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ACKNOWLEDGEMENTS. We are grateful to Dr Harsh K. Gupta, Director, NGRI, for constant encouragement and guidance. We thank Dr Peter Molnar and an anonymous reviewer for valuable suggestions to improve the manuscript.

Received 26 May 1997; revised accepted 11 May 1998

Geoarchaeological and palaeoenvironmental studies around Bap–Malar playa, district Jodhpur, Rajasthan

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We report here stratigraphical, palynological, archaeological and relative radioactive carbon dating studies around Bap–Malar playa in Jodhpur district of Rajasthan, as an attempt at understanding the environmental changes in the context of prehistoric sites. We also report, Late Acheulian site in a regolith, large number of Microlithic sites with pottery and bones in the context of stabilized dunes and a few Microlithic sites with or without pottery, around a shallow Bap–Malar playa. During the mid-Holocene, the Bap–Malar was a perennial playa, and provided a congenial ecological niche for pastoral communities.

THE Bap–Malar playa (72°22′ to 72°27′E and 27°15′ to 27°24′N) extends 12 km north–south and 6.5 km east–west. It is situated 140 km northwest of Jodhpur, west of Aravalli hill ranges (Figure 1). The playa occurs in the arid core of the Thar desert and the mean annual rainfall is less than 250 mm. The rate of evaporation is around 2000 mm per annum.

The depth of playa sediments does not exceed 7 m and represents deeper facies in NE part and shallow lake marginal facies on southeastern part[1]. The playa is surrounded by sandstones and limestones of Proterozoic age on eastern and southern side and by the Bap boulder bed of Permo-Carboniferous age on the western side. Calcretes of Early Quaternary age and aeolian sands (dunes and sandsheets) of Late Quaternary age cover the pre-Quaternary bedrock formations. There are a few insignificant ephemeral feeder streams draining into the playa. According to Singh *et al.*[2] this region, especially west of Aravalli hill ranges, has experienced drastic climatic changes during the Late Quaternary.

As far as archaeology of this region is concerned, Middle Palaeolithic artifacts were discovered at Bari Dhani near village Bap[3]. Allchin *et al.*[4] discovered a few Middle Palaeolithic unstratified sites around Pokhran, Phalodi, etc. (A good number of Middle Palaeolithic and Microlithic sites have been found by Misra[5] in the Luni Valley, a region lying south of the Bap–Malar playa). None of these investigators had reported or hinted Acheulian artifacts and pottery in association with Microliths in the region under study.

On the basis of stratigraphy and geochemical studies of Bap–Malar playa, Deshmukh and Rai[6] opined that the presence of salts is of terrestrial origin. Similarly, one profile from Malar Rann was studied by Agrawal *et al.*[7] and their sedimentological, mineralogical and chemical analyses suggested significant fluctuations in lake level in the recent past. The lithostratigraphic observations on eight profiles from the same lake[1] reveal that the sediments are of aeolian origin at the base, whereas the upper levels indicate lacustrine environmental conditions before the final lake drying phase. Figure 2 shows the composite stratigraphical section as based on the sediment profiles of W9 and W10 up to a depth of 4 m, and other eight trenches having maximum depth up to 6.5 m.

On the basis of field character of the facies exposed, the stratigraphic column is divided into five major litho units (heareafter referred as units). The first unit, 0–60 cm, is dominated by bioturbated fissured clay, silt and sand. The second unit, 0.6–1.5 m, is composed of finely laminated silts with traces of gypsum and quartz sand. The third unit, 1.5–2.0 m, is comprised of finely laminated silty clay and gypsum sand. This unit is dominated by secondary growth of coarse gypsum crystals (selenite), indicating drying of the lake for some time. Unit four, 2–4 m, is comprised of silty clay laminae alternating with quartz sand. Unit five, 4–6 m, covers crudely laminated sands with occasional interlayering of faint laminae of silt and clay[1]. This unit is almost free from gypsum and rests unconformably on weathered red sandstone.

A significant number of pollen and spores are found in silty laminated clay of the unit 4 (2.5–3.0 m) of W10 profile. These are represented by morphotypes assignable to Cyperaceae, Gramineae, Chenopodiaceae/Amarantaceae, Compositae, etc. These indicate the presence of locally growing grasses, sedges in the stagnant water bodies and on the surrounding stable dunes. In view of the poor availability of pollen from the other units of the playa, it is difficult to envisage precise changes in

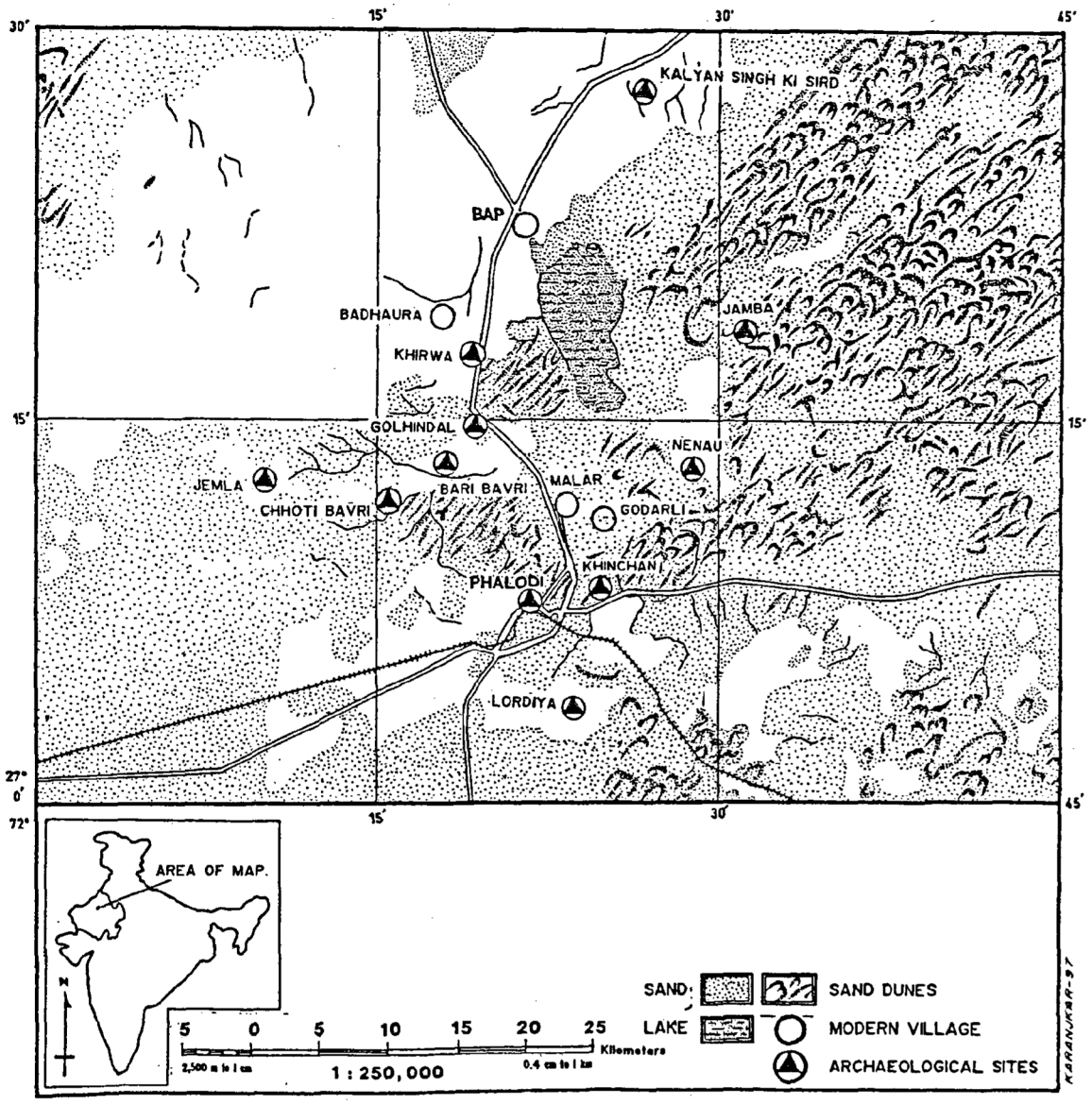

Figure 1. Archaeological sites around Bap–Malar lake.

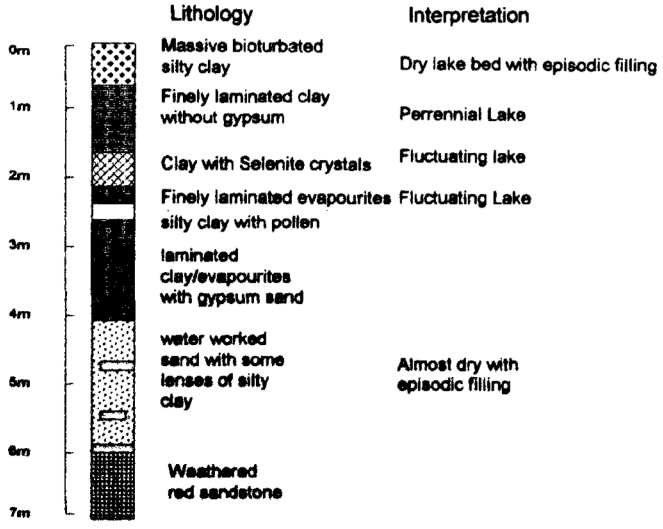

Figure 2. Composite stratigraphy of Bap–Malar playa.

the climatic and even hydrological conditions during the period of deposition of 6 m thick playa sediments. The preliminary clay mineralogical study shows variation in the amount of gypsum in different units. Its conspicuous presence in the form of laminae in the unit 3 indicates increased salinity due to the periodic drying of the playa[8]. The presence of megacrystals of gypsum in the unit 4 suggests that there was a desiccation of the playa surface during a certain period of time. The absence of gypsum in unit 5 suggests that there was a predominance of aeolian sands with high porosity, thereby permitting leaching of salts from the playa waters. The presence of weakly laminated bands of silt and clay within unit 5 shows that the playa was highly ephemeral and retained shallow water for a short period of time. Since the unit 2 is almost devoid of gypsum and bioturbation, it represents a lake-full stage with relatively freshwater conditions. The overlying unit 1 however, represents

shallowing water conditions and periodic drying of the lake surface. This is indicated by strong bioturbation and also by the presence of re-worked aeolian sand laminae. Briefly, the Bap–Malar playa was highly saline and shallow throughout its history of sedimentation except in unit 2, when the lake was more or less fresh-watered and perennial.

The preliminary ^{14}C and TL dates suggest that the Bap–Malar playa is not older than the terminal Pleistocene, and that the freshwater phase of playa, as inferred from unit 2, is of mid-Holocene age (A. K. Singhvi, pers. commun.). Moreover, the terminal aeolian activity of the surrounding stable dune, as at Jamba, is not younger than 7 ka. On the basis of the preliminary work, the lake appears to have dried up completely by 6 ka (extrapolated). This conclusion is also confirmed by chemical method (F/P ratio) of dating bones[9] found along with Microliths on a stable dune surface around the playa.

The dating of the bones older than Late Middle Pleistocene and later than Late Tertiary show F/P ratio between 6.5 and 8.5. While the bones belonging to terminal Pleistocene to mid-Holocene period have values between 1 and 2, and the bones of Late Holocene period generally show F/P ratio below 1.

It may be worth mentioning here that Singh *et al.*[2] had earlier suggested that the increase in rainfall in the semi-arid and arid belts of Rajasthan around 8000 BC led to the emergence of cereal agriculture in northwest India (quoted also in Misra[10]). Misra[10], however, differed from Singh's hypothesis of cereal agriculture, as he could not discover any convincing chalcolithic settlements in the Thar desert, particularly south of Bikaner and west of Sambhar and Didwana. Our discovery of the Microlithic sites with pottery of early mid-Holocene age right in the core of the Thar desert points out that the problem of early agriculture in the western Rajasthan is open for further research.

For collecting more evidence of human occupation during the lake-full stage, extensive exploration around Bap–Malar playa was initiated, and thirteen archaeological sites were discovered within the 50 km radius, ranging from Acheulian to early Historic in cultural traditions. The Late Acheulian/Early Middle-Palaeolithic site was found around Lordiya, about 3 km southeast of Phalodi, on the left bank of an ephemeral stream which deeply cut into cherty limestone gorge. It is situated about 20 km southeast of Bap–Malar playa. Earlier records of archaeological material from this area were essentially confined to sporadic occurrences of Middle Palaeolithic artifacts[4,5,6]. The handaxe discovered from the Late Acheulian site (Figure 3), which was made of quartzitic sandstone, as well as a few flake tools from the Middle Palaeolithic cultural tradition, were present in one meter thick regolith deposited over the limestone. While Late Acheulian (Figure 3) handaxe is in mint-fresh condition and has a characteristic desert varnish, the Middle Palaeolithic flake tools also made of quartzitic sandstone do not possess a desert varnish, but are wind-blasted. Though the late Acheulian handaxe and Middle Palaeolithic artifacts occur in the same regolithic context (a mixture of limestone blocks, chert and brownish silty sand), the handaxe appears to be older than the Middle Palaeolithic artifacts, especially in view of its distinct desert varnish. It is however very difficult to precisely date the late Acheulian handaxe due to the absence of any suitable dating material.

The Microliths and pottery of Chalcolithic tradition at Jamba and other sites occur in a weakly pedogenized calcareous dune sand of the mid-Holocene age (later than 7 ka and perhaps earlier than 6 ka). The pottery recovered from these sites is predominantly red-ware type, and is comprised of a few sherds which are painted black on red ware, a few representative types are shown in Figures 4, 5 and 6. The painted sherds are with a thin slip and some of them are painted on exterior or interior or on both the sides. The pottery, all considered, is well-baked, and some have incised designs resembling the Chalcolithic tradition. Besides pottery, a large number of Microlithic blades, fluted cores, and unworked flake tools (Figure 7) have been recovered from these sites. Table 1 lists the particulars of the artefacts recovered from the various sites. Some of the Microlithic blades (Figure 6) from Phalodi show resemblance with the blades from Harappa. The fragments of animal bones were analysed for fluorine to obtain relative dates of sites. The values of F/P ratio of bones is within the range of 1–2 in the case of sites at Jamba, Nenau, Phalodi and Khinchan. On the basis of Microliths and the F/P ratios of bones, the above four sites can be considered as belonging to the mid-Holocene[10].

The exact association of the Microliths and pottery is interesting from archaeological viewpoint, for nowhere in western India, have microliths with pottery been dated beyond 5 ka. These sites are therefore slightly older than the known sites—Harappan and Chalcolithic in northern and eastern Rajasthan and in north Gujarat including the Rann of Kutch. Our sites on dunes are connected with playa hydrology and possibly indicate some change in the cultural tradition of pastoral prehistoric inhabitants in the heart of Thar desert. Further detailed geoarchaeological and bioarchaeological studies, well supported by absolute chronology, will throw interesting light on these sites.

The archaeological sites like Bari Bawri, 10 km northwest of the Bap–Malar and Kalyansingh ki Sird, about 12 km north of Bap–Malar, which are associated with ephemeral streams, belong to the Late Holocene age, as indicated by F/P ratio of bones, (0.5 to 0.7). The ^{14}C date on charcoal recovered from a hearth buried in

Figure 3. Artifacts from Lordiya.

Figure 4. Pottery from Bari Bavri.

Figure 5. Pottery from Jamba.

channel sands is awaited. The formation of Late Holocene sites can be considered as a result of the drying of the playa, and their subsequent adaptation to the arid climatic conditions of the Thar desert. Similarly, the sites at Jemla, Khirwa and Phalodi (Figures 4 and 6) appear to be of late Holocene age as indicated by their F/P ratios of the bones which are less than 1 (Table 1).

The Bap–Malar playa came into existence during the terminal Pleistocene–Holocene transitional climatic phase. During early to mid Holocene or even also little later, though it was largely an ephemeral playa, it was semi-perennial to perennial. This lake-full phase was in response to climatic amelioration much within the boundaries of semi-arid climate. During this phase, the pastoral activity was presumably practiced on the surrounding stabilized sites on the dunes. We have attempted such a correlation between lake facies and the archaeological sites. Though the playa did not carry water in Late

Figure 6. Pottery and microliths from Phalodi.

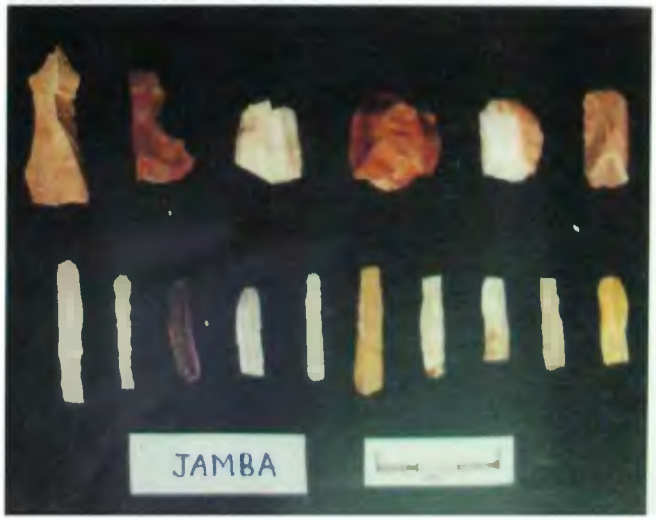

Table 1. Summary of archaeological materials and F/P ratios of bones from different sites

Site	Location	P	B	M	F/P_2O_5
Phalodi	2 km N of Phalodi on old Malar road	+	+	+	1.84
Phalodi old town	1 km W of Phalodi	+	–	–	
Jamba	8 km E of Malar lake	+	+	+	1.33, 1.28, 1.37
Nenau	5 km E of Malar lake	+	+	+	1.28
Khinchan	5 km E of Phalodi	+	+	+	1.14
Bari Bavri near tank	10 km NW of Phalodi	+	+	–	0.51
Bari Bavri near temple	10 km NW of Phalodi	+	–	+	
Kalyan Singh ki Sird	12 km N of Bap lake	+	+	–	0.71
Jemla	8 km W of Bari Bawri	+	–	–	
Hindal Gol	5 km SW of Bap lake	–	–	+	
Khirwa	5 km W of Bap lake	+	–	–	
Chhoti Bavri	9 km NW of Phalodi	+	–	+	
Lordiya	3 km SE of Phalodi	Handaxe and flake tools			

P, Pottery; B, Bone; M, Microlith,
+, present; –, absent.

Holocene period, human activity continued on the banks of ephemeral streams like Bari Bavri, during the Historical period. The antiquity of human activity in the arid core of the Thar desert also goes back to the Early Late Pleistocene or even earlier as indicated by the discovery of handaxe from Late Acheulian site.

From our studies it can be surmized that, the present arid core of the Thar desert recorded semi-arid to arid climate since the early Late Pleistocene, and provided ecological niches like ephemeral channels, perennial playas and stable dune surfaces with steppe-like vegetation during the late Quaternary .

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ACKNOWLEDGEMENTS. Financial support from the Department of Science and Technology, New Delhi, is gratefully acknowledged. We appreciate Prof. A. K. Singhvi and Dr S. Kusumagar for providing us with preliminary ^{14}C and TL dates. We also thank Drs V. D. Gogte and Sheila Misra for their help in XRD and tool-typology respectively. We are grateful to the Institute authorities for logistic support.

Received 15 December 1997; revised accepted 17 March 1998