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# Human Evolution in the Center of the Old World: An Updated Review of the South Asian Paleolithic

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## Abstract

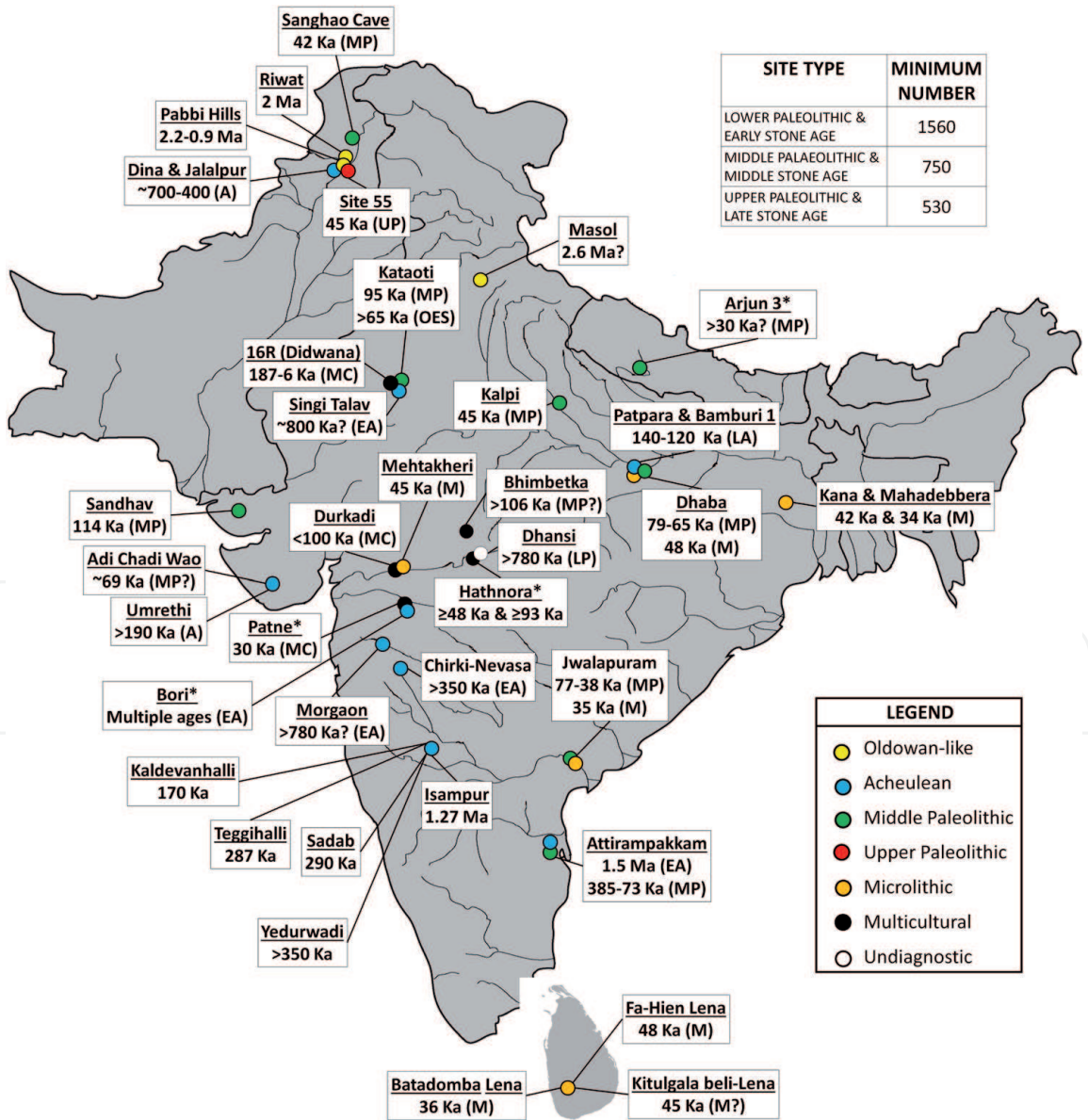
The Indian Subcontinent was an important geographic region for faunal and hominin evolution in Asia. While the Oldowan as the earliest technocomplex continues to be elusive, the oldest Acheulean is dated to ~1.5 Ma and the early Middle Paleolithic is ~385 ka (from the same site). New Late Pleistocene dates have been reported for the Middle Paleolithic which continues up to 38 Ka in southern India. The Upper Paleolithic remains ambiguous and requires critically multidisciplinary investigations. The microlithic evidence appears to spread rapidly across the subcontinent soon after its emergence at ~48 Ka (though its origin is debated) and continues into the Iron Age. The timeline of the initial arrival of *Homo sapiens* continues to be debated based on the archaeology (advanced Middle Paleolithic vs. microlithic) and genetic studies on indigenous groups. Other issues that need consideration are: interactions between archaics and arriving moderns, the marginal occurrence of symbolic behavior, the absolute dating of rock art and the potential role of hominins in specific animal extinctions and ecological marginalization. The region does not appear to have been a corridor for dispersals towards Southeast Asia (although gene flow may have occurred). Instead, once various prehistoric technologies appeared in the Subcontinent, they possibly followed complex trajectories within relative isolation.

**Keywords:** Asia, Indian subcontinent, Paleolithic, paleoanthropology, milestones

## 1. Introduction

Human evolutionary studies or paleoanthropological research are constantly yielding new information and thus revising previously assumed hypotheses as well as generating new ones. While Africa and Europe have dominated the bulk of our knowledge on human evolution over the last century, various parts of Asia are yielding new and unexpected paleoanthropological surprises. One of these vital Asian regions is South Asia or the Indian Subcontinent, its prehistory being known and regularly highlighted since the nineteenth century [1] and predominantly includes stone tool assemblages from various time periods ranging from the Lower Paleolithic to the Neolithic [2]. Prehistoric evidence is known from throughout the Subcontinent with specific geographic pockets as being exceptions due to various

factors including research bias as well as other natural attributes. Lithic assemblages belonging to all prehistoric phases have been reported including Lower Paleolithic (Oldowan and Acheulean), Middle Paleolithic, Upper Paleolithic and microlithic/ Mesolithic. Despite this large body of known evidence, very few sites have been properly dated using absolute dating techniques. The earlier results, though obtained through different dating methods [3, 4], should be viewed as provisional until verified by newly-available dating techniques. For example, some U-Th dates (between <390 Ka and < 131 Ka) processed a few decades ago at a multi-period site in Rajasthan have now been revised to younger estimates using the luminescence method e.g. [5], leading to a re-interpretation of that cultural sequence [6]. The persistent marginal profile of hominin fossils continues to afflict Indian prehistory and more systematic surveys are required to identify new areas with vertebrate fossil preservation. The only known pre-modern hominin fossils in the subcontinent, which may be contemporary with the Late or terminal Acheulean phase, come from Hathnora and nearby localities in the central Narmada Valley. They include a partial calvarium, possibly female, and possibly associated clavicles and a rib fragment, all



**Figure 1.** Map of dated Paleolithic technologies across the Indian subcontinent including Pakistan, India, Nepal and Sri Lanka (LP: Lower Paleolithic; a: Acheulean; EA: Early Acheulean; LA: Late Acheulean; MP: Middle Paleolithic; UP: Upper Paleolithic; M: Microlithic; MC: Multi-cultural; OES: Ostrich eggshell).

Site	Age	Techno-chronology
Masol	2.6 Ma?	pre-Acheulean
Riwat (Pakistan)	~2 Ma	Pre-Acheulean
Pabbi Hills (Pakistan)	2.2–0.9 Ma	Pre-Acheulean
Attirampakkam	1.5 Ma & 385–73 Ka	Acheulean & Middle Paleolithic
Isampur	1.27 Ma?	Acheulean
Singi Talav	~800 Ka?	Acheulean
Dhansi	>780 Ka	Undiagnostic
Morgaon	>780 Ka & 41 Ka	Acheulean
Dina & Jalapur	~700–400 Ka	Acheulean
Chirki Nevasa	>350 Ka	Acheulean
Sadab	290 Ka	Acheulean
Teggihalli	287 Ka	Acheulean
Umrethi	>190 Ka	Acheulean
Kaldevanhalli	174 Ka	Acheulean
Patpara & Bamburi 1	140–120 Ka	Acheulean
Bori	1.38 Ma to 23 Ka	Acheulean
Adi Chadi Wao	190 to 69 Ka	Acheulean
16R (Didwana)	187 Ka - 6 Ka	Multi-period
Sandhav	114 Ka	Middle Paleolithic
Bhimbetka Rockshelter III-F23	>106 Ka & >41 Ka	Multi-period
Nakjhar Khurd	>100 Ka	Acheulean
Durkadi	<100 Ka	Multi-period
Kataoti	95 Ka	Middle Paleolithic
Dhaba	79–65 Ka & 48 Ka	Middle Paleolithic & microlithic
Jwalapuram	77–38 Ka & 35 Ka	Middle Paleolithic and microlithic
Mehtakheri	48 Ka	Microlithic
Fa-Hien Lena (Sri Lanka)	48 Ka	microlithic
Kalpi	45 Ka	Middle Paleolithic
Site 55 (Pakistan)	45 Ka	Upper Paleolithic
Kitulgala beli-Lena (Sri Lanka)	45 Ka	microlithic
Sanghao Cave (Pakistan)	42 Ka	Middle Paleolithic
Kana	42 Ka	Microlithic
Batadomba Lena (Sri Lanka)	36 Ka	microlithic
Mahadebbera	34 Ka	Microlithic
Arjun 3 (Nepal)	>30 Ka?	Middle Paleolithic
Patne	30 Ka	Multi-period

**Table 1.**  
*List of dated prehistoric sites in the Indian subcontinent.*

recovered over a decade [7, 8]. The calvarium, originally identified as an “advanced” *Homo erectus*, was later reclassified as an archaic or early form of *H. sapiens* [9, 10]. Phylogenetic reevaluation of the calvarium reveals that it shares key morphological



features with both *H. heidelbergensis* and *H. erectus* [11]; it has been most recently classified as *Homo* sp. indet. [12]. The oldest fossil evidence for *Homo sapiens* is dated to ~38 Ka and currently comes from Sri Lanka, while all younger evidence comes from multiple sites across India [13, 14].

What is also largely missing is direct evidence for butchery in the form of cut-marked fossil bones; some possible exceptions include Isampur [15] and Masol [16], both of which require further verification and substantiation through more evidence. Additionally, use-wear analyses and other scientific methods such as residue analysis are also required on well-preserved lithic assemblages. Other types of evidence that are poorly known is the age and nature of symbolic behavior (see [17]) as well as the nature of technological transitions. Indeed, there has been a recent global movement to decolonize earlier interpretations of hominin dispersals and population replacements across the Old World [18]. This also includes India, where earlier historical interpretations defined the Upper Paleolithic and modern human behavior based on the then-known European evidence [19]. Numerous reviews of the South Asian region's prehistoric records have been published elsewhere (e.g. [3, 4, 20–28]). Over three dozen Paleolithic and early microlithic sites have been dated in Pakistan [29–33], India [5, 14, 16, 34–58], Nepal [59] and Sri Lanka [60–63] since the 1980s onwards, using different relative and absolute dating methods including biochronology, palaeomagnetism, stratigraphic correlation, U-Th, U-series, K-Ar, Ar-Ar, luminescence, electron spin resonance, radiocarbon (calibrated and uncalibrated) and AMS. These various ages range from ~2.6 Ma to ~35 Ka, and include geographically random sites belonging to various prehistoric technologies including Oldowan-like, Acheulean, Middle Paleolithic, Upper Paleolithic and the earliest microlithic assemblages (**Figure 1** and **Table 1**). While broad summaries are provided here, the primary goal of this paper is to highlight the most salient attributes of this zone, provide specific updates to previously known data and discuss possible implications of new discoveries from surrounding regions outside the Subcontinent.

## 2. Lower Paleolithic

Despite numerous efforts by several researchers such as Armand in central India [64] and the British Archeological Mission to Pakistan [33], the Oldowan has continued to remain elusive in India. Instead of unequivocally deriving from well-dated excavated contexts, almost all reported occurrences ( $n = 12$ ) come from surface contexts or there are other contextual and geochronological issues associated with these finds [65]. Oldowan evidence has been reported from the Siwalik Hills in Pakistan and northern India as well as from the Narmada Basin in central India. The latest evidence, from Masol near Chandigarh, was reported by an Indo-French team and includes stone tools from excavated contexts and a possible-cut-marked fossil bone from surface context [16]. The researchers have provided an age estimate of 2.6 Ma for this material, however the contexts are disparate and the cut-marks are not properly verified [66] as they could have been produced from other processes also, such as animal teeth or fluvial transport prior to fossilization (e.g. [67]). The Lower Paleolithic of South Asia is basically dominated by (Large Flake) Acheulean assemblages that currently range in age from 1.5 Ma to 120 Ka [40, 57]. Acheulean sites are known to occur almost throughout the Subcontinent with some exceptions - the Gangetic plains, northeastern India and surrounding areas, Kerala, the extreme southern tip of India and Sri Lanka [4]—owing to various factors such as topography, geology, ecology, climate, high sea-levels and the absence of suitable raw materials. Acheulean assemblages variably include handaxes, cleavers,

miscellaneous bifaces, picks, giant and small cores, polyhedrons, large and small flake blanks, flake tools such as scrapers and debitage at some primary-context factory sites (for examples, see **Figures 2–7**). The site with the oldest-known Acheulean evidence (Attirampakkam) also happens to preserve the oldest-known early Middle Paleolithic at 385 Ka [58]. This indicates that the full transition from the Lower Paleolithic to the Middle Paleolithic in South Asia was lengthy, geographically and chronologically uneven and behaviorally complex. This is evident



**Figure 2.**  
*Diverse handaxes, picks and trihedral elements from the Narmada Basin, Central India.*

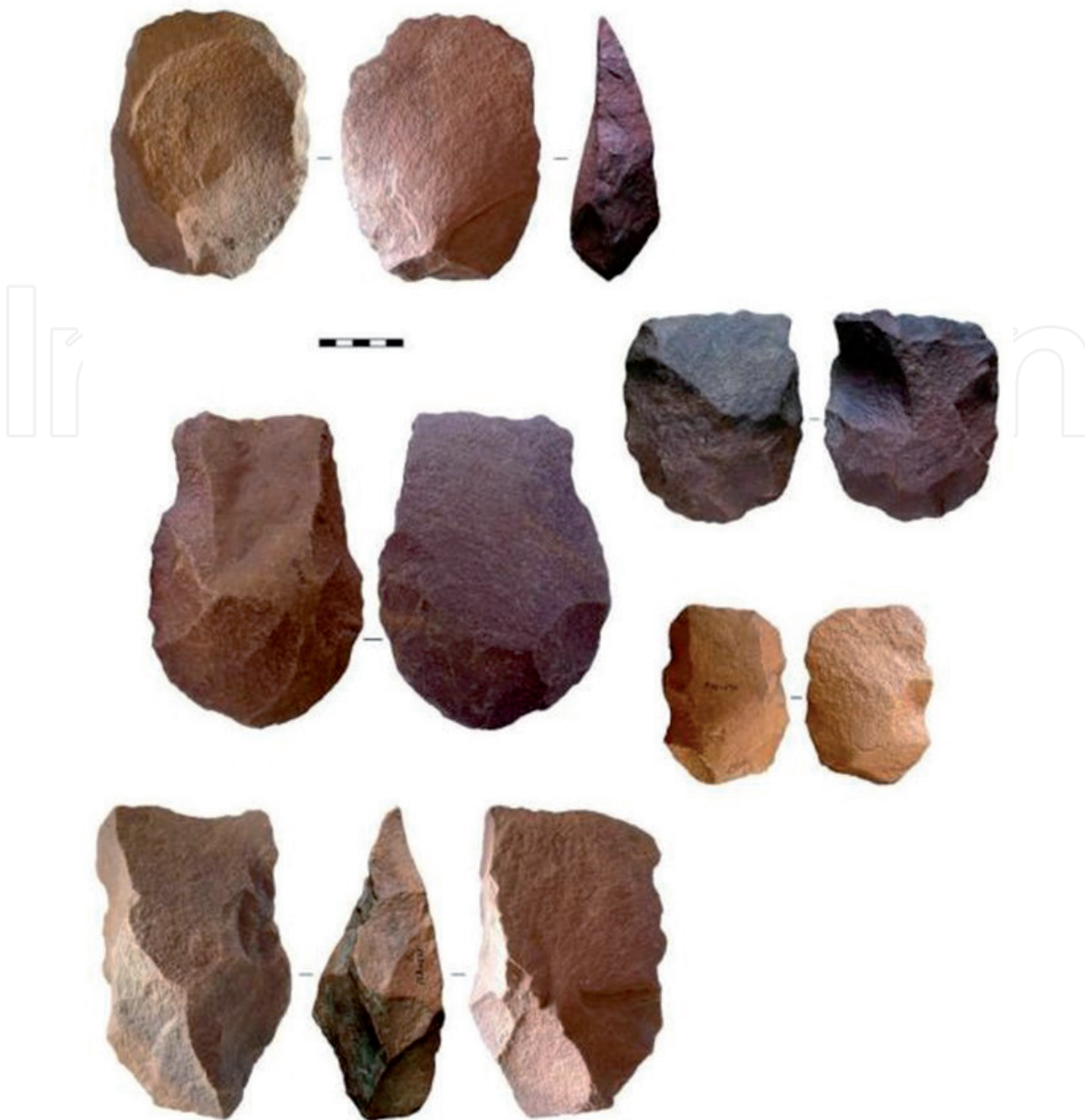


**Figure 3.**  
*Handaxe and miscellaneous bifacial elements from Son Valley, north-central India (pic courtesy: Shashi Mehra).*

from the lengthy overlap between the earliest Middle Paleolithic at Attirampakkam and the Late Acheulean dated to 140–120 Ka in the Son Valley of north-central India [40]. In addition, such a lengthy transition is making it difficult for archeologists to often separate terminal Acheulean assemblages from early Middle Paleolithic ones. For example, the Son Valley evidence was respectively classified as Middle Paleolithic and Late Acheulean by two different groups of researchers over time (see supplemental data in [58]). It is also possible that the specific hominin groups during this transition made and used different technologies in differing contexts for diverse functional purposes: e.g. assemblages with Late Acheulean handaxes for heavy-duty tasks verses Levallois dominated flake assemblages for light duty tasks, a hypothesis that can only be resolved through chronologically-targeted landscape archaeology.

Key issues that are yet to be properly understood for the South Asian Acheulean include the nature of change within this techno-chronological phase as well as understanding factors to understand regional variations in assemblage compositions, artifact and site densities, timings of regional transitions, some geographic absences of occurrence and lack of absolute ages for most of the stratified assemblages. Broader aspects that remain to be properly understood include the number and directions of Acheulean dispersals into and out of the Subcontinent, the hominin species that were associated with that technology and the diverse subsistence strategies that took place across the region. In addition, specific regions have ambiguous features for which factors are currently unclear: for instance, the Gujarat zone (westernmost India) has not yet yielded Early Acheulean sites and while Maharashtra has numerous Early Acheulean sites on Deccan Trap basalt, no Late Acheulean sites have yet been reported. While future surveys may refine such observations, we need to explore additional explanations for such discrepancies. For example, lack of assemblage burial during specific fluvial and depositional cycles and associated sub-aerial weathering processes may have affected assemblages with smaller basalt specimens than in the Early Acheulean (see [68, 69]). However, this explanation may not be equally applicable to the entire zone of Maharashtra – perhaps basalt was not deemed suitable for Late Acheulean hominins or populations shifted to other regions to target different raw materials such as quartzite, and so forth. Based on preliminary counts from compiled data, a minimum of 1560 Acheulean/Early Stone Age sites and



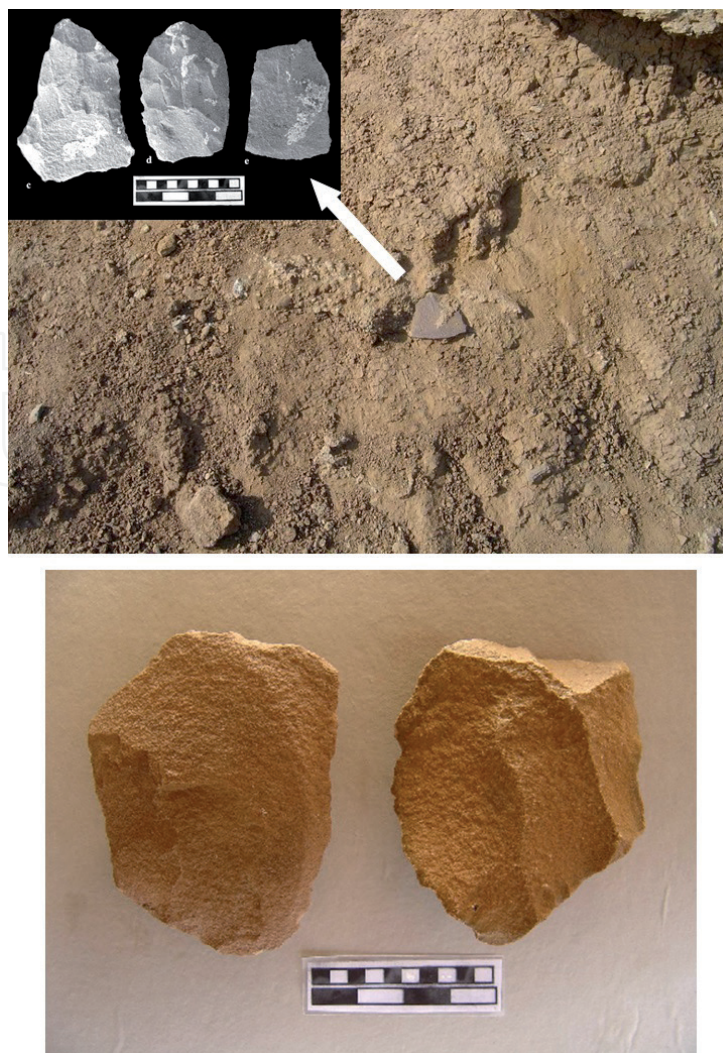


**Figure 4.**  
*Diverse cleavers from the site of Pilikarar in the central Narmada Basin.*

site-complexes have been reported and there are major differences in the geographic patterns of occurrences.<sup>1</sup> While one factor may be research bias (i.e. lack of surveys in some zones), broad observations may still hold for most regions despite future survey efforts. For example, the northern zone, northeastern zone and the southernmost tip of India have the least number of Acheulean sites totaling to 51. The remaining zones have yielded significantly higher numbers of sites, especially central, eastern and peninsular India; for example, compiled data for central India alone yielded 305 published Lower Paleolithic sites out of which 17 have been excavated [70]. The virtual lack of Lower Paleolithic sites in southern Tamil Nadu and Kerala suggests that Lower Paleolithic hominins may have never reached the southernmost Indian coastal tip; this fact, along with a probable lack of a land bridge, may explain why no Acheulean evidence is known from Sri Lanka. This may further suggest that hominins first entered Sri Lanka after about 100 Ka when large bifaces ceased being made throughout India. In any case, more intensive surveys are required in Sri Lanka

<sup>1</sup> The minimum counts of different types of Paleolithic sites provided in this paper come from an ongoing compilation of published data (e.g. *Indian Archaeology- A Review; Man and Environment; Purattatva*).





**Figure 5.**  
*Cleavers and cleaver-like flake blanks from the central Narmada Basin.*

to confirm a true absence as well as recover, excavate and date potential Middle and Upper Paleolithic sites [71].

Other key anomalies for the Lower Paleolithic include ‘missing contexts’ and ‘missing evidences’. For instance very few Early Pleistocene deposits, contexts and lithic assemblages have been identified south of the Siwalik Hills and the few known ones have been identified through limited but diverse methods such as palaeomagnetic dating, cosmogenic dating, electron spin resonance, associated stratigraphic correlation and microtremor readings [35, 50, 53, 57, 72–75]. This is probably due to a multitude of factors including the lack of focused surveys, lack of geochronological applications and geological processes which may have both deeply buried such contexts as well as destroyed them (e.g. cut-and-fill regimes). These may explain why legitimate or unequivocal Oldowan assemblages have yet to be discovered, excavated and dated. In the same vein, Middle Pleistocene contexts and sites have also not been adequately identified, primarily owing to the earlier lack of suitable geochronological methods. Reliable Middle Pleistocene dates have started to be reported only recently as some of the sites have been studied and known for many decades to yielded important stratified lithic assemblages: the multicultural sequence at the 16R dune at Didwana in Rajasthan [5] now dated to between ~187–6 Ka [5]<sup>2</sup>, the Late Acheulean occurrences of Patpara

<sup>2</sup> The new luminescence dates for the 16R dune (<190 Ka) replace the previously-reported U-Th dates which had shown the bottom-most layer as being >350 Ka; the revised chronological framework has also led to the re-interpretation of the cultural sequence (see Blinkhorn 2013).





**Figure 6.**  
*In situ or stratified handaxes in quaternary fluvial sections of the central Narmada Basin.*

and Bamburi in the Son Valley in Madhya Pradesh dated to between 140 and 120 Ka [40] and multiple early and later Middle Paleolithic assemblages from Attirampakkam in Tamil Nadu dated to between 385 and 73 Ka [58]. However, despite these investigations as well as stratigraphically and geochronologically identifying some Middle Pleistocene sites and contexts, they have not yet yielded any vertebrate fossil material. This temporal and contextual pattern of fossil preservation also applies to the known Early Pleistocene sites in central and peninsular India [50] which have yet to yield adequate vertebrate fossil evidence. Some rare





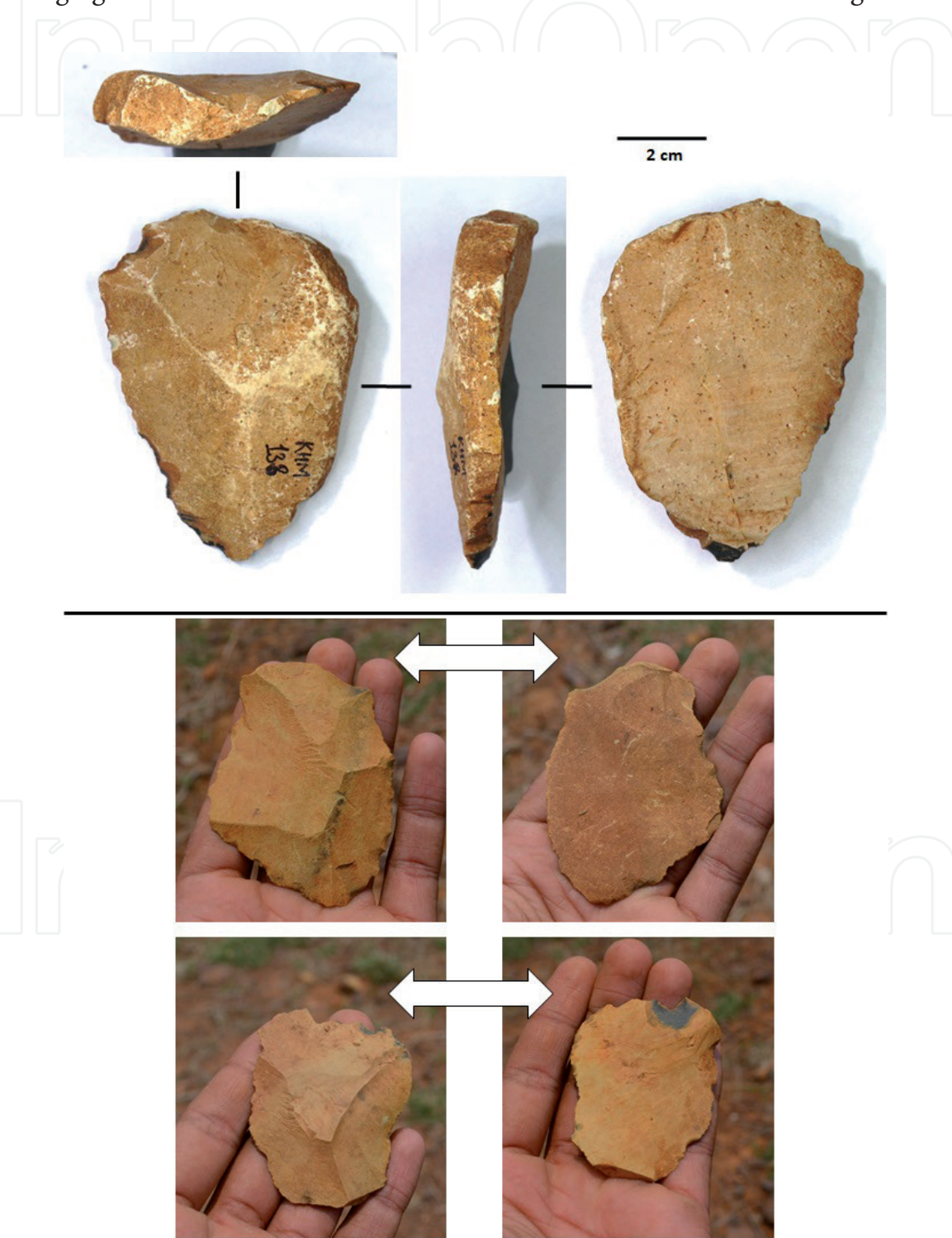
**Figure 7.**  
*Find-spots of cleavers in surface context with diverse sedimentary types from the central Narmada Basin (pic courtesy: Vivek Singh).*

exceptions of vertebrate fossils found in contexts older than the Late Pleistocene in India include Isampur [15] and Attirampakkam in southern India ([76, 77]) and Dhansi in central India [44]. While the older contexts appear to be largely devoid of fossil preservation, it is highly probable that some or most of those older fossils have been redeposited in younger depositional contexts during landscape rejuvenation cycles. This probably also applies to some of the known fossil hominin material from the central Narmada Basin [7, 8] as associated mammalian teeth from Hathnora yielded variable absolute ages indicating chronologically-mixed fossils and probably artifacts as well [44]. Therefore, it is vital to date well-preserved vertebrate fossils directly using such methods as electron spin resonance and uranium-series, to obtain exact ages of the specimens rather than ages of their burial or minimum ages.



3. Middle Paleolithic

The early Middle Paleolithic appears to begin before 385 Ka [58] and is characterized by a gradual transition from large bifaces to small bifaces, before they disappear completely during the later Middle Paleolithic. In fact, the region allegedly preserves the youngest diminutive bifaces in the world (see [37, 78]), although this requires verification through more contextual and geochronological research across the Subcontinent as earlier U-Th dates need to be revised (e.g. [5]). The changing toolkit also includes the introduction of different reduction strategies and



**Figure 8.**  
*Multiple perspectives of three Levallois flakes from the Son Valley, north-central India (pic courtesy: Shashi Mehra).*

the emergence of prepared cores, points and blade elements (**Figures 8 and 9**). In fact, Middle Paleolithic points, which are first evident at 385 Ka at Attirampakkam, continue to occur in younger (Late Pleistocene) contexts as well [34, 36]. Late Pleistocene contexts and sites are more widespread but also remain inadequately dated. Recent examples of new and previously-known sites that were dated for the first time include Attirampakkam in Tamil Nadu where the later Middle Paleolithic ends at 73 Ka [58], Dhaba in Madhya Pradesh ([41, 79]), the Middle Paleolithic site of Sandhav in Gujarat [36] and Fa-Hien Lena in Sri Lanka [62]; the Sri Lankan evidence has been reported as the oldest known bow-and-arrow technology outside Africa at 48 Ka, making it contemporary with the microliths at Dhaba (also 48 Ka) and Mehtakheri which is 45 Ka [45]. The primary reason for the increase in such dates is the growing application of refined or new luminescence techniques as well as radiocarbon methods. The youngest Middle Paleolithic evidence has been



**Figure 9.**  
*Dorsal and ventral sides of three Levallois and Levallois-like points from the Son Valley, north-central India (pic courtesy: Shashi Mehra).*



dated to 38 Ka in southern India [56] and as with the Acheulean, Middle Paleolithic assemblages have been reported from throughout the Subcontinent with (more or less) the same geographic exceptions.

Preliminary compilation of published data shows a minimum of 750 occurrences of Middle Paleolithic/Middle Stone Age sites and site-complex across India. While earlier researchers have identified Middle Paleolithic sites based on the absence of bifaces, dominance of flake-based assemblages and the presence of Levallois elements, some regions do not preserve a clear signature of this phase. For example, most of the enigmatic ‘Soanian’ evidence (**Figure 10**) in the Siwalik Hills region appears to variably comprise contemporaneous Mode 1 and Mode 3 technologies [4]. No absolute dates for that tradition/adaptation are yet available from excavated or stratified contexts and the only two earlier-dated occurrences in the Siwalik Hills of Pakistan [31] and Nepal [59] have *not* been classified as *Soanian*. Likewise in other regions, the Middle Paleolithic evidence may be equally undiagnostic or ambiguous and not necessarily absent. Based on current evidence, specific diagnostic attributes such as preferential Levallois elements and points do not appear to be as abundant or geographically widespread as expected. That being said, most of the earliest dispersals of *Homo sapiens* may not be typo-technologically diagnostic as seen with the younger technologies in the archeological record. In fact, the initial arrival of *Homo sapiens* continues to be debated based on archaeology (advanced Middle Paleolithic vs. microlithic) and genetic studies on indigenous groups [80]. Future surveys aimed at filling key geographic and stratigraphic contexts may gradually change this pattern. Over the last few decades, this technology has been increasingly thought to be associated with the initial arrival of *Homo sapiens* by various researchers, some of the most recent being the Jwalapuram evidence from southern India dated to ~77 [55], the Kataoti and Sandhav evidence from western India respectively



**Figure 10.**  
*Diverse artifact types from the Soanian site of Toka in Siwalik Hills of northern India.*



dated to 95 Ka [34] and 114 Ka [36], and the Dhaba evidence in north-central India dated to between 79 Ka and 65 Ka [41].

4. Upper Paleolithic

This prehistoric phase is the most enigmatic in the Subcontinent as it lacks absolute dates, is geographically irregular and temporally overlaps with the terminal Middle Paleolithic and early microlithic in several regions. Due to the latter attribute, the South Asian Upper Paleolithic has been replaced with or incorporated within the ‘Late Paleolithic’ by some researchers (see [81]). Preliminary counts from published data has revealed a minimum of 530 reported Upper



Figure 11. Laminar elements (blades) from the Son Valley, north-central India (pic courtesy: Shashi Mehra).

Paleolithic/Late Stone Age sites across India. It is interesting that classic and diagnostic Upper Paleolithic sites have not yet been reported (or classified as such) from Pakistan, Nepal and Sri Lanka. The dominating and defining features of this techno-chronological phase include a notable increase in the production of more specialized laminar tools such as blades and burins (**Figure 11**). Additional tool types during this techno-chronological period include flakes, knives, awls, borers, scrapers, cores including cylindrical types, choppers, and bone tools. Unfortunately, and surprisingly, there are still no absolute dates available for any exclusive (i.e. without a microlithic component) Upper Paleolithic assemblages in India, though numerous



**Figure 12.**  
*Diverse microlithic artifacts from the site of Bayan in the Central Narmada Basin (pic courtesy: Nupur Tiwari).*



**Figure 13.**

*Diverse microlithic cores and microblades/bladelets on different raw materials from the Son Valley (top row; pic courtesy: Shashi Mehra) and Patne (bottom row) in west-central India.*

sites have been reported. The only date currently available for a blade-dominated assemblage in the entire Subcontinent is 45 Ka for Site 55 in Pakistan [31], making it contemporary with the young Middle Paleolithic assemblages in northern India [38] and old microlithic assemblages in central India and Sri Lanka [41, 62].

Besides chronology and ecological adaptations, a key issue that remains to be understood is the nature of the transitions between the Middle Paleolithic, Upper Paleolithic and early microlithic in South Asia (**Figures 12 and 13**). What is also lacking in association with these technologies is comparatively abundant symbolic behavior (see [82]), the main explanation for which may be the lack of adequate research and preservation. Given the geographic mosaic of ecological diversity across the Indian subcontinent, it is likely that only some regions do contain classic/typical Upper Paleolithic technologies as distinct techno-chronological entities. In the other geographic zones, their absence may be explained by the lack of suitable raw materials such as siliceous rocks (e.g. chert, fine-grained quartzite) and other factors such as a lack of geographic movements into some zones due to various climatic, ecological and adaptive constraints. Slightly younger evidence which was dated using the AMS method has also yielded new paleoanthropological insights including the youngest dated (~16 Ka) hippo fossils in India [83] and a new microlithic-faunal-pollen association (~18 Ka) from Odisha in eastern India [84], a poorly known but promising region for Indian palaeoanthropology. Such data demonstrate the broad temporal interface between fauna, environments and/or humans. Both studies span not only the end of the Last Glacial Maximum but also perhaps indirectly reflect major transformations within the microlithic phase including the beginning of geometric microliths, human burials and other symbolic behaviors, i.e. the beginning of the Mesolithic proper. Increased human-fauna interactions and rapid colonization of the Subcontinent may have led to the beginning of long-term eco-geographic marginalization of some species (e.g. lion, rhino) as well as their subsequent extinctions (e.g. hippo, ostrich). Only high-resolution multidisciplinary



studies including robust chronological frameworks from across India can, however, verify or reject such broad multi-proxy relationships.

## 5. Discussion and conclusion

In addition to the observations and brief summaries provided above, additional key paleoanthropological discoveries in recent years include the first-ever recovery of *Sivapithecus* fossils outside the Siwalik Hills [85], extraction of DNA from ostrich eggshells and protohistoric human bones [86, 87] and the report of tool-use and object manipulation by the macaque populations of Andaman and Nicobar Islands [88, 89]. The *Sivapithecus* find comes from the western region of Gujarat and clearly demonstrates how little we know about past faunal distributions at the pan-Indian level. More systematic surveys of key sedimentary contexts in targeted locations across India may yield additional faunal surprises including the much-needed hominin fossils. The successful extraction of DNA from two diverse materials – human bone and ostrich eggshell – also demonstrates that there is now greater potential for further such studies despite earlier failed attempts which were attributed to tropical environmental conditions [90]. The observation of tool-use in monkeys further highlights the critical need for more primate studies in South Asia at various levels including primate archaeology, cognitive studies, ecological adaptations, social relationships, subsistence patterns, conservation strategies and so forth. One arguably important conclusion from the review of known data is that, with the exception of the Pabbi Hills in the Pakistan Siwaliks, no clear evidence currently exists for the presence of Oldowan evidence in the entire Indian subcontinent [65]. Based on the current lack of diagnostic Paleolithic (e.g. Acheulean, Levallois, Upper Paleolithic) and microlithic technologies in the northeastern part of the Indian Subcontinent (i.e. northeast India, Bhutan, Bangladesh, Myanmar), it does not appear to have been used as a biogeographic corridor during hominin dispersals to Southeast Asia. However, intensive surveys are required in the concerned areas as well as Southeast Asia to confirm whether the Subcontinent was a bio-cultural cul-de-sac. In that respect, Pakistan and surrounding border areas also require further surveys to increase the number of Paleolithic sites there, especially due to their significance as the geographic entry point into the Subcontinent. Numerous known sites require re-investigation through multidisciplinary methods including excavations, geological analyses, palaeoenvironmental reconstructions and absolute dating. This is especially critical as some previously-known sites are gradually getting destroyed through various geological and anthropogenic processes (e.g. Chirki-on-Pravara; Personal communication: Sheila Mishra).

Unfortunately, broad hypotheses/theories have been made for South Asian pre-history without adequate evidence, such as the innovation of microlithic technology following environmental deterioration soon after 40 Ka [46]. Not only is there no clear evidence for environmental degradation across the Subcontinent, but later discoveries have demonstrated that microlithic technology was well established in central India and Sri Lanka, respectively, between ~50 Ka and 45 ka. Though the source and nature of their origin remain ambiguous (innovated vs. introduced), it may be possible that specific evolutionary milestones converged at roughly the same time: arrival of *Homo sapiens* into South Asia with microlithic technology and the arrival of the ostrich into South Asia, possibly reflecting shared arid environments [66, 91]. On a related note, the nature of biological transition(s) between the archaic populations and incoming *Homo sapiens* has also not been theoretically explored. Was this replacement process gradual or rapid? Did the replacement

of archaic populations include interbreeding, and what was its temporal rate and geographic pattern at the pan-Indian level? Did the technologies of both respective hominin groups mix and influence each other at any point in time and space? These and other questions require serious multidisciplinary attention at both empirical and theoretical levels.

Another example is the ongoing debate of the impact of 74 Ka Toba super-eruption on hominin behavior and lithic technology [55, 92–96]. While the Jwalapuram evidence in southern India yielded a problematic wide age range for the Toba-tephra-associated Middle Paleolithic evidence (77 Ka and 38 Ka), a similar investigation at the site of Dhaba in north-central India chronologically narrowed that gap to 79 Ka and 65 Ka [41]. Nonetheless, the lengthy time gap of 10,000 years between the eruption and the post-Toba archeological evidence makes it challenging to draw major conclusions regarding true occupational continuity and it is not clear if fluvial or other processes facilitated occupational/technological continuity by minimizing the ecological impact of the Toba tephra in the immediate region. In short, we have yet to identify a reliable site or area which preserves stratified and dateable lithic assemblages in *primary chrono-stratigraphic contexts immediately prior to and following* the Toba tephra [97], especially when considering that the impact of Toba was probably geographically variable across the Subcontinent [96]. Only when this is done in multiple ecological contexts *across* the Indian subcontinent, will we get a more comprehensive and objectively nuanced perspective on the degrees of impact.

Due to the unique geographic location and associated features of the Indian subcontinent, factors of hominin dispersals and adaptations observed in other Old World regions cannot readily apply here. For example, the link made between the dispersals of *Bos* and the Acheulean [98] may be applicable only to regions with Acheulean records considerably *younger* than India. Likewise, the discovery of a considerably older *Homo sapiens* presence in Europe at ~210 Ka [99] does not necessarily reflect a similar time of their arrival in Asia. However, new discoveries reported in the last few years within Asia may be more applicable and relevant to the Subcontinent. For example, the new decrease (to between 1.5 and 1.3 Ma) in the arrival date of *Homo erectus* in Southeast Asia [100] and the geographic extension of the Denisovans on the Tibetan Plateau in China [101] indirectly suggest the possibility of their presence in the Indian Subcontinent. Likewise, the chronological extension of *Homo sapiens*' arrival into Southeast Asia between 73 Ka and 63 Ka [102] and Australia to ~65 Ka [103] as well as the age of Sulawesi rock art [104] at par with Europe at ~44 Ka has major implications for the Indian zone. The oldest dated rock art from Europe is >64 Ka and has been attributed to Neanderthals [105]. Firstly, the complexity and skill reflected in these paintings suggest the global origin of figurative art is probably much older. Secondly, these discoveries indirectly hint of a possible biogeographic dispersal of *Homo sapiens* from west to east through tropical rainforest and coastal contexts across Southern Asia [106, 107]. While it is possible that the SE Asian and Australian hominin populations reached there via mainland China, the areas representing northeastern India, Bangladesh and Myanmar need to be intensively surveyed to confirm the routes of dispersal. It is also possible that both southern Asian and central Asian routes were used by various species over time to reach Southeast Asia and Australasia.

From a broader research level, the most important palaeoanthropological accomplishments in South Asia in the last few years include the chronological extension of the Middle Paleolithic to 385 Ka and of microlithic technology to ~48 Ka and the beginning of decolonization of past interpretations and conceptual frameworks regarding human dispersals and population replacements [66]. Nonetheless, much more palaeoanthropological research is required to make more

holistic and meaningful comparisons with not only surrounding Asian regions but also with human evolutionary records in other parts of the Old World. The current lacunae suggest that more surveys are required to locate Oldowan sites and Early Acheulean sites to understand their pan-Indian distribution, possible demographic implications, and potential relationships (if any) with East and Southeast Asian lithic records. In light of the fact that the South Asian prehistoric record is poorly known when compared to other parts of Asia, Africa and Europe, and because much more empirical data is required (priorities being hominin fossils and absolute dates), it is premature and unnecessary to propose hypotheses or theories based on preliminary evidence. At this stage in our research in South Asian prehistory, we should perhaps focus on generating abundant empirical data and simply reporting it in a neutral manner without *any* specific hypothesis-building.

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