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Artifact densities and assemblage formation: Evidence from Tabun Cave

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ABSTRACT

Archaeological assemblages are fundamentally records of discard behavior. Lewis Binford's pioneering ethnoarchaeological research focused attention on the differing pathways that lead to artifacts being abandoned in different locations on the landscape. Recurring relationships between artifact density and assemblage content at Middle and Upper Paleolithic sites reflect simple behavioral dynamics pertaining to artifact production and discard. In the very long archaeological sequence from A. Jelinek's excavations at Tabun Cave, Mousterian assemblages show the expected pattern, but earlier Acheulean, Amudian and Yabrudian assemblages do not. In combination with evidence that different classes of artifacts were discarded at different rates, these results suggest that land use and raw material provisioning in the later Middle Pleistocene were organized differently than they were among later populations of Neanderthals and modern humans.

1. Introduction

Along with Schiffer (1972, 1976, Reid et al., 1975), Lewis Binford is largely responsible for convincing archaeologists to think about the archaeological record as the outcome of a diverse set of behavioral and natural processes. Rather than treating the record as a sequential set of static snapshots capturing a narrow range of invariant past conditions (cultures, phases, etc.), both Binford and Schiffer emphasized, in different ways, the essential project of linking contemporary observations about artifacts, features and assemblages to past behaviors that varied at a range of temporal and spatial scales. Binford's seminal work on hunter–gatherer subsistence adaptations and mobility (1977, 1979, 1980, 1982, 2001) further focused the attention of archaeologists on artifact life histories and land use as key factors for explaining variability in the material record of foragers. In this intellectual framework, artifacts and other debris may be treated as trace fossils of people moving across landscapes (Ebert, 1992; Holdaway and Wandsnider, 2006). What we call sites are essentially depositional phenomena, places where, for behavioral or geologic reasons, artifacts and other debris accumulated in sufficient concentrations to attract the attention of archeologists. Land use is also a major determinate of how, and in what conditions artifacts are abandoned (Binford, 1979; Kelly, 1992; Kuhn, 1995).

The ideas proposed by Binford, Schiffer and others concerning the formation of sites and assemblages have fundamentally altered standard practice in Paleolithic archaeology across the globe. However, it remains difficult to match explanatory models to the temporal resolution of the archaeological record. Paleolithic archaeologists, almost regardless of theoretical position, employ the geologically-defined assemblage as a minimum unit of analysis, measuring variability in terms of differences among assemblages. Yet they often favor explanatory models founded in ethnographic scales of observation. This can lead to a profound mis-match in scale between the behavioral dynamics of interest and the empirical evidence. Ideas about variation in hunter–gatherer mobility and artifact production expressed at the scale of days or seasons are mapped directly onto archaeological assemblages that accumulated over centuries. In some cases a view of the record as a series of superimposed culture phases has been replaced with views of the record as a series of superimposed site types or mobility regimes.

There are two responses to mismatches in scale between behavioral models and the temporal grain of the archaeological record. One is to concentrate on the best preserved localities and most finely reticulated stratigraphies, unique sites that afford something like an "ethnographic" scale of resolution on past behavior (e.g., Leroi-Gourhan and Brézellon, 1972; Roebroeks, 1988; Vaquero, 2008; Vaquero and Pastó, 2001; Zubrow et al., 2010). An alternative strategy is to accept the coarse chronological resolution of many stratigraphic records and to consider how processes operating at

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comparatively brief time scales might be expressed at longer timescales (see Akoshima and Kanomata, 2015 for a similar perspective on very different data).

Here the problems are more theoretical and analytical than they are technical. Following the lead of some of Binford's (1982, 1987) pioneering studies, this paper takes the second path. We use the inherent temporality of the archaeological record to investigate changes over time in hominin mobility and technological responses to it. In part, this is accomplished by shifting scales, by comparing patterns of variability both within and across stratigraphic and "cultural" units. The paper examines evidence for behavioral shifts over the period of ca. 400–100 ka at the site of Tabun Cave (Israel). This interval saw important evolutionary developments in lithic technology as well as in hominin populations. Application of a series of simple models of assemblage formation points to significant changes in the ways that assemblages of stone artifacts were accumulated over the long history of occupation of Tabun. These in turn implicate changes in the organization and mobility of hominin groups.

2. Background: the archaeological record at Tabun Cave

Tabun Cave, with its remarkably deep stratigraphic sequence, remains the key sequence for the Lower and Middle Paleolithic of the Levant. The well-known site is situated on the western slopes of Mt. Carmel in the Nahal Me'arot (Wadi el-Mughara), Israel. D.A.E. Garrod conducted the first excavations of Tabun from 1929 to 1934 (Garrod and Bate, 1937:1–2), exposing a sequence of Paleolithic layers nearly 25 m thick. She divided the cultural stratigraphy into seven cultural layers, beginning with the so called "Tayacian" (layer G) and ending at the late Mousterian (layer B) (Garrod and Bate, 1937). A. Jelinek (Jelinek et al., 1973; Jelinek, 1982a, 1982b) worked at Tabun from 1967 to 1971, re-excavating a face ten meters high and six meters wide that penetrated roughly two meters into the intact profile. Excavations continued from 1975 to 2003 under the direction of A. Ronen (Gisis and Ronen, 2006; Ronen and Tsatskin, 1995).

The geology and sedimentology of Tabun Cave have been reported in various publications (Bull and Goldberg, 1983; Goldberg, 1973, 1980–81; Jelinek et al., 1973; Jelinek, 1982a). Jelinek divided the sequence into beds and units. Beds represent the finest sedimentary "package" discernable in the field. Units represent larger groups of beds that show similar macroscopic characteristics and appear to represent similar depositional conditions. Units are separated by disconformities. Jelinek recognized 14 major stratigraphic units (Jelinek, 1982a), which correspond to Garrod's layers C–E and possibly the top of layer F. Jelinek's studies provided much better stratigraphic resolution than earlier excavations. His teams were able to follow steeply inclined beds and identify areas of erosion and infilling that Garrod had not observed.

Major erosional gaps are present at the top of unit XIV (Ronen et al., 2011) and at the top of Garod's layer D (units III–IX) (Farrand, 1979). From unit XIII up through Jelinek's unit II, the Tabun stratigraphy is dominated by aeolian sedimentation. The sandy sediments in the earliest levels (Garrod's layers G and F) probably had a marine origin. Over time, proportions of silt and fine sand (still aeolian) increase. The upward fining could have simply resulting from the progressive infilling of the cave: as sediment layers rose, progressively smaller particles were deposited inside (Jelinek, personal communication, 2010). A major change in sedimentation occurs with units II and I. Sediments in unit II are more strongly anthropogenic, with much evidence of fire. Units II and I also show an influx of colluvial and alluvial sediments from a hole that opened in the cave's roof.

Units I and II, the most recent deposits excavated by Jelinek's team, correspond to Garrod's layer C and the lower part of B. The Levallois Mousterian assemblages from these layers are dominated by centripetal preferential or recurrent Levallois production, although Tabun C-type assemblages may contain a diversity of Levallois production methods (Hovers, 2009). Retouched tools are comparatively scarce. At Skuhl and Qafzeh, Tabun C-type assemblages are associated with fossils that share many features with *Homo sapiens* (Klein, 1999: 402–403). However, the Tabun 1 Neanderthal skeleton discovered by Garrod may have come from the layer C. Radiometric dates from Tabun C range from 165 ± 16 (TL) to 135 + 60/−30 (ESR) (Grün and Stringer, 2000; Mercier and Valladas, 2003; Bar-Yosef, 1995).

Unit IX, equivalent to the lower part of Garrod's layer D, contains assemblages attributed to the early Levantine Mousterian. The assemblages are fairly homogeneous. Unidirectional parallel or convergent Levallois production predominates: non-Levallois blade production is less common and centripetal Levallois flake production is rare. Most blanks are elongated, but shorter flakes as well as naturally backed knives were also produced from the same cores (Shimmelmitz and Kuhn, 2013). Retouch is frequent and well developed compared to other Levantine Mousterian assemblages. To date no diagnostic hominin fossils are associated with early Levantine Mousterian assemblages. Unit IX has been dated by TL to 256 ± 26 kyr (Mercier and Valladas, 2003) although a combined model of U-Series and ESR provided an age of 143 + 41/−28 (Grün and Stringer, 2000). ESR-dated bones came from Garrod's excavation so their precise position relative to Jelinek's stratigraphy remains uncertain.

Units III through VIII were formed through a complex series of cut and fill events. As a consequence, the assemblages contain a large number of artifacts re-deposited from lower beds. Because they are mixed, the materials from these units are either excluded from or are treated separately in the analyses below.

Units XI–XIII, which corresponds roughly with Garrod's layer E, contain a range of assemblage types that make up Jelinek's Mugharan tradition (1990), also referred to as the Acheulo-Yabrudian complex. This complex or tradition is comprised of three facies – today termed Acheulean/Acheulo-Yabrudian, Yabrudian and Amudian/Pre-Aurignacian. The Acheulean facies is characterized by comparatively abundant bifacial tools, the Yabrudian mainly by flake production and heavy scrapers, often with scalar Quina retouch, and the Amudian by blade production and 'Upper Paleolithic' tools forms. These differences are more quantitative than qualitative: elements such as handaxes, heavy scrapers and blades occur in varying frequencies in most assemblages (Copeland, 2000; Jelinek, 1981). Jelinek (1981) ascribed unit XIV, which may have no clear counterpart in Garrod's scheme, to late Acheulean, although the abundance of heavy scrapers suggests that these assemblages may still be part of the Acheulo-Yabrudian complex (Gisis and Ronen, 2006; Ronen et al., 2011).

The Acheulo-Yabrudian complex occupies an ambiguous position with respect general classification of Paleolithic industries. Most researchers assign it to the late Lower Paleolithic (Bar-Yosef, 1995; Copeland, 2000; Gopher et al., 2005), although some consider the assemblages to be more Middle Paleolithic in character (Jelinek, 1982b; le Tensorer et al., 2007). Fossil hominins associated with Acheulo-Yabrudian and Amudian assemblages in other sites have been variously classified as archaic *H. sapiens* or *Homo hiedelbergensis* (e.g., Hershkovitz et al., 2010; Sohn and Wolpoff, 1993). Associated TL dates have a mean of 264 ± 28 kyr for unit XI, 324 ± 31 kyr for unit XII and 302 ± 27 kyr for unit XIII (Mercier and Valladas, 2003). ESR/U-series date of Garrod's sub Layer Ea is 208 + 102/−44 kyr (Grün and Stringer, 2000), whereas animal teeth from sediments equivalent to Garrod's sub-layer Ed provided a mean age of 387 + 49/−36 kyr by ESR/U-series (Rink et al., 2004).

Unit X at Tabun is also somewhat controversial. Levallois elements are fairly abundant in the uppermost layers but decline with depth while typical Yabrudian artifacts such as heavy scrapers become more common. Jelinek (1981) argued that unit X documents a transition from Yabrudian to Levallois Mousterian whereas Bar-Yosef (1995) asserts that the assemblages are mechanically mixed. Unit X is also excluded from most of the analyses which follow.

3. Artifact density as a record of occupational intensity

The first analyses presented in this paper are based on a simple premise: all other things being equal, the frequency with which artifacts are deposited in sites should reflect the number of person-hours spent at the location. Of course other factors can affect the density finds within archaeological deposits. Discard rates may vary among technological systems and activity sets. Because one computes density based on the volume of the sediment in which the artifacts are encased, rates of sediment accumulation can directly affect artifact densities independent of human activities. Fortunately, sedimentation regimes were similar throughout much of the Tabun sequence, although there is a gradual decrease in particle size over time. The only radical change in mechanisms, and probably rates of sediment build up, occurred at the boundary between units II and III. Of course the pace of aeolian sedimentation probably fluctuated through the sequence, meaning that artifact density is an imprecise but consistent estimator of the amount of time hominins spent at the cave.

Several studies have used the relationship between artifact density and the frequency of retouched tools as an indicator of the duration of occupations and, less directly, of regional mobility patterns (Barton et al., 2011; Clark, 2008; Kuhn, 2004; Riel-Salvatore and Barton, 2004; Riel-Salvatore et al., 2008). These studies are based on the supposition that mobile people carry a certain number of artifacts with them to use as they move across the landscape (what Binford, 1977 calls personal gear). In the context of extremely short stays people would rely completely on what they brought with them, and a few of these transported tools would enter the record. The more time people spend at a site, the greater the likelihood that they will manufacture additional artifacts there: prolonged occupations would offer greater opportunity to gather raw materials and to make tools on the spot. To the extent that decisions to use transported tools or make new ones are linked to the durations of occupations, they can be considered to reflect frequencies of residential mobility. The expectation is that, holding rates of sedimentation constant, the frequency of retouched tools will be negatively correlated with artifact density: low density deposits equate to repeated short stays and little on-site production, whereas high density deposits indicate more prolonged occupations, more *in situ* manufacture, and more waste flakes and debris. Of course mobility is a multi-dimensional phenomenon, but the relationship is a useful tool for organizing an otherwise mixed and variable set of signals from a dynamic system.

Archaeological layers in Paleolithic sites normally represent multiple occupation events. This would be unimportant if the site was utilized in a consistent manner but if the nature and duration of occupations changed over the interval when particular layer was formed event-specific patterns would be obscured. Thin archaeological layers, which represent shorter periods of time, could potentially send a clearer signal than layers which spanned a greater amount of time, although they are also more subject to variation due to sampling and post depositional processes. The result of all these factors is that we expect a continuum in the relationship between artifact density and retouched tool frequencies. Cases at either end of the continuum would represent consistent extremes in occupational duration, whereas cases in the middle would represent either occupations of moderate duration or variable mixtures of short and long-term occupations.

The expectation of a negative relationship between artifact density and retouched tool frequency is met for a range of Middle and Upper Paleolithic cases (Barton et al., 2010; Clark, 2008; Kuhn, 2004; Riel-Salvatore and Barton, 2004; Riel-Salvatore et al., 2008). However, when overall density is plotted against the retouched tool-to-flake ratio across the entire Tabun sequence it is apparent that the Levantine Mousterian (Fig. 2.1a) and Acheulo-Yabrudian (Fig. 2.1b) show very different trends. Taken as a group, the early and middle Mousterian layers (units I through IX) display the expected negative relationship between artifact density and tool-to-flake ratio observed in other sites (Fig. 2.1a, $r = -.3726$, $p < 0.01$, df = 58). The correlation remains significant when the mixed units (III–VIII) are excluded ($r = -.3637$, $p < 0.05$, df = 31). In fact, the relationship evident in Fig. 2.1a appears mainly as a contrast between the early Mousterian of unit IX, which shows low artifact densities and high frequencies of retouched tools, and the later Mousterian of units I/II, which exhibits much higher densities and lower rates of secondary modification. This basic pattern fits very well with observations from other sites and materials suggesting high residential mobility in the early Mousterian and more intense or prolonged occupations in the later Mousterian (Meignen et al., 2005; Wallace and Shea, 2006). The correlations are not especially strong but this is to be expected: many other factors, form

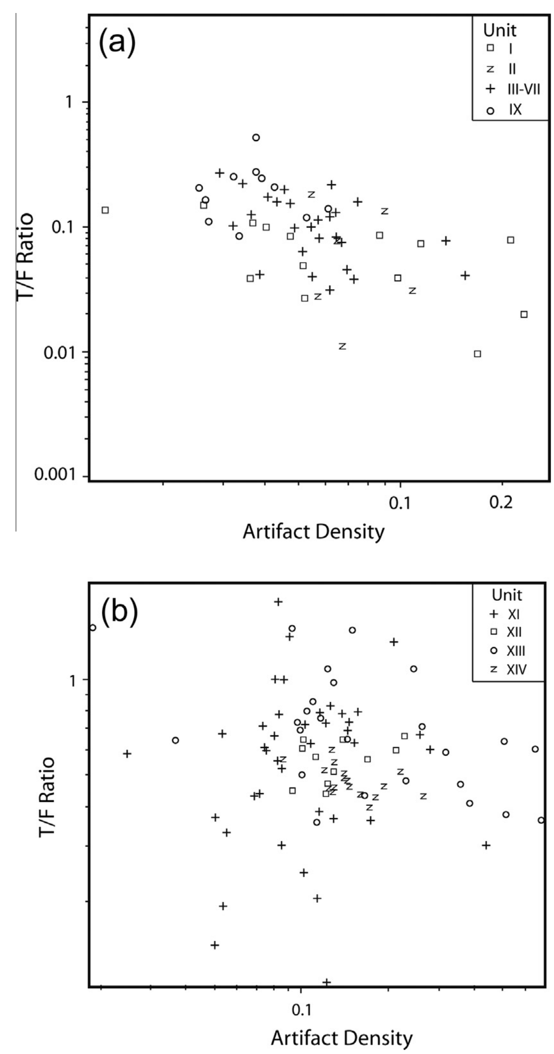

Fig. 2.1. Plots of artifact density vs. proportion of large (>2.5 cm) blanks retouched at Tabun Cave. (a) Mousterian layers (units IX–I); (b) Acheulo-Yabrudian layers (units XIV–XI).

rates of sediment input to the nature and placement of activities within the cave would complicate the relationship.

In contrast, units XI–VIV do not show the expected relationship (Fig. 2.1b). Both retouched tool-to-flake ratios and artifact densities are fairly high, but importantly they are uncorrelated (although *r* values for a few units approach statistical significance). Unit X, the transitional layer, falls neatly between the two trends, with the earlier deposits falling within the Acheulo-Yabrudian distribution and the later deposits aligning with the Levantine Mousterian correlation.

The fact that this simple relationship, so common in Middle and Upper Paleolithic, does not hold true for the lower levels at Tabun suggests that the manufacture and use of artifacts were organized differently in the Acheulo-Yabrudian than they were in later periods. To get a clearer picture of the differences we turn to an examination of the ways that different classes of artifact were deposited in the deposits at Tabun.

4. Rates of deposition for different artifact classes

The next set of analyses is organized around another simple null model of assemblage formation. If all occupations were the same and different kinds artifact were always introduced into the site through similar behavioral processes, artifacts would accumulate at rates determined only by the amount of time spent on site and rate of sediment input. Under such ideal conditions variability in density should be the same for all classes of artifact. Departures from uniformity, evidence for independent fluctuations in rates at which various classes of artifact accumulated would reflect more complex strategies. We emphasize that this is a null model. We do not expect it to hold true for any particular group of assemblages. It is simply a baseline for comparing technological behavior in different periods. Below we examine variation in densities of six major artifact classes: plain, unmodified flakes, cores, bifacial handaxes, retouched scrapers, notched and denticulate pieces, and unretouched Levallois blanks (including flakes, blades and points).[1] Cores and plain flakes are used as indices of the amount of manufacture done in place. All other artifact types are considered to have *potentially* longer life histories. Of course, some cores and plain flakes could have been transported, and any of the other artifact types could have been, and probably often were, made and discarded in place.

Variation in artifact density is summarized by the coefficient of variation (cv), a scale free measure. The average density values measure are indicative of the frequency of artifact discard, relative to rates of sediment accumulation. The cv values indicate the regularity of deposition: low values show that a particular artifact class was deposited at a relatively constant rate within a particular sedimentary unit, whereas high values show that rates of deposition fluctuated extensively. Confidence intervals about the cv provide for probabilistic comparisons of cv values. If the 85% confidence intervals for two values do not overlap we can be certain that the difference between them is statistically significant at just or beyond the standard 0.05 threshold (Payton et al., 2003). Conversely, substantial overlap in the 85% confidence intervals of a pair of cv values means that they cannot be distinguished statistically. Because we do not have independent control over rates of sedimentation, most comparisons are between artifact classes *within* sedimentary units: in this way we can assume that fluctuations in sedimentation rates were the same for artifact classes.

Table 1.1 shows average density values, cvs and 85% confidence intervals[2] about the cv values for various artifact classes in units I/II, IX, XI, XII, XIII and XIV. Fig. 2.2a and b are graphic comparisons of the cv values and confidence intervals. For this analysis we combined units I and II because the sample sizes for these units are small and combing them provides more reliable estimates of cv and confidence intervals for specific artifact classes. The density values in Table 2.1 are consistent with the differences previously observed between the two main sets of Levallois Mousterian layers at Tabun. The overall densities in units I/II are four times higher than in unit IX. The biggest discrepancy is in the densities of plain flakes (a 6.5-fold difference). Densities of Levallois flakes and points are very similar, and the value for retouched scrapers and points in unit IX is actually greater despite the lower overall density, reflecting the higher frequency of shaped tools in the early Mousterian of Tabun.

The cv values for different artifact classes provides further evidence for the ways the two groups of assemblages accumulated. In the denser deposits of units I/II, retouched scrapers and Levallois pieces show significantly lower cv values than cores, flakes and denticulates and notches. In other words, scrapers and Levallois blanks accumulated at regular rates compared to cores and knapping byproducts. This is consistent with the hypothesis that these layers contain the byproducts of occupations that were relatively prolonged compared to the other Middle Paleolithic deposits. Although units I and II contain more evidence for *in situ* flaking than unit IX, the extent of artifact manufacture (or perhaps its physical location within the cave) varied. Similar tendencies—high variance in densities of cores and flakes, lower variance for retouched tools—characterize the Mousterian sequence at Riparo Mochi in Italy (Kuhn, 2004).

Unit IX provides a rather different picture. Not only are cv values for densities of different artifact classes lower overall, there are no substantial differences among the artifact classes. In other words, while different classes of artifacts were deposited at different rates, fluctuations in those rates are quite similar. This is consistent with the notion that the low-density deposits in unit IX represent debris from a series of very redundant, short-term occupational events. Relatively minor fluctuations in overall density among layers are probably explained by the frequencies of short visits to the cave as well as the pace of sediment input.

It is worth noting that cv values for scrapers and Levallois pieces in unit I/II are on par with those for unit IX, whereas values for other artifact classes are much higher. It suggests that the behavioral processes that brought many of these artifacts to the cave were similar across the entire Mousterian sequence. In other words there was a fairly consistent deposition of scrapers and Levallois blanks into sediments at Tabun throughout the Middle Paleolithic occupation. The strongest variation between beds and units is really in (by)products of manufacture, cores and flakes, as well as in less extensively retouched forms such as notches and denticulates.

Units XI–XIV show a consistent set of patterns that differ in important ways from the Mousterian layers. Overall density values approach (unit XI) or exceed (units XII–XIV) the density of Mousterian units I/II. The cv values fall between those for the two sets of Mousterian layers. There are some strong consistencies across all four units, which comprise more than seven meters of deposits. Measurements of variability in rates of deposition are

[1] The category plain flakes includes mainly specimens >2.0 cm in maximum dimension. Due to the heavily cemented deposits, recovery of smaller artifacts was poor and unpredictable during Jelinek's excavations. The category scrapers encompasses Bordes's types 6–29, so includes both retouched points and scrapers. The category notches and denticulates includes Bordes's types 42 and 43.

[2] Confidence intervals about the coefficient of variation were calculated using an on-line utility http://www1.fpl.fs.fed.us/covnorm.dcd.html. The method is described by Verrill and Johnson (2007), available at the same url. This method assumes that the data are normally distributed. While we cannot demonstrate that this is true for every one of the samples of density values this is not highly problematic for large samples and an exploratory study.

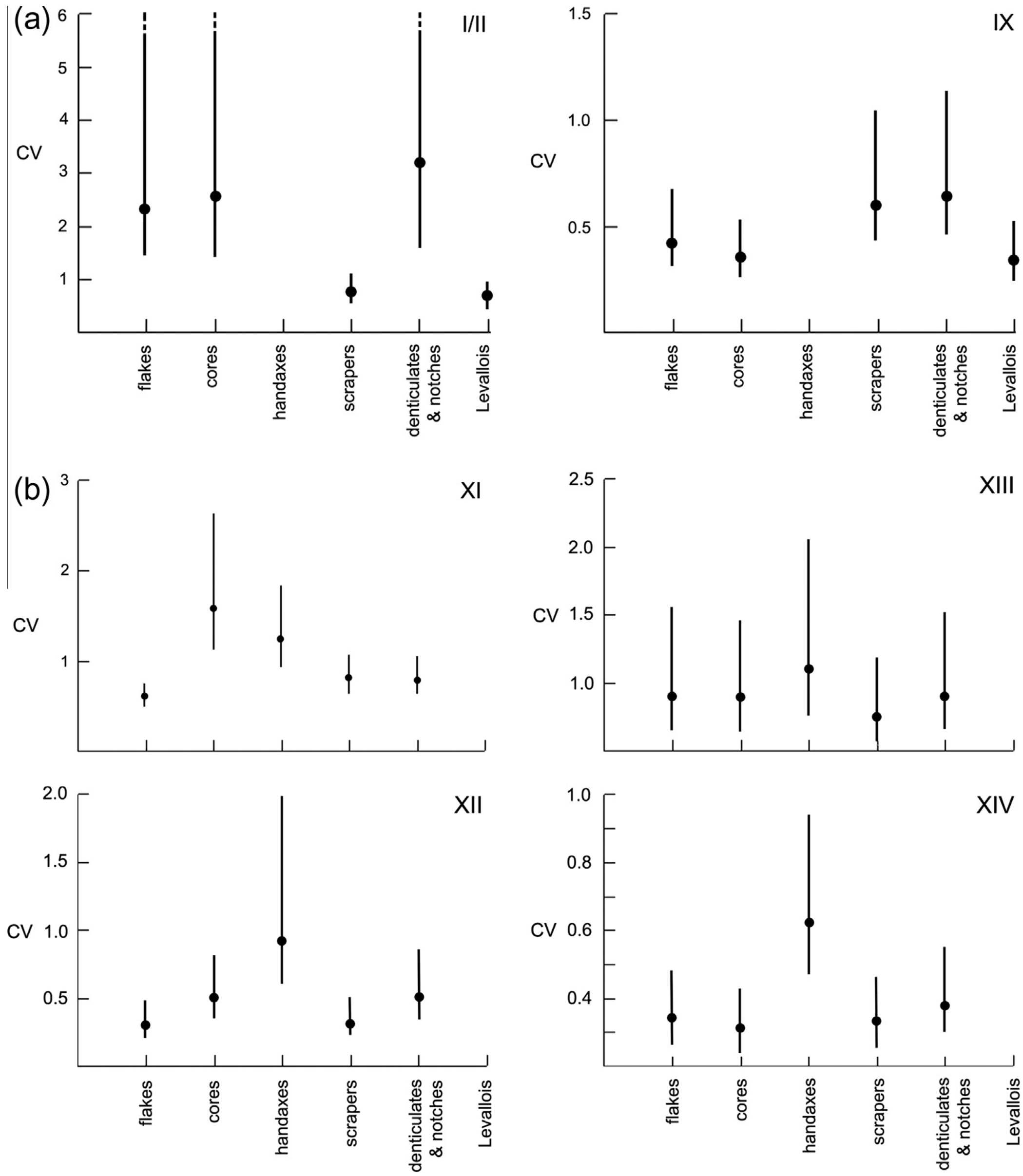

Fig. 2.2. Plots of cv for density with 85% confidence intervals for various artifact classes at Tabun Cave. (a) Mousterian layers (units I/II, IX); (b) Acheulo-Yabrudian layers (units XIV–XI).

fairly consistent across artifact classes. Except for cores in unit XI, cv values for byproducts of reduction (cores and flakes) are not significantly different from those of retouched flake tools, meaning that all were deposited with similar degrees of regularity. The only artifact class that stands out consistently is bifacial handaxes. In three units (XI, XII and XIV) densities of handaxes are significantly more variable than those of some or all other artifact classes. Clearly, handaxes were abandoned in the site with different rhythms than other artifact forms.

The variation within and among the Acheulo-Yabrudian layers is also somewhat anomalous with respect to the later Mousterian. The overall consistency among artifact classes resembles unit IX, hypothesized to be products of a series of very redundant, short-term occupations. Likewise, the high frequency of retouched pieces, and the intensity with which some artifacts were modified, is consistent with an inference of fairly short occupations. At the same time, the overall density values for units XI through XIV approach or exceed those for units I/II, which are believed to epresent more prolonged occupation events.

We can propose three alternate hypotheses to account for the discordances between the Mousterian layers and units XI–XIV at Tabun.

(1) Contrasts in overall density between the Acheulo-Yabrudian layers and the early Mousterian of unit IX are due to varying rates of sediment deposition. Unit IX is less dense because sediments accumulated much faster, not because of any changes in hominin behavior.
(2) The high density of artifacts in units XI–XIV resulted from long-term occupations, but activities leading to the deposition of various artifacts were highly redundant, much more so than in the later Mousterian.

Table 2.1
Mean, standard deviations, and cv values for artifact densities within 6 major units at Tabun Cave. Upper and lower ci values bound 85% confidence intervals. Missing values occur where counts are too small to calculate reliable estimates.

Unit		Total	Flakes	Cores	Bifaces	Scrapers	Notch/dent.	Levallois
I/II	Mean	0.132	0.098	0.008	–	0.002	0.008	0.014
	sd	0.264	0.227	0.02	–	0.0012	0.025	0.009
n = 23	Lower ci	1.22	1.43	1.41	–	0.576	1.6	0.5
	cv	2.01	2.32	2.56	–	0.74	3.17	0.64
	Upper ci	5.69	13.17	12.01	–	1.11	>15	0.92
IX	Mean	0.038	0.015	0.017	–	0.032	0.001	0.011
	sd	0.011	0.006	0.0006	–	0.0019	0.0007	0.0036
n = 11	Lower ci	0.22	0.31	0.27	–	0.43	0.46	0.25
	cv	0.292	0.42	0.35	–	0.59	0.64	0.34
	Upper ci	0.45	0.68	0.53	–	1.04	1.14	0.52
XI	Mean	0.118	0.064	0.013	0.009	0.015	0.003	–
	sd	0.751	0.037	0.02	0.011	0.012	0.002	–
n = 40	Lower ci	0.53	0.49	1.13	0.93	0.64	0.63	–
	cv	0.64	0.59	1.58	1.23	0.8	0.78	–
	Upper ci	0.85	0.75	2.62	1.82	1.06	1.04	–
XII	Mean	0.139	0.069	0.013	0.011	0.016	0.005	–
	sd	0.045	0.021	0.007	0.01	0.005	0.0093	–
n = 11	Lower ci	0.24	0.23	0.36	0.62	0.24	0.37	–
	cv	0.32	0.3	0.5	0.92	0.31	0.51	–
	Upper ci	0.51	0.48	0.83	1.99	0.49	0.86	–
XIII	Mean	0.227	0.103	0.029	0.009	0.044	0.011	–
	sd	0.182	0.094	0.026	0.01	0.032	0.01	–
n = 18	Lower ci	0.59	0.66	0.64	0.77	0.56	0.66	–
	cv	0.8	0.91	0.88	1.11	0.75	0.9	–
	Upper ci	1.29	1.54	1.47	2.06	1.19	1.52	–
XIV	Mean	0.153	0.08	0.028	0.009	0.1012	0.008	–
	sd	0.043	0.028	0.009	0.006	0.004	0.003	–
n = 17	Lower ci	0.22	0.27	0.24	0.47	0.26	0.3	–
	cv	0.28	0.34	0.31	0.62	0.33	0.38	–
	Upper ci	0.39	0.48	0.43	0.94	0.46	0.55	–

(3) The high densities in the Acheulo-Yabrudian layers resulted from short-term redundant occupations, as in unit IX, but these were much more frequent or closely spaced than in the early Mousterian.

Although we do not have direct control over rates of sediment accumulation at Tabun, changes in sedimentation are unlikely to account for differences in density between the early Levantine Mousterian and Acheulo-Yabrudian layers. Artifact densities are between three and seven times greater on average in the earlier levels. However, processes of sedimentation were basically constant between units XIII and the base of unit II: the major shift in sedimentary processes occurred later in the sequence. Grain size increases with depth so we might even expect the finer-grained sediments in unit IX to have accumulated more slowly than the coarser sediments in units XI–XIII. Moreover, the low artifact density exhibited by unit IX at Tabun is consistent with other early Levantine MP sites such as Hayonim cave (Stiner, 2005).

The second hypothesis can be partially evaluated through examining the frequencies of burned artifacts. We assume that in this context flints were burned accidentally rather than intentionally, through placement of hearths on sediments containing previously discarded flints or through tossing artifacts into fires to clean up living space. The frequency of burned lithics is thus a rough indicator of the frequencies and intensities of fires kindled within the cave. We expect the percentage of burned lithics to be positively correlated with the duration of occupations and with artifact density: there should have been be more use of fire during longer occupations, and higher artifact densities from past occupations would increase the likelihood of artifacts being burned accidentally. Frequencies of burning on plotted artifacts are shown in Table 2.2. Burning is relatively frequent in the Middle Paleolithic units I and II, which also show higher artifact densities, but more infrequent in unit IX, with lower artifact densities. Burning is relatively rare in the Acheulo-Yabrudian layers, especially units XIV and XIII, on par with or less common than in unit IX. This is surprising because the generally high density of artifacts in units XI–XIV should lead to more accidental burning of flints. This low overall frequency of burning argues against the hypothesis that the Acheulo-Yabrudian assemblages represent a series of prolonged or intense occupational events.

Table 2.2
Frequencies of burned flints by unit artifact densities for various units at Tabun Cave.

Unit	Proportion of flints burned	Density
I	0.485	0.158
II	0.274	0.070
IX	0.084	0.038
XI	0.159	0.118
XII	0.109	0.139
XIII	0.029	0.227
XIV	0.013	0.153

This leaves Hypothesis 3 as the most plausible explanation for the anomalous aspects of Acheulo-Yabrudian assemblage formation. From the information at hand it is most likely that the Acheulo-Yabrudian assemblages of units XI–XIV accumulated mainly as the result of a series of comparatively short, but closely spaced occupational events. Moreover, activities leading to the discard of stone artifacts – flakes, cores and retouched flake tools in particular – were highly redundant. Variation in overall artifact densities reflects the frequencies of short term occupations as well as fluctuations in sedimentation rates. Handaxes seem to have had different life histories than cores and flake tools in the Acheulo-Yabrudian: they were discarded on more variable schedules than other artifact types.

5. Discussion

It is a useful strategy in archaeology to work from the known to the unknown, from the familiar to the unfamiliar. The negative correlation between artifact density and the proportion of retouched blanks observed in many Middle and Upper Paleolithic sites seems to reflect a very simple and widespread property of technological systems, and it should come as no great surprise that we find evidence for this tendency among both Neanderthals and modern humans. More surprising is the absence of such a basic relationship in the Acheulo-Yabrudian assemblages of Tabun. This suggests that Acheulo-Yabrudian hominins used basic strategies of artifact provisioning and raw material management that were unlike those of either Neanderthals or later *H. sapiens*. Likewise, the redundancy of deposition in the Acheulo-Yabrudian at Tabun, despite high densities of material, suggests that artifact production and discard were organized differently than in the Levallois Mousterian.

In our view, the most parsimonious explanation for the distinctive and anomalous aspects of the Acheulo-Yabrudian is that the sequence of pre-Mousterian assemblages in Tabun represents a markedly redundant, invariant set of behavioral dynamics. Through this long sequence, individual occupational events were brief but often closely spaced. Variation in the number of artifacts per m^3 of sediment reflects the spacing between these short occupations as well as fluctuations in the tempo of geogenic sedimentation. With little evidence beyond stone artifacts it difficult to explain variation in the frequency of visits to the cave. Likely this was closely tied to local and regional environmental conditions. One possibility is that the spacing between sequential re-occupations reflects the position of the cave within hominins' foraging territories (Clark, 2008, in preparation). When the site happened to be near the center of their territory hominins visited it frequently, whereas when it was at the margins of their territory hominins came there less often.

During their many brief visits to Tabun, the hominins responsible for the Acheulo-Yabrudian tended to conduct similar kinds of activities involving the manufacture and use of stone tools. Despite the frequently heavy modification, there is no indication that the discard of Yabrudian scrapers was scheduled any differently than that of flakes and cores. This suggests that artifact production and discard were tightly correlated—in short, that flake tools tended to be deposited where they were made. If artifacts entered and left the site the additions and subtractions tended to balance out in the long term.

Only handaxes really stand out within units XIV–XI. At times they were abandoned much less predictably than other artifact classes. General observation of the assemblages within units XI–XIV indicates that biface thinning flakes are less common than would be expected if the handaxes were produced *in situ*. Acheulo-Yabrudian handaxes probably constituted a sort of multi-purpose portable toolkit, transported from place to place more regularly than other artifacts. Similar observations have been made about handaxes from the late Mousterian of Acheulean Tradition in France (Soressi, 2002). These artifacts, with their distinctive life histories may represent a specific provisioning strategy, different from that which produced most of the artifacts in a given assemblage. Whether they track particular types of individuals or particular kinds of foraging pursuits remains uncertain given the scarcity of ancillary evidence on associated faunas, use wear, or raw material sourcing.

As noted above, researchers differ as to whether the Yabrudian, Amudian and similar assemblages should be assigned to the Middle or Lower Paleolithic (contrast Bar-Yosef, 1995; Copeland, 2000; Jelinek, 1982b; le Tensorer et al., 2007). One reason for this ambiguity is that features typical of the later Mousterian are sometimes present but not consistently expressed during the period between 400 ky and 200 ky. Acheulo-Yabrudian technologies are oriented around flake (or blade) production rather than shaping of large core tools, a typical feature of the Middle Paleolithic. Yet handaxes continue to be present, albeit in reduced numbers compared to the late Acheulean. Levallois production, the signature of the Levantine Mousterian, is scarce in the Acheulo-Yabrudian (Gisis and Ronen, 2006; Solecki and Solecki, 1986; Vishnyatsky, 2000:148). In the Levant as well as western Europe, the period between 400 ka and 200 ka also sees the emergence of what may be best described as domestic spaces (Chazan, 2009; Foley and Gamble, 2009). Acheulo-Yabrudian hominins used fire (Copeland, 1975, p. 322; de Heinzelin, 1966; Ronen and Tsatskin, 1995; Tsatskin, 2000, 135), though there is evidence for an increase over time in the regularity of burning (Shimelmitz et al., submitted for publication). Many associated patterns of behavior, including consistent use of caves and rockshelters, hearth-centered activities, and provisioning of places with choice elements of animal carcasses, were already in place by this time (Stiner et al., 2009, 2011). At the same time, patterns of butchery at Qesem cave suggest that Acheulo-Yabrudian hominins divided up animal carcasses in different ways than later Mousterian and Upper Paleolithic populations (Stiner et al., 2009).

Acheulo-Yabrudian land use also appears anomalous at a larger scale as well. The nature of occupations and activities conducted appear to vary among sites, but not *within* them. The sites of Tabun and Qesem, the only two localities extensively excavated in the last 30 years, show very different tendencies. Over an occupational history of nearly 200 ky (Barkai et al., 2003), hominins at Qesem consistently produced large numbers of small, minimally modified blade tools, many of which were used for butchery activities (Barkai et al., 2009). Heavy Yabrudian scrapers are present but are rare and spatially concentrated. In Tabun, scraper-dominated assemblages are the rule throughout the long sequence: even the Amudian assemblages include many large scrapers. We hypothesize that the activities conducted at particular sites were very strongly tied to the characteristics of particular places on landscape, but not to the place of the site within a network of other localities. Changes in the role of places within forager land-use systems described by Binford (1982, 1983) for recent foragers are not manifest in the Acheulo-Yabrudian, so far as can be ascertained from the lithic evidence.

6. Conclusion

The results reported in this paper document habitual patterns of artifact discard over a period of as much as 400 ky. These observations suggest that there were important changes in land use and strategies of raw material management between the Acheulo-Yabrudian and the Levantine Mousterian. Such long-term trends in behavior become apparent only when one shifts scales, adjusting the focus from small (individual artifacts or beds) to larger (geological units) units of analysis. Like many Paleolithic archaeologists, we are interested in behavioral dynamics unfolding at a fine temporal scale, but we have adopted a coarse-grained analytical perspective because that's what the record affords. To be sure, such an approach takes advantage of the unique properties of the record generated by Jelinek's excavations at Tabun, which produced a finely-divided sample of artifacts spanning several hundred thousand years. But although Tabun is a remarkable site, the Paleolithic record generally affords this sort of temporal resolution more often than it provides "moments in time."

One of greatest challenges in Paleolithic archaeology is imagining ways of being human that are not like those of recent hunter–gatherers (Binford was also a pioneer here). In investigating the behavior and ecology of early humans it is important to avoid the tendency to "model by subtraction", imagining early hominin groups as essentially recent foragers lacking a few key elements. The period between 400 ka and 200 ka in the Levant witnessed a set of adaptations that persisted for 200 ka, and that were distinct from what we know of later populations. On one hand the period does seem to provide some of the first clear evidence of domestic spaces and "campsites" in Eurasia. On the other hand, certain anomalies suggest we are not dealing with exactly the same sorts of campsites as we know from later periods. A land use system organized around uniformly brief, redundant occupations, in which activities were tightly tied to particular places on the landscape for tens of thousands of years, is not something familiar from the Middle or Upper Paleolithic. Yet it may be typical for this earlier period. In imagining these Middle Pleistocene hominins sharing meat around campfires we should be conscientious not to drape them in the clothing of recent hunter–gatherers or even Neanderthals. Lewis Binford provided the field with many of the intellectual tools we need to come to terms with systems of behavior that have no equivalent in recent experience. It is up to future generations to build on these to reveal the richness and diversity of hominin lifeways in the remote past.

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