CHAPTER 5
DISCUSSION

This chapter discusses the results of the analysis and interpretation of data presented in the preceding chapters. The themes discussed here include the Palaeolithic cultural sequence of the studied region by situating the same within South Asia; the origin and evolution of Middle Palaeolithic technologies in South Asia; the Youngest Toba Tuff beds as a Late Pleistocene chronological marker; the initial Modern human colonization of South Asia; post-Middle Palaeolithic cultural developments in South Asia; the nature of lithic assemblages before and after the Toba eruption; and Archaic – Modern human interactions in South Asia.

The research was aimed at generating a robust chronological framework for the Palaeolithic cultures in the region under investigation along with high resolution lithic analysis. At the beginning of the research, after going through the available literature, it was identified that the lack of chronometric ages for the South Asian Palaeolithic studies limits our understanding of human cultural evolution on both the global and regional level. Therefore, the primary focus of the current research was to obtain chronometric ages for the Palaeolithic remains in the region. Secondly, more emphasis was placed on understanding lithic artefacts from an assemblage perspective to better appreciate the technology rather than mere descriptions of artefacts. Geoarchaeological analysis were limited to specific cases (e.g. YTT deposits) where ever it was necessary. The researcher was able to report 61 new Palaeolithic sites, however, only seven sites were studied intensely for analytical purpose. The research recognises that focusing on a few sites by excavating and step trenching will result in more robust chronology and secure context for the artefacts than studying surface collections from many sites. Even though this research also incorporated surface collected artefacts, specific caution was taken while selecting sites for the study of surface collections. These included selecting sites with single artefact/cultural horizon, which was further ascertained through small scale excavations and step trenching. Further, the methodological approach also included limiting surface collections by laying out systematic grids to exclude the possibility of biased random collections. The seven sites on which the research focused upon were selected as they represented a wide temporal range, resulting from sites distributed across the Gundlakamma and adjoining river basins.

An attempt is made in one of the following sections to discuss the cultural sequence of the study region by incorporating data from not only the seven sites, but also the newly discovered and previously reported sites. Further, obtaining luminescence ages were limited to the sediments containing artefacts, and those immediately underlying and overlying the artefact horizons. Detailed geoarchaeological analyses of the artefact bearing and other horizons were not conducted, as all the seven sites were associated with low-energy deposition indicated by the sediment composition and geomorphological observations. Further, lithic assemblages having micro-debitage (less than 2 cm length) and artefacts from different stages of lithic reduction sequence with little or minimal post-depositional alterations indicate the primary nature of the sites where detailed geoarchaeological investigations not required to assess the integrity of site.

5.1. Palaeolithic Cultural Sequence of the Gundlakamma and Adjoining regions

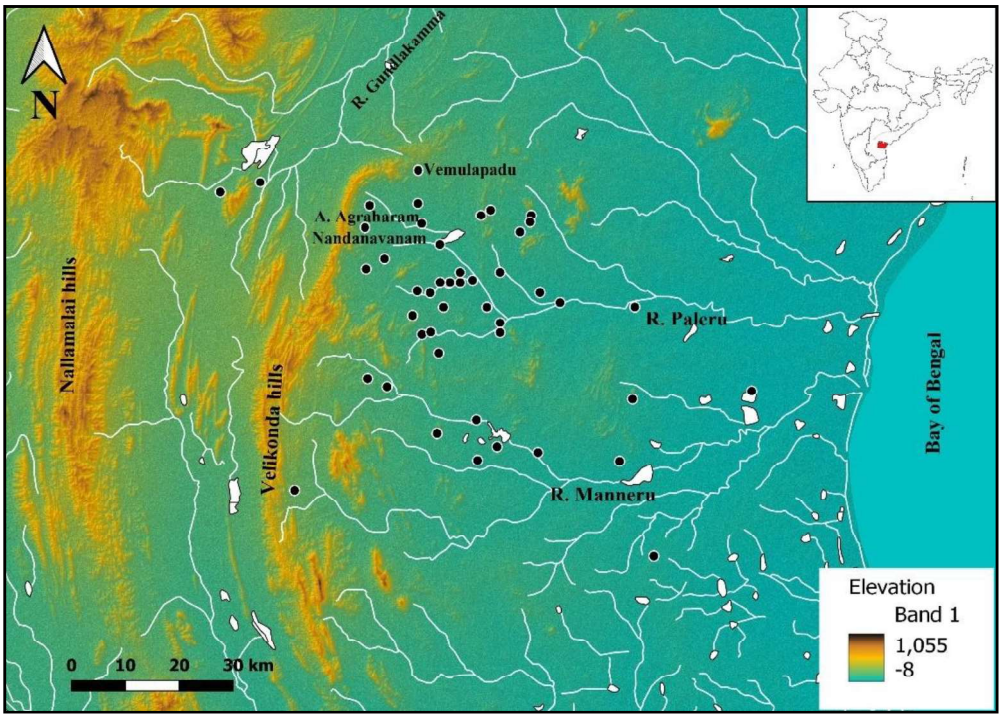
The Gundlakamma basin and the adjoining areas are bounded on the north and the south by the Krishna and Penna rivers; and on the west and the east by the Nallamali hills and the Bay of Bengal. The area measures about 10 k sq. km. in extent and politically lies in the Prakasam district of Andhra Pradesh. Palaeolithic remains from this region was first reported by Bruce Foote during the last quarter of the 19th Century (Foote, 1916). This region was further explored since the 1950's and its prehistoric potentials were highlighted by several previous researchers (Issac, 1960; Kumari, 1987; Rao, 1979; Srinivasulu, 2012). However, the previous research undertaken in this region are sporadic and confined to 'time bound research priorities' and lack the application of multi-disciplinary approaches. As a part of this research, the area was surveyed with an intention to generate chronological framework for Palaeolithic remains and to situate them within the broader South Asian context. Palaeolithic sites in this region were exposed mostly due to the natural erosional activities and at a few places by anthropogenic actions such as renovation of shallow lakes and streams to conserve rainwater. These erosional activities provide unique situations to understand the geological contexts of the artefacts and build regional stratigraphic sequences. Further, test excavations at selected localities and luminescence ages of the artefact bearing horizons and associated sediments provide a Palaeolithic cultural sequence ranging from >500 to 30 ka. This section presents the synthesis of the luminescence ages and Palaeolithic material. The environmental features of the region and their relevance in understanding the development of Palaeolithic cultures are presented in the beginning. Following this, the main features of each of the cultural stages recognized in the

study area are discussed on the basis of the data collected from the current explorations and excavations.

Flanked by the long, crescent shaped Nallamali and Velikonda hills on the west and the Bay of Bengal on the east and bounded in the north and south by the two major peninsular Indian river systems, the Krishna and Penna, the Gundalakamma basin and surrounding area form a homogeneous regional unit from the points of view of geology, drainage and topography. The western part of the area is a crescent shaped sedimentary basin enclosed by the hills of the Eastern Ghat Mobile Belt. The absence of a major river notwithstanding, the area has several perennial surface water bodies in the western part of the area owing to the presence shallow lakes and waterbodies. At present, the area receives a meagre rainfall of about 75 cm (Andhra Pradesh Space Applications Centre, 2018)and, as such, forms a part of the large semi-arid zone of southwestern Andhra Pradesh (Rayalaseema).

5.1.1 Lower Palaeolithic (> 400 ka)

The Lower Palaeolithic of the region, represented by the Acheulian, is found at 42 sites. The major localities among these are found along the Velikonda hill range and the upper reaches of the Paleru river basin (Map. 5.1.1). Surface explorations at these localities and test excavations at Vemulapadu and A. Agraharam (Anil et al., 2022) provided the stratigraphic context and chronological framework of the Acheulian artefacts.



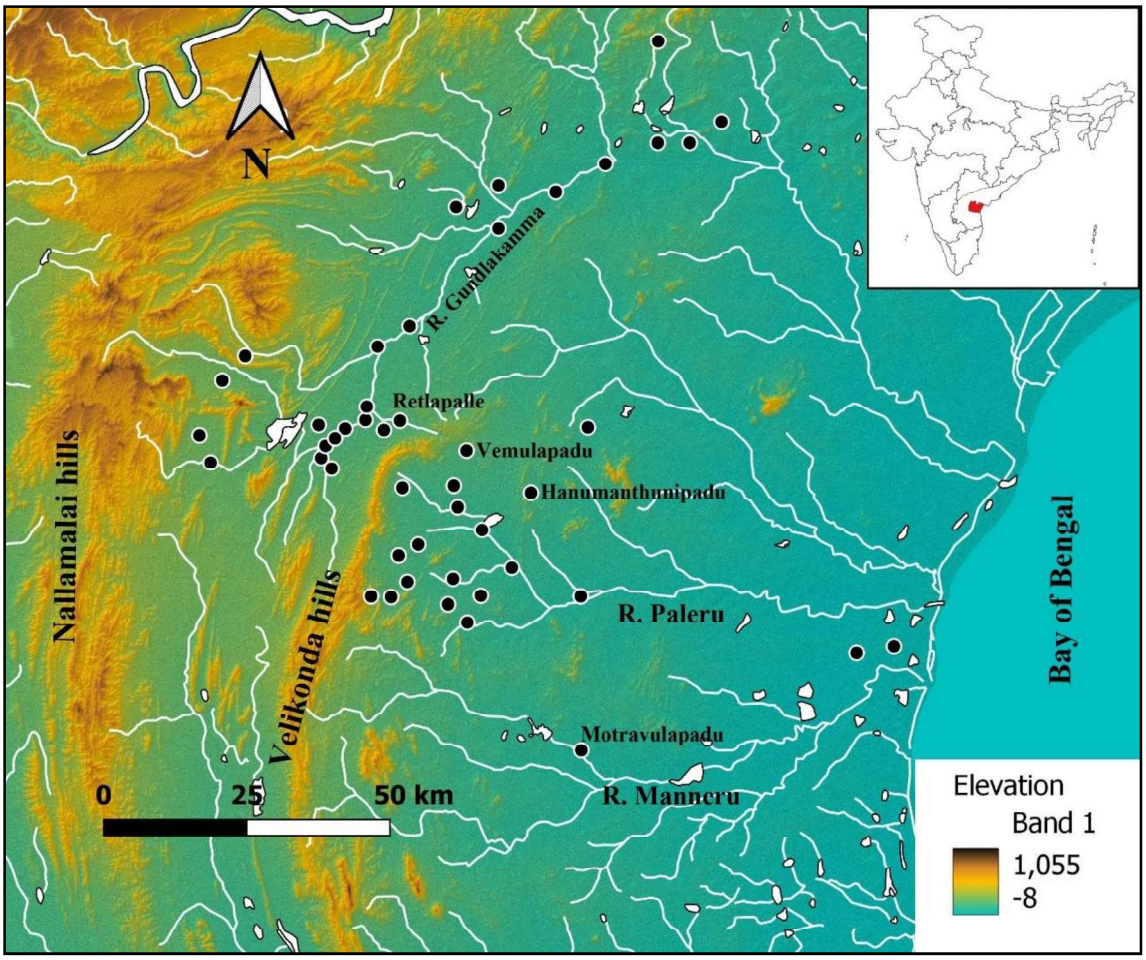
Map. 5.1.1: Map showing the distribution Acheulian sites**.**

The Acheulian sites here, are confined to the valley floor, and no sites have been found on the surrounding hills and tablelands. The eastern foothill region of Velikonda hills shows rich evidence of Acheulian sites associated with sediments directly overlying the basal rock formations.

Natural exposures of the Acheulian artefact bearing horizons are limited in the region as they were deeply buried and associated with compact sediments (see Section 4.2 of Chapter 4). However, anthropogenic activities have exposed Acheulian artefacts in a few locations, assisting in the reconstruction of the stratigraphic and chronological framework. Firm stratigraphic association of the Acheulian artefact are known from two sites i.e., Vemulapadu (Acheulian levels), A. Agraharam and Nanadanavanam (Section 4.2, 4.3, 4.4 of Chapter 4 respectively). At Vemulapadu (Acheulian levels) the artefacts are associated with compact tufa beds showing early Acheulian features with large and crudely made handaxes. Whereas, at A. Agraharam and Nanadanavanam the Acheulian artefacts are found in ferricrete gravels overlying the tufa beds and shows late Acheulian features with the dominance of prepared core technologies. Due to the issues associated with the saturation of feldspar minerals, precise age estimations of the artefacts bearing horizons were not possible. However, a minimum age of >500 ka was estimated for the Acheulian artefacts from the region.

5.1.2. Middle Palaeolithic (>247 to 59 ka)

The Middle Palaeolithic phase that succeeds the Acheulian is well represented and widely spread across the region. Middle Palaeolithic artefacts were identified at 51 localities associated with diverse sedimentary contexts. Middle Palaeolithic sites are found clustered along the upper and middle reaches of the Gundlakamma river basin with maximum concentrations in the upper reaches. This may indicate that hominins preferred these areas for occupation (Map. 5.1.2). However, the above pattern may also be influenced by the research history and the nature of potential depositional contexts. For example, most of the Middle Palaeolithic sites are associated with shallow depressions and low-energy fluvial deposits.



Map. 5.1.2: Map showing the distribution of the Middle Palaeolithic sites.

New typo-technological studies of the Levallois component in conjunction with luminescence ages of the Middle Palaeolithic in the region can be divided into early and late phases. The former consists of assemblages indicating predominance of Preferential Levallois and minor biface component. These early Middle Palaeolithic assemblages are dated to >240 ka and 145 ka from Hanumanthunipadu (Section4.5) and Retlapalle (Section 4.6) respectively. Lithic assemblages from these two sites are characterised by the presence of a few bifacial elements consisting of handaxes, cleavers and diminutive handaxes, bifacial points, discoidal cores, a few blade elements with less-diverse Levallois reduction techniques. Elsewhere in Peninsular India, such features are indicative of early Middle Palaeolithic (Akhilesh et al., 2018).

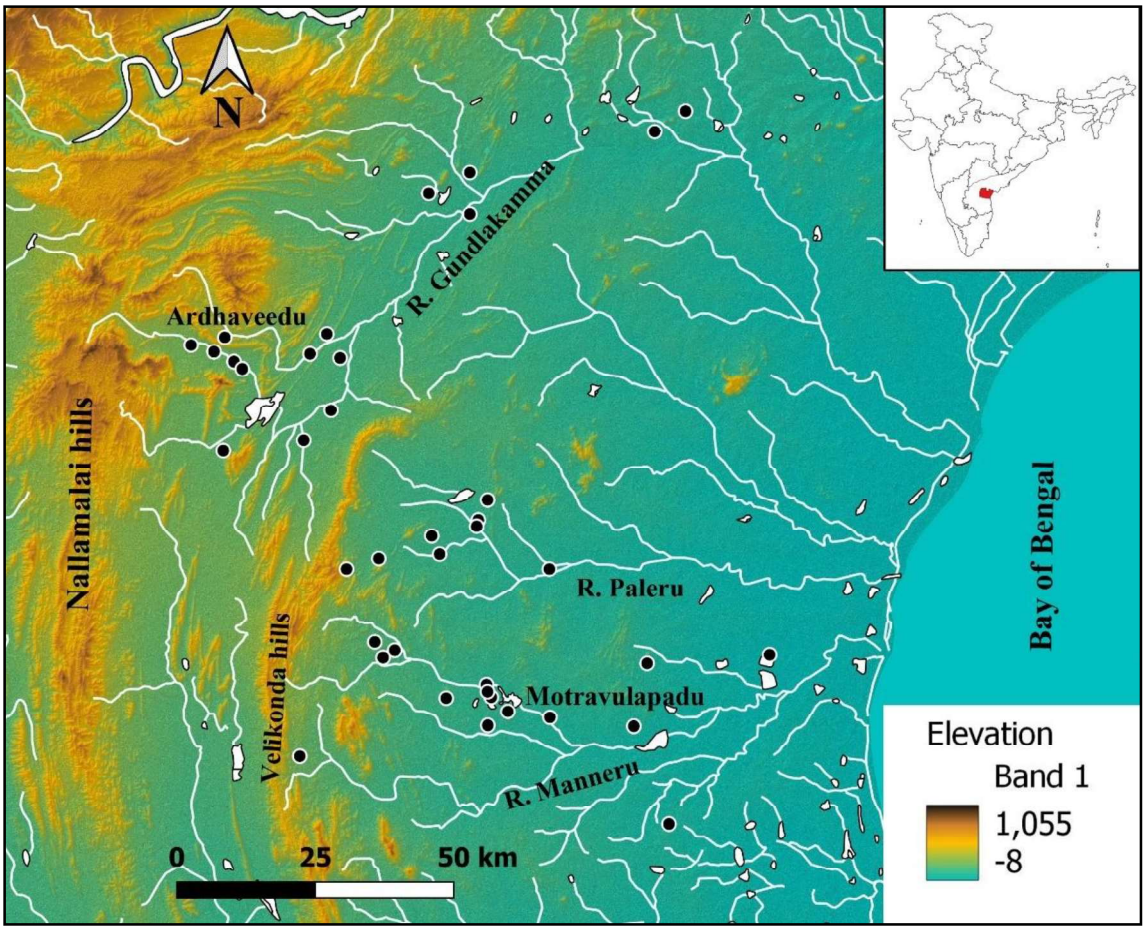
The late Middle Palaeolithic postdates the last interglacial (5c) that persisted through the catastrophic event of Toba super-eruption that happened at 74 ka. Late Middle Palaeolithic artefacts associated with the sediments underlying the YTT beds are widely spread in the upper reaches of the Gundlakamma basin (Anil et al., 2022). These pre-YTT sediments are dated to terminal MIS 5 (85 to 70 ka) and the artefacts associated with these sediments are collectively

dominated by diversified Levallois technique along with points (both retouched and Levallois), scrapers and blade artefacts. There is a less preference towards the bifacial points and handaxes and cleavers are completely absent. The Levallois become diversified with the presence of recurrent, uni-, and bi-directional recurrent reductions. The post-YTT sediments dated to 64 ka in the upper reaches of the Gundlakamma river basin shows technological continuity with the pre-YTT assemblages with more preference towards the blade-based artefacts. These assemblages are characterised by the predominance of Levallois points and blades. However, the late Middle Palaeolithic assemblages dated post 105 ka until ~ 64 ka comes from surface collections carried out at several sites in the upper reaches of the Gundlakamma river basin with stratigraphic correlations. Therefore, these observations need further validation by conducting excavations and obtaining firm chronological framework.

However, the site Motravulapadu presents significant information about the late Middle Palaeolithic assemblages dated to the transition between MIS 4 and 3. Basal layers from Trench 1 at Motravulapadu (Section 4.8 of Chapter 4) dated to 59 ka yielded Middle Palaeolithic assemblages characterised by the presence of variety of Levallois technique with the dominance of Levallois point technologies. The Levallois point technologies are evident among both the core and debitage reductions showing close affinities with the Nubian technologies. However, it seems that these point technologies may be part of a variant of Levallois point reductions than a Nubian as no Nubian technologies are reported from South Asia. The Middle Palaeolithic technology in this region probably emerged from the preceding Late Acheulian technologies between 400-300 ka, with typical Middle Palaeolithic technologies emerging ~ 250 ka onwards and continuing till 60 to ~50 ka.

5.1.3 Post Middle Palaeolithic Cultural Developments (41 to 29 ka)

The post-50 ka Palaeolithic evidence from the region is characterised by the presence of blade technology which is confined to small pockets along the upper reaches of Gundlakamma and Manneru river basins (Map. 5.1.3). Previous researchers attributed these blade-based assemblages from the region to the Upper Palaeolithic phase (Kumari, 1987; Srinivasulu, 2012). Recently the term Late Palaeolithic was suggested to denote post-Middle Palaeolithic cultural developments in South Asia based on the evidence of potential overlap between late Middle Palaeolithic (e.g., Jwalapuram) and early microlithic assemblages (e.g., Mehtakheri) in the region (James & Petraglia, 2005).



Map. 5.1.3: Map showing the distribution of Late Palaeolithic sites.

Later studies following (James & Petraglia, 2005) suggested that South Asian blade-based assemblages are part of the late Middle Palaeolithic technologies and the microlithic technologies emerged from the former (Clarkson et al., 2018).

However, in the current study region, the blade-based technologies are found associated with the sediments dated to 41 ka and continued at least up to 29 ka. The site Ardhaveedu (Section 4.9) in the upper Gundlakamma river basin yielded blade-based assemblages dated to 41 ka, and 12 more sites in the region showed similar assemblages associated with similar sedimentary contexts, indicating widespread occurrence of the technology. Such blade-based assemblages have also been identified at Motravulapadu in the upper Manneru river basin, where they are associated with sediments dated to 29 ka. Srinivasulu (2012) reported several blade-based assemblages (Upper Palaeolithic) along the upper Manneru river in 2012, which shared similarities to the Motravulapadu assemblages. This evidence indicates that the blade technology in this region existed as a distinct cultural entity for at least 10 k.

The Palaeolithic cultural sequence of the Gundlakamma and adjoining river basin can be subdivided into Acheulian, Middle Palaeolithic and post-Middle Palaeolithic phases. The Lower Palaeolithic consists of artefact assemblages containing bifaces and their associated debitage. Currently, they lack clear evidence of stratigraphic position and a chronological framework. The sites are mostly concentrated along the foothill region of the eastern Velikondas, which may reflect differences in erosional activities, rather than an occupation preference. Limited chronological controls are provided by associated deposits, although a minimum age of 500 ka is suggested. There are, however, significant numbers of known, less investigated archaeological sites, which are likely to provide better chronology alongside palaeoenvironmental evidence.

The late Acheulian/early Middle Palaeolithic transitional assemblages in the region are unique to understand the emergence of prepared core technologies. The study of the archaeological assemblages produced important datasets that contributed to the emerging framework of the origin of prepared core technologies, both at regional and global level. These assemblages show a combination of both bifacial and prepared core technologies with a greater preference on the latter. Following these transitional industries, typical Middle Palaeolithic assemblages appear in the region as early as 247 ka and continue up to 59 ka, showing temporal variations in the Levallois technology and other artefact types. The Middle Palaeolithic record of the region is extensive and widely spread across the region. The temporal variations allow the Middle Palaeolithic to be divided into two phases: an early (between MIS 7-6 and 5e) phase and a late (post-MIS 5a/post-last interglacial) phase. The post-MIS 5a Middle palaeolithic technology continues to exist up to the beginning of MIS 3. Blade based assemblages dominate the MIS 3, postdating the Middle Palaeolithic technology, and existed for a span of 10 ka. The MIS 3 sites separate between those belonging to MIS 5a and MIS 4. This currently under-researched record hints at significant insights that could be gleaned from it, such as changes in local environment, technological advancements, subsistence strategies, and structured use of space. It also holds enormous potential for addressing issues of broader scale cultural change in the region.

5.2 Late Acheulian to Middle Palaeolithic Transitions and the Origin of Prepared Core Technology

Lithic assemblages and chronometric ages obtained from the Palaeolithic sites in the eastern foothills of Velikonda ranges sheds significant light on understanding the emergence of Middle Palaeolithic technologies. Two sites, A. Agraharam (Section 4.3 of Chapter 4) and Nandanavanam, (Section 4.4 of Chapter 4) yielded lithic assemblages characteristic of transitional nature between the Late Acheulian and Middle Palaeolithic technologies. Assemblages from these two sites are discussed here within the background of transitions. The transitions from large hand-held cutting tools (Bifaces) to prepared core technologies (also named Levallois or Mode 3 (Clark, 1977)), to make smaller flakes suitable for hafting, represents the major technological innovation during the second half of the Middle Pleistocene. These technological changes represent significant behavioural changes among the hominin populations and accelerated Lower to Middle Palaeolithic transitions.

In Africa, Early Stone Age (ESA) to Middle Stone Age (MSA) transition is characterized by gradual decrease in bifaces that are eventually replaced by flake-based artefacts (Clark, 1977; Herries, 2011; Porat et al., 2010; Tryon & Faith, 2013). These flakes were produced using various prepared core (e.g., Discoid) and hierarchical (e.g., Levallois) core reduction strategies. Producing flakes with a preconceived shape and size (the characteristic feature of the later Mode 3 or prepared core technology) first appears during the Late Acheulian. Acheulian giant core methods such as Kombewa technique in East Africa (Owen, 1938); the Tachengit-Tabelbala technique in the north-west Sahara (Sahnouni, 2012); the Victoria west technique in South Africa (McNabb, 2001; Sharon & Beaumont, 2006) are examples of the early prepared core technologies that are rooted in Early Stone Age of Africa. It has been argued that these early prepared core technologies paved the way to the development of Middle Palaeolithic prepared core technologies (Lycett, 2009; Sharon & Beaumont, 2006). The ESA-MSA transition in Africa representing a gradual dominance of prepared core technology was established during the ESA over the bifacial technologies and occurred around 400-300 ka (Deino et al., 2018).

In Europe, the appearance of Levallois technology is used as a marker to define the Lower to Middle Palaeolithic transitions (White & Ashton, 2003). The Levallois technology in Europe emerged from the handaxe technology, where handaxes are used as Levallois cores (Rolland, 1995; Tuffreau, 1995; White & Pettitt, 1995). Besides, the Simple Prepared Core (SPC)

technologies associated with Lower Palaeolithic archaeological record later evolved into the Levallois core technology (Bolton. L, 2015; Scott, 2006; White et al., 2011; White & Ashton, 2003). These transitions or origins of Levallois technology was dated to 400-300 ka in Europe (Adler et al., 2014).

Recent findings of Middle Palaeolithic assemblages as early as 380-170 ka in South Asia (Akhilesh et al., 2018) have highlighted the potentials of in situ development of Middle Palaeolithic technology in the region. The South Asian Acheulian is characterized by the presence of bifaces and a few flake tools (e.g., (Misra & Rajaguru, 1978; Paddayya, 1984; Petraglia, 2001)). Acheulian giant core techniques were also reported in South Asian Acheulian i.e., the giant cores from Isampur quarry (Paddayya et al., 2002) and Chirki cleaver core method (Corvinus, 1983). South Asian Middle Palaeolithic is based on the prepared cores and retouched flakes (scrapers and points) with the presence of diminutive bifaces (Chauhan, 2009; James, 2003; Pal, 2002). Lower to Middle Palaeolithic transitions in South Asia is marked by the appearance of prepared core technologies in Late Acheulian and the continuation of bifaces into Middle Palaeolithic with a reduction in size and numbers (James & Petraglia, 2009). However, technological and chronological characterizations of these transitions and associated factors are poorly understood in South Asia. Besides, the transitional studies suffer from methodological challenges such as distinguishing the terminal/late Acheulian and Early MP assemblages; identifying criteria to define these transitions; and the possible existence of different technological traditions and/or interactions between them (i.e., Early MP, gradual transitions, durations and so forth).

The idea of in situ development of Middle Palaeolithic technology in South Asia was discussed earlier by several scholars (e.g., (Ajithprasad, 2005; Petraglia et al., 2003)). These studies are based on the typological grounds that are focused on the presence and absence of certain tool types in the assemblage. This *fossil directeur* approach is ambiguous as certain tool types are time transgressive and may not be truly temporally diagnostic (McBrearty & Tryon, 2006). In contrast, the *Chaîne opératoire* approach focuses on reduction sequence rather than the product (e.g., (Bar-Yosef, 2000; Boëda, 1992; Inizan et al., 1999; Pelegrin et al., 1988)). This approach emphasizes the entire core reduction process starting from raw material procurement to discarding the artefact. Therefore, lithic material should be analysed from assemblages' level to understand its technological character.

Based on the Lower to Middle Palaeolithic/Middle Stone Age transitional studies from Africa and Europe, a set of characteristic features was prepared to identify and understand transitional assemblages. These features and their reflections in the lithic assemblage are mentioned in Table 5.2.1.

Table. 5.2.1: Characteristic features and of Lower to Middle Palaeolithic Transitional Industries.

Assumed Characteristics	**Reflection of the Characteristics in Assemblage**
Decrease in preference of Bifacial artefacts	Low percentage of Bifacial elements
Increase of Prepared core-based artefacts	High percentage of Prepared core elements
Decrease of Biface length	Variation in Biface size
Presence of Hafting tools	Presence of Points
Presence of Levallois technology	Levallois cores and Debitage

In this background, the assemblages studied from A. Agraharam and Nanadanavanam was collected using a systematic grid laid out on freshly exposed artefact clusters. Even though the assemblage is collected from the surface, only few artefacts were observed to be slightly abraded suggesting recent exposure of the artefacts. 86% of the assemblage shows similar patina indicating the same geological context of the assemblage. The presence of debitage less than 2 cm in length and other flakes (e.g., roughout flakes, core preparation flakes) that are part of the reduction sequence demonstrates the primary nature of the assemblage. The whole assemblage comes from two sites separated by 5 km.

The artefact assemblages from A. Agraharam and Nandanavanam shows characteristics of both the Large Flake Acheulian and Early Middle Palaeolithic, the latter being dominant. The Large Flake Acheulian is represented by the presence of large flakes (> 10 cm in length) with giant cores, well-made handaxes, and cleavers. The mean elongation, refinement, and profile and plan symmetry values of the bifaces show close similarities with the Late Acheulian assemblages reported in South Asia (Shipton, 2013, 2016; Shipton et al., 2013). There are a few instances of handaxes being used as cores to produce flakes and such examples were also noted in Europe and Levant in the terminal Acheulian contexts (Petraglia et al., 2003; Rolland, 1995; Tuffreau, 1995; White & Pettitt, 1995). Prepared core technology and its debitage dominates the assemblages with some definite evidence of Levallois core reduction (Table 5.2.2). However, preferential surface cores that are a forerunner to the Levallois technology

(Bolton. L, 2015) are abundant in the assemblage. Together with discoidal and other simple core reduction strategies, the core technology at the site is represented by a variety of core reduction strategies aimed at producing flakes. Even though the flake production was dominant at the site, most of the flakes were limited with informal retouch. However, a few flakes were made into scrapers and points with proper retouch.

Table. 5.2.2: Products of Core and Biface reduction sequences from A. Agraharam and Nanadanavanm.

	A. Agraharam	**%**	**Nandanavanam**	**%**	**Total**	%
Core Reduction and Debitage						
Preferential Surface core	45	8.65	6	3.59	51	7.42
Discoidal Core	17	3.27	8	4.79	25	3.64
Simple Flake Core	14	2.69	8	4.79	22	3.20
Levallois core	3	0.58	0	0.00	3	0.44
Core on a flake	2	0.38	0	0.00	2	0.29
Laminar flake core	1	0.19	0	0.00	1	0.15
Radial Core	0	0.00	1	0.60	1	0.15
Core fragment	20	3.85	0	0.00	20	2.91
Prepared core flake	87	16.73	43	25.75	130	18.92
Core preparation flakes	178	34.23	35	20.96	213	31.00
Levallois Flake	0	0.00	1	0.60	1	0.15
Sub Total	**367**	**70.58**	**102**	**61.08**	**469**	**68.27**
Biface Reduction and Debitage						
Handaxe	39	7.50	16	9.58	55	8.01
Cleaver	8	1.54	3	1.80	11	1.60
Diminutive Handaxe	0	0.00	4	2.40	4	0.58
Handaxe with invasive flake scar	7	1.35	1	0.60	8	1.16
Biface thinning and shaping flakes	55	10.58	32	19.16	87	12.66
Biface Finishing flakes	44	8.46	9	5.39	53	7.71
Sub Total	**153**	**29.42**	**65**	**38.92**	**218**	**31.73**
Total	**520**	**100**	**167**	**100**	**687**	**100**

Biface length comparisons between A. Agraharam and Nanadanavanm suggests the latter assemblage has more bifaces with length less than 10 cm, indicating decrease in biface length. The average length of A. Agraharam bifaces is 118.43 mm (SD=34.12) and for Nanadanavanam it is 88.52 mm (SD=14.99). The average length of the bifaces from Nandanavanam is less than 100 mm with relatively low standard deviation in data indicating preference of small sized bifaces. Notably, bifacial points made on pebbles, slabs, and flakes

are abundant among the retouched categories. Some portion of the points and bifacial points shows basal modifications and tang-like projection indicating possibilities of hafting technology.

Overall, the lithic assemblage from A. Agraharam represents an overlapping of the Late Acheulian and Early prepared core technologies, which is a typical character of transitional assemblages. Besides, the presence of points and bifacial points with basal modifications suggests a preference for hafting which is another feature of the Middle Palaeolithic. These assemblages can be chronologically placed in the first half of the late Middle Pleistocene with a minimum date of 400 ka. Due to the saturated luminescence signal of the sample, it is difficult to assign a precise age for these assemblages.

5.3 Evolution of Middle Palaeolithic technology (247 to 59 ka)

Middle Palaeolithic assemblages from six spatially and temporally distinct sites provides significant insights into the evolution of Middle Palaeolithic technologies in the region. Among these six sites, two are from the Paleru, three are from the Gundlakamma, and one is in the Manneru river valleys (Table 5.3.1).

Table. 5.3.1: Sites discussed in the text.

Sr.No.	Site Name	River Basin	Age	Reference
1	Hanumanthunipadu	Paleru	247 ka	Section 4.5 of Chapter 4; (Anil et al 2022)
2	Retlapalle	Gundlakamma	143 ka	Section 4.6 of Chapter 4
3	Vemulapadu	Paleru	105 ka	Section 4.7 of Chapter 4
4	Below YTT (Unit D)	Gundlakamma	80-70 ka	Section 4.6 of Chapter 4; (Anil et al 2022)
5	Above YTT (Unit B)	Gundlakamma	70-60 ka	Section 4.7 of Chapter 4; (Anil et al 2022)
6	Motravulapadu (Trench 1)	Manneru	59 ka	Section 4.8 of Chapter 4

This section compares the lithic assemblages from all six sites and discusses the evolution of Middle Palaeolithic technologies through time. Firstly, the presence and absence of various artefact types and their relative abundance between sites will be discussed followed by a quantitative analysis of the same. Bifacial elements among these Middle Palaeolithic sites

constitute to be less than 1% in the sites dated to the end of the Middle Pleistocene (Hanumanthunipadu and Retlapalle) and are completely absent in the Middle Palaeolithic sites dated to the Late Pleistocene (Fig. 5.3.1). However, at Vemulapadu, considerable number of bifacial elements (5.84%) were present which may be due to the nature of the site being a palimpsest (see Section 4.7 of Chapter 4). Except this site, the other three Middle Palaeolithic assemblages dated to the Late Pleistocene epoch do not show any evidence of Bifacial elements.

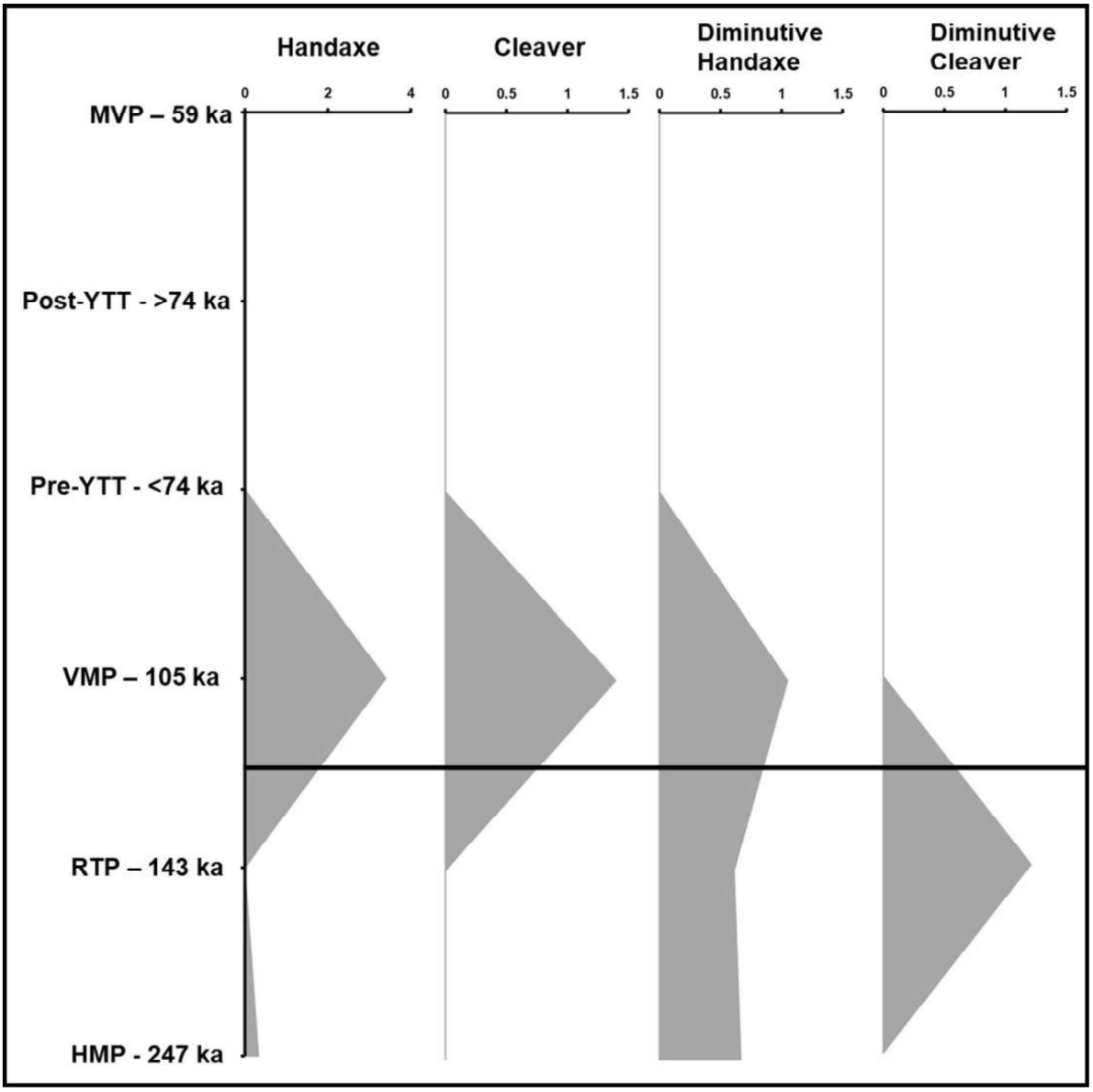


Figure. 5.3.1: Graph showing the relative abundance of Biface elements.

5.3.1 Cores

The sites have a wide range of cores present in their assemblages, except at Motravulapadu. This might be because the Motravualapdu assemblage exclusively comes from the excavations, whereas the other assemblages mostly come from surface collections. However, the surface collections were systematically done to exclude the possibility of biased collection by limiting the collections to smaller grids (areas). In addition, all sites where the surface collections were analysed have a single artefact bearing horizon, as confirmed by test pits and small-scale excavations. So, the diversity of core types in the assemblages represents the actual diversity rather than the result of temporal mixing, as most of the assemblages are collected from the surface.

The core types were further divided into 1. Levallois, 2. other formal core types consisting of discoidal, radial, blade, uni- and bi-directional cores, and 3. informal core types including simple cores, multiplatform cores for descriptions. Each of the aforementioned three core categories were discussed through time to understand patterns of changes and similarities. Multiple variants of Levallois core reductions, such as preferential, recurrent, uni and bi-directional recurrent and Levallois point cores, are present in the assemblages (Fig 5.3.2).

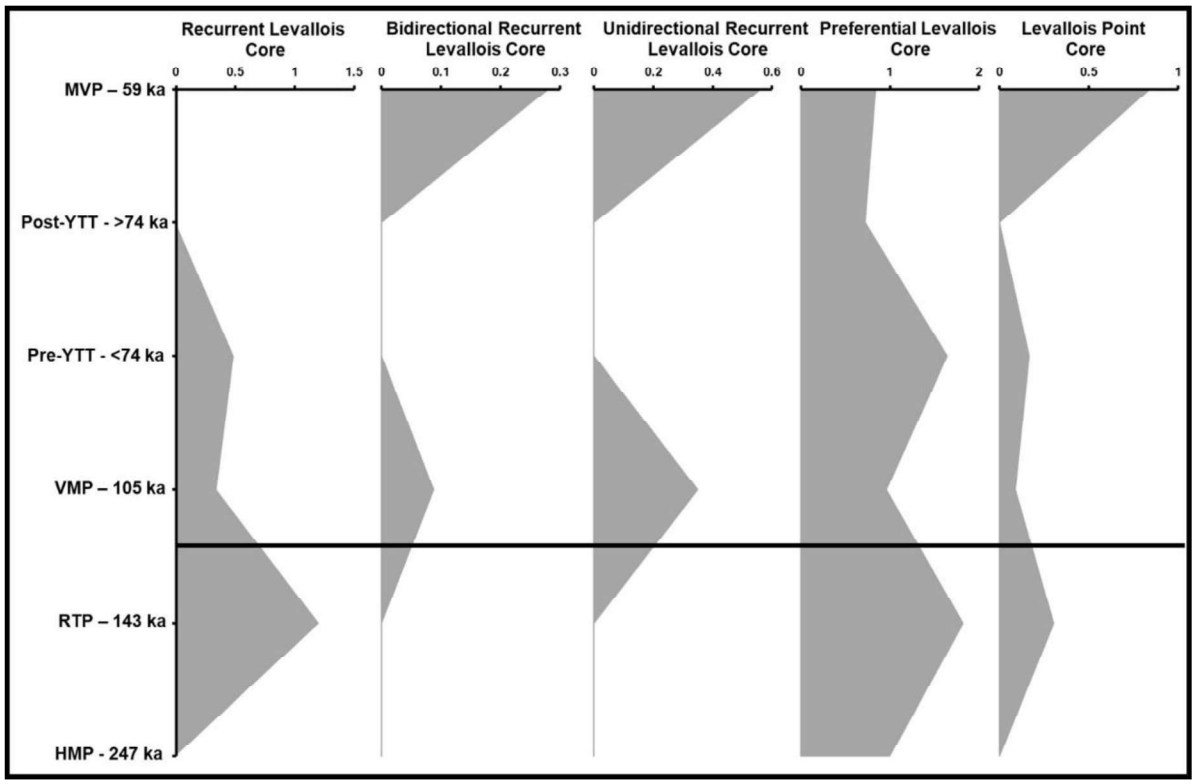


Figure. 5.3.2: Temporal distribution of Levallois cores.

The predominant Levallois core types present at Hanumanthunipadu and Retlapalle dated to the end of the Middle Pleistocene are preferential and recurrent Levallois types. Diversified Levallois core reductions including all the types mentioned above appear at Vemulapadu and Motravualapdu dated to the Late Pleistocene epoch (Fig. 5.3.2). Notably, the assemblages dated between 80 to 60 ka, the pre- and post-dating Toba eruption, collected from the upper Gundlakamma river basin do not exhibit the diversity of Levallois types. This might be due to the sampling bias rather than representing the true nature of the assemblages, which therefore needs further evaluation. Based on the presence or absence of Levallois core types, it is observed that the hierarchical core reduction technique becomes more diverse during the Late Pleistocene.

This observed variation of Levallois core diversity among the late Middle and Late Pleistocene Middle Palaeolithic assemblages was further investigated through statistical analysis. Although the relative abundance of artefact types was assessed at six sites, detailed statistical analyses were restricted to only four that revealed secure stratigraphical and chronological control. The presence of Middle Palaeolithic technology in South Asian was debated between local origins (Akhilesh et al 2018; Anil et al 2022) dated to the Middle Pleistocene and the modern human association (Petraglia et al 2007) dated to the Late Pleistocene. However, it is also possible that the South Asian Middle Palaeolithic is a product of local innovations starting around 400 ka and technologies introduced by the incoming modern humans (Anil et al 2022). The Middle Palaeolithic sites from the current study region provide a unique opportunity to investigate aforesaid statement. Therefore, the statistical analyses were aimed to understand the variation between the late Middle Pleistocene and Late Pleistocene dated Middle Palaeolithic sites.

Attributes to analyse the core variation was selected following the works of (Blinkhorn et al., 2021; Scerri et al., 2014). The core variation was examined in two domains i.e., core shape and flake production (See Section 3.3 of Chapter 3 for more details). The core shape was analysed using the attributes of proximal shape, distal shape, elongation, and flatness, which collectively contribute to the overall core shape. Initially, each of these four variables was analysed using multiple pairwise Kruskal-Wallis tests to understand the variation between the four sites. Except for the proximal shape, the rest of the three variables do not show any significant variation among the sites (Table. 5.3.2).

Table. 5.3.2: Results of Kruskal-Wallis tests of Levallois Core variables.

Variable	p value (Kruskal-Wallis test)	Observation
Core Shape		
Proximal Shape	**0.04663**	**There is a significant difference**
Distal Shape	0.05399	There is no significant difference
Elongation	0.5227	There is no significant difference
Flatness	0.6759	There is no significant difference
Flake Production		
Core rotations	**0.01076**	**There is a significant difference**
Platform Angle	0.0548	There is no significant difference
Major Flake Scars	0.124	There is no significant difference
Flake scars	**0.004219**	**There is a significant difference**
Feather Terminations	0.1487	There is no significant difference
Non feather terminations	**0.0001064**	**There is a significant difference**
Last Scar Elongation	0.9575	There is no significant difference

Multiple pairwise Mann-Whitney tests were conducted to analyse the core shape variations among individual sites (Table. 5.3.3). Only the proximal shape showed some variation among sites; the rest of the variables do not show any significant variation. Levallois cores from Motravulapad with parallel proximal margins, show variations from the other three sites, which have more expanding lateral margins.

Table. 5.3.3: Results of pairwise Mann-Whitney tests of Core variables (Core Shape).

Proximal Shape				
	HMP	RTP	VMP	MVP
HMP	-	0.3099	0.2195	0.3996
RTP	0.3099	-	0.3551	0.0357
VMP	0.2195	0.3551	-	0.02062
MVP	0.3996	**0.0357**	**0.02062**	-

Distal Shape				
	HMP	RTP	VMP	MVP
HMP	-	0.1852	0.7182	0.05796
RTP	0.1852	-	0.1961	0.5929
VMP	0.7182	0.1961	-	0.00978
MVP	0.05796	0.5929	0.00978	-

Elongation				
	HMP	RTP	VMP	MVP
HMP	-	0.5334	0.6134	0.8518
RTP	0.5334	-	0.5588	0.1955
VMP	0.6134	0.5588	-	0.3364
MVP	0.8518	0.1955	0.3364	-

Flatness				
	HMP	RTP	VMP	MVP
HMP	-	0.3502	0.3481	0.5751
RTP	0.3502	-	0.6009	0.4931
VMP	0.3481	0.6009	-	0.9149
MVP	0.5751	0.4931	0.9149	-

(HMP: Hanumanthunipadu; RTP: Retlapalle; VMP: Vemulapadu; MVP: Motravulapadu)

Variables defining the production of flakes such as core rotations, last platform angle, number of major flake scars, number of flake scars, number of feather and non-feather terminations,

and last major scar elongation are examined to understand the variation among the sites. Kruskal-Wallis tests shows only three variables among the seven showed significant variation i.e., core rotations, number of flake scars, and number of non-feather terminations (Table. 5.3.2). Pairwise Mann-Whitney test indicates that Levallois cores from Retlapalle and Vemualapadu are rotated more than the cores from Motravulapadu (Table. 5.3.4) similarly Hanumanthuniapadu and Retlapalle cores have a greater number of flake scars indicating intense reduction or core preparation. Levallois cores from Motravulapadu have lesser number of non-feather terminations compared to the other three sites.

Table. 5.3.4: Results of pairwise Mann-Whitney test of Core variables (Flake Production).

No. of Core rotations				
	HMP	RTP	VMP	MVP
HMP	-	0.2615	0.3394	0.09169
RTP	0.2615	-	0.2859	0.0007
VMP	0.3394	0.2859	-	0.02636
MVP	0.09169	0.0007	0.02636	-

Last platform angle				
	HMP	RTP	VMP	MVP
HMP	-	0.8133	0.203	0.5457
RTP	0.8133	-	0.08137	0.1883
VMP	0.203	0.08137	-	0.0158
MVP	0.5457	0.1883	0.0158	-

No. of major flake scars				
	HMP	RTP	VMP	MVP
HMP	-	0.2818	1	0.5271
RTP	0.2818	-	0.1035	0.03023
VMP	1	0.1035	-	0.3827
MVP	0.5271	0.03023	0.3827	-

No.of flake scars				
	HMP	RTP	VMP	MVP
HMP	-	0.3834	0.03689	0.02039
RTP	0.3834	-	0.00716	0.02547
VMP	0.03689	0.00716	-	0.1324
MVP	0.02039	0.02547	0.1324	-

No.of feather terminations				
	HMP	RTP	VMP	MVP
HMP	-	0.1174	0.05742	0.03837
RTP	0.1174	-	0.7254	0.7054
VMP	0.05742	0.7254	-	0.3259
MVP	0.03837	0.7054	0.3259	-

No.of non feather terminations				
	HMP	RTP	VMP	MVP
HMP	-	0.00977	0.1427	0.00155
RTP	0.00977	-	0.00296	0.00521
VMP	0.1427	0.00296	-	0.00061
MVP	0.00155	0.00521	0.00061	-

Last Scar Elongation				
	HMP	RTP	VMP	MVP
HMP	-	0.755	0.8283	0.5751
RTP	0.755	-	0.8054	0.879
VMP	0.8283	0.8054	-	0.8032
MVP	0.5751	0.879	0.8032	-

Principal component analysis was used to examine the role of metric attributes in structuring the variability among the core datasets. Among the core shape variables, the first two principal components account for ~ 65% of variability in the datasets (Table 5.3.5). The first component (35% variability) is primarily driven by core flatness which is positively correlated to proximal shape but negatively correlated with elongation (Fig. 5.3.3) indicating that flatter cores are less

elongate with a straight proximal shape. The second component (29% variability) is characterised by the differences in distal core shape, which is positively correlated with proximal shape and elongation, indicating smaller cores have more convergent distal margins. The first two principal components of core shape variables do not show significant variation among the sites.

Table. 5.3.5: Results of PCA for Core shape analysis

		PC1	PC2	PC3	PC4
Eigenvalues		1.41408	1.17293	0.87008	0.54291
Variation explained		35.352	29.323	21.752	13.573
Variable Loadings	**P Shape**	0.38087	0.62624	0.50561	-0.4551
	D Shape	0.00103	0.71844	-0.6349	0.28405
	Elongation	-0.5923	0.28646	0.55223	0.51202
	Flatness	0.71002	-0.098	0.19037	0.67084

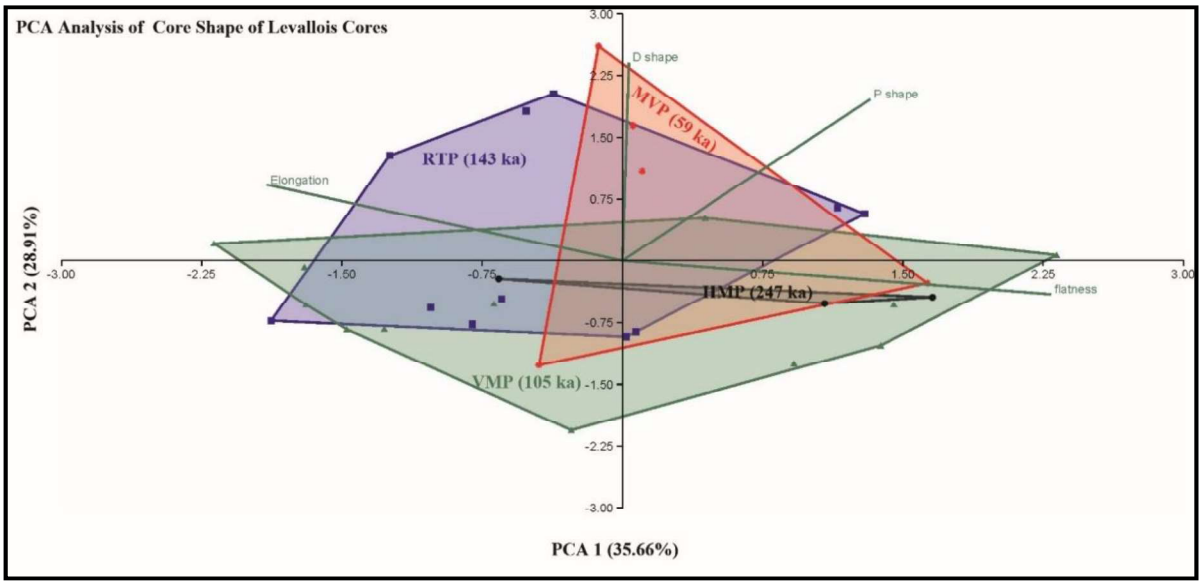


Figure. 5.3.3: Scatter plot (with biplot) of first two principal components of Core shape which account for ~ 65% variability and do not differ significantly between sites.

Among the flake production variables, the first two principal components account for ~ 60% of variability in the datasets (Table 5.3.6). The first component (33% variability) is primarily driven by core rotations, number of non-feather terminations, last platform angle and number of flake scars (Fig. 5.3.4). The second component (27% variability) is characterised by the number of major flake scars, number of non-feather terminations and last scar elongation. The first two principal components of flake production variables do not show significant variation among the sites.

Table. 5.3.6: Results of PCA for Flake production analysis.

		PC1	PC2	PC3	PC4	PC5	PC6	PC7
Eigenvalues		2.36294	1.92285	0.88899	0.79602	0.48178	0.32707	0.22035
Variation explained		32.896	27.179	12.7	11.372	6.8826	4.6724	3.1479
Variable Loadings	**No. of Core rotations**	0.44827	-0.249	-0.2337	0.50624	0.38477	0.44131	0.28873
	Last platform angle	0.51696	0.12076	0.15582	0.04286	-0.7909	0.11479	0.23102
	No. of major flake scars	0.10177	0.54928	-0.4296	0.38165	0.04095	-0.5816	0.13329
	No. of flake scars	0.40057	0.18974	0.6658	-0.1824	0.4409	-0.2771	0.23628
	No. of feather terminations	-0.1714	0.5279	0.38535	0.46789	0.00868	0.3982	-0.4073
	No. of non-feather terminations	0.57586	0.01169	-0.2295	-0.2321	0.09866	-0.0341	-0.7422
	Last Scar Elongation	0.0019	0.55397	-0.3034	-0.5387	0.14342	0.46618	0.27013

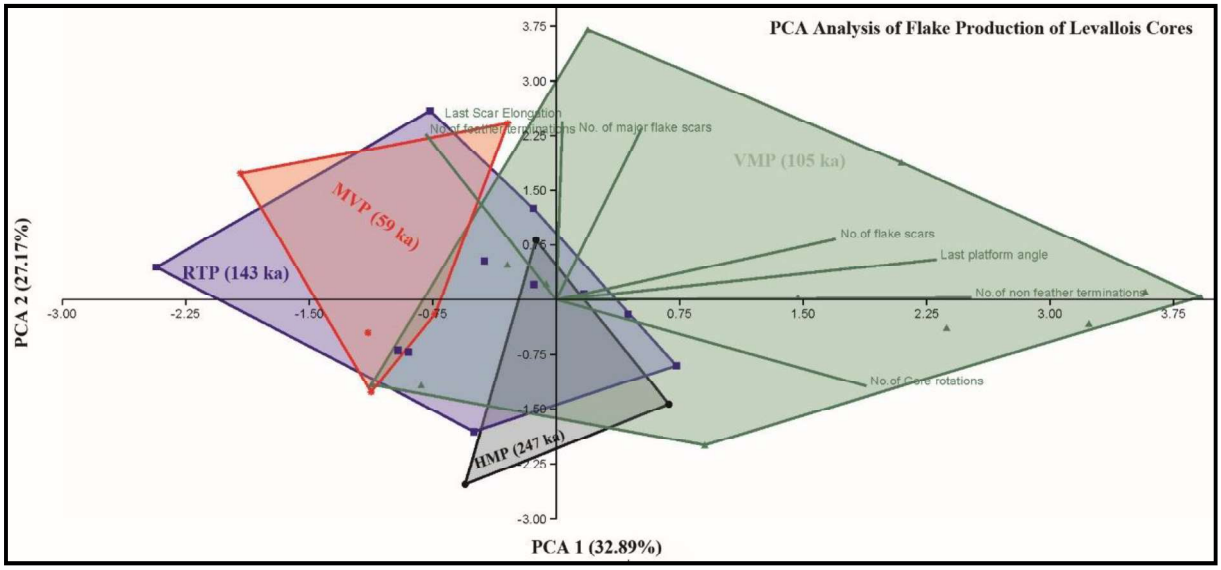


Figure. 5.3.4: Scatter plot (with biplot) of first two principal components of Flake production which account for ~ 60% variability, which do not differ significantly between sites.

Among the other formal core reductions such as discoidal, blade, uni- and bi-directional cores, the former type is predominant at Retlapalle and Vemulapadu sites, dated between the end of Middle Pleistocene and the beginning of Late Pleistocene (Fig 5.3.5). Blade cores, though sparsely present, are better represented at Retlapalle and in post-YTT sediments (70-60 ka). The latter two core types are more prominent in the sites dated to post 80 ka. The informal core types of simple and multi-platform cores do not show any specific patterns. They are present randomly; the former being reported only at Vemulapadu and the latter dominant at Hanmunathuniapadu. At both these sites artefacts are stratified below YTT sediments (Fig 5.3.5). The radial cores are predominant in the sediments stratified below and above YTT and reported in considerably large numbers from Retlapalle.

Overall, there are significant differences in the presence and absence of various core types between the late Middle Pleistocene and the Late Pleistocene dated Middle Palaeolithic sites. The core types become more diversified towards the late Pleistocene epoch. However, quantitively the Levallois cores do not show any significant variation among the sites dated between ~ 247 ka to 59 ka in the region, probably indicating the continuation of the Levallois technology.

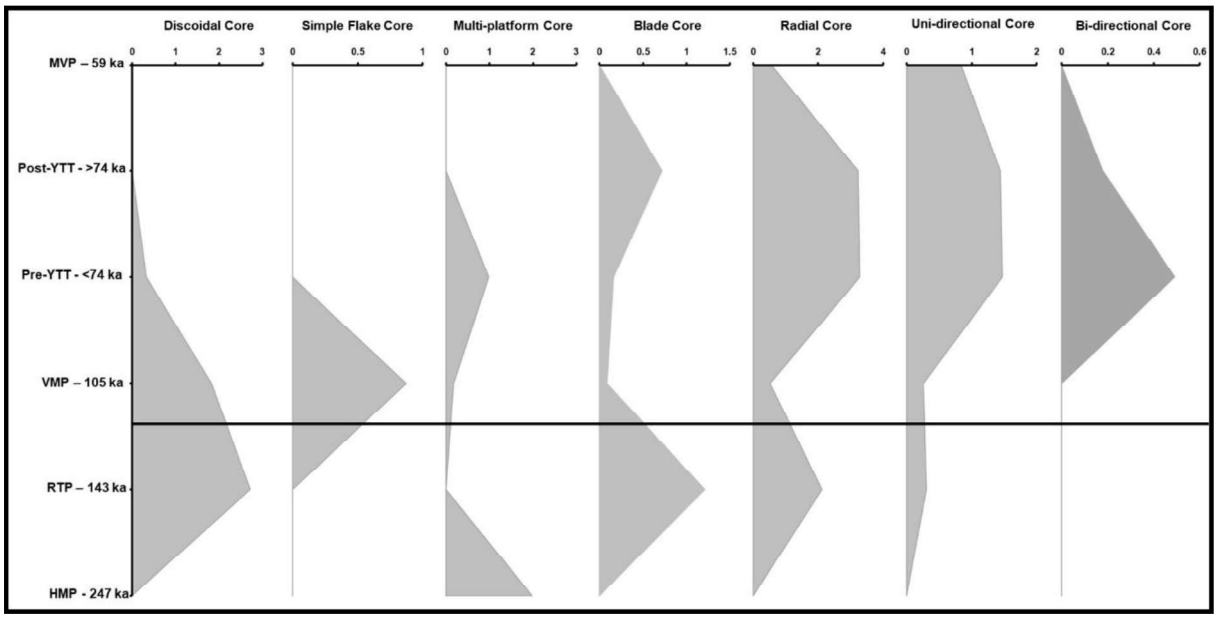


Figure. 5.3.5: Temporal Distribution of other core types.

5.3.2 Retouched

Retouched artefacts discussed here belong to two categories: a) formally retouched artefacts falling into conventional typological categories (e.g., scrapers, borers, etc.) and b) informally retouched ones having random retouches, but not fitting into any known formal tool typology. The late Middle Pleistocene Middle Palaeolithic sites show less variety in formal retouched tool types, limiting them to a few scrapers. On the other hand, the Late Pleistocene Middle Palaeolithic shows a greater variety of retouched artefacts, including notches, borers, burins, and scrapers (Fig 5.3.6). Notably, the sites dated between 80-60 ka from the upper Gundlakamma river basin shows rich and diverse retouched tools. Similar observations can also be made on the informally retouched tools. Late Pleistocene assemblages show greater diversity and more number of tools than the late Middle Pleistocene, indicating a clear preference for retouched artefacts (Fig. 5.3.7).

5.3.3 Points

Points were an important tool during the Middle Palaeolithic phase and were said to have been used as projectile points. Considerable number of points were recovered from all the Middle Palaeolithic sites in the region. Bifacial points are more common in late Middle Pleistocene sites, and they disappear from sites that are datable to post 80 ka (Fig 5.3.8). Levallois points and retouched points/Mousterian points are rarely present in the late Middle Pleistocene dated sites and they become more common during the Late Pleistocene. A few tanged points are present in all the sites, with Vemulapadu showing the least number.

5.3.4 Unretouched

Unretouched assemblages consist of flakes from different core reduction stages and end-products such as blades, Levallois flakes and Prepared core flakes. The dominance of Levallois and Prepared core flakes can be seen in the Late Pleistocene dated sites (Fig 5.3.9).

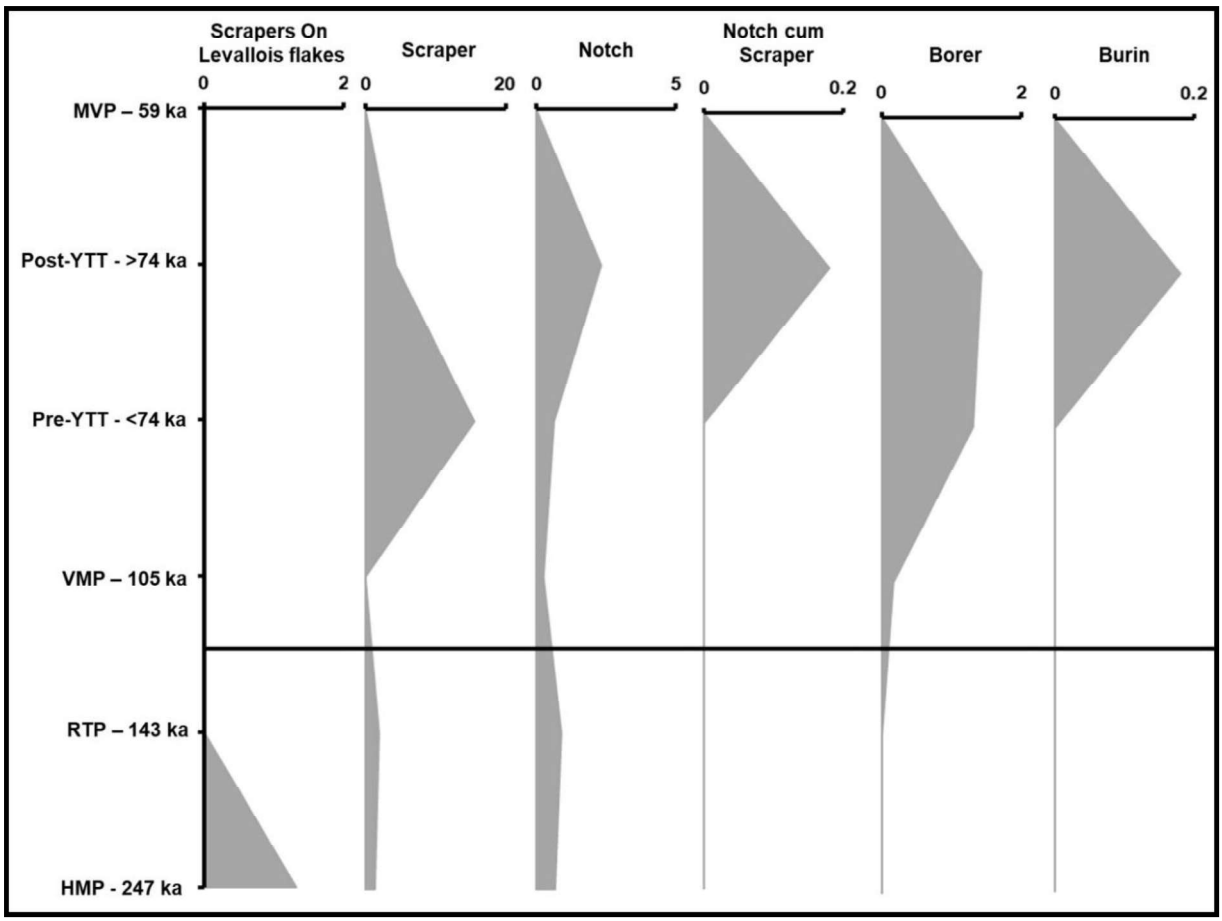


Figure. 5.3.6: Temporal distribution of retouched artefacts.

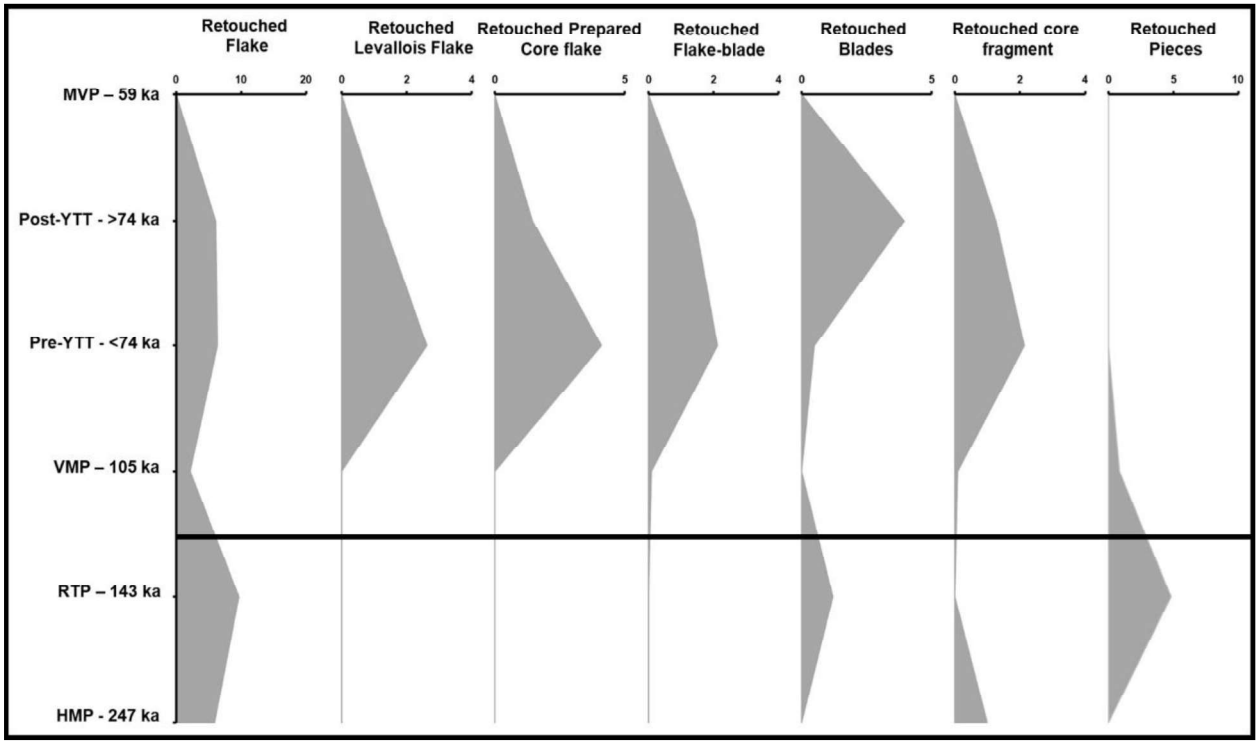


Figure. 5.3.7: Temporal Distribution of informal retouched artefacts.

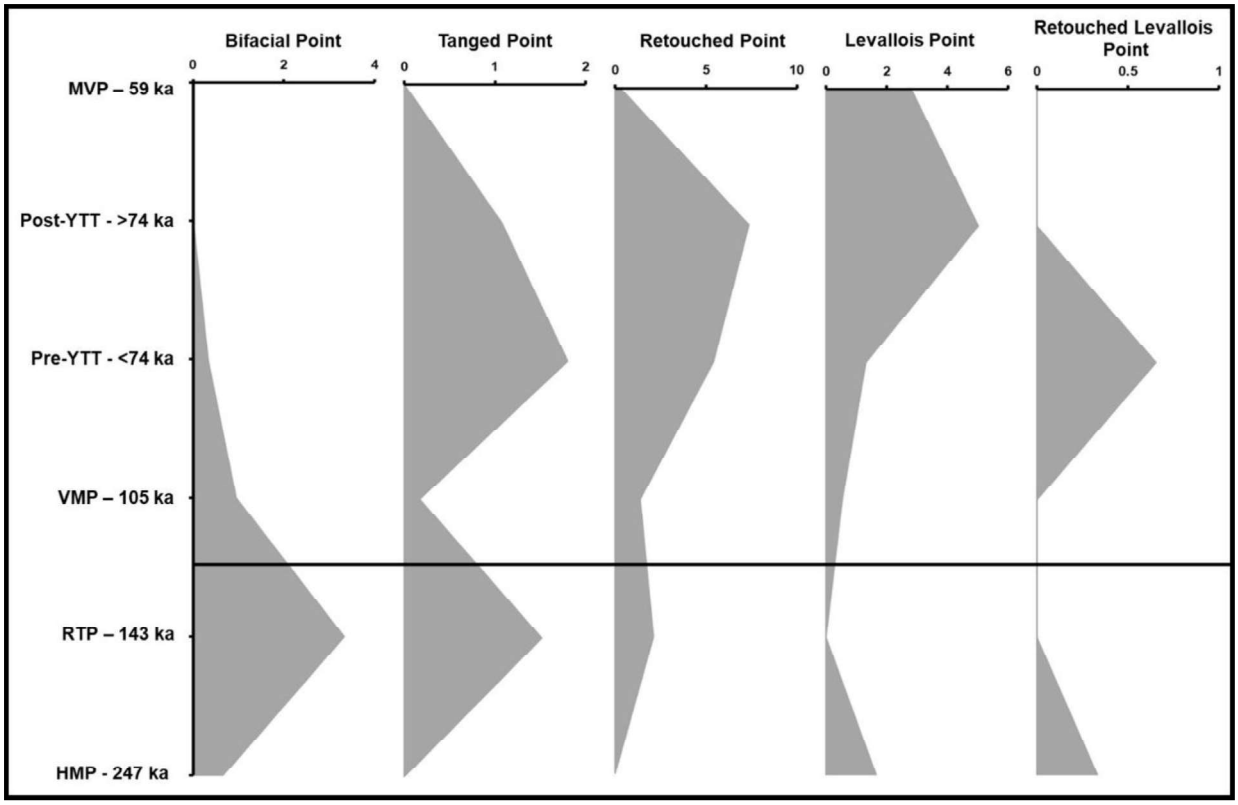


Figure. 5.3.8: Temporal distribution of Points.

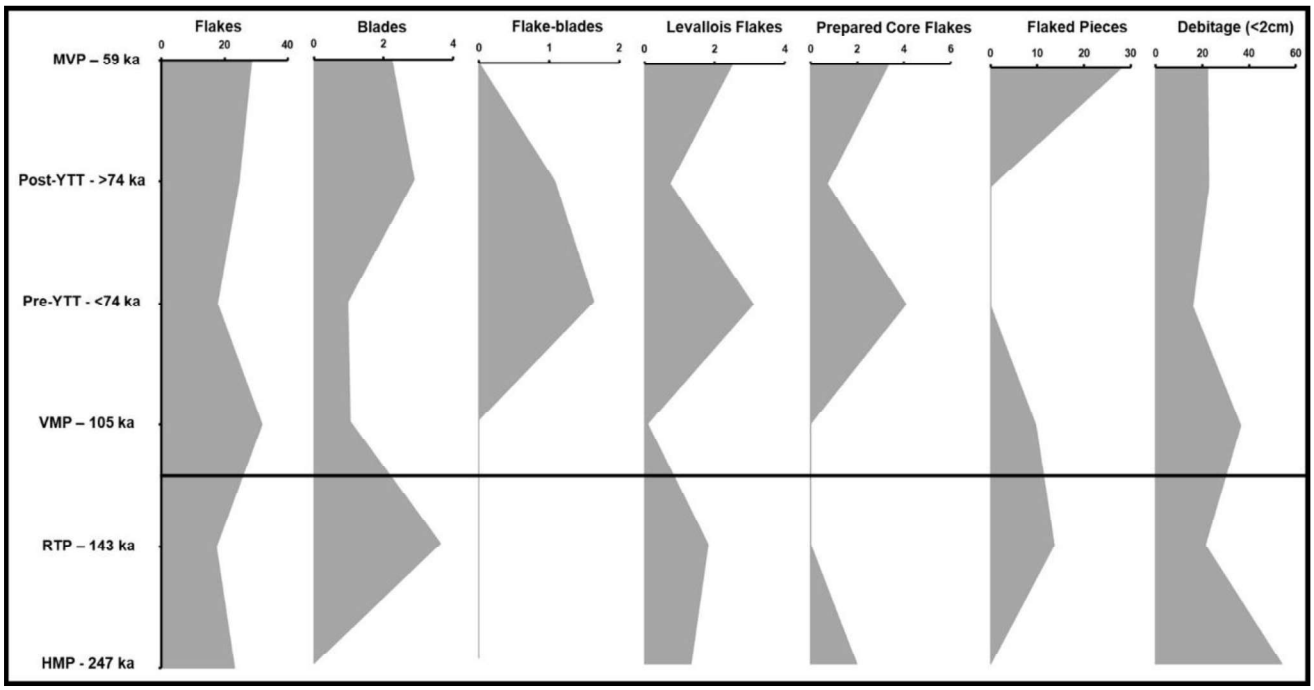
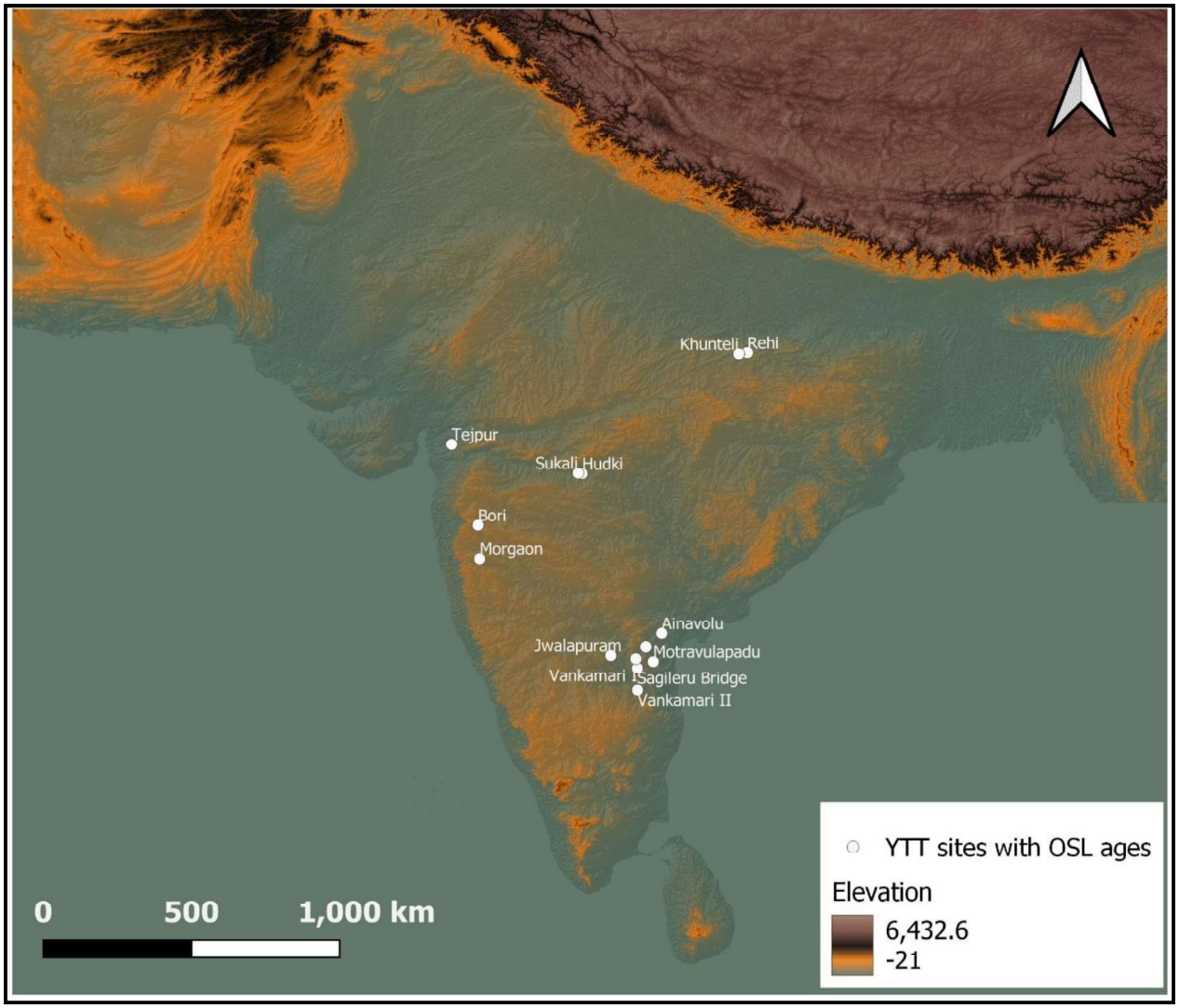


Figure. 5.3.9: Temporal distribution of unretouched artefacts.

5.4 Youngest Toba Tuff beds in South Asia as a Late Pleistocene chronological marker?

The eruption of Toba in 75 ka (Mark et al., 2014) is the largest volcanic eruption documented in the past 2 million years. It erupted ca. 2800 km^3 of rhyolitic magma, resulting in a minimum ashfall of 800 km^3 (Chesner et al., 1991). Distal Youngest Toba Tephra (YTT) appears widespread in marine cores obtained from the Indian Ocean and the Arabian Sea (Pattan et al., 1999, 2001; Schulz et al., 1998; Schulz et al., 2002) and is found as thick terrestrial deposits across South Asia (Acharyya & Basu, 1993; Blinkhorn et al., 2014; Jones, 2007; Williams & Royce, 1982), as well as appearing as cryptotephra in lake cores (e.g. (Lane et al., 2013a), flowstone records (see (Ge & Gao, 2020) and archaeological sites (E. I. Smith et al., 2018a). The scale of this eruption has resulted in significant debates regarding its impact on global climate, terrestrial ecosystems, and hominin populations (Oppenheimer, 2002). Recent modelling studies have suggested uneven climatic impacts of the eruption, suggesting severe temperature anomalies at higher latitudes contrasting with muted impacts on precipitation at lower latitudes and in the southern hemisphere (Black et al., 2021), which broadly correspond to evidence from fossil and archaeological records for minimal impacts on faunal and human populations (Clarkson et al., 2020a; Louys, 2012; M. Petraglia et al., 2007b)). Nevertheless, the airfall event from the eruption of Toba resulted in a blanket of ca. 4-5 cm of YTT deposited in South Asia (N. Matthews et al., 2012), with the potential to cause both short- and long-term impacts on the region's geomorphology with significant variability at a landscape scale, which may have ensuing impacts on human populations.

In this context, several studies were conducted in the past aimed at understanding the impacts of Toba eruption on human populations and to establish the link between the Palaeolithic artefacts and YTT deposits in South Asia. These studies were focused on the YTT deposits from the Son valley, Madhya Pradesh; the Jurreru, Sagileru, and Gundlakamma valleys, Andhra Pradesh; Bori, Morgaon, and the Purna valley, Maharashtra; and Tejpur, Gujarat (Fig. 5.4.1). However, except the Jurreru, the Gundlakamma, and the Son valleys, no archaeological remains associated with YTT deposits were identified from the remaining regions. Notably, luminescence ages bracketing the YTT deposits in these regions provide significant insights into the depositional history of the ash (Table 5.4.1).



Map. 5.4.1: Map showing the distribution of YTT sites with OSL age estimations.

Table. 5.4.1: List of sites with YTT deposits constrained with Luminescence ages in India.

Site	Below YTT (ka)	YTT (ka)	Above YTT (ka)	Method	Reference
Jwalapuram 22, Jurreu Valley, Andhra Prdesh	85	-	35	OSL	(Haslam et al., 2012)
Jwalapuram 3, Jurreu Valley, Andhra Prdesh	77±6	-	< 55	OSL	Petraglia et al 2012
Ghoghara, Son Valley, Madhya Pradesh	53±2.6	-	50±2.6	OSL	Neudorf et al 2014
Khunteli, Son Valley, Madhya Pradesh	53±2.1	-	51±3	OSL	Neudorf et al 2014
Khunteli, Son Valley, Madhya Pradesh	61±7	82±13	-	OSL	Biswas et al 2013
Rehi, Son Valley, Madhya Pradesh	83±9 and 70±9	81±15	40±5	OSL	Biswas et al 2013
Tejpur, Madhumati, Gujarat	74±6	71±9	60±7	OSL	Biswas et al 2013
Bori, Kukdi river, Maharasthra	-	27±3	-	OSL	Biswas et al 2013
Morgaon, Karha river, Maharasthra	-	41±5	-	OSL	Biswas et al 2013
Vankamari I, Sagileru river, Andhra Pradesh	64±7	-	48±4	OSL	Geethanjali et al 2019
Vankamari I, Sagileru river, Andhra Pradesh	22±3	-	2.3±0.1	OSL	Geethanjali et al 2019
Sagileru Bridge, Sagileru river, Andhra Pradesh	67±2	-	65±3	OSL	Geethanjali et al 2019
Singampalli, Sagileru, Andhra Pradesh	28±2	-	0.3±0.01	OSL	Geethanjali et al 2019
Ainavolu, Gundlakamma river, Andhra Pradesh	57±5	-	22±3	OSL	Geethanjali et al 2019
Hudki, Purna river, Maharasthra	70±4	-	57±5	OSL	Singh et al 2022
Sukali, Purna river, Maharasthra	66±5	-	67±4	OSL	Singh et al 2022
Retlapalle, Gundlakamma river, Andhra Pradesh	**76.3±5.5**	**-**	**64.4±3.9**	OSL	Current Study
Motravulapadu, Manneru river, Andhra Pradesh	**33.9±1.5**	**-**	**29.2±1.2**	OSL	Current Study

Luminescence ages associated with the YTT deposits from Jwalapuram come from two localities; Jwalapuram 22 and Jwalapuram 3. Jwalapuram 22 has Middle Palaeolithic evidence just before the eruption dating prior to 74 ka (Haslam et al 2012). The post YTT deposits from Jwalapuram 22 has been dated to 35 ka suggesting the absence of sediments immediately after the Toba event. The pre-YTT sediments at Jwalapuram 3 locality are dated to 77 ka, while the sediment above the YTT was originally dated to 74 ka but has since been revised (Petraglia et al 2012) to be younger (~ 55 ka). The Jwalapuram site has well-preserved pre YTT sediments with Middle Palaeolithic artefactual evidence, but post-YTT sediments are far younger than the Toba event.

The Son valley, Madhya Pradesh where the YTT deposits are identified and studied from 1980s onwards, yielded ash deposits associated with alluvial sediments (Gatti et al., 2011). However, their studies revealed no intact Palaeolithic sites directly associated with YTT in the Son valley and the ash beds were found to be in redeposited contexts, which questioned the integrity of the YTT beds as a chronological marker (Gatti, 2013; Jones, 2007; Neudorf et al., 2014). Luminescence ages constraining the final deposition of YTT beds from Ghoghara and Khunteli of the Son valley indicate varying depositional histories of the ash. Neudorf et al (2014) suggests the YTT at Ghoghara and Khunetli are fluvially reworked after its original deposition at ~ 74 ka based on the age of 53 ka for the below YTT sediments. Whereas Biswas et al (2013) suggests an age of 80 and 73 ka for the below YTT sediments at the Rehi section of the Middle Son valley. Prior to the OSL age estimations, based on geomorphological and geochemical analysis, the YTT deposits from the Son valley are said to be primary in nature (Gatti 2012). These studies highlight the role of complex fluvial and alluvial process involved in the ash mobilization and deposition in the Son valley. Recent studies of the sediments and associated archaeological materials from the Dhaba site in the Son valley, spanning the time from 80 to 40 ka that includes the time of Toba eruption, revealed the presence of cryptotephra in sediments dated ~74 ka.

The sites from Maharashtra such as Bori, Morgaon, Hadki and Sukhali yielded OSL ages associated with YTT deposits. At Bori and Morgaon the YTT was directly dated using the OSL method which gives the burial age 27±3 and 47±5ka (Biswas et al 2013) indicating redeposition long after the Toba super-eruption. Similarly, at Hadki and Sukhali sites in the Purna river basin, both the pre- and post-YTT sediments are younger than the age of eruption (Singh et al., 2022). Recent studies aimed at estimating the burial age of YTT from the Sagileru river valley,

Andhra Pradesh further indicate younger ages for the sediments underlying the YTT sediments (Geethanjali et al., 2019). These chronometric ages suggest that not all of the YTT beds in South Asia are primary deposits; rather, most of them are found to be in a redeposited context. Tejpur in Gujarat is the only site in South Asia that yielded the closest age bracket for YTT deposits ranging from 74±7 to 60±6 ka (Biswas et al 2013). However, no archaeological material was identified associated with the Tejpur YTT deposits.

The current study identified several sites with YTT deposits across the upper Gundlakamma and the Manneru river basins. At five sites, artefact association was noted with the YTT deposits from the upper Gundlakamma river basin (Anil et al 2022) and two sites in the Manneru river basin have artefact association with the YTT beds. The study confirms the attribution of volcanic ash deposits in the Gundlakamma and Manneru river basin as YTT through direct geochemical fingerprinting of glass shard and biotite composition. Luminescence age estimations were made for the underlying, overlying and YTT deposits to constrain the burial age of the YTT at two sites, Retlapalle (Section 4.6 of Chapter 4) and Motravulapadu (Section 4.8 of Chapter 4). At Retlapalle, the deposition and mobility of tephra occurred within low energy soft sediment contexts dated to ca. 10 thousand years after the eruption of Toba.

The YTT horizon at Retlapalle is around ten times thicker than the primary ashfall deposits identified from marine cores (Schulz et al., 1998; Schulz et al., 2002) as well as through direct study of terrestrial sequences (Matthews et al., 2012), clearly indicating the reworking of this ash within the landscape. Our study of mineral magnetics indicates the redeposited tephra as anomalous within the sediment sequence, which otherwise demonstrates considerable continuity, with gradual and consistent changes in ferromagnetic concentrations bracketing the influx of YTT. Here, the YTT deposits appear as a discrete entity within the basin sediments, become stabilized within the valley in the comparatively short time frame of ~10 ka, and do not appear to have undergone multiple phases of redeposition, as may have happened elsewhere (e.g., Son Valley (Neudorf et al 2014); Sagileru Valley (Geethanjali et al 2019)). The rapid stabilization of this depositional landscape following the influx of YTT presents an important context to examine environmental and behavioural changes across the eruption of Toba, which are harder to achieve in contexts where multiple or lengthy episodes of reworking of YTT deposits are evident.

On the other hand, the YTT deposits from Motravulapadu (Trench 4) were constrained with ages of 33 and 29 ka for the sediments underlying the ash bed. Notably, the thickness of the YTT beds at Motravulapadu is less than that of at Retlapalle, and they do not seem to have been mixed with other sediments before final deposition. The luminescence ages clearly indicate that the YTT deposits from Motravulapadu are secondary in nature and redeposited ~ 40 ka after the original deposition.

More broadly, this study emphasizes the importance of undertaking geomorphological and chronological assessment at a local scale to establish the utility of YTT as a discrete sedimentological and chronological marker and, in this case, to establish the timeframe in which post-Toba landscapes stabilized. Further research is required at Retlapalle and in the Gundlakamma basin to clearly demonstrate the presence of a primary ashfall deposit, which provides the most secure isochron (following Matthews et al. 2012). Therefore, the current study highlighted the hazards of using YTT as a chronological marker in palaeoenvironmental constructions and to understand modern human dispersals.

5.5 Nature of Lithic Assemblages before and after the Toba Super-eruption

Models for the impact of the eruption of Toba on environments and human populations have often relied on YTT to provide a robust isochron (Williams et al., 2009). Establishing the depositional and chronological context of YTT deposits is critical for its use as an essential benchmark horizon. This is true regardless of whether the eruption of Toba at 75 ka had catastrophic consequences (e.g., (Ambrose, 1998; Rampino & Self, 1992)and immediate changes in environmental and archaeological evidence are anticipated, or whether the impacts of the eruption on human populations have been exaggerated, without causing any break in cultural transmission or population continuity (e.g., (Clarkson et al., 2020b; Petraglia et al., 2007; Smith et al., 2018)). Notably, these alternatives of a sharp rapid change or continuity and gradual changes in archaeological records before and after the eruption of Toba broadly correspond with competing models for human expansions into South Asia (J. Blinkhorn & Petraglia, 2017; Groucutt et al., 2015a; Mellars et al., 2013a; Mishra et al., 2013b).

South Asia presents a unique context to examine the impact of the recent eruption of Toba regardless of the potential impacts to regional or global climates, which appear to have had limited influence on broader patterns of cultural evolution (e.g., South African site (Smith et al 2018)). It is only in South Asia that we have evidence for clear impacts that Toba had on landscapes and hominin populations, manifest in the deposition of a blanket of ash that

subsequently swamped drainage networks and patterns of change in behaviour in stone tool assemblages that span this timeframe. In both regional (Jurreru Valley) and more distant (Son Valley) sites, continuity in Middle Palaeolithic technologies preceding and succeeding the eruption of Toba are well documented (Petraglia et al. 2007; Clarkson et al. 2012; 2020).

The upper reaches of the Gundlakamma river basin provides unique association of Middle Palaeolithic artefacts and YTT deposits to evaluate the impacts of the Toba on South Asia hominins and environments. Previous studies in the region have brought to light rich prehistoric record ranging from Acheulian to microlithic (Issac 1960; Kumari 1987). However, no ash associated Palaeolithic sites were discussed by previous researchers because until the early 1990',s the subcontinental Palaeolithic research had seldom emphasised upon the ash deposits and their implications in paleoanthropological studies. Early Middle Palaeolithic artefacts consisting of a few handaxes, diminutive handaxes and cleavers, Levallois cores and flakes, discoidal cores and various flake tools were found from Retlapalle associated with sediments dated to 143 ka (Section 4.6).

The rapid stabilization of low-energy soft sediment deposition observed at Retlapalle following the eruption of Toba is particularly fortuitous for examining its impact on human behavioural change. The identification of Middle Palaeolithic assemblages from Layer E deposits suggests a longstanding inhabitation of the Gundlakamma basin, which could significantly predate the eruption of Toba and potentially extend into the Middle Pleistocene based on comparable discoveries in Andhra Pradesh that share comparable technologies (Anil et al. 2022). Previous research in the region had recorded several sites yielding Middle Palaeolithic artefacts associated with both Layers B and D across the upper reaches of the Gundlakamma river basin (Anil et al. 2022). At Kalagotla, Kagitalagudem and Telladinne, lithic artefacts were identified within the deposits that are comparable to the Layer D sediments at Retlapalle, directly underlying the YTT horizon, which are now attributable to the latter stages of MIS 5, ca. 76.3± 5.5 ka. These stone tool assemblages show the presence of alternate Levallois reduction methods (preferential and recurrent flakes, points etc.) alongside discoidal and other radial reduction approaches, as well as a range of expedient reduction strategies (Fig. 5.5.1). Retouched tools attributed to these late MIS 5 deposits include diverse retouched Levallois flakes and points, diverse scrapers, notches and borers, and the presence of tanged points.

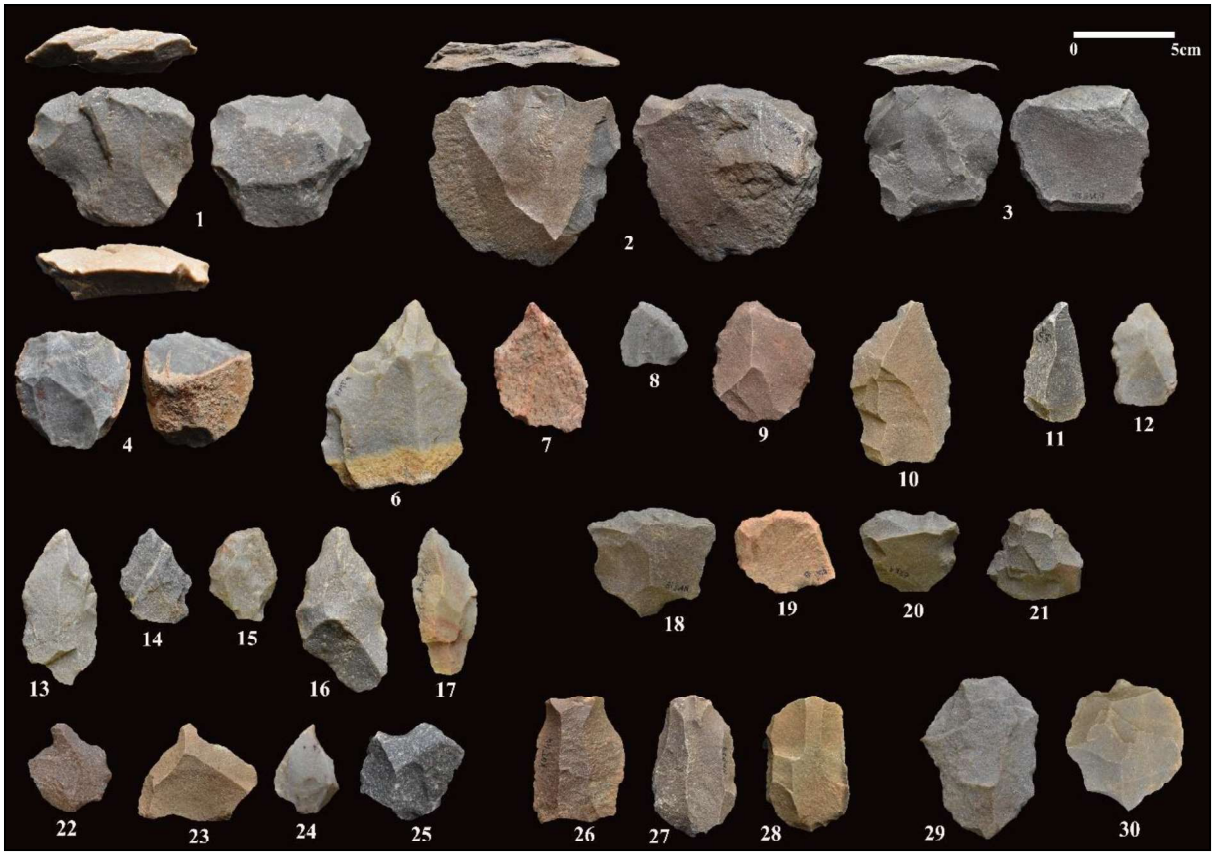


Figure. 5.5.1: Artefacts representing the below YTT archaeology from the upper Gundlakamma river basin. 1 and 2: Recurrent Levallois core (KGM); 3: Unidirectional Levallois core (TDE); 4: Bidirectional Levallois core (KGM); 6 to 10: Retouched Points (KGT, RVP, TDE); 11 and 12: Levallois points (NMP, KGT); 13 to 17: Tanged points (AGB, KGM, KGT); 18 to 21: Scrapers (TDE, NMP, KGT, HMT, CTK); 22 and 23: Borers (AVK, ERK); 24: Burin (TDE); 25: Notch (CVD); 26 to 28: Flake-blades/Blades (NMP, KGT); 29 and 30: Levallois flakes (TDE, NMP). All these artefacts are from the surface collections of twelve different sites and are shown together for representative purposes. (Source Anil et al 2022).

The range of technology observed in Layer D deposits, with the combination of alternate Levallois and discoidal reduction schemes and production of a range of retouched toolkits including tanged points matches closely with evidence from other MIS 5 dated sites across South Asia (Sandhav: (Blinkhorn et al., 2019); Katoati: (Blinkhorn et al., 2013); Jwalapuram: (Clarkson et al., 2012b); Middle Son Valley: (Clarkson et al., 2020b); 16R Dune: (Blinkhorn, 2013); Arjun 3: (Corvinus, 2002); Bundala: (Deraniyagala, 1992); Karna; (Blinkhorn, 2014)).

At JP Cheruvu and Vemulapeta, within the Gundlakamma river basin, lithic artefacts were recovered in sediments directly comparable to Layer B and overlying YTT deposits (Anil et al. 2022) and now attributable to MIS 4 ca. 64.4±3.9 ka. Reduction strategies evident in these

assemblages include preferential Levallois flake and point production, the use of radial reduction practices, as well as more prominent focus on blades evident across cores, blanks and retouched pieces (Fig. 5.5.2). The prominent presence of Levallois points in the blank assemblages are complemented by the appearance of tanged points amongst the retouched toolkit alongside the appearance of burin production.

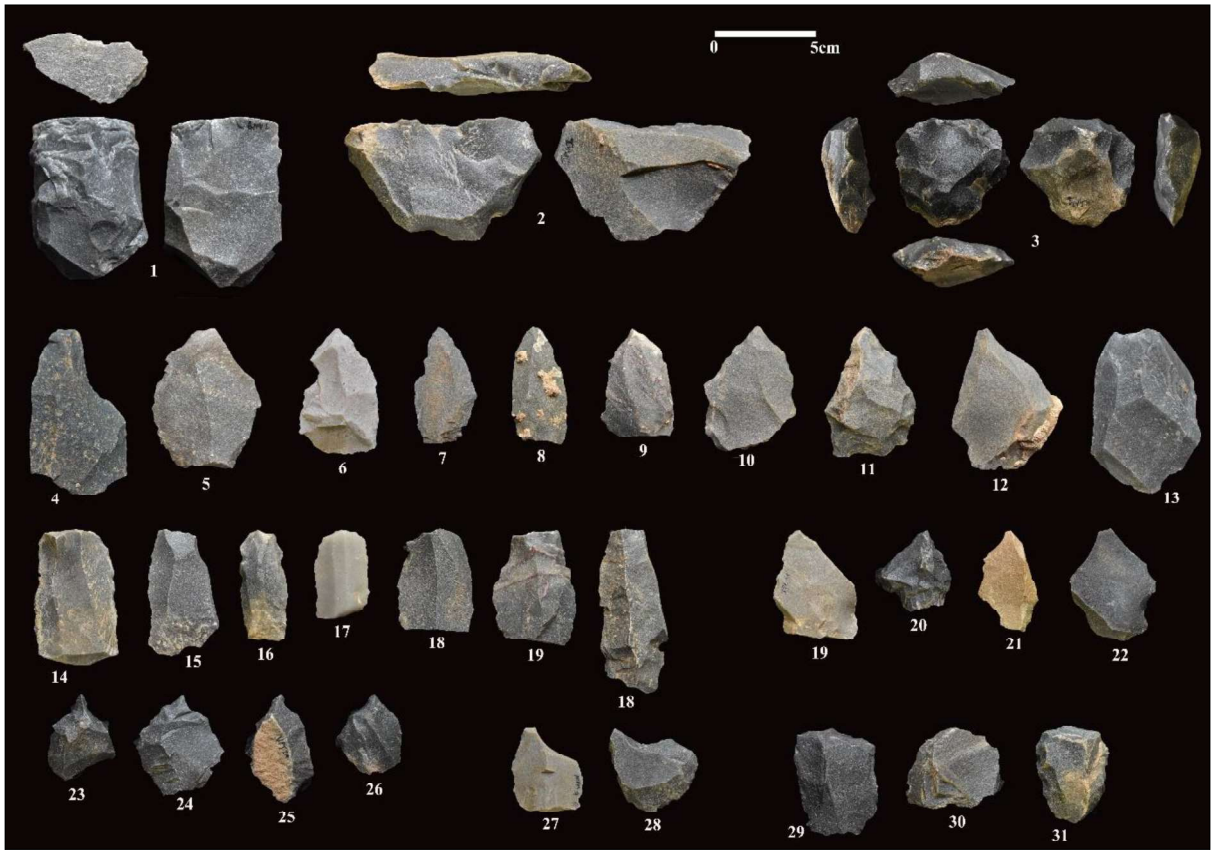


Figure. 5.5.2: Artefacts representing the above YTT archaeology from the upper Gundlakamma river basin. 1: Blade core (VPT); 2: Unidirectional core (CLP); 3: Recurrent Levallois core (JPC); 4 to 12: Levallois points (VPT, VBP, JPC); 13: Levallois flake (VBP); 14 to 18: Blades (VBP, VPT, BNV, AVD); 19 to 22: Tanged points (VPT, JPC, MDM); 23 to 26: Borers (MMp, JMG); 27: Burin (MDM); 28: Notch (AGB II); 29 to 31: Scrapers (BNV, MDM, JNV). All these artefacts are surface collections from eleven different sites and shown together for representative purposes (Source Anil et al 2022).

The presence of Middle Palaeolithic assemblages overlying YTT horizons is consistent with evidence observed elsewhere in Andhra Pradesh – the Jurreru valley (Clarkson et al. 2012) and the Sagileru valley (Blinkhorn et al. 2014) – and other sites such as the Son valley (Clarkson et al. 2020) in South Asia. The range of technological variability observed in the Gundlakamma river basin in the mid-MIS 4 is also comparable to that seen in other Middle Palaeolithic sites

across South Asia dating to MIS 4 and 3, noticeably at Jwalapuram (Clarkson et al. 2012), Katoati (Blinkhorn et al. 2013), Jetpur (Baskaran et al., 1986), the Middle Son Valley (Clarkson et al. 2020), Shergarh TriJunction (Blinkhorn 2014), Bhimbetkha (Bednarik et al., 2005), and the Orsang valley (Ajithprasad 2005).

These findings corroborate a shared pattern, with substantial continuity in lithic technologies derived from Layers D and B in the Gundlakamma basin. Moreover, the comparatively narrow chronological gap between these assemblages further refines evidence for the response of South Asian Middle Palaeolithic hominins to the eruption of Toba. Lithic artefacts associated with Layer B from JP Cheruvu and Vemulapeta, now the oldest examples of lithic technology to directly overly YTT horizons, suggests limited disruption to regional patterns of occupation. Not only does this illustrate the enduring utility of Middle Palaeolithic toolkits to engage with and adapt to substantive environmental challenges occurring at a landscape scale, but also indicates contemporaneity between the deployment of these technologies by South Asian populations and the earliest appearance of *Homo sapiens* in Southeast Asia (e.g., Tam Pa Ling; (Demeter et al., 2012) and Australia (Madjebebe; (Clarkson et al., 2017)).

5.6 Nature of post Middle Palaeolithic cultural Evolution in South Asia

Lithic assemblages recovered from Ardhaveedu and Trench 4 from Motravulapadu associated with sediments dated back to 41 and 29 ka respectively provide significant insights to understand the post-Middle Palaeolithic cultural evolution in the region. Based on the morphometric analysis of the lithic assemblage, the main objective of lithic reduction from both sites was to produce elongated flakes and blades. The use of prepared core and Levallois technology seems minimal at Ardhaveedu and are completely absent from Trench 4 of Motravulapadu. Based on the dorsal flake scar patterns on complete flakes and the presence of predominant unidirectional cores, the unidirectional reduction strategy seems to be most preferred at the sites. In addition, the presence of blade cores and blades indicates a clear preference for elongated flakes and blades at the site. Similar blade-based assemblages were also observed from ten other sites in the upper reaches of the Gundlakamma river basin associated with a similar geological context as of Ardhaveedu (Anil et al 2021). In addition, at 21 sites blade-based assemblages similar to the trench 4 of Motravulapadu were reported in the upper reaches of the Manneru river basin and were assigned as Upper Palaeolithic sites (Srinivasulu 2012). This blade dominated assemblages from both the regions dated between 41 to 29 ka, suggest blades as a distinct temporal behaviour vestige existed at least for 10 ka.

Notably, the Ardhaveedu assemblage contains small portions of retouched artefacts which are dominated by informally retouched tools limiting our understanding of the nature of the retouched tool kit at the site. However, surface collections made from ten other sites associated with similar geological contexts in the region show the presence of Levallois points, scrapers, retouched flake-blades, blades, and points (Anil et al 2021).

South Asia is a region of higher significance as it acts as a geographical corridor connecting two major regions of the Old World (i.e., West Asia and East Asia), containing several provocative shreds of evidence of human origins research. Despite the paucity if fossils, the diverse archaeological records of South Asia, particularly during the time of MIS 3, reflect evidence of complex behavioural patterns demonstrating the remarkable cultural transformation. The co-existence of multiple technological trajectories not only shows the diversification and regionalization of stone tool technology but also highlights the complexity of cultural processes (like convergence, displacement, and diffusion). It is extremely crucial to define the nature of the relationship and interaction between these technological populations. In this background, Table 5.6.1 presents the archaeological sites in South Asia dated to MIS-3 timeframe among which most sites are hindered by the uncertainties in chronologies and limited sample size. However, it seems clear that at least two technological trajectories existed during this time frame. One is microlithic technology dated back to 48 ka and the other is Middle Palaeolithic technology continuing up to 38 ka showing the potential temporal overlap between the two. However, it has been argued that South Asian microlithic technology was indigenously invented by modern human populations from Middle Palaeolithic technology (Blinkhorn & Petraglia, 2017b; Clarkson et al., 2009). These conclusions were made based on the excavations conducted in Jwalapuram 9 rock shelter which yielded microlithic assemblages dated to 34 ka and in Jwalapuram 20 where Middle Palaeolithic assemblages dated to 38 ka. Similar claims were also made from the site Dhaba in the middle Son valley, Madhya Pradesh where Middle Palaeolithic technology continued up to 48 ka and the emergence of microlithic technology dated at 48 ka and later (Clarkson et al 2020). The aforesaid studies attribute this independent innovation of microlithic technology in South Asia to modern humans who migrated to the region from Africa between 120-70 ka with Middle Palaeolithic technology. However, microlithic assemblages stratigraphically and chronologically overlying the Middle Palaeolithic assemblages do not necessarily signify the transition between the two.

Table. 5.6.1: Table showing the known Archaeological sites assigned to MIS 3, time range in South Asia. Nature of Lithic assemblages and issues associated with chronology are also presented.

Site	Chronology	Assemblage Character	Reference	Comments
Sanghao Cave	42.5±4ka to 21.9±3.5ka; C14 method	Quartz based laminar flake/blade assemblage. Late Middle Palaeolithic	(Dani, 1964; Possehl, 1994)	Uncertainties in chronology
Site 55	45ka; TL method	Quartzite based blade industry; Initial Upper Palaeolithic	(R. W. Dennell et al., 1992)	Uncertainties in chronology
Katoati 1	< 61+9ka; OSL method	Highly cortical flakes and core on Quartzite; non diagnostic	(Blinkhorn et al., 2013)	Non diagnostic assemblage
Chamu	58-27ka; OSL method	Flakes on sandstone; no cores; non diagnostic	(Blinkhorn, 2014)	Limited sample size and less diagnostic
Shergarh Tri-Junction	60-43ka; OSL method	Diverse core reduction techniques; rhyolite; Late Middle Palaeolithic	Blinkhorn et al 2014	Limited sample size and less diagnostic to claim the systematic blade production
Son and Belan valleys	55-25ka; OSL method	Unspecified lithic assemblages; limited sample size; Upper Palaeolithic to microlithic	(Jones & Pal, 2009; Pal et al., 2005; Williams et al., 2006) Petraglia et al 2012	Non diagnostic; poor stratigraphic integrity

Arjun	>30ka; TL method	Middle Palaeolithic; unifacial reduction prominent	(Corvinus, 2002)	Uncertainties in chronology
Mehtakheri	45ka; OSL method	Microblade based assemblage; Chalcedony and chert	Mishra et al 2013	Microblade technology and securely dated
Patne	25ka; C14 method	Younger Upper Palaeolithic	(Sali, 1989)	Blade based assemblages preceded by unifacial dominant MP and succeeded by blade and microblade assemblages stratigraphically
Jwalapuram 3	<55ka; OSL method	Middle Palaeolithic; dominance of single platform cores; Limestone	Jones 2007; Petraglia et al 2007; (Haslam et al., 2010)	No publications of revised OSL ages and the artefacts from above YTT layers from JWP Loc 3 are associated with gravel lens may be redeposited
Jwalapuram 21 and 20	38ka and 34ka; OSL method	Middle Palaeolithic; Unidirectional core reductions; Limestone	(Jones, 2007); (M. Petraglia et al., 2009)	Stratigraphic uncertainties; may be in secondary contexts
Kana and Mahadebbera	42ka and 34-25ka	Microlithic on Chert	(Basak & Srivastava, 2014)	Microblade technology and securely dated
Fa Hien Lena. Sri Lanka	48-45ka; C14 method	Microlithic on Quartz	(Wedage et al., 2019)	Microblade technology and securely dated
Dhaba 2 and 3	55-24; MET-pIRIRSL	Middle Palaeolithic (chert) and Microlithic (Quartz)	Clarkson et al 2020	Securely dated Middle Palaeolithic and Microlithic technologies

The lithic assemblages from Ardhaveedu and Motravulapadu (Trench 4) along with other blade-based assemblages from the upper reaches of the Gundlakamma and Manneru river basins denote the existence of blade technology during MIS 3 in the region. Technologically, these assemblages are different from the Middle Palaeolithic and the microlithic technologies and the presence of such assemblages pose significant questions on the currently understood framework of Palaeolithic cultural developments in South Asia. In the model of Middle Palaeolithic to microlithic transitions, these blade-based assemblages could be transitional assemblages between the former and latter, which were not observed in Jwalapuram and middle Son valley. But chronologically these blade-based assemblages are older than the youngest known Middle Palaeolithic assemblages (38 ka) and younger than the oldest known microlithic assemblages (48 ka) not supporting the idea of transitional nature. However, Palaeolithic transitions do not necessarily have sharp boundaries, rather they happened in a mosaic way where the temporal and spatial overlap is expected.

On the other hand, these blade-based assemblages can be part of the late Middle Palaeolithic technology with more preference towards the blades/elongated flakes limited to only certain regions in South Asia. These regions (ex. Eastern Ghats) must have acted as refugia during severe climatic conditions where this blade technology can be seen as a technological adaptation. In this scenario, the Indian microlithic technology may be due to the modern human migrations to South Asia rather than an independent innovation, and the Middle Palaeolithic technology was practiced by unknown archaic hominin in the region. This scenario indicates there is a temporal overlap of 10 ka between the oldest known microlithic technology at 48 ka and the youngest Middle Palaeolithic technology at 38 ka.

5.7 Initial Modern Human Colonization of South Asia: New Perspectives

The origin of modern humans in Africa and their subsequent migrations into the rest of the world has been the most debated topic in palaeo-anthropology and archaeology in recent years (Petraglia et al. 2010; Appenzeller 2012; Blinkhorn and Petraglia 2017). The absence of fossil remains from the key regions along the dispersal route further complicates the issue. There currently exist two conflicting models, post-Toba (also known as MIS 4-3 Model) and Pre-Toba (MIS 5 Model), for the earliest modern human colonization of South Asia ((Mellars, 2006; Mellars et al 2013; Petraglia et al 2007; Groucutt et al. 2015; Blinkhorn and Petraglia 2017), which rest on a slender foundation of archaeological evidence and absence of human

fossils in the region. The first model states that the modern humans arrived ~50–60 ka, from Eastern Africa along the coastlines of South and Southeast Asia, to reach Australia by ~45–50ka (Mellars 2006; Mellars et al 2013). The second proposes the dispersal of modern humans from Africa as early as 120–130 ka (Petraglia et al 2007; Groucutt et al. 2015), reaching southern Asia via the Levant or the south Arabian Peninsula, well before the Toba "super-eruption" at 74 ka. The Post-Toba model is supported by molecular genetic dating, combined with similarities between Indian microlithic assemblages and Howiesons-Poort-like ones in South and East Africa. Arguments advanced in support of the latter model rest on the evidence unearthed from Jwalapuram where a series of stone tool assemblages have been recovered from locations both underlying and overlying the thick deposits of Toba ash-fall, with a series of associated OSL dates ranging from ~77 to ~38ka (Petraglia et al 2007).

Both the models are however characterized by certain drawbacks. DNA analysis often assumes that modern sample populations are an accurate reflection of all past populations, which ignores or rarely considers demographic changes (Petraglia et al 2010). On archaeological grounds, both the models are problematic. The Pre-Toba colonization model suggests that the Indian microlithic technology was an in-situ development from local post-Toba Middle Palaeolithic technologies. However, the earliest Indian microlithic technologies appear similar to those documented over large parts of Old World, with no evidence of technologically transitional industries from 70 ka to 45 ka to support the in-situ development of microlithic technology in the region. The Post-Toba model, on the other hand, fails to explain the gaps between the genetically estimated age of the initial modern human colonization of South Asia (50-60 ka) and the earliest directly dated occurrences of typical microlithic industries in South Asia (35-45 ka) (Groucutt et al. 2015). The human occupation of Australia by at least 50 ka also suggests that earlier sites should be found in South Asia along the route to Australia. However, the oldest evidence for modern humans outside of Africa was revised to be older than 210 ka based on the fossil evidence from Apidima Cave in Greece (Harvati et al., 2019) and Misiliya cave in Israel (Hershkovitz et al., 2018). These findings suggest an older age for the presence of modern humans outside of Africa, around 210 ka, which is much earlier than 120 ka. This, however, does not necessarily warrant the South Asian dispersal earlier than 120 ka unless modern human sites dated earlier than 120 ka are reported from South Asia.

South Asia's significance in the modern human dispersal route is due to its location and rich Palaeolithic record. The presence of Middle Palaeolithic technology in South Asia was attributed to modern humans arriving from Africa between 120-70 ka (Petraglia et al. 2007).

Middle Palaeolithic artefacts recovered from the sediments underlying the 74 ka Youngest Toba Tuff deposits at the Jwalapuram site were closely similar to African Middle Stone Age artefacts (Petraglia et al. 2007; Haslam et al. 2012). Therefore, the Indian Middle Palaeolithic technologies were said to be of African origins, and the pre-Toba model (Petraglia et al. 2007) became popular to explain the initial modern human colonisation of South Asia. The luminescence ages further supported this model for the Middle Palaeolithic assemblages from Katoti in Rajasthan and Sandhav in Kachchh, reported as 96±13 ka and 114±12 ka, respectively (Blinkhorn et al. 2013; Blinkhorn et al. 2019). Recent research from the Dhaba site in the Middle Son Valley yielded middle Palaeolithic assemblages dated between 80-40 ka agreeing with the pre-Toba model (Clarkson et al. 2020). These studies, with reliable chronometric ages for Middle Palaeolithic assemblages between 120-40 ka, suggested that South Asian Middle Palaeolithic technology was introduced to the region by the modern humans as a part of the Eurasian migration. Besides, the youngest ages for the Late Acheulian assemblages dated to 137±10 ka (PAT4/1) from Patpara and 131±9 ka (BAM 3/2, Lower member) Bamburi in the middle Son Valley (Haslam et al., 2011), further corroborating the existence of archaic hominins just before the appearance of modern humans in the region. A

In contrast, Middle Palaeolithic assemblages from Attirampakkam dated to 385±64 ka (Akhilesh et al. 2018) and the ages from the current study indicate the presence of Middle Palaeolithic technology in South Asia was older than the currently known ages for the modern humans outside Africa. This would clearly suggest that the Middle Palaeolithic technology alone cannot be used as a type of fossil for determining the presence of modern humans in the region. Besides, independent innovations of Middle Palaeolithic technologies are reported from Europe and South Asia. Technological convergence and similarities in the lithic technology of diverse hominin groups have also been noted in Levant (Shea, 2008) and Indonesian sites (Moore et al., 2009). The Mode 3 dominant lithic assemblages and the >247 ka date for the same from Hanumanthunipadu clearly argue for the prevalence of Middle Palaeolithic technologies much earlier than 120 ka in the region under investigation. At present, it would be difficult to assign this technological development to any particular hominin group because of the absence of relevant fossils. In addition, sites like A. Agraharam and Nandanavanam show Late Acheulian to Middle Palaeolithic transitional assemblages supporting the indigenous development of Middle Palaeolithic technologies.

It is also necessary to note that this observation is not inimical to the proposed 120 ka dispersal event of modern humans; the difficulty, however, is associating that group with the introduction

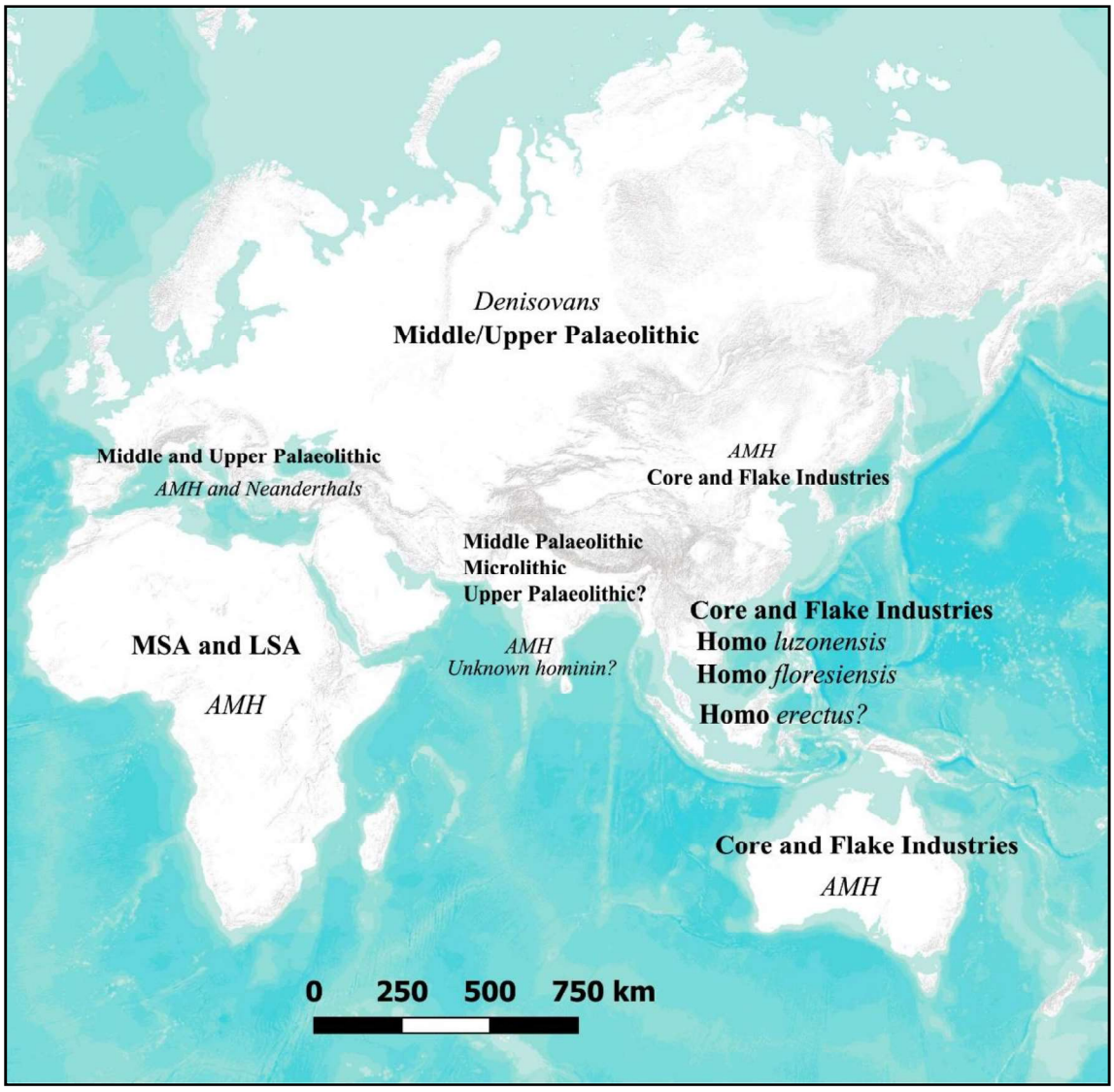
of Middle Palaeolithic technologies in South Asia. It is also possible that the South Asian Middle Palaeolithic is a product of local innovations starting around 400 ka and technologies introduced by the incoming populations of modern humans later on. Notably, there are significant differences were observed between late Middle Pleistocene and Late Pleistocene Middle Palaeolithic assemblages which may support the aforesaid observations. However, further investigations are required to better understand such issues.

5.8 Archaic Hominin and Modern Human interactions in South Asia: Emerging Perspectives

The current study identifies potential overlap between late Middle Palaeolithic technologies (Blade dominated) and microlithic technologies in South Asia during MIS 3. Possibly these two distinct lithic technologies were practised by two different hominin species that co-existed temporally; one being the modern humans producing microlithic technology and another an unknown archaic hominin species producing late Middle Palaeolithic technology. Notably, this scenario is significant as recent research in the fields of genetics and paleoanthropology not only contributed much to our understanding of hominin evolution and dispersals, but also made it more complex than previously thought. The discovery of new hominin species has changed the landscapes of paleoanthropological research and highlighted the complexities of evolution, dispersals, and diversity of the genus Homo. The discovery *Homo floresiensis*, a small-bodied, primitive hominin species from Liang Bua (Flores, Indonesia) has generated wide interest and debates among the scientific communities (P. Brown et al., 2004; Morwood et al., 2004, 2005). The skeletal remains of *Homo floresiensis* were found in sediments that are dated between 100 to 60 ka and the associated lithic artefacts were dated to 190-50 ka (Sutikna et al., 2016). Further, the presence of another new hominin species, *Homo luzonensis*, whose remains were discovered in Callao cave (Northern Luzon, the Philippines) dated to 67 ka, highlights the importance of Island Southeast Asia in the evolution of genus Homo (Détroit et al., 2019; Mijares et al., 2010). Another previously unknown hominin species, *Homo naledi*, was discovered in the Rising Star cave system, South Africa dated around 285 ka (Berger et al., 2015; Dirks et al., 2017). The ages of this primitive species suggest that at least three hominin species existed across the African continent at 300 ka with the other two being the *H. sapiens* and *H. heidelbergensis* (Galway-Witham et al., 2019). Denisovan fossils are known from the Denisova cave in Altai mountains (Siberia, Russia) and Baishiya Karst cave on the Tibetan plateau, Xiahe, China dated between 200-50 ka (Chen et al., 2019; Douka et al., 2019). Two

other well-known species of genus *Homo*, the Neanderthals, and *H. erectus* persisted until about 40-45 ka in Europe and Indonesia respectively (Stringer, 2002). Besides, the recent advancements in the field of genetics and aDNA reconstructions helped us to access the previously unknown facets of human evolution and dispersals. While colonizing Eurasia around 60 ka anatomically modern humans (AMH) interbred with multiple extinct hominin species (Skoglund & Mathieson, 2018). The traces of such interbreeding events were recorded in the genomes of the modern-day population. These interbreeding events first occurred between AMH populations and Neanderthals in western Eurasia around 50-55 ka and contributed 2% of introgressed Neanderthal DNA that is now found in non-African populations (Green et al., 2010). In Asia, at least three different hominin groups appear to have been involved in these interbreeding events of which the Denisovans are currently known (Teixeira & Cooper, 2019). The two unknown hominin species are from South Asia and East Asia.

The aforementioned fossils and genetic data suggest that during the Late Pleistocene epoch particularly around 60 ka multiple hominin species have existed in different parts of the Old World of which only our species survived (Map. 5.8.1). In addition, *Homo sapiens* interacted with the Neanderthals, Denisovans, and possibly with two other unknown hominin species in Asia. However, the nature of these interactions is still unclear concerning the behavioral similarities and differences between these multiple hominin species. How other hominin species (e.g., Neanderthals and Denisovans) acted at a biological and behavioral level with relation to our species is an important question to answer? Because, if the other distinct species of genus Homo exhibits behaviors similar to our species should they be considered as modern as we are on a cultural and cognitive level. Similarly, is it the differences in behaviors that helped our species to survive while others become extinct? Therefore, it is crucial to reconstruct the behaviors of these multiple species to answer the aforementioned questions. In this regard, the MIS 3 archaeological record of South Asia can throw significant light on the hominin introgression events and behavioral evolution.



Map. 5.8.1: Old World during MIS 3-time frame with known hominin species and associated Lithic technologies.