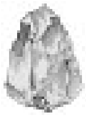

3

TECHNOLOGICAL AND TYPOLOGICAL VARIABILITY IN THE BIFACES FROM TABUN CAVE, ISRAEL

Shannon P. McPherron

Jelinek's 1967–72 excavations of Tabun Cave yielded more than 2,000 complete and partial bifaces. These bifaces come from a series of beds, but the bulk of the assemblage can be attributed to the Late Acheulian and Yabrudian industries. This chapter builds on a detailed morphometric analysis of the Tabun bifaces published by Rollefson in 1978, in which he identified several patterns in biface shape throughout the sequence. In particular, it applies a reuse and resharpening reduction model to the morphological variability within several stratigraphic units. Variability between stratigraphic units is examined from this same perspective, and relationships between patterning in the bifaces and variability in the flake tool components of the assemblages is sought. The focus is to achieve some level of understanding of the relationships between technology, raw materials, reduction intensity, and typology and to how these variables changed through time in the Tabun sequence.

Elsewhere I have put forth a reduction model to explain the variability in biface shape (McPherron 1994, 1995, 1999, 2000). The model links the intensity of bifacial reduction with variability in biface shape. It is based on the simple assumption that a biface, once made, will be resharpened or periodically reworked before it is discarded into the archaeological record for the last time. With each resharpening event, the size of the biface, whether measured by the length, width or thickness, is reduced. The question is whether shape is altered in the process as well. If a particular shape, as we measure it, was important to these hominids, then we would expect the shape to remain relatively constant despite the diminishing size of the biface. On the other hand, if factors other than shape were more important, then we might expect shape to gradually change as the biface diminished in size. In fact, when I examined several Acheulian assemblages from northern France, I found a consistent and predictable relationship between size and shape (McPherron 1994, 1999). There are several ways to measure size; in my work I have focused on length of the tip (measured from the point of maximum width to the tip). I selected tip length because it seemed like a safe assumption that the tip is the primary focus of bifacial reduction, and in reworking or resharpening the tip the length will almost certainly be effected. Thus, tip length can be said to be a measure of the intensity of bifacial reduction. When looking at previously published data on biface shape, in the absence of data on tip length, I substituted length with identical results. In the assemblages that I have examined, length and tip length are always very highly correlated.

Length (or any measure of size) is effected by the size of the nodule or flake blank one begins with, and this can be highly variable. Unlike reduced flakes in which the size of the original flake blank can be estimated from measurements on the preserved platforms (Dibble 1997), there is very little that can be done with bifaces to consistently estimate the size of the original blank from which it was made. Thus, I have made the simplifying assumption that hominids consistently sought the largest nodules available, and that these nodules would have been roughly the same size for a particular assemblage of bifaces. Thus, size reflects intensity of reduction. This is an assumption commonly made with cores for instance. Smaller cores are regularly interpreted as more heavily reduced than larger cores in the same assemblage. In some assemblages I have been able to test the relationship between raw material variability and size using the percentage cortex remaining on the pieces. If all the nodules start out roughly the same size, then as reduction intensity increases and as size decreases, the amount of cortex remaining on the piece should decrease. On the other hand, if the nodules start with varying sizes, then there should be no relationship between cortex and size.

Such a cavalier attitude towards raw material variability certainly invites disaster. Raw materials obviously varied to a great extent and certainly played a role in bifacial reduction. White (1998) has worked on just this problem using some of the English biface assemblages that Roe (1964, 1968) had previously analyzed. In a set of 38 assemblages, Roe found a clear distinction between assemblages characterized by pointed forms and assemblages characterized by rounded or ovate forms; this pattern has been repeatedly confirmed (Doran and Hodson 1975; Callow 1976). It is important to note that each assemblage contains a mixture of both forms. Although to at the assemblage level, the distinction is clear between the two kinds of biface assemblages, at least for the British 38, the same distinction has never been demonstrated within an assemblage. Assemblages are characterized by a modal shape around which there is typically substantial variability and a gradual or continuous transition from one form to another.

White examined the British bifaces and noted the type of raw material from which they were made. He found a consistent pattern that led him to suggest that variability in raw material size, shape, and quality is behind the shape patterning in these assemblages; something that Ashton and McNabb (1994) had also noted. Pointed forms tend to be made on smaller, poorer quality raw materials obtained from secondary deposits on river terraces. In these instances, the shape of the nodules often placed constraints on the type of form that could be manufactured. Conversely, rounded forms were generally made on larger, high-quality raw materials obtained from primary sources. Because pointed or ovate forms could have been manufactured in these instances, White (1998:22) takes the analysis a step further, argueing that ovate forms were in fact the preferred form of Britain's hominids and that pointed forms were simply an accommodation to inferior raw materials.

Arguing preferences from the trash hominids left behind is a tricky business in a reductive technology like stone (Frison 1968; Jelinek 1976, 1977; Davidson1991; Davidson and Noble 1993). In my own analysis of Roe's assemblages (1995), I noted the exact same patterning that I found in the northern French assemblages and had attributed to reduction intensity. Although there is naturally a great deal of variability in the British bifaces, size and shape are still statistically significantly correlated. The average length of the bifaces in Roe's pointed assemblages is greater than in the rounded assemblages. Moreover, other measures of shape, not just whether the edge is pointed or rounded, also vary between these assemblages in the exact same way the reduction model shows them to work elsewhere.

Which model is correct? As Ashton and White indicate, both models lack information about the process of bifacial reduction. My own approach has been to argue that the bifaces of an assemblage represent different stages of the reduction process. Some will be in the earlier stages of reduction when they enter the archaeological record and others will be nearly exhausted. By looking at the whole collection, the process can be thereby reconstructed. What is more, if the reduction model is correct, it also allows the average reduction intensity in an assemblage to be assessed and quantified and then compared with other factors (i.e., distance from raw materials, environmental changes) just as it has been done with the flake tool component of Mousterian assemblages (Rolland and Dibble 1990). This is, in fact, exactly what I try to do with Tabun and have attempted elsewhere (McPherron 1999:14).

To a very large extent, however, both models are likely correct. The two models work very well together. Raw materials certainly play a role in determining the reduction strategy. In particular, if they follow the kinds of patterns documented elsewhere for other kinds of stone tools, large, high-quality raw materials should see extended use-lives and enter the archaeological record in a more intensively reworked and reduced form. I have argued that this is exactly what White has documented (McPherron 1999:14). In my reduction model, pointed forms represent an early stage of reduction and rounded forms a later stage. It makes good sense that the bifaces made of poor-quality material are being discarded into the archaeological record at an early stage of reduction and that the large, high-quality material bifaces are being curated and more intensively reduced before they enter the record as rounded forms. White (1998:20) seems to agree. He repeatedly offers that ovate bifaces show signs of being more intensively reduced than pointed forms.

Where I disagree with White is in the attribution of preference to the rounded form. My own data from northern France (McPherron 1994, 1999), the British assemblages (1994, 1995), and even comparisons of assemblages at the level of continents (2000), show the same recurrent patterns in which pointed and rounded forms are simply stages along a single trajectory. Factors like raw-material quality affect when a biface falls from this trajectory into the archaeological record. It is the trajectory, therefore, and not the stage along the trajectory that is preferred.

Ashton and White attempt to address the question of process, but their methods are so different from my own that we may be talking past each other at this point. There is a way to bring the two together. It would be interesting to take an assemblage, divide the bifaces into raw material types, and apply the tests of the reduction model, as I have outlined them, to each. Regardless of whether pointed and ovate bifaces are points along a single trajectory or two separate trajectories, I would expect them each to show a reduction sequence. If not, we can stop there. On the other hand, if they show reduction trajectories, then how are they different? The two could be plotted on the same graph. If they are right, then the reduction trajectories should look distinctly different despite the fact that pointed and round forms grade into one another. One trajectory, for instance, might emphasize the removal of material from the tip with each resharpening reduction episode, whereas the other may not. These differences should be evident when the shape ratios are plotted against the reduction intensity.

That said, I will take a difference approach here with the Tabun data. Tabun offers an excellent opportunity to pursue this question of the roles of reduction intensity and raw

Table 3.1 Biface Counts for Jelinek's Excavations of Tabun

Garrod	Jelinek			Complete
Layer	Unit	Bed	Bifaces	Bifaces
C	III	35	1	1
C	V	41	4	3
C	VI	45	1	1
C	VI	49	1	1
C	VII	58	1	1
C	VIII	59	2	1
C	VIII	61	1	1
D	IX	63	2	1
D	IX	64	1	0
D	IX	66	4	4
D	IX	67	2	1
D	IX	68	1	1
D	X	70	8	7
D	X	71	31	13
D	X	72	97	72
Ea	XI	73	65	40
Ea	XI	74	80	61
Ea	XI	75	135	100
Ea	XI	76	541	365
Ea	XI	77	53	33
Eb	XII	78	3	2
Eb	XII	79	260	174
Eb	XII	80	149	97
Ec	XIII	81	18	11
Ec	XIII	82	62	39
Ec	XIII	83	187	108
Ec	XIII	84	72	47
Ec	XIII	85	11	8
G	XIV	90	289	190
		Total	**2082**	**1383**

Garod's layers are based on Jelinek's stratigraphic correlations. Bifaces from boxed beds were examined by the author as part of this study.

material variability for several reasons. First, Tabun is unusual among biface sites in that it has a deep sequence of bifacial levels. Not only can patterns within assemblages be examined, but also any changes in these patterns through time. Second, the sample size from many of these levels is large enough to be amenable to the kinds of statistical analysis on which the reduction model relies. Third and most importantly in the context of the debate between Ashton and White and myself, some aspects of raw-material variability in the Tabun sequence are thought to be constant. In particular, the raw material source is likely constant, meaning that the quality and the shape of the nodules are less variable. It is possible, however, that the quantity of available nodules varied with environmental changes and with the rate at which they were being used. Tabun therefore, offers an opportunity to examine the relationship between bifacial reduction intensity and shape through time with some control over raw-material variability.

Tabun

Tabun Cave is located in Israel near the mouth of the Wadi Mughara, on the western margin of Mount Carmel, approximately 20 kilometers south of Haifa and between 3 and 3.5 km inland from the Mediterranean Sea. The site is 45 m above sea level and faces northwest overlooking the Mediterranean coastal plain. The cave itself consists of a large outer chamber open to the sky, a smaller inner chamber open to the sky due to a large chimney that opened during the prehistoric occupation of the site, and an intermediate and smaller chamber that communicates with the other two (Jelinek 1982; Mercier et al. 1995; Rollefson 1978).

The archaeology of the cave is known principally from two excavations. First, Garrod excavated a large portion of the site, as well as the nearby caves of Skhul and el Wad, between 1929 and 1934. Second, more recently, Jelinek re-excavated a portion of the site from 1967 to 1972 and produced a more detailed stratigraphic sequence along with an artifact assemblage of approximately 45,000 pieces. Whereas Garrod recognized seven principal Layers A–G, Jelinek organized the stratigraphy into fourteen Units I-XIV, which are further subdivided into approximately 90 beds, many of which are further subdivided into smaller groups of associated materials. For the most part, Garrod's and Jelinek's sequences can be correlated (Jelinek 1982), although some of Garrod's sequence was not sampled by Jelinek and vice versa.

More than 2000 bifaces come from Jelinek's excavations (Table 3.1). Most of these come from the lower part of the sequence in Jelinek's Late Acheulian (Layer G), Mugharan (Layer E), and early Lower Mousterian (Layer D). Bifaces occur only sporadically through the Middle Mousterian (Layer C) and are absent thereafter. The Tabun bifaces are best known from Rollefson's 1978 dissertation in which he completed a detailed morphometric, typological, and technological analysis using multivariate and PCA statistical techniques. The observations on the material presented here are based on Rollefson's publication, a reanalysis of his published data, and my own observations of the material from the three Beds with the largest samples: 76, 79, 90.

Some of the finds to date with regard to the reduction model are presented; however, the work is still in progress. The long-term goal is to update Rollefson's work, principally in terms of the stratigraphic information, which is now out of date in Rollefson's original publication (Rollefson 1978:68–69), and to reexamine the patterning in these collections in light of two decades of work into the kinds of factors which can affect the structure of variability in biface assemblages.

Table 3.2 Regression Analysis of the Relationship Between Tip Length and Shape

	Level 76 (N=333)		Level 79 (N=134)		Level 90 (N=125)	
	R	P	R	P	R	P
Tip length to Elongation	0.4280	**0.0000**	0.4804	**0.0000**	0.2702	**0.0001**
Tip length to Refinement	0.0985	0.0725	-0.0308	0.7243	-0.0316	0.7263
Tip length to Bordes' Edge	0.6017	**0.0000**	0.6076	**0.0000**	0.5568	**0.0000**
Tip length to Roe's Edge	0.4479	**0.0000**	0.5498	**0.0000**	0.4785	**0.0000**

Statistically significant relationships are set in boldface type.

Tabun's Bifaces

In terms of typology, following Bordes' (1961) terminology, the Tabun bifaces tend to be relatively thick, broad, and more rounded than pointed. Amygdaloid, thick ovate, and thick disc shapes are quite common (Table 3.2). There are also a fairly substantial number of cleaver types. These pieces have a relatively straight distal edge usually formed by some combination of tranchet removals and retouch from the distal end. In some instances, the distal end is formed by two tranchet blows from opposite sides. It can also be formed by bifacial retouch directly from the distal end, and sometimes it is a combination of tranchet on one side and retouch on the other. Unsystematic data collected on whether the tranchet preceded or followed the retouch revealed no consistent pattern; although it did seem that most instances in which it could be determined, the end was retouched following a tranchet removal. As Rollefson (1978) notes, there is also a fairly high percentage of bifaces that have to be classified as diverse or miscellaneous. A couple of examples that resemble prodniks from central Europe are particularly interesting.

Similarly, using Roe's typological approach wherein bifaces are placed in either the cleaver, ovate, or pointed category based on the ratio of the base length to the length (Figure 3.1), ovate types are relatively more common than pointed forms. In Roe's system, to characterize an assemblage, at least 60% of the bifaces must be of one type or another. In the Tabun sequence, when we consider beds with at least double digit frequencies, pointed bifaces never predominate (Table 3.2). The assemblages are most often indeterminant, meaning that neither type exceeds 60% of the assemblage, or ovate. Interestingly, two of the three largest assemblages, are ovate.

Most of the bifaces retained some cortex, often in the form of a cortical base. Raw-material data are not available, but it appears that the vast majority of bifaces are made on locally available flint. Roughly 20% of the bifaces could be positively identified as having been manufactured on flake blanks. This figure undoubtedly underestimates the true proportion of bifaces made on flakes because the type of support could not be determined in most instances. In some instances it could be determined that the bifaces were made on thin, flat nodules of flint or thin tabular pieces of flint.

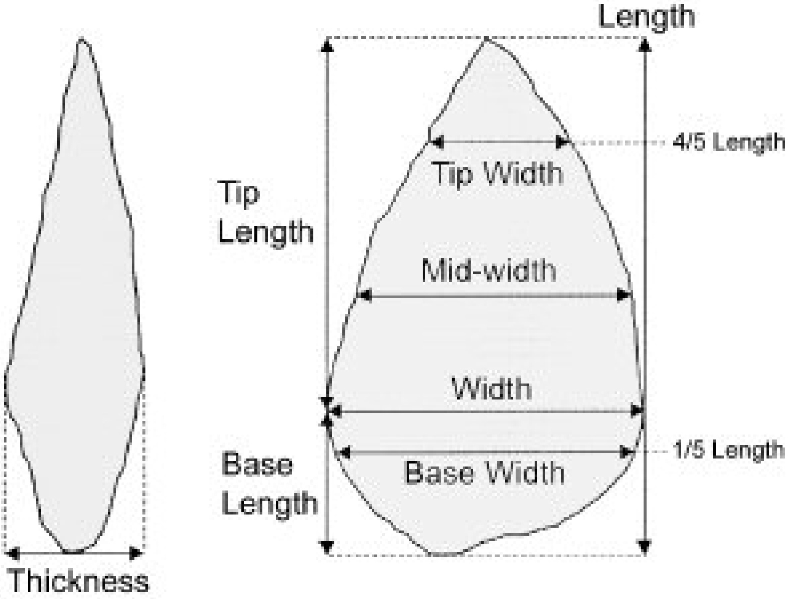

Figure 3.1 The biface measurements referred to in this article. All of these measurements are drawn from the combined systems outlined by Bordes (1961) and Roe (1964).

Within Assemblage Variability

From the tables and descriptions presented, it is clear that whereas some modalities in shape exist, there is also a great deal of variability. At a most basic level, for instance, there are both ovate and pointed forms. Whereas White found that in the British data pointed forms tended to be manufactured on poorer quality raw materials, there is absolutely no indication at Tabun that raw-material quality varied. The general assumption has been that raw materials were of high-quality throughout. In my own observations of the material, I saw some instances in which nodule shape seemed to have influenced to some extent the final form of the biface; this is difficult to quantify because it is only obvious if the biface enters the archaeological record at an early stage of reduction when traces of the original nodule are still present on the piece. On more reduced bifaces, there is no way of knowing what the original form might have been like.

Variability in the Tabun bifaces does seem, however, to follow the reduction model. The model predicts a correlation between size, which is a function of the intensity of reduction when raw materials are constant, and shape. In nearly all studies of patterning in biface shape, size is explicitly removed from the analysis, presumably because it represents "noise" or unintended variability related to factors outside the control of the knappers; namely, the size of the original raw materials. The idea is that once the effects of size are removed from the analysis, we can see the true intentions of the knapper. Indeed, as a most basic level, this is one of the basic reasons why we calculate shape ratios that have the effect of standardizing one measure relative to another. We compare elongation ratios (length/width) rather than directly comparing absolute length and width.

Until size is removed from the analysis, multivariate studies of biface shape have found that size explains or predicts most of the variability. Particularly interesting in this regard is Wynn and Tierson's (1990) study of bifaces from several continents. They found that size explained more than 90% of the variability in their 22 radial measurements of biface shape, and then attempted to discarded this from their analysis so that they could look at the remaining variability (I have argued that they were not successful in removing size from their analysis [McPherron 2000]). The significance of their finding is that size plays such an important role. It is especially significant if we acknowledge that size is more than variability in raw materials. Size also has a behavioral component, namely the intensity of bifacial reduction.

At about the same time that I first published my reduction model, Gowlett and Crompton (1994; Crompton and Gowlett 1993) also directly tackled the issue of size-related variability from a different perspective. They analyzed assemblages from East Africa and found significant relationships between size and shape. For them, it is the very relationship between size and shape that has behavioral significance. I agree completely with this assessment, but I disagree with their interpretation of the behavior behind this pattern. The important point of agreement, however, is that size must be included in an analysis of biface shape.

Whereas Gowlett and Crompton use allometric statistics, I have focused on correlations between size and shape. To test the reduction model, regression analysis is applied and correlation coefficients calculated between tip length and various measures of shape that existing typologies and multivariate analyses have already identified as significant areas of morphological variability in bifaces. If maintaining a biface of a particular shape was important to prehistoric knappers despite multiple resharpening reduction episodes and variability in raw material size, then there should be no correlation between tip length and shape. If, on the other hand, shape varies as the tip is reduced in length, then there will be a statistically significant correlation.

By and large, the patterns that I have found elsewhere hold at Tabun (Figures 3.2–3.4, Table 3.3). In the three beds with the largest samples (Beds 76, 79, and 90), there is a strong correlation between edge shape, as defined by both Bordes and Roe, elongation, and tip length. As tip length decreases, the bifaces become broader and rounder. In other words, during bifacial reduction, length-related variables decrease more quickly than width, particularly near the base. As a result, the width gradually becomes larger relative to the length (elongation) and the width near the tip becomes larger relative to the width at the base (edge shape). It is important to emphasize that Tabun is similar to other bifaces sites not only for having a statistically significant correlation between size and shape, but the direction of this relationship is also the same. In other words, there is a shared bifacial reduction strategy. Refinement (width / thickness), on the other hand, does not correlate with tip length. In fact, refinement is fairly constant in the Tabun assemblages regardless of changes in size, shape, or blank type (flake or nodule).

With other assemblages that I have examined, I have found supporting evidence for the relationship between size, shape, and reduction intensity in the percentage of cortex left on the pieces. If nodules of roughly the same size are worked into bifaces, then the

Table 3.3 The Relationship Between Size, as Measured by Length, and Percentage Cortex

Bed	Small	Large	t-statistic	p
76	23.9 s.d.= 19.81 (N=149)	19.4 s.d.= 16.13 (N=136)	2.066	0.040
79	22.9 s.d.= 14.47 (N=66)	22.9 s.d.= 18.88 (N=47)	0.009	0.993
90	16.0 s.d.= 14.50 (N=60)	13.6 s.d.= 12.96 (N=47)	0.869	0.387

The groups small and large are based on the mean length in the respective beds.

expectation is that as the nodules are more intensively worked, the size and the percentage of the cortex remaining on the nodule will decrease together. This model works if at some point in the reduction sequence cortex at the base is removed and the bifacial edge eventually extends around the entire periphery of the biface. On the other hand, if a cortical base is retained, then the *percentage* of cortex remaining on the piece will actually increase with decreasing size. The Tabun data show that cortex either remains the same or increases with changes in size (Table 3.4). In Bed 76, smaller bifaces, on average, have more cortex as a percentage than larger bifaces. In Bed 79, cortex remains constant with changes in size, and Bed 90 follows the Bed 76 pattern, although in this case the difference is not statistically significant. One of the bifacial reduction strategies employed at Tabun involved leaving cortex on the pieces, typically as a cortical base, which led towards small, fairly cortical, broad, rounded bifaces. Interestingly, typologically these bifaces can look like small chopping tools. In looking through the material, I did come across several instances in which pieces I would have classified as bifaces had been classified as chopping tools or vice versa.

This reduction strategy may also explain why refinement, measured as the ratio of the width to the thickness, remains fairly constant throughout and is not correlated with reduction intensity. I have argued previously that in the early stages of bifacial reduction, the biface will have a refinement equal to that of the nodule or flake blank from which it is being made. As the bifacial thinning technology expands to include the entire periphery of the biface and as the technology penetrates across the surfaces of the biface, the refinement will begin to reflect this technology rather than the original blank. As bifacial reduction progresses, however, it reaches a limit in which the piece can no longer be thinned. At this point, if bifacial reduction continues, the piece may actually become relatively thicker or less refined. As a result, the direction and strength of the correlation between reduction intensity and refinement will vary with the stage of reduction. In the early stages, refinement increases as reduction increases (tip length decreases). In the middle stages, refinement remains fairly constant despite increased reduction. And in the later stages, refinement decreases as reduction increases.

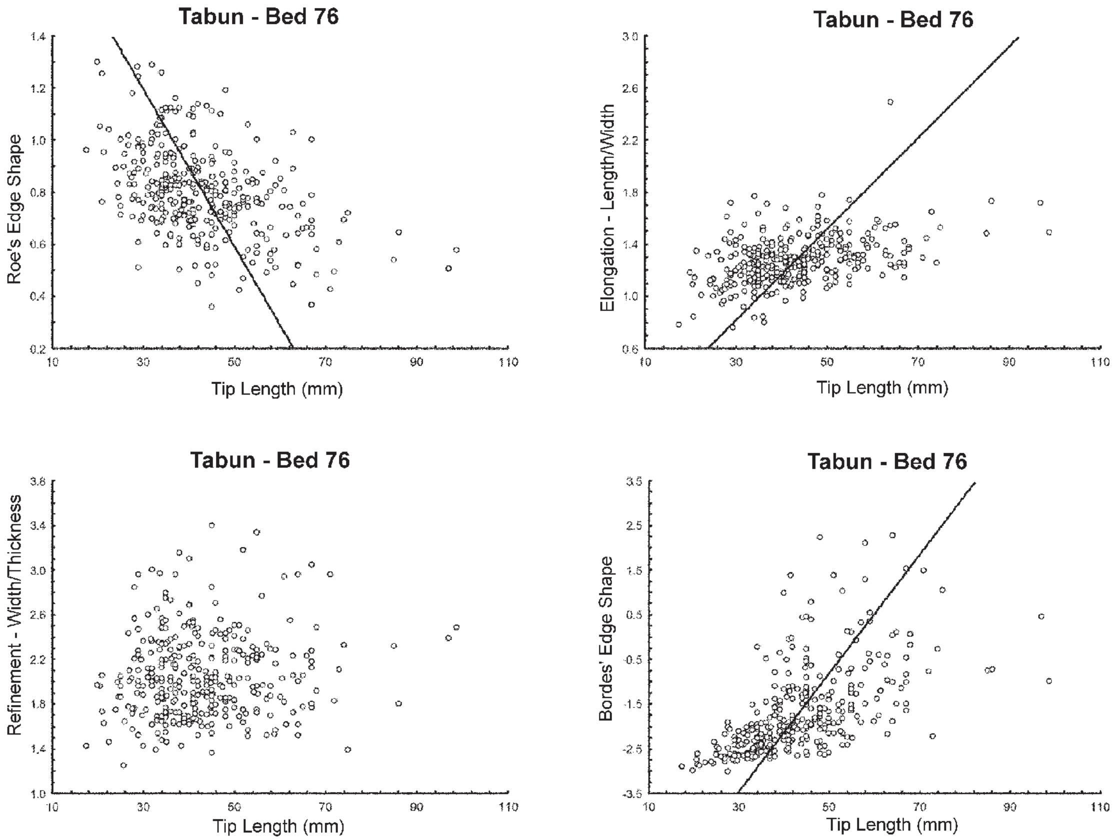

*Figure 3.2 Bed 76. The relationship between tip length and elongation (length / width), refinement (width / thickness), Bordes' calculation of edge shape, and Roe's calculation of edge shape. Bordes' edge shape is a combination of midwidth, width, length and base length following the formula (length / base length) - (4.575 * (midwidth / width)) (Bordes 1961). As a result, pointed forms have high values and rounded forms have low values. Roe's edge shape is based on the ratio of the width near the tip to the width near the base (Roe 1964). In this system, rounded forms have high values and pointed forms have low values. The graphs with regressions lines have a statistically significant correlation between the two variables.*

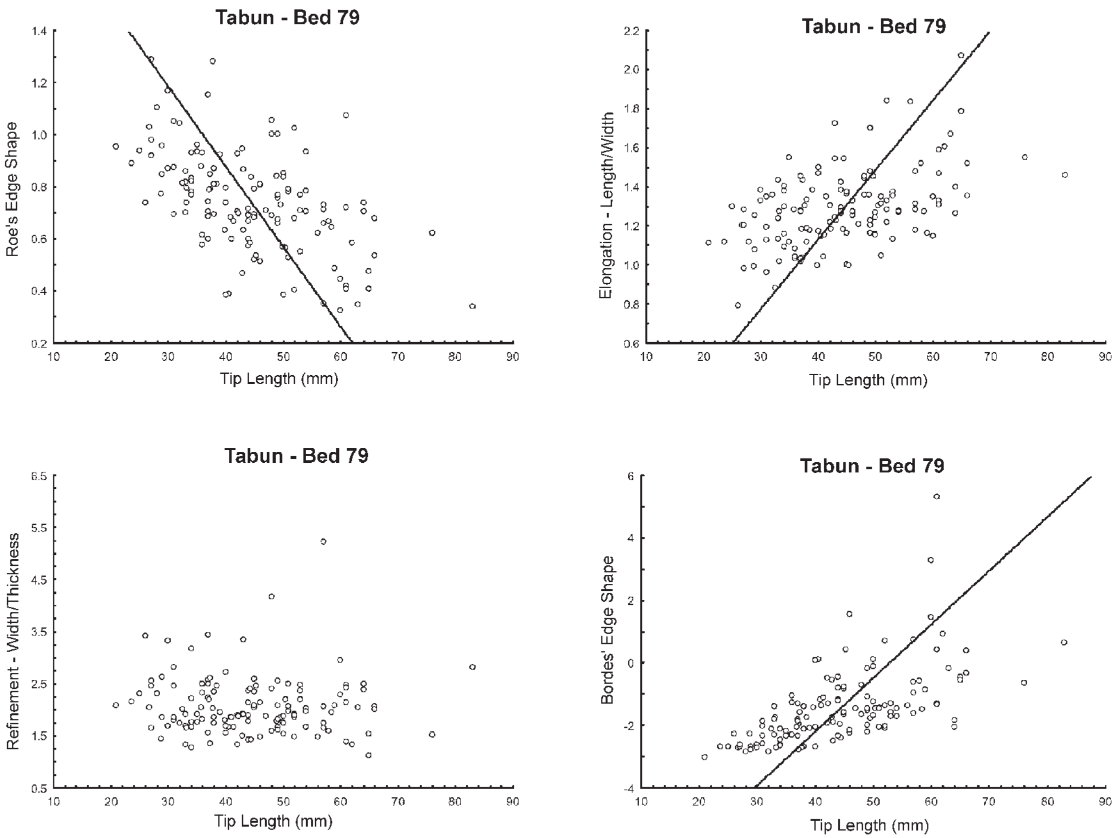

Figure 3.3 Bed 79. See Figure 3.2 for a description of the graphs.

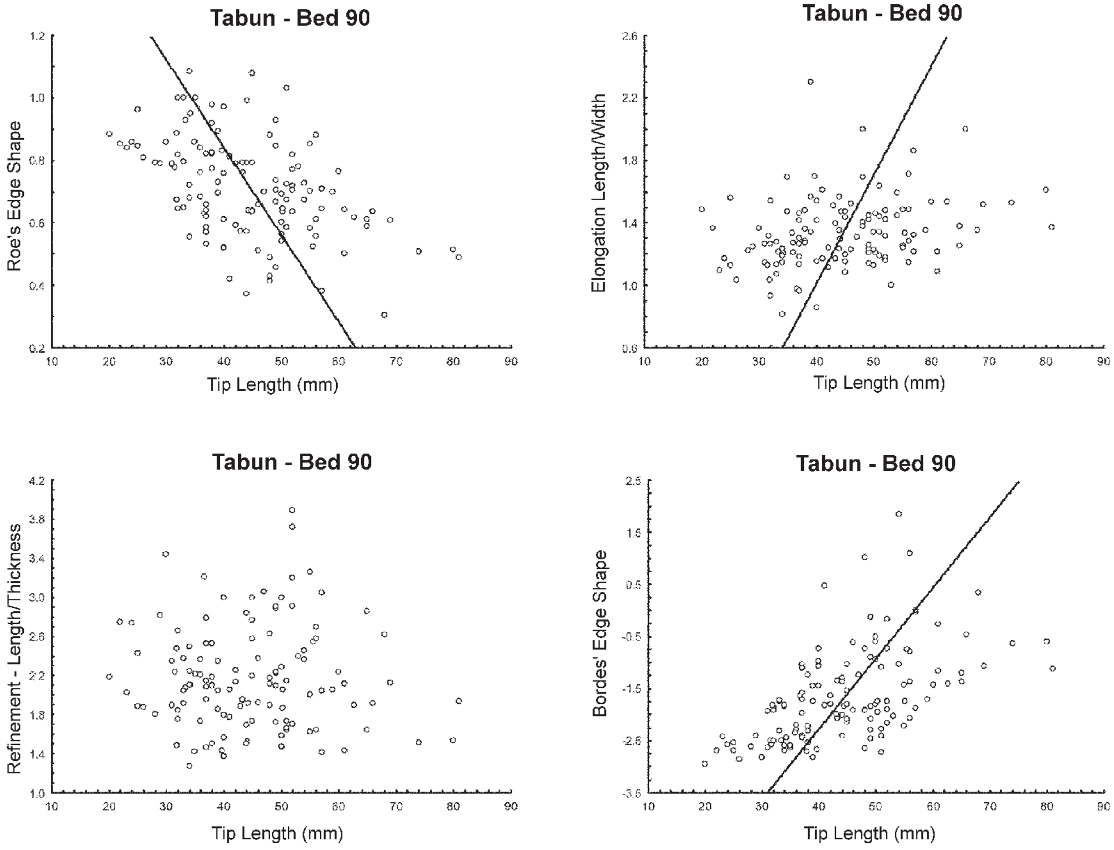

Figure 3.4 Bed 90. See Figure 3.2 for a description of the graphs.

Table 3.4 Comparison of Basic Size Measurements Between Beds with ANOVA Test of Significance

		Length		**Tip Length**		**Width**		**Thickness**		**Weight**	
Bed	N	Means	Std.Dev.	Means	Std.Dev.	Means	Std.Dev.	Means	Std.Dev.	Means	Std.Dev.
72	50	84.54	15.21	55.08	14.40	56.66	9.88	28.56	7.41	121.10	60.57
73	35	80.77	18.86	52.23	20.52	56.46	11.40	27.83	8.02	129.63	93.28
74	46	79.17	15.88	50.17	14.60	56.13	10.53	25.61	8.30	112.57	68.79
75	75	85.09	20.72	52.16	17.05	59.56	12.38	28.95	9.72	152.31	105.37
76	333	72.65	15.19	43.08	12.47	57.27	10.02	28.64	6.39	120.37	64.80
77	18	68.39	16.99	42.22	12.51	54.83	11.27	27.83	6.90	110.00	61.48
79	134	72.07	13.53	44.36	11.52	56.41	9.31	28.68	6.77	111.82	55.95
80	66	69.39	13.32	42.80	13.37	55.09	9.11	26.26	5.78	98.80	45.79
82	21	77.43	21.39	48.29	19.79	55.14	12.59	29.62	10.31	165.43	150.81
83	61	83.05	22.04	55.21	16.85	57.13	13.35	28.82	10.05	125.75	86.31
84	32	85.81	21.02	54.53	15.65	60.34	11.93	28.03	9.14	147.25	113.32
90	125	74.05	15.40	44.53	11.80	56.48	12.06	27.28	8.44	116.54	76.58
ANOVA	F	9.238		9.864		1.098		1.374		3.102	
	P	**0.000**		**0.000**		0.359		0.179		**0.000**	

Table 3.5 Comparison of Basic Shape Ratios Between Beds with ANOVA Test of Significance

		Elongation		**Refinement**		**Bordes' Edge Shape**		**Roe's Edge Shape**	
Bed	N	Means	Std.Dev.	Means	Std.Dev.	Means	Std.Dev.	Means	Std.Dev.
72	50	1.51	0.23	2.06	0.42	-1.04	1.21	0.67	0.20
73	35	1.45	0.30	2.12	0.44	-1.04	1.83	0.67	0.16
74	46	1.42	0.17	2.34	0.63	-1.09	1.54	0.69	0.18
75	75	1.43	0.21	2.21	0.65	-1.49	1.10	0.79	0.22
76	333	1.27	0.19	2.05	0.38	-1.72	0.99	0.80	0.17
77	18	1.25	0.19	2.02	0.42	-1.65	0.76	0.75	0.14
79	134	1.29	0.20	2.06	0.56	-1.45	1.20	0.74	0.19
80	66	1.28	0.24	2.18	0.52	-1.31	1.68	0.76	0.21
82	21	1.42	0.30	1.98	0.56	-1.35	1.23	0.67	0.16
83	61	1.49	0.37	2.15	0.72	-0.59	1.82	0.61	0.18
84	32	1.43	0.23	2.28	0.54	-1.20	1.06	0.61	0.20
90	125	1.33	0.22	2.17	0.52	-1.65	0.89	0.71	0.16
ANOVA	F	12.428		2.410		6.122		10.295	
	P	**0.000**		**0.006**		**0.000**		**0.000**	

If the reduction strategy leaves a cortical base, then regardless of how thin the tip may become as a result of the bifacial thinning technology, the maximum width and thickness will likely be measured at the base where the cortex preserves the original shape of the nodule from which it was made. In this case, refinement is unlikely to change much with reduction intensity.

Between Assemblage Variability

One of the more interesting aspects of the Tabun data set, in contrast to so many other Acheulian sites, is that it contains a deep sequence of bifacial industries, making it possible to examine patterns through time. In addition, it is already clear that in the Tabun sequence there are several chronological patterns in the retouched tools, flakes, and core reduction strategies (Jelinek 1982). Thus not only can changes in bifacial technologies be examined through time at a single occupation locus, but these changes can also be correlated with changes in the rest of the industry.

There are a number of very clear chronological changes in the Tabun bifaces. Like Jelinek's (1982) scraper to biface ratio these changes are cyclical rather than directional. Consider, for instance, changes in biface size through time as measured by length, tip length, width, and thickness (Figure 3.5, Table 3.5). Only length and tip length are significantly different between beds. Although some time trends are visible in width, statistically these changes are indistinguishable. Thickness shows the least variability through the section.

With regard to shape, using the basic shape ratios of both Roe (1964) and Bordes (1961), the patterns are nearly identical. All of the ratios show cyclical patterning that results in statistically different shape ratios between various groups of beds (Figure 3.6, Table 3.6). It can also be seen from this graph that changes in the shape ratios tend to follow one another. At the bottom of the sequence in Bed 90 and moving through time to Bed 83, the bifaces are becoming more elongated, more pointed, and more refined. Then each of these aspects of shape start to move in the opposite direction, particularly from Beds 80 through Bed 76. Lastly, the shape ratios switch back again towards the same type of configuration seen in the lower beds.

Given that there is a relationship in each bed between size and shape (based on the data presented here for Beds 76, 79, and 90), and that size varies cyclically through the sequence, it is no surprise that shape also varies in much the same way. If my model is correct and reduction intensity is controlling the size and shape of bifaces within each level, it appears that reduction intensity also varies in a cyclical way through the sequence. The interesting thing at Tabun is that these patterns can be tested against the rest of the assemblage.

Figure 3.7 shows the relationship between Jelinek's (1982) scrapers to bifaces ratio along side the two measures of size that best show reduction intensity: length and tip length. All measures have been standardized to a scale of 0 to 1 based on their range for the beds under consideration in the figure. The two measures co-vary in a manner such that when bifaces are few relative to scrapers, the bifaces are longer, and when bifaces are many relative to scrapers, bifaces are shorter. It is also interesting that in the lower beds, changes in size seem to preoceede changes in the relative importance. As the bifaces become smaller on average, they also gain in importance relative to scrapers.

Figure 3.8 shows Jelinek's scraper to biface ratio; however, this time against the shape ratios. The patterns are predictably the same. As shape changes, so too does the relative frequency of bifaces and scrapers. In this case, when bifaces are a larger proportion relative to scrapers, they are broader and more rounded. Conversely, when scrapers dominate over bifaces, the bifaces are more elongated and more pointed. To some extent refinement seems to follow the same cyclical pattern, although it is less clear in this case. The changes in refinement are not pronounced throughout the sequence.

Discussion

When the Tabun hominids made more bifaces, in relative proportion to scrapers, they also worked them more intensively before discarding them. Because shape is a function of the reduction intensity, this too varies with the relative importance of bifaces in the assemblage.

The question then becomes why were they making proportionately more bifaces in some levels and more scrapers in others? Eventually, of course, they stopped making bifaces altogether in the Tabun sequence. This basic pattern underlies Lower and Middle Paleolithic variability throughout the Old World, but relatively few sites have it so well represented in a single sequence.

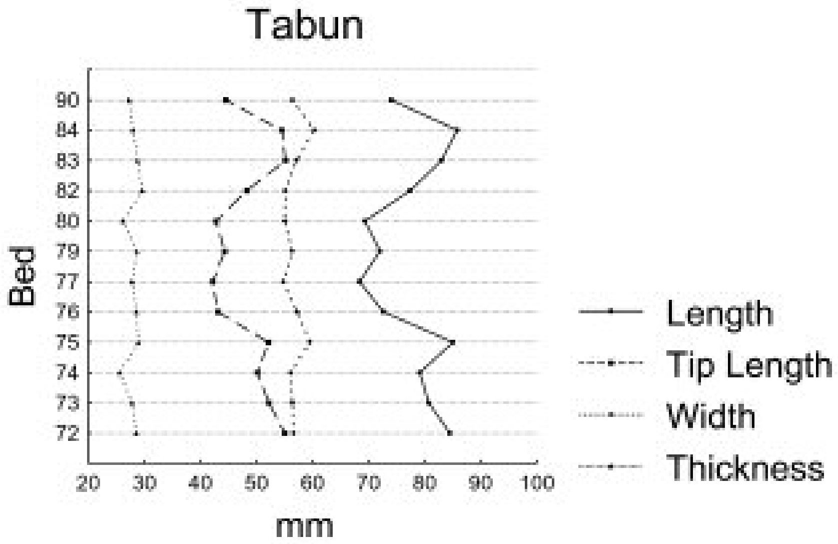

Figure 3.5 Basic measures of size for each bed.

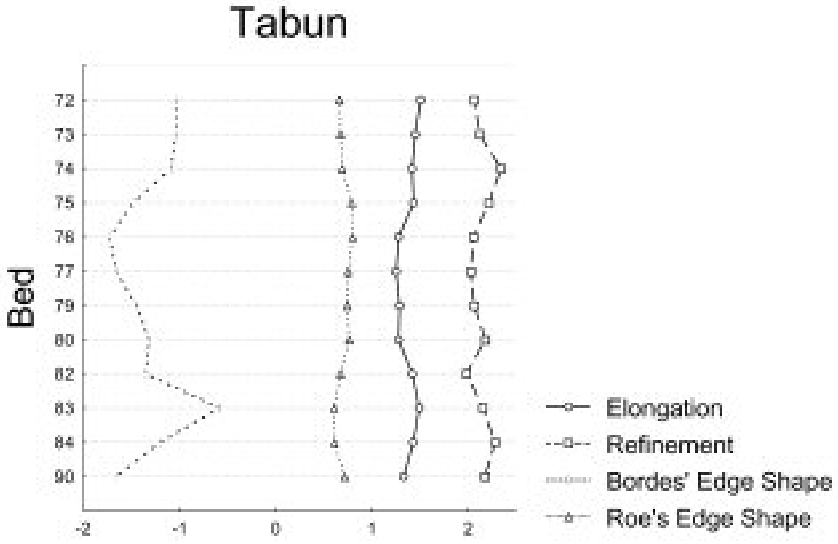

Figure 3.6 Basic measures of shape for each bed.

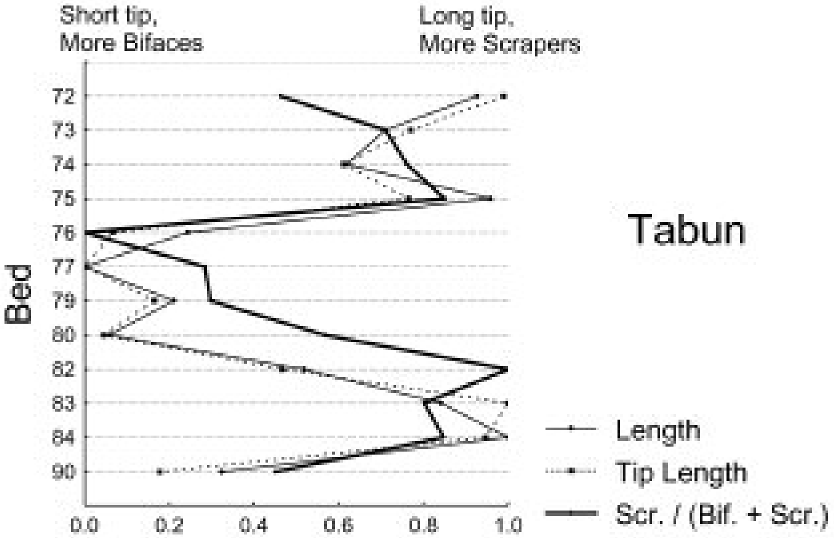

Figure 3.7 Basic measures of size and Jelinek's (1982) biface to scraper ratio (scrapers / (bifaces + scrapers). All measures have been standardized to a scale of 0 to 1 based on the actual range for each.

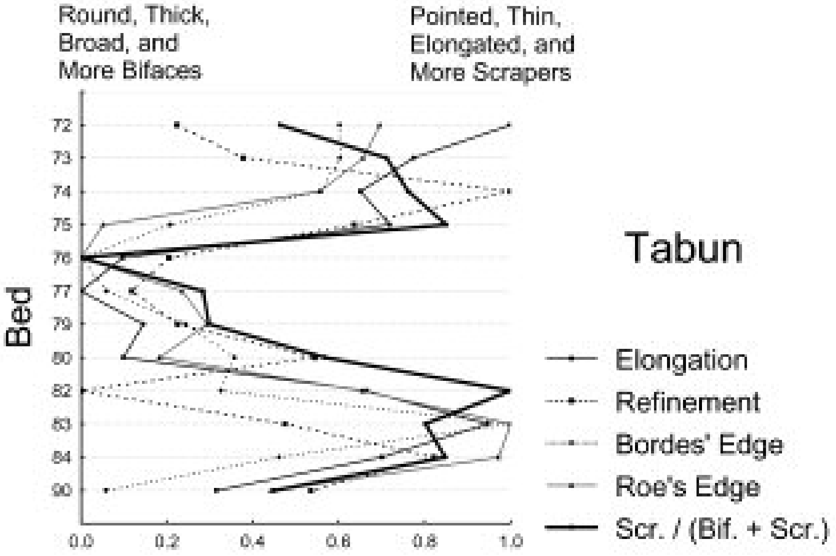

Figure 3.8 Basic measures of shape and Jelinek's ratio (see Figure 3. 6). Roe's edge shape ratio has been reversed to make the associated shapes parallel Bordes' edge shape ratio.All measures have been standardized to a scale of 0 to 1 based on the actual range for each.

Table 3.6 The Tabun Bifaces as Classified According to Roe's System

Bed	Cleaver	Ovate	Pointed	N	Roe's Type
35	0.0	100.0	0.0	1	
41	0.0	0.0	100.0	1	
45	0.0	0.0	100.0	1	
49	0.0	100.0	0.0	1	
59	0.0	0.0	100.0	1	
63	0.0	0.0	100.0	1	
66	0.0	50.0	50.0	2	
67	0.0	0.0	100.0	1	
68	100.0	0.0	0.0	1	
70	0.0	0.0	100.0	3	
71	0.0	45.5	54.5	11	Indeterminant
72	0.0	52.0	48.0	50	Indeterminant
73	8.6	48.6	42.9	35	Indeterminant
74	4.3	52.2	43.5	46	Indeterminant
75	9.3	52.0	38.7	75	Indeterminant
76	6.8	65.2	28.0	339	Ovate
77	0.0	72.2	27.8	18	Ovate
78	0.0	100.0	0.0	1	
79	10.1	51.4	38.5	148	Indeterminant
80	10.6	51.5	37.9	66	Indeterminant
81	0.0	87.5	12.5	8	
82	4.8	52.4	42.9	21	Indeterminant
83	3.3	41.0	55.7	61	Indeterminant
84	3.1	50.0	46.9	32	Indeterminant
85	0.0	100.0	0.0	6	
90	5.0	64.0	30.9	139	Ovate
Totals	6.5	57.3	36.2	1069	Indeterminant

For an assemblage to be classified as one type or another, the type needs to comprise at least 60% of the assemblage. A classification is given here only for assemblage with double-digit biface frequencies.

The fact that we really only have a limited idea of what these tools might have been used for makes it all the more difficult to answer this question. We do not even know for certain whether the bifaces were manufactured primarily as tools with a bifacial edge or as cores for a source of small sharp, flakes or both. In other word, we do not even know what it means to compare scrapers to bifaces. Are we comparing the equivalent of Philips screwdrivers to flat-head screwdrivers or a box of nails to a screwdriver?

To some extent further analyses of Rollefson's data set may help answer some of these questions. Rollefson, for instance, recorded detailed observations on the shape and type of retouch on each edge of the biface and has already shown that some of these data are amenable to this kind of change through time analysis. It may be possible to formulate predictions as to how many and what kinds of edges should predominate under what kinds of conditions in the bifacial and non-bifacial components of the assemblages. It will be interesting to see whether these kinds of bifacial attributes vary as well through the sequence, similarly.

It will also be interesting to see what other kinds of patterns are apparent in the flake tool component of the assemblages and the relative importance of other core technologies. There are numerous other possibilities. The important point is that at Tabun changes in the intensity of bifacial reduction, shape, and their importance relative to flake tools can all be linked together. This means that it may be possible to link bifacial variability into existing models of the kinds of factors, such as availability and access to raw materials and mobility, that are known to structure variability in the flake tool component of other Lower and Middle Paleolithic stone tool assemblages.

Finally, to return to White's suggestion that pointed and ovate forms are the result of two different bifacial reduction strategies applied to different raw materials, the Tabun data do not support such an approach. There are pointed and ovate bifaces in each of the levels considered here. They are all part of a single bifacial reduction strategy applied to an apparently homogenous raw material. The pointed forms are early in the reduction sequence and the rounded forms are late. This is the exact same pattern I found in my own analysis of the British assemblages (McPherron 1995). Likewise, it follows that, in the Tabun assemblages, one cannot say that ovates are the preferred form. Rather, the extent to which ovates occur more frequently than pointed forms is a function of the intensity of bifacial reduction in the assemblage.

It is possible that the Tabun hominids were behaving differently in this regard than the British hominids, but it seems unlikely given that the Tabun patterns match those in the northern French and British data. Ashton, McNabb, and White have demonstrated that raw material is playing an important role in the British assemblages that it does not seem to play at Tabun. Raw material quality, form, and abundance all have the potential to affect how intensively the material will be worked before it is discarded. Together the two lines of explanation have the power to explain the morphological variability we see in bifaces much more satisfactorily than has been previously possible.

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