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# THE CUTTING EDGE:

## New Approaches to the Archaeology of Human Origins

*Editors*

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*Top: Homo habilis Utilizing Stone Tools. Painting by artist-naturalist Jay H. Matternes. Copyright  1995, Jay H. Matternes. Inspired by a prehistoric scenario by K. Schick and N. Toth in Making Silent Stones Speak: Human Origins and the Dawn of Technology (1993), Simon and Schuster, New York. Pp.147-149.*

*Lower right: Whole flake of trachyte lava from the 2.6 million-year-old site of Gona EG-10, Ethiopia. Reported by S. Semaw (2006), "The Oldest Stone Artifacts from Gona (2.6-2.5 Ma), Afar, Ethiopia: Implications for Understanding the Earliest Stages of Knapping" in The Oldowan: Case Studies into the Earliest Stone Age, eds. N. Toth and K. Schick. Stone Age Institute Press, Gosport, Indiana.  Pp. 43-75. Photo courtesy of Tim White.*

*Lower left: Prehistoric cut-marks from a stone tool on Sterkfontein hominin partial cranium StW 53. Reported by T. Pickering, T. White, and N. Toth (2000) in "Cutmarks on a Plio-Pleistocene hominid from Sterkfontein, South Africa". American Journal of Physical Anthropology 111, 579-584. Scanning electron micrograph by N. Toth.*

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# CHAPTER 3

# Was There an Oldowan Occupation in the Indian Subcontinent? A Critical Appraisal of the Earliest Paleoanthropological Evidence

Parth R. Chauhan

## Introduction

The Lower Paleolithic record of the Indian subcontinent has been traditionally divided into Mode 1 (pre-Acheulian) and Mode 2 (Acheulian) industries (Misra, 1987; Mishra, 1994; Petraglia, 1998; 2001; Gaillard and Mishra, 2001). These two traditions often occur independently as well as in shared geographic, geomorphologic, and stratigraphic contexts (e.g., de Terra and Paterson, 1939; see Sankalia, 1974; Jayaswal, 1982). The current geochronological evidence for archaeological and fossil evidence in Eurasia points to a late Pliocene or Early Pleistocene age for the earliest dispersal from Africa and involves the genus *Homo* (Larick and Ciochon, 1986; Anton and Swisher, 2004; Langbroek, 2004; also see Dennell and Roebroeks, 2005). However, the Paleolithic record of South Asia, a region that lies between the three sources of the earliest *Homo* fossils in Africa, the Republic of Georgia, and East Asia (Woldegabriel et al., 2000; Gabunia and Vekua, 1995; Gabunia et al., 2000; Swisher et al., 1994), does not clearly fit into this chronological framework and is conspicuously discontinuous (Dennell, 2003). Most of the Paleolithic localities have been dated through the Thorium-Uranium method and include a predominance of Acheulian sites in India (Mishra, 1992; Korisetter and Rajaguru, 1998; Chauhan, 2004, 2006). The majority of these occurrences appear to be late Middle Pleistocene in age, although some localities may be considerably older than 350 or 390 Ka, the maximum temporal limit of the Th-U method used. An older exception is the Early Acheulian site of Isampur in the Hunsgi Valley, recently dated to ca. 1.27 Ma using electron spin resonance on herbivore teeth (Paddayya et al., 2002). Unfortunately, this chronostratigraphic attribution remains tentative and requires more extensive study, especially when considering the possibility of geological reworking at the site (A. Skinner: pers. comm.) and current problems with ESR on Indian faunal specimens in specific depositional environments (e.g., Blackwell et al., 2007).

Following the early impact of the Clactonian evidence in England (see Dennell and Hurcombe, 1992), a pre-Acheulian technology based on pebbles and cobbles was also proposed for the Indian subcontinent in the form of the Soanian industry in what is now northern Pakistan (de Terra and Paterson, 1939). This industry was viewed as a distinct cultural phenomenon preceding and partly overlapping with the local Acheulian evidence in relation to Pleistocene glaciation phases. Their primary goal was to seek evidence of Pleistocene glaciation phases (after Penck and Brückner, 1909) and highlight its impact on early human cultures in the sub-Himayalan region (Sankalia, 1974; Dennell and Hurcombe, 1992; Dennell and Rendell, 1991). This model became a standard for subsequent prehistoric and Pleistocene research in India and prevailed for four decades (see Rendell et al., 1989). Later work by the British Archaeological Mission to Pakistan (BAMP) resulted in a major revision of de Terra and Paterson's interpretations. Most importantly, the concept of Soan terraces and the associated Soanian typo-technological sequence as recognized by de Terra and Paterson was deemed untenable because the Soan 'fluvial' terraces actually turned out to be erosional features (Dennell and Hurcombe, 1992). Subsequently, multiple lines of evidence including a comparison of Soanian and Acheulian technology (Gaillard, 1995), landscape geoarchaeology (Chauhan, 2008a), surveys of dated geological features (Soni and Soni, 2005) and


*Figure 1. General locations of the pre-Middle Pleistocene paleoanthropological sites discussed in the text.*

a comparative morphometric analysis (Lycett, 2007), clearly revealed that the majority of Soanian assemblages, if not all, represent a Mode 3 technology and relatively post-date the Acheulian (Gaillard and Mishra, 2001; Chauhan, 2003). Subsequent claims for a pre-Acheulian occupation have come from the Narmada Valley of central India and from the Siwalik Hills in the northern zones of Pakistan and India (Figure 1 and Table 1). This chapter represents a critical review of these occurrences and explores the possibility of a younger occupational history for the Indian subcontinent.

## Narmada Valley

Central India is dominated by the Narmada River which flows through Madhya Pradesh and Gujarat from Amarkantak in the east to the Arabian Sea in the west–a total of about 1300 km. Numerous Quaternary geological and archaeological investigations have been conducted in the entire valley since the 19th century (see Kennedy, 2003). Prehistoric hominin occupation associated with the Narmada River appears to have occurred since at least the Middle Pleistocene, but potentially earlier (discussed later). Direct evidence of repeated human occupation is reflected by numerous sites ranging from the Lower Palaeolithic to the Chalcolithic Periods (Misra, 1997). The region is most famous for yielding the oldest fossil hominin evidence in the subcontinent at Hathnora, which is represented by an incomplete calvarium and two clavicles and a possible rib fragment (Sonakia, 1984; Sankhyan, 1997, 2005). The cranium remains to be accurately dated but has been variably attributed by different investigators as *Homo erectus, archaic H. sapiens or H. heidelbergensis* (Sonakia, 1984; Kennedy and Chiment, 1991; Sankhyan, 1997, 2005; Cameron et al., 2004). Because it possesses diverse but undiagnostic

*Table 1. The earliest South Asian paleoanthropological sites as discussed in the text.*

| SITE | REPORTED AGE [DATING METHOD] | STRATIGRAPHIC CONTEXT | MATERIAL RECOVERED | REFERENCES | COMMENTS |
|---|---|---|---|---|---|
| Riwat | 2.0-2.2 Ma? [PM, GS] | stratified in gritstone | 3 to 23 cores and flakes (based on numerical ranking) | Rendell et al. 1987 | requires corroboration through *in situ* fine-grained contexts |
| Pabbi Hills a | 2.2 – 1.7 Ma? [PM, GS] | surface of fine-grained sediments | 198 cores (various types), flakes, flake blades, scrapers, knife | Dennell, 2004 | requires corroboration through *in situ* contexts |
| Pabbi Hills b | 1.4-1.2 Ma? [PM, GS] | surface of fine-grained sediments | 307 (same as above) | Dennell, 2004 | requires corroboration through *in situ* contexts |
| Pabbi Hills c | 1.2 - 0.9 Ma? [PM, GS] | surface of fine-grained sediments | 102 (same as above) | Dennell, 2004 | requires corroboration through *in situ* contexts |
| Uttarbaini | >1.6/>2.8 Ma? [FS] | stratified below dated ash horizon | not reported | Verma, 1991 | requires confirmation, re-dating of ash |
| Jainti Devi ki Rao | EP-MP? [GS, BS] | stratified within Lower Boulder Conglomerate Fm. | 150 Acheulian handaxes, cleavers, choppers, large flakes, | Sharma, 1977 | requires confirmation, dating through *in situ* fine-grained contexts |
| Kheri-Jhiran | LP-EP? [GS, BS?] | stratified within Pinjore Fm. | >45 ‘Abbevillian’ handaxes, choppers, scrapers, ‘rounded pebble tools’, a discoid | Verma, 1975 | requires corroboration |
| Nadah | 2.2 – 2.0 Ma? [GS, BS] | stratified (?) within Pinjore Fm. | *H. erectus* maxillary incisor | Singh et al. 1988 | ambiguous; require diagnostic specimen(s) |
| Khetpurali & Masol | ca. 3.4 Ma? [ ] | eroded out from Tatrot Fm.? | hominid fossils: (mandibular, proximal femur, distal femur, patella, & post-cranial fragments, stone tools: (choppers, flakes?), other vertebrate fossils | Singh, 2003 | represents false claims and substantiation |
| Durkadi | 1 Ma? [GS, AT] | stratified in surface of conglomerate | 650 artifacts (see Table 2) | Armand, 1979, 1983, | requires dating and corroboration through fine-grained contexts |
| Mahadeo Piparia | early MP? [GS, AT] | stratified in surface of conglomerate | >1215 but not all Lower Paleolithic | Multiple papers of A.P. Khatri; Supekar, 1985 | requires dating and confirmation of context |
| Dhansi | >780 ka? [PM] | stratified in thin gravel horizon | 5 cores, flakes, flake fragments | Patnaik et al. n.d. | requires confirmation of context and age |

*PM: paleomagnetism; GS: geo-stratigraphy; FS: fission track; AT: artifact typology; BS: biostratigraphy; LP: Late Pliocene; EP: Early Pleistocene; MP: Middle Pleistocene.*

anatomical traits, Athreya (2007) has suggested that it be provisionally classified as *Homo* sp. indet.

Initial palaeomagnetic studies led by Agrawal et al. (1988) suggested that the Narmada Quaternary deposits fall within the Brunhes Chron (or, as presently dated, <0.78 Ma), while studies by the Geological Survey of India indicated an Early Pleistocene age for the oldest Quaternary sediments (see below). However, their respective studies were not applied to the same stratigraphic sections and because the Quaternary geology varies significantly across the entire basin, associated Lower Paleolithic sites are yet to be securely dated, including the ones discussed below. Based on the stratigraphic relationships, erosional unconformities, sedimentary mineralogy, granulometry, and structures, pedogenic characteristics, and tephra deposits, and palaeomagnetic signatures, the central Narmada Quaternary sequence have been divided into seven formations listed here from oldest to youngest: Pilikarar, Dhansi, Surajkund, Baneta, Hirdepur, Bauras and Ramnagar (Tiwari and Bhai, 1997). However, the author and his colleagues have recently demonstrated that the Pilikarar stratigraphic sequence cannot be defined as a geological formation (Patnaik et al., in press), thus provisionally qualifying Dhansi as the oldest Quaternary formation in the central Narmada Basin. This is provisionally based on Rao et al.'s (1997) paleomagnetic results which demonstrate that the latter formation at the Dhansi type-site belongs to the Matuyama Chron. Claims of pre-Acheulian evidence have come from two sites in the valley (Mahadeo Piparia and Durkadi) and preliminary observations at Dhansi suggest a Lower Paleolithic occupation prior to ca. 780 ka.

## Mahadeo Piparia and Durkadi

In the 1960s, a pre-Acheulian lithic occurrence was reported in the form of the Mahadevian industry in the eastern part of the Narmada Valley. This industry was named after the site of Mahadeo-Piparia by Khatri (1963, 1966) who equated it to the Oldowan industry and interpreted it as a technological

*Table 2. Fresh and rolled tool types from Durkadi. (Compiled from Armand, 1983)*

| TYPE | FRESH SPECIMENS | ROLLED SPECIMENS |
|---|---|---|
| **HEAVY DUTY TOOLS:** | **48** | **28** |
| *Choppers:* | 37 | 23 |
| Discoide | 10 | 2 |
| Side | 19 | 19 |
| Angular (on angle) | 4 | 1 |
| End | 4 | 0 |
| *Proto-cleavers* | 1 | 0 |
| *Proto-handaxes* | 6 | 0 |
| *Handaxes* | 1 | 0 |
| *Heavy duty complex tools* | 4 | 2 |
| *Heavy hollow side-scrapers* | 0 | 4 |
| **LIGHT DUTY TOOLS:** | **63** | **35** |
| *Scrapers:* | 46 | 28 |
| Round | 5 | 4 |
| Double side | 2 | 1 |
| Single side | 33 | 19 |
| Hollow side | 1 | 2 |
| Single end | 5 | 2 |
| *Borers:* | 6 | 2 |
| Angular (on angle) | 5 | 2 |
| End | 1 | 0 |
| *Burins* | 1 | 0 |
| *Light duty complex tools* | 10 | 5 |
| *Other types of heavy or light duty tools* | 8 | 18 |
| **TOTAL TOOLS:** | **119** | **82** |
| *Prepared cores:* | 22 | 11 |
| On-pebble | 17 | 4 |
| On-flake | 5 | 7 |
| *Unprepared cores:* | 20 | 6 |
| On-pebble | 16 | 3 |
| On-flake | 4 | 3 |
| *Other types of cores* | 9 | 7 |
| TOTAL CORES: | 51 | 24 |
| *Prepared -platform flakes:* | 59 | 83 |
| Plain | 50 | 67 |
| Faceted | 9 | 16 |
| *Unprepared-platform flakes* | 63 | 49 |
| Vertical | 50 | 46 |
| Horizontal | 13 | 3 |
| Other types of unworked flakes: | 9 | 27 |
| **TOTAL UNWORKED FLAKES:** | **131** | **158** |
| Percuter | 0 | 2 |
| Anvil | 0 | 1 |
| **WASTE:** | **62** | **17** |
| **TOTAL DEBITAGE:** | **244** | **202** |
| Non-classified artifacts | 0 | 3 |
| **TOTAL ARTIFACTS** | **363** | **287** |

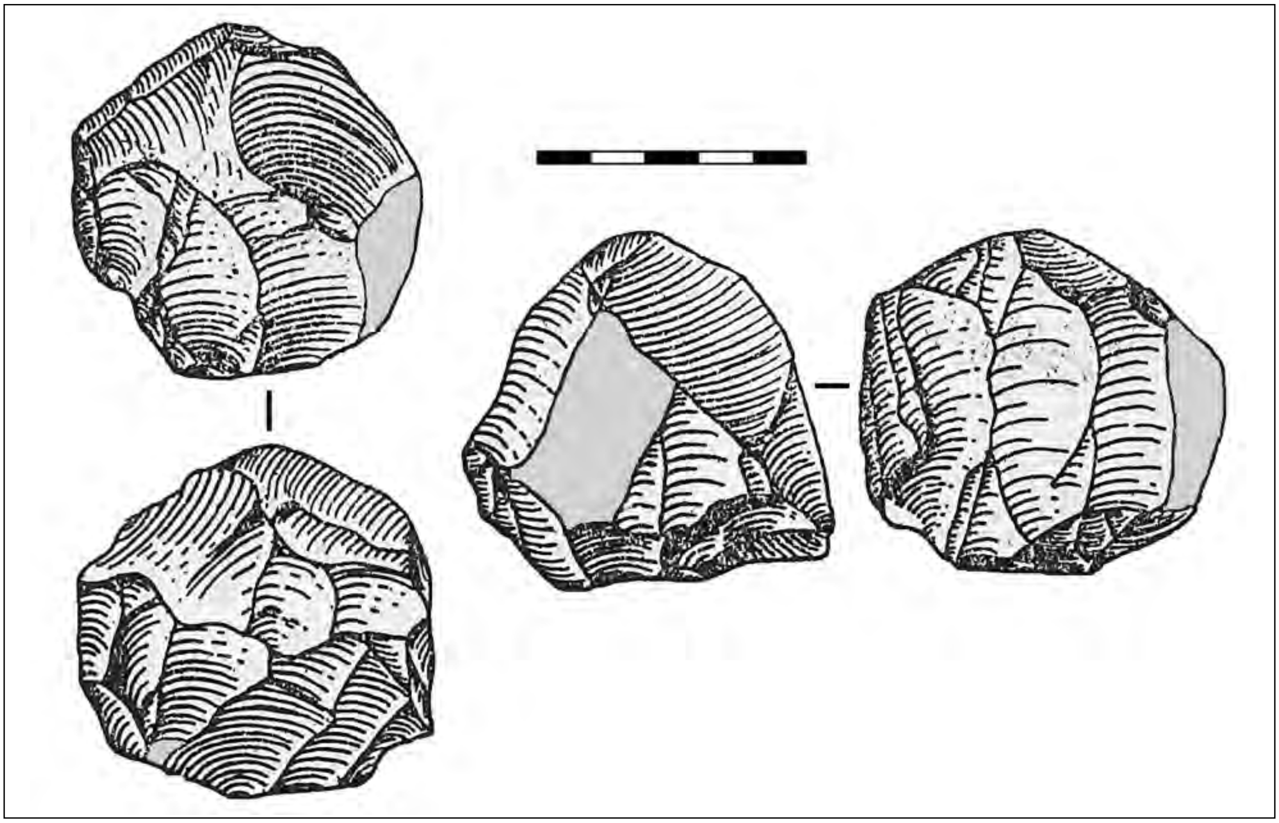

*Figure 2. Polyhedron from Durkadi. (Modified after Armand, 1983)*

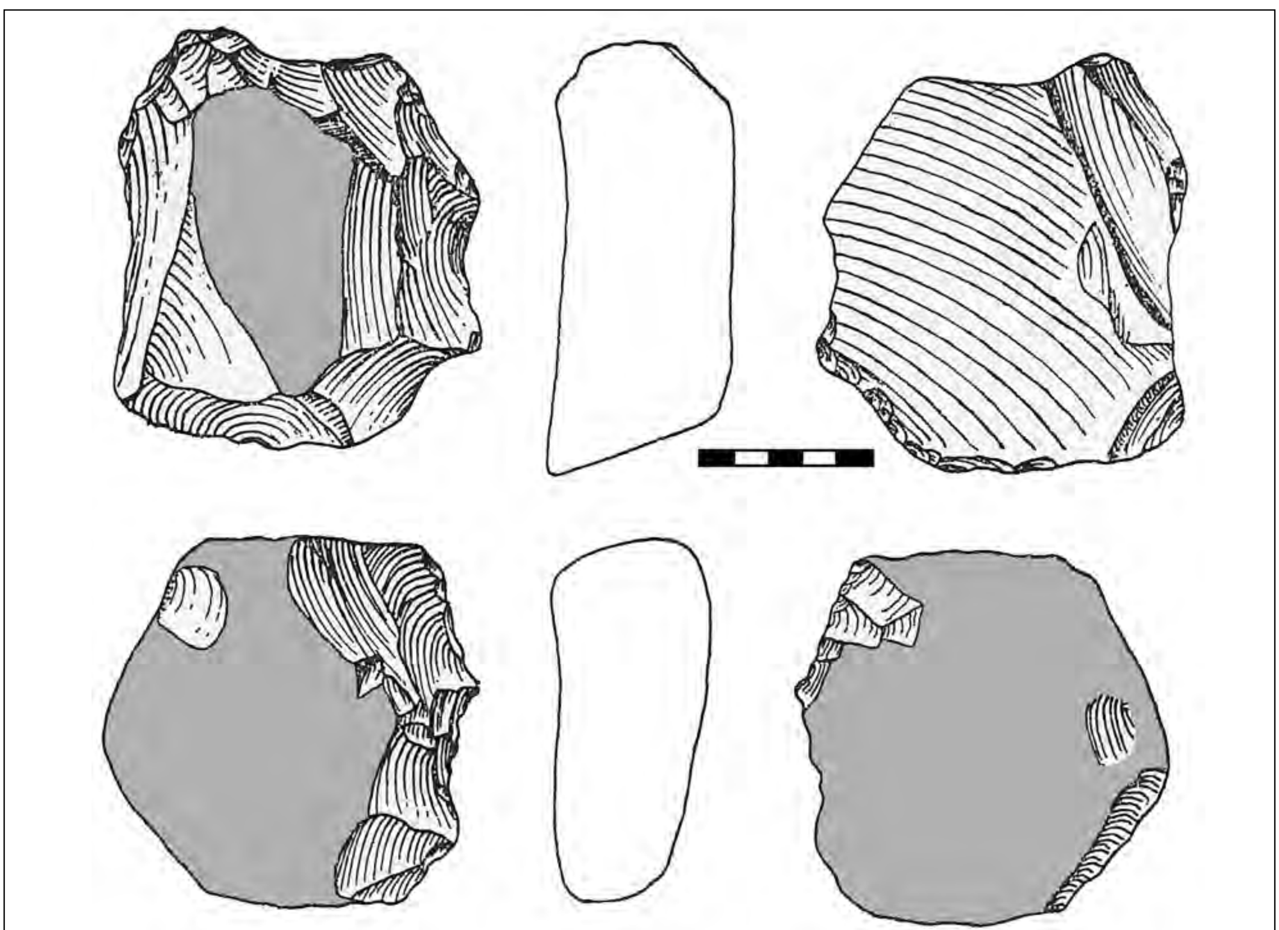

*Figure 3. Core and chopper from Durkadi. (Modified after Armand, 1983)*

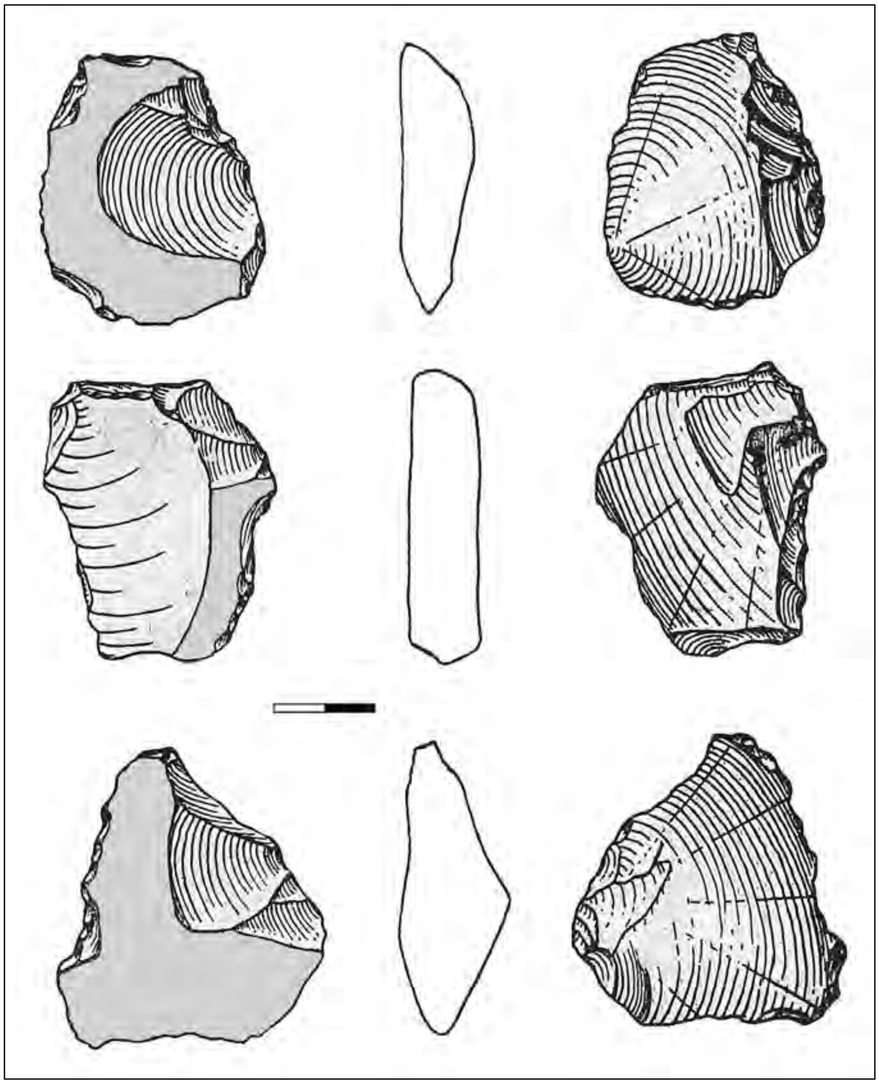

*Figure 4. Flake specimens from Durkadi. (Modified after Armand, 1983)*

early Middle Pleistocene in age (Khatri, 1963), Durkadi was interpreted to be about 1 Ma in age (Armand, 1983), based largely on geological stratigraphy and typology.

It is also now generally accepted that the South Asian Acheulian is a result of early migrations of the genus *Homo* from Africa sometime in the Pleistocene rather than being an indigenous or regional technological development (Sankalia, 1974). In other words, neither Mahadeo-Piparia and Durkadi, nor any other site in the Indian subcontinent, shows any convincing stratigraphic evidence for a technological transition from an Oldowan-type into the more sophisticated Acheulian technology (Jayaswal, 1982). Nonetheless, both Durkadi and a part of Mahadeo-Piparia remain typo-morphological anomalies within the South Asian Lower Paleolithic record and thus merit a reinvestigation to clarify their temporal and behavioral relationships (if any) with the regional Acheulian. Although these occurrences may not be as old as previously thought, they currently appear to represent some of the earliest typologically Mode 1 evidence in peninsular India. While Mahadeo-Piparia has yielded Acheulian bifaces and Middle Paleolithic elements in addition to the Mode 1 component (Supekar, 1985), Durkadi continues to be an exclusively Mode 1 site, despite Armand's (1983, 1985) report of 1 'proto-cleaver', 6 'proto-handaxes' and 1 'Abbevillian' or evolved Durkadian handaxe. These 8 specimens do not conform to the current typo-morphological definition of Acheulian bifaces as they lack bilateral and planform symmetry and adequate bifacial reduction (Figure 7). They also do not appear to resemble typical early developmental stages of the Acheulian as known from, for example, Olduvai Gorge, Konso-Gardula, Peninj and 'Ubeidiya (see Clark, 1998).

predecessor to the Indian Acheulian. Later excavations and stratigraphic observations by Sen and Ghosh (1963) and Supekar (1968) refuted Khatri's claim of a Mode 1 to Mode 2 transition here. A similar claim to that of Khatri's was made more systematically through controlled excavations by Armand (1979, 1983, 1985) who defined the Durkadian industry at the site of Durkadi from excavated contexts 2 km south of the lower Narmada channel (Table 2). At both Durkadi and Mahadeo Piparia, a large amount of non-biface artifacts were recovered in stratified contexts and comprised of cores, choppers, flakes, "protobifaces", and other formal tool types (Figures 2 to 6). Both assemblages were recovered from within and over-lying the high-energy gravels of the Narmada River and many artifacts at both sites are relatively in fresh condition. This signifies the use of the conglomerate surface through multiple visits for clast acquisition and stone tool production prior to the surface's burial by fine-grained sediments, a key geoarchaeological feature at such sites associated with gravel or conglomerate contexts in the subcontinent (Chauhan, in press, a). While Mahadeo-Piparia was discerned to be

## Dhansi

As mentioned earlier, the Dhansi Formation at the type-site is thought to belong to the Matuyama Chron based on paleomagnetic studies by Rao et al. (1997). Preliminary archaeological investigations here have recently yielded several Paleolithic aritfacts *in situ* from a thin gravel horizon at the bottom of the exposed type-

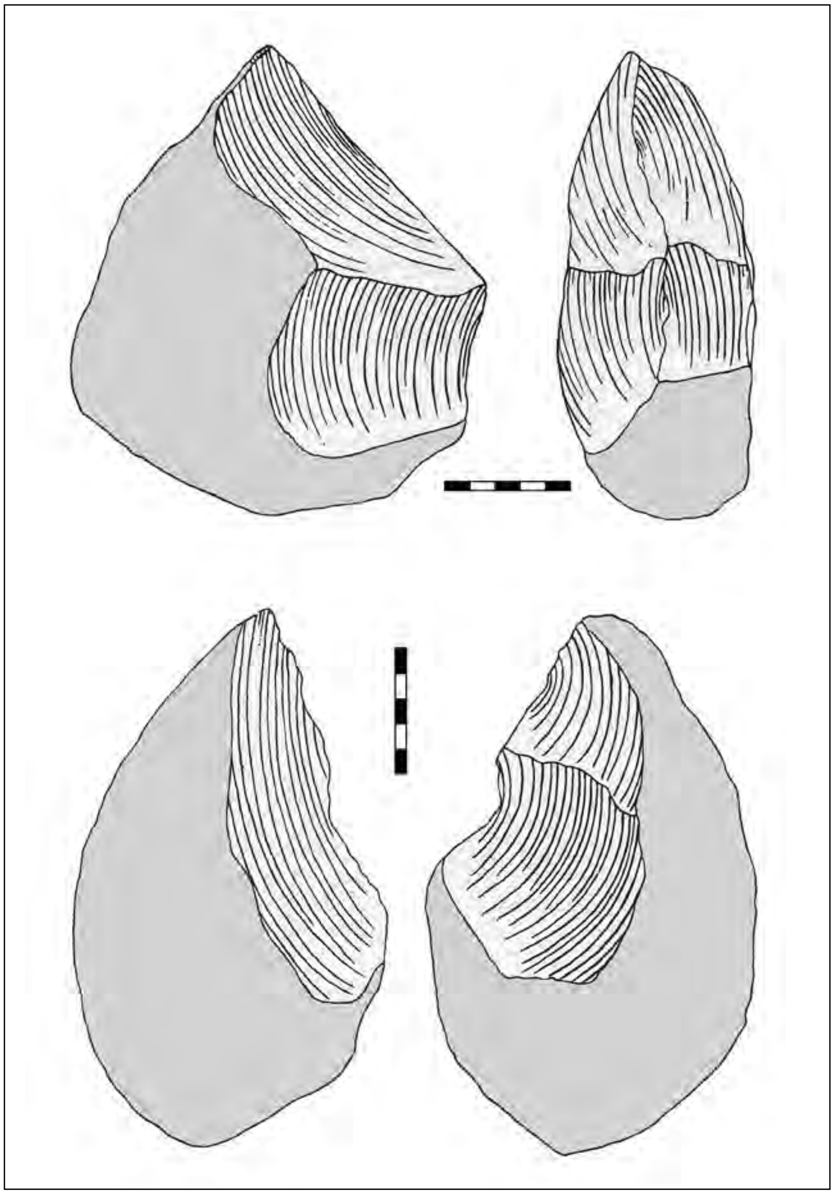

*Figure 5. Cores/choppers from Mahadeo Piparia. (Modified after Khatri, 1963)*

section. The specimens include a core/chopper, polyhedron and a few flakes or flake fragments in stratigraphic association with a highly-weathered fossil herbivore tooth recovered several meters away. Due to the potential significance of the site, a revision of the chronostratigraphic context of this site and additional excavations are currently underway. If Rao et al.'s (1997) paleomagnetic results ultimately prove to be accurate, the associated lithics may represent the first unequivocal evidence for an Early Pleistocene hominin occupation of the subcontinent. Elsewhere along the Narmada River, other exposures and sites possibly also of comparable age (provisionally based on soil color and morphology and lithic typology) also warrant careful archaeological and palaeontological reinvestigations. The remaining claims for pre-Middle Pleistocene palaeoanthropological evidence come from multiple locations in the Siwalik Hills of northern Pakistan (2) and northern India (4).

## The Siwalik Hills

The Siwalik Hills or the Siwalik Foreland Basin consist of fluvial sediments deposited by hinterland rivers flowing southwards and southwestwards (Gill, 1983) from the Lesser and Greater Himalayas, when the region south of these mountains was originally a vast depression or basin (referred to as the foredeep) (Brozović and Burbank, 2000). They span from the western side of the Indus (northern Pakistan in the west) to the Bay of Bengal (Sikkim/Assam region in the east), covering a total length of approximately 2,400 km. The topography of the Siwalik Hills became a prominent feature on the landscape and reached its present elevation during Middle Pleistocene times (Kumar et al., 1994). The range is less than 13 km wide in places (average of 24 km), and it reaches an elevation between 900m and 1,200m. Quartzite pebbles and cobbles was the main raw material exploited by the hominin occupants of this ecozone at multiple temporal intervals throughout the entire Siwalik range (Dennell, 2007; Chauhan, 2008a). In addition to being located within the Boulder Conglomerate Formation of the Upper Siwalik Subgroup (Johnson et al., 1982), these localized quartzite clasts also occur in streambeds, on Siwalik surfaces of varying ages, and in the terrace sections of intermontane valleys. Paleolithic sites in the Siwaliks, situated within a range of eco-geographic contexts, have been traditionally divided into two types, Acheulian and Soanian,and are found in the form of sites, site-complexes, find-spots and numerous surface scatters (e.g., de Terra and Paterson, 1939; Stiles, 1978; Mohapatra, 1981; Chauhan, 2008a). However, claims made of the earliest occupation in the Siwalik region are reported to be considerably older than both these industries and have not been classified as Soanian, despite some broad morphological similarities.

### Kheri-Jhiran (northern India)

From paleontological investigations in the Solan District of Himachal Pradesh, Verma (1975:518) reported a rich vertebrate fossil locality from the Pinjore Formation as well as "*closely associated* [emphasis mine] human artefacts–like crude handaxes, choppers, scrapers, light duty flakes and other pebble tools." This

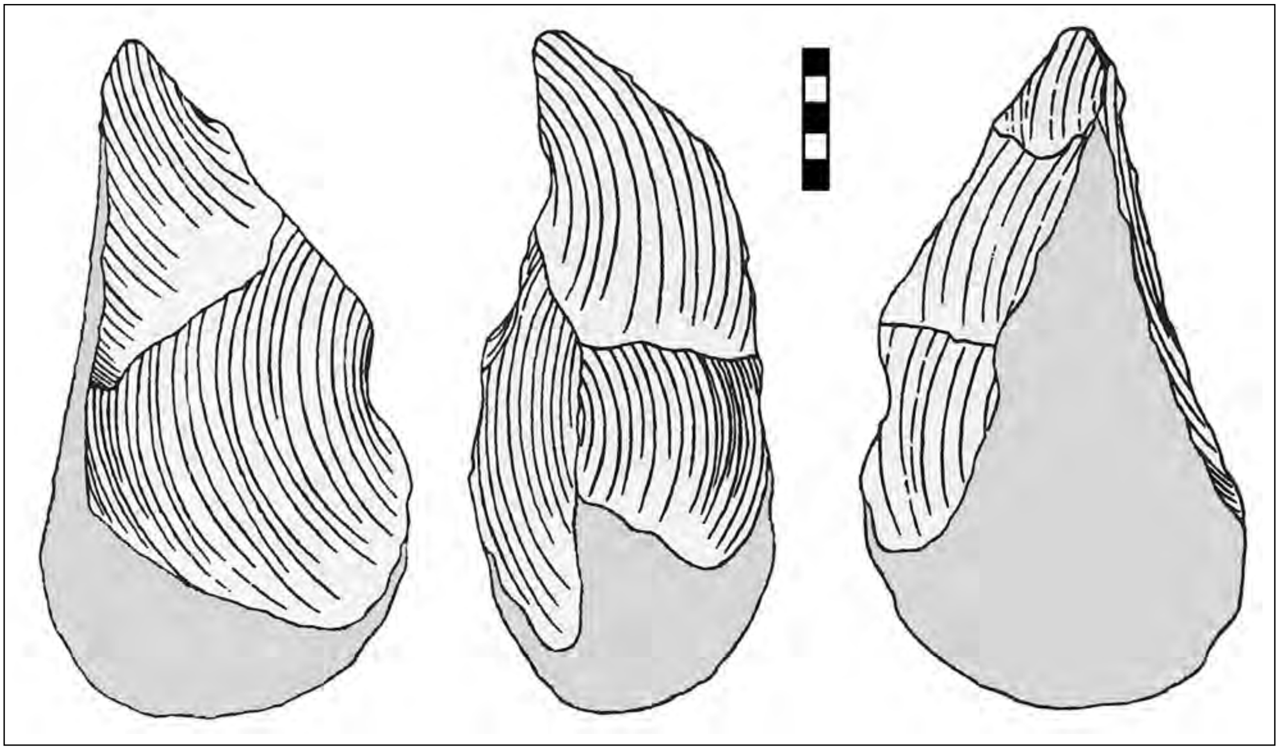

*Figure 6. Pointed core/chopper from Mahadeo Pipari. (Modified after Khatri, 1963)*

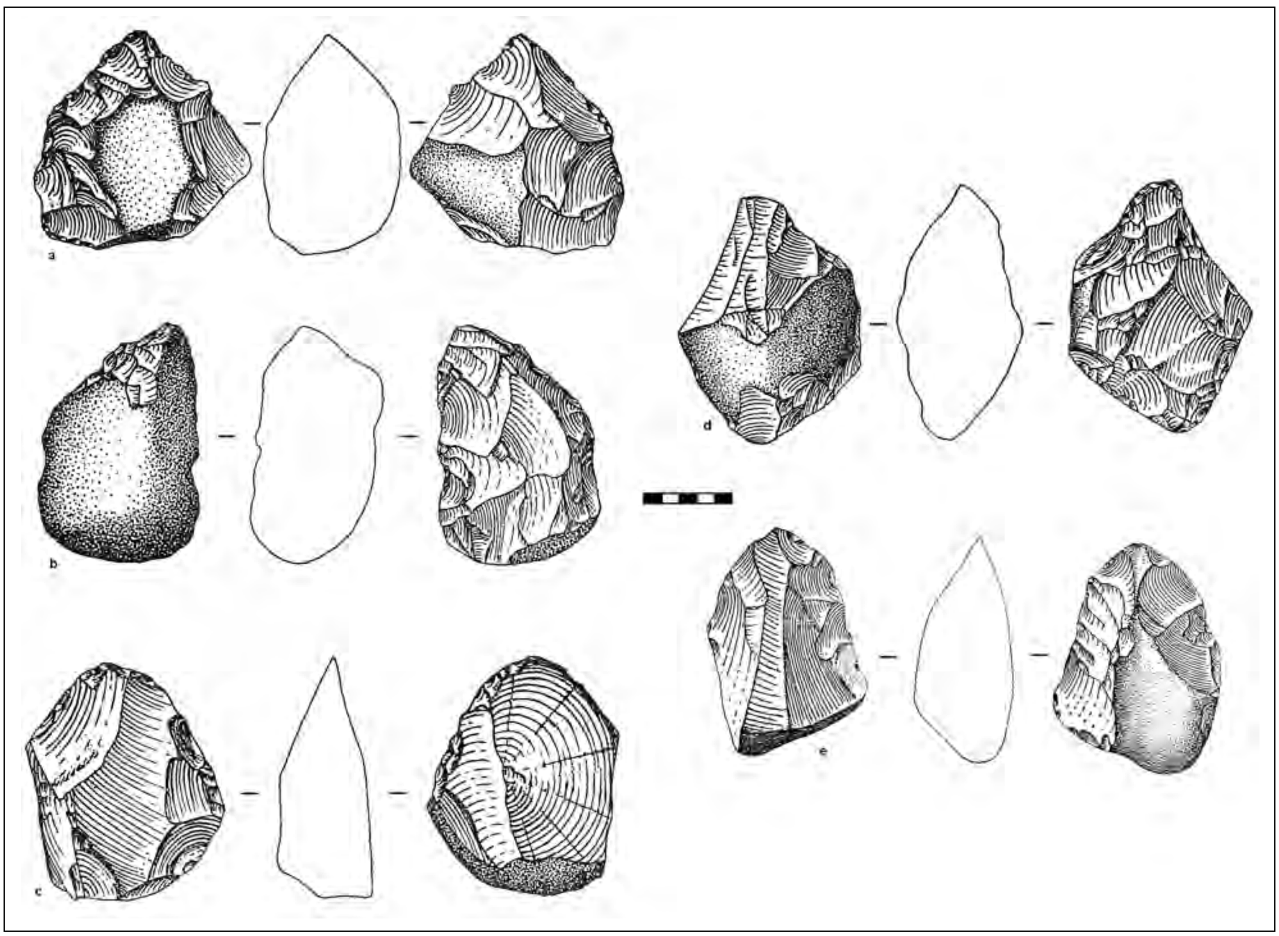


*Figure 7. Some specimens from Durkadi classified as 'proto-handaxes' (a - d) and 'Abbevillian' handaxe (e) by Armand (1983).*

locality, called GSI 107, is in the Kheri area and located about 30 km from the Pinjore type-section (Pinjore village). The Pinjore Formation here is thought to yield highly-fragmented but well-fossilized specimens of about a dozen different species within an area of 75 $m^2$. He reports about 45 fresh artifacts including ‘Abbevillian type’ handaxes, unifacial and bifacial choppers and scrapers, one discoid and several ‘rounded pebble tools’. The raw materials are pebbles and cobbles of quartzite and chert. The artifacts are described as lacking retouch and being of ‘crude typology’. Some of the artifacts were allegedly excavated *in situ* from the sandstone/conglomerate bed of the Pinjore Formation. The site also yielded about 50 unmodified quartzite pebbles (5–10 cm in diameter) in surface association with the vertebrate fossils. Twenty meters below GSI 107 and forty-five meters above, additional fossil material and ‘pebble tools’ are reported as well as a fourth occurrence 220 meters above GSI 107 and near the interface between the Pinjore Formation and the overlying Boulder Conglomerate Formation. This fourth occurrence is described as yielding several ‘crude’ specimens similar in nature to those from GSI 107, as well as two bifacial scrapers/choppers and a ‘multi-facetted’ discoid.

The evidence is collectively interpreted to represent a “slow and gradual evolution in the culture and topology [typology?] of the artefacts through the long depositional history of Pinjors” (Verma, 1975:519). Although the Kheri-Jhiran section from which the paleoanthropological material is thought to derive is not adequately described, a schematic figure is provided by Verma showing the different occurrences of lithics and fossils within the section, all allegedly *in situ* (Figure 8). The photographs of four lithic specimens shown by Verma (1975:520) appear to be either pointed cores, core-fragments and/or pointed choppers. The flake scars are clearly visible and some of the illustrated artifacts morphologically resemble the pointed-core specimen from Riwat which may be of late Pliocene age (discussed later). However, the current descriptions in the text and associated illustrations are inadequate, thus reflecting the ambiguous nature of the Kheri-Jhiran assemblages and their stratigraphic contexts. Its current status can be viewed as being typologically undiagnostic, as most Paleolithic surface scatters in the Siwalik region are. The Kheri-Jhiran occurrences most likely represent contexts where lithic specimens (some of which may even include naturally-flaked clasts) have fallen from the Boulder Conglomerate Formation and/or from above it, suggesting their possible post-Siwalik age. Additionally, the surface association of vertebrate fossils and lithic specimens is a common occurrence in the Siwalik region (Chauhan and Gill, 2002; Chauhan, in press, b) and not a single such locality has been proven to represent evidence of butchery or hominin-modification. Nonetheless, the fact that Verma reports the material as being *in situ* and in association with vertebrate fossil material, this section and the surrounding area require further investigation.

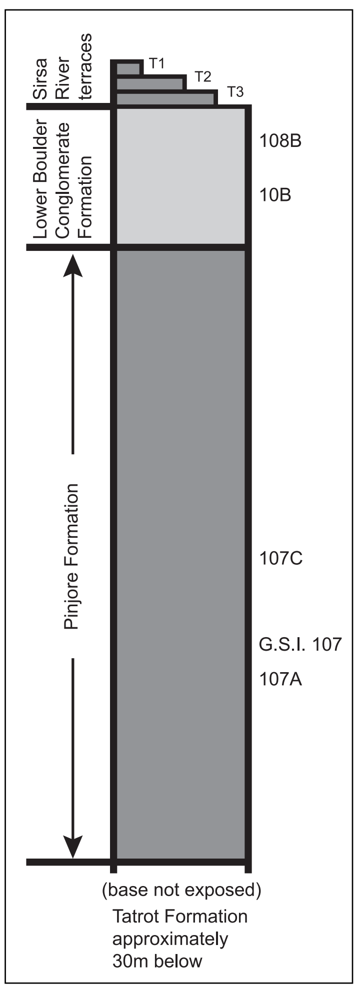


*Figure 8. Schematic stratigraphic section at Kheri-Jhiran (redrawn from Verma, 1975).*

## Jainti Devi Ki Rao (Chandigarh area, northern India)

Near Chandigarh, Sharma (1977) reported a ‘habitation site’ from the Boulder Conglomerate Formation between Mullanpur and Parol on the northwestern bank of a seasonal stream called Jainti Devi ki Rao. From the geological and fossil vertebrate evidence, he assigns a Middle Pleistocene age to the material based on Upper Siwalik stratigraphy but also states that some or all of it may be Early Pleistocene. Interestingly, the investigator reports Acheulian bifaces in association with a prominent Mode 1 assemblage (‘pebble chopper/chopping-tool industry) as well as ‘large flake tools’. From two vertical sections of the Lower Boulder Conglomerate about 20 feet in vertical thickness, the investigator reports 150 artifacts including many specimens *in situ*, although the majority appear to be rolled. The assemblage includes unifacial and bifacial choppers, massive ‘borer-cum-choppers’ (possibly just pointed choppers), bifacial handaxes and cleavers and large flakes (many flakes being made by the Clactonian technique). From the facetted platforms on some specimens, a prepared-core technology or the Levallois technique also appears to be present, with increased frequency in the younger context at the site. Based on the variable technology of the lithic industries and associated states of preservation, Sharma (1977:94) invokes broader environmental changes and recognizes an associated gradual evolution (similar to Verma, 1975) of the behavioral evidence in this area from the Abbevilian to the Acheulian and beyond: “*Small flake-blade tools (along with the handaxe-cleaver and chopper industries_ appear only in the later phases-the Upper Pleistocene and post-Pleistocene-indicating an Upper Palaeolithic culture in the region that is perhaps derived from the local Lower Paleolithic cultures*.”

This scenario is presented using the Lower Paleolithic evidence from the Boulder Conglomerate Formation combined with typologically younger lithic evidence from the nearby post-Siwalik terrace deposits (i.e. younger than the Boulder Conglomerate Formation) about 10-15 feet in height. From this younger context, Sharma reports 100 artifacts including flakes, blades and abundant debitage as well as a continuation of some Lower Paleolithic types (choppers, handaxes, cleavers) but with decreased frequency, made on flakes and in fresh condition unlike those from the Boulder Conglomerate Formation. The post-Siwalik flakes are of various dimensions and morphology and their striking platforms show no signs of preparation, though secondary working and retouch appears to be prominent. The blades only occur in the post-Siwalik alluvium and are described to be technologically more refined (e.g., thin, elongated, prepared platforms but no retouch) and thought to belong to the Upper Paleolithic of Panjab. Unfortunately, Sharma does not provide any photographs of the site or figures and tables for the lithics; a detailed stratigraphic description and figure are also lacking. The large amount of rolled specimens and the mixed nature of the lithic material may preclude the site as being primary context or even a 'habitation site' as no evidence of refitting specimens is provided. Instead, the occurrence may be a result of frequent post-depositional processes such as seasonal fluvial activity from the monsoons, erosion through tectonic processes and colluvial action–all common in the Siwalik region (Chauhan and Gill, 2002). In addition, it has long been proven that the rolled vs. fresh condition of artifacts is not always a reliable indicator of the relative comparative age of the material. For example, older artifacts may have rolled less and thus be more fresh than younger artifacts from the same site that may have rolled over a longer distance or to a greater degree. Also, a linear model of lengthy technological evolution in the Siwaliks is highly unlikely. Rather, the Paleolithic record in the entire Siwalik region and the subcontinent in general is notably discontinuous (Dennell, 2003) and the variable presence of Mode 1, Acheulian and Soanian assemblages clearly suggests intermittent occupation (Chauhan, 2008a). Although there are significant deficiencies in the report by Sharma (1977), the area and particularly suitable outcrops of the Boulder Conglomerate Formation merit a survey for primary-context Paleolithic occurrences (preferably those capped by fine-grained sediments). Unlike the Pinjore Formation, the Boulder Conglomerate Formation contains a vast amount of quartzite clasts (along with the dominant sandstone clasts) for the production of stone tools which may have stimulated an increase in hominin occupation of the Siwalik frontal zone compared to Pinjore times (Chauhan, 2008a). The location of sites in such contexts may yield valuable information regarding not only raw material exploitation and transport behaviors but also pinpoint the initial timing of colonization by incoming hominin groups (i.e. earliest Acheulian of South Asia).

## Toka (northern India)

In the Toka area in southern Himachal Pradesh, Verma and Srivastava (1984) reported Paleolithic artifacts eroding out from the Tatrot sediments of Pliocene age and in association with vertebrate fossils (see Gaillard and Mishra, 2001 for a similar argument elsewhere in the Siwalik Hills). Despite the lack of excavations or *in situ* occurrences, they concluded that the artifacts on the Upper Siwalik slopes (but lacking on Lower Siwalik exposures) as well as some assemblages on the nearby Markanda terraces are eroding out from the ancient Siwalik surfaces. The investigators sought support for their observations from the previous work of Verma (1975) and Sharma (1977) (both discussed earlier): "The tool types recovered from both these stratigraphic levels indicate the pre-existence of the culture and suggest the possibility that the artefacts occurring in the Siwalik outcrops in the Markanda Valley have their provenance in the Tatrot Formations" (Verma and Srivastava, 1984:17). In conclusion, they state: "The occurrences indirectly suggest that the toolmaker lived in this region during the Upper Pliocene times, contrary to the earlier belief that the stone tools are confined to the terrace deposits only and the early man appeared in the Siwalik region during the Middle Pleistocene" (Verma and Srivastava, 1984:19).

As a part of my doctoral research, basic geological attributes were examined at Toka to hypothesize about site formation processes and reassess its stratigraphic context, partly in light of these claims. The resulting observations (Chauhan and Gill, 2002) refuted Verma and Srivastava's claims through several types of evidence: 1) the concerned artifacts are Soanian (i.e. a combination of Modes 1 and 3) rather than being pre-Acheulian, 2) they derive from post-Siwalik Upper Pleistocene contexts capping the Tatrot sediments, 3) the post-Siwalik artifacts happened to be deflated on the underlying Tatrot sediments instead of eroding out of them, and 4) artifacts and vertebrate fossils are also mixed and thus not contemporaneous with each other. This was all confirmed through two test-trenches on a post-Siwalik terrace as well as a pre-existing water pipeline trench across a part of Toka through exposures of the Tatrot Formation (Chauhan, 2008a). Where artifacts were found within Tatrot sediments or seemingly eroding out of them, they actually represented results of re-burial and/or re-exposure through colluvial action, monsoon-related surface runoff, or downslope displacement (Mohapatra and Singh, 1979; Chauhan and Gill, 2002).

In contrast, the contextual integrity of the artifacts appears to be associated with the post-Siwalik sedimentary layers *above* the Tatrot beds, implying a considerably younger age as Verma and Srivastava (1984:17) originally considered, but then negated, from observations at 75 localities (of only 5 to 15 artifacts at each location): "Close association of stone artefacts and vertebrate fossils throughout the area under examination poses an intriguing problem as whether to accept them to be of a common stratigraphic level or taking one (fossils) as Pliocene in age and the artefacts of a later period, and accidental. This however, seems highly improbable." From general observations by the author, this "close" but misleading association of stone artifacts and vertebrate fossils appears to be a result of winnowing and deflation from erosion and seasonal fluvial processes on the underlying Tatrot sediments (the source of the fossils) and post-Siwalik sediments (the source of the artifacts) in addition to the lack of post-Siwalik sedimentation (i.e., the lack of artifact burial) at different places on the site. Ultimately, it is presumed that the archaeological material is not older than the associated post-Siwalik raw material source (i.e. Tirlokpur Nadi) since the Tatrot Formation exposures here and elsewhere do not contain any quartzite clasts (Gill, 1983).

## Uttarbaini (northern India)

A claim of an Early Pleistocene lithic occurrence has also been made from the Jammu-and-Kashmir region of northern India. Here, Verma (1991) reports artifacts *in situ* from below a tuffaceous layer which was initially dated to 1.6±0.2 Ma and then re-dated to 2.8±0.5 by Ranga Rao et al., (1988) using the fission-track method. However, this claim has not been verified through further detailed investigations including excavations and the application of other geochronological techniques. Not only does the ash require re-dating, but the context of the artifacts and their archaeological integrity for that matter, also need to be confirmed. For example, no photographs of the section, the stratified ash or the artifacts are provided, and a description of the assemblage composition is also lacking. Nonetheless, this alleged occurrence warrants a systematic survey of the area in light of the ash deposits whose inconsistent age may be more accurately constrained using the well-established Upper Siwalik biochronology (Nanda, 2002; Dennell, 2004) in addition to re-dating.

## Riwat and the Pabbi Hills Assemblages (northern Pakistan)

The best-studied but also the most controversial pre-Acheulian lithic evidence in South Asia is currently known from the Siwalik Hills of northern Pakistan and includes the ca. 2.0 Ma site at Riwat (Rendell et al., 1989) and the 2.2–0.9 Ma old Mode 1 assemblages from the nearby Pabbi Hills (Hurcombe, 2004). The work was carried out by the British Archaeological Mission to Pakistan (BAMP) which lasted almost two decades and also yielded the oldest securely-dated Acheulian in the subcontinent at Dina and Jalalpur (Rendell and Dennell, 1985) and a unique post-Siwalik Paleolithic site (Rendell et al., 1989). The lithics at Riwat were first noticed in 1983 and then studied during subsequent visits over a decade. The site is a part of the Soan Syncline, a landscape-level geological feature that dips at an angle of about 10-15$^{o}$ on its southern edge (Rendell et al., 1989). Previous paleomagnetic applications (Burbank and Johnson, 1982) had suggested that the Syncline formed in the late Pliocene or between 1.9 and 2.1 Ma. Additionally, a volcanic tuff from the overlying horizontally-bedded fluvial sediments subsequently indicated an age of 1.6±0.2 Ma through K/Ar. According to Dennell (2007), scientists have never questioned the age or the dating of the Soan Syncline stratigraphic sequence, which implies that the tilted artifact-bearing horizon was established prior to the folding and is considerably older than the overlying ca. 1.6 Ma old horizontal strata. Later work by Rendell et al. (1987, 1989) sought to confirm the late Pliocene age of the concerned strata and also demonstrated that the artifact-bearing horizon was a prominent stratum of the Soan Syncline rather than being channel fill of a younger age. Through the collection of 280 samples from 71 sampling locations (with mean spacing of 1.7 meters), they confirmed the magnetic polarity to belong to the Matuyama Chron (see Dennell, 2007). The stratigraphic context of the Riwat assemblage is the lower gritstone/conglomerate horizon (LGC) in the syncline.[1]

### *Riwat*

To distinguish between naturally-flaked clasts–a common feature in conglomeratic deposits–and genuine artifacts, the investigators developed a methodology based on experimentation and ranked the various artifacts based on length, breadth, thickness, flake features, number of directions of flake removal, percentage of remaining cortex, positive/negative scars, evidence of retouch, edge roundedness and post-depositional damage (Rendell et al., 1989). Ultimately, 23 flaked quartzite specimens were initially collected and ranked (see Table 7.2 in Rendell et al., 1989: 110) after observing over 1000 cobbles within the LGC, but only three specimens have been promoted as being the most convincing artifacts and thus have received the most attention (Figure 9). Specimen R001 was first observed in 1983 to be imbedded in a gritstone/comglomerate horizon near the base of an erosional gully. This large core has eight or nine flake scars in three different directions and the size of the flake scars are thought to be comparable to Oldowan evidence from Bed I of Olduvai Gorge (Dennell, 2007). It is worth noting however, that the overall dimensions and morphology of the actual core is rather large and pointed, respectively, unlike typical Oldowan cores which are generally smaller and amorphous. Except for the cortical butt, the remainder of the specimen exhibits flaking on its two faces, also not common in the Oldowan in general. Specimen R014 was extracted from a gritstone block that had fallen from the same horizon nearby and is represented by a large flake struck from a

1 An upper gritstone is 100–200 ka and the overlying loess yielded a TL date of 74.3 8.3 ka. A hemispherical disc core and a rolled handaxe were collected from this upper gritstone horizon.

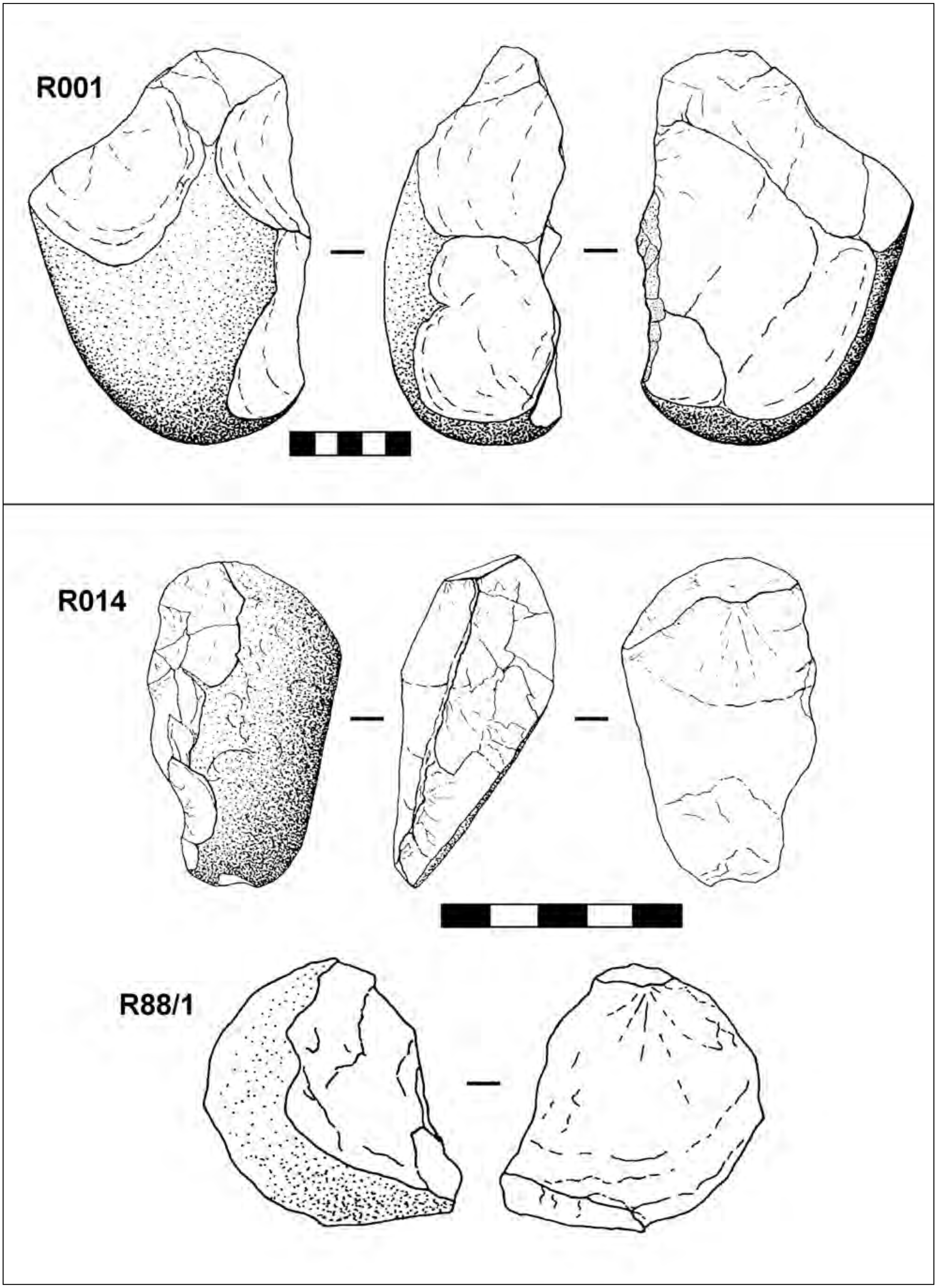


*Figure 9. The three main lithic specimens, one core (above) and two flakes from Riwat. (Modified from Dennell, 2007).*

*Table 3. The Pabbi Hills assemblage composition (modified from Hurcombe, 2004).*

| **Artifact type** | **Quantity** | **%** | **Retouched** | **Quartzite** | **Flint** | **other rock pieces** |
|---|---|---|---|---|---|---|
| proto-biface | 1 | 0.3 | | 1 | | |
| straight edged core tool | 5 | 0.8 | 3 | 5 | | |
| flake blade core | 6 | 1.0 | | 6 | | |
| high action core tool (HACT) | 14 | 2.3 | | 14 | | |
| microcore | 6 | 1.0 | | | 6 | |
| squared core | 10 | 1.6 | | 10 | | |
| bipolar core | 4 | 0.7 | | 4 | | |
| shattered wedge core fragment | 51 | 8.4 | | 50 | | 1 |
| irregular core | 30 | 4.9 | | 30 | | |
| split cobble | 16 | 2.6 | | 16 | | |
| unifacial core | 16 | 2.6 | | 6 | | |
| bidirectional/bifacial core | 48 | 7.9 | | 48 | | |
| simple disc core (discoid) | 23 | 3.8 | | 22 | | 1 |
| complex disc core (discoid) | 14 | 2.3 | | 14 | | |
| polyhedron | 3 | 0.5 | | 3 | | |
| **TOTAL CORES/CORE-TOOLS** | **247** | **40.7** | **3** | **239** | **6** | **2** |
| shatter-split flake | 2 | 0.3 | | 2 | | |
| angular flake | 11 | 1.8 | | 11 | | |
| irregular flake | 110 | 18.1 | 1 | 105 | 1 | 4 |
| (decortication flakes) | (21) | | | | | |
| split flake | 64 | 10.5 | | 60 | 3 | 1 |
| (decortication flakes) | (4) | | | | | |
| double bulb flake | 5 | 0.8 | | 5 | | |
| rounded simple flake | 76 | 12.5 | 1 | 75 | 1 | |
| (decortication flakes) | **(39)** | | | | | |
| rounded complex flake | 13 | 2.1 | | 12 | | 1 |
| straight-edged flake | 37 | 6.1 | 3 | 37 | | |
| flake blade | 14 | 2.3 | 2 | 14 | | |
| scraper | 6 | 1.0 | 6 | 5 | 1 | |
| HACT flake | 6 | 1.0 | | 6 | | |
| knife | 1 | 0.2 | 1 | 1 | | |
| **TOTAL FLAKES/FLAKE TOOLS** | **345** | **56.8** | **14** | **333** | **6** | **6** |
| **TOTAL CHIPPED STONE** | **592** | **97.5** | **17** | **572** | **12** | **8** |
| ring stone | 2 | 0.3 | | 1 | | 1 |
| rubbing stone | 1 | 0.2 | | 1 | | |
| rubbing stone flake | 2 | 0.3 | | | | 2 |
| polished stone fragment | 6 | 1.0 | | 2 | | 4 |
| **TOTAL GROUND/POLISHED** | **11** | **1.8** | **0** | **4** | **0** | **7** |
| hammerstone flake | 1 | 0.2 | | 1 | | |
| hammerstone | 3 | 0.5 | | 3 | | |
| **TOTAL HAMMERSTONES** | **4** | **0.7** | **0** | **4** | **0** | **0** |
| **TOTAL SPECIMENS** | **607** | | **17** | **580** | **12** | **15** |
| % in assemblage | | | 2.8 | 95.6 | 2.0 | 2.5 |

cobble. It possesses a prominent bulb of percussion as well as ripple marks and eight flake scars from three different directions. The third specimen, R88/1, is a fresh Type-5 flake (Toth, 1985) with a prominent bulb of percussion and with evidence of additional flaking from three directions and has positive and negative flake scars on each respective side. It was recovered from a freshly-eroding vertical section and 50 m from Specimen R001. Two additional specimens (R88/5 and R88/6) were originally counted as artifacts but were later discounted because they were thought to derive from post-Siwalik colluvial fill in the area. Overall, 1,264 clasts were plotted and studied in the LGC, however no additional artifacts were recovered. Therefore, in addition to the ca 2.0 ma age requiring substantiation, the Riwat sample is meager and comes from a gravel horizon (i.e. secondary context) and thus, offers little behavioral information. On the other hand, the Pabbi Hills evidence offers paleoanthropologists greater behavioral and technological information, in spite of its surface context.

### *Pabbi Hills assemblages*

In comparison to the Riwat evidence, the Pabbi Hills assemblages (Hurcombe and Dennell, 1993) are considerably richer and have often been overshadowed by the former. Following the work at Riwat, the main research objectives of BAMP in the Pabbi Hills was to pinpoint the context of the artifacts, confirm the Early Pleistocene age of much of the material, and distinguish between artifacts and naturally-fractured stone in the region. Only one find spot is reported and the rest of the specimens are surface occurrences distributed across the Siwalik landscape. The find spot is that of a stone tool on the surface of an escarpment of Sandstone 14. It fit in an *in situ* socket located in a secondary channel context above from the location it was recovered. A total of 607 specimens were interpreted to hominin-produced (Table 3; Figures 10 & 11) but their density of occurrence was observed to be very low: out of 211 locations where flaked-stone was recovered, isolated pieces occurred in 45% of the cases and no more than 3 specimens were found in 78% of the instances (Dennell, 2007).

The fluvial channel that deposited the sediments in the region was a part of a large floodplain environment and helped in establishing the depositional history of the area as well as possibly explained the absence of certain types of artifacts. Some of the possible debitage specimens collected weighed as little as 1 gm. The investigators (see Dennell, 2004) have also attempted to chronologically divide the entire assemblage based on the specimens' surface association with the underlying sediments and associated biochronology and stratigraphic correlation. For example, 102 specimens were distributed on sediments dated to 0.9–1.2 Ma; 307 specimens were collected from the surface of Sandstone 12, interpreted to be between 1.2 and 1.4 Ma; and 198 specimens were collected from a surface interpreted to be between 2.2 and 1.7 Ma. Approximately 41% are cores and 58% are flakes and the majority of specimens (96%) were produced on quartzite with 2.8% of all specimens showing deliberate retouch (Hurcombe, 2004). Six micro-cores, four hammerstones and six fragments of polished stone axes were made on flint and are thought to possibly belong to the Neolithic or a later phase.

Thought to be typologically comparable to most typically-African Oldowan assemblages, the investigators (see Dennell, 2004, 2007) maintain their interpretations and defend the contextual and behavioral integrities of the Pabbi Hills evidence using the following lines of argument: a) except for the Neolithic-like specimens, there is a virtual lack in the region of artifacts from younger time periods such as the Acheulian and Middle or Upper Paleolithic, b) the archaeological evidence cannot be road or rail ballast because the latter is generally smashed, not flaked and the artifacts were found at higher elevations and several kilometers from the nearest road/railway, c) there is no evidence of lithic or fossil material eroding/deflating from younger contexts and d) it is unlikely (from the currently-observable erosional processes) that such old artifacts and fossils could have remained on the surface of these formations throughout the Middle and Upper Pleistocene; thus they have eroded out in recent decades from the underlying sediments. Similarly, Dennell (2007) also attributes the lack of fossil hominin material in the otherwise rich vertebrate fossil evidence from northern Pakistan to such possible factors as: i) taphonomic bias towards the preservation of larger mammals (Dennell, in press), ii) seasonal flash floods, iii) water-borne infections and illnesses, and iv) episodic major flood events every two to three decades–hypothesized from modern analogs and thus having implications on raw material availability and procurement.

## Claims of Pre-Middle Pleistocene Hominin Fossils

The majority of human fossil material in the subcontinent comprises Late Pleistocene and Holocene specimens of *H. sapiens* from various parts of India and Sri Lanka (Kennedy 1999; 2001). The *Homo* calvarium from Hathnora in the central Narmada Valley in central India is thought to be of at least late Middle Pleistocene age and currently represents the oldest hominin fossil evidence in the Indian subcontinent (Sonakia and Biswas, 1998). Two other finds alleged to be older have generally been ignored in published reviews, probably because of their doubtful status as hominin fossils. For the sake of being comprehensive and unbiased, they are formally included as a part of this critique of the earliest claimed South Asian evidence. The two finds are of Early Pleistocene and late Pliocene age respectively and both come from Nadah and Khetpurali in the Siwalik region near Chandigarh in northern India.

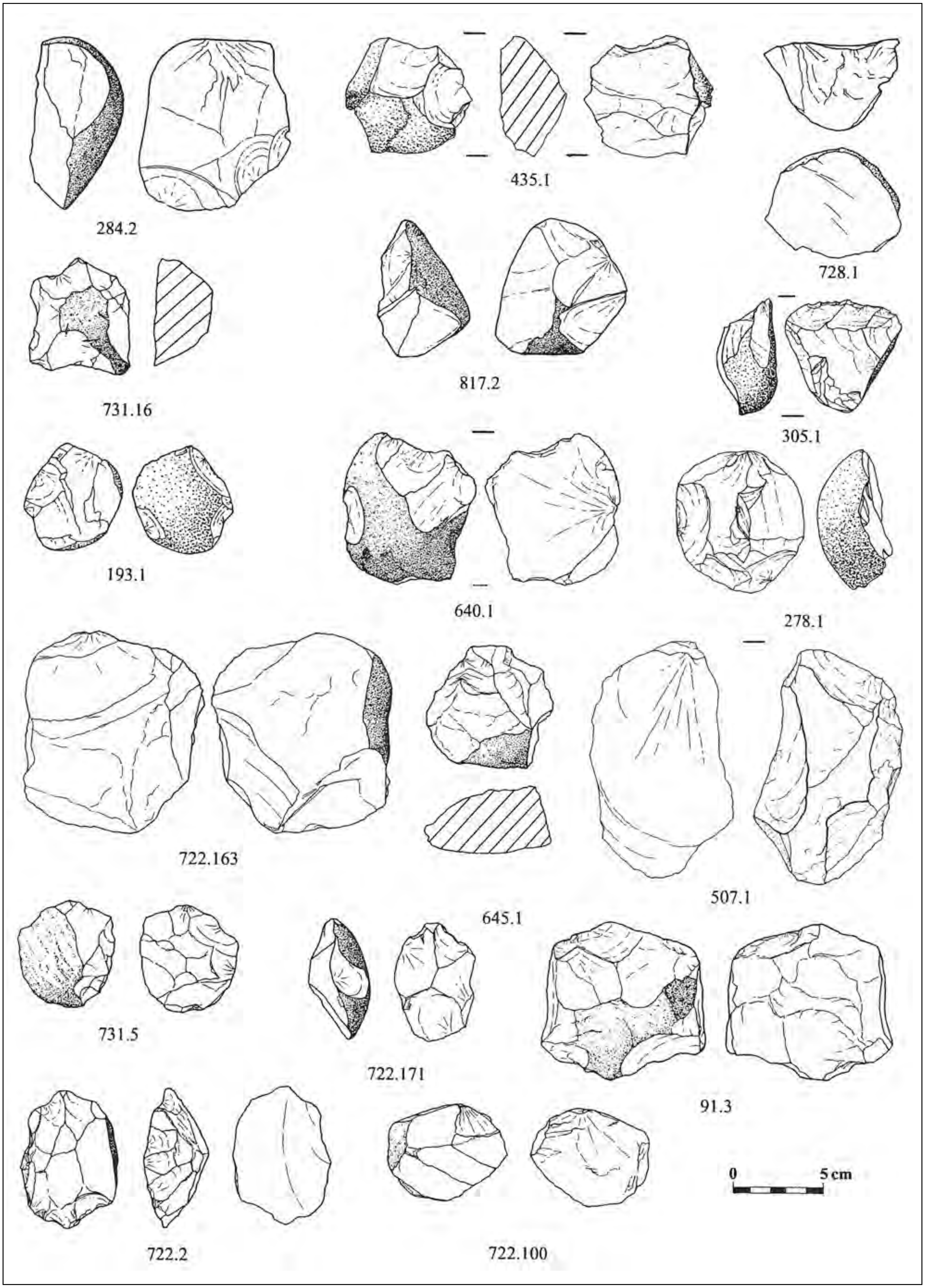


*Figure 10. Select core specimens from the Pabbi Hills (Source: Hurcombe, 2004)*

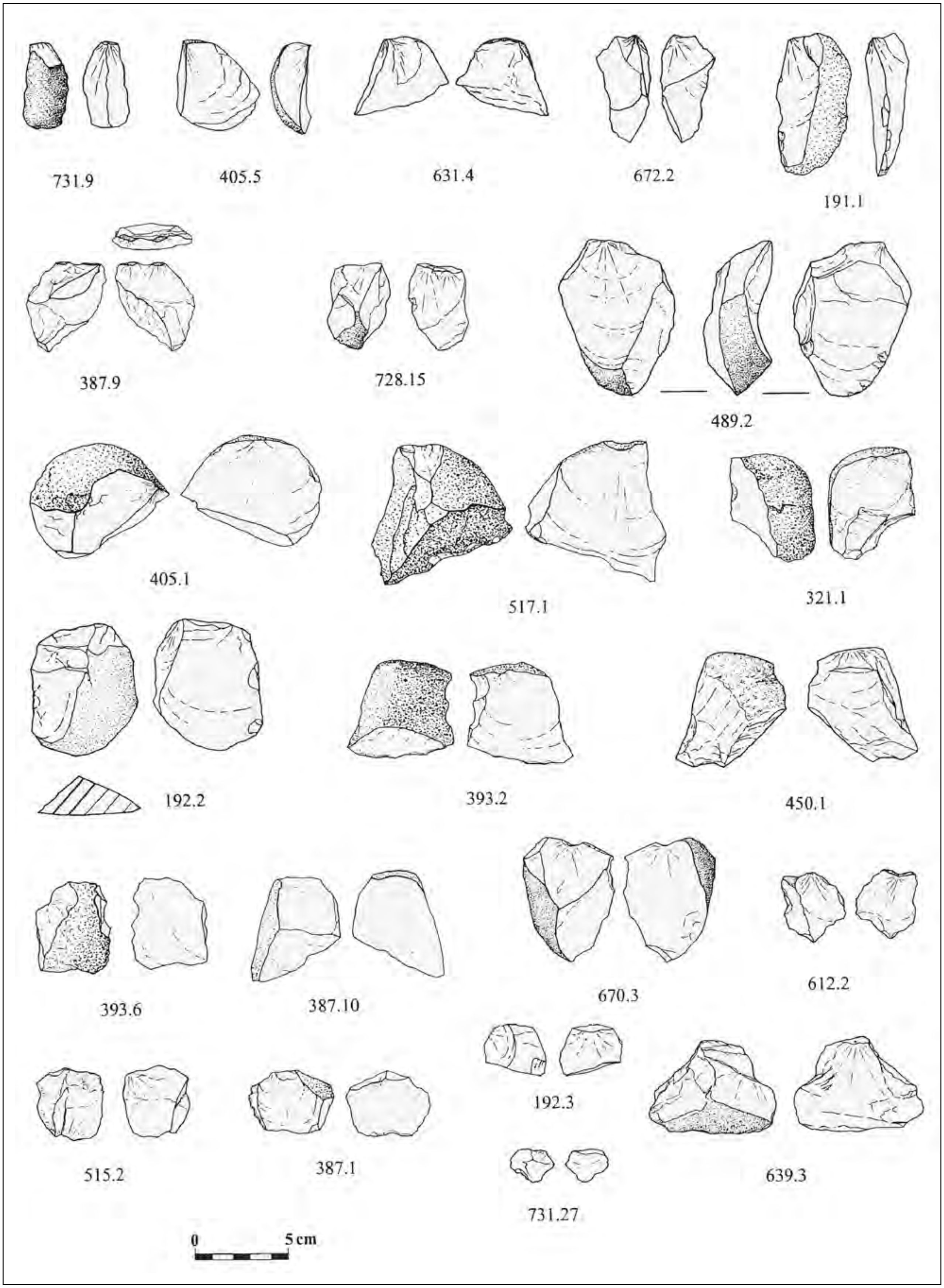


*Figure 11. Select flake specimens from the Pabbi Hills (Source: Hurcombe, 2004)*

## Nadah

The hominin specimen from Nadah is represented by a left maxillary central incisor recovered from the Pinjore Formation and attributed to *Homo erectus* (Singh et al., 1988). Although the lead author mentions the discovery by him of 'at least' three teeth thought to belong to three different individuals, the primary focus in their paper is on the one incisor. The specimen was discovered in 1985 from a buff-colored mudstone stratum 200 m from the base of the section and the basal portion of the Pinjore Formation and 0.5 km south of Nadah village. The other two incisors were recovered from 100 m away from the main specimen. The stratigraphic sequence here is approximately 275 m in total vertical length and consists of gray and greenish sandstones inter-bedded with brown and purple siltstone as well as cemented conglomerate and hard sandstone. Based on associated biostratigraphy and comparative stratigraphy of the Tatrot-Pinjore contact, the specimen is estimated to be 2.0 to 2.2 Ma old. Singh and colleagues describe the tooth in great morphological detail and attempt to systematically prove the hominin classification of the specimen. They list several key features to invalidate it as a Siwalik hominoid but do not systematically compare the specimen with other mammalian species. Features thought to be characteristic to hominids are highlighted by the authors as: i) a distinct occlusal abrasion pattern; ii) arched occlusal contour; iii) axial curvature of the longitudinal axis of the root and crown; iv) Pattern-3 prism of enamel structure; and v) mesiodistal and labiolingual metric data falling in the then-known range of other hominid dental evidence (see Table I in Singh et al., 1988: 570). Given the often ambiguous morphological overlap between certain hominin teeth and other mammalian species, the purported incisor(s) from Nadah remains circumstantial; it cannot be accepted as hominin until more diagnostic fossil specimens are recovered. At the very least, this specimen may represent a primate incisor if not hominin (A. Sahni: pers. comm.).

## Khetpurali and Masol

Most recently, Singh (2003) has also reported hominid mandibular and post-cranial fragments in association with stone tools from the Tatrot Formation near Khetpurali Village. From available paleomagnetic dating results on the known Upper Siwalik Formations, he proposed an age of ca. 3.4 Ma for the evidence. All fossil and lithic specimens are reported to have eroded out from a brown siltstone bed approximately 10 meters from the base of the Tatrot Formation which is thought to be 220 meters thick here. An additional 50 vertebrate taxa were also recovered at and around this locality. The mandibular fragment comprises a lower right first molar (M1) and the alveoli of the 3rd and 4th premolars and Singh highlights several features including i) the low position of the mental foramen below the mesial root of M1; ii) pattern of worn enamel and dentine; and iii) the transversely thick horizontal rami as well as other related details such as a facet on the cusp and the width of the root. M1 is thought to be metrically double the size of that tooth in *Homo sapiens*. Later work allegedly yielded more hominid fossils including a similar mandibular ramus with the P3, P4, M1 and alveoli of the canine present, a proximal-end of a left femur, the distal-end of a left femur and a right patella (from a brown clay at the basal portion of the Tatrot section near Masol village).

Unfortunately, not only are the descriptions parochial, but the fossil specimens are presumably classifiable as various large vertebrates rather than hominin. The associated lithic illustrations are also of poor quality and lack a photographic scale. There are also no comparative tables or related data (i.e. geochronology, sedimentation, metric data for the fossils and lithics and so forth) that are normally found in the current literature regarding paleoanthropological finds of such significance. Lower Paleolithic artifacts of a Mode 1 nature (including quartzite and ivory) are mentioned but the investigator does not provide any qualitative or quantitative details of the material except that they are made from quartzite pebbles and comprise unifacial and bifacial choppers. In that respect, they can easily be (and probably are) significantly younger Soanian assemblages that derived from younger contexts nearby. Overall, these localities reported by Singh (2003) do not appear to merit further scientific attention except for their geological and vertebrate paleontological aspects.

# Discussion and Conclusion

The foregoing review and critique of the South Asian pre-Acheulian palaeoanthropological evidence has included claims of both lithic and hominid-fossil occurrences from northern Pakistan and two separate regions of India, respectively. There are numerous other core-and-flake lithic assemblages in peninsular India, but because they remain undated and were reviewed elsewhere (Chauhan, in press, a), they have not been discussed in detail in this paper. These assemblages are known from the Konkan coast, Karnataka, Uttar Pradesh, Bihar and West Bengal, Orissa, Andhra Pradesh and northeastern India (Jayaswal, 1982). They comprise varieties of cores, discoids, choppers, core-scrapers, flakes, scrapers, notches, polyhedrons, sub-spheroids, unifaces, occasional *atypical* bifaces and debitage. Most are made from pebbles and cobbles and are associated with gravel deposits, suggesting that such clasts and associated tools were not transported over long distances.

Most of those assemblages are small and come from surface or secondary contexts and remain typological un-diagnostic. From general observations regarding their geological contexts, reduction strategies, comparative stratigraphy and overall assemblage compositions, most of the core-and-flake assemblages in peninsular India appear to be younger than the early Middle Pleistocene, with some possible Mode 1 exceptions in the Narmada

Valley that may be older than the Brunhes-Matuyama boundary such as Dhansi and Durkadi (Chauhan, in press, a) and other localities in Maharasthra. Some Early Acheulian assemblages in western and southern India may also be of comparable age (e.g., Mishra, 1995; Paddayya et al., 2002; Deo et al., 2007), but these occurrences also require further corroboration.

Despite the still controversial nature of the Riwat and Pabbi Hills lithic evidence, it remains the best-studied among all the claims discussed in this paper. The Pabbi Hills material is morphologically and dimensionally more similar to classic Oldowan assemblages than is the Riwat evidence. However, because the Riwat assemblage is meager and comes from a gravel context, and the Pabbi Hills evidence comes from surface contexts, both remain circumstantial and require corroboration through excavated sites in fine-grained primary contexts. Indeed, Dennell (2007:41) himself states: "However, apart from a small amount of material *that remains controversial* [emphasis mine] from Riwat (Dennell et al., 1988) and the Pabbi Hills, Pakistan (Dennell, 2004; Hurcombe, 2004), there is no incontrovertible evidence that hominins were living in the northern part of the Indian subcontinent in the Early Pleistocene, even though it is the obvious corridor route between Southwest and Southeast Asia." The evidence for possible early occupation at Riwat and/or Pabbi Hills does not necessarily suggest the presence of comparable evidence in peninsular India (see Dennell, 2003).

The current absence of such assemblages in peninsular India may be attributable to a suite of factors: i) Plio-Pleistocene sediments are not well preserved/exposed in the region and/or ii) behavioral evidence is deeply buried under alluvium such as the Indo-Gangetic plains (Misra, 2001), and iii) Early Pleistocene evidence (if any exists) has been misinterpreted as being younger because it remains un-dated or because it not expected in the archaeological record. The most parsimonious or plausible explanations is that hominins were not present in peninsular India and possibly the entire Indian subcontinent. Regarding the Pabbi Hills evidence, Dennell (2007: 60) states: "*As none of this material was found in situ, the case for dating it to the Early Pleistocene remains circumstantial. Nevertheless this type of field survey data forms an important part of the archaeological literature, and those readers who might reject this evidence on the grounds that it was found on the surface might reflect how much other data collected by field surveys elsewhere should also be rejected*." However, it cannot be overstated that the most reliable chronological frameworks for early hominin occupation throughout the Old World have primarily come from well-excavated sites in fine-grained stratified contexts that were directly dated on an absolute scale.

The other pre-Acheulian occurrences in the Siwalik Hills (e.g., Uttarbaini) and Narmada Valley (e.g., Durkadi, Dhansi) of northern and central India respectively, require re-investigations of their stratigraphic contexts and the precise age of the behavioral evidence. The sites of Kheri-Jhiran and Mahadeo Piparia appear to respectively represent a mixture of various lithic industries–Mode 1, Acheulian and younger assemblages. However, they still merit a proper investigation, particularly absolute dating of the associated deposits, to confirm or eliminate the possibility of pre-Acheulian occupation at these locations. The claims of hominid fossils and stone tools from late Pliocene and late Miocene contexts at Nadah and Khetpurali (Singh et al., 1988; Singh, 2003) respectively, cannot be accepted as valid finds, most of which still require substantiation.

Based on the current paleoanthropological evidence in the Indian subcontinent and other surrounding regions (e.g., central Asia, SE Asia), a shorter chronology for the earliest hominin occupation in Asia is better supported than the currently-claimed longer chronologies in these respective regions. For example, this general review has demonstrated that there is currently no convincing evidence of hominin occupation prior to the Middle Pleistocene in the Indian subcontinent. This is broadly and tentatively supported by the lack of late Pliocene/Early Pleistocene stone tools in SE Asia (Corvinus, 2004) and the need for better chronological and contextual control, including re-dating at key site localities such as the Nihewan Basin (e.g., Zhu et al., 2004) and the reportedly-earliest hominid fossil localities in SE Asia (Swisher et al., 1994). In other words, our knowledge of the earliest timing of hominin colonization of Asia remains unclear and requires clarification at various levels. For instance, Dennell (2007) marshals such evidence as the lack of suitable raw material in the Indo-Gangetic foredeep of South Asia (Misra, 1989; 2001), the seasonal availability of raw material, and a high number of carnivores (as a major predation risk to hominins) to explain and interpret the seemingly marginal occupation of early hominin groups in this region.

In other words, late Pliocene/Early Pleistocene smaller-brained hominins may have been represented by only small populations that did not venture frequently into areas containing limited lithic resources due to a smaller home-range size and short-distance transport (of raw materials) behavior. They may have adapted through multiple options: i) utilizing small clasts, ii) curation of raw materials and finished tools, iii) caching, iv) replacing stone with other material and v) avoidance of 'stone-poor' areas (Dennell, 2007: 49). On the other hand, early Middle Pleistocene larger-brained hominins groups may have better coped with such ecological challenges and thus been able to colonize this zone as well as pass through the Indo-Gangetic plains into peninsular India. If these inferences turn out to be accurate, they may partly explain the virtual dearth of Early Pleistocene Oldowan and Acheulian occupation in the Pinjore Formation of the Siwalik Hills as well as in contemporaneous contexts of peninsular India and, possibly other parts of Asia.

Obviously, much more research is required to test and confirm such hypotheses. However, until we have absolute dates from excavations in primary fine-grained contexts, we cannot reject the possibility of a shorter chronology of hominin occupation for South Asia. Based on the most unequivocal information available, the earliest occupation of the Indian subcontinent appears to be by Early Acheulian hominins at the Brunhes-Matuyama polarity transition or slightly earlier.

## References


Agrawal D.P., Kotlia, B.S., Kusumgar, S., 1988. Chronology and Significance of the Narmada Formations. Proceedings of the Indian National Science Academy. 54, 418-424.

Anton, S., Swisher, C.C. III, 2004. Early Dispersals of *Homo* from Africa. Annual Reviews in Anthropology 33, 271-296.

Armand, J., 1979. The Middle Pleistocene pebble tool site of Durkadi in Central India. Paleorient 5, 105-144.

Armand, J., 1983. Archaeological Excavations in the Durkadi Nala- An Early Palaeolithic Pebble-Tool Workshop in Central India. Munshiram Manoharlal Publishers Pvt. Ltd., Delhi.

Armand, J., 1985. The emergence of the handaxe tradition in Asia, with special reference to India. In: Misra, V.N., Bellwood, P. (Eds.), Recent Advances in Indo-Pacific Prehistory. Oxford and IBH, New Delhi, pp. 3-8.

Athreya, S., 2007. Was *Homo heidelbergensis* in South Asia? A test using the Narmada fossil from central India. In: Petraglia, M.D., Allchin, B. (Eds.), The Evolution and History of Human Populations in South Asia: Inter-disciplinary Studies in Archaeology, Biological Anthropology, Linguistics and Genetics. Springer, Dordrecht, The Netherlands, pp. 137-170.

Blackwell, B.A.B., Montoya, A., Blickstein, J.I.B., Skinner, A.R., Pappu, S., Gunnell, Y., Taieb, T., Kumar, A., Lundbergfet, J.A. 2007. ESR analyses for teeth from the open-air site at Attirampakkam, India: Clues to complex U uptake and paleoenvironmental change. Radiation Measurements 42, 1243-1249.

Brozović, N., Burbank, D.W., 2000. Dynamic fluvial systems and gravel progradation in the Himalayan foreland. Geological Society of America Bulletin 112, 394–412.

Burbank, D.W. and Johnson, G.D., 1983. The late Cenozoic chronologic and stratigraphic development of the Kashmir Intermontane Basin, northwestern Himalaya. Palaeogeography, Palaeoclimatology, Palaeoecology 43, 205-235.

Cameron, D., Patnaik, R., Sahni, A., 2004. The Phylogenetic Significance of the Middle Pleistocene Narmada Hominin. Journal of Osteoarchaeology 14, 419-447.

Chauhan, P.R., 2003. An Overview of the Siwalik Acheulian & Reconsidering its Chronological Relationship with the Soanian–A Theoretical Perspective. Assemblage 7 (http://www.assemblage.group.shef.ac.uk/issue7/chauhan.html).

Chauhan, P.R., 2004. A Review of the Early Acheulian Evidence from South Asia. Assemblage 8 (http://wwwshef.ac.uk/assem/issue8/chauhan.html).

Chauhan, P.R., 2006. Human Origins Studies in India: Position, Problems, and Prospects. Assemblage 9 (http:/www.assemblage.group.shef.ac.uk/issue9/chauhan.html).

Chauhan, P.R., 2008a. Soanian lithic occurrences and raw material exploitation in the Siwalik Frontal zone, northern India: a geoarchaeological approach. Journal of Human Evolution 54, 591-614.

Chauhan, P.R., in press, a. Core-and-flake assemblages of India. In: Norton, C.J., Braun, D. (Eds.), Asian Paleoanthropology: From Africa to China and Beyond (Book Series: Vertebrate Paleobiology and Paleoanthropology). Kleuwer-Academic Press, New York.

Chauhan, P.R., in press, b. Large mammal fossil occurrences and associated archaeological evidence in Pleistocene contexts of peninsular India and Sri Lanka. Quaternary International.

Chauhan, P.R., Gill, G.S., 2002. The impact of geological and anthropogenic processes on prehistoric sites on Siwalik slopes: A case study. Bulletin of the Indian Geologists Association 35, 71–81.

Clark, J.D., 1998. The Early Palaeolithic of the eastern region of the Old World in comparison to the West. In: Petraglia, M.D., Korisettar, R. (Eds.), Early Human Behavior in Global Context: the Rise and Diversity of the Lower Palaeolithic Record. Routledge Press, New York, pp. 437-450.

Corvinus, G., 2004. *Homo erectus* in East and Southeast Asia, and the questions of the age of the species and its association with stone artifacts, with special attention to handaxe-like tools. Quaternary International. 117, 141-151.

Dennell, R.W., 2003. Dispersal and colonisation, long and short chronologies: how continuous is the Early Pleistocene record for hominids outside East Africa? Journal of Human Evolution 45, 421-440.

Dennell, R.W., 2004. Early Hominin Landscapes in Northern Pakistan: Investigations in the Pabbi Hills. BAR International Series 1265, Oxford.

Dennell, R., 2007. “Resource-rich, stone-poor”: early hominin land use in large river systems of northern India and Pakistan. In: Petraglia, M.D., Allchin, B. (Eds.), The Evolution and History of Human Populations in South Asia–Interdisciplinary studies in Archaeology, Biological Anthropology, Linguistics and Genetics. Vertebrate Paleobiology and Paleoanthropology Series. Springer Press, New York.

Dennell, R.W., in press. The taphonomic record of Upper Siwalik (Pinjor stage) landscapes in the Pabbi Hills, northern Pakistan, with consideration regarding the preservation of hominin remains. Quaternary International.

Dennell, R.W., Hurcombe, L., 1992. Paterson, the British Clactonian and the Soan Flake Industry: A re-evaluation of the Early Palaeolithic of Northern Pakistan. In: Jarrige, C. (Ed.), South Asian Archaeology. Prehistory Press, Madison, pp. 69-72.

Dennell, R.W., Rendell, H.M., 1991. De Terra and Paterson and the Soan Flake Industry: A new perspective from the Soan Valley, Northern Pakistan. Man and Environment 16, 90-99.

Dennell, R.W., Roebroeks, W., 2005. An Asian Perspective on Early Human Dispersal from Africa. Nature 438, 1099–1104.

Dennell, R.W., Rendell, H.R., Hailwood, E., 1988. Early tool-making in Asia: two-million-year-old artefacts in Pakistan. Antiquity 62, 98–106.

Deo, S.G., Mishra, S., Rajaguru, S.N., Ghate, S., 2007. Antiquity of Acheulian culture in upland Maharasthra: A geoarchaeological approach. In: A.R. Sankhyan (Ed.) Genome and People of India. Concept Publishers, Calcutta, pp. 292-308.

De Terra, H., Paterson, T.T., 1939. Studies on the Ice Age in India and Associated Human Cultures. Carnegie Institute Publication 493, Washington D.C.

Gabunia, L., A. Vekua., 1995. A Plio-Pleistocene hominid from Dmanissi, East Georgia, Caucasus. Nature 373, 509-512.

Gabunia, L., Vekua, A., Lordkipanidze, D., Swisher, C.C., Ferring, R., Justus, A., Nioradze, M., Tvalchrelidze, M., Anton, S. C., Bosinski, G., Joris, O, de Lumley, M-A., Majsuradze, G., Mouskhelishvili, A., 2000. Earliest Pleistocene cranial remains from Dmanisi, Republic of Georgia: taxonomy, geological setting, and age. Science 288, 1019-1025.

Gaillard, C., 1995. An Early Soan assemblage from the Siwaliks: A comparison of processing sequences between this assemblage and an Acheulian assemblage from Rajasthan In: Wadia, S., Korisettar, R., Kale, V.S. (Eds.) Quaternary Environments and Geoarchaeology of India. Geological Society of India, Bangalore, pp. 231-245.

Gaillard, C. and Mishra, S., 2001. The Lower Palaeolithic in South Asia. In: F. Sémah, Falgueres, C., Grimaud-Herve, D., Sémah, A. (Eds.), Origin of Settlements and Chronology of the Palaeolithic Cultures in Southeast Asia. Colloque International de la Fondation Singer Polignac), Paris, June 3-5, 1998. Éditions Artcom', Paris, pp. 73-91.

Gill, G.S., 1983. Sedimentology of the Siwalik Group exposed between the rivers Ghaggar and Markanda-Northwestern Himalaya. Publication of the Centre of Advanced Study in Geology, Panjab University 13, pp. 274-312.

Hurcombe, L., 2004. The stone artefacts from the Pabbi Hills. In: Dennell, R.W. (Ed.), Early Hominin Landscapes in Northern Pakistan: Investigations in the Pabbi Hills. British Archaeological Reports International Series 1265, Oxford, pp. 222-292.

Hurcombe, L.M., Dennell, R.W., 1993 A Pre-Acheulean in the Pabbi Hills, northern Pakistan? In: Jarrige, C. (Ed.), South Asian Archaeology 1989 (Proceedings of the International Conference of South Asian Archaeologists in Western Europe, Paris, July 1989). Prehistory Press, Madison, pp. 133-136.

Jayaswal, V., 1982. Chopper-Chopping Component of Palaeolithic India. Agam Kala Prakashan, New Delhi.

Johnson, N.M., Opdyke, N.D., Johnson, N.D., Lindsay, E.H., Tahirkheli, R.A.K., 1982. Magnetic polarity stratigraphy and ages of Siwalik Group rocks of the Potwar Plateau, Pakistan. Palaeogeography, Palaeoclimatology, Palaeoecology 37, 17-42.

Kennedy, K.A.R., 1999. Paleoanthropology of South Asia. Evolutionary Anthropology 8, 165-185.

Kennedy, K.A.R., 2001. Middle and Late Pleistocene Hominids of South Asia. In: Humanity from African Naissance to Coming Millennia.University of Firenze, Firenze, pp. 167-174.

Kennedy, K.A.R., 2003. God-apes and fossil men: paleoanthropology of South Asia. University of Michigan Press, Ann Arbor.

Kennedy, K.A.R., Chiment, J., 1991. The fossil hominid from the Narmada valley, India: *Homo erectus* and *Homo sapiens*? In: Bellwood, P. (Ed.), Indo-Pacific Prehistory 1990 1. Indo-Pacific Prehistory Association, Canberra, pp. 42-58.

Khatri, A.P., 1963. Mahadevian: An Oldowan Pebble Culture of India. Asian Perspectives VI, 186-197.

Khatri, A.P., 1966. Origin and evolution of hand-axe culture in the Narmada Valley (Central India). In: Sen, D., Ghosh, A.K. (Eds.), Studies in Prehistory (Robert Bruce Foote Memorial Volume). Firma K.L. Mukhopadhyay, Calcutta, pp. 96-121.

Korisettar, R., Rajaguru, S.N., 1998. Quaternary stratigraphy, palaeoclimate and the Lower Palaeolithic of India. In: Petraglia, M.D., Korisettar, R. (Eds.), Early Human Behaviour in Global Context: The Rise and Diversity of the Lower Palaeolithic Record.Routledge, London, pp. 304-342.

Kumar, R., Ghosh, S.K., Phadtare, N.R. (Eds.), 1994. Siwalik Foreland Basin of Himalaya. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Langbroek, M., 2004. 'Out of Africa' An investigation into the earliest occupation of the Old World. BAR International Series 1244.

Larick, R., Ciochon, R.L., 1996. The African Emergence and Early Asian Dispersals of the Genus *Homo*. American Scientist 84, 538-551.

Lycett, S., 2007. Is the Soanian techno-complex a Mode 1 or Mode 3 phenomenon? A morphometric assessment. Journal of Archaeological Science 34, 1434-1440.

Mishra, S., 1992. The Age of the Acheulian in India: New Evidence. Current Anthropology 33, 325-328.

Mishra, S., 1994. The South Asian Lower Palaeolithic. Man and Environment 19, 57-72.

Mishra, S., 1995. Chronology of the Indian Stone Age: the Impact of Recent Absolute and Relative Dating Attempts. Man and Environment, 20, 11-16.

Misra, V.N., 1987. Middle Pleistocene Adaptations in India. In: Soffer, O. (Ed.), The Pleistocene Old World-Regional Perspectives. New York: Plenum Press, New York.

Misra, V.N., 1989. Stone Age India: An ecological perspective. Man and Environment 14, 17-64.

Misra, V.N., 1997. Early Man and his environment in Central India. Journal of the Palaeontological Society of India 42, 1-18.

Misra, V.N., 2001. Prehistoric human colonization of India. Journal of Bioscience 26, 491-531.

Mohapatra, G.C., 1981. Acheulian discoveries in the Siwalik frontal range. Current Anthropology 22, 433-435.

Mohapatra, G.C. Singh, M., 1979a. Stratified occurrence of lithic artifacts in the Siwalik frontal range of western sub-Himalaya. Panjab University Research Bulletin (Arts) 10, 65-77.

Nanda, A.C., 2002. Upper Siwalik mammalian faunas of India and associated events. Journal of Asian Earth Sciences 21, 47-58.

Paddayya, K., Blackwell, B.A.B., Jhaldiyal, R., Petraglia, M.D., Fevrier, S., Chaderton II, D.A., Blickstein, J.I.B., Skinner, A.R., 2002. Recent findings on the Acheulian of the Hunsgi and Baichbal valleys, Karnataka, with special reference to the Isampur excavation and its dating. Current Science 83, 641–647.

Patnaik, R., Chauhan, P.R., Rao, M.R., Blackwell, B.A.B., Skinner, A.R., Sahni, A., Chauhan, M.S., Khan, H.S., in press. New geochronological, palaeoclimatological and Palaeolithic data from the Narmada Valley hominin locality, central India. Journal of Human Evolution.

Penck, A., Brückner, E., 1909. Die Alpen im Eiszeitalter. Tachnitz, Leipzig.

Petraglia, M. D., 1998. The Lower Palaeolithic of India and its bearing on the Asian Record. In: Petraglia, M.D., Korisettar, R. (Eds.), Early Human Behaviour in Global Context: The Rise and Diversity of the Lower Palaeolithic Record. Routledge, London, pp. 343-390.

Petraglia, M.D., 2001. The Lower Palaeolithic of India and its Behavioural Significance. In:Barham, L., Robson-Brown, K. (Eds.), Human Roots: Africa and Asia in the Middle Pleistocene. Western Academic & Specialist Press, Ltd., Bristol, England, pp. 217-233.

Ranga Rao, A., Agrawal, R.P., Sharma, U.N., Bhalla, M.S., Nanda, A.C., 1988. Magnetic polarity stratigraphy and vertebrate palaeontology of the Upper Siwalik Subgroup of Jammu Hills, India. Journal of the Geological Society of India 32, 109-128.

Rao, K.V., Chakraborti, S., Rao, K.J., Ramani, M.S.V., Marathe, S.D., Borkar, B.T., 1997. Magnetostratigraphy of the Quaternary Fluvial Sediments and Tephra of Narmada Valley, Central India. In: Udhoji, S.G., Tiwari, M.P. (Eds.), Quaternary Geology of the Narmada Valley-A Multidisciplinary Approach. Special Publication No. 46 of the Geological Survey of India. Geological Survey of India, Calcutta, pp. 65-78.

Rendell, H.M., Dennell, R.W., 1985. Dated Lower Palaeolithic Artifacts from Northern Pakistan. Current Anthropology 26, 93.

Rendell, H.M., Hailwood, E.A., Dennell, R.W., 1987. Magnetic polarity stratigraphy of Upper Siwalik Sub-Group, Soan Valley, Pakistan: implications for early human occupation of Asia. Earth and Planetary Science Letters 85, 488-496.

Rendell, H.M., Dennell, R.W., Halim, M.A., 1989. Pleistocene and Palaeolithic Investigations in the Soan Valley, Northern Pakistan. B.A.R. International Series 544, Oxford.

Sankalia, H.D., 1974. The Prehistory and Protohistory of India and Pakistan. Deccan College and Postgraduate Research Institute, Pune.

Sankhyan, A.R., 1997. A new human fossil from the Central Narmada Basin and its chronology. Current Science 73, 1110-1111.

Sankhyan, A.R., 2005. New fossils of Early Stone Age man from Central Narmada Valley. Current Science 88, 704-707.

Sen, D., Ghosh, A.K., 1963. Lithic culture-complex in the Pleistocene sequence of the Narmada Valley, Central India. Rivista Di Scienze Prestoriche 18 1, 3-23.

Sharma, J.C., 1977. Palaeolithic tools from Pleistocene deposits in Panjab, India. Current Anthropology 18, 94-95.

Singh, M.P., 2003. First record of a Middle Pliocene hominid from the Siwalik Hills of South Asia. Human Evolution 18, 213-228.

Singh, M.P., Sahni, A., Kaul, S., Sharma, S.K., 1988. Further evidence of hominid remains from the Pinjor Formation, India. Proceedings of the Indian National Science Academy 54, 564-573.

Sonakia, A., 1984. The skull cap of early man and associated mammalian fauna from Narmada Valley alluvium, Hoshangabad area, Madhya Pradesh, India. Records of the Geological Survey of India 113, 159-172.

Sonakia, A., Biswas, S., 1998. Antiquity of the Narmada *Homo erectus*, the early man of India. Current Science 75, 391-393.

Soni, A.S., Soni, V.S., 2005. Palaeolithic tools from the surface of optically stimulated luminescence dated alluvial fan deposits of Pinjaur Dun in NW sub-Himalayas. Current Science 88, 867-871.

Stiles, D., 1978. Palaeolithic artifacts in Siwalik and post-Siwalik deposits. Kroeber Anthropology Society Papers 53-54, 129-148.

Supekar, S.G., 1968. Pleistocene Stratigraphy and Prehistoric Archaeology of the Central Narmada Basin. Unpublished Ph.D. Thesis. Deccan College Postgraduate and Research Institute, Pune.

Supekar, S.G., 1985. Some observations on the Quaternary stratigraphy of the central Narmada valley. In: Misra, V.N., Bellwood, P. (Eds.), Recent Advances in Indo-Pacific Prehistory. Oxford & IBH Publishing Co, New Delhi, pp.19-27.

Swisher, C.C. III., Curtis, G.H., Jacob, T., Getty, A.G., Suprijo, A., Widiasmoro, 1994. Age of earliest known hominids in Java, Indonesia. Science 263, 1118-1121.

Toth, N., 1985. The Oldowan reassessed: A close look at early stone artifacts. Journal of Archaeological Science 12, 101-120.

Tiwari, M.P., Bhai, H.Y., 1997. Quaternary Stratigarphy of the Narmada Valley. In: Udhoji, S.G., Tiwari, M.P. (Eds.), Quaternary Geology of the Narmada Valley–A Multidisciplinary Approach. Special Publication No. 46 of the Geological Survey of India. Geological Survey of India, Calcutta, pp. 33-63.

Verma, B.C., 1975. Occurrence of Lower Paleolithic artifacts in the Pinjor member (Lower Pleistocene) of Himachal Pradesh. Journal of the Geological Society of India 16, 518-521.

Verma, B.C., 1991. Siwalik Stone Age Culture. Current Science 61, 496.

Verma, B.C., Srivastava, J.P., 1984. Early Palaeolithic sites of the outer Siwalik belt in Sirmur District, Himachal Pradesh–their age and stratigraphic position. Man and Environment 8, 13-19.

Woldegabriel, G., Heiken, G., White, T.D., Asfaw, B., Hart, W.K., Renne, P.R., 2000. Volcanism, tectonism, sedimentation, and the paleoanthropological record in the Ethiopian Rift System. Geological Society of America, Special Paper 345, 83-99.

Zhu, R.X., Potts, R., Xie, F., Hoffman, K.A., Deng, C.L., Shi, C.D., Pan, Y.X., Wang, H.Q., Shi, R.P., Wang, Y.C., Shi, G.H., Wu, N.Q., 2004. New evidence on the earliest human presence at high northern latitudes in northeast Asia. Nature 431, 559–562.