3.54
Total (n)	**1454**		**246**		**388**		**2088**	

Table 4: Typological summary of tools from sampled WF16 assemblages

	Assemblage A				**Assemblage B**				**Assemblage C**			
	bld	**blet**	**flk**	**indet.**	**bld**	**blet**	**flk**	**indet.**	**bld**	**blet**	**flk**	**indet.**
NFT	134	137	242		16	18	53		36	64	99	
used pieces	38	14	64	1	4	6	15	1	15	11	9	
points	3	150				13						
perforators	36	101	79	1	4	15	11		5	14	9	
scrapers			45	2			9	1	3	1	16	2
bitruncations	1	30										
truncations	4	11	10			2	1		1	3		
bifacials				7				2			1	2
glossed pieces	8	8	3		3	2			2		1	
burins	1	3	10		4	1	7		10	4	19	1
notch/denticulate	13	19	62	3	5	2	13		2		12	
microliths		59				1				1		
backed blades	8								1			
retouched frags.	1	10	74	20		2	9	8	2		16	12
varia	5	9	12	16	1		5	12			6	8

Total (n)	**252**	**551**	**601**	**50**	**37**	**62**	**123**	**24**	**77**	**98**	**188**	**25**
Total (%)	**17.33**	**37.90**	**41.33**	**3.44**	**15.04**	**25.20**	**50.00**	**9.76**	**19.85**	**25.26**	**48.45**	**6.44**

Table 5: Summary of blank types used for manufacture of tools in each sampled assemblage

4.1 Assemblage A

Assemblage A is fairly typical of the southern Levantine PPNA and similar to that recovered from evaluation trenches 1 and 2 at WF16 (Pirie 2007). This assemblage is manufactured mainly on wadi cobbles of medium grained opaque chert (Types 2, 3 and 4). Artefacts on these material types are generally heavily patinated. Type 1 chert is generally rare, accounting for <5% of assemblage A, although it is present in higher proportions in some sequences such as O14 where it constitutes up to 40% of the material from some contexts. Type 1 raw material is always heavily patinated and appears to have been preferentially used for the manufacture of microliths, although these are also made on other material types (Type 2 and 3), whilst other tool types (e.g. El-Khiam points) are sometimes manufactured on Type 1 chert. Type 5 material is extremely rare in assemblage A, but does occur in low proportions (c.5%) in the O12 sequence.

Debitage is based around the *ad hoc* production of bladelets, small blades and flakes from a range of informal core types that show limited platform preparation and core maintenance. A total of 147 cores are present, and the core:debitage ratio is 1:70.3. The most common core type is the single platform core at 37% of the sample and irregular cores are also abundant (34%). Change of orientation cores are less common (11%) and opposed platform core (2%) types are extremely rare. Core trimming elements (n=138, 0.9%) are composed of platform rejuvenation flakes (13%), crested pieces (9.4%), and most commonly, core face removals (77.5%). Most cores were used for mixed flake/bladelet production (38.7%). It is likely that the production of bladelets was the primary target of these cores and that many flake scars represent core preparation. However, the presence of numerous cores that were used solely for the production of flakes (these account for 31% of the core assemblage) indicates that flakes were also a desired product. Flake cores are usually extremely irregular in form. Cores that were used only for the production of bladelets are less common; accounting for just 7% of the assemblage. These are generally pyramidal/sub-pyramidal in form with a single platform, although change of orientation examples (usually with two platforms) and opposed platform types also occur. Blade cores are rare (1%) which, given the relative abundance of blades (5%) in the assemblage, suggests that blade cores were reduced beyond blade size (50mm) and are thus present in the assemblage as other (bladelet) core types.

Flakes are the most common knapping product (52.4%), with blades at 4.7% and bladelets at 12.4%, the blade:flake ratio is 1:3.1. Blades are mostly rather small (max length c. 80mm) and form a metrical continuum with bladelets, as noted by Pirie (2007). When combined blades and bladelets form 17.1% of the assemblage and were almost exclusively produced by unidirectional reduction. Burin spalls are extremely rare; constituting <1% of the assemblage. Both distal and proximal microburins are present; again accounting for <1% of the assemblage.

In terms of typology, Assemblage A is dominated by NFT (35%), which comprise retouched flakes (47.2%), retouched blades (26.1%) and retouched bladelets (26.7%). As is typical for the many PPNA assemblages small, often symmetrical, pointed pieces form a substantial component of the tool sample and both perforators (awls and borers) (15%) and projectile points (11%) are present in substantial numbers (total n=370). Perforators vary in terms of size, tip morphology and overall shape and blank types, and are manufactured on bladelets (46.8%), flakes (36.8%) as well as blades (16.4%). As with NFT, such morphological variability likely reflects the fact that this tool class includes a range of functional 'types'; including drill bits and other piercing tools. Detailed analysis of perforators, including attribute analysis and use wear, is presently being undertaken. Points form 11% of the tool assemblage and are found in all sampled Objects. Points are dominated by the El-Khiam type, which form 82.6% of the point assemblage. The majority of El-Khiam points adhere to the standard WF16 form identified in previous analysis (Smith 2007). These have straight bases and inversely retouched tips that are located at the distal end of the blank. The only exception to this is a cluster (n=4) of El-Khiam points recovered from O75 that have tips formed by direct retouch. Salibiya points are occasionally present (6%) whilst Jordan Valley (0.5%) examples are rare. Points are often distributed unevenly and small collections of points are frequently found together in single contexts. For example, in O14 nine of the 14 points were recovered from context (495) (an ash/silt fill of a lined pit), and in O12 ten of the 24 points derive from context (484) (a dump of burnt material).

Glossed pieces were not identified in Pirie's (2007) report, but are present here and account for (1.3%) of Assemblage A. Glossed pieces generally take the form of unretouched blades and bladelets with bifacial gloss on a single lateral margin. Proportionally these are most abundant in 'workshop' O56 where they account for 3% of the assemblage, this is interesting given the tentative interpretation of O56 as a possible bead manufacturing workshop (see Mithen et al in press) and suggests the gloss (or polish) on these pieces may derive from non-harvesting tasks. Other tool types include bitruncations (0.5%), both Hagdud (87%) and Gilgal (13%) types, microliths (4.1%) and backed blades (0.6%). Burins (1%) and bifacial tools (0.5%) are rare.

Microliths are consistently present and were recovered from all Objects containing Assemblage A. Microlith types include both straight and arched backed bladelets (44.3% of microliths), lunates (23%) and fragments (16.4%) together with a range of other types. Microlith backing types include direct, inverse and bipolar, and 18% of microliths feature bifacial Helwan backing. Microliths are mainly manufactured on fine grained Type 1 raw material, although small proportions are made on types 2 and 3. Notably, no microliths manufactured on brown raw materials (types 4 and 5) were identified. Microliths form significant components of the tool assemblages in several Objects; constituting 17% of the O64 assemblage and they also feature prominently in the assemblages from O33 (8%), O14 (5%) and O73 (4%). The presence of microliths in PPNA assemblages is controversial (e.g. Kuijt 1996, Gopher & Barkai 1997) and some researchers have argued that in PPNA contexts microliths are most likely to be recycled from earlier, underlying Epipalaeolithic contexts (Kuijt 1996). At WF16, microliths tend to be heavily patinated, but there is no indication that these have suffered greater post depositional movement than other components of the assemblage. Based on the present evidence, there seems no reason to single out microliths as being intrusive and it seems most straightforward to accept that microliths (and the microburin technique occasionally used in their manufacture) are integral parts of Assemblage A at WF16.

4.2 Assemblage B

Assemblage B is dominated by Type 2, 3 and 4 raw materials, as well as both 'unusual' chert and coarse stone materials (particularly in contexts from Midden O60). Type 4 material is present in higher proportions (c.30%) than in Assemblage A. More significantly, Type 5 material is present in higher proportions; accounting for c.10% of both the assemblage from O91, and contexts (906) and (907) from O100. In contexts from O60 a similar story is revealed, and although type 5 raw material is rare (<5%) in the earliest sampled context (706), it accounts for c.30% of the assemblage from the immediately overlying context (700).

As with Assemblage A, single platform cores are common (35%). However, there is a marked increase in the proportion of both change of orientation (21%) and opposed platform cores (5%). There is a small decrease in the proportion of irregular cores to 31%. Cores showing evidence for mixed flake/bladelet production are even more dominant (47.4%) than in Assemblage A. Flake cores are again extremely irregular in form. Cores that were used only for bladelet production are slightly more frequent than in Assemblage A, at 9% of the assemblage. These are generally pyramidal/sub-pyramidal in form and feature a single platform, although change of orientation examples (usually with two platforms) and opposed platform types are also present. Blade cores continue to be rare (1%). CTE (n=54, 1.5%) are more frequent than in Assemblage A, with platform rejuvenation flakes

(18.5%) and crested pieces (13%) both more common. Core face removals are less frequent at 68.5%. Taken together, the subtle shift in core and CTE types may suggest a greater concern with control over knapping products by the manufacturers of Assemblage B.

Flakes, again, are the most common knapping product (48.02%), with blades at 4.6% and bladelets at 11.8%. The blade:flake ratio is 1:2.9. Blades are again mostly rather small (max length c. 80mm) and form a metrical continuum with bladelets. Blades and bladelets form 16.4% of the assemblage. Other key technological departures from Assemblage A are that burin spalls are more common and there is no evidence for the use of the microburin technique.

In terms of typology, Assemblage B has a lower proportion of retouched tools (6.6%) than Assemblage A (9.9%). However, as in Assemblage A, tools are dominated by NFT (35%), which include an extremely high proportion of retouched flakes (60.9%), together with lower proportions of retouched blades (18.4%) and retouched bladelets (20.7%). Perforators (12.2%) are again well represented but the frequencies of both projectile points (5%) and microliths (n=1, 0.4%) are sharply reduced. Assemblage B features a marked increase in the proportion of burins (5%). Glossed pieces (2%) and bifacial tools (0.8%) are present in low numbers and no bitruncations are present in Assemblage B.

Points (n=13) are all of the El-Khiam type and again are unevenly distributed; six of these were recovered from O60 context (576)- a context rich in type 5 raw material. Strikingly, the El-Khiam points from Assemblage B are more diverse in form than those from Assemblage A. For example, the point from O100 (906) and several of those from O60 feature tips formed by direct retouch (Figure 3 a & b), often located at the proximal end of a bladelet. The two examples from O91, however, adhere to the 'standard' Assemblage A form. Assemblage B incudes 18 tools classified as varia; these include rolled/residual Palaeolithic tools, retouched chunks, retouched spalls, and a flake with bitumen residue adhering to its surface.

4.3 Assemblage C

Although all five raw material types are present in Assemblage C, this assemblage is clearly differentiated from Assemblage A- and to a lesser extent from Assemblage B- by the extremely low proportions of Type 1 material, which is absent from most sampled contexts, and by the fact that Type 5 material constitutes c.30% of the assemblage and is most often used to manufacture blades and bladelets from heavily prepared and maintained cores. These include occasional examples of careful, opposed platform blade/let production. The choice of raw materials marks one of the clearest differences between Assemblages A and C.

Assemblage C has 82 cores (1.8% of the assemblage) and a core:debitage ratio of 1:42.9. The most commonly found core type is still the single platform core at 34%, but the proportion of irregular cores declines to 28%, the frequency of change of orientation cores again increases (23%), and opposed platform cores now constitute 6% of the assemblage. As such, the changes in core type seen within Assemblage B continue to develop. Although many cores are regular in shape, there are several unusual examples which resemble burins, perhaps suggesting a desire to maximise use of non-local raw materials. Cores used to produce a mixture of flakes and bladelets are marginally more common than in Assemblage B, at 48.7%, while there is a continued decline in cores used solely for the production of flakes (23%). Flake cores are again extremely irregular in form. Cores that were used only for the production of bladelets are almost twice as common as in Assemblage A, accounting for 17% of the core assemblage. Although there are no blade cores, one of the opposed platform cores (now of a size to produce bladelets (Figure 3f) features scarring that suggest that it had previous been used for bi-directional blade production. Although analysis of core technology is ongoing, preliminary observations suggest that bladelet cores from Assemblage C are more standardised in form, targeting higher quality (Type 5) raw material, with greater evidence for preparation and maintenance. Core trimming elements (n=86, 1.9%) again increase in frequency; platform rejuvenation flakes (36%) are more frequent while crested pieces (11.6%) are approximately as common as in the Assemblage B. Continuing the trend seen between Assemblage A and Assemblage B, core face removals become still less frequent at 52%.

Flakes are the most common knapping product (55 %), with blades at 6.2% and bladelets at 14.6%, the blade:flake ratio is 1:2.6, continuing the trend for increasing production of lamellar items seen in Assemblage B. As in the other WF16 assemblages, blades are mostly rather small (max length c. 80mm. As in other WF16 assemblages these form a metrical continuum with bladelets, however, Assemblage C blades are generally more regular than those from Assemblages A and B, with greater evidence for careful preparation/isolation of striking platforms. Blade/lets feature several pieces manufactured on opposed platform cores, consistent with the range of cores recovered from these contexts. Burin spalls continue to increase in frequency, and now constitute 0.88% of the assemblage. A single tranchet spall is also present. As with Assemblage B, there is no evidence for use of the microburin technique.

Tools are more dominated by NFT (51.3%) than either Assemblage A or Assemblage B. These comprise a relatively low proportion of retouched flakes (49.8%), together with retouched blades (18.1%) and a high proportion of retouched bladelets (32.2%). Whilst the retouched flakes are generally large with irregular, chunky retouch, retouch on bladelets is often fine and irregular, which may suggest that the 'retouch' on these pieces is, in fact, unintentional edge damage. This is a plausible interpretation given the depositional context (e.g. midden) of much of the Assemblage C material.

Perforators are less frequent (7.2%) than in other WF16 assemblages and there are no points. Where present, perforators are generally more robust and less regular in form than those from Assemblage A. There are also fewer examples that resemble projectile points. Together this represents a significant departure from the general character of southern Levantine PPNA assemblages; which are usually dominated by slender, bilaterally pointed tools made on bladelets. Amplifying the trend seen in Assemblage B, burins represent a significant component (8.8%) of Assemblage C. Burins, mostly manufactured on type 5 material, take a range of forms and include both single and multiple types, with burin blows initiating on a range of surfaces. As with points in both Assemblage A and Assemblage B, the distribution of burins is uneven. For example, 10 of the 25 burins from O60 were recovered from context (199), whilst 11 of the 16 burins from O100 were found in context (801). Both (199) and (801) are fills of stratigraphically late PPNA pits dug into earlier deposits.

Glossed pieces remain relatively rare (n=3, 0.8%), but are often larger and feature far more developed gloss than is seen in the other WF16 assemblages. One of the glossed pieces (Figure 3e) is a possible Beit Tamir sickle. Assemblage C includes a low proportion of bifacial pieces (n=3, 0.8%).These are generally irregular in form, including several rough outs including examples made on basalt. No tranchet axes (four of which were identified in Pirie's (2007) report from evaluation Trench 3) are present in Assemblage C, although a tranchet sharpening spall from a small biface was recovered from O60. Scrapers are present (n=22, 5.7%), and are generally fairly large (>40mm) and feature a range of, usually irregular and chunky, styles of retouch. Several scrapers retain cortex on their dorsal surfaces. A single microlith is present, in the form of a rather battered lunate manufactured on Type 1 material. Both the raw material and condition of this piece suggest that it has been recycled from earlier levels. There are no bitruncations in the assemblage.

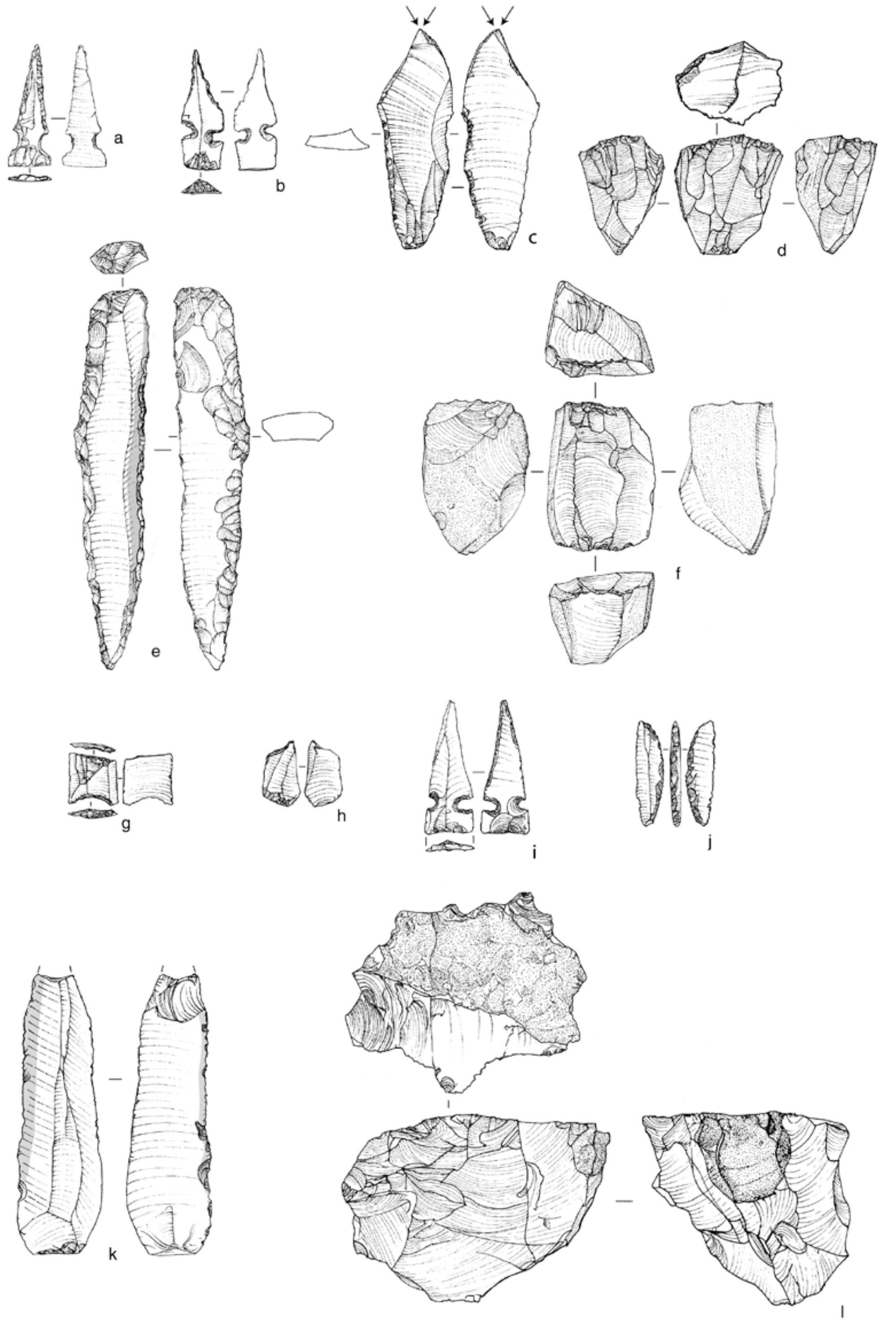

Figure 3: Chipped stone artefacts from Assemblages A (h-l), B (a and b)and C (c-f) at WF16. Note different El-Khiam point stylistics (see text) between assemblages A and B, and greater concern with core form in Assemblage C. a) El-Khiam point O100 (906), b) El-Khiam point O60 SF983 (576), c) dihedral burin O100 (801), d) single platform bladelet core O60 (438), e) glossed piece (Be'it Tamir?) O100 (SF 2567) (896), f) opposed platform bladelet core O60 (438), g) Hagdud bi-truncation O56 (676), h) Proximal microburin O33 (356), i) El-Khiam point O12 (484) (SF 794), j) Helwan lunate O33 (357), k) glossed blade

O56 (676), l) single platform mixed flake/ bladelet core O33 (377).

	Assemblage A	Assemblage B	Assemblage C
Raw materials	Locally available chert wadi cobbles dominate. Primarily grey brown types 2, 3 and 4 Occasional/rare occurrences of Types 1 and 5.	Locally available chert wadi cobbles dominate. Primarily grey brown types 2, 3 and 4 Increased use of Type 5 material (c.10%).	Mix of locally available chert wadi cobbles and non-local chert. Sharply increased use of Type 5 material (c.30%). Type 1 extremely rare
Reduction technology	Relatively unstandardized use of single platform and change of orientation mixed flake/bladelet cores. High proportion of irregular cores. Limited evidence for platform preparation. CTE dominated by core face removals. Occasional use of MBt	Increased proportions of change of orientation and opposed platform cores. Fewer irregular cores. Increased proportions of CTE including platform rejuvenation and crested elements. No use of MBt	Increased proportions of opposed platform and change of orientation cores. Fewer irregular cores. More evidence for platform preparation. Increased proportions of CTE including platform rejuvenation and crested elements. No use of MBt
Typology	Dominated by NFT alongside points and perforators. Points of standard form. Bitruncations & microliths present. Burins rare.	Dominated by NFT and perforators. Points rare and diverse in form. Bitruncations absent, microliths rare. Sharp increase in proportion of burins.	Sharp increase in NFT. Perforators less common and of unusual form. Points and bitruncations absent. Microliths rare. Further sharp increase in proportion of burins

Table 6: Qualitative summary of main characteristics of the three WF16 assemblages

5.0 Diachronic change

Although the three assemblages defined above share a range of technological and typological features; they are clearly distinguishable in terms of raw material use, core reduction strategies and tool manufacture as summarised in table 6 and figure 3. At the present level of analysis, it has not been possible to delineate reduction technology in any detail, nor fully comprehend the full repertoire of techniques used in blank production, tool manufacture or tool use. These analyses are currently in progress. From the current perspective, the key issue is to explain the causes of assemblage variability and, more specifically, to delineate chronological change.

The clearest differences occur between assemblages A and C, with Assemblage B appearing to be intermediate, or transitional, in nature. The presence of 'unusual' El-Khiam points that are manufactured on Type 5 material strongly supports the interpretation of Assemblage B as transitional between assemblages A and C. Indeed, this, together with the dearth of Raw material 5 in most sampled Objects, indicates that there has been limited movement of chipped stone between Assemblage C contexts and those yielding Assemblage A and B material. This appears to confirm that contexts yielding Assemblage C material postdate the formation of sampled contexts from other Objects at the site.

This assertion is supported by stratigraphic analysis. Although the deflation of upper deposits, and the complex nature of wall construction, mean that it is rarely possible to develop robust stratigraphically based chronological relationships between Objects, the sequence of Objects from the northwest of the site provides a rare chance to explore diachronic change. Here it is clear that O100 and O91 postdate the abandonment of O75 and that O60 also postdates O91 and the initial construction of wall (795) surrounding O100 (Figure 2). This sequence appears to be reflected in the succession of chipped stone assemblages (Assemblage A, Assemblage B, and Assemblage C) that have been identified from these Objects. Stratigraphically, where Assemblage C has been identified it always overlies both Assemblage A and Assemblage B, and (where it has been identified) Assemblage B always overlies Assemblage A. This provides the strongest evidence that the inter assemblage variability at WF16 has a strong chronological dimension.

While these three assemblage types demonstrate a clear change over time, not all the observed variability will represent diachronic change: clearly there will be spatial, functional and taphonomic dimensions of variability. Such issues proved to be a major obstacle to the widespread acceptance of the Khiamian/Sultanian chronological model of the PPNA (e.g. Nadel 1990) and in the present context these factors are relevant. For example, the sample of Assemblage B material is rather small and is mainly derived from Surface O91 (c.40%) and Midden O60 (40%). As O91 has been interpreted as an outdoor knapping area and O60 is a midden, it is likely that at least some aspects which distinguish this material from that in Assemblages A and C relate to function and taphonomy. Assemblage C has also, so far, only been recovered from a restricted range of contexts. These are dominated by deposits from Midden O60 and the fill of a large pit (801) in O100, and it is possible that the small sample of context types creates a restricted view of Assemblage C. Therefore, although we argue that chronology is the main driver of assemblage change; we recognise that function, spatial factors and sample size have also influenced observed variability between the three assemblage types.

In terms of absolute chronology the situation at WF16 is less clear. Wicks et al (2016) and Finlayson et al (2011a) have recently shown that interpretation of the AMS ^{14}C chronology at WF16 is complicated by a range of both site specific and more general factors including the effect of old wood, a plateaux on the ^{14}C calibration curve, recycling of timbers and charcoal fragments, and the effect of burrowing insects and animals. In this light it is difficult to provide any absolute ages for the three assemblage types, beyond saying that they all likely derive from occupations dated to between 11.84 ka cal BP and 10.24 ka cal BP and that the Assemblage C material likely dates towards the end of this period. When focussing on the north-western area of the site, these issues quickly become apparent and the dates from the stratified sequence of O75, O60, O91 and O100 feature numerous stratigraphic inconsistencies. We also note that no dates have been obtained from contexts yielding Assemblage C material. Given the present state of knowledge, it seems that ^{14}C is unable to help tie down the absolute timing of the transitions between the assemblages.

6.0 Discussion: the LPPNA in southern Jordan

The WF16 settlement includes both early (Assemblage A) and a late (Assemblage C) phases, however, these do not accord with the old notion of a short-lived, non-architectural Khiamian followed by a ‘village Neolithic’ based Sultanian (e.g. Byrd 2005). Although there are some similarities between the Khiamian and Assemblage A (presence of microliths, lack of bifacials, plenty of points) and between the Sultanian and Assemblage C (fewer points, no microliths) there are several areas where the WF16 assemblages identified here do not conform to this schema. For example, bitruncations, seen as a Sultanian tool (Nadel 1990), are only present at WF16 as part of Assemblage A, whilst the presence of burins (not generally identified as chronologically sensitive within the PPNA) are a defining typological feature of Assemblage C. More obviously, at WF16 contexts yielding Assemblage A material are clearly associated with architecture and appear to have a longer time depth than those associated with Assemblage C. Finally, at WF16 the transition between assemblage types occurs late in the sequence, perhaps reflecting a local dimension to wider regional patterns of change at the end of the PPNA.

In a regional context, the Assemblage C material shares some affinities, such as the increase in the use of high quality brown raw materials, a reduction in the proportion of points and an increased concern for core maintenance/preparation with material deriving from WF16 evaluation Trench 3 (Pirie 2007). Assemblage C also shares traits (such as a lack of points and high proportions of burins) with both the LPPNA material from site of el-Hemmeh (Smith et al 2016) and (to a lesser degree) that from ZAD 2 (Sayej 2004). Overall, Assemblage C appears likely to date to the LPPNA, a distinctive southern Jordanian phase of the PPNA (Finlayson et al, 2014; Finlayson and Makarewicz 2017). Importantly, at WF16 we have evidence for the gradual *in situ* development of this LPPNA chipped stone industry, highlighting the potential of the WF16 sequence to shed light on PPNA cultural developments. Here we would like to point out that the identification of a LPPNA chipped stone assemblage at these southern Jordanian sites does not deny the existence of an EPPNB in the region. Nor do we suggest that the EPPNB has its roots in southern Jordan. However, we propose that the LPPNA material from these sites provides a glimpse of the undoubtedly complex cultural dynamics that were at play in the southern Jordanian PPNA and it seems entirely reasonable that the LPPNA may reflect interactions between EPPNB communities and ideas and more traditional Jordanian PPNA lifeways.

Assemblage C and the LPPNA

Assemblage C appears to be part of a distinct LPPNA development in southern Jordan, with three sites (WF16, el-Hemmeh and ZAD 2) showing broadly similar trends towards more controlled, bidirectional knapping. It must be emphasized that the LPPNA assemblages described here are clearly distinct from EPPNB assemblages, and the classic features of EPPNB assemblages (increased use of obsidian, production of pre-determined blades using Naviform reduction and the presence of Helwan points) are all absent from the LPPNA assemblages. While a full Naviform technology is not adopted until the MPPNB, the LPPNA developments go part way to filling a technological gap, and a considerable way to filling the chronological gap between the PPNA and the MPPNB in the region.

Late PPNA dates and MPPNB dates from Beidha and Shkarat Msaied in southern Jordan indicate there is no missing Early PPNB between these Neolithic phases (Finlayson and Makarwicz 2017). Continuity in architectural practice, a role for communal architecture, and distinctive regional burial practices, all confirm very local cultural trajectories. Indeed, the early dates from both MPPNB sites, and the presence of undated layers below the well-known MPPNB architecture at both sites, suggests there is no chronological space for an EPPNB at these sites. The LPPNA chipped stone technology suggests a local population, aware of developments in lithic technology in the wider Neolithic world, developing their own local variant. Early within the local MPPNB sequence, these local populations finally adopt the fully developed Naviform technology.

This process of local development combined with the adoption of knowledge and skills from other Neolithic areas appears typical of PPN developments. It is seen again at Beidha where, after the initial indigenous development of animal management practices that appear close to those used to manage fully domesticated herds, the local herders import new, domesticated breeding stock. Intriguingly this process appears to be reflected in newly emerging DNA data, which suggests that gene flow between Neolithic regions did not begin until after the Neolithic innovations had begun to emerge in many different locales (Lazaridis et al 2016).

At the same time, there is increasing evidence for an EPPNB presence in the southern Levant. Results from Motza, near Jerusalem, had suggested that other sites in northern/central Jordan, such as Jilat 7 (Baird 1994) and Mushash 163 (Rokitta-Krumnow this volume) tentatively designated as EPPNB, might more securely be placed within that cultural grouping. Recent information from southern Jordan (Fujii, this volume) suggests a more local EPPNB presence that may be partially coeval with the LPPNA described here. This new information is intriguing, as it does not replace the emerging LPPNA paradigm, but sits beside it. The most parsimonious interpretation is that, within a landscape full of highly distinctive local adaptations and cultural variation between every site, there was room for more than one population.

More detailed analysis of the blade industry at Motza have further elucidated the process of change. Multiple knapping methods were used to produce PPNB bidirectional blades in the southern Levant, and additional techniques were used to produce the blanks used to produce characteristic EPPNB Helwan points (Barzilai 2013). While Barzilai notes that one of the techniques used at Motza appears (on current evidence) to have evolved in the northern Levant, he sees this arrival as most likely part of a cultural diffusion from the north. By the MPPNB this particular technique ceased to be used. It seems likely that several variants of EPPNB and LPPNA existed at the same time, and all had probably evolved out of local populations, with more or less exchange of knowledge with the north.

7.0 Conclusion

Research on the early Neolithic in Jordan is rapidly uncovering new information on the PPNA and multiple routes of transition to the MPPNB. The Neolithic of the southern Levant is not a monolithic entity, indeed there are sub-regional differences within Jordan. At present, the diversity between individual sites remains considerable, and there are still questions regarding what may be functional, chronological, or cultural/ethnic dimensions of chipped stone variability. In this paper we have provided a glimpse of the potential of WF16 to contribute to our resolution of these issues. Ongoing analyses focusing on understanding the technological choices made by PPNA communities in Southern Jordan will flesh out and enrich the interpretations provided here.

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