LANDSCAPES, ACTIVITY, AND THE ACHEULEAN TO MIDDLE PALEOLITHIC TRANSITION IN THE KALADGI BASIN, INDIA

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Abstract

Renewed archaeological surveys were conducted in the southern margin of the Kaladgi Basin, Karnataka, India. These surveys identified a 10 km long distribution of Paleolithic assemblages along the base of quartzitic bedrock, presenting a novel situation for archaeologists working in the Indian subcontinent. Test excavations in several places recorded separable landscape segments containing typologically distinct stone tool assemblages, classifiable as a late Acheulean and an early Middle Paleolithic. The Acheulean assemblages were characterized by a biface industry with handaxes and cleavers and the Middle Paleolithic assemblages were composed of a prepared core-flake industry with diminutive bifaces. The Acheulean assemblages occurred as a “stone line” surface, in association with springs, and sealed between a nodular laterite and a latosol. The Middle Paleolithic assemblages were associated with latosols. Occupations were marked by the reduction of quartzite clasts procured along bedrock and colluvial exposures, establishing a significant behavioral pattern for the Indian Paleolithic. The current research provides new information about the Lower to Middle Paleolithic transition in Peninsular India and reports on a particular environmental context sought and used by hominins.

INTRODUCTION

A considerable amount of paleoanthropological research has been devoted to the biological and behavioral meaning of the Middle to Upper Paleolithic transition (e.g., Mellars and Stringer, 1989; Mellars, 1990). Certain researchers, however, have asserted that models of modern human origins are misguided because of the inordinate level of attention placed on the European evidence, and moreover, the roots of modern human behaviors extend deeper in time (e.g., McBreartey and Brooks, 2000). Fortunately, investigators have begun to place more emphasis on the Middle Pleistocene record across the globe (e.g., Petraglia and Korisettar, 1998; Barham and Robson-Brown, 2001; Straus and Bar-Yosef, 2001). A key behavioral shift that occurs during the late Middle Pleistocene is the reorganization of technology from a large biface industry of the Acheulean to a small flake tool industry of the Middle Stone Age, dated to about 300–250 ka in Africa (McBreartey and Brooks, 2000). Moreover, adoption of this “Mode 3” technology in Africa has been connected with a speciation event and the subsequent dispersal of modern humans to other continents (Lahr and Foley, 1998, 2001). Given the importance of these late Middle Pleistocene events, the archaeological record of other substantial geographic regions of the Old World, including the Indian subcontinent, should be of comparative interest to paleoanthropologists.

Archaeologists working in the Indian subcontinent have identified a substantial Middle and Late Pleistocene record in open air and rockshelter contexts (e.g., Paddayya, 1984; Misra, 1987;...
Mishra, 1994; Korisettar and Rajaguru, 1998; Petraglia, 1998, 2001; Kennedy, 2000; Korisettar, 2002). Paleolithic sites are known to occur in various physiographic zones, and are found in sub-mountainous regions, lowland basins and valley settings, and along coastal margins. Radiometric dating confidently places Lower Paleolithic occupations in the Indian subcontinent at the middle part of the Middle Pleistocene (Korisettar and Rajaguru, 1998; Petraglia, 1998, 2001). Lower Paleolithic sites have been identified in a range of paleoecological and geomorphic contexts (e.g., Misra, 1987, 1989, 1995; R. S. Pappu 1995, 2001). Like Lower Paleolithic assemblages in other geographic regions of the Old World, the Indian Lower Paleolithic is primarily known by a suite of tool types typical of the Acheulean Industrial Complex (i.e., handaxes, cleavers, choppers, knives; e.g., Sankalia, 1974; Misra, 1987, 1989). A temporal change in Indian Acheulean biface assemblages has been proposed because later assemblages are marked by refined flaking through soft hammer percussion and consistent use of prepared core techniques (Misra, 1985, 1987, 1989). Settlement studies show that Lower Paleolithic sites occur in different ecological contexts (Paddayya, 1982a; Jacobson, 1985), in stratigraphic succession (Misra, 1987, 1995, Petraglia et al., 1999), and show activity variations (e.g., Paddayya and Petraglia, 1993; Petraglia, 1995; Jahidin, 1997; S. Pappu 1999).

The Indian Middle Paleolithic is encountered in various physiographic settings, and stone tool assemblages sometimes occur in alluvial settings and rockshelters (e.g., Sankalia, 1974; Misra, 1989; Sali, 1990). Although the radiometric age range of the Middle Paleolithic remains problematic, available dates in one stratified context definitively places the industries between 30 and 144 ka (Misra, 1989). The Middle Paleolithic is characterized by prepared core techniques, diverse flake tools (i.e., scrapers, points, borers), small bifaces, and tool manufacture on crypto-crystalline materials. Certain assemblages are thought to represent an early stage of the Middle Paleolithic since they share continuity with the Acheulean in the persistence of certain tool forms (e.g., diminutive handaxes and cleavers; Misra, 1985, 1989). Increased geographic diversity in Middle Paleolithic stone tool composition has been postulated, with a Luni industry in northwest India and a Nevasan in the central and southern portions of the country (Misra, 1967; Allchin and Allchin, 1989). Differences among assemblages are shown in variable percentages of tools, with Luni industries displaying a large proportion of flake tools and some small bifaces, and the Nevasan consisting of relatively low numbers of flake tools on crypto-crystalline materials (Allchin and Allchin, 1989).

While the broad outlines of the Indian Paleolithic record have been established, many past investigations have unfortunately relied on the study of surface finds and naturally sorted assemblages, thereby providing little information about hominin behavior (Petraglia, 1995). Given this state of research, renewed investigations in India are needed to identify more secure depositional contexts and stratigraphic sequences, allowing researchers to better document technological changes and behavioral activities. The current archaeological investigations were conducted to explore potential relationships between depositional environments and technological change in a single well-known basin of southern India.

KALADGI BASIN INVESTIGATIONS

The Kaladgi Basin was chosen for investigation as previous surface surveys showed that the area preserved Quaternary deposits and Paleolithic localities. Artifact-bearing locales were first recorded in the Kaladgi Basin during the nineteenth century (Foote, 1876). After a seventy-year hiatus, a survey in the 1950s was conducted along a 160 km stretch of the Malaprabha River, where 20 Acheulean sites were identified (Joshi, 1955). One of these locales, the Khayd site, contained several hundred bifaces, indicating the substantial nature of the archaeological assemblages. Additional surface surveys in the Basin showed that Lower and Middle Paleolithic sites in the region were present (e.g., Malwad and Sankalia, 1956; Banjere, 1957; Joshi, 1987). The most intensive survey in the Kaladgi Basin was undertaken between the 1960s and 1980s by R. S. Pappu, who recorded 74 Acheulean and 191 Middle Paleolithic sites along the margins of the Malaprabha and Ghataprabha rivers.
(R.S. Pappu, 1981, 1984). Subsequently, geomorphic studies were performed to outline the history of Quaternary sedimentation and to map sequences (Deo, 1991). The regional information was synthesized, and included discussion of Quaternary landforms, alluvial stratigraphy, paleoclimates, and archaeological sites (Pappu and Deo, 1994). Acheulean assemblages were found to contain handaxes and cleavers whereas Middle Paleolithic assemblages featured diagnostic cores and flake tools (e.g., scrapers, points, borers). Quartzite was the favored raw material for the Acheulean and chert predominated in the Middle Paleolithic assemblages. Although the surface surveys established a framework for human occupation, investigations were mainly confined to the river margins. The depositional contexts of particular sites were not well-studied and stone tool assemblages were not analyzed in any level of detail.

In 1993, a preliminary survey was conducted in the Malaprabha Valley (Korisetty and Petraglia, 1993). The goal was to re-identify key locations and examine their depositional contexts. Baseline field observations confirmed that a Quaternary stratigraphy was preserved in the valley, dominated by an extensive lateritic surface overlain by calcrites, silts, and clays. Based on preliminary sedimentary sequences and geoarchaeological observations, it was realized that Paleolithic assemblages exposed in the Malaprabha River bed were not necessarily in a paleostream setting as had been presumed by earlier workers (Korisetty et al., 1993). Instead, the Malaprabha River localities were typically situated on a series of ancient coalescent fans that were intersected by a more recent (Terminal Pleistocene) channel incision. Furthermore, surveys in the region indicated the prevalence of extinct springs and lakes. These preliminary observations indicated that additional surveys were needed to systematically explore the relationship between depositional environments and artifact distributions.

LAKHMAPUR LOCALITY:
SETTING AND ARCHAEOLOGICAL INVESTIGATIONS

In 1995, further archaeological surveys were conducted in the vicinity of the modern village of Lakhmapur (75° 37' E, 15° 52' N; Fig. 1). The study area traversed a piedmont coalescent fan complex whose drainage lines flow north into a tributary of the Malaprabha, the Saraswati Halla. The fans drained the foothills of the Kaladgi escarpment, the most prominent topographic feature of the landscape. The Kaladgi escarpment consisted of an east-west trending quartzite ridge, rising to a crest of 730 m, with local plateau elevations ranging from 600–650 m. Lakhmapur village is located at a structural break in the ridge (where a modern railway line passes; Fig. 1). The quartzites comprising the ridge are Proterozoic in age, and belong to the basal Bagalkot Group of the Kaladgi Supergroup. The quartzites are composed of 98 percent silica, although they are of variable textures.

The sites under investigation are clustered within the fan complex north of the Kaladgi escarpment and substantially removed from the flood belt of the Malaprabha River (Fig. 1). Accordingly, they are presumed to be removed from Pleistocene and Holocene fluvial transport or sorting processes. The upper slopes of the north trending coalescent fans were capped by colluvium. North and west of the ridge, the northern slopes merged with an extensive lateritized peneplain surface. The topography became increasingly subdued as the peneplain graded down to a lower-lying basin segment, where elevations were at their lowest, ca. 560–540 m. The laterised peneplain was subject to long-term erosion, resulting in segmentation of exposed and buried surfaces. The most extensively exposed or exhumed-surface was an eroded latosol. The latosol was discontinuously buried by a 0.1–0.4 m thick veneer of “black clay”, apparently representing a residual deposit of former drainages. A series of subsurface sediment bodies provided the stratigraphic contexts for the archaeological assemblages.

A significant finding of the survey was the identification of Paleolithic artifacts spread over a 10 km stretch along the northern side of the east–west trending ridge. In places, the surface distributions were accompanied by buried assemblages observable in modern burrow pits and road cuttings dug by local villagers. The discovery of a laterally extensive stone tool distribution was a milestone for the Kaladgi Basin surveys as no other spatial pattern like this had been previ-
Fig. 1. Surface geology, Lakhmapur Archaeological Site Complex. Principal excavation areas noted by circles. Note that Lakhmapur West, Lakhmapur East, and Benkaneri are located along different landform segments.

ously reported. Based on the identification of widespread and buried deposits along the 10 km stretch, test excavations were conducted in 1997. Two separate areas were chosen for more intensive work, Lakhmapur West, 1.0 km northwest of the village, and Lakhmapur East, 2 km northeast of the village. A third artifact-rich locality, Benkaneri, was tested (in the 2000 season), along
### Table 1

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
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</table>
| I    | Upper latosol (0.0–0.2 m)  
2.5 YR4/6 loose matrix of poorly sorted and gritty fine sands plowed at top half of deposit; Middle Paleolithic artifacts. Interspersed with firm, small, subangular blocky clays; organic staining; diffuse and wavy lower boundary. |
| II   | Lower latosol (0.2–1.2 m)  
2.5 YR4/4 to 2.5 YR4/6 cohesive matrix of moderately compacted (compound) moderate to coarse peds of angular blocky clay-sands; pisolithic ferricrete nodules (ca. 5 percent by volume) interspersed in matrix but increase with depth; ferragullaceous coatings around clay peds; clear and wavy lower boundary. Latosol interdiggitses with calcareous matrix and tufaceous blocks. |
| III  | "Stone line" (1.2–1.5 m)  
2.5 YR4/4 clast supported porous matrix of stones (ca. 90 percent by volume) with loose to firmly packed sands, silts and clays; Acheulean assemblages, stones are quartzite artifacts (6–90 mm along major axis) and pisoliths, irregularly and weakly cemented; nodular pisoliths are lustrous and slightly pitted; sharp and smooth lower boundary. |
| IV   | Upper nodular laterite and basal tufa (1.5–3.2 m)  
2.5 YR4/6 coarse sands, dense ferricrete filaments and pisoliths (ca. 65 percent by volume), and quartzite debitage, artifacts and debris; matrix is laterally and vertically interdigitated to base with discontinuous tufa blocks and tufaceous cements (5 YR6/6) and concretions (7–12 mm) formed around root casts (up to 40 percent of matrix by volume); clear and wavy lower boundary. |
| V    | Lower indurated laterite (3.2–>4.8 m at base of exposure)  
10 YR4/6 cemented beds of lateritic sands and decaying rubble from underlying bedrock (saprolite); beds inclined at 32° to SSE. |

The western portion of the transect, at the foot-slope of the Kaladgi escarpment, Benkaneri preserved Middle Paleolithic artifacts in a colluvial sediment matrix, thereby furnishing additional information about the landscape stratigraphy. The goals of the testing program were to establish stratigraphic sequences, depositional environments, and landform contexts, and to classify the stone tool assemblages for typo-technological successions and behavioral analysis.

### Lakhmapur West

During initial inspection of Lakhmapur West, Acheulean artifacts were readily observable in modern burrow pits dug by local villagers. The walls of a large burrow pit showed that a buried Acheulean surface extended semi-continuously for at least 100 m north–south and 50 m east–west. Four separate blocks, composed of a total of thirteen one-meter square units, were subsequently placed in the area to test the disposition of the artifact-bearing surface. One block, consisting of five one-meter units, was particularly productive as it produced a diverse assemblage containing tools and debitage. The stone tool assemblages, as observed in the profile of the burrow pit and in the excavated units, were typologically and technologically consistent with the Acheulean.

#### Stratigraphy

The stratigraphic profile identified at Lakhmapur West was significant as it showed the presence of successive Acheulean and Middle Paleolithic assemblages, associated with particular sedimentary environments (Fig. 2; Table 1). A prominent feature of the profile was the semi-continuous "stone line" (Unit III) surface composed of Acheulean assemblages. Unit III was ca. 1.2 to 1.5 m below surface and about 20–30 cm thick. The stone line was preserved between the indurated laterite (Unit V) and the
lower latosol (Unit II), in association with tufaceous deposits (Unit IV). The stone line of Unit III was dominated by quartzitic clasts measuring ca. 40–50 mm in diameter of which ca. 15 percent were Acheulean artifacts; non-cultural stones consisted of nodular, lustrous pisoliths, 3–6 mm in size. The cultural materials in Unit III were not separable (laterally or vertically) from the nodules. In viewing the sequence as a whole, the Acheulean assemblages (Unit III) represented a disconformity between the nodular and indurated laterite deposits of Units IV and V and the latosols of Units I and II, with the latter defining the more recent component of a composite weathering profile.

**Acheulean Assemblage**

Five contiguous excavation units produced a total of 151 quartzite artifacts from the stone line surface (Table 2). The relatively low artifact density was consistent with the laterally extensive, but thin (one to two artifacts thick) stone line that could be observed in the walls of the villager’s burrow pit.
Table 2
Paleolithic assemblages recovered from the Lakhmapur locality

<table>
<thead>
<tr>
<th>Artifact Category</th>
<th>Lakhmapur East No. (%)</th>
<th>Lakhmapur West No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handaxe</td>
<td>14 (9)</td>
<td>11 (7)</td>
</tr>
<tr>
<td>Cleaver</td>
<td>1 (.5)</td>
<td>3 (.2)</td>
</tr>
<tr>
<td>Chopper</td>
<td>--</td>
<td>3 (.1)</td>
</tr>
<tr>
<td>Tabular Piece</td>
<td>2 (1.5)</td>
<td>--</td>
</tr>
<tr>
<td>Uniface/scaper</td>
<td>2 (1.5)</td>
<td>9 (.5)</td>
</tr>
<tr>
<td>Borer</td>
<td>--</td>
<td>3 (.2)</td>
</tr>
<tr>
<td>Point</td>
<td>--</td>
<td>1 (.1)</td>
</tr>
<tr>
<td>Biface on Flake</td>
<td>--</td>
<td>3 (.1)</td>
</tr>
<tr>
<td>Regular Core</td>
<td>17 (11)</td>
<td>47 (3.1)</td>
</tr>
<tr>
<td>Prepared Core</td>
<td>2 (1.5)</td>
<td>15 (.8)</td>
</tr>
<tr>
<td>Pyramidal Core</td>
<td>1 (.5)</td>
<td>4 (.2)</td>
</tr>
<tr>
<td>Flake</td>
<td>111 (73.5)</td>
<td>1,593 (93.6)</td>
</tr>
<tr>
<td>Struck Flake</td>
<td>--</td>
<td>6 (.3)</td>
</tr>
<tr>
<td>Hammerstone</td>
<td>1 (.5)</td>
<td>3 (.2)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>151 (100)</td>
<td>1,701 (100)</td>
</tr>
</tbody>
</table>

Bifacial Tools

A total of 11 of the 14 handaxes were whole, ranging from 7 to 17 cm in length. The handaxes fell into four main shape categories, including ovate (n=5; Fig. 3.1), long ovate (n=2), discoidal (n=2; Fig. 3.2) and pointed (n=2; Fig. 3.3). The two discoidal handaxes were similar to each other in dimensions and attributes. One was made on a flake and the other was fashioned on a thin tabular piece as there was cortex on both sides. One of the pointed handaxes was flaked on one side, yet the opposite side was a ventral flake surface exhibiting no flaking. Despite the fact that most of the handaxes retained cortex, they were finely flaked as indicated by the high number (mean=19) of negative flake scars. The single cleaver was made on a cortical flake (Fig. 4).

Other Tools

The two unifaces were manufactured on flakes. The two tabular pieces had similar dimensions and both were nearly fully cortical, with each showing five and eight flake scars along their perimeters (Fig. 5). The single hammerstone was a fully cortical cobble that displayed heavy battering at one end.

Cores

The 20 cores were variable in size (16 cobbles and four pebbles) and shape: subround (n=11); tabular (n=5); angular (n=3), and; round (n=1). All cores displayed cortex, but the cortical percentage varied widely, from 10 to 80 percent. Certain cores were intensively flaked as evidenced by low cortex percentages (9 cores had less than 25 percent cortex) and high flake scar counts (6 cores had more than 10 flake scars).
Four cores were tested, showing a higher cortex percentage (greater than 60 percent cortex) with low flake scar counts (2–4 flake scars). The largest core (16×2×10 cm) displayed parallel flakes at the distal end to produce a bifacial tip. The smallest core measured 5×5×3 cm. Two prepared cores and a pyramidal core had evidence of systematic and controlled flaking. The cores were flaked along their perimeters, and along one main surface, each displaying a negative flake scar indicative of a struck flake. Overall, the core technology indicated some degree of flexibility in the working of the cobbles and pebbles; some were minimally flaked while others displayed more deliberate preparation.

Flakes

Of the 111 flakes, 19 retained cortex (nine had cortex on the dorsal surface and platform, seven had cortex on the dorsal surface, and three had cortex on the platform). While a range of flake sizes was found, there was a relatively diminished percentage of flakes 2 cm or less in size, and a larger relative percentage in the 3–7 cm range. The relatively high proportion of larger sized flakes was probably not a direct reflection of manufacturing activity, but rather consistent with a model for “stone line” evolution (see discussion below), where artifacts appear to be locally sorted and rearranged by post-depositional processes. The large flake component and the evidence for cortical pieces corroborated the notion that local stone tool manufacturing occurred in the area. This is consistent with the core data that indicated local reduction of cobbles and pebbles. None of the flakes was diagnostic of any particular reduction technique other than percussion flaking; the sole exception was a single struck flake indicative of the prepared core technique.

Lakhmapur East

Middle Paleolithic assemblages were initially identified as a buried surface along a road cut at Lakhmapur East. The excavations were conducted in two separate areas (Blocks 1 and 2) along the distal (piedmont) margin of the lower peneplain. Six 1×1 m² units were excavated in Blocks 1 and 2 (3 units each).

Stratigraphy

Block 1 was placed 1 km north of the ridge, at the interface of the footslope and the coalescent fan. Excavation exposed a “black clay” (or “Paleoverisol”/Unit II) resting unconformably above a nodular laterite (Unit III; Table 3).

Fig. 4. Cleaver on a cortical flake, Lakhmapur West
Distributions of Middle Paleolithic artifacts were largely diffuse and extended from the “black clays” (Unit II) to the top of the nodular laterite, Unit III. The “black clay” of Unit II produced an uncalibrated radiocarbon determination of 8,190±90 B.P. (Beta–104890), indicative of sedimentary reworking during the Early Holocene. The artifacts in Units II and III were rounded, probably a consequence of long-term exposure and weathering across the formerly eroded pediment plain prior to later burial.

Block 2 was placed 1.5 km north of the ridge, at the distal margin of the coalescent fan. Middle Paleolithic assemblages were buried by a latosol (Unit II; Table 4). The artifacts occurred in a laterite (Unit III), resting on top of the indurated portion of the section (Unit IV). The artifacts typically had sharp, fresh edges and occurred in high density (567 artifacts/m²), with a high percentage of small pieces of debitage (nearly 50 percent were less than 2 cm). The pronounced integrity of the Block 2 assemblages was consistent with a location at the distal margins of the piedmont slope, further removed from peak hillslope activity and sediment mobilization.

Middle Paleolithic Assemblage

Block 2 produced a total of 1,701 artifacts (Table 2). Flakes (93.6 percent) comprised the majority of the assemblage, with diminutive handaxes and cleavers accounting for a small, but typologically important component. Nearly all of the assemblage was produced from quartzite (99.7 percent) with only six pieces of chert (0.3 percent; one scraper and five flakes were from the underlying Unit IV chert-breccia). One of the cleavers was moderately large (15×11×4 cm) although two were small (mean=10×7×3 cm), one made on a cobble, and the other two were made on flakes (Fig. 6). Scrapers, borers, and points (Fig. 7) occurred in low frequencies. The choppers showed minimal flaking, but flaking occurred on two sides of the cobbles. Three bifacial pieces were on flakes, but these had few flake scars and the pieces displayed cortex, showing that they were not completed to a particular form. All four hammerstones were cobbles.

Handaxe shapes were of four types, including ovates (n=7; Fig. 8.1), pointed (n=2; Fig. 8.2), discoidal (n=1), and triangular (n=1). One of the handaxes retained cortex on most of one side (similar to the handaxe in the Acheulean assemblage which displayed single-side flaking). The bifaces varied with respect to the degree to which they were shaped, as indicated by cortex percentages and negative flake scar counts. Two handaxes had no cortex, while the remainder retained cortex; seven fell within the 10–25 percent range, and two displayed 40 percent cortex.
Stratigraphy of Lakhmapur East, Block 1

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
</table>
| I    | "Plow zone" in upper black clays (0.0–0.15 m)  
7.5 YR4/3 heterogeneous matrix of gritty sands and clays; structures are weak, subangular blocky; cobbles and stones abundant; roots are common and fibrous; occasional sedimentary nodules (reworked from upslope soils); secondary carbonates ("kankars") at base; clear and smooth lower boundary. |
| II   | Black clay ("Paleovertisol") (0.15–0.85 m)  
7.5 YR4/2 to 2.5 YR4/6 columnar to coarse prismatic, firmly structured black clays with thick (1–2 mm) sandy veins; few stones and roots; diffuse sedimentary inclusions (disaggregated ferricrete nodules); abundant organic films/clay skins (organans); carbonate filled root casts at base; shrink-swell structures account for diffuse artifacts; sharp and smooth lower boundary. |
| III  | Nodular laterite (0.85–1.20 m at base of exposure)  
2.5 YR4/4 to 4/6 medium-coarse friable to moderately cemented sands and consolidated clays with dense ferricrete filaments and pisoliths (ca. 35 percent by volume; 3–6 mm size range); extensive oxidation-reduction streaking (5 YR5/6) at ped interfaces. Laterite contains quartzite boulders. |
| IV   | Weathered Kaladgi Quartzite Bedrock |

The number of negative flake scars ranged from a low of 12 (on four bifaces) to a high of 28 and 30 on two finely flaked bifaces. The tools were relatively small, with lengths ranging from 8–13 cm (mean=10), and narrow widths (mean=7 cm) likely reflecting the use of thin flakes for manufacture.

**Cores**

Sixty-six cores densely distributed cores were recovered. The cores were subdivided into three main types: regular, prepared, and pyramidal.

- Regular cores. The 47 regular cores varied in size and morphology; 34 were produced on cobbles and 13 on pebbles. Original shapes of natural clast were maintained on many cores, with sub-round being the most common (n=32), followed by tabular (n=9), angular (n=3), and round (n=3). With the exception of four cores, all others preserved some percentage of cortex. Cortical percentages varied from five to 75 percent, with an average cortical percentage of 35 percent. Some of the cores were heavily flaked as shown by the low remaining cortex percentage (22 cores had less than 25 percent cortex) or the high flake scar count (20 cores have greater than 10 flake scars). Other cores were tested pieces, showing a larger cortex percentage (16 cores had greater than 50 percent cortex) or few flake removals (nine exhibited five to six flake removals). The regular cores indicated some degree of flexibility in the working of the cobbles and pebbles to various states of completion.

- Prepared cores. The prepared cores were systematically flaked (Fig. 9). Nearly every core displayed continuous flaking along its entire perimeter. Once the cores were prepared, they were sometimes struck to obtain individual flakes or core segments that could in turn be used as tools (Fig. 10). While the sizes of the prepared cores varied (e.g., lengths ranged from 5 to 9 cm), the average length to width ratio was 1:1.2 indicating that the pieces ranged from nearly round to oval. The cores usually had some remnant cortex, but this was generally low. One exception was a core with 25 percent cortex. This was considered an early stage piece as it showed no flaking on one half of one side of the piece.

- Pyramidal cores. The pyramidal cores were byproducts of a prepared core flaking technique. Each of the four cores had a flat ventral surface and a steep and keeled dorsal surface. Flake angles ranged from 60 to 80 degrees. The dorsal surfaces showed flaking around the perimeter, with number of flake removals ranging from four to six. Cortex occasionally remained on the dor-
### Table 4

**Stratigraphy of Lakhmapur East, Block 2**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
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<tbody>
<tr>
<td>I</td>
<td><strong>Upper latosol sediments (0.0–0.1 m)</strong>  &lt;br&gt;2.5 YR3/4 friable to weak, sub-angular blocky gritty fine and medium sands; abundant, well-rounded pebbles (2–5 mm); roots and root casts with organic inclusions; sharp and smooth lower boundary.</td>
</tr>
<tr>
<td>II</td>
<td><strong>Lower latosol (0.1–0.35 m)</strong>  &lt;br&gt;2.5 YR3/3 weak sub-angular blocky to friable clay-sand with ferricretes and manganese filaments, largely disaggregated (2–7 mm size range, 25% by volume); clear, smooth lower boundary. High density of Middle Paleolithic artifacts; sharp artifact edges.</td>
</tr>
<tr>
<td>III</td>
<td><strong>Nodular laterite (0.35–0.5 m)</strong>  &lt;br&gt;2.5 YR3/4 weak to moderately subangular blocky clay sands, subhorizontally bedded; loose to indurated matrix with ferricretes and manganese nodules, densely packed; clear, wavy lower boundary.</td>
</tr>
<tr>
<td>IV</td>
<td><strong>Chert breccia and indurated laterite (&gt;0.5 m)</strong>  &lt;br&gt;Cemented and consolidated calcareous cement with spongy fabric.</td>
</tr>
</tbody>
</table>

![Diagram of artifacts]

**Fig. 6.** Diminutive cleaver, Lakhmapur East

...surface, but this was limited to about 10 percent. Three were of the same size (mean=7×5×4 cm), and one was much smaller (4×4×3 cm). One of the larger cores had a few additional flaking attempts on the flat dorsal surface.

**Flakes**

Of the 1,599 flakes, 246 (15 percent) retained cortex, 90 recorded cortex on both the dorsal surface and platform, 117 had cortex on the dorsal
DISCUSSION

Landform relations, depositional environments, and archaeological stratigraphy

The Acheulean and Middle Paleolithic assemblages in the Malaprabha Valley are preserved across discrete landform segments and within specific sedimentary deposits. Figure 11 is a composite landscape profile spanning a 3 km transect from the quartzitic ridge of the Kaladgi escarpment to the exhumed lateritic surfaces of the lower lying basin. As noted, the peneplain is at an elevation of about 580 m, and consists of two landform segments, the piedmont coalescent fan and the basin flats. The piedmont fans abut the eroded basin laterites in the approximate vicinity of Lakhmapur village. Subsurface relations are distinct for each landscape segment and contain unique depositional contexts, each with separable temporal components.

Within the basin segment, the buried and well-developed nodular laterites are linked with Acheulean occupations (Fig. 11). Latosols directly overlay the nodular laterites, forming and sealing the earlier Pleistocene archaeological and sedimentary horizon. The linkage between the laterally extensive stone line and the Acheulean assemblage provides critical chronostratigraphic input to the much debated question of stone line formation. Stone line genesis and the relative contributions of anthropogenic, biogenic, geogenic, and pedogenic components have been a source of controversy in India and elsewhere (e.g., McFarlane, 1983; Johnson, 1993, 2002; Dhir, 1995; Ollier, 1995; Mercader et al., 2002). While there is no consensus surrounding the genesis of stone lines, they all can be characterized as linear configurations of gravel-sized clasts formed above bedrock and capped by fine silts or clays (Lanfranchi and Schwartz, 1990; Thomas, 1994). A typical profile consists of an upper “resorted earth” with loose to firm sediment overlying increasingly compacted and cemented ferricrete with pisoliths; this component conforms to the latosol registered by Units I and II in the basin profile of Lakhmapur West (Fig. 2; Table 1). The second zone is a laterite developed on a lower saprolite classically signaled by a laterite crust underlain by a pallid zone; these are generically

Fig. 7. Flake tools: 1) scraper; 2) point, Lakhmapur East. Note unifacial flaking along one edge of the scraper. The point tool is a rare occurrence at Lakhmapur East, but this type is more commonly found at other Paleolithic localities.
Fig. 8. Handaxe types from Lakhmapur East: 1) ovate; 2) pointed. Note the high number of flakes and scars, which are indicative of fine and controlled flaking.
equivalent to Units IV and V at Lakhmapur West. The stone line (Unit III) separates the two zones. At Lakhmapur West, the nature of the artifacts in the stone line, their lateral continuity, and their stratification above the cemented laterite of the lower zone provides indications of a disruption in the vertical regime of latozation. The disruption of the vertical weathering sequence appears to be linked to the stone line and the tufa. The tufaceous blocks and attendant concretions on plant materials were laterally interdigitated with the stone line and the nodular laterite facies.

Stone line formation is thought to be caused by the operation of biological and physical processes (Johnson, 1989, 1990, 2002; Johnson and Stegner, 1990), or sedimentary “lag” deposits produced by surface lowering through rainwash and the accompanying loss of fines (Thomas and Thorp, 1986; Nortcliff et al., 1990). Others have contended the surfaces are the product of heterogeneous processes, with significant cultural inputs (e.g., Mercader et al., 2002). At Lakhmapur West, a relatively consolidated substrate, comprised of both the saprolite and the calcareous tufa, provided a firm base for the “stone line” to accumulate. The convergence of the stone line, tufaceous blocks, and residues of the laterite nodules – pisoliths and hematite nodules with mineralized coatings – underscore the complexity of site formation processes that clearly included stream or spring discharges, pronounced weathering (i.e., ferricrete formation), and resorting of artifacts in conjunction with the diagenetic processes that modified the surface textures and even the lateral and vertical positions of the laterite nodules. The pisoliths in particular are strong indicators of the former vadose zone and the extent of water table oscillations during an earlier, wetter phase (McFarlane, 1983), very possibly penecontemporaneous with the occupation.

It is difficult to determine the original sedimentary context of the Acheulean artifacts, but it is apparent that erosion, possibly by surface attrition, sorted the assemblages as the smallest flakes have a lower than expected frequency. While this was the case, the presence of flakes and tools of all sizes, and the non- rounded appearance of the artifacts is indicative of an assemblage that has not been transported. Artifacts articulate with
rounded gravel and detrital materials, at least some of which were derived from the disaggregated laterite profile. The artifact horizon therefore represents a combined geogenic lag (with limited vertical translocation by pedogenic and bioturbic process) in the general vicinity of original human discard. While there was some vertical displacement of the primary assemblage, the integrity of the Acheulean assemblage as a whole does not appear to have been significantly compromised. Thus, while postdepositional influences are implicated, the assemblages are in close proximity to their original discard loci, making technological and behavioral evaluations possible.

Middle Paleolithic assemblages are in several sedimentary contexts, most securely preserved within the basal, and more strongly weathered, latosol (Fig. 11). At Lakhmapur East, the Middle Paleolithic underlies the upper latosol and clearly articulates with the weathered lower latosol, which is absent at the footslopes. The lower latosol nearly always contains Middle Paleolithic artifacts showing fresh flake facets and edges. In Block 2 of Lakhmapur East, the absence of the black clay is consistent with the more pristine preservation of Middle Paleolithic remains at the distal end of the piedmont fans, specifically at the juncture of the fans with the lower peneplain. At this location, latosol deposition apparently provided a gentler environment for artifact burial. Especially noteworthy along the slopes of the Kaladgi escarpment is the preservation of a wedge of colluvium containing Middle Paleolithic assemblages. Artifacts are located between the nodular laterite and the base of the eroded upper latosol. A prominent section preserving these stratigraphic relationships is at the site of Benkaneri. The Benkaneri colluvium contains dense accumulations of fresh Middle Paleolithic artifacts along the length of the footslopes (representing primary quarrying activity). This stratigraphic context is consistent along the base of the Kaladgi escarpment for a distance of 10 kms, thereby forming a strong marker horizon.

Both the archaeological and geological sequences confirm that the laterites and the lower latosols were eventually buried across the piedmont by a series of coalescent fans. Middle Paleolithic artifacts occurred within the upper latosols and "black clays," both of which are redeposited and considerably younger sediments. In Block 1, the presence of rounded artifacts in colluvium indicated long term exposure and weathering, and burial by black clays with rounded artifacts confirmed sedimentary reworking. An uncalibrated age of 8,190 B.P. on the organic component of the clays (Unit II "Paleoverstisol") argues for redeposition along the piedmont during the Early Holocene.

Typology and technology

Separable stratigraphic deposits provided the framework for establishing a relative stone tool sequence. The stone tools found on the two main landscape segments are separable as distinct Acheulean and Middle Paleolithic industries.

The Acheulean industry within the stone line of Lakhmapur West was consistent with typological features recorded at other Lower Paleolithic sites throughout the Kaladgi Basin (Pappu and Deo, 1994). The Lakhmapur West bifaces were similar to assemblages that have been assigned to a late stage of the Acheulean – the bifaces were highly symmetrical, they exhibited marked morphological variability, and they showed multiple negative flake scar removals indicative of well controlled percussion methods (demonstrating...
the use of preparatory steps and the probable employment of the soft hammer technique). The presence of two prepared cores and a pyramidal core in this evolved Acheulean assemblage fore- shadows the frequent evidence for this technol- ogy in the Middle Paleolithic assemblages. At Lakhmapur East, the recovery of an abundant prepared core and flake tool industry was rec- ognizable as a Middle Paleolithic technology. Characteristics of the Lakhmapur East assem- blage were consistent with an early stage of the Middle Paleolithic based on the presence of diminutive handaxes and cleavers, the quality of heterogeneous core types including prepared cores, and the simple level of retouch on flakes, with little effort at shaping. The Lakhmapur evidence clearly straddles the Lower to Middle Paleolithic transition, and shows a gradual technolog- ical change from the evolved biface indus- tries to one in which prepared core technologies become more firmly established.

The identification of the early Middle Paleolithic assemblage at Lakhmapur East is sig- nificant as it fills in an important technological gap in the Kaladgi Basin and in southern India. The identification of early Middle Paleolithic artifacts on quartzite implies a less abrupt change from the Lower to Middle Paleolithic, i.e., previous studies indicated that the trend was for Acheulean assemblages to be produced on quartzite and for Middle Paleolithic assem- blages to be manufactured on siliceous materi- als, such as chert, jasper, agate, and chalcedony (Paddayya, 1984; Allchin and Allchin, 1989; Sali, 1990; Pappu and Deo, 1994). Moreover, the Lakhmapur East assemblage breaks with the geographic division between Middle Paleolithic Luni industries (flake tools, with bifaces) of the
northwest and Nevasan industries (low number of flake tools on cryptocrystallines) of central and Peninsular India. The Lakhmapur East assemblage contains diminutive bifaces and prepared cores on quartzites, thereby diverging from earlier findings in the Kaladgi Basin (Pappu and Deo, 1994) and the evidence found in other southern basins (e.g., Paddayya, 1982b). It should be recognized that the Lakhmapur East assemblage complements the technological findings found in other nearby basins, both in the presence of diminutive bifaces (e.g., Raju, 1988) and in the extensive use of quartzite (S. Pappu, 2001). The current research indicates less distinct temporal and spatial boundaries and more flexibility in tool types and raw material use in the Middle Paleolithic.

**Technological behaviors**

Acheulean hominins reduced quartzite colluvium, primarily in the form of cobbles and pebbles, for stone tool manufacture. The clasts were knapped into flake-cores and bifaces, the latter directly on nodules, but more commonly on flakes. Stone tools were made at Lakhmapur West, but as indicated by relatively low cortical percentages, the majority was likely transported in as partially shaped tools from the nearby colluvium at the base of the bedrock escarpment. The mineralogical characteristics of the Acheulean bifaces are consistent with the geological exposures along the ridge. The stone tool assemblages therefore are linked with this natural outcrop, their spatial proximity indicating low transport distances by hominins. The Lakhmapur evidence contrasts with other Malaprabha Valley localities that show more mineralogical variation in stone tool assemblages. The mineralogical variation between and within sites shows that Acheulean hominins were aware of and used different quartzite sources for stone procurement and manufacture.

The Lakhmapur West core frequency was relatively high, and exceeded other regional Acheulean assemblages by 2.5 to 10 times (cf. Raju, 1988; Paddayya and Petraglia, 1993). The only exception to this finding was the Isampur Quarry, in the Hunsgi Valley, where large numbers of cores were recovered (Petraglia et al., 1999). Lakhmapur West and Isampur show differences in procurement methods and flaking strategies. At Lakhmapur West, handaxes and cleavers were both made on secondary quartzite clasts and flakes, whereas at Isampur quarry limestone bedrock was extracted to make handaxes on slabs and cleavers on flakes. This demonstrates some degree of technological variability and flexibility on the part of Acheulean hominins.

At Lakhmapur East, the high density of cores and flake debris supports an interpretation for stone tool reduction on-site. As natural clasts did not occur at Lakhmapur East in any abundance, the clasts and initially shaped stone tools would have been transported to the locus, and further reduced. The source for materials was likely the nearby quartzitic hillslopes. Middle Paleolithic stone tool procurement was also evident along the colluvium at the base of the quartzitic ridge, where a laterally extensive landscape of quarried tools and debitage was identified at Benkaneri. Excavations at the Benkaneri showed a one-meter thick colluvium with a dense accumulation of cores, bifaces, and retouched flakes. Benkaneri represents a direct source for raw material procurement and stone tool manufacture, where hominins intensively exploited the quartzite hillslopes, intensively reducing colluvial clasts. Middle Paleolithic hominins then presumably transported materials short distances, to nearby localities such as Lakhmapur for further reduction and tool shaping.

The Middle Paleolithic assemblages of Lakhmapur East contained prepared cores and retouched flakes, together with small, finely flaked bifaces. The high core frequency set Lakhmapur East apart from all other regional assemblages, which had much lower core percentages (cf. Korisettar, 1979; Raju, 1988; S. Pappu, 2001). Additionally, Lakhmapur East had a relatively low percentage of retouched flake tools (i.e., scrapers, points, borers) compared to other regional assemblages. The high percentage of cores and the low percentage of tools clearly set Lakhmapur apart from other basins, thereby indicating different types of activities among laces.

**CONCLUSION**

Archaeologists working in the Kaladgi Basin since the 1950s have identified the presence of a substantial Acheulean and Middle Paleolithic
record. While previous investigators mapped nearly three hundred localities during comprehensive surface surveys, the depositional contexts were poorly documented, and little effort was placed on inferring Paleolithic behaviors. As part of the current survey and excavation program, increased attention was placed on understanding environmental contexts, stone tool technology, and hominin activities.

The renewed survey resulted in the identification of buried archaeological assemblages that were minimally mobilized. Reconstructions were made between landscape segments, stratigraphic deposits, and assemblage components. The stone tool assemblages were found to be in laterally distinct sediment matrices across a wide area. Acheulean and Middle Paleolithic hominins clearly utilized an area of high resource utility, marked by quartzite outcrops and spring activity. Together with valley-wide observations, this evidence indicates that sites were associated with springs, ponded environments, and streams of different orders. The heavy stone tool reduction activities at the Lakhmapur locality are a significant finding, as this is the first landscape of its kind to be identified in Peninsular India. The only other quarrying effort that has been described is at Isampur, where Acheulean hominins reduced limestone at a particular spot (Paddayya and Petraglia, 1997a, b; Petraglia et al., 1999). Environmental shifts at Lakhmapur were registered by sedimentary changes, associated with the laterites and latosols, and hydrological changes, marked by spring drying and the incision of the Malaprabha River.

In considering the Kaladgi Basin and Indian Paleolithic evidence in wider perspective, the technological evidence continues to support a close relationship with industries to the West, and a less similar one with stone tool industries of Eastern Asia (e.g., Petraglia, 1998, 2001). Additionally, there appears to be resemblances between Indian and African biface assemblages in stone tool procurement and transport patterns (Noll and Petraglia, 2002). Although “Acheulean-like” assemblages of quartzite have been identified in China (Hou et al., 2000), they are unlike the Acheulean assemblages made of quartzite in the Kaladgi Basin, as the latter show the frequent production of certain tool types (e.g., cleavers from large flakes), the use of different flaking methods on nodules and flakes, and the application of certain reduction techniques (likely both hard and soft hammer reduction, prepared core techniques).

Like the Acheulean, the Indian Middle Paleolithic appears to have closer technological similarity with assemblages in the West compared to those in Eastern Asia. The identification of prepared core industries in India certainly provides a technological parallel with industries found in West Asia and East Africa. The presence of a distinct prepared core industry in India is especially significant in light of the fact that the Middle Paleolithic of China is said to be technologically indistinct from the Early Paleolithic (Gao and Norton, 2002).

The Middle Paleolithic of India does not necessarily equate with assemblages to the West, however, as the region seems to have some unique characteristics. Although certain researchers have adopted the term “Levallois” to describe Indian assemblages (e.g., Alam, 1990), tools often do not conform to multiple flake reduction sequences characteristic of core and flake debris found towards the West (cf. Van Peer, 1992). The cores and flake tools of Lakhmapur and other areas of India may be best described as “prepared”, showing less standardization and flaking sequences compared to multiple stage and refined flaking seen in some Levallois flaking technologies.

The Middle Paleolithic transition in India marks a period of major technological innovation from the long-lasting Acheulean industry. In addition to potential social, behavioral and cognitive shifts, the technological change occurring in India has important implications with respect to continuity versus dispersal models for human evolution. The Kaladgi Basin evidence is not abrupt, but shows a gradual shift from large bifaces to smaller ones and the increased adoption of prepared cores, thereby favoring an in situ evolutionary model for technological change. In this sense, the Indian evidence parallels the African, Near Eastern, and European records, which have been argued to show a continuous technological evolution based on a link between Acheulean and Levallois technologies (Rolland, 1995; Debono and Goren-Inbar, 2001; White and
Ashton, in press). With respect to the African evidence, researchers have indicated that the technological boundary between the Acheulean and the Middle Stone Age is associated with modern human origins, including the appearance of Homo heidelbergensis and possibly Homo sapiens by 250–300 ka (Lahr and Foley, 1998, 2001; McBrearty and Brooks, 2000). In both cases, the MSA in Africa is considered to be the time in which modern human behaviors begin to emerge, including the broadening and diversification of economic behaviors, settlement patterns, and hunting strategies. If the gradual change and technological continuum between the Lower and Middle Paleolithic can be further demonstrated in India (and Europe and the Near East), it would imply that either local populations independently evolved without major population replacements at the transition, or techniques and ideas were being passed through social networks over a wide area. Although no hominin fossils are associated with the Indian Middle Paleolithic, the later populations may have evolved from Homo heidelbergensis (Narmada) using a Late Acheulean technology (Kennedy, 2000; Rightmire, 2001). Given this tantalizing backdrop, it is anticipated that further investigation of Acheulean and Middle Paleolithic transition in India will help to understand technological changes and evolutionary processes taking place in various parts of the Old World. Only until paleoanthropologists place increased attention on under-appreciated regions will we be in a position to properly compare and evaluate large-scale geographic patterns, adaptive differences, and demographic variability.

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