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Pursuing Site Formation Research in India

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Abstract

The goal of this article is to examine the degree to which cultural and natural formation process studies have been initiated and applied in India. Stone Age archaeological investigations are reviewed on the level of the region, the site, and the artefact or the artefact industry. Following a description of the archaeological investigations, experimental, ethnoarchaeological and taphonomic research projects are outlined. A discussion and conclusions about the current state and future direction of formation process studies in India are drawn.

Introduction

The study of formation processes, both cultural and natural, has become a basic, driving research avenue in archaeology. Today, most archaeologists recognize that the archaeological record is an amalgamation of numerous cultural and natural processes operating in depositional and post-depositional realms. To decipher the processes which form material patterns and associations, a number of analytical approaches have been developed. Although more sophisticated approaches and techniques have been devised, most researchers would probably agree that formation process studies are in their developmental infancy. The aim of this article is to examine the degree to which formation process studies have been employed in Stone Age research in India and to consider the future direction of formation process investigations in the Indian context.

Concern about the processes which formed the archaeological record can be traced to the very beginning of archaeological research. Antiquarian debates often centred on the recognition of ancient tools and determinations as to whether associations of lithic and faunal material were the result of natural or human agents (Grayson 1986). Although examination of prehistoric sites eventually indicated that deposits were the result of a complex interplay of natural and cultural agents, particular nuances of material creation and alteration were not given significant attention. Instead, most emphasis was placed on establishing broad, stratigraphic schemes, useful for documenting technological developments and culture histories.

Greater attention was paid to details of site formation once investigators wished to decipher human activities from artefact associations and patterns on occupation

floors (e.g. Binford and Binford 1966; Binford 1973; Whallon 1973). While behavioural studies brought a new and enduring perspective to archaeology, functional interpretations were immediately criticized for their simplicity. Critics argued that behavioural inferences based on relations between material remains were naive statements about the operation of cultural and natural environments, without any regard for many of the processes which created and altered archaeological associations and patterns. In an attempt to dispel behavioural interpretations made from occupation floors, Bordes (1975) and Bordes *et al.* (1972) pointed out that sedimentological rates of burial were often not quick enough to seal discrete episodes of prehistoric activity, and moreover, disturbances often altered the configuration of patterns on any potential prehistoric living floor. Divergent views about the meaning of patterns expressed on horizontal surfaces suggested that archaeologists were not able to pinpoint the processes responsible for site formation.

In an attempt to understand the meaning of archaeological patterns, a holistic approach was formulated by Schiffer (1972, 1976). According to Schiffer's approach, artefacts in a systemic context undergo cultural transformations, hence archaeologists needed to investigate the life history of materials, determining how artefacts and consumable items were procured, maintained, prepared, used, consumed and recycled before they were discarded (see Binford 1981a for a contrasting view). Moreover, once incorporated into the archaeological record, the way in which natural processes "distorted" cultural patterns had to be understood. In further developing and promoting this approach, Schiffer (1983, 1987) later launched a more sophisticated campaign to examine the formation processes responsible for archaeological patterns. Schiffer discussed some of the best known cultural and natural processes, provided guidelines to identify these processes, and attempted to formalize general principles of site formation. Although formation processes were recognized to be highly varied and their potential combinations seemingly infinite, cultural and environmental regularities were considered of utmost importance for sorting out the operation and result of diverse processes (see also Reid 1985). The site formation approach therefore provided a practical and viable way to examine the patterns found in archaeological contexts.

Since Schiffer's behavioural models were initially formulated, attempts have been made to thoroughly document, catalogue and theorize about formation processes. To better understand major aspects of site formation, archaeologists have initiated research programmes in ethnoarchaeology, geoarchaeology, taphonomy and experimental archaeology (e.g. Behrensmeyer and Hill 1980; Butzer 1982; Stein and Farrand 1985; Kent 1987; Nash and Petraglia 1987a; Bonnichsen and Sorg 1989; Robinson 1990; Gamble and Boismier 1991; Waters 1992; Goldberg *et al.* 1993). These studies demonstrate that more sophisticated approaches are being undertaken to understand the interactions between humans, the natural environment and depositional contexts.

To provide a framework for the investigation of formation processes, the archaeological record can be studied in terms of developmental stages. From this perspective, sites are viewed as containers which undergo occupation, deposition and abandonment (Gifford 1978) (Table 1.). During each stage of site formation, a certain set of cultural and natural processes may occur, leading to specific and identifiable material manifestations. These material manifestations will be directly related to environmental conditions, the geomorphological context and the nature of activities performed. Given that certain processes occur during particular stages of site formation, these processes may be examined through specific investigatory techniques.

Table 1: Representation of the stages of site formation from occupation to recovery (after Gifford 1978: Figure 4.1)

Stage	Process	Material manifestation	Avenues of explication
Occupation	Human Behavior, Natural Processes	Cultural Residues, Horizontal Movements	Ethnoarchaeology, Experimentation, Modern Observations
Deposition	Natural Processes	Burial	Modern Observations, Experimentation, Geoarchaeology
Post-deposition	Natural Processes	Erosion, Transport, Vertical Movement	Modern Observations, Experimentation, Geoarchaeology

During site occupation, the actions of humans are responsible for the internal make-up and creation of cultural patterns. While this is the case, there may be dramatic differences in the resolution and integrity of material patterns. For instance, material differences can be expected since each site experiences variations in the length of occupation and in the nature of activities performed (Villa 1976; Binford 1982). Moreover, single episodes of prehistoric activity may be represented on an occupation floor, or conversely, a horizon may be repeatedly utilized, resulting in residues of overlapping activities.

With regard to depositional processes, human activity occurs in many different contexts, where rates of sedimentation may vary considerably (Butzer 1982; Stein 1987; Stein and Farrand 1985; Waters 1992). In certain contexts, archaeologists may be ideally confronted with a situation where quick burial leads to preservation of lenses of contemporaneous artefactual material. More often, however, rates of geological burial are not rapid enough to preserve synchronic activities, therefore functionally unrelated artefacts or assemblages are usually found sandwiched together in thin depositional units.

During site occupation or after its abandonment, post-depositional processes may influence artefact patterns on horizontal surfaces, and once buried, their positions may be vertically altered. Geological and biological agents may contribute to spatial rearrangement and selective artefact sorting (Wood and Johnson 1978; Schiffer 1987; Nash and Petraglia 1987a).

This brief discussion suggests that the archaeological record is extraordinarily complex, produced by numerous factors operating during site occupation, deposition, and after abandonment. Importantly, however, this discussion also suggests that while cultural and natural processes are numerous and seemingly infinite in their potential combined interactions, certain regularities will prevail. Archaeologists must therefore evaluate and address the patterned, but complex, processes of site formation during the planning, recovery, and analysis stages of archaeological research.

The remainder of this article is devoted to the analysis of formation process studies in India, placing emphasis on the Stone Age, particularly on the Lower to Upper Palaeolithic periods. First, site formation investigations are reviewed on the level of the region, the site, and the artefact or the artefact industry. Following a review of the

archaeological studies, actualistic research projects are described. Finally, conclusions are drawn about the future direction of formation process studies in India.

Site Formation Research in India

Fortunately, formation process research in India is possible since major technological developments and cultural schemes have been established (Sankalia 1974; Jacobson 1979; Paddayya 1984; Misra 1987, 1989). While much has been learned about the distribution and nature of Stone Age localities in India, little information about human activity has been acquired. This is the case because most traditional emphasis was placed on documenting culture-stratigraphic relationships, with many sites occurring in secondary, or derived context.

Behaviour-oriented archaeologists have drawn attention to the limitations of traditional studies devoted to the examination of secondary sites (Paddayya 1978). Paddayya has pointed out that secondary sites are not conducive for palaeoanthropological reconstructions since the archaeological assemblages were the result of erosion, transportation and deposition by fluvial processes. As a consequence, contemporaneity between cultural materials, sediments and faunal remains could not be taken for granted, and moreover, climatic reconstructions and behavioural information could not be inferred.

Of profound importance for palaeoanthropological studies in India, archaeologists began to recognize that primary sites existed in various geographic areas and in frequencies that were much greater than previously acknowledged (Paddayya 1978). Archaeologists realized that to better understand Palaeolithic settlement and activity, regions away from major river valleys needed to be examined, and comprehensive surveys and excavations needed to be conducted.

A focus on primary sites and the study of material patterns, meant that archaeologists had to devise new research directions (Paddayya 1979). Ethnoarchaeological and experimental approaches were considered to be important research avenues which would help to elucidate patterns of human behaviour. Providing a valuable framework for the investigation of formation processes in India, Paddayya (1987a, 1990) strongly emphasized the need to examine the multitude of cultural and natural processes that created the Stone Age archaeological record.

Scales of Archaeological Research

Formation processes may be studied on different levels of analysis, including the region, the site, and the artefact or the artefact industry. Examination of formation processes on these different analytical levels provides the investigator with a heuristic device, useful for evaluating the importance and resolution of certain cultural and natural processes.

A) The Region

In a review of the geomorphic settings of Acheulian occurrences, Pappu (1985) found that identical sites occurred in various locations, including in alluvial, surface,

and rock-shelter and cave contexts. Because of the traditional research emphasis, the vast majority of known Acheulian occurrences were found in riverine settings. While the alluvial settings did not contain primary sites, Pappu reasoned that these secondary contexts were useful for providing clues about the potential existence of intact sites, inferred to be in nearby locations. Moreover, alluvial sites were considered useful for establishing a geomorphic history of river valleys. Depositional sequences, marking phases of aggradation and down-cutting, and local stratigraphies, useful for wider areal studies, could be studied in these contexts. A number of Acheulian sites were also found to occur in non-riverine settings, especially on surfaces far removed from Pleistocene river valleys. These non-riverine surface sites were found in piedmont contexts or in hilly plateau terrain. Archaeologists have considered surface sites as in situ, primary occurrences. While relatively few caves and rock-shelters have been identified to contain Acheulian assemblages, these deposits were considered as the best containers for preserving entire tool industries and for documenting stages of technological development.

In one of the most systematic investigations to locate primary surface sites in India, Jacobson (1970, 1975, 1985) carried out a survey in the Raisen District of Madhya Pradesh. Far removed from the Narmada River valley, nearly one hundred Lower Palaeolithic sites were located at high elevations in the plateau plains. The sites occurred on open plains and hill bases in a region of small headwater rivulets and brooks, hence no natural agency was considered capable of transporting the artefacts to their positions. To assess inter- and intra-site variability and patterning, systematic sample collections were made. Density was used to examine potential disturbance and dispersion of sites. Artefact frequencies and provenances were used to establish technological patterns and to infer aspects of settlement diversity and activity.

The Raisen sites were considered to be primary, surface occurrences, and as such, some significant points were raised for the investigation and evaluation of Acheulian sites in India. The most fundamental point to emerge was that primary open-air sites could be located beyond main river valleys. The survey also showed that although the sites were surface occurrences, inevitably displaying variation in their intra-site integrity, entire assemblages were wholly visible, useful for analyzing technological developments and settlement patterns.

Similar to the Raisen survey, intensive investigations have been undertaken in the Hunsgi and Baichbal valleys, Karnataka, identifying the presence of over one hundred Acheulian sites (Paddayya 1977a, 1977b, 1978, 1982a, 1985, 1987b, 1989). This was a deliberate attempt to investigate sites away from the major drainage, the Krishna River. As a result of the survey, Acheulian sites were discovered in a variety of settings. Important to arguments supporting site integrity, the assemblages were within an enclosed topographical basin, hence there was little scope for long-distance transportation of the assemblages. Minimally, localities situated in riverine and non-riverine settings were considered to be useful for the study of Lower Palaeolithic technology. In non-riverine, surface settings, several of the sites were excavated, delimiting aspects of Acheulian occupation and activity (Paddayya 1979, 1987b).

While Paddayya's discovery of non-transported Acheulian sites was certainly valuable for Stone Age research in India, Straus (1983) critized the view that the Hunsgi sites were "pristine" manifestations of human behaviour, and questioned interpretations about the "primary" nature of the sites. Responding positively to this criticism, Paddayya (1987a) attempted to show that while many of the Acheulian occurrences

were in their original areas, there was indeed variation in their integrity, each site experiencing a different level and set of disturbances. Recently, Paddayya and Petraglia (1993, also in this volume) have assessed the Hunsgi and Baichbal sites in terms of the processes which may have occurred in fluvial, colluvial and deflationary environments. To provide a context for assessing site integrity and formation, the Acheulian occurrences were assessed as to whether artefact assemblages were in their original areas (i.e. spot provenance), and if so, whether the original positions of the individual items (i.e. point provenance) were preserved. The goal of the study was to place the localities on a relative scale, assessing the degree to which natural processes influenced the composition and condition of the artefact accumulations, and to infer the type and extent to which behavioural information was preserved.

Judging from the Acheulian localities of the Hunsgi and Baichbal valleys in terms of their preservation, fluviatile and colluvial situations were found to lack both spot and point provenance. While colluvial occurrences did not retain provenance, distance of transport and degree of sorting of these assesmblages was probably not as severe as fluvial occurrences. In most cases, deflationary occurrences were characterized by spot provenance, the artefactual material preserved within the confines of their original localities. Granting that some of the localities were on or close to their original spots of hominid activity, point provenance was probably not preserved. In a majority of the cases, the individual pieces forming part of the Acheulian floors were inferred to have been displaced, ranging from a few centimetres to many metres. The study allowed the researchers to determine the degree to which behavioural aspects could be inferred. On the most general level, settlement patterns, technological variations, and raw material variability could be studied, whereas in the best conditions, particular instances of artefact curation were inferred.

In another regional survey, the distribution of sites in the Middle Son valley was investigated (Sharma and Clark 1982; Clark and Williams 1986). One of the goals was to locate primary context sites that could be used for palaeoecological and palaeoanthropological interpretations. Based on detailed sedimentological and stratigraphic information, the investigators were able to document the sequence of depositional and erosional events, demonstrating its effects on the cultural record of the area. In terms of the Acheulian assemblages, the investigators found that artefacts occurred adjacent to the main river in colluvial gravels, suggesting that the assemblages must have been formed over a long period of time since some were in a fresh condition and some showed a range of abrasion from light to heavy. While the artefacts were distributed randomly, both horizontally and vertically, the objects were considered to be local in origin. In terms of Middle Palaeolithic sites, the investigators showed that artefacts were not significantly moved from where they were first buried, and though not in meaningful relationship to each other, they were unlikely to have moved far from the places where they were made and used.

Demonstrating the location of sites in various contexts, a survey of the Belan-Seoti valleys, Uttar Pradesh, identified the presence of a number of Upper Palaeolithic occurrences (Jayaswal 1990). Upper Palaeolithic sites yielding blade technologies were found in three main contexts, including river valleys, hillslopes and rock-shelters. In the river valley contexts, blades were found in gravels. In one alluvial location, a number of artefacts were recovered, considered to be representative of a wider group of sites. Along low hill ranges away from the Belan-Seoti valleys, a number of stone workshops were identified. These assemblages were located on gentle hillslopes and

along the sides of small hillocks. These hillslope sites consisted of small knapping scatters or large workshops of material. In the hill ranges, rock shelter sites were numerous, the shelters varying in their dimensions. The rock-shelters, however, often contained only very shallow deposits of material.

B) The Site

The distribution of materials within sites, vertically and horizontally, potentially indicates chronological succession and activity during particular periods. Given that formation processes are very different in open-air and cave and rock-shelter contexts, the following discussion is organized under these two separate headings.

1) Open-air Sites

Excavations by Corvinus (1968, 1973, 1981, 1983) at Chirki-on-Pravara were designed to expose Palaeolithic artefacts over horizontal occupation surfaces. The Chirki investigations were a significant departure from most other early excavations in India because of the emphasis on lateral excavation and because of the recognized importance of depositional and erosional processes. Beyond simply identifying a primary context site, attempts were made to understand the degree to which natural processes contributed to intra-site patterns. The stone artefacts on the horizontal surfaces did not show alignment or preferred orientation, hence stream action was not considered to have disturbed the floor to a great extent (Corvinus 1973). However, the low frequency of waste flakes in the site indicated the possibility for post-depositional disturbance. Based on this information, it was inferred that water flow washed away most of the smaller components of the site, leaving the larger artefacts and only a small percentage of the smaller ones.

Of importance for understanding Pleistocene palaeoecology and hominid behaviour, buried Palaeolithic sites have been identified in the Thar desert, a semi-arid and arid zone occurring in Rajasthan (Gaillard *et al.* 1983; Misra 1987; Misra and Rajaguru 1989). In one location, the 16R dune near Didwana, a 19 m deep trench section revealed a stratified sequence of Lower to Upper Palaeolithic material. The stratigraphic sequence preserved a significant chronometic record of palaeoenvironmental and palaeoanthropological information. At another location, spatial distributions were examined at Singi Talav, an Acheulian site (Gaillard *et al.* 1983). The investigators wondered why there were bare spaces on horizontal floors, and attempted to identify whether cultural activity or natural agents were responsible for the patterns. In addition, the investigators identified some major site formation problems, and attempted to examine why fresh artefacts were found with worn artefacts. A scenario was proposed which appeared to account for the archaeological observations (Misra 1987; Misra and Rajaguru 1989). The investigators inferred that Acheulian groups camped near pools and lakes along floodplains and along shallow water pans in interdunal depressions. A portion of the discarded tools were then weathered by wind action. The fresh and weathered artefacts therefore eventually became incorporated into fine sediments deposited by the low energy water sources.

Among recent investigations launched in the Narmada valley was a survey dedicated to locating primary sites in fine-grained deposits (Misra *et al.* 1990). The survey identified the site of Samnapur, in the foothills of the Vindhyas, away from the main

river channel. Samnapur contained a dense accumulation of artefacts, attributed to the Middle Palaeolithic. The artefacts occurred in rubble, buried by a thick deposit of alluvial silt. In contrast to the secondary sites found in the Narmada, the artefacts were in a fresh condition and consisted of a range of artefact sizes, suggesting that the assemblage was not transported.

2) Caves and Rock-shelters

As depositional containers, caves and rock-shelters often provide abundant information about human activity. However, owing to variability in geological processes and cultural contributions, the formation of cave and rock-shelter deposits may vary considerably. A number of caves and rock-shelters in India have been tested, demonstrating the importance of these unique contexts.

In Adamgarh, Madhya Pradesh, a group of rock-shelters have been excavated (Joshi 1978). Because the sites were situated in the Vindhyan hills south of the Narmada River, the position of these sites provided a reliable sequence of cultural occupation. In fact, a sequence of occupation from the Acheulian to the Mesolithic was documented in some excavations. However, the stratigraphy of the rock-shelters was shown to vary greatly owing to differences in depositional and erosional regimes.

The excavations carried out at Shelter III-F23 at Bhimbetka, located in the Vindhyan range of central India, revealed a sequence of Acheulian, Middle Palaeolithic, Upper Palaeolithic and Mesolithic industries in stratified deposits (Misra 1985). The assemblages were considered to be in undisturbed contexts, providing insights into technological developments.

Several caves have been excavated in Kurnool District, Andhra Pradesh (Murty 1974, 1979; Reddy 1977). In the excavation at Muchchatla Chintamanu Gavi (MCG), Murty (1974) identified deposits containing Late Pleistocene faunal remains and an Upper Palaeolithic blade assemblage. The faunal remains from MCG were considered to be worked, representing a bone tool industry. The cave appeared to have been occupied intermittently based upon the absence of well-defined occupation floors. In two other caves — at Billasurgam and at Kottala Polimera Gavi (KPG) — Reddy (1977) identified well-preserved deposits. The Billasurgam deposits were at least 3.5m in depth, (Foote (1884a and b) reported that the deposits were more than 9-10 m in depth), and the passage deposits at KPG were at least 1.5 m in depth (the chamber was not accessible and not excavated). The caves produced Upper Palaeolithic stone and bone industries, complementing the work of Murty at MCG.

C) Artefacts and Industries

Artefacts, or artefact assemblages, often provide vital clues about the processes operating on sites. Artefacts themselves may bear signs of use, transport, or post-depositional modification. Moreover, entire artefact industries may result from very specific natural processes, either producing heavily sorted assemblages, or types that resemble cultural tools.

Stone artefact rounding and abrasion are perhaps the most commonly noted variables in Stone Age studies, often used to distinguish primary and secondary sites. Rounded artefacts were usually considered to represent transported objects, whereas fresh artefacts were thought to be in situ, or objects moved over short distances.

In an attempt to assess the formation of the Hunsgi and Baichbal sites, a set of artefact variables (i.e. artefact size distributions, artefact rounding, patination, weathering) were examined (Paddayya and Petraglia 1993). The variables were used to interpret whether assemblages were in primary or secondary contexts, and if in primary contexts, to assess the integrity of cultural patterns and the relative influence of natural processes. As part of the analysis, an artefact rounding model was tested, attempting to make the distinction between transported assemblages and those partly buried or exposed subaerially. Artefact patination and weathering stages were also codified, attempting to determine depositional environments and the length of time an assemblage may have been exposed on the surface.

Artefact refitting has provided archaeologists with a way to examine the meaning of patterns on horizontal surfaces and sequences of lithic reduction. A refitting project was successfully implemented at Pithad, a Mesolithic site in Gujarat (Ajithprasad 1992). Demonstrating relative depositional integrity, conjoined flakes and core pieces were found in the same level. The refitting evidence also documented the sequence of tool reduction and blade production, defining a new technique, referred to as the slashed flake method. One of the conjoined sets consisted of the two halves of a large broken flake. The proximal segment of the large flake, which had a thick and convex cross section at its bulb of percussion, was then converted into a blade core. Because refitting was performed, it was possible to demonstrate how the slashed flake method differed from the crested ridge method, the technique usually inferred to be used for the production of microlithic blades.

Microwear analyses have rarely been employed on lithic assemblages in India, despite the recognized importance of the technique for elucidating aspects of tool function, subsistence, and activity (Sinha 1985). In one microwear study, Upper Palaeolithic artefacts from Baghor III, Madhya Pradesh, were examined (Sinha 1989). The microwear study indicated that blades, bladelets and shaped tools were used in a number of activities and on various materials. Among the uses were cutting, whittling, slicing, scraping, piercing, boring and chopping, against plant, wood, meat, bone antler or hide.

Microartefacts, debris smaller than 1 cm in size, may be potentially useful for assessing cultural and natural processes. Unfortunately, this technique has not been applied to sites in India, although small debris has been collected and examined by at least one investigator (S.B. Ota: personal communication, 1992).

Turning to industrial complexes, there has been a long-standing controversy about the validity of the Soan technocomplex, and its purported contemporaneity with the Acheulian. In several areas of India, Early Soan choppers have been found together with advanced types of handaxes. One hypothesis is that the Soan and Acheulian associations were the product of admixture, natural processes acting to transport and redeposit the assemblages, thereby leading to false associations (Armand 1985).

Basalt weathering has been tied to the absence or rare occurrence of Lower Palaeolithic industries in some contexts (Mishra 1982, 1986). Mishra has argued that basalt weathering has been so severe in some cases that the Nevasian, a Lower Palaeolithic cryptocrystalline flake tool assemblage, was misinterpreted to be a Middle Palaeolithic industry. The Nevasian in places simply lacked typical Acheulian bifacial forms because of basalt weathering. Therefore, Acheulian flake tools, made on cryptocrystalline materials, survived, whereas the bifacial basalt component of the Acheulian did not. Further expanding on this line of reasoning, differing proportions of light and

heavy duty tools of basalt were considered a measure of the intensity of post-depositional processes. Therefore, the presence of basalt flakes would signal a high rate of survival, implying that a site was not severely disturbed or transported.

Actualistic Research

Comprised of experimental, ethnoarchaeological and taphonomic studies, actualistic research has become an invaluable theoretical and methodological avenue in archaeology. The basic goal of actualistic research is to analyze extant systems so that the material results of processes can be observed. Identification of dynamic processes and their material effects can then be used to recognize and analyze patterns in the archaeological record. The following discussion briefly reviews actualistic investigations conducted in India.

A) Experiments

Experiments may consist of studies designed to examine a variety of processes occurring in behavioural or natural realms (Paddayya 1979, 1982b). Among experimental techniques are replicative technological studies, designed to reproduce ancient tool manufacture and use, and observational studies, designed to examine material distributions in natural or laboratory settings.

With regard to stone tool experiments, investigators have attempted to replicate prehistoric manufacturing techniques. In one experimental programme, Palaeolithic handaxes were produced by free hand percussion, and polished axes were reproduced through reduction and polishing (Shinde 1989). In another series of experiments, replicas of artefacts recovered from a number of Palaeolithic sites were manufactured to study reduction techniques and local raw material variability (Leng 1992). The attributes of the resulting tools and debitage were measured to evaluate the effect of the raw material on artefact manufacture and use. The study indicated the relationship between reduction techniques and raw materials on final artefact shapes.

Experiments have been performed to test the efficiency of artefacts for butchery (Paddayya 1982b). During a calf dismemberment experiment, light duty tools with sharp edges were found to be effective in skinning and slicing operations, whereas heavy duty tools were found to be essential when more force was required, such as separating long bones from the body.

To ascertain the nature and extent of disturbance of materials caused by surface runoff, material remains in several field settings were observed (Paddayya 1982b, 1987a). Observations in one area in Pune over the course of several monsoons failed to reveal any significant displacement, although reshuffling within the spot was evident. A similar situation was observed at a workers camp, where stones and features were unaltered by natural agents. At a location in Hunsgi, the position of some stones was found to be seriously disturbed, although few fragments were displaced outside the plot boundaries. Preservation of materials was due to burial by silt or because of vegetative growth, which tended to stabilize materials. Once materials were stabilized, the effects of erosional processes operating on the surface was minimalized. These observations were considered to have parallels with Acheulian surface sites in the

Hunsgi valley, suggesting that while the Palaeolithic sites may represent original surfaces, the horizontal distribution of artefacts was likely to have been rearranged.

B) Ethnoarchaeology

Practiced for at least twenty years, ethnoarchaeological research in India is certainly not a new enterprise. Considering that a number of groups are living in various environments and at different technological levels, the Indian context has long been recognized as an excellent forum for ethnoarchaeological research (Nagar 1975; Paddayya 1979; Dhavalikar 1983). Important insights about past economies has resulted from the large number of studies devoted to observation of modern groups.

Aiming to better understand Stone Age cultures, ethnoarchaeological research on tribal groups in the Bhimbetka region was carried out (Nagar 1983). The goal of the study was to find vestiges of early economic adptation to the local ecology, and to better understand aspects of current culture for interpreting terminal Stone Age material found in the Bhimbetka rock-shelters. Tribal groups inhabiting northeastern India have also been studied to document aspects of their economy, settlement, agricultural practices and material possessions (Medhi 1983).

Semi-nomadic, hunting and gathering communities of Rajasthan and Uttar Pradesh have been described, documenting their settlement, housing, subsistence practices, technology, and hunting techniques (Nagar and Misra 1990; Misra 1990). A detailed study of hunter-gatherers of the Cuddapah District of Andhra Pradesh have been undertaken in order to derive clues about Palaeolithic activties (Raju 1985, 1988). The layout of the settlements, house designs, subsistence strategies, hunting and foraging technology and methods were described.

Demonstrating the importance of archival research, 19th century British administrative accounts of hunting and gathering groups in Uttar Pradesh were examined (Nagar and Misra 1989). Aspects of settlement, subsistence and technology were documented, providing insights into the dynamics of cultural processes by which the groups were able to survive in drastically changing natural and social environments.

The use of wild plant foods by hunter-gatherer communities and incipient agricultural tribes in Andhra Pradesh were examined (Murty 1985a). Wild plant foods were used for a number of purposes including subsistence, dwelling construction, and for making implements. A model for wild plant food exploitation was designed to understand the prehistoric ecosystems of the region. In another study of hunting and foraging groups, certain hunting methods and dietary practices were likened to the archaeological remains found in the Kurnool caves (Murty 1985b). Local hunting tactics, weaponry and butchering practices were examined to achieve a better understanding of hunting alternatives, methods of food procurement and processing by prehistoric inhabitants.

In an abandoned workers camp, all objects, materials and features relating to the construction and use of huts were studied (Faculty and Students 1989). Patterning in the construction of huts and their associated facilities were described. The occurrence of household objects inside and outside the huts provided information about activities and group structure. The investigators attempted to understand post-abandonment preservation and modification. The nature of the flat terrain, the soft sediment surface, the lack of scope for fluvial activity and erosion, and the growth of grasses and

vegetation were shown to be factors in the preservation of certain patterns. While this was the case, soil mixing processes also were found to occur, with vertical movement of artefacts. Patterning in displacement was observed by artefact size, with light items displaying the greatest movement.

C) Taphonomy

A number of significant Pleistocene localities and fossilized faunal assemblages have been identified on the Indian subcontinent (Badam 1979; also see Badam and Sathe, this volume). Although the palaeontological data have provided taxonomic information, these studies have not achieved their fullest potential because the fossils mostly occur in secondary alluvial contexts, where they have been transported by alluvial processes. As transported assemblages, the fossils provide only limited information about chronology, palaeoecology and potential hominid subsistence.

In recent years, the importance of systematic faunal analysis and taphonomy has been recognized (Chattopadhyaya 1985). Attempts have been made to document the mode of occurrence and preservation of fossils. In one case, bone element representation, breakage, abrasion and weathering were studied on Pleistocene fauna from the Narmada valley (Badam *et al.* 1986). Based on taphonomic signs, the investigators concluded that before final burial, the assemblages were initially weathered during subaerial exposure, and then subject to hydrodynamic transport, winnowing and sorting.

The Kurnool caves are among the best contexts for study of Late Pleistocene fauna, of great significance for examining potential Upper Palaeolithic subsistence. Faunal preservation was so ideal that fracturing patterns were considered the result of bone tool manufacture and use. The bone tools were identified as scrapers, perforators, chisels, scoops, shouldered points, barbs, spatule, worked bones, blanks, and other finished forms (Murty 1974, 1979; Reddy 1977).

The disposal of animal carcasses of disease-infected animals was examined (Paddayya 1987a). Water-buffalo carcasses were discarded along an ephemeral stream and in nearby thickets. Observations after one year showed that vultures and village dogs acted upon the carcasses. The vertebral columns, crania, and horn cores remained at the spots. Gnawing marks, punctures and other traces of dog interactions were identified on the bone. Limb bones and ribs were found to be missing, probably carried away by the dogs.

In another observational study, important taphonomic information was extracted from the study of faunal remains in an abandoned workers camp (Faculty and Students 1989). Several dozen bone scatters were identified and taphonomic factors operating on the plot were studied. The faunal material distributed around the huts was interpreted to be kitchen refuse. Features on bones suggested the interactions of both humans and animals. Cut marks, chopping marks and roasting features were signs of butchery practices, whereas the dispersal of bones, and signs of gnawing and chewing, were identified as the activity of dogs and birds. The investigators monitored the natural processes of dismemberment and spatial dispersal of animal carcasses over time, noting the original condition of the carcasses, their degree of decomposition and scavenger modifications.

Discussion

An aim of this article was to show the degree to which researchers have examined formation processes in the Indian context. A number of studies have been outlined which suggest that site formation research in India is in a healthy state of progression. While there is certainly cause for optimism given that many studies have implicitly or explicitly been designed to study the processes responsible for material patterning, there also appears to be room for significant improvement in future research endeavours. Clearly, many of the aforementioned studies were only casual or preliminary studies, and few were systematic research programmes which aimed to decipher the multiple causes of site formation.

As Binford (1981b, 1983) has clearly enunciated, if archaeologists are to accurately infer the meaning of archaeological patterns, major problems must be delimited and a variety of pattern recognition and actualistic studies must be conducted. Following this line of reasoning, Paddayya (1987a) provided an outline for the investigation of formation processes in the Indian context including, 1) studies designed to understand the formation of open-air sites and shelters; 2) experiments for studying cultural and natural processes; 3) ethnoarchaeological projects on tribal and rural populations; and 4) taphonomic studies for distinguishing human and natural modifications on bone.

A) Open-Air Sites and Shelters

Perhaps the most significant change in the scope of archaeological research in India was the redirection of studies away from major river valleys to the identification of primary sites in less energetic settings. Detection of open-air and sheltered sites with primary deposits has allowed researchers to potentially address a wide range of palaeoanthropological issues, previously unavailable from the study of secondary sites.

Emphasis on the identification of primary sites and the study of hominid settlement and activity, however, has meant that archaeologists must examine material distributions and patterns over landscapes and on horizontal floors. With the exception of a few intensive regional surveys (e.g. the Raisen and Hunsgi-Baichbal surveys), there have been very few studies which have attempted to obtain a broad picture of Palaeolithic settlement. In fact, there are virtually no landscape studies which have systematically collected, examined and analyzed artefact assemblages for elucidating aspects of inter-site settlement. Moreover, relatively little attention has been focused on inferring aspects of prehistoric activity from artefact patterns on horizontal floors. While several attempts have been made to assess Acheulian activities at Chirki and at Hunsgi, the integrity of the patterns at these sites was less than ideal for such studies.

As palaeoanthropological containers, caves and rock-shelters may be the best places to examine intra-site patterns (Straus 1990 for a discussion). While sheltered sites have been indentified and excavated in India, horizontal distributions have not been analyzed to address aspects of hominid activity. For example, while the vertical sequence of Shelter III F-23 at Bhimbetka preserved a series of superimposed Palaeolithic occupation floors, variations of artefact density and distribution on horizontal levels

were not thoroughly examined. Indeed, in the Kurnool caves, where Upper Palaeolithic blade tools were associated with fauna, spatial associations were not studied. Further, lateral excavations have not been employed in open-air contexts where deep, high integrity sequences of occupation surfaces were demonstrated (e.g. the 16 R locality at Didwana). Clearly, if large scale lateral excavations and spatial studies were performed in these higher integrity contexts, more information about hominid behaviour could be extracted.

To address aspects of hominid settlement and activity over landscapes and on horizontal floors, sophisticated excavations and a variety of analytical techniques must be employed. Traditionally, however, many archaeological investigations in India were not conducted using modern field and laboratory methods (Dhavalikar 1985; Armand 1985). To accurately interpret processes of site formation, material distributions over surfaces need to be mapped, well-displayed and thoroughly examined. Moreover, certain techniques such as artefact refitting (e.g. Cziesla *et al.* 1990; Hofman and Enloe 1992) and microdebitage analysis (e.g. Fladmark 1982; Hull 1987) need to be conducted. To conduct these types of analyses, archaeologists will have to provenance artefacts and screen for small materials. Without application of pattern recognition studies, modern laboratory methods, and analytical techniques, cultural and natural processes cannot be accurately inferred and differentiated.

Little substantive, systematic research has been conducted to examine the relationship between artefact variables and formation processes. Only limited research has been conducted in the Indian context to document the relationship between artefact rounding, patination and weathering and site integrity (see Paddayya and Petraglia 1993 for an example). Despite the fact that Palaeolithic sites occur in a number of depositional contexts, most statements about the condition of artefacts are often subjective and rarely quantified. Archaeologists will certainly need to initiate detailed and rigorous studies of artefacts in the future.

B) Experiments

Experimental research, consisting of stone replication and natural field observations, has been recognized to be an important research avenue. While some initial replication experiments have been conducted, a repertoire of experiments needs to be devised to examine the relationship between stone tool reduction techniques and raw materials. Moreover, spatial distributions resulting from replicative experiments could be examined to infer patterns produced during these various reduction methods (e.g. Newcomer and Sieveking 1980; Schick 1986).

While archaeologists have initiated some field experiments, clearly the scope for such investigations in India is enormous. India, because of its tremendous cultural and environmental diversity, provides an opportunity to examine natural transformations of field plots and human settlements. Artifical field plots, established in a variety of topographic and environmental settings, should be set up to examine the effects of depositional and post-depositional processes. Archaeologists should also map abandoned camps and monitor spatial distributions over time, thereby better understanding how post-depositional processes affect site preservation.

C) Ethnoarchaeology

Ethnoarchaeological research has provided the archaeologist with a greater understanding of settlement diversity throughout India. However, few studies have been devoted to the examination of the distribution of material remains within and between sites. For instance, archaeologists have not yet attempted to systematically examine inter-site relationships and the activities performed in camps, mapping the position of all artefacts and features (see Binford 1983; Kroll and Price 1991 for examples). Further, while there have been many productive ethnoarchaeological projects initiated in many parts of India, most studies have been devoted to finding ethnographic parallels in order to equate these with the inferred behaviour of ancient groups (Sinopoli 1991). Ethnoarchaeological research in India should therefore be geared away from a science devoted towards defining analogous situations to one which attempts to document regularities in human behaviour and material patterning. A major challenge will be to establish models from the material operation of living cultural systems, so that independent lines of evidence may be used to evaluate the archaeological record, ultimately of use for explaining the operation of ancient behavioural systems (e.g. Binford 1981a; Simms 1992).

D) Taphonomy

Taphonomic research in India will certainly assume more importance as an increasing number of primary sites are identified. The identification of faunal assemblages in riverine contexts suggests that archaeologists should remain optimistic about finding fossil bone in better preserved deposits. Until well preserved Pleistocene faunal assemblages are identified, however, investigators must remain satisfied with current palaeontological data sets.

While many Pleistocene faunal assemblages may represent natural accumulations, significant information can be derived, providing an opportunity to address a variety of important taphonomical issues. For instance, secondary faunal assemblages of the Narmada have provided information on hydrological sorting and damage, of potential comparative use once primary assemblages are located. Moreover, the Kurnool faunal assemblages may provide an excellent test case for investigating the distinction between natural and cultural assemblages. Since the Kurnool bone tool industry was identified, many modern studies have been conducted on carnivore induced damages, indicating that faunal remains may be modified in ways mistakenly attributed to cultural use and workmanship. Therefore, the Kurnool bone industries appear to share many characteristics of faunal remains modified and gnawed by animals (see Binford 1981b: 35-86). Close inspection of the Kurnool faunal remains will likely yield information about carnivore modifications (e.g. gnawing) and human interactions (e.g. cutmarks). Finally, but importantly, there is tremendous scope for the study of bone preservation and destruction in experimental and ethnoarchaeological contexts.

Conclusion

This article has attempted to show that the detection and evaluation of cultural and natural formation processes is critical for solving contemporary research problems in archaeology. This overview suggests that site formation is a complex subject, each site experiencing a different set of cultural and natural processes. While this may be the case, formation processes are regularized manifestations of human behaviour and environments, producing particular, identifiable archaeological patterns. To examine the complexities and variable influences of formation processes, archaeologists may use multiple lines of evidence at varying scales of analysis. Archaeologists must therefore determine the degree to which archaeological patterns preserve cultural behaviours, matching specific research questions to particular properties of the archaeological record (Schiffer 1987; Nash and Petraglia 1987b). For example, although many Palaeolithic sites may be surface sites, without preservation of intra-site spatial patterns or features, a large sample of the assemblage should be recovered so that meaningful statements can be made about other cultural aspects, such as raw material variability, for instance. If this approach is adopted, the inferential potential of much of the archaeological record in India will be virtually limitless.

This article suggests that great strides have been made in the study of formation processes in India. To progress further, archaeological sites must be excavated with greater rigour, and a variety of analytical techniques must be employed to decipher formation processes. Moreover, actualistic studies must model gathered knowledge, and criteria concerning identification of cultural and natural processes must be developed. As these studies are initiated in India and throughout South Asia, there will be a more realistic change in our understanding of the archaeological record and the contribution of hominids to its formation.

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