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Pleistocene Geoarchaeology of Thar Desert

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Abstract: The antiquity of early humans in the central part of Thar Desert goes back to the Terminal Early Pleistocene (~0.8 Ma). This culture, technically known as Acheulian, continued in the entire Middle Pleistocene. By and large the climate was semi-arid with dominance of C_4 vegetation. The arrival of new cultural trait, known as the Middle Palaeolithic, is dated around early Late Pleistocene (~100 ka). This culture was adapted to relatively more arid climate than during the preceding Middle Pleistocene. The vegetation was largely C_4 type with patches of C_3 type in favorable geomorphic niches. On the whole the early hunting and food gathering prehistoric communities survived in disorganized autochthonous drainage, playas, wet lands and pond environments. So far there is no evidence of the existence of palaeolithic cultures in later part of the Late Quaternary (~30 to 10 ka).

Key words: Palaeolithic archaeology, palaeoenvironment, geomorphology, calcrete.

Ever since the pioneering discovery of prehistoric stone tools by the British geologist, R.B. Foote in 1863 (Foote, 1866), earth sciences have played a crucial role in the study of Palaeolithic sites in India. The term 'Palaeolithic' is used for the earliest period of human prehistory that begins with the first archaeological evidence of stone tools. Traditionally the Palaeolithic is sub-divided into following three periods:

i. Lower Palaeolithic, Middle Palaeolithic and Upper Palaeolithic in Europe and Asia, and

ii. Early Stone Age, Middle Stone Age and Later Stone Age in Africa.

It is important to note that 99% of the human technological development took place during the Palaeolithic period, approximately covering a time span of the Pleistocene period from about 2.5 Ma to about 10 ka B.P. This period also documents the emergence of and evolution of 'Homo'.

The Lower Palaeolithic in Indian sub-continent is represented by the Acheulian stone technology. In comparison with Africa and Europe, the chronology for the Indian Acheulian is not of high resolution. Absolute dates from three sites namely, Attirampakkam in Tamilnadu (1.7 Ma; Pappu *et al*., 2011), Isampur in Karnataka (1.2 Ma; Paddayya *et al*., 2002) and Morgaon in Maharasthra (older than 0.8 Ma; Sangode *et al*., 2007) indicate that the antiquity of Indian Acheulian is as old as that of Africa, where the Acheulian culture is dated to 1.7 Ma (Lepre *et al*., 2011). This Lower Palaeolithic culture survived till about 125 ka in some parts of India and was replaced by the Middle Palaeolithic (120 ka to ~40 ka B.P.). Subsequently the Upper Palaeolithic and Microlithic cultures appeared (~40 ka to ~10 ka B.P.).

The Acheulian tradition is characterized by large cutting tools besides artefacts like scrapers, choppers, and debitage products, generally made on rocks like quartzite, sandstone, basalt, dolerite, siliceous limestone, etc. Middle Palaeolithic artefacts mainly proceed from flake production, sometimes resulting from prepared core reduction. Tools comprized of scrapers, points, etc., were mainly made on chert, jasper, chalcedony, quartzite, and fossil wood. These artefacts are generally smaller than the Lower Palaeolithic artefacts in size and belong to early Late Pleistocene. Late Palaeolithic is characterized by the production of blades and bladelets; fluted cores are common. Scrapers, points, backed blades, knives are the main tool types and are generally made on chalcedony, chert, and jasper. This technical stage is younger than 50 ka B.P. (Mishra *et al*., 2013; Clarkson *et al*., 2009).

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The discipline of geoarchaeology was initiated in USA in mid 20th century, while in India it developed in late 20th century (Pappu, 1995). Geoarchaeology in India deals with stratigraphical and environmental aspects of archaeological sites preserved in various geomorphological settings such as river valleys, lake shore, pediments with regolith, hill slope colluvium, cones, fans, dunes, sand sheets, ancient soils, etc. Apart from traditional techniques of geology and geomorphology, modern scientific techniques of geophysics, geochemistry, mineral magnetics and stable isotopes are also used for interpretation. These studies are being supported by absolute dating methods e.g. Carbon-14, AMS Carbon-14, Thermo-Luminescence including OSL, Uranium series, Fission Tracks and K-Ar or Ar^{40}-Ar^{39}, and Electron Spin Resonance (ESR). Besides, palaeomagnetic dating is also found useful for a period beyond Brunch's normal (older than 0.78 Ma).

Human fossils are rare in Indian context, though animal fossils such as cattle, elephant, hippo, turtle, horse, deer, etc., have been found with stone tools in different river valleys of India. The only human fossil found in alluvial deposit of the Narmada River near Hathnora in Madhya Pradesh belongs to either late form of *Homo erectus* or early form of *Homo sapiens-sapiens*.

Recently, based on geomorphological studies of Palaeolithic sites in Peninsular India, Deo and Rajaguru (2014) have shown that the climate during the Early Pleistocene (2.5 Ma to 0.78 Ma) was wetter than the climate during the Middle Pleistocene (0.78 Ma to 130 ka B.P.). The Late Pleistocene (~130 ka to 10 ka B.P.) was markedly drier than the Middle Pleistocene. Most of the Middle Palaeolithic sites in coastal areas of India are adjusted to marine regression and sea level lower than the present one (Deo and Rajaguru, 2014). The climate during the Pleistocene in the present semi-arid parts of India has largely remained semi-arid, at times fluctuating between sub-humid and arid. On the whole the climatic changes were not as drastic as in higher and mid-latitude regions. The summer monsoon was a dominant climatic parameter and winter monsoon played significant role, particularly in north-west and south-east India. Geomorphological, palaeontological and stable isotope data suggest that the rocky stable Peninsula with its relatively stable river channels was covered by savanna forest with dominance of grasslands and galleria forests in valleys during the major part of the Quaternary.

Against the background of cultural-ecology of Palaeolithic sites in Peninsular India, an attempt is made to provide an overview of Palaeolithic sites around Didwana in Central Thar (Fig. 1), where substantial multi-disciplinary data have been generated (Singh *et al.,* 1974; Allchin *et al*., 1978; Wasson *et al*., 1983; Misra *et al*., 1982, 1986, 1988, 1995a, b; Misra and Rajaguru, 1986, 1987; Misra, 1989, 2014; Raghavan *et al*., 1989; Singhvi and Kar, 2004; Singhvi *et al*., 2010).

Thar Desert

In the early 20th century the Thar Desert was considered very young because of the existence of several proto-historic and early historic sites along the palaeochannel of the river Ghaggar in the northern part of the Thar. The famous geologists like Krishnan (1952) and Wadia (1960) suggested that the present aridity in the Thar was not older than the mid-Holocene. On the other hand, other geologists like Ahmed (1969) suggested that the aridity in the Thar was very old, as an accumulation of the thick cover of sand over a vast area of the Thar might have taken a long time to form. The later part of the 20th century witnessed renewed interest of earth scientists, palaeobotanists, geoarchaeologists and archaeologists in understanding the evolutionary history of the Thar Desert and early human history (Singh *et al*., 1974; Allchin *et al*., 1978; Wasson *et al*., 1983; Misra *et al*., 1982, 1988, 1995 a, b; Misra, 1989; Singhvi and Kar, 2004; Singhvi *et al*., 2010). These multidisciplinary investigations convincingly established that the arid/semi-arid climate of the Thar Desert dates back to the Late Neogene and the antiquity of early man is much earlier than 200 ka B.P. (Rajaguru *et al*., 1992; Dhir *et al*., 1994; Dhir, 1995). Application of remote sensing techniques, well-supported by field studies, at times involving excavations of important soil-sediment sections and of palaeolithic sites, particularly around Didwana (Misra *et al*., 1982, 1988) have added new information on cultural ecology of the south central Thar Desert. Laboratory studies included special petrographic techniques like

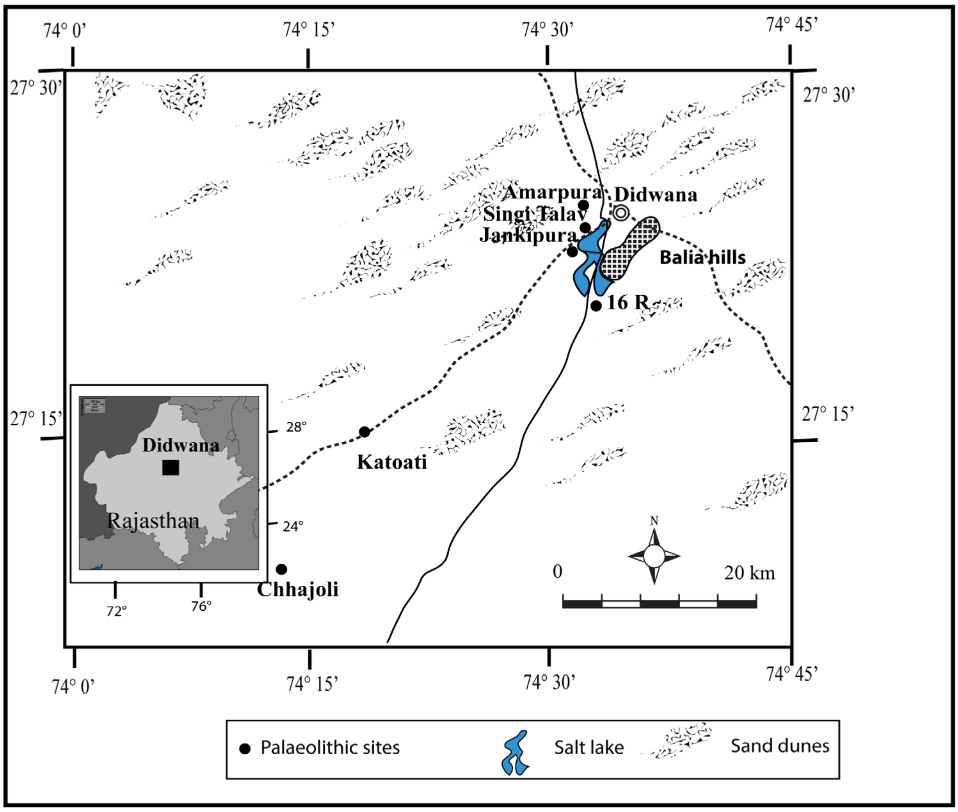

Fig. 1. Location of palaeolithic sites mentioned in text.

micromorphology, cathode luminescence, EPMA and XRD, geochronological methods including conventional ^{14}C, TL, Thorium-Uranium and ESR techniques (Achyuthan *et al.*, 2007; Dhir *et al.*, 2004) were used for this study. A summary of results on the Palaeolithic sites of Didwana is given here in order to focus on the importance of multi-disciplinary studies in understanding 'man-land' relationship in semi-arid/arid parts of the Thar Desert in general and Didwana in particular.

Archaeological Records

Didwana

Didwana (27°24'N, 74°55'E), district Nagaur, is located about 300 km north-east of Jodhpur. It receives about 400 mm rainfall per annum, mainly from summer monsoon. Winter rainfall contribution is less than 10%. A 7 x 2.5 km salt lake (playa) exists to the south of the town, while a 3 x 1 km shallow depression occurs 1.5 km south-west of the town at Singi-Talav. These two depressions are separated by stabilized linear and obstacle dunes with rich scatters of microliths on the stable dune surfaces. Low lying hillocks composed of carbonaceous phyllites/shales and schists with intrusions of quartzite and vein quartz occur as inselbergs in the area. Morphologically the site is situated on a rocky pediment with thin cover of surficial deposits, consisting of hill slope rubble, aeolian sand sheets and dunes and calcretes of various types. Palaeolithic artefacts have been recovered in primary/semi-primary and secondary contexts after careful excavations of surficial deposits at many sites namely Singi-Talav (playa site), Amarpura Quarry, 16 R (dune site), Indola-ki-Dhani, Jayal ridge, Chhajoli and Katoati (Fig. 1).

Singi-Talav

It is one of the richest sites around Didwana yielding typical Acheulian tools, especially handaxes (Fig. 2). An excavation was opened on the southern edge of the "murrum" quarry. It was conducted from 1981 to 1985 by V.N. Misra, S.N. Rajaguru and C. Gaillard and extended on 72 m² to an average depth of nearly 1 m. Besides, a trial pit of 2 x 2 m was dug to a depth of 4 m, up to the water table. These artefacts usually occur in the "murrum",

Fig. 2. Excavation trench at Singi-Talav.

a geological formation rich in calcareous nodules. Calcareous loamy sediments with nodular calcrete were initially labelled as Amarpura Formation (Misra *et al*., 1982, 1988). Subsequently Dhir *et al*. (2004) detailed multi-disciplinary investigations around Didwana and in central and western parts of the Thar have shown that the 'Amarpura Formation' is a part of shallow water aggraded alluvial plain (SWAP) dominated by low energy floods, disorganised drainage and strongly affected by periodically fluctuating carbonate-rich ground water. The thickness of the SWAP around Didwana is 12 m, as visible in Amarpura Quarry, 1.5 km east of Singi-Talav.

The composite stratigraphy, as revealed in trenches at Singi-Talav consists of reworked yellowish aeolian sand (35 cm) with good number of abraded artefacts of Middle Palaeolithic tradition and a few calcrete nodules. This re-deposited sandy layer rests disconformably on calcareous sandy loam, rich in calcrete nodules in upper part (~40 cm to 200 cm). The nodular loam grades to greyish green silty loam at a depth of 200 to 308 cm. The lower silty layer is whitish and partly mottled with iron-oxide and manganese oxide segregations. Calcrete nodules vary in size from 5 to 50 mm. Layers 3 and 4 yielded 401 and 891 artefacts, respectively, and consisted of good number of handaxes (Fig. 3), a few cleavers and large number of flakes, debitage chips (>40%), small retouched tools (6%), and choppers and polyhedrons. These artefacts are made on locally available metamorphic

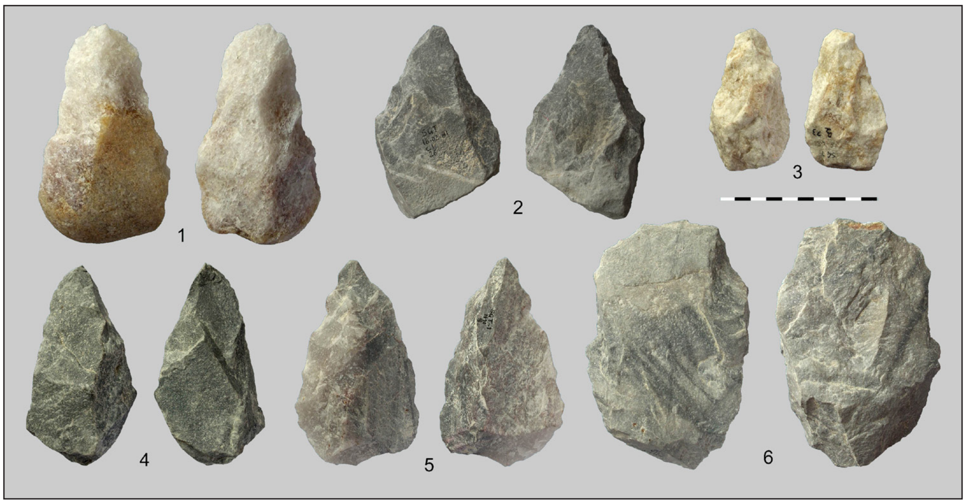

Fig. 3. Handaxes and cleavers from Singi-Talav.

Fig. 4. Gastropod shells and unrolled opercula recovered from Singi Talav excavation.

rock like quartzite. Artefacts are more or less fresh, coated with carbonate and are misfit into sedimentary matrix of sandy or silty loam. Thus, excavation at Singi-Talav revealed two main layers, where the archaeological material appeared not much disturbed after the departure of the prehistoric dwellers. In association with the handaxes and a few cleavers, flakes and various stone fragments were also unearthed. The raw material for this assemblage was mainly brought from the Balia Hills but also, for a few artefacts, from a cobble bed 20 km away from the site (Gaillard *et al.*, 1983, 1986, 2010).

Presence of small Gastropod shells (<2 mm in diameter) and unrolled opercula (Fig. 4) in artefact-bearing layer 4 support our hypothesis that Early Acheulian primary context activity had taken place on the shore of ancient playa (Gaillard *et al.*, 1985). Besides this, occurrence of six pieces of mono-pyramidal quartz crystals (2 to 8 mm in length) also indicates the primary activity (Fig. 5). These crystals were intentionally brought to the site and thereby clearly reflect on aesthetic sense of early humans occupying this part of the Thar (d'Errico *et al.*, 1989; Moncel *et al.*, 2012).

Fig. 5. Mono-pyramidal quartz crystals from Singi-Talav.

Amarpura Quarry (Fig. 6)

In Amarpura Quarry 1.5 km east of Singi-Talav SWAP type of sediments are exposed to a depth of 4 m below the surface. At this locality, artefacts mainly occur in the clayey layer, grey in color, forming the top of the pinkish sand at about 4.1 to 4.2 m from the surface. The artefacts also occur above the clayey layer, but not below. About 40 specimens were collected, comprising flakes, polyhedrons or cores, choppers and 4 handaxes in mint condition (Misra *et al*., 1982; Gaillard *et al*., 1986). This assemblage compares very well with that from Singi-Talav.

Kailath *et al*. (2000) dated the calcretes collected from 1 m below the top of the murrum at Amarpura Quarry to 797 ka B.P. by ESR dating method. Based on the available absolute chronology, technologically similar types of Acheulian artefacts and their geomorphic context i.e. calcretised loamy sediments both at Singi-Talav and at Amarpura Quarry sites thus, represent the earliest (older than 0.8 Ma B.P.) evidence of Early human presence in the Thar Desert.

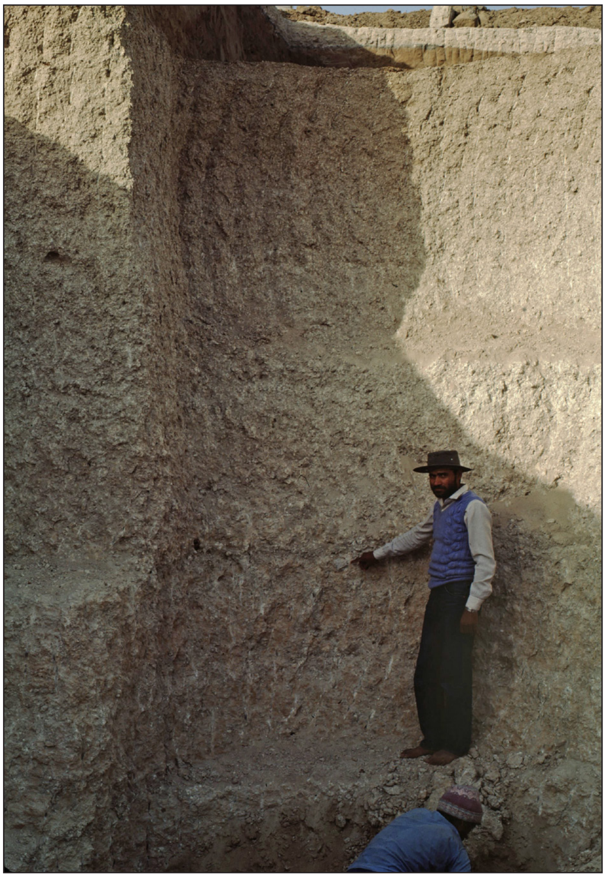

Fig. 6. Amarpura Quarry (the person is pointing artefact layer).

16 R

Most of the prehistoric artefacts were discovered during a multidisciplinary program launched in the late 1970s by V.N. Misra and S.N. Rajaguru from Deccan College, Pune (Misra *et al*., 1982). The first discoveries occurred in the quarries where "murrum" was dug out, especially at Singi-Talav, Indola-ki-Dhani and Amarpura. Excavations were then conducted in some of these quarries and also in the sand dune along the Bangor Canal, at "16 R".

The excavated locality *16 R* (Fig. 7) is named after its height above the ground level as shown in Survey of India topo sheet. It is situated about 2 km west of Didwana town and is on the left bank of the canal dug in 1941-42 for channelizing rainwater from the nearby hill into the tank near Didwana. The presence of prehistoric population around Didwana is attested by the occurrence of stone artefacts. Bones, neither animal nor human, are preserved, although as it is usually the case in dry environments.

A 2 m wide trench was dug to a depth of 18.5 m in a stepped manner without reaching the base of fossil linear-cum-obstacle dune (Fig. 8). Misra *et al*. (1982, 1988) divided this dune into three major lithological units on the basis of field characters such as color, texture, calcrete bands and nodules and major depositional breaks indicated by colluvial layers and palaeosols. These units are briefly described below (Fig. 9).

Unit I (0 to 4.9 m): It consists of well-sorted medium to fine loamy sand, brownish to yellowish brown in color and has weakly developed vertical cracks and prismatic peds in its upper part (0 to 1.7 m). Development of soft carbonate pellets (1 cm diameter) indicates that quartz-rich dune sand has been weakly pedogenized by calcisol processes during the stability of the dune. Recently, Singhvi *et al*. (2010) have provided TL and OSL dates for all three units. The Unit I appears to represent rapid aeolian sand accumulation between 9 ka to 14 ka. The dune accretion started around 21 ka and ended abruptly around 6 ka. During the stable phase, the dune was affected by weak calcisol development.

Fig. 7. Sand dune at 16 R.

At the base of litho Unit I, a colluvial layer (~10 cm thick), rich in coarse quartz and fragments of black platy shale derived locally from nearby hillocks, is very well-preserved. The colluvial layer is found to rest on calcrete nodules. Archaeologically, this unit did not yield any artefacts though its upper layer of stable brownish silt was littered with microliths made on quartz and chalcedony.

Unit II (5 m to 9 m): It is dominated by yellowish loamy sand sandwiched between two calcrete bands at depth of 5 m and 9 m, respectively. The sand is moderately sorted and consists of pedogenic cakcrete nodules, randomly distributed throughout its thickness. Calcrete bands have also developed at depths of 5.00 m, 5.65 m, 7.70 m, and 8.85 m. According to Singhvi *et al*. (2010) this unit is affected by long stability, pedogenisis, ground water fluctuations and erosion during rains. Singhvi *et al*. (2010) dated this unit between 40 ka (5 m depth), 80 ka (6.6 m depth) and 130 ka (7.7 m depth). A horizontal excavation over an area of 30 sq. m between 5.40 m and 6.10 m yielded high concentration of artefacts like flakes, blades, and a few miniature handaxes made on locally available white quartzite. This rich archaeological horizon at a depth of 5.3 to 6.0 m from the top of the section has yielded 683 artefacts. Originally this lithic complex was labeled as 'Upper Palaeolithic' (Misra *et al*., 1982). The lower part of Unit II from 8.5 to 9.0 m has yielded only 8 artefacts as excavation trench was smaller in size in this part.

Fig. 8. 16 R excavated trench.

Unit III (9 m to 18.5 m): This litho unit is brown to reddish brown in color, dominated by fine to medium sandy loam with abundant calcrete nodules (5 cm to 20 cm in diameter). The sand is compact, hard and has alternation of hard calcrete bands, particularly at levels of 12 m, 14 m, 16 m, 17 m and 18.5 m below the surface. These calcrete bands are 5 cm to 20 cm thick and possess different degree of hardness. The band at 18.5 m depth was extremely hard and therefore, excavators could not continue digging below this depth. Singhvi *et al*. (2010) suggested that this unit is a cumulative product of short-lived episodic dune sand accumulation, followed by long period of stability and surface water erosion. The calcisol pedogenesis is weak to moderate. During the stability period, Middle Palaeolithic human occupation appears to have taken place in upper part of Unit III (particularly between 9 and 13 m), which is dated between 100 ka and 130 ka. Total 43 artefacts were recovered from 12.2 to 12.8 m depth. At 17.2 m depth 11 artefacts (including a bifacial core) were reported. At the bottom of the trench (18.4 m depth) only 2 artefacts (1 cm long blade and a pounder) were recovered and these layers have been dated to the Late Middle Pleistocene (~190 ka to ~140 ka B.P.). Archaeologically, the Unit III is significant as it has yielded good number of non-diagnostic Middle Palaeolithic of early Late Pleistocene age and a few non-diagnostic Lower Palaeolithic artefacts belonging to the late Middle Pleistocene (Fig. 9).

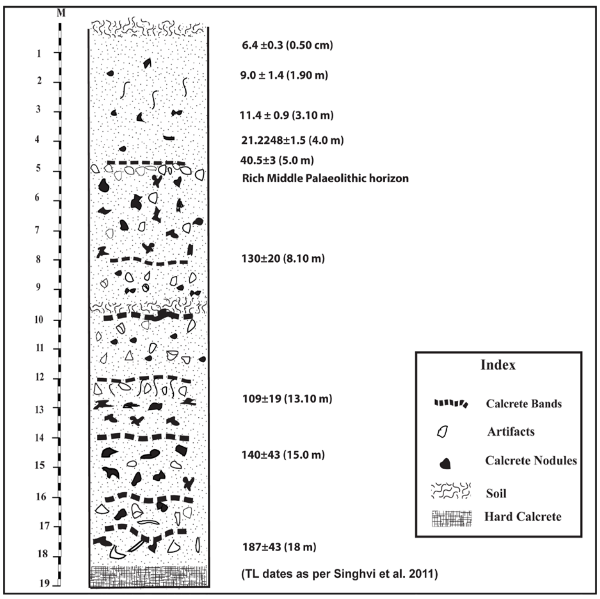

Fig. 9. Lithological units exposed from 16 R excavation.

Indola-ki-Dhani

At Indola-ki-Dhani, 1 km west of Singi-Talav, digging was carried out in clayey loam to a depth of 5.13 m. The tool-kit from upper layer 1 (1.35 to 1.85 m) is made of discoids, choppers, denticulates, scrapers, points of smaller size. There are no handaxes found from this layer. The layer 2 (1.86 to 3.85 m) has yielded large number of stone tools, comprising handaxes, points, scarpers, choppers, and knives (Misra 2007).

Jayal ridge

This locality (74°11’ E 27°13.2” N) is situated in area of boulder gravel ridge locally known as *magra*. This ridge is 40-70 m high above the plain at Jayal and runs for 14 km from Katoati to Chhajoli. The exposed portion of this gravel ridge is 20 m. The gravel ridge is rich in quartzite, quartzitic sandstone and clast supported in a matrix of calcareous silty sand (Fig. 10). The lower part of the ridge is ferricretised and upper part is strongly to moderately calcretised. Recently Dhir *et al.* (2004) has dated strongly developed calcrete at Katoati (2 k north of Chhajoli) to about 1500 ka B.P. The surface of this ridge is rich in Lower Palaeolithic artefacts. Small scale excavation was carried out in this gravel (Misra *et al*., 1982). Four trenches were dug at different spots. Stone tools are confined to a depth of 40 cm only. More than 400 artefacts were collected from excavation, out of which 17% were finished tools and the rest are unfinished tools. The tool kit consisted of flakes, cores, and dominated by scrapers (54%), handaxes (14%) and a single cleaver. These artefacts are made on locally available quartzite.

Chhajoli

Three trenches were laid out around the village Chhajoli about 2 km south-west of Jayal on the top and slope of the gravel ridge. Artefacts were found up to a depth of 2.30 m and comprised the same tool-kit as at Jayal (Misra, 2007).

Katoati

Blinkhorn *et al.* (2015) carried out small excavation in fluvio-aeolian deposit at Katoati. The site is located at the foot slope of ‘bouldery gravel ridge’ of Chhajoli near village Katoati. It yielded Ostrich eggshells along with large and

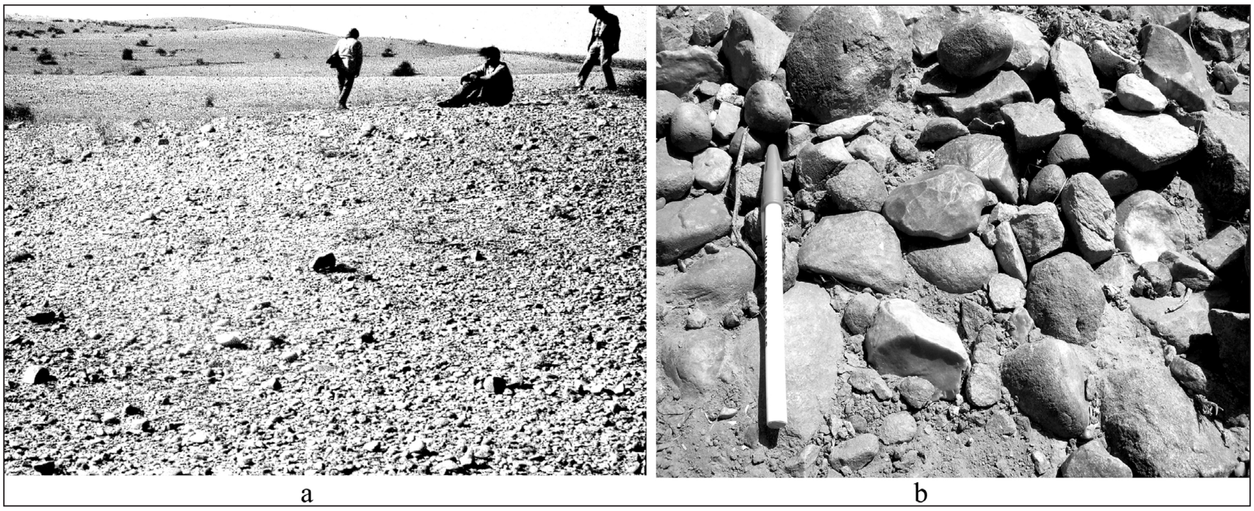

Fig. 10. Gravel ridge at Jayal (a) and close of artefacts within the gravel (b).

highly cortical cores and flakes. On the basis of presence of prepared point cores and retouched pointed artefacts the Katoati assemblage has been classified as Middle Palaeolithic phase. The stratigraphic sequence at Katoati site is well-supported by absolute chronology and it is within the time bracket of 95 ka to 40 ka by OSL dating method.

Lordia

The site of Lordia is situated on Jodhpur highway, about 3 km east of Phalodi in district Jodhpur. A small scale (1.0 m x 1.5 m) excavation was carried out in a gravelly rubble (2.5 m thick) resting on weathered siliceous limestone, at a height of about 4 m above the present channel of a ephemeral stream. This channel is at present blocked by modern dune sand. Palaeolithic artefacts comprised of handaxe, flakes and blades made on quartzite, chert, sandstone and siliceous limestone were recovered in the excavation (Fig. 11). One of the handaxes is having a thick reddish brown patina on it. On the other hand flakes and blades are not patinated, but show features of wind blasting. This site is undated and the artifact collection is not enough to categorize in standard typological framework.

Palaeoenvironment

The overview of excavated Palaeolithic sites around Didwana suggests that Acheulian artefacts at Singi-Talav establishes the earliest human activity in the eastern margin of the Thar to the Terminal Early Pliestocene (~0.8 Ma B.P.). Acheulian activity continued during the entire Middle Pleistocene as indicated by several sites found by prehistorians in close association with SWAP in the Central Thar (Misra *et al.*, 1982; Dhir and Singhvi, 2012; Misra, 2014). Middle Palaeolithic culture began in the early Late Pleistocene (~130 ka as observed in 16 R section) and flourished between 95 and 40 ka (as revealed in well-dated aeolian section at 16 R and in very well-documented Katoati fluvio-aeolian section (Blinkhorn *et al.*, 2015). Middle Palaeolithic sites have also been found in the Luni valley and also in Jaisalmer and Barmer districts (Allchin *et al.*, 1978; Misra, 1989; Misra, 2007). As mentioned earlier, versions of identification of the presence of the Upper Palaeolithic cultural material recovered in the upper part of Unit II at 16 R are no longer considered to be of the Upper Palaeolithic tradition (Gaillard, 2006; Blinkhorn, 2013) and gets our support after re-examining artefacts from the point of view of tool taxanomy. It is therefore, necessary to find out the reasons (cultural or environmental) for the absence of the Upper Palaeolithic during the Terminal Pleistocene (~40 ka to 10 ka B.P.). This aspect of cultural development in the Central Thar will be discussed against the available information about the Pleistocene environment of the area.

Today's landscape of the Thar is dominated by varieties of dunes and sand sheets, alluvial flats covering either rocky pediments with low hill ranges, inselbegrs and tors. Anomalous boulder-cobbly gravel spreads, isolated playas and hill slope colluviums also form major components of the landscape. The bedrock structural configuration is complex, giving rise to horst and graben topography. The latter is filled with thick (up to 300 m) surficical deposits, particularly in northern Ghaggar basin and the southern Luni basin. Region lying between these river basins is almost free of any conspicuous drainage system.

As stated earlier the geomorphic proxies such as ferricrete, calcrete, aggraded alluvial calcretised deposits with palaeolithic arfetacts have so far been investigated. Relatively new technological input such as stable isotopic studies of calcretes and dating them with TL, OSL, and ESR methods has revolutionized geoarchaeological interpretations. Animal fossils are almost absent in the Thar. Bioenvironmental interpretation therefore, is dependent on stable isotopic composition of calcretes of pedogenic origin and a few pollen profiles of playa sediments of the Holocene age. A summary of the environmental history of the south central Thar is given as follows.

The Neogene (Late Miocene to Early Pleistocene), approximately covering a time span from 10 Ma to 1 Ma years B.P.: Ferricretes developed over Shumar beds of fluvio-marine origin along western margin of the Thar in Jaisalmer basin and over boulder gravels of Jayal ridge along eastern margin of the Thar in Nagaur District, indicate humid tropical climate during the Neogene. Erosional features such as knick points, rocky gorges which are totally dry today in many parts of the Thar probably belong to this period. The end of the Neogene is represented by some of the well developed lithic calcretes, labeled as ancient calcretes by Dhir *et al*. (2004) and dated between 2.5 Ma and 1.0 Ma B.P. These calcretes are post-ferricrete in age and older than the calcretised aggraded alluvial deposits (SWAP). The younger calcretes have been dated between 0.8 Ma and 145 ka B.P. (Dhir *et al*., 2004). The stable isotope results show that the lithic calcretes developed over rocky pediments with shallow (close to the pediment surface) ground water under a thick carpet of C_4 dominated tropical vegetation (Dhir *et al*., 2004). On the other hand stable isotope studies of pedogenic calcretes developed within braided channel gravels of the late Neogene or Pliocene age(?) (Jain *et al*., 2005) indicate prevalence of mix type of vegetation cover of C_3 and C_4 with significant proportions of C_3.

Briefly, the early Neogene witnessed humid climate, which turned to the semi-arid in Pliocene(?) or early Pleistocene. The Luni river

Fig. 11. Palaeolithic artefacts from Lordia.

was probably braided and perennial flowing in rocky upland dotted with a forest of mixture of grassland and woodland. Though there existed early man (probably Homo erectus) in other parts of Peninsular India during the Early Pleistocene (1.5 Ma B.P.) as yet there is no evidence of the existence of early man during this period in the Thar.

Middle Pleistocene (i.e. terminal Early Pleistocene to Early Middle Pleistocene ~0.8 Ma to 145 ka B.P.): A few ESR dates obtained on pedogenic calcrete nodules developed within aggraded alluvial deposits (including Amarpura formation) indicate that during this period the climate was largely semi-arid and the drainage was disorganized, inefficient with wide shallow channels and low banks and was seasonal to ephemeral. This low energy drainage system favoured the formation of playas (ephemeral lakes or ponds or shallow pans) in wide flood plains which were affected by cumulic calcisol processes leading to development of pedogenic calcrete nodules. Development of interlayers of hardpan calcretes within this aggraded alluvial plain indicate that ground water was close to the surface, with a tendency to seasonal fluctuations. Stable isotope data show dominance of C_4 type of vegetation with scattered pockets of C_3 plants (Dhir *et al.*, 2004).

As mentioned earlier, Singi-Talav Early Acheulian site (> 0.8 Ma B.P.) belong to this phase. It is probably a rare primary context playa site in Thar Desert. Other than Singi-Talav, a few Acheulian or Lower Palaeolithic sites have been reported in the aggraded alluvial plain at places like Indola-ki-Dhani, Chhajot and these sites belong to the later Middle Pleistocene (~350 ka to 145 ka B.P.).

The terminal Middle Pleistocene was drier (arid to semi-arid) than the early Middle Pleistocene as indicated by the presence of aeolian sandsheets alternating with gravels of ephemeral channels. Contemporary to this phase, colluvial slope deposits with Acheulian artefacts also formed at the foot of the low hill range at Kolia, 5 km from Didwana. A few OSL dates in the lower unit of 16 R section and in the middle Luni valley indicate that this phase of semi-arid/arid environment ultimately shifted to arid climate with interludes of semi-aridity during the Late Pleistocene (~130 ka B.P. to 13 ka B.P.). The river Luni was ephemeral and the region north of it turned into the landscape without drainage, but with prolific development of varieties of dunes (particularly parabolic, longitudinal, linear and obstruction types). It appears that dune aggradation was dominant at ~100-80 ka, ~60 ka and 30-22 ka B.P. The dune aggradation took place in an approximate time period of 19 ka and was favored during transitional climatic phase from arid to semi-arid, i.e. at times when south-west monsoon system was getting strong. Thus the optimum development of dune was not during the peak of aridity (like LGM), but during the early phase of strengthening of south-west monsoon. The dune accumulation of 19 ka period was followed by long period (20 to 40 ka) of stability, allowing development of cumulic calcisols and also by periodic erosion by surface water of monsoonal rains (Singhvi *et al.*, 2010). The retention of groundwater in inter-dunal depression was also common as indicated by the presence of calcrete bands at 16 R (Singhvi *et al.*, 2010). Good number of OSL dates on aeolian sands in the Thar in general and at 16 R and Katoati in particular indicate the presence of Middle Palaeolithic culture in wide area of the Thar, including the Luni basin between 130 ka and 40 ka B.P. with a peak between 80 ka and 40 ka B.P. (Singhvi *et al.*, 2010; Blinkhorn *et al.*, 2015).

Terminal Pleistocene and Early Holocene phase (~22 ka to 6 ka B.P.): As mentioned earlier, the south-west monsoon was almost weak, fluvial and even aeolian processes were dormant between 22 ka and 13-14 ka B.P. As a result of these conditions the climate became arid with dwindling water sources. These unsuitable climatic conditions must have compelled the stone age hunter-gatherers to migrate from this region to eastern or south-eastern parts of the Thar. The hunter-gatherers re-appeared in the Thar during the Early Holocene (~7 ka B.P.) due to strengthening of summer monsoon (Deotare *et al.*, 2004). Playas carried fresh to brackish water and the river Luni started its erosional mode. Presence of large number of microlithic sites in the entire Thar Desert provides one of the best examples of culture-environment interrelationship in the desert.

The site of Katoati is important from the point of view understanding biological environment during the early Late Pleistocene. Stable Isotope data on pedogenic carbonates, fossil shell fragments of ostrich (*Struthico* sp.) and braided ephemeral channels indicate wet semi-arid climate and dominance of C_3 plants. Based on well-prepared vegetation maps for wet as well dry climatic phases of early Late Pleistocene Blinkhorn *et al*. (2013) proposed Sahel like Savanna type vegetation between 70 ka and 40 ka B.P.

The ephemeral stream at Lordia, which is today blocked by dune sand was flowing during prehistoric times and provided congenial geomorphic environment due to climate amelioration as observed at Didwana and Katoati.

Overview

The present communication demonstrates the importance of prehistoric sites around Didwana. No other prehistoric site in India has provided a well-dated landscape evolution in response to semi-arid/arid climatic changes of the entire Pleistocene. It appears that Palaeolithic humans carried out their hunting and food gathering activity around playas, ephemeral and disorganized drainage system and on stable surfaces of dunes and sand sheets mainly during the relatively wet climate yet semi-arid.

The Pleistocene geoarchaeology of the Central Thar appears to be far more complex than attempted by earlier workers in the late 20th century and by recent researchers in the early 21st century. Geoenvironment has dramatically changed from the Neogene to Late Quaternary. In spite of employing available latest techniques in geochronology, geochemistry and artifact taxonomy we are unable to get acceptable results, even at a level of hypothesis of cultural ecology of hunter-gatherer who occupied Central Thar and the Luni basin since Middle Pleistocene transition (0.8 Ma). The main geomorphic proxies are varieties of calcretes, episodic aeolian aggradations and disorganized ephemeral drainage systems in shallow basins carved in rocky pediments. Palaeolithic sites though occur in above mentioned proxies with reasonably well-dated sequence, however, lack diagnostic typological characters. Environmentally, we get only broad signatures of semi-arid/arid monsoon climate and even stable isotope data provide elementary level vegetation data.

Thus the present understanding of cultural-ecology of hunting-gathering communities in the Thar is more or less in an embryonic stage and we require high resolution multi-disciplinary studies of palaeolithic sites within dunes, on shores of saline playas, in relict calcretised alluvial deposits and in surfical regolith preserved in strongly calcretised rocky pediment.

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