Lithic Raw Material Use at the Late Middle Pleistocene Site of Panxian Dadong

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AT STRATIED MIDDLE PLEISTOCENE SITES where the use of several lithic raw materials is observed, it is possible to examine patterns of resource exploitation to test hypotheses about cognitive abilities and behavioral change over time. Numerous studies have attempted to explain the organization of technologies, including raw material diversity and strategies of resource management, at localities in Europe, the Levant, and China.

Mallol (1999) analyzed lithics from the Lower and Middle Pleistocene levels TD6 and TD10A at Gran Dolina, Sierra de Atapuerca, Spain. She demonstrates that paleoeconomic strategies can be identified by examining relationships between lithic raw material selection and technical traditions. The Lower Paleolithic, pre-Acheulean level (TD6) exhibits little standardization with regard to raw material selection while the Middle Paleolithic core and flake technology of level TD10A shows a pattern of preferential use of fine-textured stone as well as more standardization in tool form. Similarly, Martinez (1998) relates planning behavior involving the processing of animal carcasses to the differential use of local raw materials from five localities in the Iberian Peninsula (Aridos 01,02, Torralba, Ambrona, and Sierra de Atapuerca).

Technological planning behaviors, as evidenced by material selection, curation, and artifact transport have also been examined in relation to mobility and subsistence (Andrefsky 1994; Kuhn 1991, 1992, 1994). Kuhn (1992) argues that the organization of technology is most dependent on patterns of land use and foraging strategies. With regard to mobile toolkits he suggests that optimal artifact utility reflects both edge length and the potential for resharpening (Kuhn 1994). On the other hand, Andrefsky (1994) documents a close relationship between abundance and quality of raw material and tool typology. From ethnographic and

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archaeological data he demonstrates that poor-quality raw materials are most often made into informal tools while high-quality stone is fashioned into formal tool types. When high-quality material is abundant, toolkits contain both informal and formal tool types. Other studies attest to the transport of quality raw materials from distant sources and detail the efforts Middle Pleistocene hominids made to select particular resources (Meignen 1988).

Researchers analyzing Chinese lithic assemblages have focused on evaluating the effects of raw material quality on typological variability, technological attributes, and operational sequences of tool manufacture (Gao 2000; Hou et al. 1999; Jia and Huang 1985; Keates 2001; Miller-Antonio 1992; Schick 1994). Much of this work highlights the poor quality of Chinese raw materials. The most readily available material often is stone that fractures in unpredictable ways. Leng (2001) suggests that tool manufacture from recalcitrant material offered a considerable challenge to the cognitive abilities of these Chinese toolmakers. The question then becomes, how did these early humans meet that challenge? Did they experiment with other, less obtainable or scarcer materials? The deposits at Zhoukoudian Locality 1 (Fig. 1) contain 40 different raw materials, yet 88.8 percent of the tools are made from just one type of poor quality stone (Keates 2001). Did they develop new technologies using non-lithic resources, as has been argued for bamboo (Pope 1989) and dental faunal remains (Miller-Antonio et al. 2000)? Or did they develop new flaking techniques, specifically to work the most readily available, difficult materials? A notable example of a flaking strategy specifically associated with intractable raw material is the bipolar flaking of vein quartz at Zhoukoudian Locality 1, while direct hard hammer percussion was applied to the more tractable materials like chert and sandstone. Technological change through time is also apparent at Locality 1. The artifacts in later layers are more frequently made of better raw materials and appear more standardized in form (Zhang 1985, 1989). It appears that Zhoukoudian humans met their stone resource challenges by becoming more selective of raw material and more skilled at toolmaking.

This paper examines how humans at the late Middle Pleistocene locality of Panxian Dadong met the challenge of using their most readily available resource, a poor-quality limestone. Following a description of the lithology, we provide an overall characterization of the technological and typological features of stone artifacts recovered during four seasons of excavations. Three questions relating to raw material diversity are then addressed: (1) Does the use of one raw material predominate? (2) How does raw material correlate with tool typology? (3) Does raw material usage change over time? In light of these observations and comparisons with other raw material use studies, we examine hypotheses about specific aspects of resource selection and management.

SITE LOCATION, ESR DATES, AND LITHOLOGY OF THE DADONG STONE ARTIFACTS

Dadong Cave is a karst cavern in Guizhou Province, South China (25°37′38″ N, 104°44′ E), situated in a small valley 1630 m above sea level on the western Guizhou Plateau (Fig. 1). The active tectonic uplift of this region during the Middle Pleistocene and shifting river systems along associated fault lines contributed to the formation of this large karst cave that is now the middle in a series of three

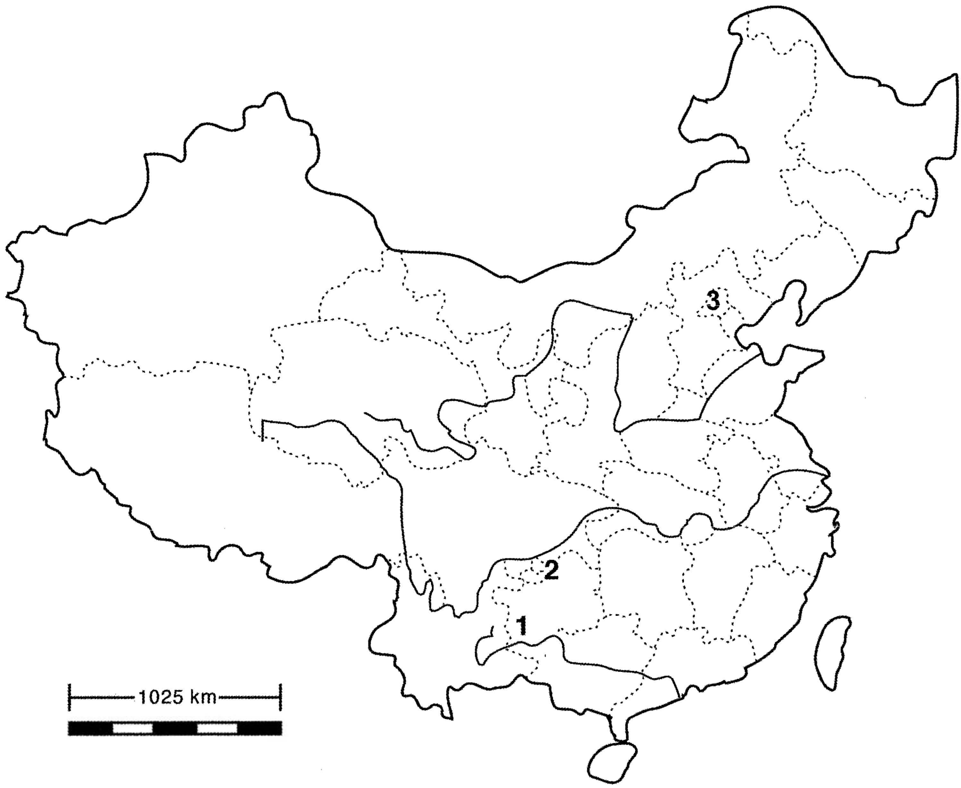


Fig. 1. Location of Dadong (1), Guanyindong (2), and Zhoukoudian (3).

interconnecting caverns. The Pleistocene environment was mostly mixed woodland, indicated by the presence of water buffalo, musk deer, barking deer, and rhinoceros (see Bekken et al., this volume). There were some more densely forested areas with bamboo as suggested by faunal remains of panda, orangutan, and colobine monkeys (Pan and Yuan 1997). This range of habitats is characteristic of mountainous environments with elevational diversity. There is little change in overall species representation through time, suggesting that the animals found in Dadong were able to tolerate the climatic oscillations known for this portion of the Pleistocene (Wang et al., this volume).

The earliest ESR dates of the Dadong occupation studied here come from four mammal teeth samples at depths between 94.2 and 94.0 m (approximately 5.8–6 m below datum or 3 m below present ground surface). These samples yielded mean ages of 214 kya (Early Uptake Model [EU]) to 262 kya (Late Uptake Model [LU]) (Rink et al. 2003). The limestone boulders in this unit are encrusted with manganese oxides and cemented together with phosphates and chemically precipitated calcite. These are indicators of strong weathering phenomena and carbonate-rich waters flowing inside the cave while these deposits formed. The micromorphological analysis of this unit also reveals organic matter and bone fragments that show surface weathering. These are interpreted as anthropogenic constituents that accumulated on a former paleosurface. This unit could have formed during the relatively mild climatic conditions of Oxygen Isotope Stage 7.

Just above this, at 94.5–94.2 m, are microstratigraphic features that are interpreted as possible freeze-thaw activity and a transitional period to more harsh climatic conditions, perhaps representing the beginning of Oxygen Isotope Stage 6. Unsorted sandy loam with travertine, basalt, chert, and bone fragments characterize the next group of sediments at 95.0–94.5 m. In this unit there is evidence of redeposition of materials (including soil aggregates) washed into the cave from upslope.

A second set of ESR dates obtained from five mammal teeth at depths between 95.5 and 95.0 m (4.5–5 m below datum or approximately 1.8 m below the present ground surface) yielded mean ages of 137 kya (EU) to 156 kya (LU) (Rink et al. 2003). The unit is mostly breccia and loose gravels; however, at the microscopic level, soil-derived material and bits of basalt, chert, and bone fragments are identified. Freeze-thaw is frequently observed and is attributed most likely to the culmination of the cold Oxygen Isotope Stage 6.

All of the raw materials used for the Dadong stone industry are locally obtainable on the plateau but they differ in both accessibility and flaking properties. Limestone is readily available either inside the cave or nearby (within 100 m) from outcrops of carboniferous and permian limestone. It is an unlimited resource, but of poor quality for toolmaking because it is brittle and breaks in unpredictable ways. Small nodules of basalt come from local hillside outcrops (between one and two kilometers distance) and from river gravels. At present these water courses, located within one kilometer of the site, have been diverted for agricultural uses. In the Middle Pleistocene there was river drainage into the base of Dadong Hill, and thus the source of river gravels was within immediate access. The basalt ranges in quality from a porous variety to a very fine-grained type, the latter a better tool material. There are also several varieties of chert. Like the basalt, some cherts occur as nodules in limestone outcrops and some are found as river gravels. While the cherts have superior flaking properties, the nodules are small and difficult to extract from veins in the limestone outcrops. Their exploitation, therefore, would represent a considerable amount of energy expenditure by the ancient toolmakers.

RAW MATERIAL FREQUENCY

The three stone materials used at Dadong differ in their frequency of usage (Fig. 2). Limestone is the predominant material (over 49 percent of the total assemblage), even though it is the most difficult stone to use for tool manufacture. Basalt artifacts comprise 28.7 percent of the assemblage, and the remaining 22.1 percent are chert.

ARTIFACT CLASSES AND RAW MATERIAL USE

In the last fifteen years, researchers have argued that the lack of techno-typological congruity for Middle Pleistocene lithic assemblages throughout China makes the three-part Paleolithic division (Lower, Middle, and Upper Paleolithic) confusing (Keates 1997; Olsen and Miller-Antonio 1992; Pope 1989). The solution has

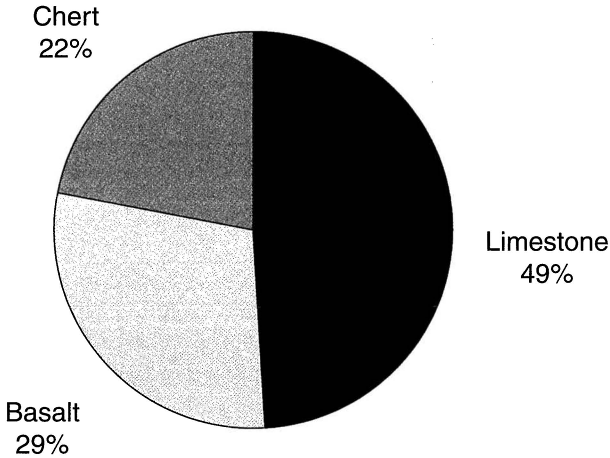


Fig. 2. Raw material frequencies at Dadong (limestone N = 185; basalt N = 108; chert N = 83).

been to refer to these assemblages as late Middle Pleistocene, but often a clearly defined chronology is problematic as well. Recent lithic studies (see, for example, Gao 2000; Hou 1998) have focused on core reduction strategies and recognizing *chaînes opératoires*. Lithic analysts have acknowledged the limitations in tool form imposed by recalcitrant raw materials common in Chinese Paleolithic assemblages, such as quartzite, sandstone, and limestone, but few studies have included relative frequencies of artifact types by raw material as pointed out by Keates (2001), Miller-Antonio (1992), and Schick (1994). This is our emphasis here—to investigate how the local raw materials were utilized for different types of implements.

Table 1 provides raw artifact counts and percentages by raw material type. The data are from the entire excavated sequence of approximately four meters at its greatest depth. A total of 60.12 m^3 were excavated. The artifact classes for the Dadong lithics are as follows:

1. Retouched flakes/flake tools—This category includes side- and end-scrapers, flakes with notches and denticulated edges, and tools fashioned on flake fragments.
2. Unretouched flakes—Artifacts in this category exhibit no clear retouch,

Table 1. Lithic Assemblage of Dadong

	Limestone		Basalt		Chert		Combined	
Class	N	%	N	%	N	%	N	%
Cores/Core tools	15	8.1	2	1.9	7	8.4	24	6.4
Ret. Flakes/Flake Tools	26	14.1	23	21.3	22	26.5	71	18.9
Unretouched Flakes	31	16.8	54	50	18	21.7	103	27.4
Chunks	111	60	24	22.2	23	27.7	158	42
Shatter/Debris	2	1	5	4.6	13	15.7	20	5.3
Total	185	100	108	100	83	100	376	100

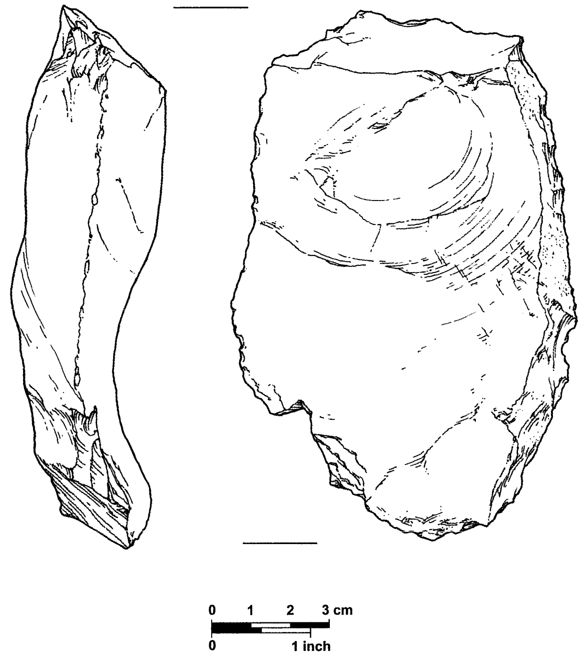


Fig. 3. Large limestone flake.

but utilization or edge damage may be present. These artifacts have clear flake features.

3. Chunks—50 percent of the artifacts in this category show some utilization or retouch. For example, there is often a notched edge, but typologically they are not cores and they have no well-defined flake features. Some of the artifacts in this category represent waste by-products of tool manufacture, but they exceed the average size of the pieces classified as shatter/debris.

4. Cores/core tools—Core tools display some utilization or resharpening.

5. Shatter/debris—Small flaking debris (avg. dimensions: 28.8 mm × 23.9 mm × 11.7 mm).

Figures 3–8 illustrate some of the Dadong lithics. The majority of flakes have broad, simple unfaceted platforms comparable to the large limestone flake in Figure 3. There are a few cases of platform preparation evident (Fig. 4), but the classic facetted *chapeau de gendarme* platform associated with the production of Kebara Levallois points, for example (cf. Bar-Yosef and Meignen 1992) is not represented. Wide square flake morphology is common, as are *eraillure* scars (Fig. 5). The prominence of the bulbs of percussion is variable. On some flakes the bulb is well defined and on others it is more diffuse. This feature is related to the type of percussion utilized, but may also be closely linked to the flaking properties of the raw material.

Dadong tools are predominantly notches and scrapers. The end-scrapers in Figure 6 show invasive retouch and the small notch (Fig. 7) is made on a basalt flake. The small scraper illustrated in Figure 8 is an uncommon tool in the as-

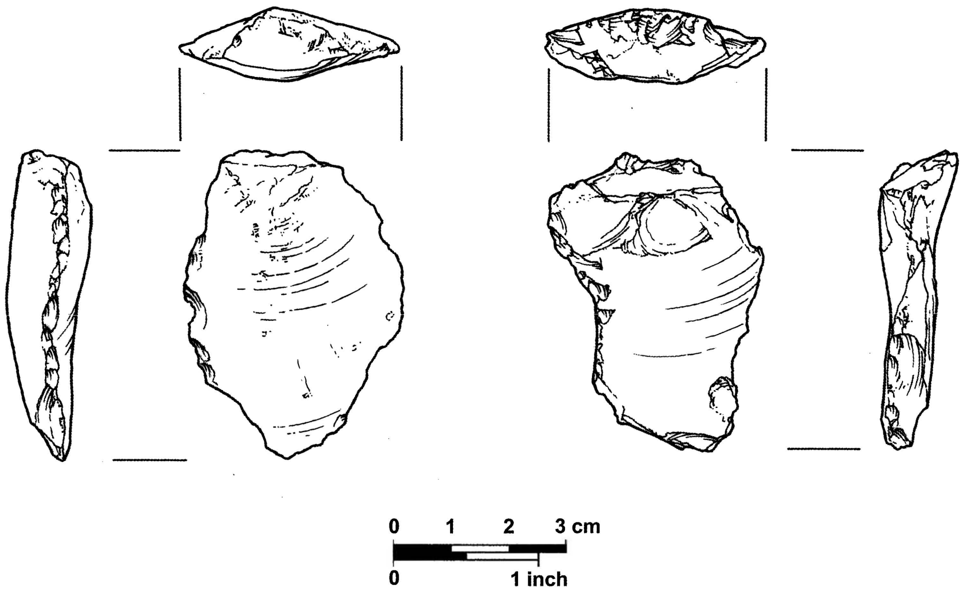


Fig. 4. Platform preparation.

semblage. It is carefully shaped on a flake of high-quality, very fine-grained chert. The most commonly recovered artifact class is chunks (42%), followed by unretouched flakes, retouched flakes and tools, cores and core tools, and shatter and debris (Table 1 and Fig. 9).

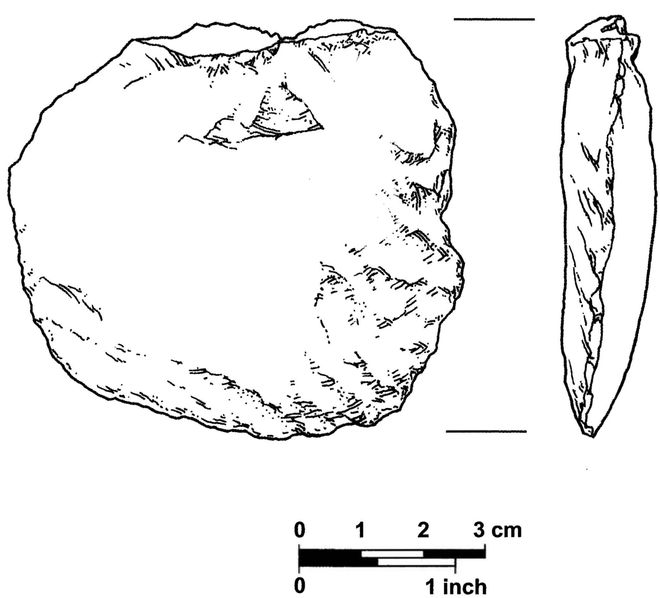


Fig. 5. Square flake form.

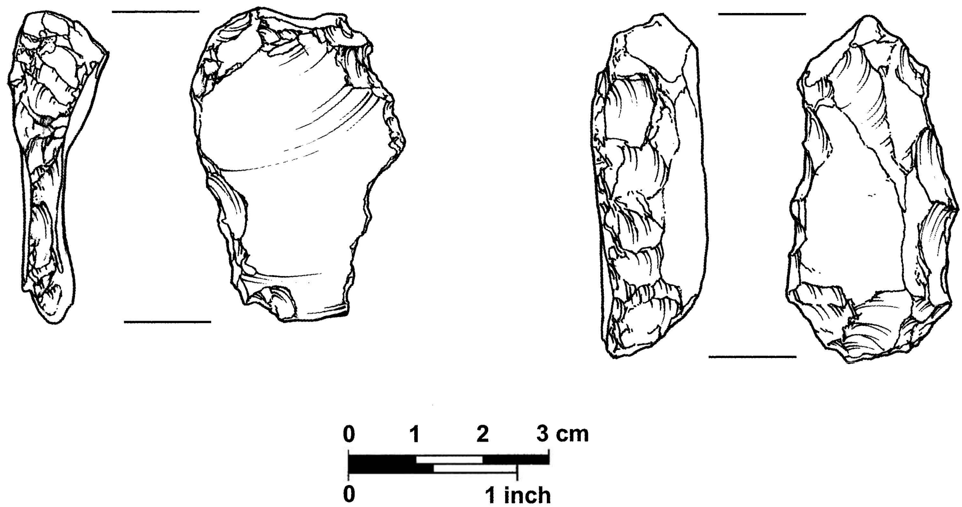


Fig. 6. End-scrapers with invasive retouch.

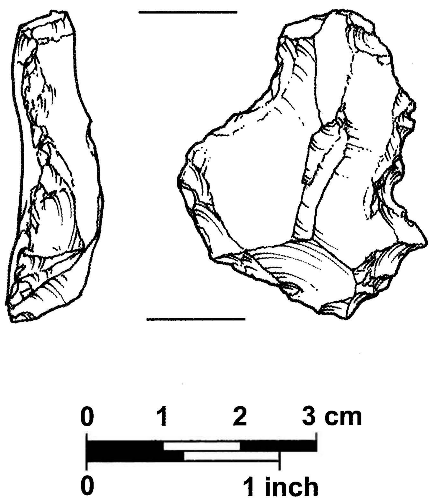


Fig. 7. Notch.

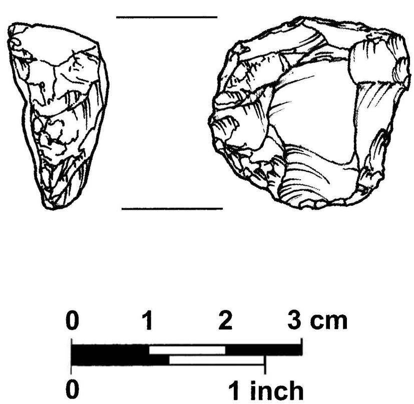


Fig. 8. Small chert scraper.

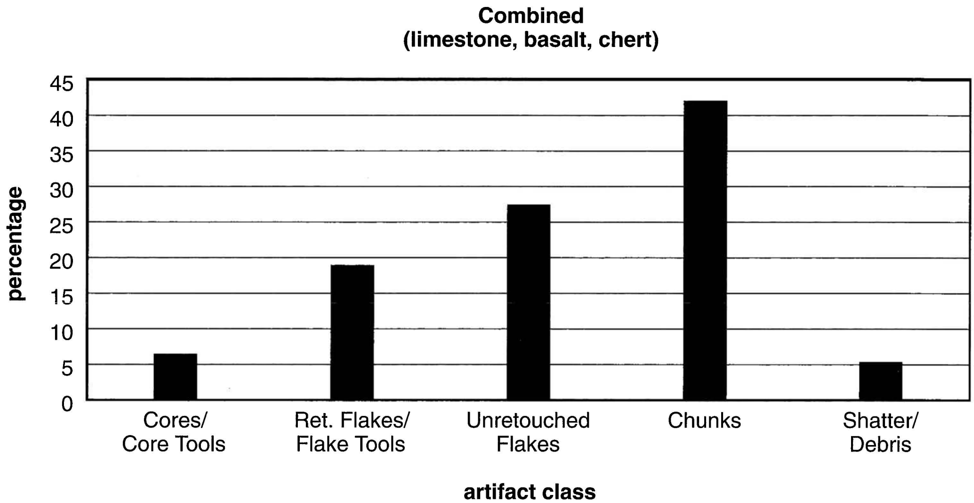
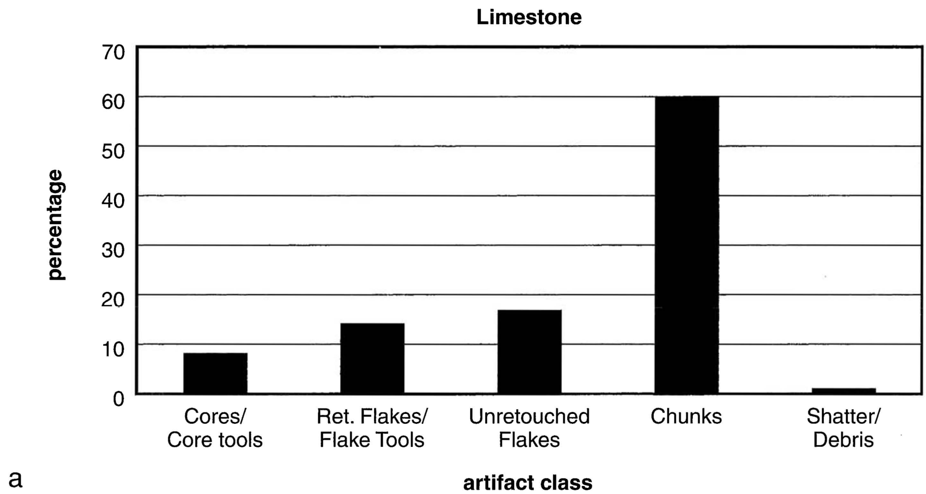


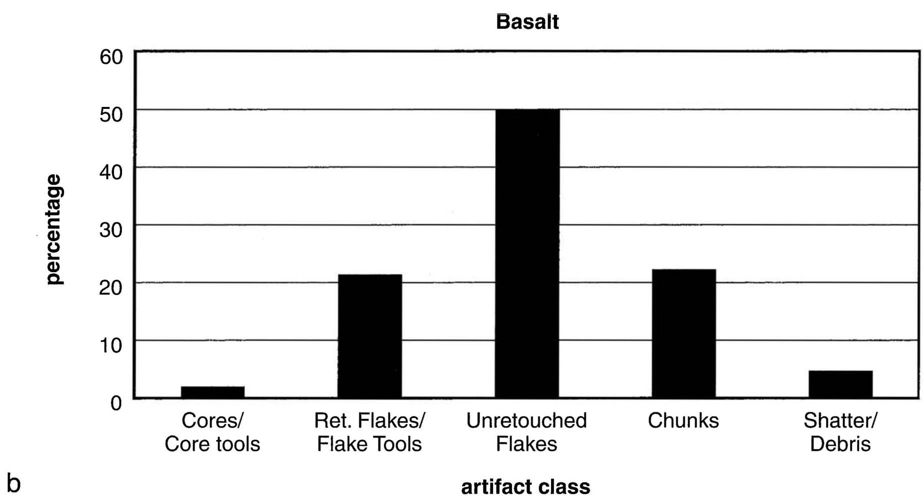
Fig. 9. Representation of artifact classes in the Dadong assemblage.

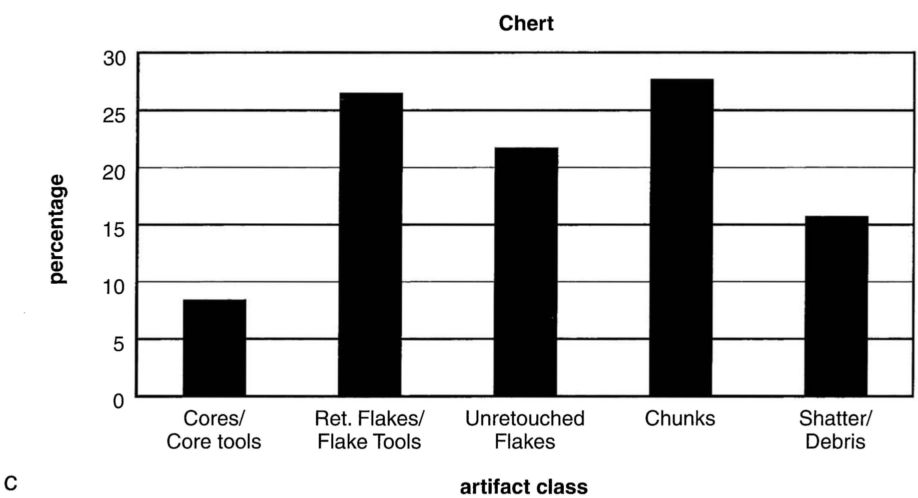
Graphic representation (Figs. 10*a–c*) of the percentage use of each raw material by lithic category shows some interesting patterns. While the choice of limestone was more frequent, it was utilized in an apparently expedient or opportunistic way compared to the other two materials. A very high percentage (60%) of chunks made of limestone are not intensively worked or carefully shaped (Table 1 and Fig. 10*a*). Basalt flakes (Fig. 10*b*) are most frequently unretouched, while chert (Fig. 10*c*) shows the highest percentage of retouched flakes and flake tools, as well as the biggest proportion of shatter/flaking debris. Core and core tools are equally represented in limestone and chert, but poorly represented in basalt. Overall, cores are scarce in this assemblage (N = 24).

There is significantly different use of raw material for the manufacture of specific artifact classes at Dadong. For example, if we examine the relationship between cores, core tools, and chunks vs. all the flake tool classes combined, the difference in the combined use of basalt and chert is highly significant (Chi-square = 125.7941 with df = 1; $p \leq 0.001$). Limestone was used 69 percent of the time to produce cores, core tools, and chunks. If basalt and chert are each compared to limestone, the difference with limestone usage is also highly significant (Chi-square = 129.0489 with df = 2; $p \leq 0.001$). The better quality material is being used to make flakes or simple tools made on flakes.

There is a conspicuous absence of hammerstones in the Dadong assemblage. Only two basalt artifacts were identifiable as possible hammerstones. In several of the Early Paleolithic localities in China and India where Leng (2001) did experimental knapping, she encountered the problem of finding suitable hammerstones of local raw material. Selected cobbles either fractured too easily or were too large to hold. At one locality, an ovate sandstone cobble resembled a retouched artifact after it had been utilized as a hammerstone, suggesting that the typological assignment of hammerstones on some raw materials is often ambiguous. The following examination of flaking technology at Dadong also sheds some light on the issue of the presence or absence of hammerstones.







Figs. 10*a*–*c*. Percentage use of raw material by artifact class.

TABLE 2. SIZE OF LITHIC ARTIFACTS BY RAW MATERIAL

	AVG. LENGTH mm	S.D.	AVG. WIDTH mm	S.D.	AVG. THICKNESS mm	S.D.
Limestone	77.8	29	60	21.6	27.3	12
Basalt	60.7	23	49.4	17.6	19	8.9
Chert	45.3	18	36.5	14.4	16.7	6.9

TECHNOLOGY

In characterizing the technology, and keeping in mind the apparent absence of hammerstones, we looked for evidence of soft hammer percussion. Antler was recovered from the deposits and hardwoods would have been available locally, based on the presence of mammalian species associated with forested areas. None of the antler, however, shows use as a billet and the characteristic type of flake made by soft hammer percussion (i.e., large flakes having small platforms with lipping) is not evident.

Table 2 provides summary data on artifact dimensions for each of the raw materials. All artifact classes are combined here to give an overall characterization of lithic size variability in the assemblage. From these data, it is apparent that there is considerable variability for all the stone types, but limestone is the most variable as it has the highest standard deviation. The chert artifacts are the least variable, probably reflecting less variability in raw nodule size. In terms of size, the mean dimensions of limestone artifacts are greater than those of either basalt or chert.

Figure 11 illustrates flake length relative to width for complete flakes and flake tools for each raw material. Both the limestone and basalt flakes show similar variable morphology and size range, whereas chert flakes exhibit less variability, reflecting the smaller nodule size of that raw material and its more exhaustive use. Considering the assemblage as a whole, short wide flakes and a lack of dorsal flake scars characterize 28 percent of all flakes, suggesting they were struck from flat natural surfaces. The overall ratio of flake length to width is 1.2 (S.D. = 0.36) indicating that most flakes have widths approximately equal to their lengths. This is consistent throughout the assemblage and there is no trend toward the elongation of flakes or the production of flake-blades in the later levels.

The differential use of resources is also evident in the reduction sequence for each of these raw materials. For example, the frequent occurrence of cortex on basalt artifacts is evident (Fig. 12). Forty-four percent of all basalt pieces show some cortex and, even more dramatically, 73 percent of the flakes and flake tools retain cortex. The number of dorsal flake scars is low and averages not more than two. The early stages of reduction are clearly represented here and basalt is not intensively reduced or shaped in the formation of tools. The scarcity of basalt cores and shatter debris is notable, and may suggest that cortical flakes were produced outside the cave.

By contrast, there are only six chert cortical flakes. Overall, chert artifacts are smaller and have more dorsal flake scars (most often 4–5). Retouched flakes and flake tools are the most numerous category of chert artifact represented. The frequency of chert shatter/flaking debris suggests production and resharpening of these tools in the cave. Therefore, later stages of the reduction sequence are well

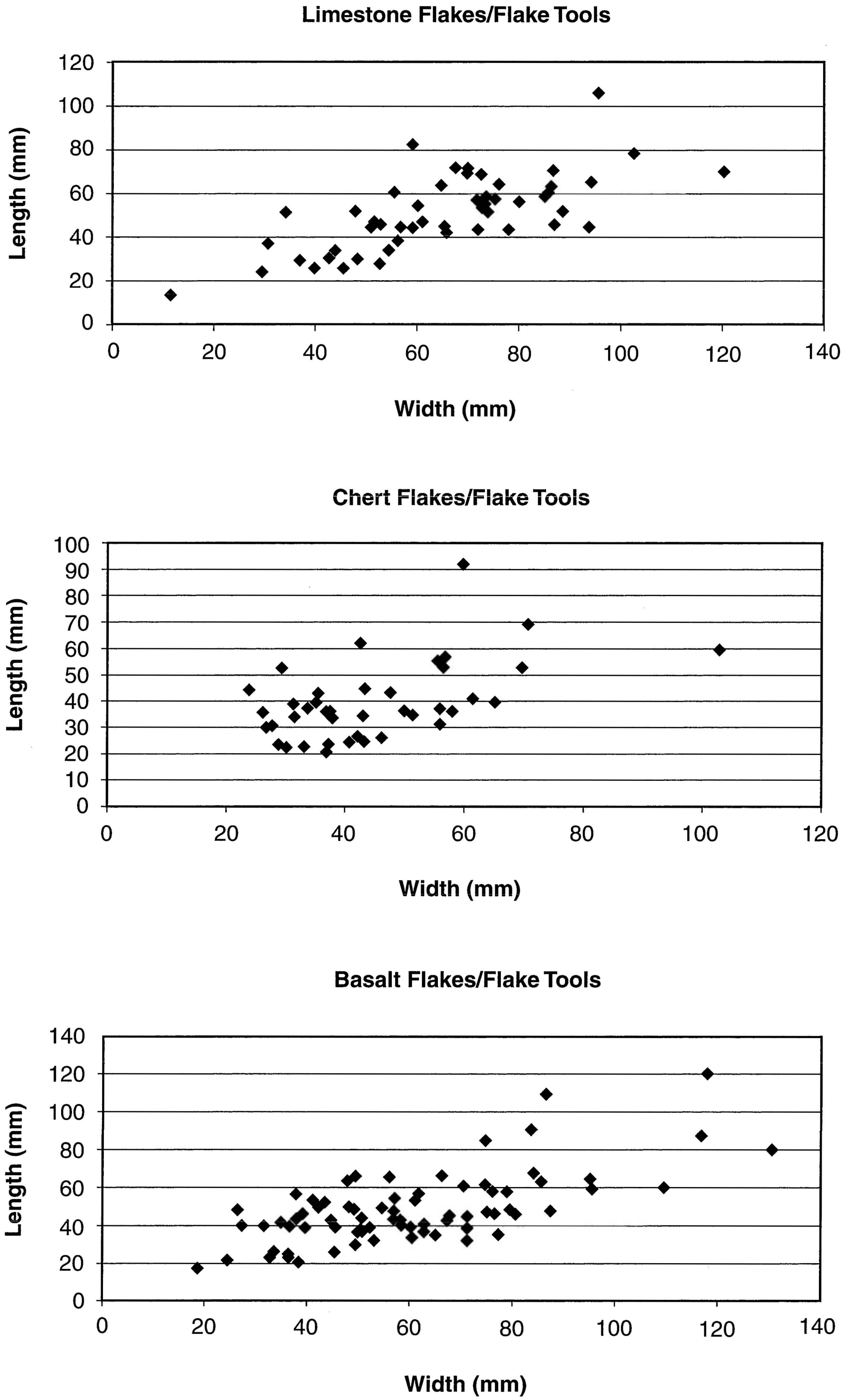


Fig. 11. Flake and flake tool length relative to width by raw material.

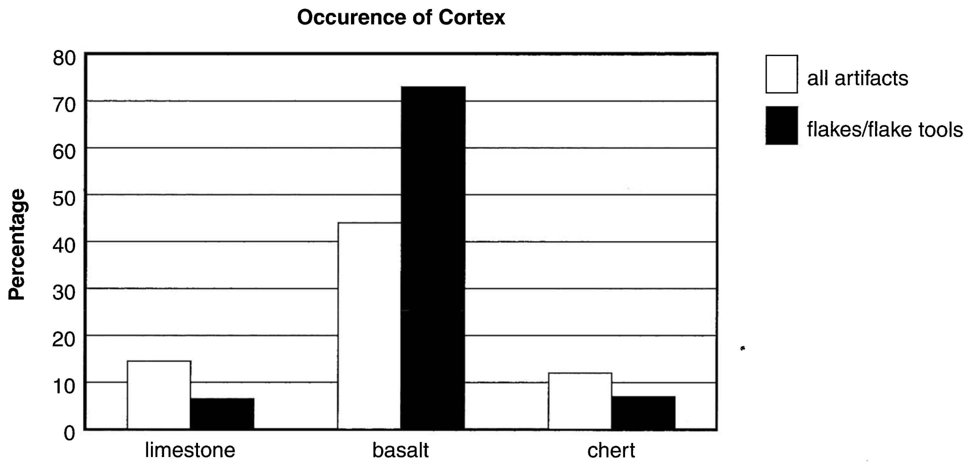


Fig. 12. Occurrence of cortex on artifacts by raw material.

represented and this material was used most intensively. With this reduction sequence in mind, we could classify the small chert scraper (Fig. 8) as a small core with final flake removal covering most of the exploitation surface, similar to the small Levallois cores recovered at Haua Fteah (Chazan 1995).

The reduction sequence of limestone artifacts is hard to recognize because flake features, like the striking platform and bulb of percussion, are not always obvious. Because of this, all limestone was conservatively evaluated. The Dadong deposits contain numerous limestone blocks and fragments derived from the cave ceiling and walls. However, the occurrence of cortex-bearing limestone flakes is low (Fig. 12). Thus, it may be that the initial flaking of limestone blocks was done outside the cave and suitably sized limestone pieces were brought into the cave and utilized expediently. Shatter/flaking debris has the smallest representation in limestone (Fig. 10*a*). This correlates with the low frequency of resharpened and reduced limestone artifacts in the assemblage.

Chinese archaeologists have suggested that the technique of anvil-chipping (block on block) was a mode of core reduction throughout the Paleolithic (Jia 1985; Zhang 1985). A replication experiment designed by Shen and Wang (2000), using quartzite from the Longyadong Cave locality, investigated criteria that could be used to identify this core reduction strategy from flake features of an assemblage. Their results are applicable to the Dadong lithic assemblage with regard to the average length-to-width ratio of flakes produced by this method. The majority of their experimentally produced anvil-chipped flakes had widths approximately equal to their lengths (average L/W ratio = 1.1; S.D. = 0.5). Additionally, they observed that this core reduction technique produced a high proportion of cortex-bearing flakes, similar to our observation for basalt artifacts. In the Dadong deposits and all over the adjacent region there are many large limestone blocks, most of which are too large for hammerstones, but they could have functioned as anvil stones. If the initial reduction of limestone was done by this technique (and outside the cave), this would explain the lack of cortex-bearing limestone

TABLE 3. RAW MATERIAL USE BY TIME PERIOD

	LIMESTONE		BASALT		CHERT	
DATE AND DEPTH	N	%	N	%	N	%
younger than 137–156 kya (96.5–95.6 m)	118	64	58	53.7	52	62.7
137–156 kya (95.5–95 m)	12	6.5	35	32.4	28	33.7
214–262 kya (94.9–94 m)	49	26.5	13	12	3	3.6
older than 214–262 kya (93.9–92.9 m)	6	3	2	1.9	0	0
Total	185	100	108	100	83	100

flakes in the assemblage and also would account for the observed short, wide flake morphology and the apparent lack of hammerstones.

RAW MATERIAL USE OVER TIME AT DADONG

Thus far, we have described two patterns of differential raw material use at Dadong involving the predominance of limestone and the different reduction sequence for each raw material. A third pattern of differential raw material use is identified when the assemblage is evaluated chronologically using four general temporal units (Table 3). The portion of the sequence dating to 137–156 kya and younger (the top two temporal units) shows a marked difference in the use of basalt and chert, which are more frequent than limestone. Fifty-seven percent of the artifacts from these levels are made of basalt and chert. In contrast, in the two oldest temporal units, only 25 percent of the artifacts are made from basalt and chert. The difference in basalt and chert use between these younger and older portions of the assemblage is statistically significant (Chi-square value = 24.7663 with df = 1; $p \leq 0.001$). If each raw material is evaulated separately, the difference is still significant (Chi-square = 27.9329 with df = 2; $p \leq 0.001$) with the overall use of limestone decreasing relative to chert and basalt over time.

Hence, at Dadong it appears there is a dramatic difference in raw material selection and utilization over a chronological span of approximately 100,000 years. We can further illustrate this by examining the temporal distribution of retouched flakes and flake tools. These tools require the most effort to produce and resharpen. Retouched flakes and flake tools are evenly represented in the three raw materials (for limestone, N = 26; for basalt, N = 23; and for chert, N = 22), but their distribution over time is quite different. The Dadong hominids made retouched flake and flake tools throughout the sequence. In the early levels, most of them are made of limestone (68%). However, 78 percent (N = 55) of the retouched flakes and flake tools come from the younger levels, where only 20 percent are limestone. There is a significant relationship between time level and raw material for this class of artifact (Chi-square = 9.1870 with df = 1; $p \leq 0.01$). This reflects the more frequent use of basalt and chert to make retouched flakes and flake tools in the later portion of the sequence, rather than a technological distinction between the levels. There are differences in the frequency of stone tools throughout the sequence that are discussed below.

DISCUSSION

The range of faunal and vegetal resources that is available for hominid exploitation is obviously linked to prevailing climatic conditions. Similarly, technological needs depend on available natural resources. At Gran Dolina, researchers identified both clear technological distinctions and differences in selection and management of lithic raw materials between the chronologically distant TD6 and TD10A levels (Carbonell et al. 1999; Martinez 1998). Mallol (1999) proposes that cultural and biological factors account for these observed diachronic changes. If similar factors were at work in Dadong, we would expect that the older and younger levels would be technologically distinct. This is not the case. At Dadong, there are no sterile levels in the sequence and we have not identified discrete periods of occupation analogous to the divisions at Gran Dolina. However, we see a marked increase in the frequency of artifacts and a decrease in the relative use of limestone in the two younger time units (Table 3) that correlates with the culmination of OIS 6 and transition to OIS 5. This indicates both a change in cave use and a change in the preferential use of basalt and chert at this time that is not associated with any cultural (typological) change. We would expect the cave to be used more intensively during the climatic culmination of OIS 6. If a colder, dryer episode lowered river levels, it may have increased the visibility of nodular cherts and basalts along these water courses and facilitated their selection for tool manufacture.

Studies of lithic raw material use by the Sierra de Atapuerca researchers also offer a broader comparative perspective especially useful for reconstructing occupational models in karst environments (Martinez 1998). Three localities, TD6 (Gran Dolina), TG11 (Galeria), and TN (Tres Simas Boca Norte), have sample sizes comparable to Dadong and the lithic raw materials utilized at these localities were locally available in varying degrees of abundance. One of the sites, Galeria, provides an interesting comparison with our Dadong study. Reported dates for Galeria are 350–118 kya, roughly contemporaneous with Dadong. The deposits are interpreted as a sequence of superimposed hominid occupations devoted to primary and secondary processing of animal carcasses (Carbonell et al. 1999; Martinez 1998). This interpretation is based upon the following characteristics of the lithic assemblage. Common to the three Atapuerca sites is the preferential use of neogene and cretaceous flint to produce retouched flakes and flake tools. At Dadong, chert is used in this manner. In the Galeria assemblage, unretouched flakes of flint also occur in high frequency (47% of the flint artifacts), and Martinez (1998) suggests that they may have been intentionally struck as cutting tools since they have a high potential for this use, as demonstrated by several use-wear and butchery experimental studies (Jones 1980; Keely 1980). The basalt at Dadong seems to have been used in a similar way—that is, primarily to produce simple flakes. The increased use of basalt and chert relative to limestone in the younger levels of Dadong correlates with the highest frequencies of cutmarks, percussion damage, and burnt bone (Schepartz et al. 2003). This suggests that, as at Galeria, differential selection of raw material might be related to animal carcass processing.

Heavy-duty tools at all three of the Atapuerca localities were selectively made on sandstone and quartzite. Like the limestone artifacts at Dadong, the sandstone tools at Galeria show a lesser degree of modification than quartzite tools. Martinez (1998) suggests that these tools were selectively made of the poorest quality material because their functional uses, such as violent incision or percussion, made them especially prone to breakage. They were expendable because they were made of the most easily obtainable, abundant raw material and shaped with the least amount of effort. So, while the heavy-duty tools appear to be technologically and typologically opportunistic, the behavior that guided the selection of raw materials for the suite of implements at these localities was far from opportunistic, involving instead forethought and planning—a strategy that can be called "economical." We identify a similar strategy at Dadong. Easily obtained and abundant limestone was most often used to produce heavy-duty implements that were not carefully shaped, while the basalt and chert were increasingly used for tasks requiring finer edges.

The cave of Guanyindong, located 180 km northeast of Dadong (Fig. 1), provides an appropriate contemporaneous regional comparison where the use of lithic raw material has some similarities and differences with the patterns we have described. Shen (1993) reports U-series dates of 100–190 kya for the late Middle Pleistocene deposits at this cave. Guanyindong toolmakers selectively obtained chert nodules from a source approximately 4 km from the cave. Although limestone was readily available at Guanyindong, it has brittle properties and was not used for toolmaking. The chert nodules were intensively utilized (as they are at Dadong) with two or three working edges present on each tool, and almost all flakes show use or retouch in the form of steep scars (Leng 2001). In contrast to Dadong, cores were relatively numerous at Guanyindong. Their abundance suggests that they were being reduced in the cave—a pattern opposite to what we observe at Dadong. At both sites, hammerstones are scarce. Leng (2001) explains the absence of hammerstones by suggesting that perhaps they broke into pieces that were easy to trim into tools (a subsequent phase of reduction). For this or other reasons, such as use of the anvil technique discussed above, hammerstones are poorly represented in the Dadong assemblage.

The use of raw material at Dadong can also be compared with Zhoukoudian Locality 1. As discussed above, there is evidence for selection of better quality raw material that correlates with technological change (increased standardization of tool form) at Locality 1. At Dadong, while the better quality raw materials are selected more frequently in the later levels, this is not accompanied by a change in typology or flaking strategies.

CONCLUSIONS

The use of lithic raw material at Dadong shows three distinct patterns. An abundant but poor quality limestone predominates the tool assemblage. The Dadong hominids responded to the challenge of this material by using it for tools that required less effort to produce, and perhaps using them in expendable ways. Second, there is a significant correlation between raw material and tool typology. Basalt is most often used to make unretouched flakes, chert is most commonly used for retouched flakes and flake tools, and limestone artifacts are most frequently classified as chunks. Third, raw material use changes over time. The proportion of basalt and chert increase in the later levels and they are used to make retouched flakes and flake tools. These changes in raw material usage correlate with a colder climatic regime and may relate to the intensified use of the cave for animal carcass processing and shelter. The contrasts in raw material selection seen at Chinese Middle Pleistocene localities illustrate the diverse ways hominds in Asia managed their natural resources.

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ABSTRACT

The possibility of selective use of lithic raw material in the Middle Pleistocene cave deposits of Panxian Dadong is examined in order to evaluate hominid strategies of resource management. Limestone, chert, and basalt, available in or nearby the cave, were differentially used for the production of tools and unretouched flakes. Limestone was predominantly used to produce expedient tools, unretouched flakes were most commonly made of basalt, and chert was most frequently used to produce retouched flakes and tools. Patterns in the reduction sequence for each raw material also indicate that these lithic resources were selectively used. The early stages of core reduction are clearly represented in basalt flakes, whereas chert artifacts exhibit the later stages of tool production and the greatest degree of resharpening. When the selection of raw material is examined through time, over a span of more than 100,000 years, two patterns are clear. The proportion of chert and basalt and the overall frequency of artifacts increases. These changes in the frequency and selection of raw material occur without a techno-typological change. The major shifts in raw material usage correlate with a colder climatic regime and may relate to the intensified use of the cave for animal carcass processing and shelter. Keywords: Middle Pleistocene, lithics, reduction sequence, hominid.