LATE PLEISTOCENE TECHNOLOGY, ECONOMIC BEHAVIOR, AND LAND-USE DYNAMICS IN SOUTHERN ITALY

Julien Riel-Salvatore and C. Michael Barton

This paper proposes a new methodology to study prehistoric lithic assemblages in an attempt to derive from that facet of prehistoric behavior the greater technoeconomic system in which it was embedded. By using volumetric artifact density and the frequency of retouched pieces within a given lithic assemblage, it becomes possible to identify whether these stone tools were created by residentially mobile or logistically organized foragers. The linking factor between assemblage composition and land-use strategy is that of curation within lithic assemblages as an expression of economizing behavior. This method is used to study eight sites from southeastern Italy to detect changes in adaptation during the Late Pleistocene. We compare and contrast Mousterian, Uluzzian, proto-Aurignacian and Epigravettian assemblages, and argue that the first three industries overlap considerably in terms of their technoeconomic flexibility. Epigravettian assemblages, on the other hand, display a different kind of land-use exploitation pattern than those seen in the earlier assemblages, perhaps as a response to deteriorating climatic conditions at the Last Glacial Maximum. While we discuss the implications of these patterns in the context of modern human origins, we argue that the methodology can help identify land-use patterns in other locales and periods.

Nous proposons une nouvelle approche pour l'étude des ensembles lithiques permettant d'identifier les systèmes technoéconomiques dans lesquels ils s'insèrent. Utilisant comme paramètres analytiques la densité volumétrique d'artéfacts et le rapport outils/débitage, il devient possible d'attribuer un ensemble lithique préhistorique à un mode d'organisation « logistique » ou « à mobilité résidentielle ». Le degré de « conservation » au sein d'un ensemble lithique, interprété comme l'expression variable d'une attitude économe vis-à-vis de la matière première, constitue le lien entre la composition d'un ensemble lithique et un mode préférentiel d'exploitation du territoire. Nous appliquons notre méthodologie à l'étude de huit sites de l'Italie méridionale remontant au Pléistocène supérieur. En comparant les résultats tirés d'ensembles moustériens, uluzziens, proto-aurignaciens et épigravettiens, nous constatons que les trois premières industries semblent caractérisées par une similarité marquée en ce qui a trait à leur flexibilité techno-économique alors que l'Épigravettien apparaît défini par un modèle distinct d'exploitation du territoire, représentant vraisemblablement une adaptation aux climats plus rudes du dernier maximum glaciaire. Nous interprétons les résultats de cette approche dans le contexte de l'origine de l'homme moderne, mais soulignons que cette méthodologie peut aussi permettre d'identifier les modèles d'exploitation du territoire dans les sites stratifiés d'autres périodes et régions.

Due to the prevalence of stone artifacts in the archaeological record, behavioral models for prehistoric nomadic foragers are based almost exclusively on lithics. Fortunately, the morphology of stone implements is a result of prehistoric activity and, therefore, can yield useful insights into the behavior of their makers. But, while chipped stone artifacts are widely recognized as fundamental components of the technologies used to acquire and process needed resources in prehistory, the causes and meaning of variation among and within lithic assemblages—especially with respect to retouched artifacts—remain hotly debated today. Two facets that have emerged from the debate surrounding the meaning of lithic variability are particularly relevant to the study of the adaptations of prehistoric foragers. The first of those contrasts the role of drift and selection in shaping lithic morphology. Some researchers view interassemblage variability as primarily the result of drift-like, stochastic processes often glossed as "cultural tradition."[1] From this outlook, patterns of similarities (treated like evolutionary homologies) and differences among lithic assemblages (especially retouched tools) are felt to trace cultural descent spatially and temporally. The contrasting

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perspective sees lithic variability mainly as the result of selection favoring morphologies that better serve to accomplish varying combinations of resource acquisition and processing activities. Thus, patterns of similarity (treated as evolutionary analogies) and difference among assemblages are instead felt to indicate suites of resource acquisition/processing strategies or "adaptive poses." In Paleolithic archaeology, this facet is typified by the well-known Bordes-Binford debate of the mid-twentieth century (Binford 1973; Binford and Binford 1966, 1969; Binford and Sabloff 1982; Bordes 1969, 1973, 1981; Bordes and de Sonneville-Bordes 1970; see also Barton 1997; Barton and Neeley 1996).

The second, related facet contrasts intentionality and life-history approaches in how to interpret lithic variability. In the original Bordes-Binford debate, both sides viewed retouched artifacts as "tools" whose morphologies (i.e., the forms found in archaeological assemblages) were the intended product of ancient artisans behaving technologically according to mental templates (see also Mellars 1996). To a degree, this perspective is exemplified today, albeit in a more sophisticated fashion, by the *chaîne opératoire* approach to the study and classification of Paleolithic assemblages (Bleed 2001; Boëda 1994, 1995; Boëda et al. 1990; Lemonnier 1992; Schlanger 1994; Sellet 1993). In contrast, a number of mostly American researchers have argued that retouched artifacts in archaeological context are primarily the unintended—and generally unwanted—end products of extending lithic artifact use-life through repeated resharpening. This model, now supported by numerous actualistic studies and quantitative analyses of prehistoric assemblages, attributes much of the morphological variability in retouched tools to variations in the length and nature of their life histories (Barton 1988, 1990a, 1990b, 1991; Barton et al. 1996; Bleed 2001; Dibble 1984, 1987, 1988, 1995; Flenniken and Raymond 1986; Flenniken and Wilke 1989; Hiscock and Attenbrow 2003; Hoffman 1985; Kuhn 1989, 1990, 1994, 1995; Rolland 1977, 1981; Rolland and Dibble 1990; Shott 1989, 1996; Weedman 2002; Wilke and Flenniken 1991). While the *initial* form of a lithic artifact can undoubtedly be shaped by cultural tradition or intended function (or some combination of these [Jelinek 1976, 1988; see also Bisson 2000]), the *final* form recovered in archaeological context will mainly be the result of the range of tasks performed, length and intensity of use, and decisions about whether to replace or rejuvenate the artifact. As such, the morphology of archaeologically recovered retouched stone tools may therefore be somewhat different from their initial one (Barton 1991, 1997; Dibble 1987; Frison 1968; Neeley and Barton 1994).

We find the evidence supporting the life-history perspective especially compelling for many prehistoric assemblages and feel that, while social descent certainly can contribute to lithic morphology, the fundamental role of lithic technology in a forager economy means that selection is likely a much more important determinant of lithic form. From this perspective, technological decisions about the replacement and/or maintenance of lithic artifacts are embedded in a wider web of economic considerations and land-use strategies because of the variable cost/benefit balance (in time and energy) of lithic raw material procurement and differential effectiveness of fresh and rejuvenated artifacts in critical resource acquisition and processing tasks. Hence, while there is undoubtedly insight to be gleaned from the study of retouched stone "tools" alone, we would argue that more behaviorally meaningful information can be obtained from problem-oriented studies of how retouched implements relate to the whole of a site's lithic assemblage (including unretouched debitage, cores, and other production debris) and the larger context of forager socioecosystems. This perspective is supported by three additional points about prehistoric technological behavior and its expression in the archaeological record.

First, it appears highly unlikely that retouched artifacts represent the only lithic material used by prehistoric foragers. There is, in fact, substantial evidence from microwear studies that unretouched flakes were frequently used for a range of functions by prehistoric hunter-gatherers (Beyries 1987; Keeley and Toth 1981; Young and Bamforth 1990).

Secondly, retouched "tools" usually comprise only a small fraction of the total lithic assemblages found in archaeological contexts. Relying on typologies that focus almost exclusively on retouched stone implements therefore prevents archaeologists from addressing the full range of prehistoric technological behavior. Because unretouched flakes were actively used components of prehistoric lithic assemblages and because other forms of debitage and cores (as manufacturing and maintenance by-products) indicate artifact production and use, it is necessary to develop methods to incorporate the full range of lithic products in the analysis of chipped stone assemblages in order to gain a complete picture of prehistoric technological—and therefore economic—behavior. Despite its importance, studies of debitage have tended to be rare in general (see Ahler 1989; Sullivan and Rozen 1985), although recent publications have begun to emphasize its analytical usefulness (e.g., papers in Andrefsky 2001; see also Hiscock 2002).

Lastly, it is essential that lithic variability be framed within broader theoretical frameworks in order to assign meaning to recurrent observable patterns in the archaeological record and help formulate further research questions. For example, building on forager studies by Binford (1979, 1980), a number of scholars have provided integrated models linking technological behavior to stone artifact form and patterns in lithic assemblages (e.g., Bamforth 1986, 1991; Bamforth and Bleed 1997; Bleed 1986; Kuhn 1989, 1991, 1992; Nelson 1991; Shott 1989, 1996). Nelson (1991), for instance, articulates a clear difference between curated and expedient lithic assemblages in the archaeological record. The unique nature and structure of each type of assemblage, and their position at opposite ends of a continuum of economic behavior (see also Shott 1996, for a review of the concept of curation), constitute useful theoretical reference points upon which we can formulate a general model of the relation between economic behavior, mobility strategies, and relevant aspects of lithic variability at the assemblage level. With this in mind, we endeavor to identify variables that monitor lithic variability consistently across diverse assemblages within a framework designed to address questions of prehistoric forager land-use.

Methodology

Recently, Barton developed a simple approach to link assemblage-scale variability with Late Pleistocene behavioral patterns at sites in Gibraltar and eastern Spain (Barton 1998; Villaverde et al. 1998). Rather than focusing on formal properties of retouched tools, this whole assemblage analysis approach examines the nature and intensity of technological behavior by comparing *artifact volumetric density* and the *relative frequency of retouched pieces* within an assemblage. Artifact volumetric density is defined as the total number of pieces of chipped stone per cubic meter of excavated sediment, and serves as a proxy for artifact accumulation rate. The relative frequency of retouched pieces is simply the count of retouched "tools" (e.g., the pieces in Bordes Middle Paleolithic type list minus unretouched types 1–3 and 5) divided by the total number of pieces (including all flakes, cores, and other debitage) in the assemblage. Artifact volumetric density potentially can vary with excavation technique (e.g., different-sized screens or no screening) and so direct comparisons can only be made between sites when this is accounted for. It also can vary as a result of fluctuating sedimentation rates during deposition (see Barton and Clark 1993; Farrand 2001; Stein et al. 2003) and/or a range of post-depositional taphonomic processes that can reduce its final volume through selective diagenesis of certain sedimentary components (e.g., Karkanas et al. 2000; Weiner et al. 2002). To avoid the potential impact of time averaging, it would be preferable to calculate actual artifact accumulation rates rather than use artifact density as a proxy, but many sites—including those discussed here—lack the high-resolution radiometric dating required to do this. Fortunately, there is no indication that sedimentation rates varied by orders of magnitude within each of the sites analyzed here and in fact, as we discuss below, the analysis of lithic assemblages presented here holds the possibility to help distinguish those cases where sedimentation rates do vary significantly. We certainly do not mean to trivialize the need for detailed geoarchaeological studies in helping to understand site formation processes when possible. Rather, our model simply posits that *ceteris paribus* there is a direct relationship between an assemblage's relative frequency of retouched pieces and its artifact volumetric density that holds constant the relationship between three components of an assemblage: (1) its absolute size, (2) its relative frequency of retouched pieces, and (3) the sedimentary volume in which it was found. Based on the expectations about lithic technology outlined below, if an assemblage does not to conform to the model, the

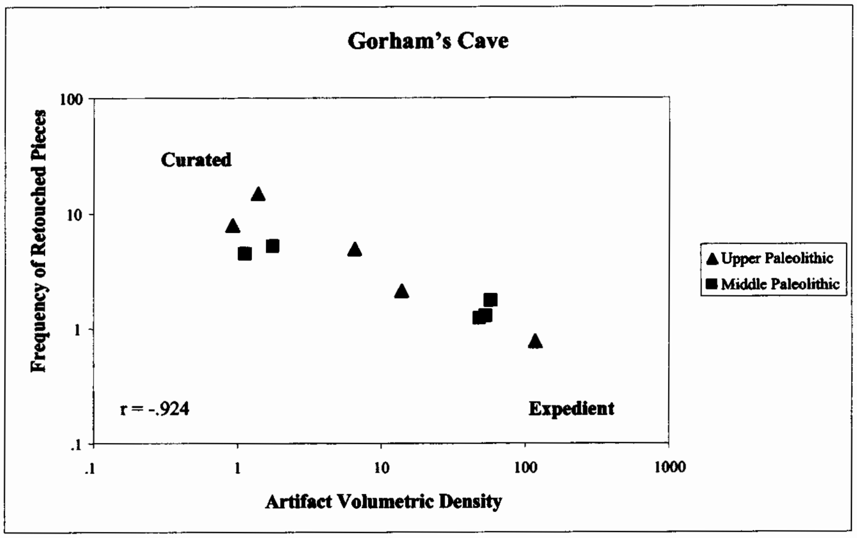

Figure 1. Patterns for Paleolithic assemblages from Gorham's Cave, predicting a negative relationship ($r = -.924, p = .000, N = 10$) between artifact volumetric density and frequency of retouched pieces, along with associated technological strategies (after Barton 1998).

most likely source of distortion should be the excavated volume of archaeological sediment, a factor that can then be isolated, thereby highlighting those layers that might have been subjected to variable rates of sediment deposition and retention.

Results from Gorham's Cave and other Iberian Paleolithic sites (i.e., Barton 1998; Villaverde et al. 1998) display a strong negative relationship between artifact density and relative frequency of retouched pieces (Figure 1). Assuming that the overall need for stone tools does not change significantly over time, this relationship can serve as a heuristic device to infer technoeconomic behavior from archaeological assemblages. If we combine the theoretical framework for lithic technology discussed above with the long-term evolutionary tendency for humans to make critical economic decisions to maximize benefit/cost ratios within a perceived socioecological context (Winterhalder and Smith 2000), assemblage characteristics will be influenced by the propensity to maximize lithic utility under varying land-use strategies. Under conditions of *effective local lithic scarcity*—controlled as much by human land-use decisions and situational variables as by absolute raw material distribution—hunter-gatherers are expected to conserve lithic resources by producing fewer flakes and extending the use-life of flakes that are produced through regular maintenance (i.e., retouch). Under conditions of *effective local lithic abundance*, on the other hand, such conservation measures are unnecessary, leading foragers to produce and discard more flakes while investing comparatively little effort in extending their use-life through repeated maintenance and resharpening.

Given these considerations, the two ends of the curation-expediency continuum depicted in Figure 1 can be assigned to prevalent site-use strategies within a continuum of residential to logistical mobility (*sensu* Binford 1979, 1980). Expedient assemblages are often deposited at the "base camps" or "central residences" of logistically organized hunter-gatherers (Binford 1980; Nelson 1991). In such contexts, lithic raw material is usually effectively abundant due to direct local availability, embedded procurement, and/or stockpiling of material at the site. This reduces the premium of preserving raw material, resulting in comparatively higher artifact densities and assemblages comprised mostly of unretouched flakes. These high densities are also the result of the longer occupation spans that characterize such sites, which directly influence the quantity of lithic production debris that accumulates at a site (Morrow 1996a). Cores associated with such assemblages tend to be only minimally prepared, since extracting the maximum number of blanks from a single nodule is not the most important consideration. Overall, this modality of technological behavior can be taken to indicate a reduced need for a portable and versatile lithic toolkit at the base camp, and in Figure 1, it is associated with assemblages found in the lower right-hand corner.

Curated assemblages, on the other hand, are expected to be associated with residential mobility, where the central locus of activity of a hunter-gatherer group changes frequently. However, assemblages deposited by task groups on logistical forays away from a central residential site can also be expected to display this pattern, since they tend to have specifically manufactured, reliable tools (*sensu* Bleed 1986) to execute these extraction tasks. In both cases, because sites are occupied only for short periods of time, the stone tool assemblages created by mobile foragers tend to be of low density and comprise mostly resharpened (i.e., retouched) tools, but while the curated assemblages of residentially mobile foragers will comprise mostly exhausted maintainable lithics, those deposited by logistical task groups will contain a majority of reliable tools (Kuhn 1989). Cores found in curated assemblages can be expected to be prepared cores that produce more cutting edge per volume (e.g., discoidal cores, some forms of recurrent Levallois cores, or prismatic blade cores) and be fairly "exhausted" at time of discard (see Shott 1996). This pattern results from brief site occupations by highly mobile foragers who carry with them a lightweight, easily maintained and polyvalent toolkit (Kuhn 1989, 1994, 1996; cf. Morrow 1996b). This mobility strategy, in turn, creates an effective raw material scarcity that elicits conserving behavior from those who rely on it. As such, curated assemblages represent risk-minimizing strategies that aim to provide a constant supply of functional tools in times or places where they cannot be manufactured due to either lack of suitable material or preparation time (Bamforth and Bleed 1997). In Figure 1, this strategy is associated with sites found in the upper left-hand corner.

There is, of course, a large amount of variability that is expected along the behavioral continuum linking curation and expediency (see Barton 1998: Figure 1; Villaverde et al. 1998: Figure 5). There are several potential causes for this variability, none of which is mutually exclusive. One is variation in land-use patterns, as suggested above, which in turn affects effective raw material availability and tool design considerations (Bleed 1986; Nelson 1991). Another is that given assemblages usually represent palimpsests of multiple occupations of a site by groups that may rely on different land-use and technoeconomic strategies. As mentioned above, variable sedimentation rates affecting artifact volumetric density represent another potential factor contributing to the location of an assemblage on the graph. Low sedimentation rates will shift an assemblage's position toward the upper right-hand corner, while high sedimentation rates will have the opposite effect, dragging assemblages toward the lower left. In terms of creating interpretive ambiguity, the impact of high sedimentation rates would be most severe for assemblages deposited at logistical base camps. Low sedimentation rates would most significantly distort patterns for highly curated assemblages deposited by residentially mobile hunter-gatherers or by the task groups of logistical collectors. Alternatively, assemblages in the upper right-hand corner might represent a completely different technological strategy akin to the "snow-bound Neanderthal" model proposed by Rolland (1981), where a site is occupied for long periods even though raw material is effectively scarce.

A significant advantage of this whole assemblage method with regards to comparing prehistoric stone tool assemblages is that it can be used across traditionally assigned geographic and temporal typological divisions. For instance, for the Eurasian Paleolithic, two distinct typological systems have been used to describe the morphological variability of Middle and Upper Paleolithic stone tools (Bordes 1953, 1961; de Sonneville and Perrot 1953, 1954, 1955, 1956). Since most interpretations of Paleolithic behavioral variation are based on patterns in the distribution of stone tools, this dichotomy effectively establishes (and reinforces) a de facto behavioral distinction between the two periods (Marks et al. 2001; Riel-Salvatore and Clark 2001). However, Grayson and Cole (1998) have recently suggested that the alleged greater number and diversity of tools in early Upper Paleolithic assemblages is essentially a side-effect of larger assemblage sizes as opposed to a qualitative shift in the mental capabilities of Late Pleistocene humans (cf. Harrold 1989), thereby highlighting the limited heuristic potential of typological approaches to assess and explain inter-assemblage variability. As well as avoiding the issue of noncomparable classificatory systematics, a whole assemblage analysis approach can easily be applied to a wide number of assemblages reported in the archaeological literature. It simply requires count data for entire assemblages along with retouched tool counts, and volumetric information on the excavation units from which assemblages were recovered; these data are commonly found in published accounts.

We propose this methodology as an additional component of a growing "analytical arsenal" that helps archaeologists reconstruct prehistoric behavior from chipped stone assemblages. While a single method can generate sound interpretations, one should ideally combine a variety of methods operating at different scales of resolution (i.e., artifact- vs. assemblage-based) in order to obtain a thorough understanding of technoeconomic behavior, since each has advantages and limitations. For instance, while the methodology advocated in this paper does not quantitatively estimate the degree of curation of individual artifacts within an assemblage (cf. Dibble 1987, 1995; Kuhn 1990, 1992), it includes all retouched artifacts in its assessment of general land-use patterns as opposed to relying only on certain classes of retouched pieces on certain kinds of blanks to do so (e.g., scrapers on flakes). Our method can thus serve both as a heuristic to generate interpretations that can be complemented by artifact-based methods, and as a potential confirmatory "check" for the results of such analyses aiming to reconstruct past technoeconomic strategies. However, before the results of artifact- and assemblage-based measures of curation can be compared, it is necessary to develop the methodology needed to arrive at an assemblage-based measure on its own.

Sample Selection

There are, in Paleolithic studies, few topics more contentious than the so-called Middle to Upper Paleolithic transition, and what this entailed in terms of changes in hominid behavior (Bar-Yosef and Pilbeam 2000; Clark 1999; Stringer and Davies 2001). Because whole assemblage analysis offers a uniform way to track changes in land-use and technoeconomic strategies across typologically defined periods, we focus this study on a series of sites that have yielded Middle, Upper, and "transitional" Paleolithic assemblages. The selected sample comprises eight tightly clustered sites located on the Ionian coast of the Salento peninsula, in southern Italy, near the city of Nardó (Table 1). These sites were excavated in the 1960s and 1970s by teams from the *Istituto Italiano di Preistoria e Protostoria*, the University of Siena, and the University of Florence, reportedly using modern recovery techniques. Most of the excavated assemblages were described in their entirety, with retouched tools, debitage, and cores being described typologically and in terms of their raw material. All the sites contain Middle Paleolithic deposits, four contain Upper Paleolithic deposits (proto-Aurignacian and Epigravettian), and five contain deposits attributed to a "transitional" industry, the Uluzzian.

Palma di Cesnola (1993, 2001) describes the Uluzzian as a uniquely Italian transitional industry (but see Koumouzelis, Linter et al. 2001; Koumouzelis, Kozlowski et al. 2001) characterized typologically by backed lunate microliths and *pièces esquillées*—or splintered pieces—(Demars and Laurent 1989:94–95, 98–99), and technologically by a predominantly flake-based blank production system (see Kuhn and Bietti 2000). It is quite different from the Châtelperronian industries of southwestern France and northern Spain into which some researchers mistakenly attempt to subsume it (e.g., Gioia 1988, 1990; Mussi 2001). However, the Uluzzian may well represent a local manifestation of broader sociodemographic and evolutionary trends occurring in Eurasia as a whole between 40,000–30,000 years B.P. (d'Errico et al. 1998; Kuhn and Bietti 2000). This study offers the potential to test whether or not the behavior reflected in Uluzzian assemblages is more closely related to Middle or Upper Paleolithic patterns, and whether there are marked differences in economic strategies that coincide with the beginning of the Upper Paleolithic.

It is important to emphasize that our sampling strategy, focused on a set of comparable locales, effectively creates a useful setting to study diachronic changes in land-use patterns as it holds the location of human activities constant. If in that context the flexibility of technoeconomic strategies can be shown to vary markedly through time, we have clear evidence that the area's use by foragers must have been dictated by different factors and motivations over time. This also may help inter-

Table 1. List of Sites Included in this Study and Associated Archaeological Industries.

Site	Periods	Main references
Gr. Capelvenere	Mousterian (10)	Giusti 1979, 1980; Patriarchi 1980
Gr. del Cavallo	Mousterian (n/a) Uluzzian (4) Epigravettian (n/a)	Palma di Cesnola 1964, 1965, 1966, 1967
Gr. Marcello Zei	Mousterian (3)	Dantoni & Nardi 1980
Gr. Mario Bernardini	Mousterian (20) Uluzzian (4)	Borzatti von Löwenstern 1970, 1971
Gr. della Serra Cicora A	Mousterian (3) Uluzzian (2) Proto-Aurignacian (2)	Campetti 1986; Spennato 1981
Gr. della Torre dell'Alto	Mousterian (6)	Borzatti von Löwenstern 1966; Borzatti von Löwenstern & Magaldi 1967
Gr. di Uluzzo	Mousterian (n/a) Uluzzian (2) Epigravettian (4)	Borzatti von Löwenstern 1963, 1964
Gr. di Uluzzo C	Mousterian (17) Uluzzian (3) Epigravettian (1)	Borzatti von Löwenstern 1965, 1966

Note: The number of assemblages per industry is in parentheses.

pret the uneven number of assemblages from each period in our sample (see Table 1), since dramatic fluctuation in the intensity of occupation (i.e., the number of assemblages per time-unit) is likely to be related to changes in land-use patterns (see discussion below).

Results

Artifact volumetric density and frequency of retouched pieces were computed for all deposits for which the information was sufficient to do so, and the results are plotted graphically in Figure 2. Despite the generally good quality of information, it was not always possible to get the necessary data, even for all the layers from a single site. This means, for instance, that the Mousterian and Epigravettian layers of Grotta del Cavallo, while unquestionably present (Palma di Cesnola 1964, 1965; see also Sarti et al. 2000, 2002), could not be incorporated in a comparison with its Uluzzian layers, since only the latter had reported debitage counts. These discrepancies in data reporting might well be due to the comparatively greater emphasis placed on describing the Uluzzian layers that, at the time the site reports were published, documented a hitherto unknown Paleolithic industry. Furthermore, many Middle Paleolithic sites were already known in Italy, and as a result, the Middle Paleolithic assemblages from coastal Salento may have been considered less important to describe in their entirety, especially since detailed typological inventories of their contents had been given. Despite these shortcomings, there are still enough data to identify interesting relationships. Correlation coefficients also were computed for each site (Figure 2) to indicate the strength of relationships between retouch frequency and artifact density across time.[2] Following Barton (1998; Villaverde et al. 1998), a log scale is used for both axes of the graph. As indicated above, time-transgressive patterns in lithic variability were analyzed for each site individually to limit comparing assemblages deposited under different sedimentary environments.

While most sites display an overall adherence to the negative relationship predicted by the model, r values are low in many cases—usually due to a few anomalous assemblages. Some of these anomalous patterns could result from variation in sedimentation rates (e.g., Barton 1998). For instance, at Serra Cicora A, the low correlation coefficient is due to a single Mousterian assemblage with an anomalously low artifact density for its frequency of retouched pieces, possibly due to a higher sedimentation rate during the accumulation of that assemblage. Unfortunately, available published data do not allow us to explore this possibility here.

However, another factor seems even more important for the sites under scrutiny here, namely the nature of the raw material used to manufacture

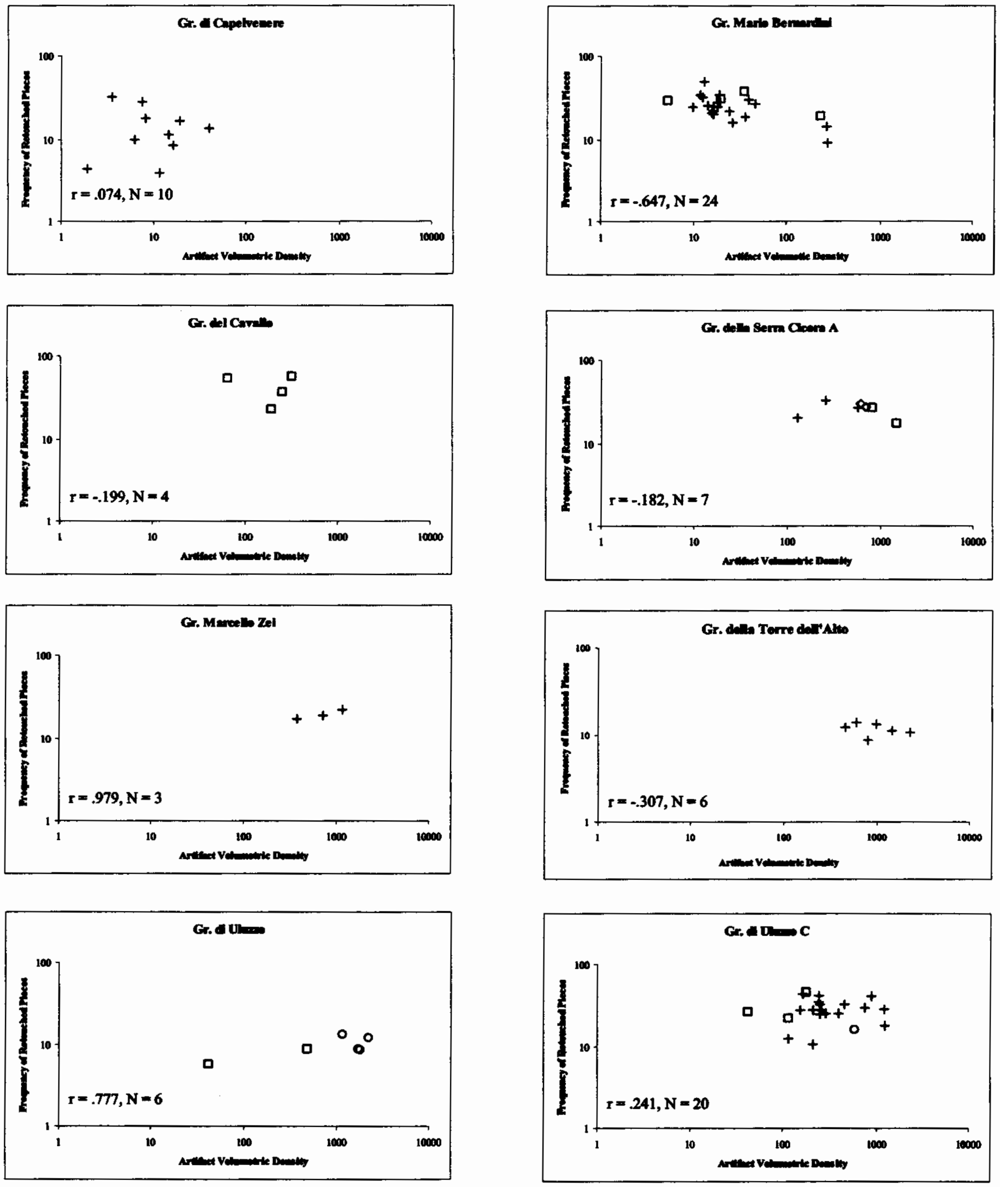

Figure 2. Graphs showing the relationship between absolute artifact density and frequency of retouched pieces, for individual assemblages from the eight sites included in this study. Symbols: + = Mousterian; ❑ = Uluzzian; ◊ = proto-Aurignacian; O = Epigravettian.

the lithic assemblages. While many documented Paleolithic industries from western Eurasia were made on high-quality, fine-grained cryptocrystalline material such as flint or varieties of chert, almost all Middle Paleolithic and Early Upper Paleolithic assemblages from coastal Salento contain substantial proportions of tools, cores, and debitage made on locally available, poor-quality siliceous limestone of various kinds and a minority of lithic artifacts made on flint, chert and/or quartzite (Palma di Cesnola 1996; Peretto 1992). Interestingly, in his study of the assemblages from Gorham's Cave, Barton (1998:15) also notes that flint—which is not readily available locally—was the most intensively curated raw material while locally abundant quartzite pebbles were used to manufacture mostly expedient, lightly retouched implements.

As mentioned above, artifact assemblages probably represent palimpsests of multiple occupations in most cases, due to the often slow accumulation of deposits in cave and rock shelter sites, regardless of the care taken in excavation (Barton and Clark 1993; Barton et al. 2002). Under these conditions, there are at least three scenarios through which local and exotic raw materials can become amalgamated within a single assemblage. First, logistical hunter-gatherers occupying a given site simply may have acquired and used a variety of raw materials in proportion to their availability within a given range from the site. In this case, all materials would be curated and modified to a more or less equivalent degree, controlled by the land-use considerations outlined above. Second, hunter-gatherers coming from elsewhere and occupying a given site for a period of time might have discarded exhausted artifacts made on distant raw material at that site, and used local raw material to execute tasks during their occupation of the site as well as to "gear up" in expectation of their next peregrination across the landscape. Third, within a single depositional episode, groups with differing land-use strategies and associated raw material consumption regimes could have occupied a given site sequentially, discarding distinct lithic production debris that became mixed postdepositionally. In the latter two cases, different raw materials could display different degrees of curation-related maintenance (i.e., retouch). These explanations are not mutually exclusive, of course, and it is in fact likely that they combined to create the patterns of artifact discard detected in the archaeological record. This suggests it could be useful to further subdivide prehistoric lithic assemblages—in this case those from coastal Salento—on the basis of raw materials to help us better distinguish among technological behaviors.

The information contained in the published site reports allows us to recalculate artifact densities and retouched tool frequencies, with assemblages subdivided by raw material class, at four of the eight Salento sites. After subdividing by raw material, all four of these sites display very strong negative relationships, also indicated by their *r* values (Figure 3).[3] This underscores the not surprising importance of accounting for raw material differences in whole assemblage analyses of prehistoric materials (Andrefsky 1994). However, we cannot simply assume that fine cryptocrystalline materials always

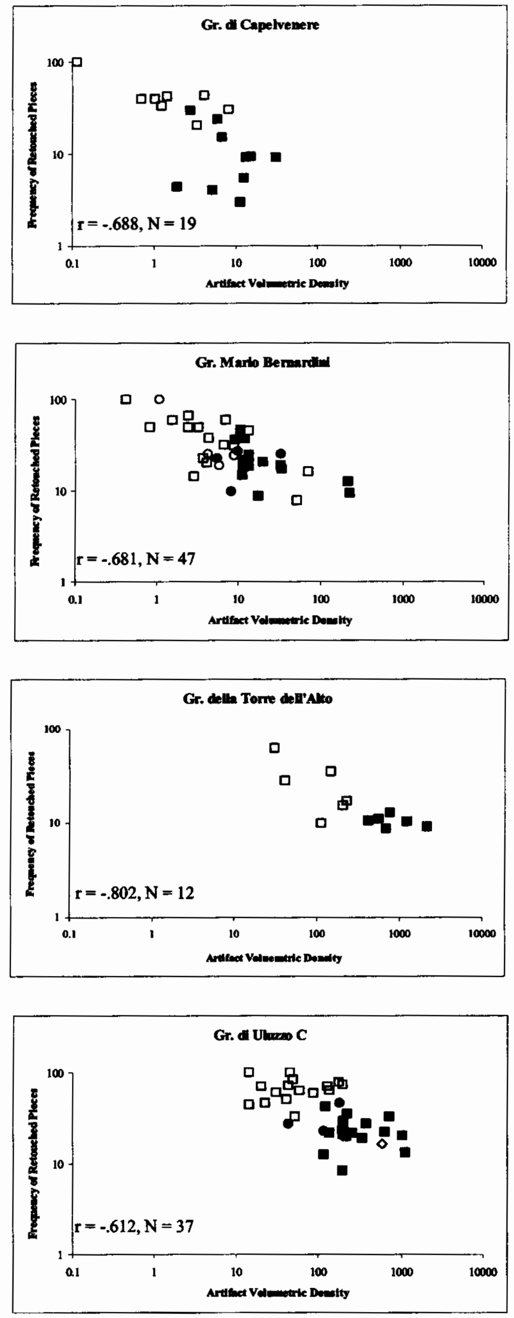

Figure 3. Graphs showing the relationship between absolute artifact density and frequency of retouched pieces after differentiating between flint (i.e., high-quality raw material) and limestone (i.e., low-quality raw material) sub-assemblages, for the four sites for which adequate information is available. Symbols: ■ = Mousterian (poor quality raw material); ❑ = Mousterian (good quality raw material); ● = Uluzzian (poor quality raw material); ❍ = Uluzzian (good quality raw material); ◊ = Epigravettian (good raw material).

will be highly curated and poorer quality materials will be used in an expedient manner. For example, all the Epigravettian assemblages in our sample contain tools made exclusively on flint and yet fall toward the expedient end of the continuum.

We also can make somewhat more subjective assessments for several sites that lack sufficient published information to subdivide assemblages by raw material. Although precise counts are missing, the Middle Paleolithic and Uluzzian assemblages from Marcello Zei, Cavallo, Serra Cicora A, and Uluzzo are described as containing significant proportions of artifacts made on siliceous limestone (Borzatti von Löwenstern 1963, 1964; Dantoni and Nardi 1980; Palma di Cesnola 1964, 1965, 1966, 1967). However, a recent review of the assemblages from the Salento documents a more or less gradual decrease in limestone utilization during the course of the Uluzzian, although limestone implements never completely disappear (Palma di Cesnola 1993:81–115). It is only with the much later Epigravettian (assumed to date to after ca. 20,000 B.P.)—represented at Cavallo, Uluzzo, and Uluzzo C by several Romanellian and Epi-Romanellian layers—that limestone becomes so scarce that its influence on patterns of lithic variability becomes negligible. Given this, it is likely that at least the Middle Paleolithic and Uluzzian layers of the four sites mentioned above would generate patterns that conform to expectations if sufficient information on raw material was available.

At Serra Cicora A, the early Upper Paleolithic assemblages studied separately display an extremely strong adherence to the pattern predicted by the model ($r = -.991$, $p = .009$, $N = 4$) even without raw material differentiation. Spennato (1981) reports that limestone is abundant in both the Uluzzian and proto-Aurignacian layers, but that it only dominates the assemblage in layer D, the lowermost Uluzzian level. Despite this, layer D is tightly clustered with the proto-Aurignacian layers (A and B), while the more "flinty" Uluzzian assemblage of layer C has lower relative frequencies of retouch, indicating an overall more expedient strategy than that of layer D.

Discussion

The results of this study have important implications for our understanding of the Middle-Upper Paleolithic transition and the origins of modern humans. An important feature of the patterns seen in both Figures 2 and 3 is that artifact curation, and by implication technoeconomic strategies, do not vary systematically according to time. That is, Middle Paleolithic, Uluzzian, and Upper Paleolithic assemblages all appear to be distributed across the spectrum of technological behaviors represented here. This is also the case for Gibraltar, where technoeconomic behaviors and inferred land-use strategies seem more closely tied to environmental variation than to archaeologically defined "cultures" (Barton 1998). This has ramifications for our understanding of Late Pleistocene hominid behavior in southern Italy and also, more generally, for our construal of the nature of the so-called Middle-Upper Paleolithic transition. In terms of the Italian Paleolithic sequence, this study suggests that in those locales where assemblages of both Middle and Early Upper Paleolithic materials can be compared using a common analytical framework, there is no marked qualitative economic shift between the two periods. The kinds of exploited raw materials and the range of technoeconomic organization remain stable across this analytic boundary. During the various Mousterian, Uluzzian, and proto-Aurignacian occupations of the coastal Salento sites, flint often was highly curated and, by extension, was likely considered a finite and highly valued resource to be managed carefully. This kind of behavior is usually taken for granted—and rarely demonstrated—for the modern human populations of the Upper Paleolithic, but its presence in the Middle Paleolithic contrasts sharply with views of Neanderthals as qualitatively different from us behaviorally (e.g., Gamble 1999; Gargett 1999; White 2000). In fact, what the data suggest is that flint only became effectively abundant to foragers in the Salento during the Late Upper Paleolithic, while it remained effectively scarce prior to that time.

To further evaluate this, we compare the lithic evidence for technoeconomic behavior among archaeologically defined chronotypological assemblage groups: Mousterian, Uluzzian, Protoaurignacian (early Upper Paleolithic), and Epigravettian (late Upper Paleolithic). Given the very strong correlation between retouch frequency and artifact density, we use retouch frequency alone as a simple proxy measure of the curation-expediency spectrum. As seen in Figure 4, this not only

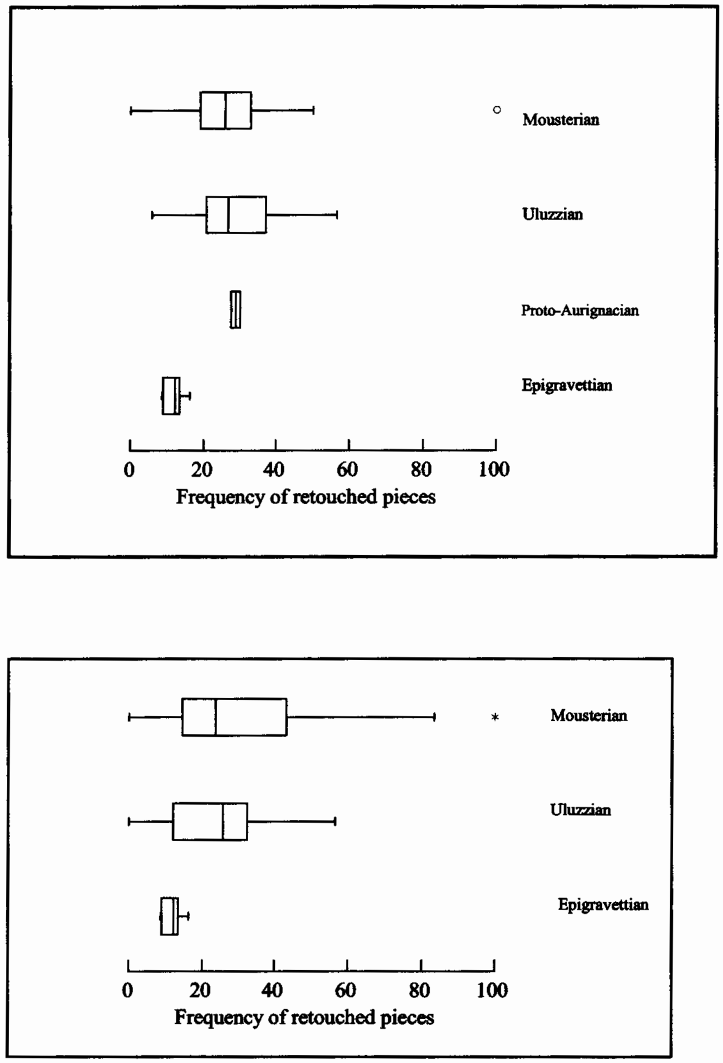

Figure 4. Box-plots of the frequency of retouched pieces for Mousterian, Early Upper Paleolithic (Uluzzian, proto-Aurignacian), and Late Upper Paleolithic (Epigravettian) assemblages (top), and for assemblages for which raw material information is available (bottom).

supports the equivalence of the range of technoeconomic behavior from the Middle to Upper Paleolithic in the Salento sites, but also reveals an even more striking pattern. There is virtually no change in the range or distribution of technoeconomic behaviors expressed in these assemblages from the Mousterian through the *early* Upper Paleolithic, be it the Uluzzian or the proto-Aurignacian. However, the *late* Upper Paleolithic is distinctive in that it is characterized only by a narrow range of lithic technology at the expedient end of the broader Late Pleistocene behavioral spectrum.

We have very little evidence of who might have been responsible for creating and depositing the industries found in the eight sites analyzed in this study. The only human fossils are two deciduous molars from Cavallo, Layer E, an Uluzzian layer. Messeri and Palma di Cesnola (1976; see also Palma di Cenola and Messeri 1967) originally classified one of the teeth as anatomically modern and the other as Neanderthal. However, a recent reexamination by Churchill and Smith (2000) assigned both to Neanderthal individuals. Based on these data, and despite the acknowledged problems of

Table 2. Relative Representation of Assemblages for Each Industry.

Periods	Total no. of assemblages	Estimated duration (in thousand years)	Assemblages/ thousand years
Mousterian	59	90	.66
Uluzzian	15	10	1.50
Proto-Aurignacian	2	6	.33
Epigravettian	5	10	.50

linking hominids to kinds of stone tools (see discussion in Riel-Salvatore and Clark 2001), it is possible that the Uluzzian was a purely Neanderthal industry (Kuhn and Bietti 2000). Given this, it should perhaps not come as a surprise that the economic patterns it displays share strong similarities to those extracted from the Middle Paleolithic layers of the sites from coastal Salento. What is surprising, however, is that the proto-Aurignacian industries from Serra Cicora A display similar technoeconomic behavior as those observed in Uluzzian assemblages, patterns that are quite distinct from the Epigravettian patterns, despite the assumption that both technocomplexes were made by anatomically modern humans.

In light of these rather distinct patterns of land-use, interesting interpretive insights can also be gleaned from the uneven number of sites from each period, especially as this relates to the Epigravettian. As seen in Table 2, absolute and relative numbers of assemblages are not directly correlated;[4] for example, the more numerous Mousterian assemblages are nonetheless less relatively abundant than Uluzzian assemblages in our area. Table 2 shows that, if we except the two proto-Aurignacian assemblages, Epigravettian assemblages are relatively the least abundant in our sample, being noticeably less frequent than assemblages from the previous periods. In other words, in addition to showing a land-use pattern distinct from those of earlier occupants of the Salento coast, the makers of Epigravettian industries appear to have occupied the area less intensively than most of their forebears. Thus, the relatively low number of Epigravettian assemblages in our sample constitutes a corroborating thread of evidence indicating that rather different land-use strategies were in place for this area prior to and following the Last Glacial Maximum (LGM).

These complementary results suggest that, while human land-use strategies ranged from logistical to residential mobility over much of the Late Pleistocene at these sites, they became strongly focused on logistical strategies in the Epigravettian of the LGM. Admittedly, we are dealing here with a sample of two proto-Aurignacian layers, and we should be cautious about generalizing. However, a similar pattern is seen at Gibraltar (Barton 1998). Furthermore, in other studies in which a single method of measuring variability has been applied to archaeological data across the Middle-Upper Paleolithic transition, changes in lithic technology do not correspond with the traditional distinction between the Middle and Upper Paleolithic (Grayson and Cole 1998; Kuhn 1995; Simek and Price 1990). This leads us to suspect that an important (maybe *the* most important) archaeological distinction between the Middle and Upper Paleolithic in western Eurasia may be an artifact of the use of very different Middle and Upper Paleolithic typologies to characterize lithic variation (Clark 1997; Hiscock 1996). This does not discount the existence or importance of change in material culture and associated behaviors through the Late Pleistocene. However, the most important changes may well not correspond with the Middle-Upper Paleolithic boundary as traditionally envisioned (Clark and Lindly 1989, 1991; Straus 1997). For example, in the technoeconomic behaviors and inferred land-use strategies investigated here, the most significant change seems to correspond with the LGM (see Barton et al. 1994 for a comparable argument based on Paleolithic art). Similarly, a recent study of burial practices suggested more or less continuous, gradual change through the Late Pleistocene that culminated in recognizably modern behaviors by the LGM (Riel-Salvatore 2001).

These results hold the potential for significantly reframing the current debate about modern human origins. Most discussion today is focused on the nature of the biological transition from archaic to modern *Homo sapiens*. It is probably safe to say that sometime between 40,000 and 25,000 years ago Neanderthals disappeared from western Eurrasia. Whether by extinction, gene flow, or in situ morpho-genetic change, it is likely that selection was the cause of this pervasive evolutionary event. However, the available archaeological evidence for critical economic behaviors that could best account for the replacement of "archaic-ness" with "modernity" in human populations indicates that the most important behavioral changes took place 10,000–20,000 years *after* the biological appearance of modern skeletal forms, but closely corresponding to worldwide environmental change in the Late Pleistocene. In our view, the most important question then becomes, "What were the selective forces driving the evolutionary spread of 'modernity'?" rather than "What was the detailed process of this spread?" Given the apparent large temporal disjunction between evidence for biological and behavioral change, this question looms very large in understanding our origins.

Finally, this study presents an alternative way to evaluate the meaning of "transitional" lithic industries like the Uluzzian and Châtelperonian in the Late Pleistocene. When we examine them from a perspective other than a purely typological one, the Early Upper Paleolithic industries from coastal Salento appear to articulate quite well with the range of adaptations represented by Middle and Upper Paleolithic assemblages. "Transitional" industries such as the Uluzzian may not, in fact, have been transitional in any sense of the word, but rather simply one of many different typological expressions of the same range of technological variability that characterized hominids in the northern Mediterranean probably at least since the end of the last interglacial. Thus, on behavioral grounds, it is hard to argue for a revolution of any kind coinciding with such archaeologically defined "cultures." Researchers may gain more useful interpretive insights by highlighting behavioral macro-patterns within complete lithic assemblages (i.e., comprising tools *and* debitage) through the use of approaches such as the one developed in this paper, rather than losing the forest for the trees by limiting their interpretations to the minutia of typological analysis and *chaîne opératoire* reconstruction.

Conclusions

The results of this study provide a number of important insights. On a methodological level, it appears that the approach described and employed here and in two previous papers (Barton 1998; Villaverde et al. 1998) is a useful method for distinguishing varying degrees of curation and expediency in archaeological lithic assemblages. Its potential to evaluate variability in technoeconomic behaviors over long time spans was demonstrated in its application to assemblages spanning the entire Late Pleistocene at Gibraltar and eastern Spanish sites. Successfully applying this approach to generate useful insights into the behavioral adaptations and land-use strategies of Late Pleistocene hominids in southern Italy further demonstrates its applicability across an extensive geographic region. We also highlight the importance of differentiating among different raw materials in analyzing Paleolithic assemblages in this way (see also, e.g., Andrefsky 1994).

As a potentially interesting aside that deserves further study, if the kind of patterning between the variables used here proves to be consistent across more prehistoric assemblages, this kind of whole assemblage analysis potentially can help distinguish variation in sedimentation rates at deeply stratified sites. Given the ease and accessibility of this method, it could help in addressing a series of deposition-related questions ranging from site formation processes to temporal change. Because we are dealing with lithics that are usually much more resistant to sedimentary diagenetic processes, the characteristics of any given assemblage (i.e., its overall size and its frequency of retouched pieces) should not be impacted by sedimentary vagaries, keeping in mind that they represent time-averaged pictures of long-term behavioral trends. This means that assemblages derived from unusual sedimentary contexts (relative to the overall pattern of sediment deposition and retention within a given site) should be easily visible on a graph. For instance, an assemblage having lost 50 percent of its sedimentary volume should be immediately apparent because, instead of falling on the line dictated by the overall rate of sedimentary integrity of a site (the regression line), it would fall clearly below it, indicating an anomaly in its sedimentary context. Conversely, layers and assemblages accumulating under unusually fast deposition regimes and suffering little subsequent deflation should fall above the general pattern. In this way, the methodology we advocate not only offers the potential to highlight significant aspects of prehistoric behavioral variability, but also to tentatively identify which layers of a site were subject to unusual sedimentary processes and, thus, where it might be most informative to conduct in-depth geoarchaeological analyses.

The easy applicability of the methodology described above potentially also makes it useful to tackle problems related to patterns in lithic technology in other places and/or periods. While we have thus far only tested it on Late Pleistocene assemblages from southern Europe, it should be emphasized that its applicability is by no means limited to those contexts. All archaeological assemblages comprising a chipped stone component are amenable to a study of technoeconomic patterns based on the methodology presented here. For instance, one can readily see how it could be applied to Paleoindian assemblages to address some of the issues related to land-use patterns recently raised by Bamforth (2002) by allowing researchers to better identify which assemblages represent expedient or curated technological strategies.

This paper had two principal goals: (1) to test the utility of a method of whole assemblage analysis proposed by Barton and colleagues to study prehistoric forager behavior in different regions, and (2) to assess variability in technoeconomic behaviors in hominid groups across the Middle-Upper Paleolithic transition using this uniform methodological tool. By generating interpretable patterns based on additional data, we demonstrate that the method is potentially applicable to a wide range of contexts provided raw material is given due consideration. It would be interesting to apply it to contexts other than Mediterranean coastal Paleolithic sites and in other periods, although such studies are beyond the scope of this paper. Ultimately, however, this research makes it clear that lithic assemblages are better analyzed as wholes and that exclusively relying on studies of retouched stone implements severely handicaps our understanding of prehistoric technoeconomic strategies. Debitage, cores, and other lithic elements all need to be included.

With respect to the second goal, this study suggests that Late Pleistocene lithic technology in southeastern Italy was geared toward, or organized according to, a flexible range of economic strategies. These would have balanced the need to move about the landscape to obtain sufficient food and raw material with the prolonged occupation of given areas where one or both of these resources are more easily procured. Our evidence indicates that this pattern was in place by the Middle Paleolithic in southern Iberia and southern Italy, and that the appearance of the Aurignacian and of allegedly modern humans did not fundamentally change the way people moved about and exploited the landscape. Only with the Last Glacial Maximum do we see a significant change, with humans specializing in a narrow subset of the strategies that characterized the Late Pleistocene as a whole.

This study enriches the growing set of critical frameworks that archaeologists can usefully employ to translate material remains into increasingly secure inference about prehistoric life. We believe that alternative methodologies such as the one proposed here can serve as stepping stones from which renewed studies of lithic technology and associated aspects of prehistoric behavior can be undertaken.

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Notes

1. This refers to the patterning and process of change over time, not to the lack of intentionality in human behavior

2. The p values for the correlation coefficients are: Capelvenere, .838; Cavallo, .801; M. Zei, .131; M. Bernardini, .001; Serra Cicora A, .696; Torre dell'Alto, .554; Uluzzo, .069; Uluzzo C, .306. Thus, while the data usually match the expected pattern, it appears that they are generally not statistically significant before accounting for raw material (see below).

3. The p values for the correlation coefficients are: Capelvenere, .001; M. Bernardini, .000; Torre dell'Alto, .002; Uluzzo C, .000. This suggests that the relationships outlined by taking raw material into consideration are not only very strong, but also very unlikely to be random.

4. Estimated durations derived from the following sources: 90,000 years for the Salento Mousterian (Palma di Cesnola 1996); 10,000 years for the Uluzzian (Kuhn and Bietti 2000); 6,000 years for the proto-Aurignacian (Kuhn 2002); and 10,000 years for the Epigravettian (Bietti 1990). It should be mentioned that 10,000 years is probably an overestimation of the duration of the Uluzzian, and that 90,000 years likely is an underestimation of the duration of the Mousterian, although this is hard to ascertain given the lack of absolute dates for most assemblages assigned to that industry.

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