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Discovery of a Mesolithic Site at Madapatana–Yallappana Palya in the Arkavathi Basin, Southern Karnataka

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Abstract: Now, Madapatana-Yallappana Palya, is a key South Karnataka Site allowing discussion of Microliths and rock art discovered for the first time in the Arkavathi basin. In 2019-2023, as part of the doctoral research, a fresh investigation was carried out to see the prehistoric potential, cultural gap and chronology of the earliest occupation in the Arkavathi Basin, which is a microlithic site whose appearance closely relates to the Mesolithic phase. The present research documents the appearance of the Mesolithic assemblages at Madapatana-Yallappana Palya, which shows hunting type and raw materials used for making tools, as compared to the neighbouring site Jalahalli, based on available literature data. In this paper, we further identify the non-locally available raw material that chert was used to manufacture tools. Madapatana-Yallappana Palya currently produces lithic assemblages like bladed core, side-scraper, retouched blade, pointed blade and two-sided blades, with occupants dominating selected local crystal and quartz for making tools. Finally, we hope this discovery in the Arkavathi Basin fills a significant geographic gap in studying Mesolithic cultures. It also challenges the prevailing research to re-examine regional prehistoric behaviour and settlement patterns in southern Karnataka. This paper further assumes the originality of the Madapatana-Yallappana Palya assemblages within the context of the other late Pleistocene cultures in South Karnataka.

Keywords: Mesolithic, Arkavathi, Chert, Open-Air, Rock Art, Hunting-type.

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Introduction

The study of microlith assemblages opens a crucial window into technological adaptations, environmental adaptations, subsistence strategies and cultural trajectories of prehistoric human populations worldwide. These distinctive small thin stone tools, generally measuring less than 5 cm in their longest dimension, represent a significant innovation in lithic technology, particularly prevalent in the late Pleistocene and early Holocene periods (e.g. Clark, 1997; Blinkhorn, 2018; Bousman & Brink, 2018; Hess 2022). Their widespread distribution and diverse forms have fuelled

extensive scholarly debate regarding their meaning, function and the underlying socio-economic drivers of their production.

A central debate in microlith studies revolves around the 'functional' interpretation of tools and raw materials and the characteristics of these tools. Early interpretations of Mesolithic culture often focused solely on microliths; however, a contrasting view emerged, emphasising the economic adaptations people made to the altered environment (e.g. Price 1987; Straus, 2017; Brown, 1997; Misra, 1973; Lal, 1963:147). In India, this led scholars like Sali (1990), Mohanty (2000) and Sinha (2009) to highlight the distinction between the broader 'Mesolithic Cultural Period and specific 'microlithic' Technology. As V Jayaswal (2009) aptly puts it, the whole 'microlithic' Technology may be identified as the diagnostic character of Mesolithic, but it is not synonymous with Mesolithic. However, Mesolithic culture and lithic artefacts, which are called microliths, are still debated and are debatable by several scholars. Several prehistoric investigations and a few excavations in north Karnataka, especially sites like Watgal (DuFrense et.al, 1998), Sanganakallu-Kuppagallu (Subbarao, 1948), Piklihal (Allchin, 1960) and Brahmagiri (Wheeler, 1947) are well-studied areas that offer compelling evidence of complex transition. These sites in Northern Karnataka reveal a remarkable continuity of microlithic industries from the Mesolithic phase through the Iron Age and, in some contexts, to the Early Historic period. The persistence underscores the thin stone tools adaptability and enduring utility, even as communities transitioned to a new way of life.

The microlithic industry within Neolithic sites in these areas primarily relied on Chert from its Mesolithic origins, only for quartz to gain prominence later in the Neolithic (e.g. DuFrense, 1998; Shipton et.al, 2012). Procuring these raw materials further illuminates the strategic decisions of prehistoric groups. However, some studies show that the quartz was intentionally selected as the preferred raw material and there were no technological or raw material usage changes over time (Cornelissen, 2003). Some scholars in India, such as Paddayya (1993), Devaraja et.al. (1995), assumed that Chert and other cryptocrystalline materials were sourced from the neighbouring formation where abundant raw materials were available, such as the Karnul formation to the Shorapur Doab. Further, Korisettar also observed that Quartz was readily available from local granite gneiss veins (e.g. Korisettar et.al.2002; Arjun, 2017). These studies clearly show the prehistoric people's movement of using raw materials to manufacture tools in a particular context and area.

Research has demonstrated that microlithic assemblages from the Deccan plateau and Central India are characterized by standardised morphological tool types such as bladelets, points, burins, arrows and geometric shapes that suggest a higher level of technological organisation (Misra, 2001). The special association of microlithic settlement with rock art shelters is a growing area of scholarly concern, especially in areas like these represented at Bhimbetka and in the Kurnool district, where evidence of cultural layering signifies long-term continuity in the human use of the various landscapes (e.g. Wakankar, 1975; Korisettar et.al., 2001). In southern Karnataka, mainly quartz and crystal quartz have been analysed for sites like Kibbanahalli and Jalahalli, where the same access to raw materials shaped the morphology of tools and the kind of reduction strategies used (Todd, 1947; Seshadri, 1955, 1956).

Microlithic open-air sites across peninsular India have been studied by various researchers, suggesting that hunter-gatherers adapted to a variety of ecological niches (Pappu, 2001; Murthy, 1979). The microlithic open-air sites are situated in raw materials zones and close to the water sources, which provide a wide range of landscapes suitable for lithic production and subsistence. The preference for raw materials like Milky Quartz, rock crystal and Chert, as shown at the current study location, is consistent with the general pattern of the Indian Mesolithic, where raw material availability had a significant impact on technological behaviour (Allchin, 1966; Clarkson et al., 2009 & 2018).

Various studies show that late Mesolithic communities were generally near river tributaries (Mishra, 2001). It seems that with the advancement of agriculture and hunting occupation, later in the Neolithic period, these groups might have shifted from the main areas of the hilltop settlements to the vicinity of river tributaries (Shipton *et al.* 2012: 156–173).

Since the early 20th century, a limited number of microlithic sites have been reported in the extensive area of southern Karnataka (Kumar, 2023). Robert Bruce Foote first documented the microliths from this region in 1895 (Foote, 1916), who was a geologist in the former Mysore state. Foote discovered many microlithic sites in southern Karnataka. Moving within the southern Karnataka context, the Jalahalli industry in Bengaluru (Currently Urban) near the study region provides an excellent example of a well-documented microlithic assemblage dating to the late Pleistocene (Todd, 1948; Seshadri, 1956). Todd's excavation at Jalahalli in Bengaluru (Todd, 1948) remains the only microlithic site excavated in the Bengaluru region. The systematic production of small blades characterises this Jalahalli industry, from distinctive cores such as quartz, jasper, crystal and agate. Often interpreted as a component of composite 'hunting tools' (Todd, 1948; Seshadri, 1956). M Seshadri's analysis demonstrates that Jalahalli-Kibbanahalli-Brahmagiri microliths represent the transitional phase with the 'hunting group nature' in south Karnataka (Seshadri 1955, 1956:37-43; Kumar, 2023).

Discovery of sites like the French Rocks in Pandavapura, Traveller Banglow in Hiriyyur, Kaldurga in Tarikere by Foote, Halokal in Shira, Race Course in Bengaluru, Minakshayya Estate by Kinciade Lee in 1986 (Seshadri, 1956), Hindustan (1948) and Kibbanahalli by Sampath Iyengar (Iyengar, 1924) in Southern Karnataka. Moreover, a systematic exploration conducted by Poonacha for his doctoral research led to the discovery of several microlithic sites in the Malnad region (Poonacha, 1990). All these sites have yielded extensive microlithic assemblages offering detailed insight into their technological organisation and presence in open-air locations.

All these sites are still debatable and yet somehow show through comparison and morphology of the artefacts. These sites consistently reveal substantial evidence of lithic assemblages dating from the late Pleistocene and early Holocene (Seshadri, 1956, p. 37-43). The industry's widespread distribution and relatively rapid adaptation across southern Karnataka have led to debates regarding whether it represents a rapid replacement of earlier technologies or a convergent adaptation to challenging environmental conditions during and after the last glacial maximum. Further, these sites are distributed in a significantly limited geomorphological context in South Karnataka. Specifically, microlithic sites have been discovered in two primary settings:

1. On an elevated landform with significant granite outcrops.
2. Foothills of a hilly region.

These sites (see **Table 1**) are associated with rock shelters, indicating a broader range of prehistoric occupation. The microlithic assemblages from these sites in South Karnataka, especially in the Bengaluru region, are overwhelmingly geometric. They are primarily characterised by backed and truncated tools, including lunates, scrapers, petits, tranchets, burins and a blunted-back 'knife (Seshadri, 1956: 34) and retouched blades. Besides the microliths, a few scholars have also discovered rock art, especially in the Bengaluru regions, which have a relatively small number of documented sites. Past archaeological studies in this area have not heavily relied on earlier findings of prehistoric rock art, although several individual studies have highlighted significant sites. For instance, Vishvanath (1999) reported on rock art at Doddaballapura-Devanahalli, while Jayaramayya et al. (2000) examined Vedic Nagara. Manjappa (2009) documented rock art at Doddabati and Hanumanayaka (2009) investigated sites at Cheluvhalli, Gavi Matha, Bhairagondanahalli and Bendekere. Vemagal Murthy (2013) studied rock art at Perjenahalli and Mutturaju (1995) highlighted Sulekal Matha as a notable site. More recent works include those by Mohana and Rajesh at Madapatna (2017) and Shobha at Minyam (2017). While these studies are not systematic, they still provide valuable insights into the distribution and characteristics of rock art in South Karnataka, suggesting that further research in this region is necessary. To date, there is no further investigation or discovery of any rock art or Microlithic sites in the Arkavathi basin.

Study Area and Environmental Setting

The Arkavathi Basin, a non-perennial river, flows in the western Bangalore region. The surrounding region features undulating terrain, high to low hills and a younger granite peninsula series that stretches around 500 km from north to south. This region is also a lower stretch of the younger granite series. The semi-arid climate and non-perennial water sources would have supported seasonal foraging activities.

The present research area lies in the middle reaches of the Arkavathi River basin, i.e., Magadi Taluk (Ramanagara District, South Karnataka). This taluk lies on the borders of Bengaluru urban district in the northeast, Bengaluru urban in the east, Ramanagara in the south and Tumakuru in the west, respectively. Arkavathi is a non-perennial tributary of the river Kaveri, originating at Nandi Hills and flows towards the southern direction for about 190km and confluences with Kaveri at Muttatti (Sangama) near Kanakapura. The elevation of this rising ground at Magadi, one of the highest parts of the Mysore table-land in 950.36 m AMSL.

Current discovered archaeological sites of Microlithic assemblages are a prominent open-air site situated on the left bank of the Arkavathi. Geologically, the area is traversed by peninsular gneiss, closepet granite and iron ore deposits with dolerite dyke intrusions. The area is covered by tropical thorn forest, tropical dry scrub and deciduous forests, pasture and agricultural land, receiving an average rainfall of 850 mm. It occupies a strategic cultural position due to its geographic location, especially in the central and lower regions. Cultural continuity and interaction in this scenario reflect its importance in shaping South Karnataka's prehistoric and protohistoric development.

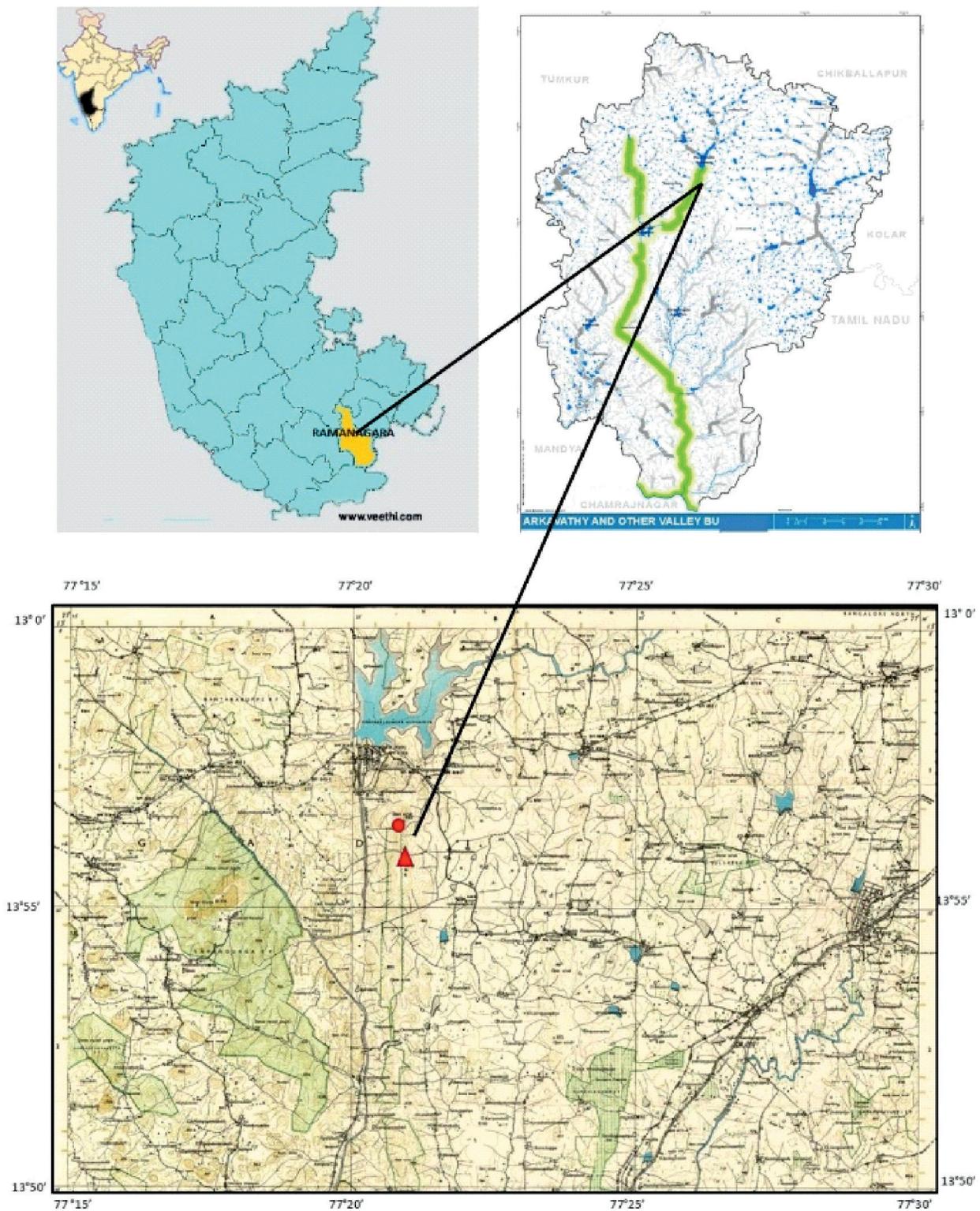


Fig. 1: Map of Arkavathi basin showing the location of the Madapatna-Yallappana Palya Mesolithic and Rock art site

The Stone Age and Neolithic period in the Arkavathi region are largely understudied. This article attempts to present and discuss the Mesolithic assemblages uncovered during my doctoral

research project, titled ‘*Protohistoric Investigations in the southern Karnataka with special reference to Arkavathi Basin, South Karnataka,*’ submitted to the Deccan College Post-Graduate and Research Institute in Pune (Kumar 2023). Until this research, there was limited knowledge about the Mesolithic period in this area, despite the discovery and excavation of several sites in nearby regions, such as Bengaluru and Kibbanahalli in Tumakuru, both of which are near the current research area.

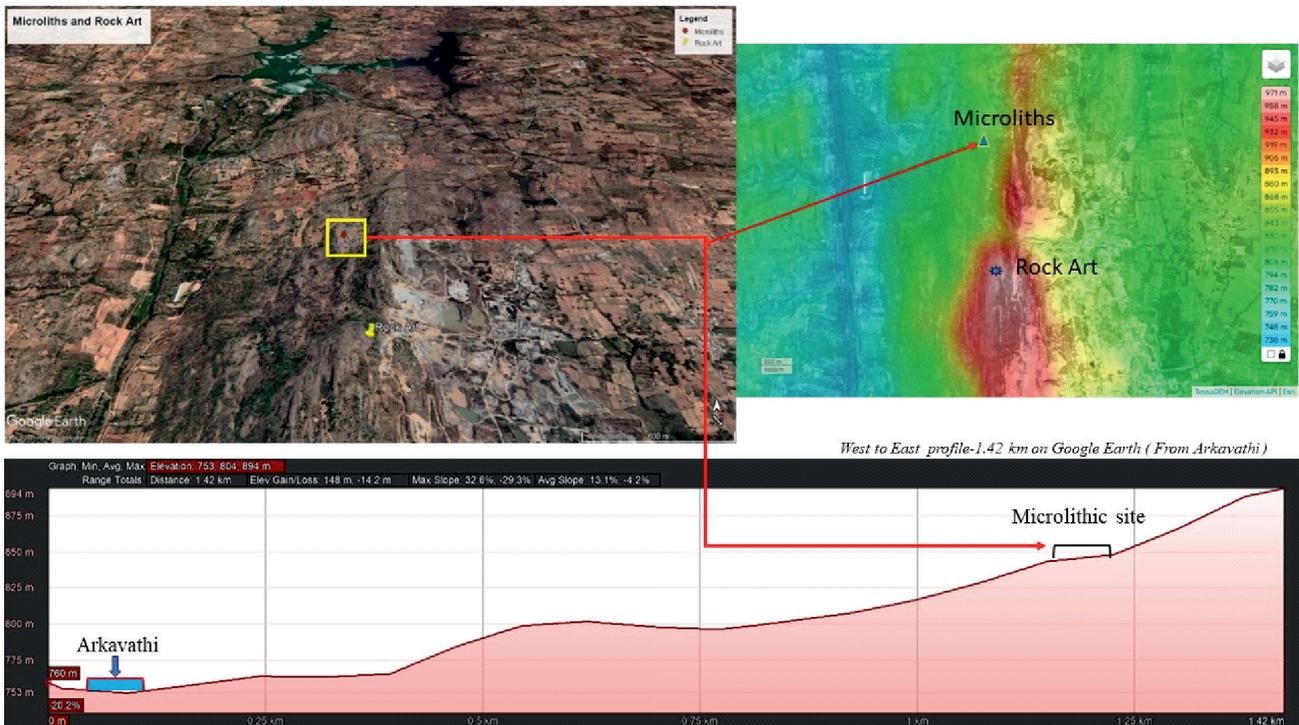


Fig. 2: Map showing microlithic and rock art locations on Google Earth, elevation on Ersi imagery map and the graph below shows the elevation information of the plotted location from Yallappana Palya-Madapatana (After Kumar 2023).

The current investigation has revealed Mesolithic evidence for the first time in the research area at Yallappana Palya on the left bank of the Arkavathi (Figs. 1 & 2). The lithic assemblages may be broadly considered as belonging to the late Mesolithic cultural phase, given the presence of bladed cores, points, scrapers, retouched blades and broken arrow tips in varying proportions—this site's flakes and debitage exhibit evidence of a small-scale tool manufacturing industry. Furthermore, there is a connection between this site and the nearby rock at the hilltop, where a few microliths were also found. The presence of handprints in rock shelters at *Bankarasana Gundu* on the Madapatna hilltop provides a clear picture that the prehistoric hunter-gatherer Mesolithic group once temporarily inhabited this area (Fig. 2).

Madapatna Hill Range: Yallappana Palya (12° 56.511' N 77° 20.694' E)

The site is 12 km east of Magadi town on the left bank of the river Arkavathi. The village of Yallappana Palya is 12 km East of Magadi on the Bengaluru-Magadi Road and the microlithic site is 1.5 km southeast of the Yallapana Palya village. It lies on the left bank of the river Arkavathi

about 1 km to the east on the foothill (**Figs. 1 & 2**). During exploration along the river basin, two localities yielded Mesolithic artefacts- a discovery for the first time in the Arkavathi Basin.

Locality-1: Raajanare

Locality-1 is a microlithic site situated approximately 1.25 km east of the river, on the bedrock at the foot of the hill, at an altitude of 927 AMSL. The microliths were found in a site extent measuring 110 meters (north-south) x 80 m (east-west) (**Fig. 3.a**), which is locally known as *Raajanare* (Place of King, presently the worshipping place of Iruliga tribes).

Associated Materials and Other Structures

A good number of artefacts have been collected during the exploration. The assemblages comprised of side flakes, a bladed core, a side scraper and a broken arrowhead. These microliths are scattered (**Fig. 3.b**) at the upland bedrock on the foothill near the Arkavathi seasonal river and indicate the small tools manufacturing industry at this site.

In the Microlithic manufacturing area, there is a stone rubble temple worshipped by Iruliga tribes, along with two dolmens also found in the vicinity (**Fig. 3.c**). About 150 meters to the south-west, at the foot of the microlithic bedrock, there are contemporary burials belonging to the Iruliga tribes. These burials resemble megalithic features, made using small rubble stones where the deceased was buried sitting (discussed the ‘Iruliga tribes’ burial practice separately).



Fig. 3: a) General view of Microlithic manufacturing industry; b) Microliths in situ; c) Worshipping structure of Iruliga in microlithic from Loc-1, Yallappana Palya (After Kumar 2023)

Locality-2: Bankarasanagundu (12° 55.931'N 77° 20.775' E)

This locality is located 1 km south of locality-1 at the top of the hill, locally known as *Bankarasana Gundu* (Boulder of *Bankarasa*). This shelter can be approached from Madapatna village, after a long walk through the granite crusher way, where quarrying activities occur. A rock shelter is

located at 985 AMSL on the top of the hill (Fig. 4.a). It is a small shelter facing north. This shelter was discovered by Mohana and Rajesh in 2016, with two types of rock paintings drawn in red pigment on an open shelter. Ten hand stencils and five horizontal lines were drawn; others faded due to weathering and were scratched by locals. Out of 10 hand stencils, at least five were left hands (Fig. 4. b and c).

Associated Materials and Structures

- A stone structure, like a fort or a wall, has been found near the shelter area. This would suggest the medieval structure of the wall.
- A few microlithic flakes and a bladed core are noticed near the shelter on the bedrock (Fig 4.d and 4.e).



Fig. 4: a) General view of the Rock art shelter; b) Handprints of rock art; c) Horizontal lines (Unidentified); d) Stonewall; e) Occurrence of the lithic assemblage from Madapatna Hilltop (After Kumar 2023).

Yallappana Palya- Madapatna Hill range

Yallappana Palya, locally known as “Rajanare” at the foothills, lies 12 km east of Magadi town. The microlithic site is located 1.5 km south-east of Yallappana Palya and 800 m east of Dhanyataha Ashrama. Yallappana Palya has an area of 90 x 60 m on the bedrock with a colluvial context (Fig.), near the forested landscape at the foothill. In 2016, a rock shelter was discovered by Mohana and Rajesh (2016) with hand prints at the top of the Madapatna Hill called “*Bankarasana Gundu*”. They reported handprints and parallel lines in red pigments. No cultural material was found in this area except for the rock art. However, this is one of the most important findings in the Arkavathi Basin to understand its prehistoric potential. The site has the highest collection of microliths from the Arkavathi Basin. The types included side scraper, pointed blade, two-sided blade, broken arrow

and retouched blade. The debitage category, on the other hand, is characterised by Bladed core, flakes and fluted core (See Table 2; Figs. 5 and 6).

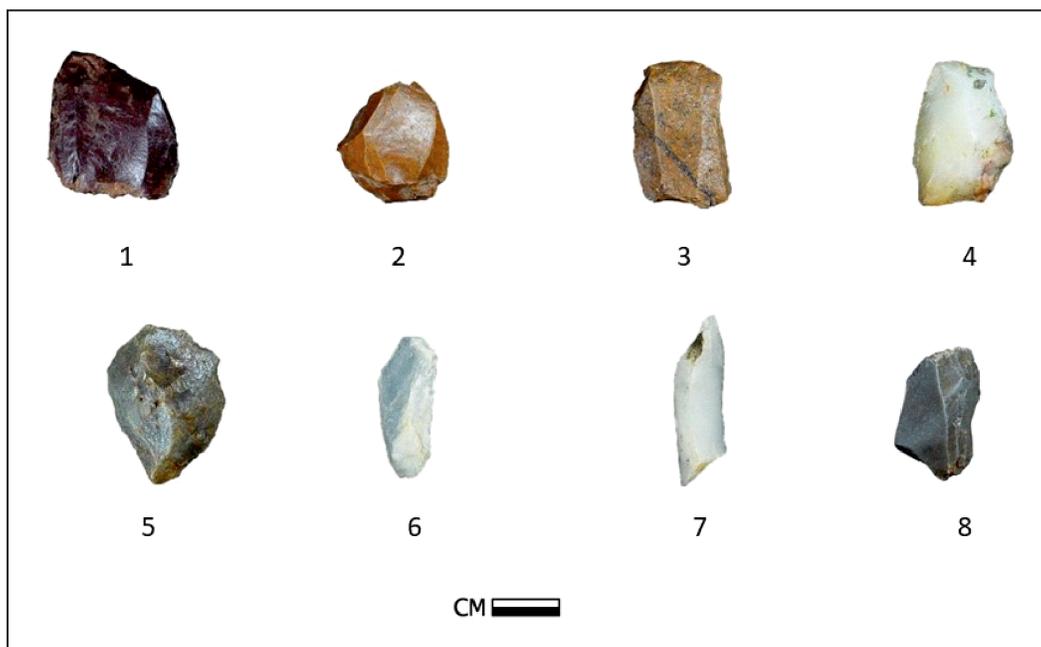


Fig. 5: Examples of the lithic assemblage recovered from Yallappana Palya, Locality-1: 1-3) Bladed Core, 4-5) Side scraper, 6) Retouched blade, 7) Pointed blade, 8) Two-sided blade. (After Kumar 2023).

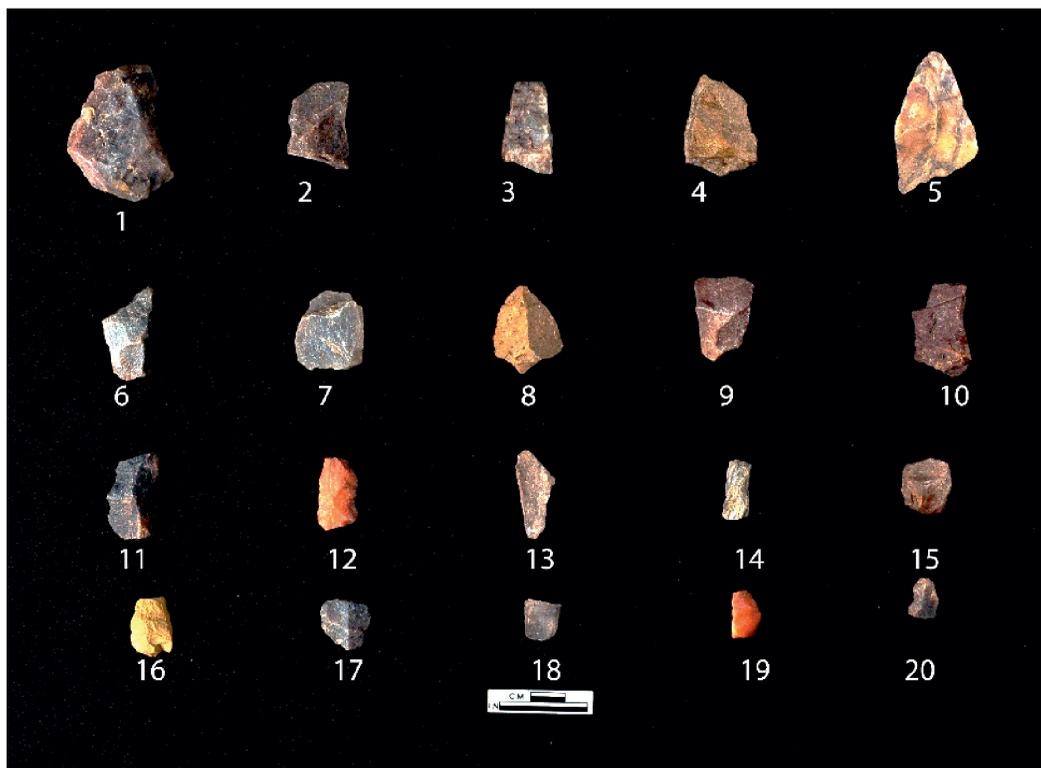


Fig. 6: Lithic assemblage recovered from Yallappana Palya, Locality-1: 1) Core, 2) Flake, 3-4) Bladed Core, 5) Core, 6) Point, 7) Flake Core, 8) Broken Arrow, 9) Blade, 10) Flake Core, 11-20) Flakes and Flint (After Kumar 2023).

Table 1: Previously reported microlithic sites in the Southern Karnataka region (After Kumar 2023)

<i>Investigator</i>	<i>Site name</i>	<i>Microliths</i>	<i>Materials</i>
Robert Bruce Foote	French Rocks (Pandavapura)	Core	Chert, Milky Quartz
	Traveller Bungalow (Hiriyur Taluk)	Flakes	Chert, Milky Quartz, Quartz
	Kaldurga hill (Tarikere Taluk)	Worked flake	Dark Chert
Sambasiva Iyer (Seshadri, 1956)	Halokal Hill (Shira)	Thick triangular flake and core	Chert and Lydian stone
Kinciade Lee In 1986	Race Course-Bengaluru	Flakes and Core	Chert, Milky Quartz
	Minakshayya Estate	Flakes and Core	Chert, Milky Quartz
D. H Gordan (1945).	H.A.L (Hindustan Aeronautical Limited), Bengaluru	Flake and core	Quartz
	Sarjapura	Flake and core	Quartz
Todd (1948)	Jalahalli	Arrow barbs, Points, blades, Lunates, Petites, tranchets, burins and scrapers	Milky quartz, Rock crystal.
Sampath Iyengar (1924)	Kibbanahalli	Core, Flakes, Side scraper, transverse, arrowheads, blades, lunates and trapeze.	Milky quartz, Rock crystal.

Table 2: The Lithic Assemblages of Yallappana Palya (After Kumar 2023)

<i>SL. No</i>	<i>Artefacts</i>	<i>Raw materials</i>	<i>Dimensions in mm</i>		<i>Description</i>
			<i>Length</i>	<i>Width</i>	
1	Bladed Core	Chert	21.0	19.5	Dark brown chert- slightly spherical shape, small-bladed core with five striking platforms (Conical)
2	Bladed Core	Chert	16.8	15.9	Plain brown chert has a slightly spherical shape, a small bladed core with a broad flake-out form on one side and the rest of the surface has four sticking platforms.
3	Bladed Core	Chert	21.1	13.5	Black-banded chert- Small bladed core with five striking platforms and a single-slanted black band.
4	Side-Scraper	Milky quartz	22.0	13.4	One-sided scraper on the abandoned bipolar core.
5	Side-Scraper	Quartz	23.3	15.0	Double-scraper
6	Retouched Blade	Quartz	21.0	8.0	Single side-blade
7	Pointed Blade	Milky quartz	26.0	7.2	Single-sided blade with a pointed tip and broken at one end.
8	Two sides-Blade	Quartz	19.8	11.2	Double-sided flaked blade with a blunted edge on one side.

Table 3: The Lithic Artefacts and Debitages of Yallappana Palya (After Kumar 2023)

SL. No	Artefacts	Raw materials	Dimensions in mm		Description
			Length	Width	
1	Core	Quartz	39.8	31.0	Single platform conical core with detached flakes platform.
2	Flake	Chert	24.2	20.0	Flake with a sided blade form
3	Bladed Core	Quartz	28.0	15.0	Single platform having a detached flakes platform.
4	Bladed Core	Chert	27.9	24.2	Single platform having a detached flakes platform.
5	Core	Quartz	41.0	25.5	A single platform with a pointed core and a detached flake platform is on one side.
6	Point	Quartz	27.7	17.8	Retouched point
7	Flake Core	Quartz	22.0	19.6	The fake core has a detached flake platform.
8	Broken Arrow	Chert	25.7	19.8	Triangular broken arrow.
9	Blade	Chert	24.4	16.8	Sharp-edged blade
10	Flake Core	Chert	27.0	15.5	Flake core has a detached flake platform.
11-20	Flakes and Flint	Quartz & Chert (n=15)	Max: 26.4 Min: 11.3	Max: 14.4 Min: 8.0	Flint debitage in various sizes of chert and quartz

Summary of Microliths

The microlithic assemblages of Yallappana Palya- Madapatna Hills range show predominantly the presence of lithic types such as Pointed blade, scraper, sided blade, points, broken arrow tip, retouched blade and debris like Core, bladed core, flake core, flakes and flints. The rare occurrence of a bladed core in these assemblages suggests that the pressure reduction process was used at these sites. The microliths of Arkavathi, for the first time, indicate a small tool industry, adding to the region's significance in pre- and protohistory.

There are a few microlithic sites reported in the Bengaluru region in Southern Karnataka and the only microlithic site excavated in the Bengaluru region was Jalahalli (Todd, 1948:27; Seshadri, 1956), which lies today in the urban city of Bengaluru. This site was excavated and microliths were collected from a stratified context. Stratified deposits generally provided a relative chronology, with the case of the Jalahalli microliths being an example of hunting-type tools that belong to the late Mesolithic (Todd, 1948:27; Seshadri, 1956).

At Yallappana Palya, in the Madapatna hill region, many lithic assemblages have been recovered from the bedrock, revealing that the Arkavathi Basin is well known for prehistoric study and rock art investigations. On these types and morphological bases, the microlithic industry Yallappana Palya is characterized by geometric and non-geometric microliths made on bladelet cores, including points, scrapers, two-sided blades, flakes, triangle arrowheads and retouched blades.

The colour variations observed range from dark brown to light brown for cherts, milky and creamy colours for quartz. The Cherts are used to produce microlithic artifacts despite being unavailable locally or in the site's surrounding area, while quartz is a local raw material. The

flakes and debris at this site exhibit evidence of the small-scale tool manufacturing industry. All the negative platforms indicate that some blades and bladelets were made using the pressure technique. In contrast, the bulb of percussion indicates the use of striking Technology on the spherical cores with irregular platforms for tool making.

There might be a connection between this site and the nearby rock at the top of the hill, where a few microliths were also found. The depiction of handprints and rock shelters provides clear evidence that a prehistoric hunter-gatherer Mesolithic group once temporarily inhabited this area.

It is interesting to note that Yallappana Palya revealed the artifacts on the bedrock and the chert-bladed core and fluted cores were found for the first time, which were not found in the Jalahalli excavation. It is possible that chert materials, which were used for tool production at the manufacturing site at Yallappana Palya, were not available locally. This suggests the prehistoric person who used these tools may have sourced chert from far-off sources.

While the immediate archaeological record does not reveal the presence of Neolithic remains at this location, the site's enduring significance is evidenced by a dolmen and a worship structure of the Iruliga tribals. This clear continuity of sacred use over time suggests a deep-rooted cultural connection to the landscape. Furthermore, the surrounding area, especially at the foot of the hill nearby, is still used by the Iruliga tribal communities for burial practices for their death diseases. It is important to note, however, that a direct cultural link between these microlithic assemblages and these later practices has not been established. Therefore, further interdisciplinary research is warranted to explore the potential for a deeper, perhaps worship, continuity of human engagement with this specific location.

Conclusion

The current research in the Arkavathi basin marks the first documented discovery of this region's Mesolithic Cultural phase. The presence of microliths strongly suggests a temporary occupation by a hunter-gatherer population during the late Pleistocene. This preliminary analysis aims to characterise the typology of these microliths, identify the raw materials used and examine their geomorphological contexts. The research will contribute to a broader understanding of regional variations and adaptations in Mesolithic technologies, particularly in the Bengaluru area.

Ultimately, this discovery in the Arkavathi basin provides a unique opportunity to expand our understanding of microlithic life ways and technological advancement, adding a significant new dataset to the Indian tapestry of Mesolithic research. Further, A systematic and scientific survey with a multidisciplinary approach in the Arkavathi basin will yield valuable insights into hunter-gatherer activities, seasonal grouping, the distribution patterns of microliths and the continuity of tool traditions in later periods within the research area.

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