A Study of Natural Site Formation Processes in the Kortallayar Basin, Tamil Nadu, South India

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This article presents the results of a study of natural processes influencing the formation of Palaeolithic sites, in a ferricrete landscape, in the Kortallayar basin, Tamil Nadu, South India. The principal points discussed here include the Quaternary geomorphology and Palaeolithic archaeology of the region and the methodology used for the study of site taphonomy. As a result of this research, Palaeolithic sites were categorized into several types based on their sedimentary context, artefact spatial distribution, and morphology and degree of integrity. This work is the first of its kind in establishing a methodology for the study of Palaeolithic sites in ferricrete landscapes in India. The results of this research may be relevant to understanding the study of formation processes at sites in similar contexts elsewhere in the Subcontinent. © 1999 John Wiley & Sons, Inc.

INTRODUCTION

In recent years there has been a conscious attempt to systematically study site formation processes at Indian Palaeolithic sites (Paddayya, 1979, 1987; Paddayya & Petraglia, 1993, 1995; Petraglia, 1995). The earliest attempt to study Palaeolithic localities in the Subcontinent can be attributed to the British geologist, Robert Bruce Foote (Pappu, 1991–92, 1996b). Following this discovery, prehistoric studies concentrated largely on documentation of sites, construction of cultural and climatic sequences, and classification of tools. Subsequently, largely as a result of the influence of the "New Archaeology," the importance of systematic site formation studies was realized. Although connotations of the term "site formation" as used by Indian archaeologists tend to follow guidelines laid down by Western scholars (Binford, 1982; Schiffer, 1983, 1987), conceptual and methodological approaches utilized vary greatly. Irrespective of whether the term "site formation" is used or not, such studies include those which involve (i) a concentration on site landscape contexts, in particular, the geomorphic history of individual sites or regions (Pappu, 1995; Pappu & Deo, 1994; Sankalia, 1974); (ii) a consideration of geomorphic processes leading to site formation and of artefact morphology which indicate natural processes (Ahasan, 1993; von Corvinus, 1983; Jacobsen, 1979, 1983; Jhaldiyal, 1998; Mishra, 1982, 1985, 1994; Misra, 1967; Misra & Rajaguru, 1989; Misra et al., 1990); and (iii) studies which attempt to unite both natural and cultural processes leading

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to the formation of sites across a geographical region (Allchin et al., 1978; Paddayya & Petraglia, 1993, 1995; Pappu, 1996b; Sharma & Clark, 1983).

This article falls within the second category of research, concentrating on a study of natural processes influencing the formation of Palaeolithic sites in a ferricrete landscape in Tamil Nadu, South India. Over large parts of Peninsular India and along the east coast, Lower and Middle Palaeolithic sites occur either on the surface or buried within ferricretes and red soils (Gardner, 1986, 1995; Gardner & Martingell, 1990; Thimma Reddy, 1994; Sankalia, 1974; Subrahmanyam & Sireesha, 1990; Zeuner & Allchin, 1956). To date, scholars have focussed on the geomorphic history, culture sequence, artefact technotypology, or settlement patterns of prehistoric sites in these regions. This work, however, recognizes that ferricrete landscapes present a unique preservation context. In such landscapes the initial process of ferricrete formation plays an important role in influencing the burial of artefacts and their morphology. In addition to this, the subsequent disintegration of the duricrust (Goudie, 1973; Tardy, 1993; Tardy & Roquin, 1993) conditions ways in which sites are exposed and the extent to which artefacts are displaced. This study also acknowledges the fact that assemblage structure in Palaeolithic sites is a result of both hominid behavioral strategies as well as a wide variety of natural processes. Thus it is essential initially to distinguish the latter processes influencing the formation of deposits, and spatial distribution and morphology of artefacts contained within them (Binford, 1982; Goldberg et al., 1993; Isaac, 1989; Nash & Petraglia, 1987; Schick, 1974; Schiffer, 1983, 1987; Stein, 1987; Stein & Farrand, 1985; Stein & Linse, 1993; Stern, 1993). While one of the main aims of this study was the identification of sites having a high degree of integrity and potential for behavioral information, it was recognized that studying localities in differing contexts is essential for modeling natural formation processes operating on a regional level. This work is part of a broader study of hominid adaptive strategies during the Middle and Late Pleistocene in this region. Prior to examining natural processes influencing site structure, a brief description of regional physiography, the Quaternary geomorphic evolution, and the Palaeolithic archaeological record are discussed.

THE REGION

The study region comprises an area of 200 sq km (79° 40′: 79° 56′ E and 13° 17′: 13° 10′ N), in the Kortallayar Basin, which forms a part of the Palar Basin, Chengai-Anna District, Tamil Nadu (Figure 1). It comprises the Satyavedu planation surface consisting of the north-northeast and south-southwest trending Allikulli hill ranges (200–380 m AMSL), surrounded by undulating lowlands. The Upper Gondwana formations consist of the Satyavedu formation (quartzites, quartzitic sandstones and granites in a ferruginous and silicious matrix) and the Sriperumbudur formation (sandstones and shales). These interfinger with the Avadi formation of argillaceous shales (Muralidharan et al., 1993). The area is drained by the Kortallayar river (a fourth-order stream) and a network of first-, second-, and third-order streams. The region falls in an area of wet tropical moderate bioclimate and uneven

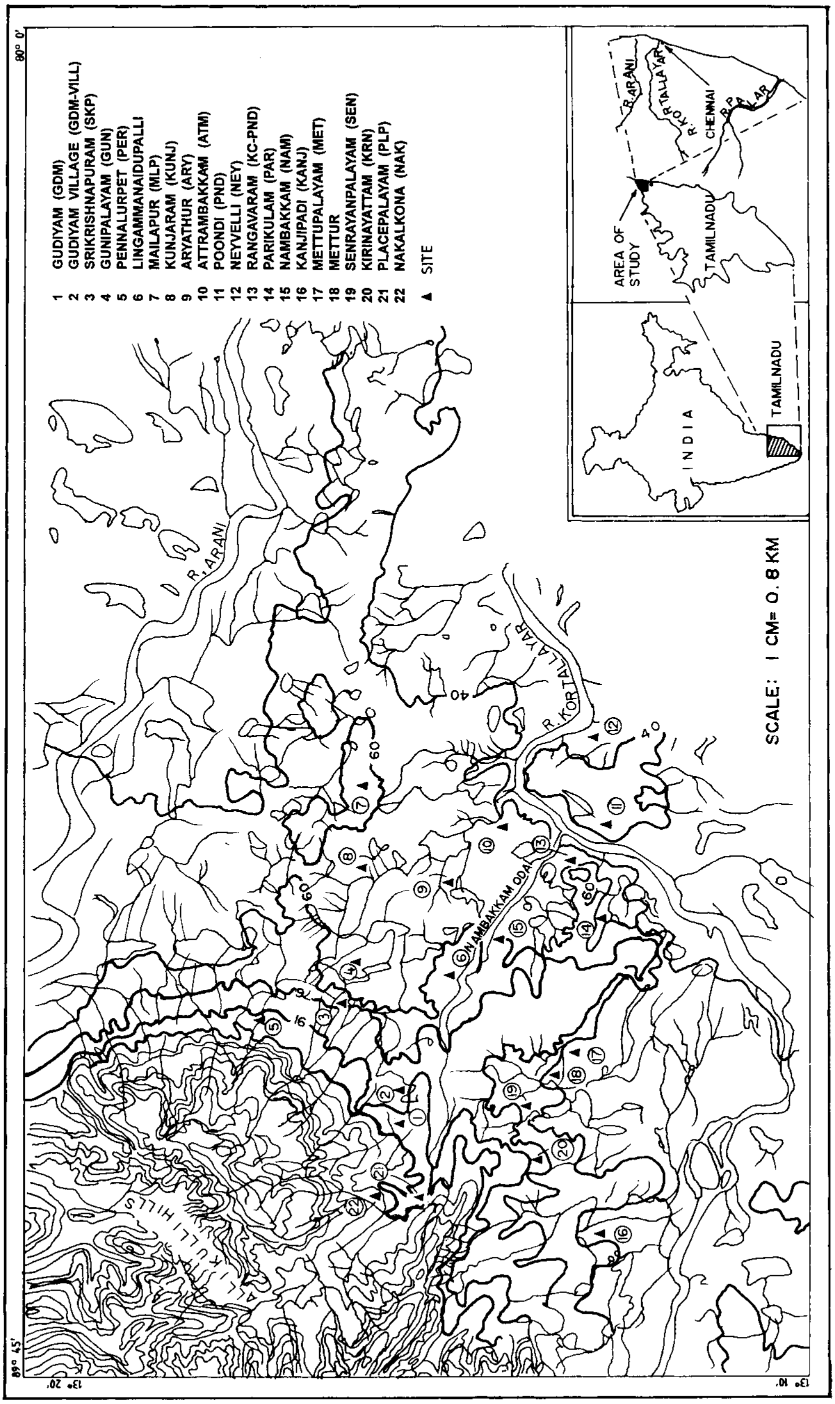


Figure 1. The Kortallayar Basin (contour and drainage) showing distribution of Palaeolithic sites.

rainfall regime with an annual range of 105–125 cm characterized by cyclonic rains from September to November and a mean temperature of 36°C. Vegetation consists of the *Albizzia amara* and *Acacia* series of semievergreen scrub, woodland, closed, and discontinuous thorny thickets and scattered shrubs (Gaussen et al., 1964).

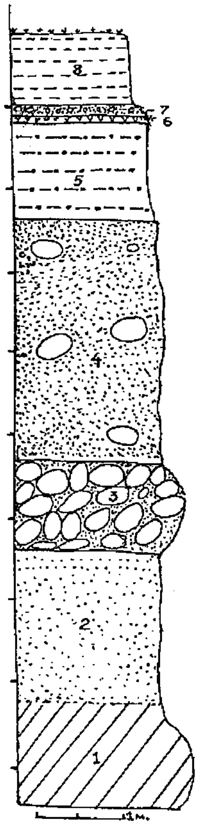
QUATERNARY GEOMORPHOLOGY

The Upper Gondwana formations are capped by Tertiary to Early Quaternary ferricretes as seen in the 4-m-thick ferricrete profile at the site of Erumaivettipalayam, 33.83 m AMSL (Achyutan & Pappu, 1997). Quaternary deposits in the Palar Basin consist of the Erumaivettipalayam surface (fluvial erosional, comprising lateritic gravel) and the Palar-Kortallayar Formation (comprising channel-bar, channel-fill, channel lag, flood basin, levee, pointbar, and terrace deposits), ranging in age from the Middle Pleistocene to the Holocene (Muralidharan et al., 1993:9). In this work the definition of ferricretes follows that of Tardy and Roquin (1993:519) which states that ferricretes are "..products of intense weathering made up of mineral assemblages that may include iron or aluminium oxides, oxyhydroxides, kaolinite and quartz and that are characterised by a ration of SiO_2: (Al_2O_3 + Fe_2O_3) that does not exceed the value required to characterise quartz and kaolinite."

Stratigraphy

The composite Quaternary stratigraphic sequence is presented in Figure 2. Quaternary ferricretes or ferricritized gravels containing, in general, Late Acheulian to Middle Palaeolithic artefacts, disconformably overlie the bedrock. Ferruginous gravels (30 cm to 4–10 m thick) vary greatly in age and in the factors responsible for their deposition and subsequent reworking. Fe_2O_3 values range from around 3.14% to 13–14% (Table I). A study of weathering rinds of quartzite, sandstone, and quartzitic sandstone clasts points to variable degrees of weathering which possibly have a chronological significance (Pappu, 1996b; Subramaniam & Mani, 1981).

Ferricretes cover most of the study area. Two phases of Quaternary ferricretes are noted. Older ferricretes contain Acheulian to Middle Palaeolithic tools. These are 1.5 to 2.5 m thick and comprise mainly coarse sands to silts with a few outsize clasts and pebble lenses (Figure 2). Chemical analyses of ferricretes (Table I) reveal that in general the Fe_2O_3 values are low (13.40–26.39%), reflective of immature ferricretes with weak mobilization of iron, lithodependency on parent material, and pointing to a predominant role of groundwater in a zone with a fluctuating water table (Subramaniam & Mani, 1981; Tardy & Roquin, 1993). Iron is derived from the ferruginous matrix of the Sriperumbudur and Satyavedu Formations and from Tertiary ferricretes. The principal zones represented include the cuirasse and the surficial dismantling horizon. Subsequent dismantling and transport of the duricrust is attributed to block gliding and thermal breakdown (Goudie, 1973; Tardy & Roquin, 1993). Ferricretes are capped by a ferricrete lag and sheet gravel containing Late Middle Palaeolithic artefacts and microliths. Localized deposits of clayey-silts



Period	Sedimentary Deposit	Associated Sites
Holocene	Palar-Kortallayar Surface (silts, sands and clays of the Kortallayar, including levees, pointbars, channel-lag deposits) gullies	sterile
	Ferricrete lag	microliths
Late Pleistocene	Sheet and stream flood deposits, (Ferricrete lag and sheet gravel)	Late Middle Palaeolithic
	Clayey-silts and calcrete lag (palaeopond)	sterile
Middle Pleistocene to Early Late Pleistocene	Ferricritised and ferruginous colluvial deposits, stream and sheet flood deposits channel-lag and channel fill deposits, terraces.	Acheulian-Middle Palaeolithic
----------------	Unconformity ----------------	Early Acheulian
Tertiary to Early Pleistocene Ferricretes		
Upper Gondwana Satyavedu, Sriperumbudur and Avadi Formations		

1. Bed Rock (Satyavedu, Sriperumbudur and Avadi Formations)
2. Tertiary to Early Pleistocene Ferricretes
3. Ferricritised Gravels (Acheulian to Middle Palaeolithic Tools)
4. Ferricretes (Acheulian to Middle Palaeolithic Tools)
5. Clayey-Silts Sterile
6. Calcrete Lag Sterile
7. Ferricrete lag and Sheet Gravel (Middle Palaeolithic Tools and Microliths)
8. Holocene Silts (Sterile)

Figure 2. Composite Quaternary stratigraphic sequence.

Table I. Results of chemical analysis of sediments.

Site	Depth (cm)	Fe (%)	Al_2O_3 (%)	SiO_2 (%)	Total Fe (%)	Fe^{2+} (%)	Fe^{3+} (%)
Ferruginous gravels							
Kanjipadi	30	14.14	8.13	80.48	9.88	0.07	9.81
Nambakkam	20	14.76	18.40	42.01	10.32	0.19	10.13
Poondi	30	11.31	13.02	48.36	7.9	0.25	7.66
Ferricritized sediments							
Attrambakkam	35	8.17	9.44	66.01	5.71	0.09	5.62
	85	38.33	22.46	49.42	26.79	0.23	26.56
Parikulam	20	3.14	5.26	79.77	2.19	0.15	2.04
	25	7.54	9.92	64.95	5.27	0.13	5.14
	50	10.68	13.38	77.66	7.47	0.18	7.29
	85	21.99	20.07	61.42	15.37	0.25	15.12
Mailapur	50	21.99	20.43	48.71	15.37	0.19	15.18
Gunipalayam	15	12.25	17.45	58.95	8.56	0.16	8.4
	25	8.79	15.05	63.89	6.14	0.12	6.02
	50	25.76	17.45	59.65	18.0	0.17	17.83
Aryathur	10	31.73	24.49	43.42	22.18	0.09	22.09

and calcrete lag (extending over an area of 4 sq km as indicated by satellite image studies) are noted as well.

Geomorphic Processes

Within the study area, weathering of the bedrock clasts, winnowing of their siliceous and ferruginous matrix, and erosion of Tertiary ferricretes were the principal processes contributing source material in the form of gravels, silts, sands, and clays that constitute the Pleistocene deposits in the region. Subsequent transport and deposition by colluvial processes, sheet, and stream floods, and stream channel processes (Pappu, 1996a, 1996b), followed by weathering of the profiles and ferricritization, have resulted in the formation of the Pleistocene landscape (Figure 3). These processes are discussed next.

Colluvial Processes

Colluvial deposits (1.5 to 4–10 m thick), are noted in the foothill zone of the Allikulli hills and their outliers with the source material derived from a reworking of Upper Gondwana debris flows and from Tertiary ferricretes. Contact with underlying beds are sharp, and they can be traced upslope. Colluvial deposits are characterized by poor sorting, occurrence of clasts, and a clayey matrix. Colluvial deposits extending along the hill slopes are in general ferruginous and represent active hillslope processes. Ferricritized gravels extend from the outliers of the Allikulli hills to Nambakkam at elevations ranging from 50 to 100 m AMSL. They appear to have been considerably reworked as a result of sheet floods. Such mantled

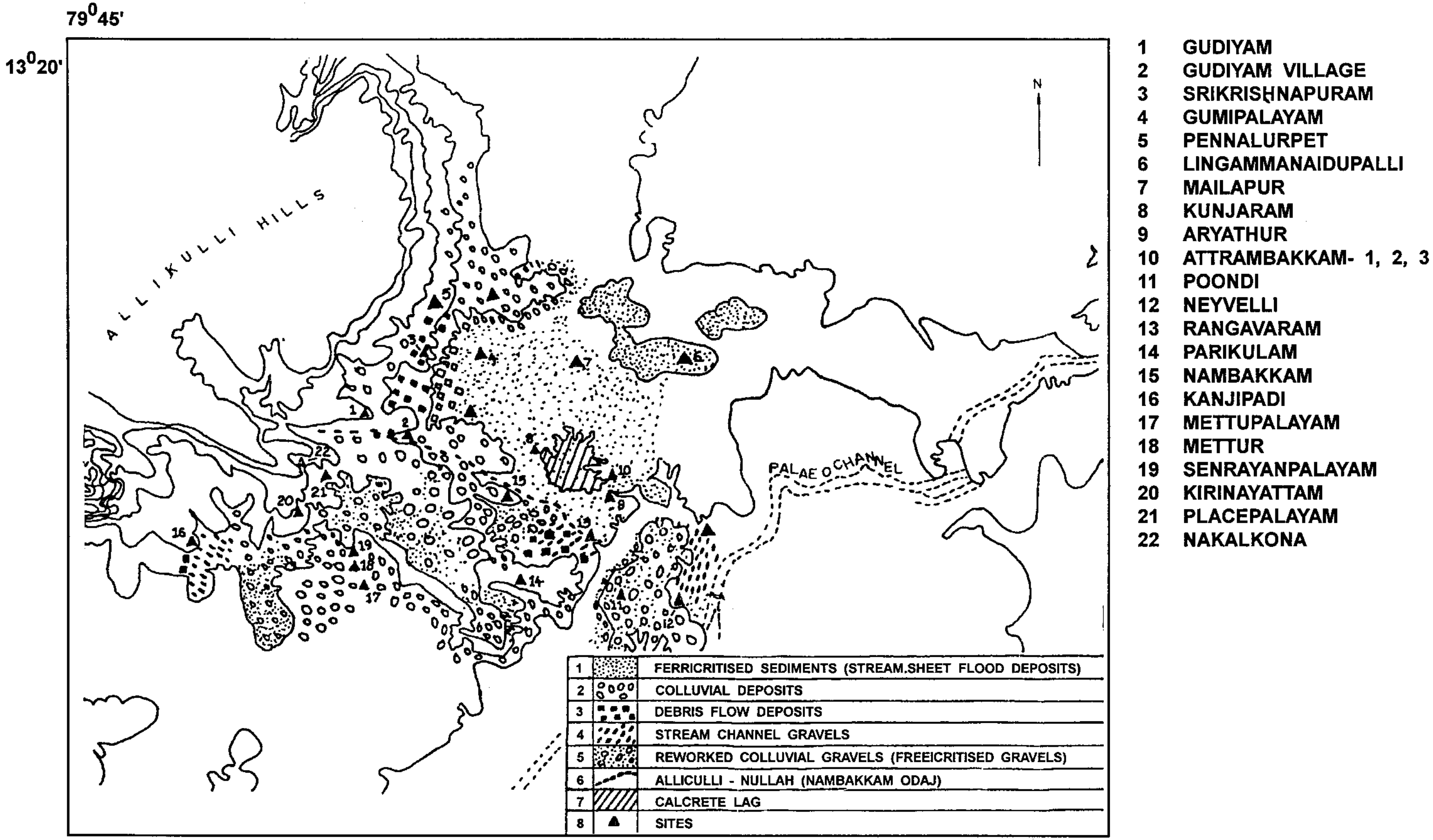


Figure 3. Site sedimentary contexts (the palaeochannel refers to the course of the Old Palar River).

pediments formed by localized transport of hillslope colluvium across an eroded bedrock surface under semiarid conditions are associated with Acheulian and Middle Palaeolithic tools in different parts of the Subcontinent (Mishra, 1985).

Reworked Colluvial Deposits (Stream Channel Gravels)

Satellite image studies (Ramasamy et al., 1992) corroborated by fieldwork, indicate that the Palar River (Figure 1) originally flowed along the present course of the Kortallayar before migrating south. Stream-laid deposits, in particular channel gravels, were deposited both by the Old Palar (Figure 3) and by a network of braided channels. Source material is derived from the reworking of older debris flow and colluvial deposits. In particular, the region lying adjacent to the hill ranges represents an alluvial fan type of deposition. (Muralidharan et al., 1993:3; S.N. Rajaguru, personal communication, 1993). Cut-and-fill features are noted at Poondi (site 11 in Figures 1 and 3) and Neyvelli (site 12 in Figures 1 and 3). Smaller cut and fill features point to the existence of braided tributaries of the main river.

Sheet and Stream Flood Deposits

Part of the study region comprises the flood plains of the Old Palar and Arani Rivers, subject to stream and sheet floods. The migration of the Old Palar (Figure 3) migrating progressively away from the present Kortallayar River as a result of tectonics and changing base levels (Ramasamy et al., 1992) led to infilling of braided channels. Fill consists of moderately sorted sediments of silts, sands, and clays with occasional outsize clasts (Bull, 1991).

Clayey-Silts and Calcrete Lag

A 50-cm-thick deposit of clayey silts is noted overlying ferricretes and covering an area of 4 sq km (Figure 3). These are capped by ferricrete lag and sheet gravel containing Late Middle Palaeolithic to microlithic tools.

Holocene deposits comprise a 1.2-m-thick deposit of alluvium of the Kortallayar and Arani Rivers, and are archaeologically sterile. Gullies dissecting these deposits can be dated to the early Holocene humid phase (Rajaguru et al., 1993:463).

METHODOLOGY

Over a period ranging from 1991 to 1996, the author's research in this region comprised field investigations, laboratory studies of soils/sediments and of stone tools, and studies of satellite images of the region. Methodological issues involved are discussed later.

Archaeological Survey

A multistage survey and sampling methodology was used, whereby an area of 200 sq km was surveyed. A regional approach was adopted, where the distribution of artefacts across the sampled areas in differing zones (defined by elevation and sedimentary context) was documented. This resulted in the plotting of sites as well as of isolated scatters of artefacts across the landscape (Dunnell & Dancey, 1983; Ebert, 1986; Foley, 1981). A total of 22 sites with a sample of 2012 stone tools, belonging to the Lower and Middle Palaeolithic and the Mesolithic were studied. Distribution maps of sites (at a regional level) and of artefacts (at the level of the site) were prepared.

Taphonomy and Site Formation

The methodology for studying natural site formation processes initially involved investigation of regional geomorphic processes. The depositional history and microtopography of each site was considered next in order to identify processes of deposition of each sedimentary unit and to correlate this with processes operating at the level of the region. Satellite images were studied in order to identify geomorphic features and to determine current land-use patterns, which were corroborated by field observations. Processes taken into consideration in this work included: (a) geomorphic processes (discussed here in detail), including fluvial, gravitational, aeolian, and soil forming processes and neotectonics; (b) biogenic processes such as faunal and floral turbation (Wood & Johnson, 1976); and (c) current and historical land-use patterns—including water management, cultivation, deforestation and afforestation, animal grazing, and construction. Variables considered were as follows:

1. Site Sedimentary Context: Textural and chemical analyses of sediments was carried out. A study of the mode, intensity, and duration of processes influencing deposition and erosion was also carried out (Isaac, 1989; Paddayya & Petraglia, 1993; Rapp & Gifford, 1985; Schackley, 1978; Schick, 1974; Stein & Farrand, 1985). Soil types and processes of deposition which effect the rate of burial of artefacts were also considered (Petraglia & Potts, 1994:230).
2. Artefact Spatial Distribution: The horizontal and vertical distribution of tools was plotted. Other factors considered involved the clustering of tools of different sizes and size-sorting of tools and natural clasts.
3. Artefact Morphology: Artefacts were treated as sedimentary particles (Schackley, 1978). This included considerations of artefact rounding, abrasion, size, and patination (parameters as per Pettijohn [1975]). These are considered to be an indicator of the intensity and nature of fluvial, or aeolian action (Nash & Petraglia, 1987; Petraglia & Potts, 1994:230; Schackley, 1978). Artefacts and natural clasts were divided by raw material (quartzites, quartzitic sandstones, quartz) with subdivisions of the quartzites based on texture and Munsell Colour.

Scholars have adopted similar criteria to classify sites into different types based on their degree of integrity (Bar-Yosef, 1993; Kaufulu, 1983; Petraglia & Potts, 1994). Drawing on these studies and taking into consideration the geomorphic context of sites within the study region, a model of site contexts along with their potential recognition criteria and degrees of integrity was established (Table II).

Table II. A model of possible site types and criteria for recognition.

Site Type	Sedimentary Context	Artefact Morphology	Integrity
Type 1a: Sites are buried in low energy ferricritized sediments; artefacts are exposed only recently owing to quarrying and construction	Low energy episodic fluvial processes; fine grained sediments; possible weathering indicative of subsequent landscape stability	Tools have unabraded to lightly abraded flake facets; minimal to no size sorting or clustering; little to no patination (depending on the rapidity of burial, soil types, raw material); some chemical weathering; all types of tools are present from chips and microdebitage to cores and heavy-duty tools	High
Type 1b: Sites buried in high energy colluvial and fluvial deposits and exposed recently owing to erosion, quarrying, and construction	In high energy colluvial and debris flow deposits, channel cut and fill gravels, point-bar deposits, and channel gravels; coarse-grained sediments	Distinct size sorting is noted with winnowing of smaller tools and with a concentration of heavy-duty and larger tools; spatial clustering of artefacts is noted; variability in artefact abrasion and patination; possible long-axis orientation of tools	Low
Type 2a: Sites occur on the surface of ferricretes or clayey-silts and are exposed by erosion, deflation, and sheetwash	Low to medium energy episodic fluvial processes; e.g., sheet and stream floods; fine- to medium-grained sediments; occasional outsize clasts; subject to rain rilling, gully erosion	Tools are largely unabraded and unpatinated; minimum spatial clustering; size sorting minimal but present; all tool types noted but possibly fewer smaller tools and some transported tools	High
Type 2b: Surface sites occurring on the bedrock, on colluvial gravels or in lag contexts and may represent both lag and winnowed components of sites	Located on the surface of bedrock, on ferricritized gravels, on older sediments; subject to gully erosion and sheet floods	Tools are largely abraded and patinated; spatial clustering noted; size sorting present with a concentration of larger tools; all types of tools are noted with fewer smaller tools and chips; more cores and bifaces; some transported tools are also present	Moderate
Type 2c: Transported surface sites	In point-bar deposits, or fluvial gravels	Distinct size sorting, spatial clustering, rounding and abrasion; tools are oriented in direction of water flow	None
Type 3: Findspots	One or two tools on the surface	Unclear owing to the small sample size	Unclear

RESULTS

Taking into consideration site-sedimentary context and artefact morphology and distribution, Palaeolithic sites have been classified into several types. Sites fall into a continuum from areas of hominid activity preserved in varying degrees of integrity, to areas where little or no information on behavior can be obtained. These are as follows (Table III).

Type 1a

These consist of sites of high integrity, which were buried and exposed only recently, due to quarrying, construction and section scrapings (Mailapur, Parikulam, Gunipalayam, Attrambakkam, Aryathur, Kunjaram, and Poondi-Town). These contain Acheulian to Early Middle Palaeolithic tools and are in ferricritized low energy stream and sheet flood deposits (Figure 4). Sediments are matrix-supported and well-sorted (although a few outsize clasts may occur randomly). Locally variable depositional contexts, for example, pebble-lenses may occur, as at Attrambakkam. Subsequent to the deposition of sediments, weathering and ferricrete formation occurred pointing to relative stability of the landscape. It is difficult to estimate the total number of such sites as most remain buried. The sites of Mailapur and Parikulam, exposed owing to quarrying and section scrapings, were studied in detail and may be considered representative of other sites in this category.

Spatial Distribution of Artefacts

At these sites, rain rills of less than 6 cm in depth have caused some artefact displacement. No orientation of artefacts is noted, and some are horizontally placed in the sediments. The vertical distribution of artefacts within the section was plotted. At Parikulam, two unpatinated and unabraded artefacts were noted at depths of 62 cm and 47 cm below the surface; and at Mailapur a microlithic blade core was noted 34 cm below the surface. This could possibly point to vertical movement of artefacts within the ferricrete. Duricrust dismantling, action of roots, and animal burrowing are possible factors responsible for this movement (Villa, 1983). Duricrust formation has led to virtual immobilization of artefacts. However, subsequent localized block weathering of the duricrust, possibly during the Holocene, has led to artefacts being transported as a block, within the confines of the site and released after disintegration of the duricrust.

Artefact Morphology

Taking into consideration the presence of tools of all size ranges, the abundance of chips less than 2 cm, the absence of size sorting between tools, and between tools and natural clasts, any major fluvial reworking of the site is excluded (Pappu, 1996b). Analysis of the abrasion of artefacts at both sites reveals four main trends, viz.: intensely abraded; less abraded with worn flake facets and fresh edges, uniformly abraded flake facets and edges; and totally unabraded artefacts (Figure 5).

Table III. Site contexts, modes of deposition, and depositional energy.

Site Name	Stratigraphic Unit	Mode of Deposition	Depositional Energy	Site Type
Attrambakkam	(a) Ferricrete (Acheulian to Early Middle Palaeolithic)	Stream and sheet flood	Low–medium	Type 1a
	(b) Ferricrete lag (late Middle Palaeolithic)	Stream and sheet flood	Low–medium	Type 2a
	(c) Gravel beds	Point Bar deposits	Low	Type 3
Aryathur	(a) Ferricrete (Acheulian to Early Middle Palaeolithic)	Stream and sheet flood	Low–medium	Type 1a
	(b) Ferricrete lag (late Middle Palaeolithic)	Stream and sheet floow	Low–medium	Type 2a
Gunipalayam	(a) Ferricrete (Acheulian to Early Middle Palaeolithic)	Stream and sheet flood	Low–medium	Type 1a
	(b) Ferricrete lag (late Middle Palaeolithic)	Stream and sheet flood	Low–medium	Type 2a
Mailapur	(a) Ferricrete (Acheulian to Early Middle Palaeolithic)	Stream and sheet flood	Low–medium	Type 1a
	(b) Ferricrete lag (late Middle Palaeolithic)	Stream and sheet flood	Low–medium	Type 2a
Kunjarum	(a) Ferricrete (Acheulian to Early Middle Palaeolithic)	Stream and sheet flood	Low–medium	Type a1
	(b) Ferricrete lag (late Middle Palaeolithic)	Stream and sheet flood	Low–medium	Type 2a
Parikulam	(a) Ferricrete (Acheulian to Early Middle Palaeolithic)	Stream and sheet flood	Low–medium	Type 1a
	(b) Ferricrete lag (late Middle Palaeolithic)	Stream and sheet flood	Low–medium	Type 2a
Nambakkam	Ferricritized gravels and surface (Middle Palaeolithic)	Reworked deposits, eroding bedrock	Low–medium	Type 2b
Mettur-Mettupalayam	Ferricritized gravels and surface (Middle Palaeolithic)	Reworked deposits, eroding bedrock	Low–medium	Type 2b
Senrayanpalayam	Ferricritized gravels and surface (Middle Palaeolithic)	Reworked deposits, eroding bedrock	Low–medium	Type 2b
Placepalayam	Eroded bedrock	Hillslope processes	Low–medium	Type 2b
Neyvelli	(a) Ferricritized gravels (Late Acheulian to Middle Palaeolithic)	Channel gravels	High	Type 2c
	(b) Surface: ferricrete lag	Sheet/stream flood	Low–medium	Type 2b
Poondi-Krishna Canal section	Ferricritized gravels	Cut and fill deposits	High	Type 2c
Poondi-Quarry	Ferricritized gravels	Cut and fill deposits	High	Type 2b
Srikrishnapuram	(a) Ferricritized gravels	Colluvial deposits	High	Type 2b
	(b) Surface	Sheet floods	Medium	Type 2b
Findspots	Surface, unclear context	Unclear	Unclear	Type 3

In addition to these, Gudiyam and Peripalayam are rock shelters with rockfall constituting the artefact bearing deposits. These were not considered in this scheme as no suitable sample of tools could be collected.

Figure 4. Section at Parikulam showing artefacts in ferricretes.

Raw material was noted to play a significant role here. Quartzite artefacts are either unabraded or less abraded with rounded flake facets and unabraded edges, while those on quartzitic sandstone are in general uniformly abraded. The presence of differentially eroded flake facets on the dorsal and ventral faces of the same artefact (Figure 6) and the existence of abraded flake facets along with fresh edges is noted, possibly pointing to water flow over firm substrates, as also noted by Petraglia and Potts (1994). The process of iron encrusting appears to be a major factor contributing to weathering of artefacts, in particular those on quartzitic sandstones. Weathering rinds on artefacts of quartzitic sandstone varied from 1 to 2 mm whereas no weathering rinds were noted on quartzite artefacts. In general, the only broken artefacts are bifaces at the apex, possibly as a result of use, rather than post-depositional processes. Artefacts range from those which are deeply patinated to those which are completely unpatinated. In general, unpatinated artefacts are chronologically younger. However, local soil conditions and raw material influence the intensity of patination. Thus the patination of artefacts on quartzitic sandstones is more intense. Artefacts which were differentially patinated on the dorsal and ventral faces are also noted, possibly as a result of their position on the soil surface (Figure 5). Patinated artefacts are also noted to have generally abraded flake facets.

Type 1b

These are sites located in sediments deposited by high energy processes such as channel fill deposits, channel lag deposits, reworked channel gravels (Kanjipadi),

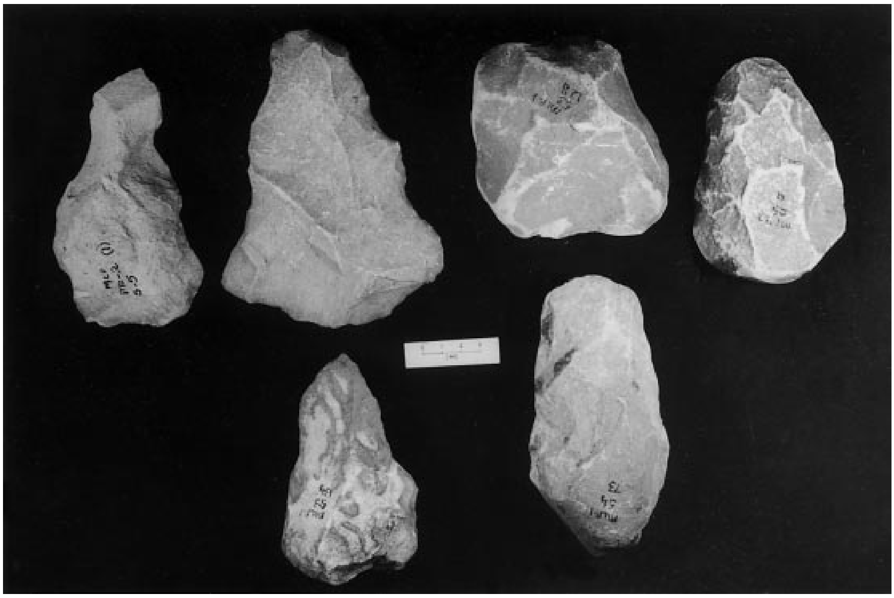


Figure 5. Artefact abrasion: showing tools (top row from left to right): unabraded; abraded flake facets and flesh edges, two uniformly abraded tools; and (bottom row, from left to right) distinct iron encrustations and a differentially patinated tool.

and colluvial gravels (Srikrishnapuram). These are clast-supported sites, where clasts have a distinct orientation and imbrication (Pappu, 1996b). Artefacts may be of all size ranges, but with a predominance of larger tools, low densities of tools (exception being Poondi-Quarry) and size-sorting with clasts. Most tools have a clear orientation (Pappu, 1996b). Minimum behavioral information is obtained from such sites.

Type 2a

These consist of surface sites. Artefacts are exposed from underlying sediments owing to deflation or sheet wash (Attrambakkam, Aryathur, Mailapur, Gunipalayam, Neyvelli, and Parikulam). Artefacts erode out of the ferricretes and in the case of Attrambakkam and Aryathur out of ferricrete lag and sheet gravel spreads as well. Sediments are fine- to medium-grained, low to medium energy episodic sheet wash deposits. In some cases, the contemporaneity between gravel and artefact spreads is also unclear. Short time periods elapsed between artefact discard and burial.

Spatial Distribution of Artefacts

Clustering of artefacts within sites is noted in almost all cases. At most of the sites, however, no distinct orientation or inclination of tools was noted (the excep-

Figure 6. Artefact; differentially abraded on the dorsal and ventral faces.

tion being Aryathur, where rain-rills predominate). In other cases, it is unclear as to how far this is a result of natural forces or discard patterns or a combination of both. A clearer idea of processes leading to spatial patterning is revealed in a study of artefact sizes.

Artefact Morphology

Variability in the size ranges of artefacts in the region is noted in Figure 7. It is seen that chips (less than 2 cm) are most common at Neyvelli and Aryathur and decrease progressively at Gunipalayam, Mailapur, and Attrambakkam. Taking into consideration possible size sorting of artefacts, a comparison of the size ranges of artefacts and natural clasts in the sediments was attempted. From this it was noted that at Aryathur, Gunipalayam, Neyvelli, Attrambakkam, and Mailapur no size sorting of artefacts and clasts occurs (Pappu, 1996b). Intrasite spatial clustering of artefacts based on size ranges was noted at some sites. The site of Attrambakkam has been subjected to gully and rill erosion, which has led to some displacement of artefacts. No particular clustering of tools as per size ranges was noted at any of the other sites.

Artefacts from surface sites are in general unpatinated. Figure 8 gives the percentages of artefacts patinated (mild, medium, intense) and unpatinated, as well as those with white patination on cortex and those with white patination on the entire flaked surface. At almost all sites, the maximum percentage of artefacts are

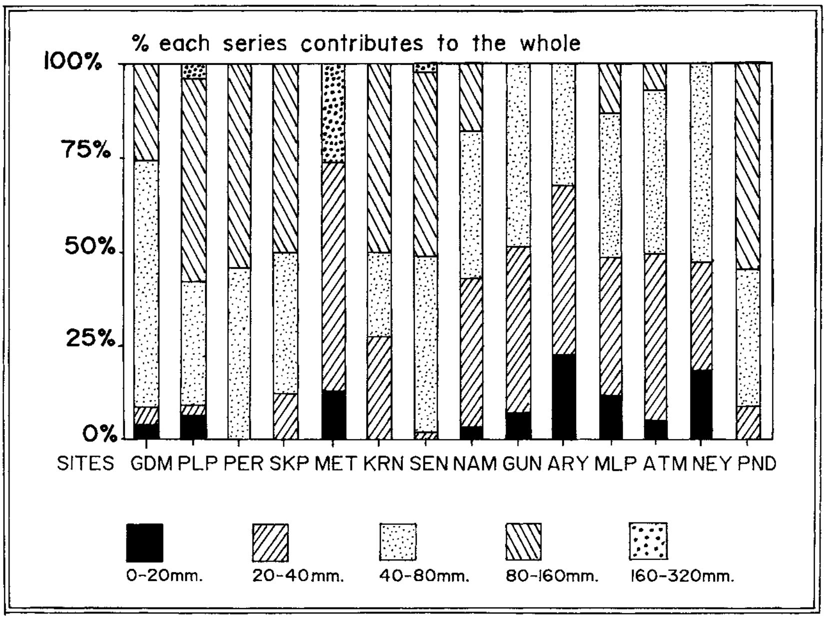


Figure 7. Artefact sizes: intersite variability.

unpatinated. Patination and staining of artefacts due to the presence of calcrete nodules is an important factor at Aryathur and Attrambakkam. Two categories of patination were noted, viz.: (i) artefacts with unpatinated flaked surfaces and patinated cortex, implying the utilization of an older stained raw material cobble/pebble/nodules and thus which might be chronologically younger than artefacts where the entire flaked surface is patinated; and (ii) artefacts where the entire cortex and flaked surfaces are patinated. Patination is clearly influenced by the nature of raw material with quartzitic sandstone artefacts being patinated and stained to a greater extent than those on quartzites. Patination and white staining are also related to the rapidity of burial, position of the artefact in the soil, and the nature of local soil conditions. At Gunipalayam, while the maximum percentage of artefacts were unpatinated, a clear correlation is noted between patination and raw material types. At this site it was noted that all artefacts on quartzitic sandstone in general have either abraded flake facets or fresh edges or are uniformly abraded. In contrast, all quartzite artefacts are very fresh. The remaining sites have largely unpatinated tools.

At most sites, the maximum percentage of artefacts are unabraded and very fresh (Figure 9). At Attrambakkam it was noted that artefacts on dark grey to black quartzites were subjected to pitting. However this phenomena is very localized and possibly due to acidic soil conditions (Pappu, 1996b).

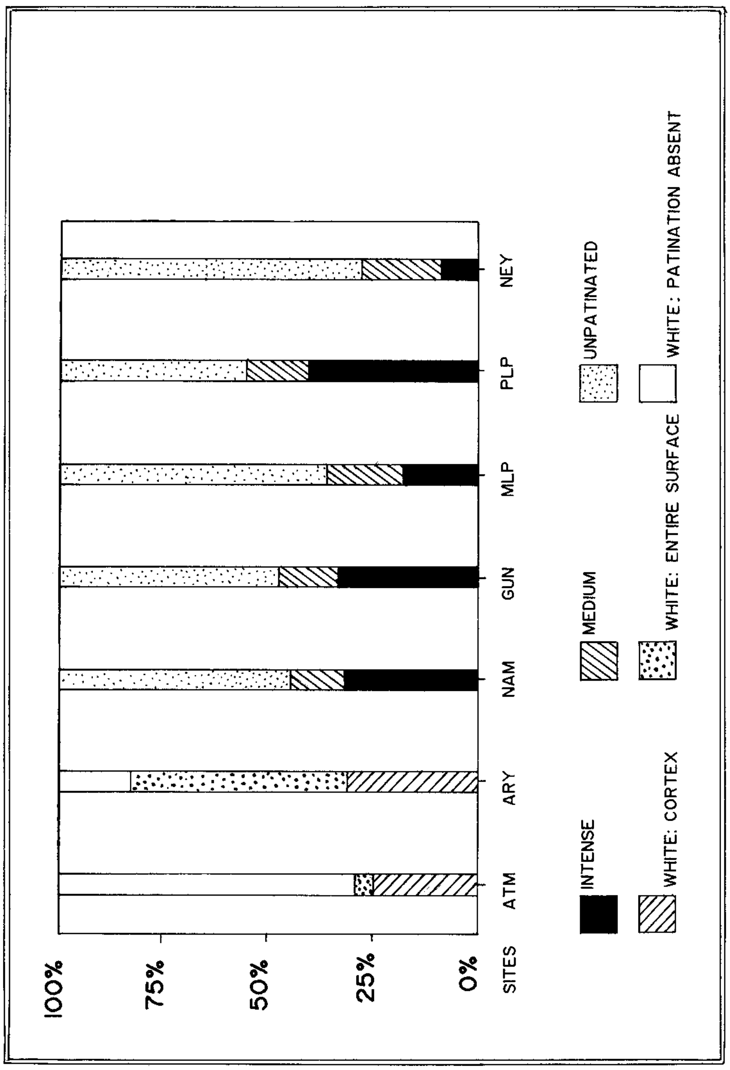


Figure 8. Artefact patination: intersite variability.

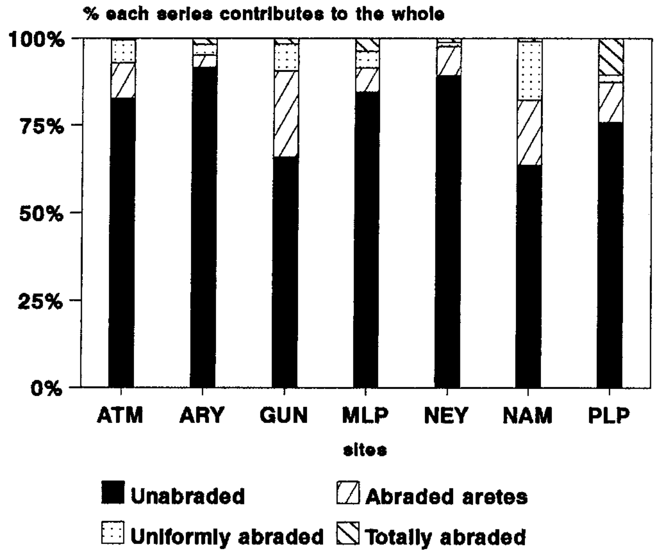


Figure 9. Artefact abrasion: intersite variability.

Type 2b

These consist of surface sites in colluvial ferricritized gravels and lag contexts (Nambakkam, Placepalayam, Mettur-Mettupalayam, Senrayanpalayam, and Kirinayattam). They occur in ferricritized gravels which are the result of reworking of weathered bedrock, on mantled pediments and, in the case of Placepalayam, on hillslopes. In general, they occur on the surface of coarse-grained gravel beds. As can be seen in Figure 7, chips are minimal and larger tools predominate at Placepalayam, Mettur-Mettupalayam, Senrayanpalayam, Nambakkam, Kirinayattam, and Poondi-Rangaveram. In lag contexts, such smaller artefacts and debitage are winnowed, leading to a concentration of larger and heavy duty tools. The transported component debitage is not noted. Some spatial clustering of tools is noted. Artefacts are in general fresh and unpatinated, but varying degrees of patination and abrasion are noted as a result of localized movement within the site. The presence of a conjoinable artefact from the site of Erumaivettipalayam points to the high integrity of some of these surface sites (Figure 10).

Type 2c

This consists of transported surface sites, for example, at Attrambakkam localities 1–2–3 in point-bar deposits. These point to downstream transport of tools and associated spatial patterning. These are isolated clusters of tools and gravels with mean areas of 50 sq m, parallel to water flow and with all artefacts and gravel oriented east–west.

Figure 10. Conjoinable artefact from Erumaivettipalayam.

Type 3

These include contexts where artefacts occur as findspots, and it is unclear as to whether their position is due to natural or cultural processes (Placepalayam, Nakakalkona, Kirinayattam, and Vellattukottai).

Common features noted at all sites are as follows:

1. The effect of block disintegration of the duricrust, leading to localized transport of artefacts in blocks, followed by their release on disintegration of the duricrust (Figure 11).
2. The process of iron encrusting on artefacts has increased the rate of weathering. This is noted specifically in the case of artefacts on quartzitic sandstone.
3. The effect of raw material weathering rates, this being maximum in the case

Figure 11. Duricrust with embedded tools.

of quartzitic sandstones and coarse-grained quartzites and minimum in fine- to medium-grained quartzites.

4. Observations over several years, point to the possibility that groundwater or stagnant water could lead to the formation of a yellowish-brown patina on artefacts.

In addition to natural processes, the region has been subjected to intensive agriculture in recent years (National Commission on Agriculture, 1976). The plough pulled by hand/animals penetrates to a depth of 15 cm and causes minimal disturbance to stone tools. All artefacts greater than 10 cm are used to line field boundaries and the rest largely remain within the boundaries of the field. In the absence of mechanized ploughing, it is felt that "plow zone" studies (Lewarch & O'Brien, 1981; Jhaldiyal, 1998) in understanding Lower and Middle Palaeolithic sites need to be reconsidered.

CONCLUSION

This study is the first of its kind in India in examining natural processes influencing Palaeolithic sites in a ferricrete landscape. This research may also be of use for archaeologists working in ferricrete landscapes in other parts of India. Ferricrete landscapes and regions covered by red soils are noted in various parts of the Subcontinent. These are of immense importance owing to the thickness of the deposits containing stratified Palaeolithic and Mesolithic assemblages. However, no study has been conducted on how geomorphic processes, characteristic of these landscapes, influence artefact morphology and spatial distribution.

This research resulted in the classification of sites into categories based on their sedimentary context and degree of integrity. Within the Kortallayar Basin, it was possible to isolate sites of high integrity (Type 1a containing tools in low-energy ferricritised sediments), which have a high potential for yielding information on the Lower and the Middle Palaeolithic. Surface sites of Type 2a, were less disturbed by fluvial processes, as was also indicated by the presence of a conjoinable tool. Sites fell within a continuum ranging from those of high integrity (Types 1a, 2a), reworked sites (Types 1b, 2b, 2c), and those in unclear contexts (Type 3). Site contexts discussed in this article are to be expected to occur in other ferricrete landscapes; and models constructed here may be of use in studying other sites. This work also shows how raw material, together with processes of ferricrete formation and subsequent duricrust disintegration, greatly influences artefact morphology. Thus caution should be exercized when artefact morphology is used to generalize on the age of the tools and on the distance over which they are thought to be transported. Further, the differential erosion of ferricretes over the Pleistocene leads to the exposure of sites of different cultural periods. Thus prehistorians should exercise care when considering the nature of the data available for the study of past settlement patterns. The regional approach adopted here, would help in a careful choice of sites suitable for excavation, thus conserving time and funds. It is hoped that this study may provide a starting point from which sites occurring in similar contexts in the Subcontinent can be examined, prior to theorizing on Palaeolithic adaptive strategies.

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REFERENCES

Achyutan, H. & Pappu, S. (1997). Observations on the geomorphology and archaeology of Erumaivettipalayam, Red Hills, Tamil Nadu. Man and Environment, XXII, 87–90.

Ahasan, S.M.K. (1993). A study of Palaeolithic site formation processes in a subhumid environment of Central India, with special reference to the Samnapur Palaeolithic Site (Madhya Pradesh), Ph.D. Dissertation, Pune: University of Poona.

Allchin, B., Goudie, G., & Hegde, K.T.M. (1978). The prehistory and palaeogeography of the Great Indian Desert, London: Academic Press.

Bar-Yosef, O. (1993). Site-formation processes from a Levantine viewpoint. In P. Goldberg, D.T. Nash,

& M.D. Petraglia (Eds.), Formation processes in archaeological context (pp. 11–32), Madison, Wisconsin: Prehistory Press.
Binford, L.R. (1982). The archaeology of place. Journal of Anthropological Archaeology, 1, 5–31.
Bull, W.B. (1991). Geomorphic response to climatic change, Oxford: Oxford University Press.
Dunnell R.C., & Dancey, W.S. (1983). The siteless survey: A regional scale data collection strategy. In M.B. Schiffer (Ed.), Advances in archaeological method and theory (volume 6, pp. 267–287), New York: Academic Press.
Ebert, J.I. (1986). Distributional archaeology, Ph.D. Dissertation, Albuquerque: University of New Mexico.
Foley, R. (1981). Off-site archaeology and human adaptation in Eastern Africa: Analysis of regional artifact density in the Amboseli, Southern Kenya, Cambridge Monographs in Africa Archaeology 3, Oxford: BAR International Series.
Gardner, R.A.M. (1986). Quaternary coastal sediments and stratigraphy, Southeast India. Man and Environment, X, 51–72.
Gardner, R.A.M. (1995). Red dunes and Quaternary paleoenvironment in India and Sri Lanka. In S. Wadia, R. Korisettar, & V.S. Kale (Eds.), Quaternary environments and geoarchaeology of India (pp. 391–404), Bangalore: Geological Society of India.
Gardner, R.A.M., & Martingell, H. (1990). Microlithic sites and their palaeoenvironmental setting, Southeast India: A re-evaluation. Geoarchaeology; 5, 1–13.
Gaussen, H., Legris, P., & Viart, M. (1964). International map of the vegetation and environmental conditions at 1/1,000,000. Notes on the Sheet Madras, New Delhi: International Council of Agricultural Research.
Goldberg, P., Nash, D.T., & Petraglia, M.D. (1993). Formation processes in archaeological context, Madison: Prehistory Press.
Goudie, A.S. (1973). Duricrusts in tropical and sub-tropical landscapes, Oxford Clarendon Press.
Isaac, B. (Ed.) (1989). The archaeology of human origins. Papers by Glynn Isaac. Cambridge: Cambridge University Press.
Jacobsen, J. (1979). Recent developments in south Asian prehistory and protohistory. Annual Review of Anthropology, 8, 467–502.
Jacobsen, J. (1983). Acheulian surface sites in Central India. In V.N. Misra and P. Bellwood (Eds.), Recent advances in Indo-Pacific prehistory (pp. 49–57), New Delhi: Oxford: IBH.
Jhaldiyal, R. (1998). Formation processes of the prehistoric sites in the Hunsgi and Baichbal Basins, Gulbarga District, Karnataka, Ph.D. Dissertation, Pune: University of Poona.
Kaufulu, Z.M. (1983). The geological context of some early archaeological sites in Kenya, Malawi and Tanzania. Microstratigraphy, site formation and Interpretations, Ph.D. Dissertation, Berkeley: University of California.
Lewarch, D.E., & O'Brien, M.J. (1981). The expanding role of surface assemblages in archaeological research. In M.B. Schiffer (Ed.), Advances in archaeological method and theory (Volume 6, pp. 297–342), New York: Academic Press.
Mishra, S. (1982). On the effects of basalt weathering on the distribution of lower Palaeolithic sites in the Deccan. Bulletin of the Deccan College Post-Graduate and Research Institute, 41, 107–115.
Mishra, S. (1985). Early man and environments in Western Madhya Pradesh, Ph.D. Dissertation, Pune: University of Poona.
Mishra, S. (1994). The south Asian Lower Palaeolithic. Man and Environment, XIX (1–2), 57–72.
Misra, V.N. (1967). Pre and proto-history of the Berach Basin, South Rajasthan, Poona: Deccan College.
Misra, V.N., & Rajaguru, S.N. (1989). Palaeoenvironments and prehistory of the Thar Desert, Rajasthan, India. In K. Frifelt & R. Sorensen (Eds.), South Asian Archaeology 1985 (pp. 296–320), Occassional Papers No. 4. Copenhagen: Scandinavian Institute of Asian Studies.
Misra, V.N., Rajaguru, S.N. Ganjoo, R.K., & Korisettar, R. (1990). Geoarchaeology of the palaeolithic site of Samnapur in the central Narmada Valley. Man and Environment XV, 107–116.
Muralidharan, P.K., Prabhakar, A., & Kumaraguru, P. (1993). Geomorphology and evolution of the Palar Basin. Abstract of papers, workshop on evolution of east coast of India, April 18–20. Tanjore: Tamil University.

Nash, D.T., & Petraglia, M.D. (1987). Natural formation processes and the archaeological record. International Series 352, Oxford: BAR.
National Commission on Agriculture. (1976). Rainfall and Cropping Patterns. Tamil Nadu XIV. Ministry of agriculture and irrigation. New Delhi: Government of India.
Paddayya, K. (1979). Palaeoethnography vis-á-vis the Stone Age cultures of India: Some methodological considerations. Bulletin of the Deccan College Post-Graduate and Research Institute, 38, 63–90.
Paddayya, K. (1987). The place of site formation processes in prehistoric research in India. In D.T. Nash & M.D. Petraglia (Eds.), Natural formation processes and the archaeological record (pp. 74–85). International Series 352. Oxford: BAR.
Paddayya, K., & Petraglia, M.D. (1993). Formation processes of Acheulian localities in the Hunsgi and Baichbal Valleys, Peninsular India. In P. Goldberg, D.T. Nash & M.D. Petraglia (Eds.), Formation processes in archaeological context (pp. 61–82), Madison: Prehistory Press.
Paddayya, K., & Petraglia, M.D. (1995). Natural and cultural formation processes of the Acheulian Sites of the Hunsgi and Baichbal Valleys, Karnataka. In S. Wadia, R. Korisettar, & Vishwas S. Kale (Eds.), Quaternary environments and geoarchaeology of India (pp. 333–351), Bangalore: Geological Society of India.
Pappu, R.S. (1995). The contribution of earth sciences to the development of Indian archaeology. In S. Wadia, R. Korisettar, & V.S. Kale (Eds.), Quaternary environments and geoarchaeology of India (pp. 414–434), Bangalore: Geological Society of India.
Pappu, R.S., & Deo, S.G. (1994). Man–land relationships during Palaeolithic times in the Kaladgi Basin, Karnataka. Pune: Deccan College.
Pappu, S. (1991–92). Robert, Bruce Foote and the study of site formation processes of the archaeological record. Bulletin of the Deccan College Post-Graduate and Research Institute, 51–52, 647–654.
Pappu, S. (1996a). Reinvestigation of the prehistoric archaeological record in the Kortallayar Basin, Tamil Nadu. Man and Environment, XXI, 1–23.
Pappu, S. (1996b). Pleistocene environments and Stone Age adaptations in the Kortallayar Basin, Tamil Nadu, Ph.D. Dissertation, Pune: University of Poona.
Petraglia, M.D. (1995). Pursuing site formation research in India. In S. Wadia, R. Korisettar, and V.S. Kale (Eds.), Quaternary environments and geoarchaeology of India (pp. 446–465), Bangalore: Geological Society of India.
Petraglia, M.D., & Potts, R. (1994). Water flow and the formation of Early Pleistocene artifact sites in Olduvai Gorge, Tanzania. Journal of Anthropological Archaeology, 13, 228–254.
Pettijohn, F.J. (1975). Sedimentary rocks, New York: Harper and Row.
Rajaguru, S.N., Deodhar, H., & Ghate, S. (1993). Changes in physical environment of Western India during the last 200 ka: A geoarchaeological approach, Abstract of Papers, Proceedings of the International Symposium on Global Climatic Change (IGBP) 27–29 March 1992, (pp. 99–613), Shinjuku, Tokyo: Waseda University.
Ramasamy, S.M., Venkatasubramaniam, V., Riaz Abdullah, S., & Balaji, S. (1992). The phenomenon of river migration in Northern Tamil Nadu—evidence from satellite data, archaeology and Tamil literature. Man and Environment XVIII, 13–26.
Rapp, G, Jr., & Gifford, J.A. (Eds.)(1985). Archaeological geology, New Haven and London: Yale University Press.
Sankalia, H.D. (1974). Prehistory and protohistory of India and Pakistan, Pune: Decan College.
Schackley, M.L. (1978). The behavior of artifacts as sedimentary particles in a fluvial environment. Archaeometry 20, 55–61.
Schick, K.D. (1974). Processes of Palaeolithic site formation: An experimental Approach, Ph.D. Dissertation, Berkeley: University of California.
Schiffer, M.B. (1983). Towards the identification of formation processes. American Antiquity, 48, 675–706.
Schiffer, M.B. (1987). Formation processes of the archaeological record, Albuquerque: University of New Mexico Press.
Sharma, G.R., & Clark, J.D. (Eds.) (1983). Prehistory and palaeoenvironments in the Middle Son Valley. Allahabad: Avinash Publications.

Stein, J.K. (1987). Deposits for archaeologists. In M.B. Schiffer (Ed.), Advances in archaeological method and theory (Volume II, pp. 337–395), New York: Academic Press.

Stein, J.K., & Farrand, W.R. (1985). Archaeological sediments in context. Orono: Center for the Study of Early Man.

Stein, J., & Linse, A.R. (Eds.) (1993). Effects of scale on archaeological and geoscientific perspectives, Special Paper 283, The Geological Society of America.

Stern, N. (1993). The structure of the Lower Palaeolithic archaeological record: A case study from the Koobi Fora Formation. Current Anthropology, 34, 201–227.

Subramaniam, K.S., & Mani, G. (1981). Genetic and geomorphic aspects of laterites on high and low landforms in parts of Tamil Nadu, India. In Laterisation Processes, Proceedings of the International Seminar on Lateritisation Process, Trivandrum, India, 11–14 December (pp. 237–245), Trivandrum.

Subrahmanyam, B.R. & Sireesha, E.J. (1990). Fossil strands-palaeo-envrionment and Palaeolithic archaeology—a case study on the Andhra Pradesh Coast. In V.G. Rajamanickam (Ed.), Remote sensing application in the study of sea level variation along the Tamil Nadu coast (pp. 313–326), Thanjavur: Tamil University.

Tardy, Y. (1993). Diversity and terminology of lateritic profiles. In I.P. Martini & W. Chessworth (Eds.), Weathering, soils and palaeosols (pp. 379–405), Developments in Earth Surface Processes 2, Amsterdam: Elsevier.

Tardy, Y., & Roquin, C. (1993). Geochemistry and evolution of lateritic landscapes. In I.P. Martini & W. Chessworth (Eds.), Weathering, soils and palaeosols (pp. 407–443), Developments in Earth Surface Processes 2. Amsterdam: Elsevier.

Thimma Reddy, K. (1994). Coastal ecology and archaeology. Man and Environment, XIX, 43–56.

Villa, P. (1983). Conjoinable pieces and site formation processes. American Antiquity, 47, 276–290.

von Corvinus, G. (1983). A survey of the Pravara River System in Western Maharashtra, India. Volume 2. The excavations of the Acheulian Site of Chirki-on-Pravara, India, Tubingen: H Muller-Beck.

Wood, W.R., & Johnson, D.L. (1978). A survey of disturbance processes in archaeological site formation. In M.B. Schiffer (Ed.), Advances in archaeological method and theory (pp. 315–381), New York: Academic Press.

Zeuner, F.E., & Allchin, B. (1956). The microlithic sites of Tinnevelle District, Madras State. Ancient India, 12, 4–20.

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