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Microliths, Landscapes and Niche Construction:A Case Study of Late Pleistocene Microlithic Technology in Purulia, West Bengal

Mayanka Kapoor
Research Scholar, Department of Fine Arts, Maharaja Agrasen Himalayan Garhwal University
Dr. Archana Tyagi
Assistant Professor, Department of Fine Arts, Maharaja Agrasen Himalayan Garhwal University

Abstract
This paper examines Late Pleistocene microlithic technology in Purulia District, West Bengal, through a focused case study of the sites of Mahadebbera and Kana. These sites, dated between roughly 42,000 and 25,000 years ago, are among the earliest securely dated microlithic assemblages in South Asia and are crucial for understanding early modern human adaptation in eastern India. Using published typo-technological data, core and blank analysis, and a reconstructed chaîne opératoire, the study explores how blade and bladelet technologies were organised, how raw materials were selected and reduced, and how retouched microliths were shaped and used. The technological patterns are read against the lateritic upland landscape, local geology and inferred palaeo-environmental conditions, highlighting the importance of ecotonal locations near water and raw material sources. The results point to a mixed strategy of curated and expedient elements within flexible, portable toolkits adapted to seasonally variable environments. Interpreted through the lens of cultural niche construction, the repeated occupation of these sites is seen as part of a long-term process of landscape learning and subtle ecological modification. The paper argues that Purulia's microlithic record forms an important early chapter in the technological history of Bengal.

Keywords
Microlithic technology; Mahadebbera; Kana; Purulia; Late Pleistocene; technological organisation; chaîne opératoire; niche construction; Bengal prehistory

1. Introduction

Microlithic technologies occupy a rather awkward but important position in Palaeolithic and Mesolithic archaeology. On one hand, they are tiny, fragile and often morphologically repetitive. On the other, they are associated worldwide with flexible, composite toolkits that helped hunter-gatherers cope with climatic fluctuation, shifting prey communities and complex mobility patterns during the Late Pleistocene and early Holocene (Andrefsky, 2005; Hiscock, 2015). In India, microlithic industries have been documented from many regions, including Rajasthan, central India, Gujarat and the Ganga plains, but secure dating has long been a problem (Bhattacharya, 2007; Misra, 2001). For this reason, the microlithic sites of Mahadebbera and Kana in Purulia District, West Bengal, have attracted sustained attention.

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Radiocarbon and luminescence dates from Mahadebbera and Kana place microlithic occupations broadly between c. 42,000 and 25,000 years ago, pushing blade-based technologies in eastern India well back into the Late Pleistocene (Basak et al., 2014; Basak & Srivastava, 2017). These results have been widely cited in discussions of modern human dispersals and the antiquity of microlithic technologies in South Asia. Yet in many of these references, the Purulia sites appear mainly as chronological datapoints. Their internal technological organisation, raw material economy and relationship to local landscapes are mentioned only briefly, if at all.

This paper argues that such a narrow use of the Purulia evidence misses an opportunity. Mahadebbera and Kana are not just "early microlithic" in a calendar sense. They also provide a window onto how Late Pleistocene foragers in the eastern Indian uplands organised technology, learned their landscape and gradually modified it through repeated use. By reading these assemblages through frameworks of technological organisation and cultural niche construction, we can move beyond typological labels and think about microliths as part of wider adaptive systems (Torrence, 1989; Laland et al., 2001; Shott, 2017).

Three questions structure the paper. First, how are microlithic technologies at Mahadebbera and Kana organised in terms of core reduction, blank production and retouched tools? Second, how do raw material selection and reduction strategies relate to local geomorphology, raw material exposures and watercourses (Basak, 1998; Chakrabarti, 1993; Ghosh & Majumdar, 1991)? Third, what do these patterns suggest about mobility, risk management and niche construction among Late Pleistocene foragers in this part of eastern India?

To address these questions, the study treats Mahadebbera and Kana as components of a single regional case study. Rather than trying to generalise to all of India, it focuses on integrating close artefact observation with a careful reading of the local environmental record. In doing so, it builds directly on the logic of the broader thesis of which this paper is a part, where typo-technological analysis is combined with contextual data to reconstruct long-term technological histories in Bengal.

2. Regional and Environmental Setting

2.1 Physiography and geology of Purulia

Purulia District lies in the western part of West Bengal, at the eastern fringe of the Chotanagpur plateau. The region is characterised by undulating uplands, isolated hillocks and dissected plateaus, cut by seasonal streams that eventually feed into larger river systems such as the Kasai and Damodar (Chakrabarti, 1993). Elevations generally range between about 200 and 400 metres, with local relief provided by inselbergs and low ridges. Much of the surface is covered by ferruginous laterite, developed on older Precambrian bedrock.

Geologically, Purulia forms part of the eastern Indian shield, with basement complexes of gneiss, schist and quartzite, intruded by dolerite and pegmatite veins (Ghosh & Majumdar, 1991).

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Weathering and erosion of these rocks produce a range of potential lithic raw materials, including quartz, chert and fine-grained quartzites. Lateritic caps often seal colluvial deposits, while stream channels and terraces expose cobbles and pebbles that can be exploited for tool manufacture.

Basak's (1998) work on the Late Quaternary environment of the Tarafeni valley in nearby Midnapore emphasises the dynamic nature of these uplands. Phases of climatic fluctuation and erosion alternated with periods of relative stability and soil formation, creating a mosaic of surfaces of different ages. Although the Tarafeni lies south of Purulia, the general picture of dissected lateritic uplands with embedded raw material sources seems to apply across much of western West Bengal.

2.2 Palaeo-environmental context

Palaeo-environmental reconstructions for eastern India suggest that during the Late Pleistocene the region experienced a mix of cooler, drier phases and more humid intervals, broadly tracking monsoon variability (Agarwal et al., 2014). In the uplands around Purulia, this likely translated into seasonal watercourses with fluctuating discharge, semi-deciduous woodland patches on more stable surfaces, and open scrub or grassland on exposed lateritic plateaus.

Basak (1998) argues that changes in river behaviour and sedimentation in the Tarafeni valley reflect broader climatic oscillations during the Late Quaternary. Although Mahadebbera and Kana themselves have not yet been subject to detailed pollen or phytolith studies, their stratified contexts and associated sediments point to multiple occupation phases embedded in this shifting environmental backdrop (Basak et al., 2014; Basak & Srivastava, 2017). For mobile hunter-gatherers, such landscapes would have presented both risks and opportunities: resources were patchy and seasonal, but raw materials and water were predictably concentrated in particular micro-habitats.

2.3 Archaeological context

Archaeologically, Purulia has long been recognised as part of an important Stone Age province in eastern India. Early work by Ghosh (1961, 1966) identified "implementiferous laterite" across parts of West Bengal, including Purulia, Bankura and Midnapore, where lateritic surfaces yielded abundant stone artefacts. Subsequent surveys and excavations across the Chotanagpur margin outlined sequences from Lower Palaeolithic core-and-flake industries through microlithic assemblages to Neolithic and Chalcolithic sites (Chakrabarti, 1993; Chakrabarti & Chattopadhyay, 1984).

Within this broader mosaic, Mahadebbera and Kana stand out because they offer stratified microlithic levels with absolute dates. Excavations revealed dense concentrations of microblades and retouched microliths associated with hearths and other features, overlain and underlain by sterile or minimally artefactual layers (Basak et al., 2014; Basak & Srivastava, 2017). This

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combination of stratigraphic control and chronometric dating makes them ideal focal points for a case study of technological organisation and landscape use.

Table 1. Basic information on the case-study sites

Site	District	Context	Dating methods and range	Key publications
Mahadebbera	Purulia	Stratified microlithic levels in lateritic upland deposits	Radiocarbon and OSL; c. 42–25 ka BP	Basak et al. (2014)
Kana	Purulia	Stratified microlithic levels on lateritic surface near drainage	Radiocarbon and OSL; c. 42–25 ka BP	Basak & Srivastava (2017)

The two sites, located in similar geomorphic settings but with slightly different relationships to local drainage and raw material patches, provide a natural comparison for examining how microblade technologies were organised within a single regional niche.

3. Materials and Methods

3.1 Data sources

The present study is based primarily on published data, in keeping with the documentary and comparative methodology of the wider thesis. Key sources include the detailed reports by Basak and colleagues on Mahadebbera and Kana (Basak, 1998; Basak et al., 2014; Basak & Srivastava, 2017), regional geological syntheses (Chakrabarti, 1993; Ghosh & Majumdar, 1991) and broader discussions of microlithic industries in India (Bhattacharya, 2007; Misra, 2001). From these, information was compiled on site stratigraphy, dating, raw material descriptions and illustrative typological plates.

Because full primary catalogues of artefacts are not yet widely available, the analysis here remains at a synthetic level. Frequencies and proportions are drawn where explicit figures are provided; where they are not, patterns are interpreted qualitatively, based on repeated descriptions and illustrations. The goal is not to reconstruct every numerical detail, but to capture the main technological tendencies of the assemblages.

3.2 Typo-technological variables

The analytical framework follows established approaches in lithic studies, particularly Andrefsky's (2005) macroscopic analysis and work on technological organisation (Nelson, 1991; Shott, 2017). For cores, variables considered include raw material, core type (single-platform, opposed-platform, prismatic, multidirectional), platform preparation (plain, faceted, abraded) and dorsal scar patterns. For blanks, attention is paid to the distinction between blades, bladelets and flakes, as well as to length-to-width ratios and the presence of laminar structures.

Retouched tools are grouped into broad functional categories commonly used in South Asian microlithic studies: backed bladelets, points, lunates or crescents, triangles, scrapers and notched or denticulated pieces (Bhattacharya, 2007; Misra, 2001). For each category, the analysis considers morphological regularity, degree and location of retouch, and likely hafting arrangements.

3.3 Chaîne opératoire reconstruction

Chaîne opératoire, the reconstruction of operational sequences from raw material procurement through manufacture, use and discard, provides the conceptual backbone of the analysis (Inizan, Roche, & Tixier, 1999). Although direct experimental replication has not yet been undertaken for the Mahadebbera and Kana assemblages, reduction sequences can be inferred by linking core morphologies, debitage characteristics and retouched tool forms.

For example, blade-oriented core types with unidirectional scar patterns and backed bladelets of similar dimensions suggest a relatively standardised sequence of bladelet production followed by backing retouch. Multidirectional flake cores and irregular scrapers, by contrast, point to more opportunistic exploitation of residual core volumes. By examining these patterns across the two sites, it is possible to sketch how foragers structured their reduction strategies in relation to risk, mobility and raw material constraints (Torrence, 1989; Shott, 2017).

3.4 Environmental correlation

Site locations and contextual descriptions from published sources are cross-referenced with geological and geomorphological maps of the region provided by Ghosh and Majumdar (1991) and Chakrabarti (1993). Although high-resolution GIS analysis falls beyond the scope of this paper, it is possible to situate Mahadebbera and Kana in relation to major landform units, watercourses and likely raw material exposures. This provides the environmental backdrop needed to discuss niche construction and landscape learning.

4. Results

4.1 Raw materials and core strategies

Both Mahadebbera and Kana assemblages are dominated by fine-grained siliceous raw materials. Basak et al. (2014) emphasise that quartz and related rocks form the bulk of the microlithic component at Mahadebbera, with chert and chalcedony also present. Similar raw materials are reported for Kana, reflecting the availability of quartz-bearing veins and nodules within the local bedrock and colluvium (Basak & Srivastava, 2017; Ghosh & Majumdar, 1991).

Core assemblages at both sites show a preference for blade-oriented strategies. Unidirectional single-platform cores and opposed-platform cores occur frequently, often with carefully prepared striking platforms and systematic scar patterns indicating repeated removal of elongated blanks (Basak et al., 2014). In addition to these, prismatic blade cores and a smaller number of multidirectional flake cores are reported. The latter appear to represent opportunistic exploitation of residual core volumes or lower-quality nodules.

Platform preparation ranges from plain to minimally faceted, with some evidence of abrasion. The limited use of elaborate faceting may reflect the small size of available nodules and the desire to conserve raw material. Overall, the core evidence points to a concerted effort to produce blades and bladelets of regular morphology, suitable for conversion into microlithic inserts.

4.2 Blank production: blades and bladelets

Blade and bladelet blanks form the backbone of the microlithic component at both sites. Although detailed metric data are not yet fully published, Basak et al. (2014) describe Mahadebbera as dominated by narrow bladelets with straight or slightly curved profiles, produced from carefully managed cores. At Kana, Basak and Srivastava (2017) also note a high proportion of bladelets, alongside some larger blades and laminar flakes.

The prevalence of bladelets suggests that reduction strategies were geared towards producing small, repeatable blanks suitable for composite tools. This is consistent with wider understandings of microlithic technology as a modular system where many small inserts can be replaced individually when damaged (Hiscock, 2015; Andrefsky, 2005). Variation in blank morphology across the two sites may reflect differences in raw material nodule size, core rejuvenation practices or specific functional needs.

4.3 Retouched microlithic tools

Retouched tools at Mahadebbera and Kana include both “classic” geometric microliths and a range of backed and non-geometric pieces. Basak et al. (2014) mention backed bladelets, points and lunate or crescent-shaped microliths as particularly common in the Mahadebbera assemblage. The Kana assemblage shows a comparable repertoire, with backed bladelets, points, triangles and a smaller number of scrapers and notched pieces (Basak & Srivastava, 2017).

To summarise these patterns, Table 2 presents a schematic comparison of microlithic tool categories. Because the published reports do not provide full percentage breakdowns, frequencies are expressed qualitatively.

Table 2. Schematic composition of microlithic toolkits at Mahadebbera and Kana

Tool / artefact category	Mahadebbera (relative frequency)	Kana (relative frequency)	Inferred main function
Backed bladelets	High	High	Cutting inserts in composite knives or projectiles
Lunate / crescent	Moderate	Moderate	Barbs or tips in hunting weapons
Points (backed or unbacked)	Moderate	High	Thrusting or projectile tips

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Geometric triangles	Low–moderate	Moderate	Inserts in composite projectiles
Scrapers	Low	Low–moderate	Hide and wood working
Notched / denticulated	Low	Low	Hafting aids, varied tasks

What stands out in both assemblages is the prominence of backed bladelets and pointed forms, pointing towards a strong emphasis on cutting and hunting functions. Geometric microliths appear as a significant but not exclusive part of the toolkit. Scrapers and notched pieces, though less common, suggest additional tasks related to hide processing, woodworking and tool maintenance.

Retouch tends to be abrupt and confined to one lateral edge in backed pieces, while points often show more invasive retouch converging towards a tip. The regularity of many backed bladelets implies deliberate standardisation, likely reflecting their role in composite arrangements where insert size and shape must be controlled for efficient hafting.

4.4 Spatial and environmental patterns

Both Mahadebbera and Kana are located on or near lateritic uplands overlooking small drainage lines. Mahadebbera lies on a slightly elevated surface with stratified deposits suggestive of repeated occupation episodes, whereas Kana is closer to a drainage system, with microlithic levels associated with slope wash and colluvial processes (Basak et al., 2014; Basak & Srivastava, 2017). In each case, proximity to water and to quartz-bearing exposures appears to have been a key locational factor.

The recurring use of such settings suggests that Late Pleistocene foragers were targeting ecotonal zones where multiple resources overlapped: raw materials in the form of pebbles and nodules, water and associated plant and animal resources. Basak (1998) notes that similar combinations of lateritic plateaus and stream valleys in the Tarafeni region also yielded Stone Age artefacts. When seen across this wider landscape, Mahadebbera and Kana appear not as isolated sites but as nodes within a broader network of resource-rich micro-habitats.

5. Discussion

5.1 Technological organisation and mobility

From the perspective of technological organisation, the microlithic assemblages at Mahadebbera and Kana display a classic mix of curated and expedient elements (Nelson, 1991; Shott, 2017). Bladelet production from carefully prepared cores, yielding standardised blanks for backed tools, can be seen as a curated component: it requires planning, investment in core preparation and an expectation of future use. At the same time, the presence of multidirectional flake cores, irregular scrapers and opportunistic retouch on flakes hints at shorter-term responses to immediate needs.

Torrence's (1989) time–risk model suggests that such combinations are typical of groups dealing with moderate but not extreme risk. When resources are highly unpredictable, emphasising portable, versatile and repairable tools makes sense; when resources are more stable, expedient production with less investment suffices. The Purulia evidence fits a scenario in which foragers moved within a familiar landscape with seasonally variable resources, using microlithic inserts as part of flexible hunting and cutting toolkits, while also relying on local expedient tools for day-to-day tasks.

The dominance of small bladelets and backed pieces also supports the interpretation of relatively high residential mobility. Microlithic inserts allow for light, portable toolkits where broken elements can be replaced quickly without transporting heavy cores or large blanks (Hiscock, 2015). In a dissected upland terrain with patchy resources, such flexibility would have been advantageous. The repeated occupation of Mahadebbera and Kana over thousands of years suggests that mobility was not random: people returned to familiar locales where raw materials and other resources could be reliably found.

5.2 Niche construction and landscape learning

Cultural niche construction theory provides a useful lens for thinking about how repeated microlithic occupations at Mahadebbera and Kana contributed to long-term landscape modification (Laland et al., 2001; Laland, Odling-Smee, & Myles, 2010). Although human impact in the Late Pleistocene was unlikely to involve large-scale deforestation or agriculture, even small-scale, repeated activities – such as clearing brush around camp sites, building hearths, or creating paths to water and raw material sources – can cumulatively alter local environments (Arroyo-Kalin, 2017).

In this sense, the Purulia microlithic sites can be seen as early nodes of landscape learning and reinforcement. Each occupation would have added to a collective memory of where to find the "right" kind of quartz, when seasonal streams were most reliable, and where hunting or foraging success was likely. Such knowledge, transmitted socially, is itself a form of niche construction: it modifies the informational environment in which decisions are made (Richerson & Boyd, 2005). Over time, certain places become "good to think with" as well as good to live in.

This perspective also helps explain the stability of technological choices across long time spans. If particular reduction strategies and microlith forms worked well in the specific micro-habitats around Mahadebbera and Kana, there would have been strong cultural incentives to reproduce them. Technological traditions are not just neutral techniques; they are bundles of practices, stories and expectations attached to particular places and tasks (Lemonnier, 1992; Dobres, 2000). The Purulia microlithic repertoire, in this view, reflects a co-evolution of people, tools and landscapes.

5.3 Comparison within South Asia

When set against microlithic evidence from other parts of India, the Mahadebbera and Kana assemblages stand out primarily for their antiquity rather than for any radically different technological form. Blade-based microlithic industries with backed pieces, geometric forms and scrapers are documented from Rajasthan, central India and Gujarat, although many of these have been dated mainly to the early and middle Holocene (Bhattacharya, 2007; Misra, 2001). The Purulia sites show that such technologies were already well-developed in eastern India by the Late Pleistocene.

This does not mean that the Purulia microliths are identical to all later microlithic assemblages elsewhere. Regional differences in raw material, blank size, frequency of geometric forms and associated faunal or botanical remains suggest that microlithic technologies were repeatedly reinvented and reconfigured in response to local conditions (Clarkson et al., 2015; James & Petraglia, 2019). Within this diversity, Purulia provides an important data point demonstrating that tiny bladelet-based toolkits formed part of South Asian adaptive repertoires earlier than was once assumed.

The case study also contributes to debates about the relationship between microlithic technologies and modern human cognition. Experimental work has shown that blade and microlith production requires complex motor skills, planning and teaching (Stout, 2011; Stout & Chaminade, 2012). The presence of such technologies in Purulia by c. 40,000 years ago supports the argument that fully modern cognitive capacities, including structured learning and perhaps language, were already in play among these populations.

5.4 Implications for Bengal's long-term technological history

Looking forward from the Late Pleistocene into the Holocene, the Purulia microlithic case study can be linked to later developments in Bengal's technological history. Neolithic and Neo-Chalcolithic sites in West Bengal show continued use of chipped stone alongside ground axes, pottery and limited copper, suggesting technological overlap rather than abrupt replacement (Datta & Sanyal, 2013). In some cases, microliths appear in contexts associated with early cultivation and sedentism, hinting at continuity of certain reduction strategies or tool concepts.

By the Chalcolithic and Early Iron Age, the same broad upland–valley landscapes in western West Bengal witnessed the emergence of mixed stone–metal toolkits, pottery specialisation and eventually iron smelting (Datta, 2004–2005; Datta, 2010; Ray & Mondal, 2013). While it would be simplistic to draw a direct line from Mahadebbera microliths to later iron ploughshares, the idea that people in these landscapes had long experience with managing raw material patches, planning production sequences and coordinating work around key resource nodes is not far-fetched.

In this sense, microlithic niche construction can be seen as an early chapter in a much longer story of technological engagement with the Bengal uplands. The cognitive and social habits involved in returning to particular places, managing risk through portable toolkits and transmitting precise technical knowledge would have remained valuable even as new materials and economic practices emerged.

6. Conclusion

This case-study paper set out to move beyond the treatment of Mahadebbera and Kana as mere points on a chronological map. By bringing together typo-technological analysis, environmental setting and theoretical perspectives on technological organisation and niche construction, it has tried to sketch a more holistic picture of what Late Pleistocene microlithic technology meant in Purulia.

The main conclusions can be summarised as follows. First, both Mahadebbera and Kana exhibit blade and bladelet-oriented reduction strategies focused on fine-grained quartz and related materials, with carefully prepared cores and standardised blanks. Second, retouched microlithic tools are dominated by backed bladelets, points and geometric pieces, indicating a strong emphasis on composite hunting and cutting tools with a mix of curated and expedient elements. Third, the sites' locations on lateritic uplands near seasonal watercourses and raw material exposures suggest deliberate targeting of ecotonal zones where multiple resources converged.

Interpreted through the lens of technological organisation, these patterns point to mobile foragers using flexible, risk-buffering toolkits adapted to a seasonally variable but familiar landscape. Seen from a niche construction perspective, repeated occupation of Mahadebbera and Kana, coupled with the development and transmission of effective microlithic traditions, represents a form of long-term ecological engineering and landscape learning in the Bengal uplands (Laland et al., 2010; Arroyo-Kalin, 2017).

In the wider South Asian context, Purulia's microlithic industries reinforce the view that bladelet-based technologies were present in parts of the subcontinent by at least the mid-Late Pleistocene, adding nuance to models of modern human dispersal and adaptation (Basak et al., 2014; Basak & Srivastava, 2017; James & Petraglia, 2019). For Bengal specifically, they provide an important early chapter in a regional technological history that later came to include pottery, copper and iron.

Much remains to be done. High-resolution use-wear and residue studies could refine functional interpretations of the Purulia microliths, while expanded dating programmes would help clarify the tempo of occupation. Experimental replication of the Mahadebbera and Kana reduction strategies could illuminate the skill and learning involved, connecting the assemblages more directly to current work in cognitive archaeology. Finally, fine-grained GIS analysis of site distribution in relation to raw material sources, soils and palaeo-hydrology would deepen our understanding of how Late Pleistocene foragers constructed and inhabited their niches.

Even with current limitations, the case study underlines a simple but important point: tiny stone tools can tell large stories. In the Late Pleistocene uplands of Purulia, microliths were not just sharp edges. They were material traces of how people learned their landscapes, hedged their bets against risk and gradually made the Bengal uplands their own.

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