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Woodworking Implements from Neolithic 'Ayn Ghazāl: Tools of Chance

Introduction

Flaked and ground-bit axes and adzes form a significant portion of the chipped stone assemblages from Levantine Neolithic sites, thus attesting to a lengthy use of wood and the pursuit of woodworking by Neolithic townspeople. Axes and adzes, as well as chisels and pick-like tools of assorted forms, generally are found throughout assemblages, often in various stages of production and use. Such is the case at 'Ayn Ghazāl, a sprawling Neolithic townsite located on the northern fringes of 'Ammān along the Zarqa River. 'Ayn Ghazāl's thirteen hectares of Neolithic structures, courtyards, and pathways encompassed a community of over 2,000 people at its peak during the Late Pre-Pottery Neolithic B (LPPNB) period between 8,500 and 8,000BC. (All dates herein are in uncalibrated radiocarbon years before present.) During its 2,200 radiocarbon years of occupation, beginning in the Middle Pre-Pottery Neolithic B (MPPNB) about 9,250BC, 'Ayn Ghazāl grew from a small hamlet to become a leading socioeconomic center. Finally, dwindling in size, it was abandoned during the Pottery Neolithic (PN) at about 7,000BC (Rollefson 1987, 1997; Rollefson and Köhler-Rollefson 1989; Rollefson *et al.* 1992). Found within its extensive deposits is a chipped-stone record of the growth and demise of the town, undoubtedly aided by exploitation of the nearby wooded environment and affected, ultimately, by environmental collapse. Ground-bit tools play an important part in this story.

While the purpose of this research is to understand the significance of these tools to the evolutionary history of the townspeople, the analysis presented below is necessarily mundane. To reach our goal we consider two bodies of data relating to four categories of tools. Understanding the use-life history of the tools is our first goal. Thus, the technology of tool production, patterns of use, tool damage, strategies of tool repair, and reuse are all necessary information that help us relate to the significance of the tools and the woodworking needs and strategies of the townspeople. Our understanding of these processes is guided by our own replicative experiments in axe/adze production (Quintero 1998), as well as by a substantial body of literature in this field. Next, the distributional history of these tools and the context of their deposition help reveal the significance of working wood during the various phases of 'Ayn Ghazāl's occupation, as well as certain organizational aspects of this portion of the lithic economy.

'Ayn Ghazāl and its Assemblage

The Town and its Timber

The structural use of wood and the need for firewood undoubtedly were important issues for the residents of 'Ayn Ghazāl during its lengthy occupation. Thus, the location of the town on the margins of what probably was open oak/pistachio woodland, and the exploitation of this resource, are important to consider here. The establishment of the initial hamlet during the MPPNB (9,250-8,500BC) marked a major step towards sedentary living for Neolithic people. As the hamlet grew, its structure grew, eventually consisting of semi-rectangular, stone residences with two or three interior rooms (for an overview of these developments see Rollefson *et al.* 1992). Methods of construction relied on wooden beams for structural supports and on wood for production of lime plaster for covering floor and wall surfaces. Because lime production required large amounts of firewood to burn limestone, house construction had a significant impact on local timber supplies (Rollefson 1990).

During the LPPNB (8,500-8,000BC) larger,

multi-storied buildings were constructed. These large rectangles were divided into smaller parallel rooms. The frequency and density of these structures is strong evidence that 'Ayn Ghazāl's population had increased substantially (Rollefson 1997). Construction methods continued to rely on wooden beams for structural supports and on lime plaster for facing floors and walls, so procurement of wood was substantial.

The ensuing collapse of the Neolithic socioeconomic structure during the PPNC (8,000-7,500BC) is now well documented, although its causes are a matter of some debate. Central to this problem is the extent to which climatic deterioration and increased aridity, and human activities such as local deforestation, overgrazing, and other human practices may have precipitated an ecological crisis (cf. Rollefson and Köhler-Rollefson 1989; Goldberg and Bar-Yosef 1990). In any case, the use of wood changed dramatically. Buildings were constructed with as little timber as possible and they often had stone roof supports. Lime plaster coating of floors and walls, with its huge fuel requirement, was discontinued. Existing PPNB structures were made smaller and reused, and new residential structures, some of which may have had fabric walls, were smaller and more widely spaced than in the LPPNB (Rollefson 1997). Dung for fires was the fuel of choice. The inferred decrease in population reflects a monumental socioeconomic change for the inhabitants of the town, probably leading to pastoral nomadism for some (Rollefson and Köhler-Rollefson 1989). This socioeconomic reversal is documented in aspects of the lithic economy, which give evidence for loss of specialized blade-production, for reliance on domestic production of flake tools, and for extensive reuse and recycling of lithic material (Quintero 1998; Quintero and Wilke 1995). The place of ground-bit tools in this reconstruction is discussed here.

The ensuing Pottery Neolithic settlement (Yarmoukian phase) was dispersed over nearly as much ground as the PPNC settlement. However, structures were much more widely spaced and exterior courtyards and open spaces were common. By this time, the population of 'Ayn Ghazāl decreased to its lowest limits. Thus, wood consumption for structures and fuel probably would have been at its lowest. The prevalence of other cultural uses of wood is unknown.

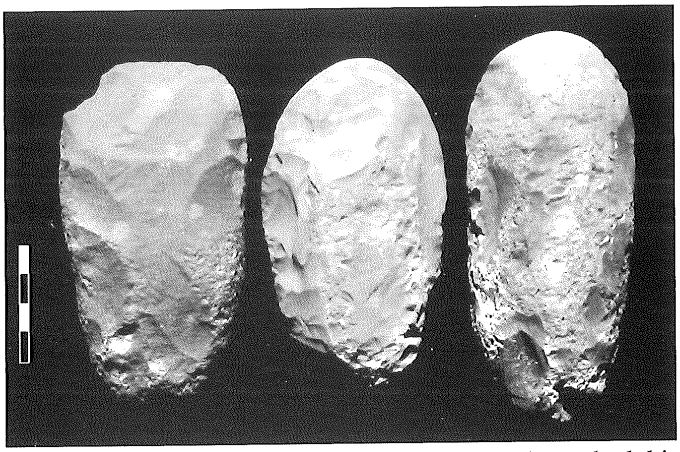
Ground-Bit Tools From 'Ayn Ghazāl

Because of the duration of occupation of the town, tools that aided its construction and assisted in the maintenance of its population provide a valuable data base for behavioral information. The database consists of all excavated and surface tools of this sort: 80 axes, 30 adzes, 23 axe/adzes, 16 chisels, and 20 picks from all periods of excavation, or 169 artifacts. It should be noted also that approximately one percent of the site deposit has been excavated, so our sample is necessarily small for a site of this size. Nonetheless, these tools and their context present a significant contribution to understanding the behaviors of the people who occupied 'Ayn Ghazāl.

Given an understanding of how structural needs and fuel use changed throughout the town's occupation, possible related functions of woodworking tools in the assemblages need consideration. Again, much of what we surmise comes from replicative research and analogies with modern life ways.

Axes: Axes have a long history of use in both recent and ancient life as woodworking tools of various sizes and with some variation in morphology. In most cases that we are aware of, however, axes are configured so that their bits are hafted generally parallel with their handles.[1] Large axes are used for a variety of "heavy-duty" wood-chopping chores. Appropriate tasks can vary from felling trees for construction of houses, boats, etc., to acquisition of fuel for fires. Small axes may have been used for lighter duty chores, such as are accomplished by small modern-day hatchets. The axes from 'Ayn Ghazāl (80) are all made from bedded chert or moderately silicic nodular flint chosen for their toughness and ability to withstand sturdy blows without breakage (FIG. 1). Their sizes vary from small to quite large (5.7-14.7cm long). All have two common attributes regardless of size: (1) a stout hafting region, which in some cases appears to have been fashioned to engage with a socket-type haft rather than with a split haft; and (2) a sturdy, slightly curved bit in plan view that allowed the center of the bit to strike a target before its edges, thus decreasing the risk of shattering of the bit.

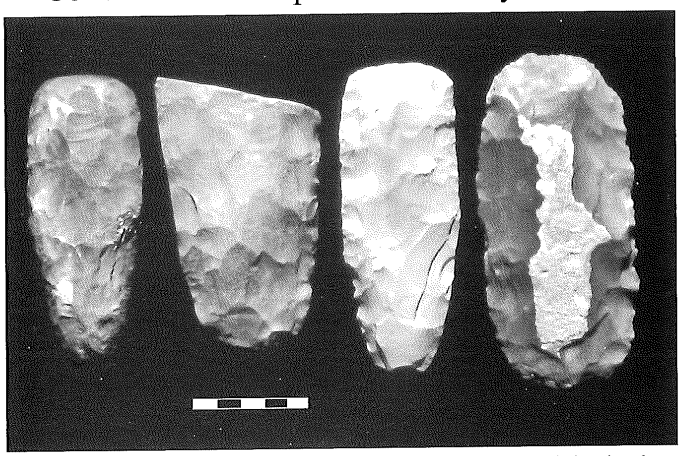
[1] The reader should be aware that this trait is not universal. In contemporary New Guinea, for example, axe heads apparently are fastened perpendicular to the haft (Heider 1967; Toth *et al.* 1992).



1. Axes. Left: Blunt-ended axe, body extensively pecked, bit reconfigured and ground; impact fracture on bit. Center: Broad axe, body and edges slightly pecked, bit ground and rounded. Right: Large axe, body heavily pecked to fit haft, bit ground.

Adzes: Also comparable to modern tools, adzes perform light duty woodworking tasks that require shaping by shaving and light chopping of wood fibers. It is of course possible that adzes might be used to shape materials other than wood, such as soft limestone. Adzes are hafted with their bits perpendicular to their handles. Adzes in this collection (30) are all of flint (FIG. 2). They are relatively smaller and thinner than axes, although there is much variation (4.3-13.9cm long). Some bear residue of hafting mastic across their flat faces, which delineates their haft zone. The most important diagnostic attribute of an adze is its relatively flat, square bit (in plan view). Adzes also generally are plano/convex in cross section. These are functional attributes that facilitate their usefulness in chopping/planing wood.

Convention and experimentation by others have suggested that chisel and axe bits are symmetrical in their lateral cross section, and that axe bits tend to be thicker and stouter than adze bits. Also, adze bits are generally thought to be asymmetrical in cross section, an attribute that facilitates their use in shaping wood by shaving off small portions of material. However, while morphological distinctions of bit profiles may be made during initial production of these tool in most cases, we caution that vagaries of production (such as flaws in material), personal idiosyncracies in knapping, and levels of knapping skill mitigated against this ideal. Also, bit resharpening and repair during use tend to alter the ideal bit configuration. Consequently, we do not use asymmetry of bit profile as a diagnostic attribute that distinguishes adzes from axes in archaeological assemblages. Our replicative work in production and maintenance of the bits of these tools demonstrates such a distinction to be unreliable.



2. Adze production. Left: Pecked and ground, finished adze. Left center: End-shocked production failure prior to pecking. Right center: Finely flaked preform, neither pecked nor ground. Right: Percussion-flaked blank.

We note here that the 'Ayn Ghazāl collection contains 23 axe/adze tools which have ambiguous attributes that defy more specific classification. In some cases these are broken or reworked tools, or tools used as cores that have lost essential attributes. However, one tool that is configured like an axe has clear mastic residue indicating that it was hafted perpendicular to its handle. Apparently there is room for variation or overlapping function of an axe head, a situation also noted in tool assemblages from other cultures (Heider 1967; Toth *et al.* 1992).

Chisels: Modern chisels are hand-held woodworking tools that are useful for fine carving and shaping. Neolithic chisels are less securely described and understood. The shape and size of those in the 'Ayn Ghazāl collection (16) suggest that they were used for light carving of soft materials, much as modern chisels are used, which they resemble. Thus, they would have been useful in delicate woodworking tasks. As a group, they are long and narrow (5.3-9.1cm long and 2.3-3.2cm wide), and have finely ground, refined, curved bits. Their long thin profiles suggest that they were not necessarily hafted, but may have been hand-held tools for much of their use-lives.

Picks: Picks in this assemblage (20) comprise the most diverse set of possible woodworking tools. They are distinguished by their roughly-flaked shapes, relatively robust bodies (8.6-16cm long),

and crudely configured, small bits. In general, picks appear to be "heavy-duty tools" that were made to withstand hard use and strong impact. They may have been used as wedges to split wood. Some may have been used as tools to quarry limestone for building blocks or for plaster, or to mine flint. Some may have been hafted, while others may have been used with indirect percussors. At present, their uses are mostly conjectural and await unambiguous attribute studies. Consequently, most of the following study relates to axes, adzes, and chisels.

Analytical Techniques and Rationale

Methods of ground-bit tool production, and tool use, breakage, repair, reuse, and eventual disposal, are revealed by the discarded tools, by production and retooling debitage found in tool-production and waste-deposit loci, and by replicative experiments in tool production and use. Experimentation for this study disclosed subtle manufacturing techniques (especially of axe and adze production), including the use of grinding slabs and grinding strategies for the final stages of production of bits. This experimentation also allowed identification of a unique archaeological bit-grinding block which was located within a structure at 'Ayn Ghazāl, and which is discussed below.

The artifacts were examined to identify methods and stages of tool production, patterns of tool damage, and strategies of tool repair and recycling. Material choices and acquisition were a concern. To this end we recorded the material type that was used, if cortex was observed, and the kind of cortex (e.g., wadi-rolled, fresh chalk, etc.).

Production stages were determined that reflected our observations during replicative studies. Accordingly, we noted if an artifact was a blank, a preform, a finished (or "working") tool, an exhausted tool, or one reused in another function. A "blank" was identified as a biface that had a roughly shaped form and unfinished bit. A "preform" had a carefully shaped form and a bit that was percussion-flaked or pressure-flaked and that was ready for grinding. A "finished" tool had a ground, functioning bit. An "exhausted" tool had a bit that was no longer useful for cutting or chopping, or was broken so that it was no longer functional. Reused tools had attributes that denoted their use in other capacities. We also recorded artifact shapes in plan view, if the bit was ground, the direction of grinding, and the shape of the bit. Further, we noted if an artifact was broken, what type of fracture had occurred, and if an artifact had been reshaped/repaired. Beyond these technological attributes, standard metric data were collected. Finally, we also identified the stratigraphic distributions of the tools to ascertain chronological data and recorded their depositional contexts.

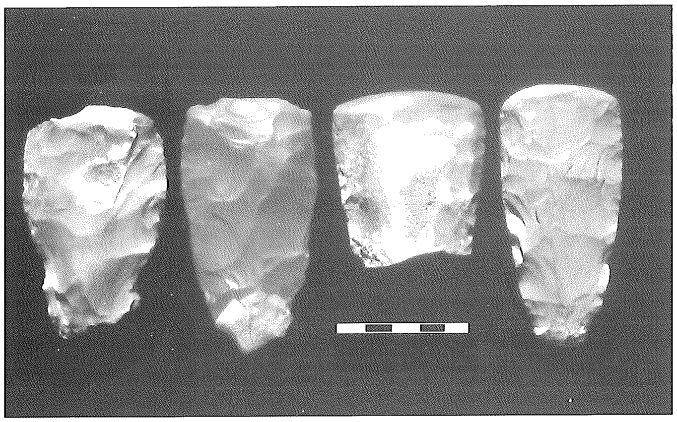
Axe, Adze, and Chisel Production

Analysis of the archaeological collection of woodworking tools from 'Ayn Ghazāl and replicative experimentation disclosed the following production strategies.

Blank Selection and Production: Flint nodules, tabular pieces of flint, or quarry flakes or blocks of bedded chert were chosen that generally were of sturdy quality rather than highly siliceous. Surveys of lithic resources near 'Ayn Ghazāl (Quintero 1996) revealed bedded chert underlying the site and in adjacent wadis, and an area where flint nodules of good-to-superior quality were being mined from the limestone matrix by Neolithic occupants of 'Ayn Ghazāl. These materials were carried to the site, then shaped into blanks of the appropriate configuration by direct percussion (FIG. 2), probably with a moderately soft hammer stone, such as a hard limestone nodule or a flint nodule with chalky cortex. Axe and adze blanks are basically lenticular in cross section, although adze blanks tend to be flatter and somewhat plano/convex. Chisel blanks are usually triangular in cross section. In some cases, crested blades from blade-core reduction may have been used for chisel blanks. We also note here that blank-production debitage may be identified archaeologically and consists typically of early-stage biface-production flakes.

Preform Preparation: Blanks were then fine-tuned into preforms (FIG. 2) with additional late-stage bifacial thinning and shaping, flaking by percussion or occasionally by pressure. At this point, axe and adze preforms were generally pecked on their lateral edges in the haft zone, and on ridges, or arrises, that needed to be reduced in size and smoothed. This procedure strengthened the haft area and was used to fit the axe or adze head to the haft.

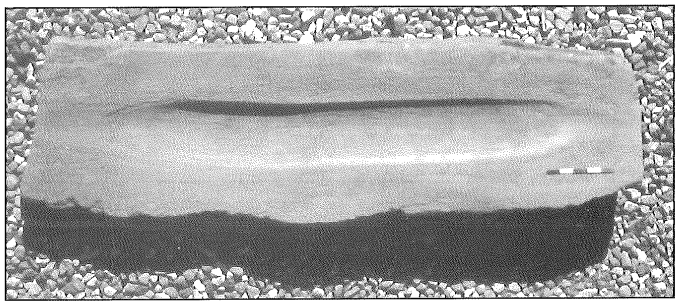
Working Tools: The finished, working tool emerged with grinding of the bit and further pecking in the haft zone, if needed (FIGS. 1, 2, 3). Bits of pre-



3. Adzes. Left: Heavily reworked adze with fractured bit. Left center: Ground adze with reflaked bit. Right center: Adze with bending break that occurred during use. Right: Large finished adze.

forms received final careful edge-shaping by being ground on a grinding surface usually consisting of a coarse, granular material, such as sandstone, quartzite, or granite. The grinding action initially was parallel with the length of the tool, whether axe, adze, chisel, or pick. Addition of grit (fine sand, ocher, etc.) and water facilitated the grinding and polishing process. Grinding of the bit was necessary to remove tiny fissures or cracks in its surface, thereby strengthening it. Finally, there is evidence that in some instances the bits of axes and adzes were ground parallel to the bit edge. This action would have removed any small nicks or flaking scars that would weaken the bit, and put a smooth, sharp finish on the edge. Pictured is a non-archaeological, sandstone grinding slab (FIG. 4) that was used in our replicative experiments to grind and polish the bits of replicated axes and adzes, and that illustrates a typical axe-grinding wear pattern on its surface.

Breakage, Reuse and Recycling: Axe, adze and chisel assemblages from 'Ayn Ghazāl also give evidence of production and use-breakage, and reuse of these tools. Typical production breaks were "end shock" bending breaks (FIG. 2), a common occurrence during biface reduction, or breaks from angular perverse fractures. Use-damage from impact usually was evidenced by chipping on the bit, observed as small flakes detached from the bit, and by spalling along the margins of the end of the bit (FIGS. 1, 3). This damage generally was repairable, so that the tool was returned to use, but was smaller. Debitage from resharpening damaged bits (and possibly producing tools) was discovered



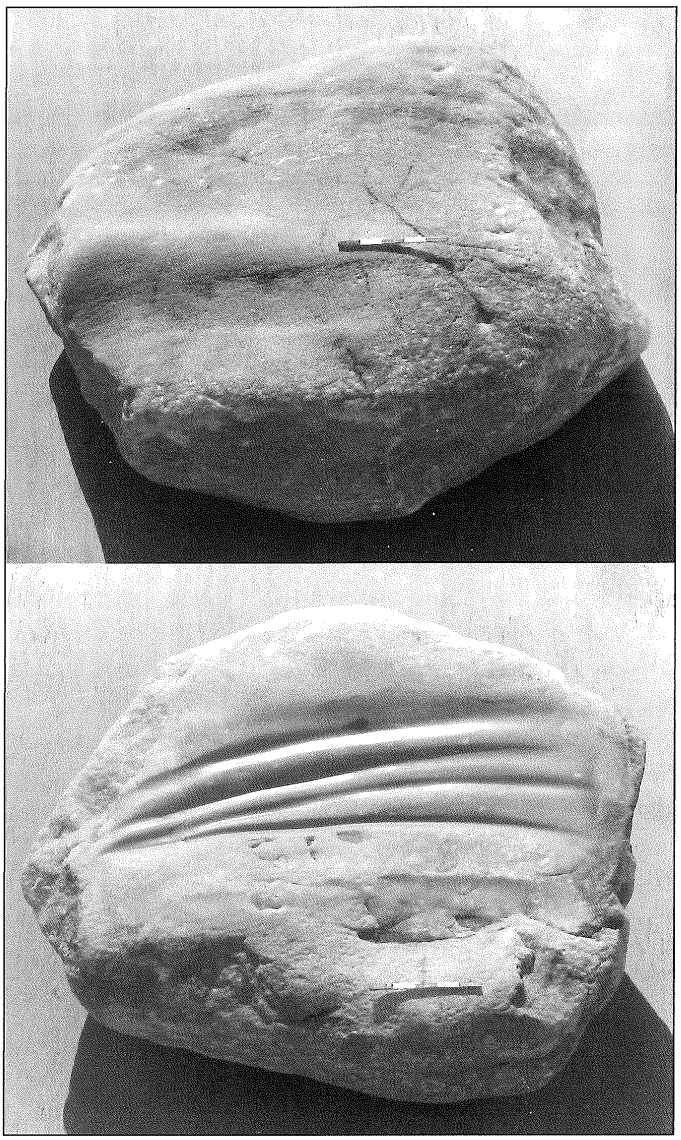
4. Sandstone grinding block used to grind the bits of replicated axes and adzes.

in some of the secondary deposits of debitage in what are interpreted as waste or dump areas near residential structures at 'Ayn Ghazāl. Catastrophic breaks from severe impact caused such great shock to axes and adzes that they sometimes spalled and snapped from distal overshot fractures, or contorted with flexing breaks that "killed" the tool (FIG. 3). On occasion, some discarded axes were given a second life and were reused as flake cores or as pecking tools. Chisels frequently suffered bending breaks and impact damage to their bits during use. However, because of their length, broken bits could be reflaked and reground several times; tools just became shorter until they were too short to use and were discarded. Picks often suffered impact damage to their distal ends, which required reshaping of the tool. At times, the distal end simply broke away from severe impact, destroying the tool.

Tool Exhaustion and Discard: Predictably, heavily used and exhausted tools are prominent artifacts in the collection. These are recognizable by their dulled and damaged bits and by irreparable use-breaks.

Axe-Grinding Stone

Of particular significance was the discovery within an LPPNB structure at 'Ayn Ghazāl of a quartzite block that evidently was used for grinding chisel, axe, and adze bits (FIG. 5). This large flat stone (31 x 25 x 12cm) was pecked to shape and has two working surfaces. One flat side of the block has two broad grinding grooves that would have been used for the first grinding process of bit preparation (whether in initial production or during bit maintenance), similar to those depicted in the experimental slab. The opposite face of the stone has four long (24cm), narrow, arching grooves that are asymmetrically V-shaped. Grooves such as these are likely to have been produced by the final bit-



5. 'Ayn Ghazāl LPPNB axe/adze-grinding block of quartzite. Upper: Two bit-grinding grooves on face one. Lower: Opposite face of same block with four well-developed grinding grooves and traces of red ochre.

polishing process wherein a bit was ground parallel to its edge. Of note is the abundant presence of red ocher on both surfaces of the block, no doubt added to facilitate the grinding and polishing process. This unique artifact provides strong confirmation of the final stages of axe and adze preparation and bit maintenance in these Neolithic industries.

The data presented here demonstrate clearly that all stages of production, use, reuse and maintenance, recycling, and discard of axes, adzes, and chisels, occurred within the town of 'Ayn Ghazāl. What remains to be discussed is the relative frequency of these tools, their distribution through time and space and the behavioral information that we might glean from these data.

Distribution Studies

The following discussion focuses on tool distributional patterns and implications for understanding how the production, use, and discard of worn-out tools were managed within the town. Considered here are the 130 tools from securely dated contexts, so that items from mixed deposits and the surface are not included. The tool sample is fairly large, but when distributed through 2,200 years of occupation and diverse occupation areas, it becomes quite small. The evaluations presented here and their perceived behavioral implications must be somewhat tentative. We believe that they explain the data at hand, and hope that with future expanded excavations they will hold true.

Tool Frequencies: Woodworking tool assemblages from 'Ayn Ghazāl give evidence not only for production and use of these tools within the town site, but also for frequencies of tool use, and thus their usefulness to the townspeople during the long history of occupation. TABLE 1 presents the chronological distribution of tool types throughout the various periods. These data were regularized for

TABLE 1. Tool Frequencies.

	MPPNB		LPPNB		LPPNB/ PPNC		PPNC		PN		Total	
Type	n	%	n	%	n	%	n	%	n	%	N	%
Axe	7	43.7	17	41.5	4	100.0	14	48.3	23	57.5	65	50.0
Adze	3	18.8	9	21.9	0	0.0	4	13.8	4	10.0	20	15.4
Axe/Adze	2	12.5	6	14.6	0	0.0	3	10.3	4	10.0	15	11.5
Chisel	0	0.0	4	9.8	0	0.0	2	6.9	7	17.5	13	10.0
Pick	4	25.0	5	12.2	0	0.0	6	20.7	2	5.0	17	13.1
Total	**16**	**100.0**	**41**	**100.0**	**4**	**100.0**	**29**	**100.0**	**40**	**100.0**	**130**	**100.0**

Note: Figures here and in the following tables are for datable contexts only. LPPNB/PPNC numbers are too small for meaningful analysis.

comparison by assessing relative frequencies of artifacts from datable contexts from each period of occupation.

First, while ground-bit tools were found in deposits from all periods, there are great differences in the frequencies of their occurrence. From all periods, axes were recovered more often than any of the other tool types. They occurred from two to five times more often than adzes, the next most abundant of these tools. Also, their relative importance increases by nearly 14% from the MPPNB to the PN. There was an apparent slight decrease in axe usage during the LPPNB, but this figure likely is the result of excavation strategies for LPPNB deposits, which tended to focus on public/ritual buildings rather than on domestic structures as in the other periods. In sum, there appears to have been no time when the people living in the town did not need and use axes for heavy wood cutting, regardless of changes in structural designs, fuel consumption, or the availability of natural resources. This need appears to have been at a relatively consistent level through time, regardless of environmental or economic changes.

Such is not the case for the lighter woodworking tools. While adzes were used throughout the site's occupation, their use appears to have decreased almost by half by the PN. By contrast, chisels apparently were scarce in the MPPNB but grew to almost 18% of the woodworking tool kit by the PN. While both of these tools are used for shaping wooden objects, they are used in different ways, suggesting that the woodworking needs of the community had shifted somewhat by the PN.

Frequencies of Technological Stages: With the exception of picks, for which we lack production data, all stages of the use-lives of woodworking tools are present at the town (TABLE 2). Consequently, it is clear that all of these tools were produced, maintained, and finally discarded on the site during its occupation. They also may have been used on the site, or elsewhere, but no data survive to attest to these events. In any case, the tools apparently were not traded into the site, but were of local origin.

Tools that are considered "functional" (or still in working condition) and those deemed to be "exhausted" comprise the bulk of the collection, and were found in about equal relative proportions. These data suggest that tool storage and loss, and tool discard were all common occurrences throughout the occupation of the town. Evidence of tool production consists mainly of tool blanks and preforms, and tools that "died" from mishaps during production. Such artifacts comprise about 20% to 30% of the collections from each period. There is also a small presence of axe/adze bit-sharpening flakes in the debitage collection. Tool recycling was present to a small extent in all periods. Most commonly, exhausted axes were reused as flake cores. Such recycling was most prevalent in the LPPNB deposit, but overall frequencies are very small, so the differences may be insignificant.

Distribution of Tools By Use-Life Stage: Patterns of tool production, curation, and discard within the town during all periods of its occupation are presented in TABLE 3. These behaviors are suggested by the occurrence of tools in various stages of their use-lives in specific contexts throughout the town. Important contextual distinctions are "living areas", which include loci where tool production occurred (i.e., knapping areas), floors of structures, structure walls, and exterior surfaces (such as courtyards) within the town. Disposal areas consist of "fill" deposits inside and outside of structures, which accumulate as various types of debris over time, and intentional trash pits or dumping regions. We recognize here that fill can be ambiguous in that it sometimes can mask *in situ* deposits. Nonetheless, these are useful distinctions that generally are valid.

Only two possible knapping areas, both in LPPNB deposits, were recognized that were associated with ground-bit tools. However, we believe this shortage is likely due to the difficulty of distinguishing such production debitage from other types of biface-production debitage (e.g., from naviform cores, bifacial knives, etc.). More important is the fact that unfinished tools, both whole and broken, were found distributed throughout the town, especially from the LPPNB through the end of the PN. Some of these artifacts were located on floors of domestic structures, some were in structure walls, and some were scattered on living surfaces outside of buildings. These areas contained both working and exhausted tools too.

Nonetheless, the highest frequencies of all tools in all stages of production, use, and discard were in interior (16.7%) and exterior (46.8%) fill deposits. These deposits very probably reflect accumulations of living debris, including discarded and lost tools,

TABLE 2. Frequencies of Tool Use-Life Stages.

	AXE		ADZE		AXE/ADZE		CHISEL		PICK		Total	
Stage	n	%	n	%	n	%	n	%	n	%	N	%
MPPNB												
B	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
P	0	0.0	1	33.3	0	0.0	0	0.0	0	0.0	1	6.2
F	2	28.6	0	0.0	0	0.0	0	0.0	0	0.0	2	12.5
W	1	14.3	1	33.3	0	0.0	0	0.0	4	100.0	6	37.5
E	4	57.1	1	33.3	2	100.0	0	0.0	0	0.0	7	43.7
(R)	(1)	(14.3)	(0)	(0.0)	(0)	(0.0)	(0)	(0.0)	(0)	(0.0)	(1)	(6.2)
Total	**7**	**100.0**	**3**	**100.0**	**2**	**100.0**	**0**	**0.0**	**4**	**100.0**	**16**	**100.0**
LPPNB												
B	1	5.9	1	11.1	1	16.7	1	25.0	0	0.0	4	9.8
P	3	17.6	4	44.4	0	0.0	0	0.0	0	0.0	7	17.1
F	0	0.0	0	0.0	1	16.7	0	0.0	0	0.0	1	2.4
W	5	29.4	4	44.4	1	16.7	2	50.0	3	60.0	15	36.6
E	8	47.1	0	0.0	3	50.0	1	25.0	2	40.0	14	34.1
(R)	(4)	(23.5)	(0)	(0.0)	(0)	(0.0)	(0)	(0.0)	(0)	(0.0)	(4)	(9.8)
Total	**17**	**100.0**	**9**	**100.0**	**6**	**100.0**	**4**	**100.0**	**5**	**100.0**	**41**	**100.0**
PPNC												
B	1	7.1	0	0.0	0	0.0	1	50.0	0	0.0	2	6.9
P	3	21.4	1	25.0	0	0.0	0	0.0	0	0.0	4	13.8
F	2	14.3	0	0.0	0	0.0	1	50.0	0	0.0	3	10.3
W	4	28.6	2	50.0	0	0.0	0	0.0	3	50.0	9	31.0
E	4	28.6	1	25.0	3	100.0	0	0.0	3	50.0	11	37.9
(R)	(1)	(7.1)	(0)	(0.0)	(0)	(0.0)	(0)	(0.0)	(0)	(0.0)	(1)	(3.4)
Total	**14**	**100.0**	**4**	**100.0**	**3**	**100.0**	**2**	**100.0**	**6**	**100.0**	**29**	**100.0**
PN												
B	1	4.3	0	0.0	0	0.0	0	0.0	0	0.0	1	2.5
P	3	13.0	2	50.0	0	0.0	0	0.0	0	0.0	5	12.5
F	1	4.3	0	0.0	0	0.0	1	14.3	0	0.0	2	5.0
W	9	39.1	1	25.0	2	50.0	0	0.0	0	0.0	12	30.0
E	9	39.1	1	25.0	2	50.0	6	85.7	2	100.0	19	50.0
(R)	(1)	(4.3)	(0)	(0.0)	(2)	(50.0)	(0)	(0.0)	(0)	(0.0)	(3)	(7.5)
Total	**23**	**100.0**	**4**	**100.0**	**4**	**100.0**	**7**	**100.0**	**2**	**100.0**	**40**	**100.0**
TOTAL	**61**	**48.4**	**20**	**15.9**	**15**	**11.9**	**13**	**10.3**	**17**	**13.5**	**126**	**100.0**

Note: Use-live stages are: B=blank, P=preform, F=production failure, W=working tool, E=exhausted tool, (R)=recycled into other tool or core. A small number (4) of tools from transitional contexts were not used in this table.

TABLE 3. Distribution of Tool by Use-Life Stages.

	LIVING AREAS								DISPOSAL AREAS									
	Knapping Area		Structure Floor		Structure Wall		Exterior Surface		Interior Fill		Exterior Fill		Trash Dump		Total	
Stage	n	%	n	%	n	%	n	%	n	%	n	%	n	%	N	%
MPPNB																
P	0	0.0	0	0.0	0	0.0	0	0.0	1	16.6	1	14.3	0	0.0	2	12.5
W	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5	71.4	1	33.3	6	37.5
E	0	0.0	0	0.0	0	0.0	0	0.0	5	83.4	1	14.3	2	66.3	8	50.0
(R)	(0)	(0.0)	(0)	(0.0)	(0)	(0.0)	(0)	(0.0)	(1)	(17.0)	(0)	(0.0)	(0)	(0.0)	(1)	(6.3)
Total	**0**	**0.0**	**0**	**0.0**	**0**	**0.0**	**0**	**0.0**	**6**	**100.0**	**7**	**100.0**	**3**	**100.0**	**16**	**100.0**
LPPNB																
P	0	0.0	0	0.0	0	0.0	2	22.2	2	50.0	7	36.8	1	25.0	12	29.3
W	1	50.0	0	0.0	2	66.6	3	33.3	1	25.0	5	26.3	3	75.0	15	36.6
E	1	50.0	0	0.0	1	33.3	4	44.4	1	25.0	7	36.9	0	0.0	14	34.1
(R)	(0)	(0.0)	(0)	(0.0)	(0)	(0.0)	(2)	(22.2)	(1)	(25.0)	(0)	(0.0)	(0)	(0.0)	(3)	(7.3)
Total	**2**	**100.0**	**0**	**0.0**	**3**	**100.0**	**9**	**100.0**	**4**	**100.0**	**19**	**100.0**	**4**	**100.0**	**41**	**100.0**
PPNC																
P	0	0.0	1	50.0	1	33.3	2	66.6	0	0.0	5	33.3	0	0.0	9	31.0
W	0	0.0	0	0.0	0	0.0	0	0.0	3	60.0	6	40.0	0	0.0	9	31.0
E	0	0.0	1	50.0	2	66.6	1	33.3	2	40.0	4	26.7	1	100.0	11	37.9
(R)	(0)	(0.0)	(1)	(50.0)	(0)	(0.0)	(0)	(0.0)	(0)	(0.0)	(1)	(6.7)	(0)	(0.0)	(2)	(6.9)
Total	**0**	**0.0**	**2**	**100.0**	**3**	**100.0**	**3**	**100.0**	**5**	**100.0**	**15**	**100.0**	**1**	**100.0**	**29**	**100.0**
PN																
P	0	0.0	0	0.0	0	0.0	3	42.9	2	33.3	3	16.7	0	0.0	8	20.0
W	0	0.0	3	42.9	2	100.0	1	14.2	2	33.3	3	16.7	0	0.0	11	27.5
E	0	0.0	4	57.1	0	0.0	3	42.9	2	33.3	12	66.7	0	0.0	21	52.5
(R)	(0)	(0.0)	(0)	(0.0)	(0)	(0.0)	(0)	(0.0)	(0)	(0.0)	(3)	(16.7)	(0)	(0.0)	(3)	(7.5)
Total	**0**	**0.0**	**7**	**100.0**	**2**	**100.0**	**7**	**100.0**	**6**	**100.0**	**18**	**100.0**	**0**	**0.0**	**40**	**100.0**
TOTAL	**2**	**1.6**	**9**	**7.1**	**8**	**6.3**	**19**	**15.1**	**21**	**16.7**	**59**	**46.8**	**8**	**6.3**	**126**	**100.0**

Note: Use-life stages are: P=any unfinished tool (in production), W=working tool, E=exhausted tool, (R)=recycled into other tool or core. A small number (4) of tools from transitional contexts were not used in this table.

dirt, and trash that developed over the many years of site use. This pattern of accretion is widespread throughout the site in all periods. In fact, during the MPPNB no ground-bit tools were found on recognizable living surfaces whether inside or outside of structures. Trash pits were used to dispose of a few tools, but this apparently was not a common practice during any period, and was not noted at all during the PN. One may conclude that unwanted flint tools such as these, even broken ones, were not considered hazardous waste that required special treatment or disposal. This attitude towards waste treatment contrasts sharply with that observed for flint blade-production debitage, which was generally removed from living areas and dumped in trash pits and refuse areas (Quintero 1997, 1998).

Summary Discussion

The above patterns reflect a consistent, town-wide behavior of tool production, use, and disposal primarily in domestic areas. Some curation of tools probably is indicated where tools were placed in wall niches, possibly for storage, or on floors by household members. However, most tools appear either to be inside house structures, where they were lost or discarded and eventually became part of fill, or, more often, outside houses where they were made, maintained, discarded, and ultimately left as part of the landscape. We believe this pattern reflects an organizational structure that is solely

domestic in origin. That is, the economic organization of production, distribution, use, and discard occurred entirely within individual households by people for themselves. This aspect of 'Ayn Ghazāl's lithic economy, regardless of the period of occupation, falls within the realm of self-sufficient household economies. Put another way, we see no evidence for specialized production of these tools by a few for consumption by others at any time.

Given all of the evidence supporting intensive consumption of wood for construction, fires, plaster, etc., through the LPPNB and the implied gradual deforestation of the environment immediately around the site, the consistent use of axes and adzes during these periods is no surprise. Certainly these tools facilitated the construction and maintenance of structures and various wooden implements, such as handles for tools, as well as innumerable tons of firewood over the centuries. It is easy to envision the gradual decline of nearby woodlands through the passing years.

But the persistent use of these tools into the PPNC and PN when other archaeological evidence for the use of wood is scarce seemed initially a puzzle. At present we are inclined to believe that the evidence still strongly supports wood chopping, but perhaps farther and farther away with greater cost of time and labor. It is also quite probable that much of the earlier structural wood used in the MPPNB and LPPNB was reconfigured and reused as needed, as time went by from the PPNC onward. Both axes and adzes would have been useful for this task. Certainly in many respects people's needs and the resolution of these needs did change. Timbers and beams of MPPNB houses gave way to less-substantial structures in the PPNC, and finally to roofs and slender ramadas probably constructed of small trees and branches in the PN (Rollefson 1995). In this last reconstruction it is easy to envision chopping down small trees (remnants in the woodland?) some distance from the now-small town, hauling these back home, shaping the poles with an adze, and finally swapping the adze for a chisel to groove and lash the poles.

And there are, of course, countless other tasks that can explain the increased presence of small woodworking tools like chisels from the LPPNB into the PN. Since chisels generally are used for fine shaping tasks, there was perhaps an increasing need for more delicately crafted wooden implements, or tools that satisfied a wider range of uses. Not preserved, and thus unimagined until now, are probable wooden accoutrements like furniture, utensils, tools such as carefully grooved sickle hafts and perforated axe hafts, combs, bowls, boxes2, cups, pendants, and so on. But we can perhaps envision their existence now that the tools of their production are better understood. So, we have an inkling of a rich wooden material culture for these later years. Such is the advantage of probing the roots of technologies and the behavioral implications of their place in the archaeological landscape. The long history of 'Ayn Ghazāl and its people and their strategies of living become real and more understandable.

Acknowledgements

Work at 'Ayn Ghazāl is conducted under permits from the Department of Antiquities of Jordan, and we thank Drs. Ghazi Bisheh and Fawwaz al-Kraysheh for their continued support. Drs. Philip Wilke and Gary Rollefson contributed valuable critiques of early drafts of this paper. Dr. Rollefson kindly allowed us access to the 'Ayn Ghazāl collection, and Dr. Wilke assisted with our replicative research, for which we are grateful. Matthew Des Lauriers assisted with preparation of the figures.

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[2] Recall here the discovery of a wooden box in LPPNB Bayḍā by Mortensen (1988).

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