The latest chapter of the earth’s history, the Quaternary Period that covers a time span of about last 2.6 million years (earlier 1.8My; Singhvi and Kale, 2008) has gained importance amongst the earth scientists due to its dramatic episodes and their relevance to the existence of human race. Rapid changes in the earth’s temperature and resultant fluctuations in the sea level during this period remained a subject matter of investigation world over. Obviously the coastal areas are of utmost importance to appreciate such environmental changes due to its potential of recording it in the form of oscillations in the land-sea interface. The evolution of coastal landscape is out of a net response of the land to various erosional and depositional processes that tries to maintain equilibrium between sediment flux, energy domains and accommodation space; in the case of a coast relative sea level and local tectonics define such morphodynamic evolution (Carter and Woodroffe, 1994). To differentiate local tectonic effect from the climate driven change in the sea level one needs a reference
curve known as the glacio-eustatic sea level curve. One widely referred sea level curve based on oxygen isotope studies of undisturbed marine sediments (foraminiferal tests) that could be translated to changes in the ocean water volume, is that of the Shackleton (1987; Figure 6.1). Accordingly, there occur at least five events of relatively higher sea level since ~350 kyr. These are termed as the Marine Isotope Stages (MIS) or Oxygen Isotope Stages indicated with odd numbers viz., MIS 1, MIS 3, MIS 5, MIS 7 and MIS 9. The stages indicated by even numbers represent intervening lower sea levels. Out of these, MIS 5 and MIS 1 had remained higher than the present sea level, while the MIS 2 represents latest significant lowering of sea level by about 110 m referred to as the Last Glacial Maxima (LGM). The global rise in the sea level, which accompanied the melting of great ice sheets of the last glacial episode, started ca. 14.5 kyr BP and continued with minor oscillations till the present sea level was reached. Mainly, there exists three views on the sea-level changes during the last 10 kyr viz., (i) the sea level underwent relatively large and repeated fluctuation from 1.5 m below to 3 m above the present level (Fairbridge, 1961); (ii) the sea-level has been lower than the present but, has maintained a continuous rising trend with an ever decreasing amplitude, before reaching its present level (Shepard, 1964), and (iii) the sea-level rose above the present level at about 5 kyr BP and oscillated between 2 m above and the present level (Baker and Haworth, 2000). However, for the Holocene (<11.5 kyr) time there is no general agreement for a global sea level curve (Pirazzoli, 1991). Therefore, region specific sea level curves should be referred to and such popularly accepted curves for Indian coast are
presented by Kale and Rajaguru (1985) and Hashimi et al. (1995) which are presented in Figure 6.2, with some additional data points from Saurashtra, an adjacent region to the study area.

![Figure 6.1: Global sea level curve and marine isotope stages after Shackleton (1987).](image)

The studies of Quaternary geological records in coastal areas of the Gujarat State have mainly remained focused on the carbonate deposits occurring all along the Saurashtra coast, famous among earth-scientists as the ‘miliolitic limestone’ or the ‘Miliolite Formation’ for its direct relevance to the Quaternary sea level changes and climatic fluctuations (Gupta and Amin, 1974; Brückner et al., 1987; Patel 1991; Juyal et al., 1995; Bhatt and Patel, 1998; Mathur and Pandey, 2002; Mathur, 2005; Bhatt and Bhonde, 2006).

In comparison, the Quaternary sediments from Kachchh have gained lesser attention. Although, the miliolitic limestone have been dated to range from 37 to 140 kyr from Kachchh using Uranium disequilibrium technique (Baskaran et al., 1989; Chakraborty et al., 1993). The miliolitic limestones of Kachchh are in general aeolian deposition on the hill slopes and fluvial reworking in the valleys; a conspicuous
absence of coastal miliolitic limestone is noticeable (Patel and Allahabadi, 1988; Bhatt, 2003).

![Figure 6.2: Holocene sea level curve for western Indian continental margin with added data points from recent studies (After Kale and Rajaguru, 1985; Hashimi et al, 1995).](image)

Recently Maurya et al. (2003a & b) presented a detail account of coastal Quaternary sediments with some radiocarbon ages of calcretes formed due to the pedogensis in fluvial sediments of Rukmavati, Naira and Nagwanti rivers of the coastal alluvial plain of south Kachchh. The fluvial sequence of the coastal plain of Kachchh consists planar cross-bedded gravels, sandy gravels, cross-stratified sand and silt with a red to brown coloured palaeosol from where the pedogenic calcretes
have been dated (18.9 to 24.3 kyr BP) to suggest pre-LGM fluvial activities and
weakening of the same (as indicated by pedogenesis) close to the LGM (Maurya et al., 2003). However, the coastal geomorphology of the Kachchh especially the
ancient mudflats and raised beaches have been discussed by previous workers with
tentative chronology linking them to about 6 to 2 kyr sea levels but, relating their
disposition to the tectonic uplift (Kar, 1993; Maurya et al., 2008; Patel and Desai,
2009). The review of available studies on geomorphology of the Kachchh coast
suggests the followings.

1. Based on geomorphology the Kachchh coast is divisible in to distinct
   segments like deltaic coast, irregular coast, straight coast, spit and cuspate
   coast, and mudflat coast.

2. The western part of the coastline characterize drowned coast while towards
   east it appears as emergent coast with a presence of palaeo mudflats.

3. The Median High passing through Mandvi-Mundra area has controlled the
two distinct domains on either side having sandy straight coast on its west and
mudflat coast on its east.

4. The occurrence of abandoned cliffs amongst the tidal flats, moderate cliffs in
the tertiary rocks, abandoned river mouths due to the mouth bar formation,
fringing of mudflats by palaeo mudflats, etc. have been considered to be a
manifestation of tectonic uplift in recent time.

The present author is of the opinion that all these features can also be explained in
relation with the coastal sedimentary processes and the Holocene sea level history of
the region. Particularly the occurrence of similar landforms at same elevation along
the coast of Saurashtra and South Gujarat, and also some part of Maharashtra raises a
question against such a simplistic interpretation (Merh, 1987; Patel, 1991; Mathur,
2004). The study discussed in the previous chapters is summarized in the following
text to appreciate these. The dependable geochronology albeit can constrain the
evolution history and can also identify the tectonic episodes more precisely. This part
could not be attempted in the present study.

Coastal Landscape

Coastal areas are known to respond the sea level changes and sediment fluxes by the
formation of unique landforms that include single to multiple terraces and lateral
g geomorphologic variations (Ramirez-Herrera and Urrutia-Fucugauchi, 1999). To see
the reflection of neotectonics and sea level changes in various geomorphic landforms,
çostal geomorphic study was attempted and discussed in detail in chapter 3. The
Gulf of Kachchh is a macrotidal environment and its coast is characterized by sand
composed geomorphic landforms like beaches and backshore dunes in its western or
mouth areas that stretch between Jakhau and Bhada facing the wave dominant coast
of the Arabian Sea whereas, wide mudflats occur in the eastern tide dominating part
or head ward areas of the Gulf of Kachchh. The geomorphic assemblage indicates
that the Bhada-Mundra segment of the study area acts as a transition zone between
the sand rich coast in its west and the mud rich coast towards its east due to a mix
wave and tide dominating nature of the coast. The amalgamated beach-ridge complex
at Modwa is prograding along its eastern end. In continuation of its extent and orientation some distinct sand ridges can be seen surrounded by the active mudflats in this segment. These ridges are not receiving sand anymore, as the eastward progradation of the Modwa beach-ridge entraps the sediments transported by littoral drift. This has cut off the sand supply to these sand ridges. Some narrow chennier ridges however receive sand near low water line as the tidal waves carrying fine sand from the offshore shoals breaks here. Such abandoned sand ridges therefore indicate a change in sediment dynamics but, not necessary a tectonic uplift. The coast between Mundra and Kandla shows the presence of extensive mudflats which are about 1.5–2 km in width. The mudflats are silt and clay dominated landform that gradually becomes clay rich eastwards. The mudflats receive suspended sediments at slow but steady pace, which are not eroded after deposition due to their cohesive nature and currents of lower energy. Thus, they define a prominent ‘sink’ for the suspended sediments in the Gulf of Kachchh. Surface suspended sediment concentration in this head ward region of the Gulf of Kachchh reaches up to 443mgl$^{-1}$ (Ramaswamy et al. 2007). Thus, the Kachchh coast has three distinct energy domains from west to east that characteristically provide sub sinks to selected size fraction of sediments under transportation. This also partially sort out the sediments from two end provenance viz, Indus River and Kachchh hinterland. The sand dominating straight coast running between Pingsleshwer and Layza has a narrow coastal zone that accommodates the sand size sediments derived from the Kachchh hinterland brought to the coast by the rivers like Nayra, Kharod, Rukmavati and debouched against a strong littoral drift.
Obviously the beaches, bermplain, foreshore and backshore dunes are repository of these sediments. Whereas, the suspended sediments manages to travel further to form the mudflats with decreasing effect of the tidal currents. On a gross look, similar conditions have prevailed on the Kachchh coast since Middle Holocene. Therefore, in the present study much emphasis has been given to understand the sediments and their dispersal system that finally shape out the coastal landscape.

**GPR Studies**

Recent advances in geophysical exploration techniques have made it possible to understand the shallow subsurface sedimentary architecture, especially in the sand bodies (Jol et al., 2002; Neal, 2004; Switzer et al., 2006; Lindhorst et al., 2008; Shukla et al., 2008; Bennett et al., 2009; Garrison et al., 2010). GPR studies were attempted in the study area and details are discussed in chapter 4.

GPR studies in Bhada-Mundra segment demonstrate recognition of various sedimentary reflectors that can be suitably interpreted as bounding surfaces and facies, manifesting a gross sedimentary architecture of the body. The study indicates major radar surfaces that delineate depositional facies, reflecting the dynamic nature of this beach ridge system. These bounding surfaces and radar facies delineate beach ridge (br), washover (wo), coastal dune (cd) and swale (sw) depositional facies. Similar facies have been identified by adopting the principles of radar stratigraphy in the coastal areas of England (Neal and Roberts 2001; Neal et al., 2002; 2003). The
GPR data and the surface expression of the amalgamated beach ridges, outlined by vegetated linear swales, confirm the progradation history of the Modwa beach.

The GPR profiles from the coastline of Kachchh show a presence of prominent beach ridge system at 2 – 3 m depth in the segment between Layza Nana and Modwa, which probably could be imprints of low stand of sea just before the Middle Holocene. Also the conspicuous presence of washover deposits from all the profiles point towards the high energy events (storm?) coeval to a transgressive phase whereas, the more inland presence of stabilized coastal dunes could be related to higher sea stands. After the LGM, the Gulf of Kachchh started getting inundated by ~15 kyr as inferred on basis of radiocarbon dates of dolomite crust and corals from the offshore (Rao et al., 2003). The global and regional sea level history of western India (Fairbank, 1989; Kale and Rajaguru, 1985; Hashimi et al., 1995) shows lower sea level then present in the Early Holocene. The beach ridge facies documented in present study would have acted as an active berm ridge / foreshore dune along the coastal configuration just before Middle Holocene high stand (Figure 6.3a). The sea level kept on rising and about 6 kyr BP it reached its peak with a high stand of 2 – 4 m above present day mean sea level (Hashimi et al., 1995; Rao et al., 1996; 2003). Owing to this high stand coastal dune building activity took place, which can be presently seen in the form of wide stabilized coastal dune field. Such stabilised dunes linked with higher sea level during this period are also reported from the Gujarat plains, Nal Sarovar-Bhal area and coastal Saurashtra (Patel, 1991; Prasad et al. 1997; Chamyal et al., 2003; Juyal et al., 2003). The period also witnessed seasonal high
energy events along the Kachchh coastline, which have been documented in present study in the form of washover deposits and formation of swales in between successive foreshore dune ridges (Figure 6.3b). It is believed that after reaching the peak at 4 kyr BP the relative sea level started to recede and since 2 kyr BP the present day coastal setup had been established (Figure 6.3c). Tectonic uplift along the coastal segment have been cited as reason for sea level to fall rather than glacio-eustacy, owing to active tectonic setup of Kachchh. However, in absence of stratigraphically or geomorphologically constrained ages the present author refrain from concluding tectonic uplift in this study.

**Sediment Texture and Composition**

To examine the nature of sediments constituting various geomorphic units on the Kachchh coast, grain size and mineralogical analyses were done following standard laboratory procedure and the results of the same are presented in chapter 5.

The statistical parameters like skewness, kurtosis, standard deviation and mean of the sand dominated coarser than 63micron sediments from different sub environments were calculated and standard deviation values were plotted against the skewness values on standard discriminatory plots of Friedman (1967), which suggested that most of the samples correspond to riverine environment and very few to marine environment (Figure 6.4). This is supplementary to the inference that this segment acts as ‘sub-sink’ for coarse sediments which are mostly derived from hinterland rivers.
Figure 6.3: A schematic model of relative change in sea level and response of the sandy segment as inferred from GPR studies.
Geomorphologically, this stretch of coast consists of two major zones: the straight and sandy segment between Pingleshwar and Layza Nana and the transition zone from Layza Nana to Rawal Pir (Prizomwala et al., 2010). The result of the granulometric analysis shows the fining in sediments and the increase in standard deviation from the west toward the east (Figure 6.5).

Figure 6.4: Discriminatory plot (Friedman, 1967) of sand samples from Kachchh coast indicating its derivation from river environment and a very less effect of marine transportation.

The Kurtosis values decrease from the west to the east, indicating increased bimodality in grain-size distribution, which is due to the mixing of varied sediment sizes transported in the longshore currents and supplied by the coastal rivers.
(Kankawati, Kharod, Rukmawati, etc.). The increased negative skewness of the intertidal microenvironment is indicative of strong wave actions leading to fine sediments being washed away. The granulometric characteristics of the dune, berm plain, berm, and intertidal microenvironments are indicative of nearshore mixing and subordinate sorting of sediments supplied from two distinct sources viz., the distal Indus River mouth and the proximal Kachchh mainland.

Hitherto, it was thought that the River Indus was the only major source of sediment in the region because it is the region’s only perennial river, and the Kachchh falls within arid/ hyperarid climatic regime (Chauhan, 1994; Chauhan et al., 2006; Ramaswamy et al., 2007). The Kachchh mainland has numerous coastal seasonal rivers, and the arid climate characterizes the coastal fluvial systems with no/sparse vegetation on its channel banks. Typically, such dryland rivers are highly susceptible to the erosive effects of flash floods because of limited resistance from the sandy bank material and the sparse vegetation (Tooth, 2000). Some previous studies have found that dryland rivers are likely to transport large quantities of sediments during flood events, both as suspended load and as a bed load (Reid and Frostick, 1997). Hence, the absence of any perennial river in the Kachchh mainland doesn’t prevent it from being a source of sediment supply within the Gulf of Kachchh.
Figure 6.5: Relationship between different statistical parameters derived from the granulometric analysis of the sediments from sandy segment of the Kachchh coast (P: Pingleshwer, K: Khuada, C: Chhachhi, L: Layza, M: Mandvi, R: Raval Pir).
(a) Mean, (b) Standard Deviation, (c) Kurtosis, and (d) Skewness values from different station; (e) variation in Mean and (f) variation in Standard Deviation from west to east.
The distinction between sandy outer coast and muddy inner coast can also be linked with the presence of a barrier across the Gulf of Kachchh between Mundra and Vadinar that controls the tidal currents and movement of sediments within the Gulf of Kachchh (Vethamony et al., 2005). The compositional studies of the fine grained fraction using XRD analysis have revealed dominance of illite and chlorite, and lesser amounts of kaolinite and montmorillonite. The sediments delivered from Himalayan rivers like Indus and Ganga-Brahmaputra are rich in illite and chlorite, while sediments derived from peninsular Indian source are rich in kaolinite (Goldberg and Griffin, 1970; Kolla et al., 1976; Naidu et al., 1985; Chauhan, 2006). This major difference in physical and mineralogical characteristics of these sediments makes it possible to distinguish the provenance of the offshore sediments in the Gulf of Kachchh (Ramaswamy and Nair, 1989; Ramaswamy et al., 1997; Chauhan et al., 2006). The rivers from Saurashtra and Kachchh which debouch into the Gulf of Kachchh drain from Deccan Trap Formation basalts, but due to their lower discharge the amount of montmorillonite is negligible. The dominance of illite and chlorite also indicate that the Indus river is a major source for the clay minerals in the Gulf of Kachchh. The presence of montmorillonite in the samples from the southern coast of the Gulf at Jodiya and Pindara (Figure 6.6) (Prizomwala et al., 2010) is due to the filtering of most of the Indus borne clay sediments in the sediment sink in headward area and nearness of weathered basalt source to these stations.
The coast between Mundra and Kandla is acting as a sink for suspended sediments. A north-south zone between Mundra and Vadinar in the Gulf of Kachchh has suspended sediment free zones habitat to the corals in the offshore. The occurrence of carbonate sediments, which are mostly molluscan shell fragments, coralline debris and foraminiferal tests, show that the northern and eastern part of the Gulf of Kachchh provide pathways for the Indus born fine sediments and locally derived coarse sediments with sub-sinks for coarse and fine sediments that are deposited into beach ridges and mudflats. The head area of the Gulf of Kachchh
forms a large sink for most of the suspended sediments and thus, the southwestern coast receives mainly locally derived detritals from the hinterland that mix with offshore derived carbonate sands.

Sedimentary processes, such as weathering, physical abrasion, and hydrodynamic sorting during transport, storage, and diagenesis may obscure the sediment provenance signature (Morton and Hallsworth, 1994). The heavy-mineral assemblages have still long been regarded as strong indicators of sediment source (Garzanti et al., 2005; Garzanti and Ando, 2007). Garzanti et al. (2005) have documented the heavy-mineral signatures of the Indus River sands in a study of the sediment provenance of areas of the Himalayas and the palaeo drainage changes recorded by clastic wedges deposited in the Himalayan foreland basin and the Arabian Sea. River Indus traverses through granitic, gneissic, and various grades of metamorphic terrain and is rich in tourmaline, zircon, staurolite, sillimanite, biotite, and muscovite (Mallik et al., 1976; Chauhan, 1994; Garzanti et al., 2005). Because the Kachchh mainland is devoid of any metamorphic or granitic source, the presence of these minerals in considerable amounts along the coast can be attributed to the longshore currents, which redistribute these minerals along the entire coast. The heavy-mineral analysis strongly distinguishes the sediment provenance of different sources along the coastline by contrasting and characteristic lithologies in their catchments. Based on mineralogy, there are three distinct sediment provenance assemblages:
• tourmaline–zircon–biotite–muscovite mineral assemblage, indicating a granitic–gneissic source;

• staurolite–sillimanite assemblage, indicating medium- to high-grade metamorphic source; and

• diopside–magnetite assemblage, indicating a Deccan Trap basalt source.

The granitic–gneissic and medium to high-grade metamorphic source can be linked to the Indus River catchment because, it is known to carry these sediments and also to the absence of such parent rocks in the Kachchh hinterland. Because Deccan Trap basalt is present in the Kachchh mainland, its derivatives can be considered to be solely of hinterland/Kachchh mainland origin. Figure 6.7 shows relative percentage of these three distinct assemblages at different locations along the coast.

It clearly shows how the River Indus source sediments are dominant in heavy-mineral assemblages at Pingleshwar, and thereafter the Kachchh mainland (i.e., Deccan Trap Formation) source dominates in the sand fraction of the sediments. The enrichment in heavy minerals from Chhachhi eastward indicates that the Kachchh mainland is a rich source of heavy minerals, which seems to have been governed by the Deccan Trap basalts in its hinterland. The lower concentration and the less distinctive mineralogical trends in heavy mineral distribution at Khuada can be explained by the geological setup of the Naira River basin just west of Khuada. Naira flows through Tertiary and Quaternary sediments and covers a lesser extent through
Figure 6.7: Heavy mineral analysis of intertidal sediments along the coast showing relative abundance of different end members.
the Deccan Trap rocks, which is again seen in less concentration in the Deccan Trap–
derived sediments at Khuada.

Dominance of Indus-born sediments at Pingleshwar is due to the direction of
the currents in the region, which are toward the east (Nair et al., 1982a) and
Pingleshwar is situated west of the Naira River mouth.

Microscopic studies confirmed the presence of muscovite and biotite as
dominant mica minerals in >63micron sediment fraction. The Cretaceous, Tertiary
and Quaternary formations of Kachchh have major lithology like basalt, sandstone,
shale and limestone whereas, Saurashtra has Late Cretaceous basalt and lateritic rocks
with a cover of Tertiary shale and limestone. These are devoid of mica which is a
major product of metamorphic terrain. River Indus travels through a varied lithology
including high-medium grade metamorphic, igneous and sedimentary rocks of
Himalaya and debouches about 50 x 10^6 tons of sediments annually into the Arabian
Sea (Chauhan, 1994; Garzanti et al., 2005). Part of these sediments travels under the
influence of long-shore currents to enter the mouth of Gulf of Kachchh and moves
eastwards. River Indus is known to have a significant amount of mica in its sediment
load (Mallik, 1976; Garzanti et al., 2005; Chauhan et al., 2006). The mica minerals
being flaky in nature are capable of being transported for longer distances in
suspension due to their shape. It is estimated that >63micron size of mica grain has
similar transit mechanism as of silt size quartz being transported by suspension
making them hydraulically equivalent (Doyle et al., 1983). Figure 6.8 depicts
variation in the concentration of mica along different parts of the Gulf of Kachchh coast viz., outer subsink, transition zone, inner sink and the gulf mouth.

The straight coastal segment between Jakhau and Bhada is consisting of sandy landforms like beaches and dunes, and exhibits higher concentrations of mica minerals (Figure 6.8). Koteshwar is the most proximal station to mouth of River Indus and is situated near Kori creek. It has highest concentration of mica (24%). This higher concentration of mica minerals is linked with its proximity to the River Indus mouth. The lithoclasts concentration varies from 2-8%. This is due to the coastal rivers which debouch their load with increasing lithoclast proportion mostly derived from basalt and sandstone country. The sediments of this segment have provenance signatures from Kachchh mainland in the form of increase in lithoclast percentage and from the River Indus as mica minerals.

The coast between Bhada and Mundra hosts both, sandy landforms like wide beaches and dunes as well as muddy landforms like mudflats. The >63micron fraction from the mudflats exhibits a comparatively higher concentration of mica minerals (14-15%) than that of the sandy landforms (12-13%). The concentration of lithoclasts is low to about 2-4%. Studies on mudflats worldwide have shown that mudflats act as major receptors of suspension load (Allison et al., 1996; Kuehl et al., 1996) and are potentially good archives to palaeo-environmental changes. Due to longer residence time of sediments in mudflats the relative concentration of mica minerals in mudflats is more than sandy landforms.
The inner most part of the Gulf of Kachchh is predominantly composed of monotonous mud bearing landforms i.e. mudflats. The mica mineral concentration is varying along the northern and southern coast of Gulf of Kachchh. Higher concentration of mica minerals is seen in mudflats of the Gulf of Kachchh coast i.e. Mundra (15%), Bhadreshwar (12%), Jognimata (10%), Gandhidham (14%) and Kandla (13%). These stations being distal ones compared to the stations of previous segments should continue a decreasing trend of mica concentration. However, a slight increase in mica concentration is seen at stations 10 and 11 that supplement the fact that mudflats act as ‘sub-sinks’ for the sediments being transported as suspension load in a sediment transit system. The southern coast having wide mudflats shows lesser concentrations of mica minerals with increased lithoclast and carbonate proportion as seen at stations 18 to 20 (Navlakhi, Jodiya, Bedi and Vadinar). The reason for this drop could be an increase in locally available sediments from the Saurashtra being transported by the rivers like Machchhu, Aji, Rangmati, Ghi, etc. These largely basalt derived sands suppress the relative proportion of mica in the >63micron sediment fraction in the mudflats.

As per the current understanding (Nair et al., 1982; Guptha and Hashimi, 1985; Kunte et al., 2003; Deshmukh et al., 2005) a tidal barrier exists across the Gulf of Kachchh that prevents Indus load from reaching directly southward to the Arabian Sea and diverts that towards the Gulf of Kachchh. The longshore currents move eastward along the northern flank of Gulf of Kachchh till they reach to the head of the Gulf of Kachchh, and continues to flow along the southern flank to finally exit the
mouth at Okha from where they are throwing the sediments at depths of >200m into the Arabian Sea. A small portion of it is transported southward along the Saurashtra coast. This inferred sediment transport model was proposed on basis of mica and clay mineral distribution in and off the mouth of Gulf of Kachchh that has shown reduction in amount of mica and lack of variation in amount of clay minerals south of the tidal barrier. The presence of tidal barrier has been attributed to the higher amount of Indus sediments off the mouth of Gulf of Kachchh and dominance of characteristic peninsular load off the Saurashtra coast (Nair et al., 1982a & b). However, this variation can also be explained on simple basis of ‘vicinity and proximity of sources’ off the Gulf of Kachchh mouth and Saurashtra. Note the trend of mica distribution all along the coast of Gulf of Kachchh (Figure 6.8). If the presence of tidal barrier which effectively reduces the movement of mica across the gulf mouth, the amount of mica should subsequently reduce all along the coast and it should become negligible at the southern mouth of Gulf of Kachchh. However, an anomalous increase at southern mouth of the gulf has been noticed in our study (i.e. stations 22-Pindara and 23-Okha). This implies that there exists a very complex movement of currents in and off the mouth of Gulf of Kachchh, which are seasonally dynamic as supported by study of suspended sediment transport using OCM satellite imagery by Kunte et al. (2003). During summer the dominant currents in and adjacent to the gulf are southward, southeastward and east-west which controls the movement of Indus sediments and makes them to enter the mouth of Gulf of Kachchh and travel all along the northern flank, up till they reach the head of the gulf and then travel along the southern flank.
to finally exit the mouth. During winter months dominant current direction along the northern coast of Gulf of Kachchh remains southeastward and eastward whereas, currents move northward along the Saurashtra coast and partly enter in to the mouth of the gulf.

On account of this, the increase of mica at southern mouth of the gulf can be explained by two ways;

(1) The tidal barrier is ineffective in restricting the movement of mica across gulf mouth, due to transit mechanism of mica minerals being in suspension.

(2) The southern flank of mouth of gulf receives mica from the seasonally northward and northeastward currents.

As stated earlier, fine to very fine mica grains behave hydraulically identical to silt size quartz (Doyle et al. 1983). Therefore, an anomalous increase of mica mineral concentration in >63micron sediment fraction from 5% at Vadinar to 10-12% at Pindara and Okha points more likely towards direct transport of mica from north as River Indus is well known rich fluvial source of it (Mallik, 1976; Garzanti et al. 2005; Chauhan et al. 2006). In absence of this possibility the increase in mica mineral concentration would not be of considerable amount, due to the lack of mica minerals in the country rocks of northern Saurashtra and near shore currents of the Arabian Sea in this part of the region. The second possible mechanism requires enough proportion of mica in the Arabian Sea near to Okha. Moreover, if it is true then seasonal variation in the concentration of mica should be there which is not yet noticed.
In general, the present study has demonstrated the sediment dispersal system along the Gulf of Kachchh coast that receives the sediments from distal source, like Indus River and proximal source like Kachchh hinterland which gets mixed in the coastal environments and subjected to relative sorting under the influence of the strong tidal currents. Further reworking of these sediments transfers the sediments from intertidal areas to the foreshore and backshore zones to give rise to the berm plain, foreshore and backshore dunes and also thin sand sheets with varying width of the coastal zone. As the whole coastal sedimentary package rest on the fluvial sediments constituting the coastal alluvial plain that has stabilized by ~20 kyr (Maurya et al., 2003b), the sequence under study should be linked with the relatively higher sea level during the middle Holocene that shows now a low stand. The stratigraphic relationship between the various coastal sequences, younging towards the shore (an onlap sequence) further supports this inference. However, chronology of the geomorphologically or stratigraphically constrained samples is highly warranted to identify any anomaly directing towards the neotectonic uplift of the area. Only available geochronology on the Gulf of Kachchh coast suggests 11040-10430 and 10150-9530 cal yr BP age of the mudflats at 1.3 and 2.0 m depth near Navlakhi, below this depth the substrate of Deccan Trap basalt was encountered (Rajshekar et al., 2004). The present arguments like lateral discontinuation of raised beaches, occurrence of rocky shore platforms, closure of river mouths by mouth bars, siltation of tidal channels, incision of coastal rivers and the presence of palaeo mudflats considered as a manifestation of neotectonic uplift (Kar, 1993; Maurya et al., 2008)
can also be explained by lateral sedimentary facies variation due to coastal processes and sea level change. For example, the present disposition of sandy and muddy landforms along the Kachchh coast clearly suggests their formation due to change in the energy condition and shoreline configuration from the west to the east. Similarly, in the arid and hyper-arid area like Kachchh the rivers are seasonal and their runoff can not flush out the sediments deposited by strong long shore currents in its mouth area and thus form typical yazoo pattern. The upwarping of the coast is therefore not necessary. The incision of fluvial sequences that are older than ~20 kyr could be linked with the sea level drop during LGM. However, this does not rule out the neotectonic activities in Kachchh; only objection is to its appreciation from the coastal landscape. It is therefore, necessary to identify the changes in the coastal sediment fluxes during the Holocene with its dependable chronology to decipher the real neotectonic effects in the coastal area. This can be attempted from the mudflat areas as they represent an archive with negligible erosive effects. The absence of coastal deposits related to the MIS 5, which are otherwise very distinct in the adjacent coastal areas of Saurashtra further needs to be explained while building the Quaternary history of the Gulf of Kachchh.