I.

INTRODUCTION
The Saurashtra Peninsula, which forms a part of the state of Gujarat, lies between the Gulfs of Kutch and Cambay. On the north side it is bound by the Rann of Kutch and on the south and west by the Arabian sea. Its size and unique geographical position have provided many situations where the relationship between marine, transitional and continental deposits as well as associated land surfaces can be worked out. Saurashtra has been region where the environment has shown
a wide degree of plasticity in response to the changes that took place during the late Neogene or the Pleistocene and Holocene periods. Both the degree of these changes and their duration was such that Early Man was able to adapt to them.

In recent years a controversy has developed regarding the various epochs of the late Tertiary and Quaternary. It has been suggested that the distinction between Tertiary and Quaternary is invalid and rather artificial, because no significant stratigraphic or faunal discontinuity occurs between the Pliocene and Pleistocene as they are defined today (Flint, 1965; Hays and Berggren, 1971).

In the Saurashtra Peninsula, the Miocene is characterised by a marine microfauna designated stratigraphically as the Gaj beds. In the northwestern parts of the Peninsula the Gaj beds are overlain by what have been described as the Dwarka beds (Pedden, 1864). In the course of the writer's field studies similar fossiliferous beds have also been observed in parts of southeastern Saurashtra. The Dwarka series were assumed to belong to the Pliocene (Pascoe, 1964), but this distinction is now considered invalid both stratigraphically and faunally (Verma K.K. and Mathur U.B.-p.c.) It would, therefore, be tempting to use the
term "Neogene", for the time span covering the stratigraphic formations discussed in the present study, i.e., the period extending from the close of the Miocene to the present and comprising the post-Gaj formations. On the other hand the boundary between the Neogene and Quaternary continues to be a subject of dispute (IWGP, Italy, 1975). Therefore, in order to avoid confusion at this stage the writer has decided to retain, for the purpose of this study, the terms Quaternary, Pleistocene and Holocene.

"Late Quaternary studies on the Bhadar Valley - Saurashtra," (Lele, 1972), is to-date the only available palaeoenvironmental and archaeological study for Saurashtra. On the other hand there are numerous purely archaeological references to the Stone Age cultures of Saurashtra (Pandya, 1958, 1959; Rao, 1959; Sankalia, 1965; Soundra Rajan, 1967, Lele, 1968 etc.)

Detailed studies in prehistory and the palaeoenvironment were initiated by the classic monograph of De Terra and Paterson and later carried out in Gujarat (Zeuner, 1950; Johri, 1955; Pappu, 1974), Karnataka (Joshi, 1955; Pappu, 1974), Maharashtra (Rajguru, 1970; Pappu, 1974), Saurashtra (Lele, 1972), Northwest India (Allchin, Hegde and Goudie, 1972; Allchin and Goudie, 1974; Goudie, Allchin and Hegde, 1975) and coastal Maharashtra (Guzder,
1975). The investigations of De Terra and Paterson were based on the study of the glaciated terraces of northwest India while the other workers focused their attention on the Peninsular region. In the Deccan, Palaeoenvironmental and chronological studies were mainly based on fluvial morphology (Joshi, 1955; Rajaguru, 1970; Pappu, 1974). In Gujarat and Rajasthan apart from studying the fluvial morphology, considerable attention has been paid to fossil dunes, buried soils and coastal formations (Hegde, 1976; Rajaguru and Marathe, 1976) and it has been suggested (Allchin et al., 1972, 1974) that the present arid and semiarid parts of western India experienced drastic climatic changes during the late Pleistocene with the driest climatic phase occurring towards the close of the Pleistocene. Other workers are of the opinion that climatic changes during the Pleistocene were of a degree only and not of a kind (Lele, 1972, Rajaguru and Marathe, 1976).

With the exception of Gujarat and Rajasthan, neither the semiarid uplands of Karnataka (Joshi, 1955) and Maharashtra (Rajaguru, 1970; Pappu, 1974) nor the subhumid coastal tracts of the Konkan (Guzder, 1975) have preserved geomorphic evidence for any significant climatic changes during the Quaternary. There is no marked difference in climate between Saurashtra and the other semiarid regions of the subcontinent. In Saurashtra, however, the semiarid climate and the general configuration
of the landscape, have together produced a unique situation where the sedimentary facies have preserved the record of the interplay between marine and fluvial processes during the Quaternary. Furthermore, for the first time, Lower Palaeolithic artifacts have been discovered in a stratified context thereby conclusively establishing:

a) the existence of Early Man in this region at a very early date (Rajguru and Marathe, 1976), substantiated by the discoveries of Lower Palaeolithic tools in the Hiran (Marathe et. al., 1977), Sonarkhi (Marathe – in press) and Kalubhar valleys (S. Chakrabarty – p.c.) and Middle Palaeolithic tools in the Bhadar valley (Sankalia, 1965; Lele, 1968) and in Rajkot and Bhavnagar districts (S. Chakrabarty – p.c.).

b) that the theories of the submergence of the entire Peninsula during the Palaeolithic period, were no longer tenable.

The recent archaeological discoveries have opened up several fields of investigation e.g. the nature of eustatic, tectonic and climatic changes and their relationship with the prehistoric cultures of Saurashtra. As yet, nowhere in India is there a precise or complete record of the development of prehistoric cultures against
the background of environmental changes, though there exist independent evidences for the former (Chirki - Maharashtra; Bhimbetka - Madhya Pradesh; or Adamgadh - Madhya Pradesh) or the latter (Rajasthan, North Gujarat or Northwest India).

Perhaps, the best way to achieve a complete record of the correlation between cultural development and environmental changes is to concentrate on smaller areas. It is only after several regional sequences have been reconstructed that, correlation can be attempted among the different regions of the Indian subcontinent and other parts of the world. It is for this reason that the writer selected the Hiran valley (Fig. 1) in southern Saurashtra.

The Hiran river rises in the central Girnar hills (Fig. 2), flows a distance of 58 km and joins the Arabian sea at Prabhas Patan. In the source region the river flows on the Deccan Traps and once it enters the plain it flows on the miliolite formation. The variation observed in the geomorphology and vegetation in this river valley are largely due to the changes in altitude and precipitation. In the source region the vegetation comprises dry deciduous forest and the soils are of red pedifer type while in the drier parts of the valley further downstream the vegetation predominantly thorn-scrub and the soils are black, pedocal type.
FIG. 2. HIRAN VALLEY.
The Hiran valley was selected as a type area for detailed studies, although similar environments occur in the other parts of southern Saurashtra, e.g., the valleys of the Shingoda, Saraswati, Machhu and Meghal rivers and also along the coast (from Bhavnagar to Chorwar) as well as further inland (Rajkot and Girnar). Field work was carried out for a number of seasons (1972–76). Initially, the writer surveyed central, eastern and southern Saurashtra. Subsequently, work was concentrated in the Hiran valley where detailed studies were carried out on the stratigraphic sequence in the area (paying particular attention to miliolite formation), fluvial morphology (Characters of drainage basins and morphometric analysis) and coastal morphology (morphometric analysis of the Peninsula). A large number of samples were collected from fluvial sediments, inland and coastal miliolites and modern as well as fossil dunes and beaches. Wherever possible, well-sections were examined and the excavation sites for dams and bridges visited, in order to observe subsurface strata and to collect samples for laboratory analysis.

Laboratory studies comprise grain size analysis of fluvial silts, beach and dune sands and miliolite; total chemical analysis of silts and miliolites; Differential Thermal Analysis (DTA) of selected silt and miliolite samples, petrological examination of thin sections of miliolite and silt samples and lastly, observations on
selected samples of miliolite under a Scanning Electron Microscope (SEM).

Archaeological evidence was obtained both for the Lower and Middle Palaeolithic periods. Middle Palaeolithic artifacts comprise mainly surface collections. The majority of the Lower Palaeolithic artifacts are also surface finds with the exception of a few stratified tools found at Umrethi (lat. 20°1'N; long. 70°30'E) and at the base of Adi Chadi Wao, Junagadh (lat. 21°33'N; long. 70°31'E). The total collection is small, but the discoveries at Umrethi and Adi Chadi Wao are especially significant because these artifacts comprise the only available evidence for Lower Palaeolithic tools in a stratified context.

The Quaternary record is well preserved in the Saurashtra Peninsula and an attempt has been made to establish the nature of the changes in the palaeoenvironment, to assess their effect on cultural development and to assign a chronology to these events. The most controversial of the Quaternary formations is the miliolite. In the past, the extant inland miliolite deposits were emphatically ascribed either to marine (Srivastava, 1968; Bhatt and Patel, 1976; Lele, 1973 and 1975) or aeolian (Biswa, 1971; Sperling and Goudie, 1975; Agrawal and Roy, 1976) activity. The present study is an attempt to differentiate the various types of miliolites both from the point of view of their
origin and chronology and more particularly from the point of view of understanding man-land relationship during the Quaternary.

The pre-miliolitic topography is highly dissected and some of the rivers, like Hiran, reveal a buried channel adjusted to a base level 15 m below the present bed level. The miliolite formations rest unconformably on Deccan Traps, Gaj beds and fluvial deposits. It is suggested that the miliolite formations which occurred in the region under study can be divided into three types; marine or fluvio-marine and aeolian. Furthermore, it is possible to distinguish at least two phases of miliolite formation. The writer has hypothesised that both the miliolite formations as they are seen in the river valleys of Shingoda, Hiran and Sarasawati are the product of two separate marine transgressive phases. The earlier of the two miliolite formations identified and distinguished herein as M-I, is thicker and more extensive than the later formation, M-II. Both the miliolite formations are found to be interlayered by fluvial, tidal and aeolian deposits. The coastal dunes around Una, Kodinar and Veraval have developed during the regressive phase of the sea in the terminal phase of the late Pleistocene.

The occurrence of highly oxidised fluvial deposits overlying the M-I suggest a considerable time gap between
the two miliolite formations. This is substantiated by the
evidence of rejuvenation of the post-miliolite (M-II )
valleys. The interplay of fluvial, aeolian and marine
activities are well seen in sections exposed in the valleys
of Hirar, Shingoda, Saraswati and Sonarkhi. Both the M-I
and M-II formations in these river valleys are underlain
by fluvial deposits which have yielded a few Lower and Middle
Palaeolithic tools.

The evidence of Lower Palaeolithic artifacts found
in the fluvial gravels at the base of M-I both at Umrethi
and Junagadh indicate that Early Man occupied the slopes of
the Girnar hills prior to the beginning of the major
transgressive phase. It must be pointed out that, even
though sea level changes were a dominant factor in shaping
the landscape, neotectonic activity also appears to have
played an important role. These various aspects are discussed
in the succeeding chapters.

The remaining part of the thesis includes four
chapters. The second chapter deals mainly with the modern
environments and includes descriptions of physiography,
geology, climate and vegetation etc. Some of the data come
from published sources, the sections dealing with
geomorphology and the vegetational studies are based on
the writer's original observations. The chapter three
includes field observations and laboratory studies. The fourth
chapter has been divided into two parts. The part (A): Archaeology, includes previous work in the region, the writer's discoveries, terminology and detailed typology of the artifacts. The part (B): Palaeoenvironment, includes origin of the miliolite, Quaternary chronology, chronology of the Palaeolithic Cultures in Hiran valley, Palaeoclimate and Man-Land relationship. In the fifth chapter the writer has discussed both the archaeological and environmental data in the light of present knowledge of these factors in other parts of India and elsewhere.