NOTCHED TOOL REUSE AND RAW MATERIAL AVAILABILITY IN FRENCH MIDDLE PALEOLITHIC SITES

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Based on the analysis of assemblages from the French sites of Pech de l'Azé I, La Quina, and Combe-Capelle bas, a model of stone-tool resharpening is proposed for Middle Paleolithic notched tools. This model is based on the observation that tools with a larger number of notches have greater mean blank lengths irrespective of their typological designation. This pattern is then used to help investigate the relationship between raw material availability and tool reuse. Our results indicate that the number of notches found on a tool is a function of both the size of the tool blank and the availability of raw material.

En base al análisis de conjuntos arqueológicas de los sitios franceses Pech de l'Azé I, La Quina, y Combe-Capelle bas, se propone un modelo de reuso de artefactos líticos para herramientas de muesca del Paleolítico Medio. Este modelo se basa en la observación de que herramientas con un número mayor de muescas poseen un tamaño promedio mayor de preformas independientemente de su designación tipológica. Este patrón se utiliza para investigar la relación entre la ocurrencia de materia prima y el reuso de herramientas. Nuestros resultados indican que el número de muescas en una herramienta es una función tanto del tamaño de la preforma como del acceso a materia prima.

Following a long period of theoretical stasis (Bricker 1976), studies of Paleolithic stone artifact assemblages have witnessed the development of a number of new research directions since the mid-1980s. The classic debate between the functional interpretation, put forward by the Binfords (Binford and Binford 1966), and the stylistic interpretation, supported by the Bordeses (Bordes and de Sonneville-Bordes 1970), has been resolved—not so much by the demonstration that any one of the original protagonists was correct, but through the development of techniques of analysis that enable the construction of a different picture of lithic assemblage variability.

Several studies have contributed to this change of perspective. First, edge-wear analysis has demonstrated that there is no simple one-to-one correlation between tool form and function (Anderson-Gerfaud 1990; Beyries 1988). As is true of stone artifacts from a number of areas of the world, many Middle Paleolithic artifacts apparently served as general tools used for a variety of functions. Thus, the functional associations put forward by the Binfords have not been supported.

Second, a series of studies of Middle Paleolithic unifacial scrapers (Barton 1988; Dibble 1984, 1987a, 1987b) have shown that many of the types used by both the Bordeses and the Binfords in their seminal studies are not predetermined forms, but can be related to one another through a series of transformations interpreted as the result of tool resharpening. Because resharpening affects scraper morphology, it also affects the relative proportions of tool types in an assemblage. Thus, the differential proportions of scraper types within an assemblage used by Bordes to define his famous Mousterian facies are now interpreted as reflecting variation in the intensity and duration of site occupation and raw material availability (reflected in the degree to which tools were resharpened) and are no longer seen as the product of culturally distinct populations (Dibble 1988; Rolland and Dibble 1990).

Finally, a better understanding of site formation processes and the application of new chrono-

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metric dating techniques that go beyond the limits of radiocarbon dating have highlighted the scale of temporal resolution at Middle Paleolithic archaeological sites (Bailey 1983; Rigaud and Simek 1987). In the majority of cases, the stratigraphic units used to define assemblages of stone artifacts for analytical purposes combine archaeological material that was deposited over hundreds, if not thousands, of years. Paleolithic archaeologists are starting to acknowledge that their basic data represent a palimpsest of many behavioral episodes deposited over periods of long, and often imprecisely known, duration.

These developments have changed the way archaeologists interpret the Paleolithic record. Clearly, neither the stylistic interpretation of Bordes nor the functionally specific categories put forward by the Binfords are consistent with the existence of tools without specific functions that were resharpened frequently and deposited in assemblages that represent multiple behavioral events spread over long time periods. Many tool forms in Middle Paleolithic assemblages are closer to the maintainable, rather than the reliable, end of the technological spectrum as defined by Bleed (1986). This means that these tools were produced with relatively few constraints on their form and were used for low-impact activities that required relatively frequent maintenance. As such, they are unlikely to preserve attributes that would be easily defined as stylistic (Chase 1991).

Interpreting lithic artifact assemblages as the product of long-term behavioral palimpsests has led to changes in the explanatory models developed by archaeologists interested in this period. Models for the Middle Paleolithic are now less frequently constructed in terms of short time scale, ethnographic analogies. Instead, a number of scholars have turned to long-term models of economic optimization. Considerable attention has been given to studies of raw material variability. In France, for instance, differences in the use of nonlocal and local raw materials for the production of particular retouched tools have been documented (Farizy 1988; Geneste 1989; Meignen 1988). A number of authors have attempted to place changes in the nature of raw material procurement through time into a cultural evolutionary framework (Kuhn 1992; Roebroeks et al. 1988). In a similar manner, studies that seek to evaluate the significance of variable levels of tool reuse within assemblages have related long-term patterns of change to climatic variation (Rolland and Dibble 1990).

A major research question for the Middle Paleolithic continues to be the degree to which stone artifact assemblage variability was influenced by such factors as raw material availability and the intensity of tool reuse. Despite the demonstration that unifacial side scrapers were frequently resharpened in Middle Paleolithic assemblages from Europe and Western Asia (Dibble 1987a, 1987b; Dibble and Holdaway 1991), some authors continue to argue that Middle Paleolithic stone tools represent desired end-products rather than pieces whose form reflects the process of repeated resharpening (Close 1991; but see Dibble 1991; Otte and Keeley 1990). This debate is significant because its resolution hinges on the question of whether similarities in tool form from different regions can be interpreted in stylistic terms—as the product of cultural traditions—or whether these similarities reflect common technological approaches to the optimal use of stone.

Part of the conflict arises because studies have so far only demonstrated that resharpening is a significant process for unifacial scrapers. Although these tools are a major component of many Middle Paleolithic assemblages, another class of retouched tools, those with notches, also occur in high proportions. It has been suggested that these tool forms might also vary as the result of repeated resharpening (Dibble 1988), but this has not yet been demonstrated. In this paper, we attempt to show that notched tools do vary as the result of resharpening by examining tools with single and multiple notches from three French Middle Paleolithic sites, Pech de l'Aze I, La Quina, and Combe-Capelle bas. Using the analytical framework outlined above, we also investigate variation in the size and form of these notched tools in relation to raw material availability.

Typological and Technological Studies of Notched Tools in Middle Paleolithic Assemblages

Middle Paleolithic assemblages are characterized by a number of morphologically distinct classes

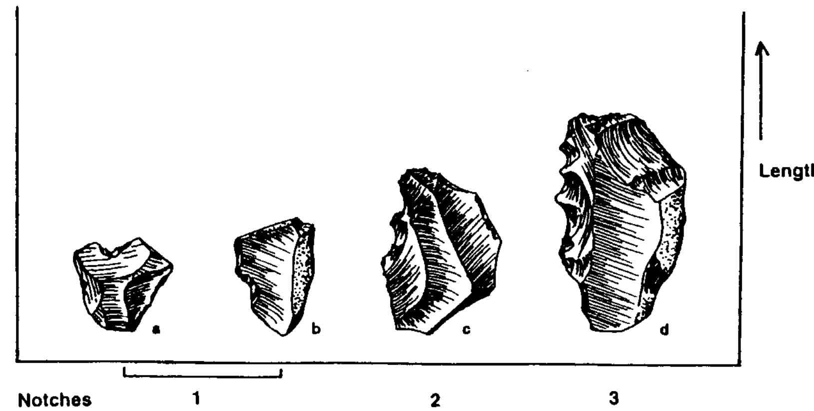

Figure 1. An end-notched flake (type 54) (a); notch (type 42) (b); and denticulate (type 43) (c, d) ordered according to an increase in mean blank length as determined in this study (adapted from Bordes 1988).

of retouched tools, but unifacial side scrapers and notched tools dominate the tool assemblages. For example, Dibble (1988) found that more than 90 percent of the variance in facies attribution for French Paleolithic retouched tool assemblages can be accounted for by the proportion of these two tool classes.

Several morphologically distinct types of notched tools have been recognized in French Middle Paleolithic assemblages (Figure 1). The notched tools in Bordes's (1961) typology for the Lower and Middle Paleolithic include notches (type 42), denticulates (type 43), end-notched flakes (type 54), and Tayac points (type 51). According to Bordes's definitions, a denticulate must have at least two adjacent, or nearly adjacent, notches, while a notch (type 42) refers to a tool with a single notch or a tool with multiple notches that are not adjacent. End-notch flakes are tools with a notch at the distal end of the blank, and Tayac points are in effect convergent denticulates (Bordes 1961; Brézillion 1968:206). For many years the proportions of notched tools have been recorded in typological analyses and used to describe Lower and Middle Paleolithic assemblages. Assemblages with high proportions of notched tools are typically assigned to the Denticulate Mousterian, one of the five Mousterian facies identified by Bordes (1961).

Recently, interest has developed in the way different raw materials were used for notched tools compared to those used for unifacially retouched scrapers. Studies of the Mousterian collections from the Grotte de l'Hyène (Girard 1978) revealed a preference for side scrapers made from flint and notched tools made from chaille, a local siliceous, calcareous rock. Similar findings are reported by Geneste (1989) based on the analysis of Mousterian sites in the Northern Aquitaine basin, where a number of different flint sources were exploited. Geneste found a clear division between side scrapers, hand axes, and Mousterian points that were usually made of high-quality flint often imported over considerable distances, and notches and denticulates that were made of poorer quality flint available in the immediate vicinity of the sites. He also notes that assemblages belonging to the Denticulate Mousterian have a higher proportion of tools made from local flint when compared to assemblages belonging to the Typical Mousterian or Mousterian of Acheulian Tradition. Technologically, imported flint tends to be used for Levallois flake production while the tool blanks used for notched tools are often cortical and non-Levallois (Geneste 1985:527). Meignen (1988) also reports differences in the proportion of notches/denticulates and side scrapers made from local and nonlocal raw materials. Her analysis of the Middle Paleolithic site of Marillac (Charente, France) revealed that denticulates and notches were made more often from locally available flint and less frequently from better quality flint imported from outside the region. Notched tools were made on thick flakes or on flake debris, while flakes of more uniform dimensions were selected for side scrapers.

In addition to raw material variability, limited consideration has been given to the processes of tool reuse and discard as a source of variability for notched tools. A number of authors have proposed that some notched tools may represent stages in the production of side scrapers. Lenoir (1986) notes that some side scrapers from Combe Grenal have a morphology that would allow them to be typed as denticulates, but some of these denticulates could be considered irregular side scrapers. He suggests that these tools represent stages in the production of Quina scrapers and proposes a reduction sequence in which the retouched edges of side scrapers were removed, leaving a series of wide notches that were then retouched into a new scraper edge. Meignen (1988) has identified denticulates from Marillac that may represent a stage in the denticulate-to-Quina scraper reduction sequence proposed by Lenoir. Verjux (1988) proposes a similar sequence based on a study of side scrapers from La Quina. As Verjux notes, the notches formed during this resharpening sequence are morphologically quite distinct, and probably should be distinguished from the narrower and shallower complex notches that are more typical of the majority of Mousterian notched tools.

Dibble (1988) suggests that a resharpening reduction sequence exists among notched tools, but as yet no method has been advanced to demonstrate its existence. He argues that denticulates may simply represent multiple notches on the same tool blank rather than functionally distinct forms. According to this proposal, multiple notched tools, such as denticulates, represent more resharpened forms of single notches. He proposes a resharpening reduction index for notched tools calculated by dividing the number of denticulates in an assemblage by the number of single-notched tools. Jelinek (1988) also suggests that denticulates can be classified as multiple notches, and metric data on notch resharpening support this (Barton 1988).

In a recent article, Rolland and Dibble (1990) argue that variations in the proportions of side scrapers and notched tools in Mousterian assemblages may reflect the differential rates at which these tool types are resharpened. They argue that side scrapers dull more quickly because of their lower edge angles and therefore need to be resharpened more often. Even when the same amount of time is spent on activities involving the use of side scrapers and notched tools, the difference in the frequency of resharpening will lead to a rapid increase in the relative proportion of side scrapers in the assemblage. Differences in the intensity of site occupation (measured as the number of resharpening episodes) could therefore account for the variation in the proportions of side scrapers and notched tools that archaeologists identify in Mousterian assemblages.

Not all researchers agree that denticulates represent more frequently resharpened notches. While acknowledging this possibility, Close (1991) argues that at Bir Tarfawi 14 in southwest Egypt, clear differences exist in the size of blanks used for single notches and multiple-notched denticulates and differences also occur in the size of the notches found on these two tool types. She uses these differences to argue that notches and denticulates are stylistically distinct tool types.

The long-held view that notched tools were used as wood-working tools (Clark 1958) has been challenged by recent edge-wear studies, including one by Beyries (1988) of six Mousterian sites reporting that edge-wear damage on notched tools (both denticulates and notches) is consistent with the working of wood, skin, antler, meat, and bone. Thus, no direct relationship between form and function in notched tools from Mousterian sites is apparent.

In sum, studies of notched tools from Middle Paleolithic sites in France and elsewhere suggest that tool reuse and discard and raw material availability are sources of significant variability for these tool forms. We explore how these processes are interrelated using data from three French Mousterian sites.

Assemblages Used in This Study

Notched tool assemblages from three French Middle Paleolithic sites are considered here in terms of tool use, discard, and raw material availability. Assemblages from two of the sites, Combe-Capelle bas and La Quina, come from excavations undertaken in the last few years, while material from the third site, Pech de l'Azé I, was excavated by Bordes just after World War II. These sites were selected for three reasons. First, all of the sites have assemblages with large numbers of notched tools. Second, two of the sites (La Quina and Pech de l'Azé I) are located at some distance from raw material sources, while the third (Combe-Capelle bas) is located directly on a flint source. These assemblages were selected to enable us to consider the influence of raw material availability on notched tool use. Third, all three authors were familiar with the collections from Combe-Capelle bas and La Quina, having participated in the excavation of these sites. The assemblage from Pech de l'Azé I was analyzed by one of us as part of a larger study (Holdaway 1991).

Six assemblages were analyzed from Pech de l'Azé I. The assemblages come from the upper levels at the site at the mouth of the Pech de l'Azé I cave. Earlier excavations by Vaufrey at this site consisted of an H-shaped trench separating two rectangular areas of in situ deposits. Bordes excavated in both of these areas, defining three levels in each. Because the two areas could not be connected stratigraphically, the assemblages from each of the levels in the two areas are treated separately. In one of the two rectangular areas the levels were labeled A, B, and C, while in the other they were called levels 7, 6, and 5 (these levels are also referred to as *niveau supérieur supérieur* [NSS], *niveau supérieur moyen* [NSM], and *niveau supérieur inférieur* [NSI], respectively). All six of these levels were excavated during the 1949 to 1951 seasons and all are attributed by Bordes to the Mousterian of Acheulian Tradition facies type B (MTA-B) (Bordes 1954, 1955, 1972).

The site of La Quina, originally excavated early this century by Henri Martin, is a rock shelter containing Mousterian deposits extending to a depth of 4.5 m. All of the assemblages analyzed in this study come from the new joint excavations at the site by the University of Arizona, Université de Bordeaux, and the University of Pennsylvania. These excavations have concentrated on the upper beds at the site, which is where the sample of notched tools was taken. Typological and technological analyses of the La Quina assemblages are as yet incomplete, but the levels used in this study appear to contain lithic assemblages belonging to the MTA-B and Denticulate facies.

Combe-Capelle bas is located at the base of a steep limestone cliff in the valley of the Couze River. Originally excavated by Henri Ami early this century, the assemblages analyzed in this study come from the recent joint excavation of the site by the University of Pennsylvania and the Université de Bordeaux (Dibble and Lenoir 1995; Dibble and McPherron 1996). The assemblages used in this study are classifiable as Denticulate Mousterian or Typical Mousterian rich in denticulates.

Methods

Table 1 lists the stratigraphic levels from which the assemblages used in this analysis were drawn. All notched tools were considered during the data collection phase of the project, but only complex notches were counted. To be included in the analysis, a complex notch had to exhibit secondary retouch over at least part of its circumference. Clactonian notches (i.e., single-blow notches) with no evidence of retouch were not included in our measurements. Although edge-wear studies demonstrate that Clactonian notches functioned as tools (Anderson-Gerfaud 1990), they are rare in the assemblages considered here. It has also been suggested that these notches may sometimes be the product of natural processes (Close 1991). For these reasons, we limited consideration to the more numerous complex notches.

In addition to notches and denticulates, the more unusual types, end-notched flakes and Tayac points, were included in the analysis following Bordes's (1961) classification of these as notched tools. Although rare in the study assemblages, these tool types were included because they represent other forms of notched tools. As will be described below, our analysis is based on the relationship between blank length and the number of notches on the blank. We were therefore inter-

Table 1. Levels Analyzed from Each Site.

Combe-Capelle bas	I-1A, I-1B, I-1C, I-1D, I-1E, I-2A, I-2B, I-3, I-4, Zone II, Zone III
La Quinta	2B, 4A, 4B, 4B2, 5A, 6A, 6A1, 6B, 6C, 6D, 7, 8
Pech del'Azé I	NSM, NSS, NS6, NS7

ested in examining the relationship between notch number and blank size, and were not concerned with where the notch was located on the tool.

Microdenticulates were excluded from the analysis by removing pieces that had a denticulated edge associated with clear scraper retouch and pieces with chipped edges that might be typed as tools with abrupt alternating retouch (types 46 through 49) in Bordes's typology, or considered as utilized flakes. We also excluded any tools with multiple retouched edges where the secondary types were not notched tools. Thus, notches or denticulates opposite a scraper edge were not included because some of the retouched edge on these tools is obscured by scraper retouch. The inclusion of tools with scraper retouch might bias the results by limiting the blank edges where notches could be placed, and reducing the size of the tool blank through resharpening reduction.

Tool-blank measurements followed the methods published by Jelinek (1975) and Fish (1979). Length was measured from the platform to the farthest extremity of the flake, and width and thickness were measured at the mid-point of length. Analyses of variance are used to compare blank-size measurements for tools with different numbers of notches.

To obtain a sufficiently large sample of notched tools for statistical analysis, it was necessary to combine tools from all levels at each site. This presented no problem at the sites of Pech de l'Azé I and Combe-Capelle bas where the distributions of tool blank sizes (measured as length/width) for the levels used in this analysis are unimodal normal. At La Quina, however, the distribution of blank sizes was slightly bimodal. For this reason tool blanks were divided into two populations, those with a length/width ratio of 1.6 or less, and those with a ratio greater than this number (1.6 represents the value between the two modes). It should be emphasized that this division was made on tool blank size, irrespective of the number of notches, and was done to ensure that blanks of similar size were compared in the analyses developed below.

Unfortunately, studies of raw material variability at Combe-Capelle bas, La Quina, and Pech de l'Azé I are just beginning. At this stage it is possible to state only that high-quality flint was readily available at Combe-Capelle bas, because the site sits atop a source of such flint. In contrast flint does not (naturally) occur near the sites of La Quina and Pech de l'Azé I. If raw material availability is an important aspect in the variability of notched tools from these sites, we would expect the biggest contrast to be exhibited in the variability apparent in the assemblages from Combe-Capelle bas (with readily available raw material) and those from La Quina and Pech de l'Azé I (where flint had to be imported).

Results

Our analysis consists of two parts. First, the relationship between tool blank size and notch number is explored. This relationship provides the basis for a model of notched tool resharpening. Second, this model is evaluated in relation to raw material availability at each of the sites.

Tool Blank Size and Notch Number

A statistically significant difference was found between the length of the blanks for complete (i.e., those with a platform and a distal termination that is not a snap) notches, denticulates, and end-notched flakes in the assemblages from all three sites (see Table 2). This table demonstrates that the number of notches on a tool is related to tool blank size. It is also consistent with that reported by Close (1991) in her analysis of the assemblage from Bir Tarfawi. Close used her results to argue that groups deliberately sought to produce single-notched tools and multinotched denticulates, as reflected in the size of the blanks they selected for tool production. We argue, however, that alternative explanations, specifically resharpening, may account for the differences in blank size.

Table 3 presents the data from the three French sites in a different form. Rather than divide the assemblage by Bordian tool type, as in Table 2, mean blank length is given according to the number of notches on each tool, irrespective of whether these notches occur on notched flakes, denticulates, or end-notched flakes. A number of interesting observations are apparent when the data are displayed in this manner. First, in all but one case, mean blank length increases with the number of notches where five or more tools are present. The one exception to this pattern lies with the Group 1 La Quina assemblage, where there is a slight decrease in the mean length of tools with two notches. Second, statistical tests show that in each case the increase in mean length with notch number is significant, although the magnitude of this change is very small. T-tests were run on the data and revealed that significant differences in length exist between tools with one or two notches and those with four or more notches. Third, the same pattern of increasing blank size with notch number is apparent at all three sites used in this analysis, but the way in which this pattern is expressed differs among the sites. At Combe-Capelle bas, for example, the size of the flake blanks for tools with one notch are larger than tools with four, five, or six notches at La Quina and Pech de l'Azé I. This is most likely due to the prevalence of high-quality flint at Combe-Capelle bas. Nevertheless, when single-notched tools from Combe-Capelle bas are compared to tools with more than one notch from the same site, they are found to be significantly smaller.

Table 2. Complete Notched Tools by Site and Tool Type.

	n	L (S.D.)	L/W (S.D.)
La Quina 1			
Notched flakes	43	36.6 (8.0)	1.2 (.2)
Denticulates	55	35.7 (8.1)	1.2 (.2)
Tayac points	—	—	—
End-notched flakes	12	30.0 (6.8)	1.1 (.3)
La Quina 2			
Notched flakes	39	44.8 (8.4)	2.0 (.3)
Denticulates	76	49.3 (11.5)	2.1 (.3)
Tayac points	1	45.5 (—)	1.8 (—)
End-notched flakes	3	33.0 (5.8)	1.9 (.2)
Combe-Capelle bas			
Notched flakes	158	55.6 (18.7)	1.3 (.5)
Denticulates	92	61.7 (25.0)	1.3 (.4)
Tayac points	—	—	—
End-notched flakes	23	50.8 (18.9)	1.2 (.3)
Pech de l'Azé I			
Notched flakes	93	40.5 (9.7)	1.6 (.4)
Denticulates	217	44.8 (10.0)	1.7 (.5)
Tayac points	5	42.8 (6.6)	1.8 (.3)
End-notched flakes	13	39.6 (7.2)	1.4 (.3)

L = mean length; L/W = mean length/width

Tables 2 and 3 thus indicate that an increase in blank length is associated with increasing notch number. This may account for differences in blank size between typologically defined notched flakes and denticulates, because as a group notched flakes have fewer notches than denticulates. It also suggests that blank size alone is not a sufficient criteria to justify the typological separation of notched flakes from denticulates. Given that there is an increase in tool blank length with the addition of each notch, equally valid typological divisions

Table 3. Complete Notched Tools by Assemblage and Number of Notches.

	La Quina 1		La Quina 2		Combe-Capelle bas		Pech de l'Azé I	
	$F=2.1$ $df=4,105$ $p=.046$		$F=4.7$ $df=3,115$ $p=.002$		$F=3.2$ $df=4,268$ $p=.007$		$F=2.4$ $df=7,307$ $p=.011$	
	n	L (S.D.)	n	L (S.D.)	n	L (S.D.)	n	L (S.D.)
1 notch	54	35.1 (8.3)	40	43.6 (8.9)	178	54.4 (18.3)	81	40.1 (9.9)
2 notches	35	33.4 (5.7)	47	47.2 (8.1)	49	59.1 (21.7)	75	43.5 (10.0)
3 notches	16	39.4 (9.0)	26	51.2 (15.2)	31	65.7 (27.8)	83	44.7 (8.5)
4 notches	4	— (—)	6	56.9 (9.4)	9	66.1 (28.1)	44	45.2 (10.9)
5 notches	1	— (—)	—	— (—)	6	69.9 (21.8)	18	45.0 (10.5)
6 notches	—	— (—)	—	— (—)	—	— (—)	10	46.9 (10.0)
7 notches	—	— (—)	—	— (—)	—	— (—)	3	— (—)
8 notches	—	— (—)	—	— (—)	—	— (—)	1	— (—)

L = mean length

Note: Means have not been given where there are five or fewer tools represented. Statistical tests were analyses of variance (ANOVA); all probabilities presented are for a one-tailed test.

could be made between tools with two or more, or three or more, notches. The regular increase in mean blank length with each additional notch evident at these sites does not support any typological division based on blank size alone.

A more difficult question concerns the status of typologically defined end-notched flakes. These tools have shorter blanks than those for notched flakes or denticulates at all three sites (see Table 2). Table 2 also presents data on the mean length-to-width ratios for each tool type. This ratio is a measure of the relative shape of the blank used for these tools. Low values indicate blanks that are relatively wide compared to their length while relatively long, narrow flakes will have higher values. End-notched flakes have the smallest mean value for this ratio. This illustrates that end-notched flakes are significantly shorter than other notched tools and they are made on blanks that are relatively wide in comparison to their length. It is possible that these short wide blanks were deliberately selected for the production of end-notched tools. An alternative explanation is that notch placement on these tools was simply a function of the fact that the distal end of these blanks was wide in relation to the lateral edges. If the only criterion for the addition of a notch was the placement on a relatively long flake margin, we might expect that short wide flakes were end-notched more often than long thin flakes.

Some additional evidence can be used to support this interpretation. If we consider the size of the standard deviations in Tables 2 and 3, it is clear that although differences in mean length are present, the differences among the means are small and the standard deviations are relatively large. This suggests that these tools were not produced according to highly constrained design models, at least in terms of blank size. In other words, notched tools may have served as maintainable rather than reliable tools (Bleed 1986). It is hard to reconcile this finding with the existence of end-notched flakes as a separate stylistic type.

We argue that the data from these sites are therefore more consistent with a model of notched tool resharpening. This model is thought to best explain the similarity in patterning in the three sites, as well as the relatively small magnitude of the differences among the means. According to our model, notched tools were reused in much the same way that has been suggested for unifacial side scrapers. As notches became blunted through use or perhaps were found to be an inappropriate size for a particular function, new notches were added to a tool blank. The new notch was sometimes placed on the same tool blank, and sometimes a new blank was selected. Longer tool blanks were therefore reused more often than shorter blanks, and this would account for the relationship between tool blank length and notch number. According to this model, denticulates would result from the reuse of notched flakes, as Dibble (1988) originally suggested. The placement of notches adjacent to one another would in effect be a byproduct of repeated notching on a flake margin. Much as we have argued for end-notched flakes, notches would tend to accumulate along the longest flake margins or flake margins with the most suitable angle for retouching, or both.

Raw Material Availability

The second part of our analysis involves examining this model of resharpening in terms of the ease with which flint could be procured at the three sites. Flint had to be brought to La Quina and Pech de l'Azé I, while Combe-Capelle bas is located directly on a flint source. This difference in raw material availability is apparent in the relative size of the blanks used for notched tools at the three sites.

Table 4 illustrates that blanks from Combe-Capelle bas are much longer than those from either La Quina or Pech de l'Azé I. Differences in the proportions of tools with single notches and those with multiple notches are also present at these sites. There are proportionally more single-notched tools than multiple-notched tools at Combe-Capelle bas than at the other two sites (see Table 4). These patterns are consistent with differences that might be expected if the model of notched tool reuse proposed above is correct. As noted above, at Combe-Capelle bas, where raw material was abundant, relatively few of the tools have multiple notches. According to our model, where raw material, and therefore tool blanks, were abundant, we would expect groups to select new blanks more frequently for notched tools, rather than place a new notch on a previously used tool. At both La Quina and Pech de l'Azé I, however, the lack of accessible raw material would presumably encourage economizing behavior, as has been demonstrated to occur at other Middle Paleolithic sites (Farizy 1988; Geneste 1989; Kuhn 1992). This would lead to a greater frequency of tool reuse and hence more multinotched tools. In sum, data on raw material availability appears to support a model of notched tool resharpening.

Table 4. Tools with One or More Notches by Assemblage.

	La Quina 1			La Quina 2			Combe-Capelle bas			Pech de l'Azé I		
	n	%	L (S.D.)	n	%	L (S.D.)	n	%	L (S.D.)	n	%	L (S.D.)
Raw material	poor			poor			rich			poor		
Single notch	54	49.1	35.1 (8.3)	40	33.6	43.6 (8.9)	178	65.2	54.4 (18.3)	90	29.4	39.9 (9.5)
Multinotch	56	50.9	35.6 (8.0)	79	66.4	49.3 (11.2)	95	34.8	62.6 (24.4)	216	70.6	44.4 (9.8)

L = mean length

Discussion

We believe the model proposed here for notched tool resharpening more parsimoniously explains the observed relationship between tool blank length and the number of retouched notches than the notion of discrete types of notched tools (Close 1991). Although Close rejects the significance of this process for notched tools, the data Close uses are in fact largely consistent with those presented here. Close notes, for instance, that denticulates from Bir Tarfawi 14 are made on blanks that are longer, wider, and thicker than those used for notches. This relationship may well reflect the linear pattern between blank length and increasing notch number reported here. One of the reasons that Close argues for a significant difference between single-notched flakes and multiple-notched denticulates may be that the former group includes pieces that have simple notches (i.e., Clactonian notches). As Close notes, it is difficult to tell whether these pieces are actually tools or simply accidental forms (Close 1991:261). Clearly this problem may have affected the results, and was one of the major reasons that these forms were not included in our study.

If our model for notched tool resharpening is accepted, obvious parallels exist between it and the pattern of resharpening reduction presented by Dibble and others for Mousterian side scrapers (Barton 1988; Dibble 1984, 1987a, 1987b; Dibble and Holdaway 1990). Like side scrapers, we would expect that notched tools were either reworked during the same functional episode or picked up at a site and reused at a later date before being discarded again. Although notched tool reuse and scraper resharpening are related, there are some important differences that have a bearing on the proportion of tool types recovered from Middle Paleolithic sites. Rolland and Dibble (1990) suggest that differences in the proportions of side scrapers and notched tools in Mousterian assemblages can be related to differences in the rate at which these tools were resharpened. They suggest that side scrapers were resharpened relatively often, and hence reduced more rapidly than notched tools. The results of this study, however, suggest that the rate of resharpening may not be as significant as the amount of tool blank removed during each resharpening episode. Because notches may be resharpened simply by adding another notch to the tool, they will "wear out" much more slowly than side scrapers that are resharpened by removing significant quantities of the blank. Thus, even if the rates of resharpening were the same for both tool classes, one would expect relatively more expended side scrapers in an assemblage than notched tools. This would in turn account for the variable proportions of side scrapers and notched tools seen in Middle Paleolithic assemblages. Despite this point, however, this study lends support to Rolland and Dibble's (1990) conclusions that the majority of the stone-tool typological variability seen in Middle Paleolithic assemblages is a product of differential rates of tool reuse. When interpreted along the lines presented in this study, notched tools help to give insights into the type of economizing behavior, and therefore behavioral complexity, that existed during the Middle Paleolithic.

Conclusion

The positive relationship between tool blank length and the number of notches for notched tools in assemblages from three French Middle Paleolithic sites is interpreted in terms of a model of notched tool resharpening. This in turn can be related to regional patterns of raw material availability to suggest that notched tools were reused more frequently at sites where raw material was scarce. Given the nature of Paleolithic sites, it is probably best to interpret these patterns as the result of economizing behavior built up from many separate behavioral episodes in prehistory. When taken in combination with other studies of raw material availability and tool discard behavior, the results of this study help to illustrate the level of organizational complexity during the Middle Paleolithic.

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