Chapter 2

BACKGROUND INFORMATION

2. BACKGROUND INFORMATION

The region taken up for detailed studies falls in the state of Gujarat, western India. Within Gujarat it is part of a vast tract of land commonly classified as Mainland Gujarat. The area encompasses a latitudinal traverse of 2° within the tropic of Cancer and is enclosed between latitudes 22°50'N & 23°45'N and longitudes 72°45'E and 74°E. It is covered by Survey of Indian topographic sheet numbers 46 B/15, 46 F/2,3,5,6,8,12,15, 46 A/12,14,15,16.. (Fig. 2.1, 2.2, 2.3). More details regarding climate, rivers and soils are described in the following paragraphs.

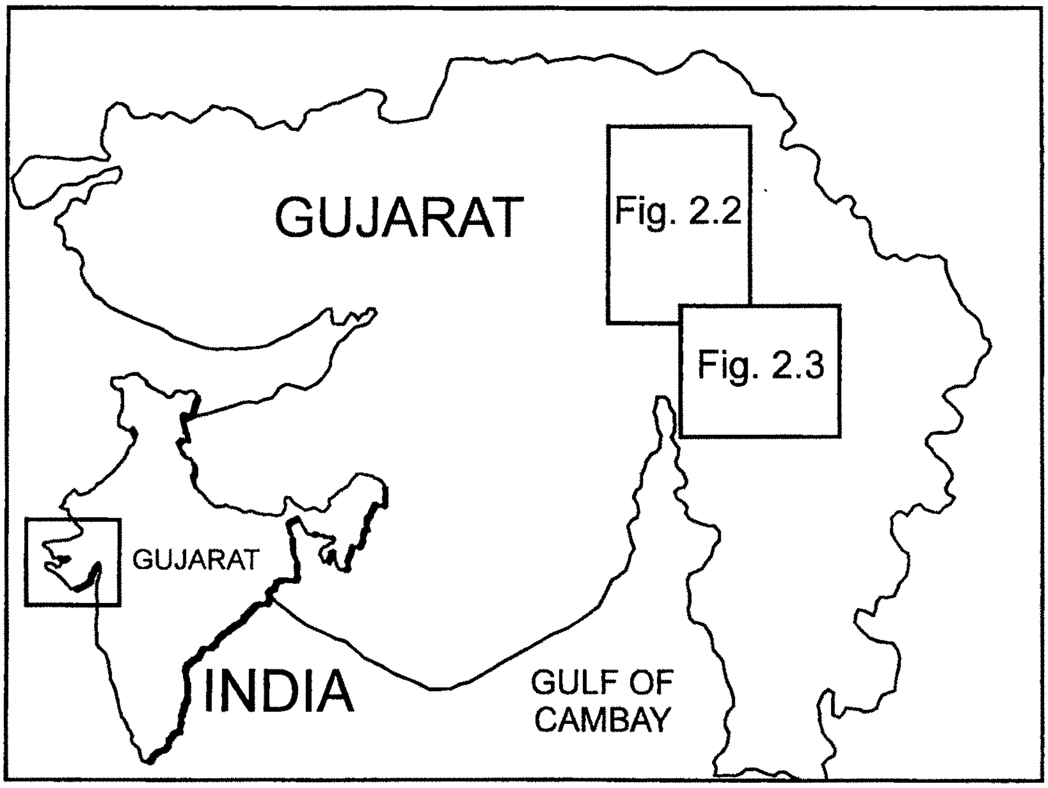

Figure 2.1: Location map of the study area

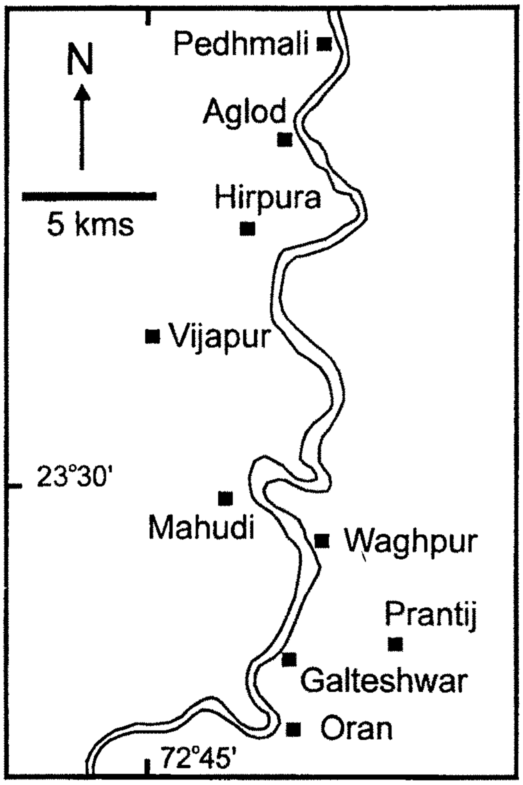

Figure 2.2: Locations of sites studied in the Sabarmati basin. Note that all sites are along the river banks only, although the nearest town/city used as the landmark is away from the bank (e.g. Vijapur).

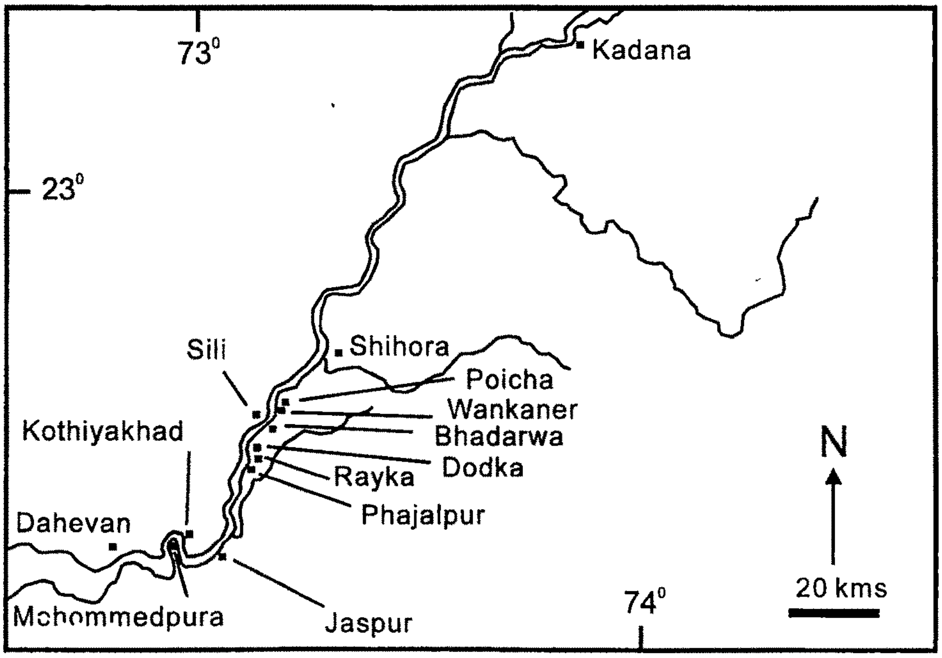

Figure 2.3: Locations of the Mahi basin. All the sites studied are along the river banks only.

2.1 Climate

The state of Gujarat comes under the influence of the southwest Indian monsoon. In contrast to mid-latitude climates tropical regions are characterized by a seasonality in the annual hydrograph. Through the year, these regions receive precipitation over a period of four months beginning in June.

In Gujarat the regional rainfall isohyets decrease towards northwest (Fig. 2.4). Mean annual rainfalls are highest in southeastern Gujarat. This region falls south of the sites studied along the Mahi river. Towards north of Gandhinagar, in areas close to Himmatnagar mean annual rainfalls are around 500 mm.

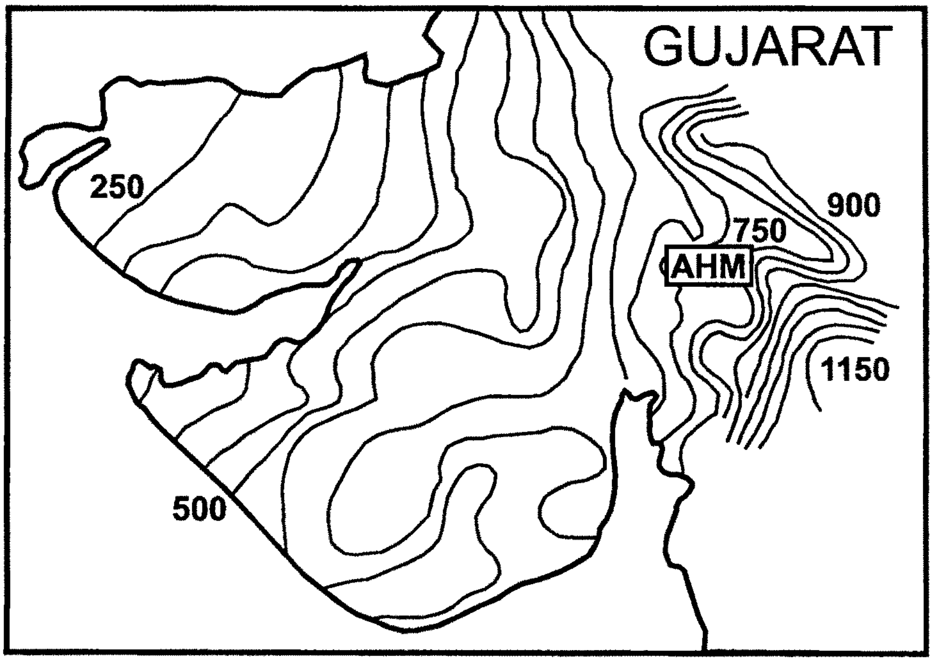

Figure 2.4 : Rainfall isohyet map of Gujarat. AHM=Ahmedabad (from Merh, 1995)

2.2 Rivers

The Gujarat Alluvial Plains are dissected by two major roughly north-south flowing rivers; the river Sabarmati and the river Mahi. The Sabarmati river originates in the Aravalli hills in Rajasthan. It has a catchment area of 21,674 km^2 and flows for around 300 km before reaching the Gulf of Cambay (Rao, 1979). The Mahi river on the other hand begins in the Vindhyas, has a length of around 533 km and its catchment covers an area of 34,842 km^2 (Rao, 1979). Both rivers are characterized by an asymmetric distribution of tributaries on their east bank. Both rivers have high width/depth ratios and steep banks that cut into an older succession of deposits. In the river Mahi prominent inset terraces are observed that increase in size towards the mouth.

The sediments that build up these terraces are gravelly upstream while at the mouth near Kothiyakhad interlayered herringbone sands and laminated organic clays containing foraminifers are observed. Preliminary dates on the terraces in the Mahi river suggest an aggradation between 4 ka BP to 2 ka BP (Kusumgar et al., 1998). followed by yet another incision event.

The rivers Mahi and Sabarmati are highly seasonal with peak discharges in the months of July to September (Fig. 2.5). This behaviour is observed in rivers of the tropics that are characterized by such a marked seasonality. This results in a nested channel pattern (Gupta, 1995). Such a pattern includes a larger channel for storm induced higher discharges and a small channel for high discharges for periods between successive storms. A typical adjustment to two sets of discharges is the development of a box shaped channel with steep banks (Gupta, 1995).

The catchments of both rivers (i.e. Mahi and Sabarmati) receive rainfall during the summer monsoon. Hence, ideally periods of high discharges in the Mahi would correspond to similar intervals in the Sabarmati. Such a correspondence should ideally be expected at all temporal scales. Figure 2.6 shows log-log plots of discharges at two stations (Sabarmati = Ahmedabad; Mahi = Itadi) for the 1965-1966 flood.

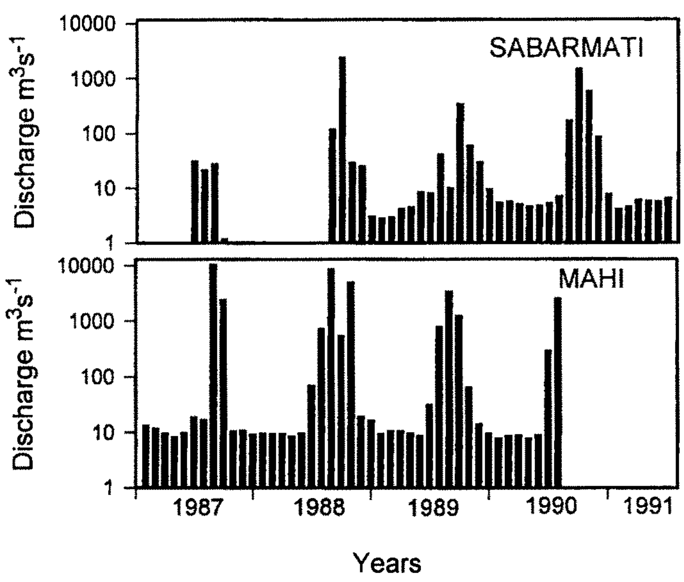

Figure 2.5 : Time series plot for the year 1987-1991 of monthly maximum discharge for the rivers Mahi and Sabarmati. Note the highly seasonal nature of water flow in both rivers and the close correspondence between periods of high discharges in both rivers (Data source: Water Resources Division, 1987-1991).

Discharges for each day were compared for these stations and plotted against each other (Fig. 2.6). A one to one relationship should have resulted in a line beginning at the origin and extending to the upper right corner of the plot. However this is not the case and there are several instances when the Sabarmati experiences high discharges (>5000 m^3s^{-1}) while the Mahi does not. Such discrepancies arise only at a 'daily' scale. At a monthly temporal scale there is a remarkable correlation between high discharge events in the Mahi and Sabarmati river basins (see Fig. 2.5).

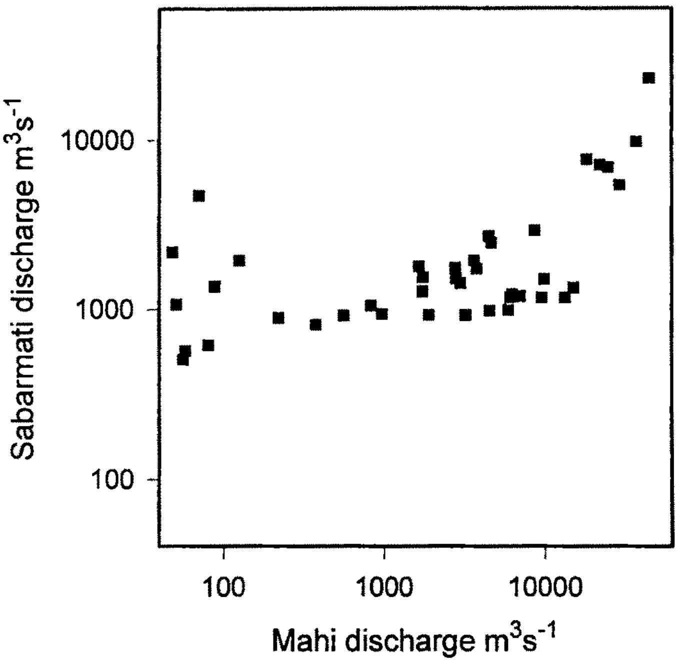

Figure 2.6 : Bivariate plot of daily discharge in the Mahi and Sabarmati rivers during the 1965 flood. During days of large floods discharges were of a similar maginitude in both rivers. The scale is logarithmic for both axis. (Data source: Water Resources Division, 1966)

This implies that years of very high discharges were geomorphologically and sedimentologically significant in both the river basins. Hence in principle it is correct to relate conglomeratic phases (not the individual conglomeratic beds) in the older succession across the river basins.

2.3 Soils

The following account is taken from 'Soils of Gujarat' (Sharma et al., 1994). Soils of Gujarat are classified into two main orders: Inceptisols and Vertisols (Fig. 2.7). It is with deliberate intent that suborder and soil series distribution is not discussed since it is only possible to classify with confidence older soils (palaeosols) upto the order level. The spatial distribution displays a control of mean annual rainfall (see Fig. 2.5). Vertisols are developed only till northern Gujarat near Himmatnagar and extend down south where mean annual rainfalls range from 700 mm to >1000 mm. The districts north of Vadodara district viz. Kheda, Gandhinagar, Ahmedabad, Sabarkantha and Mehsana have a mantle of Inceptisols with Entisols forming along the river courses. Soil depths are consistent over the area of investigation, generally falling in the 'very deep' class (>150 cm deep). However Kheda district hosts a large triangular area of 'deep' (100-150 cm) soils. The soils are loamy, well drained and slightly alkaline (pH 7.5-8.5). Calcareousness of soils varies from largely non-calcareous to moderately calcareous (5-15 % carbonate).

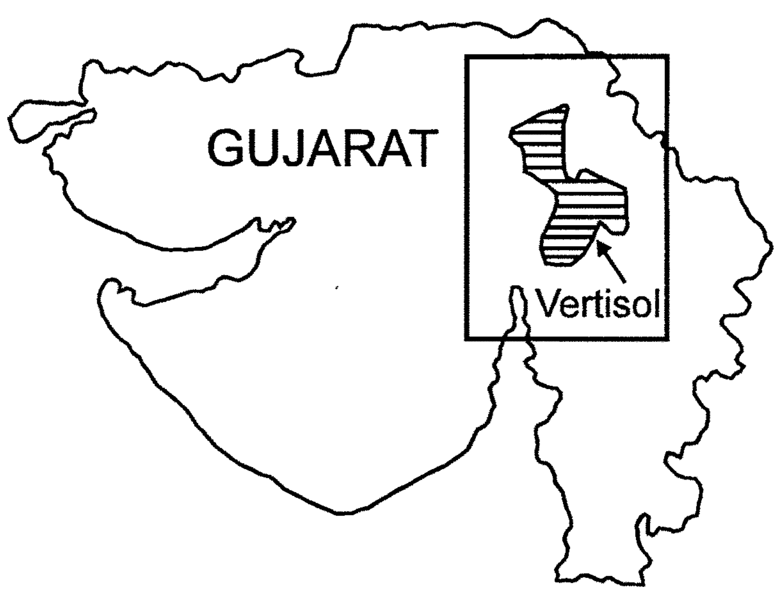

Figure 2.7 : Soil order distribution in the area (defined by rectangle). Apart from the order Vertisol the rest of the area is covered by Inceptisols. Modified from Sharma et al., 1994.

2.4 Geology and Structure

The Gujarat Alluvial Plains are located in a depression generated by the Cambay Graben. The Cambay Graben or Basin as it is referred to, is a NNW-SSE extending structure which swings towards NW to meet the Sanchor Basin in Rajasthan (Kaila et al., 1990). According to Biswas (1987), the Cambay graben is a half graben that formed in late Cretaceous times. It formed due to the extension in a northwest direction. Although it formed during the Cretaceous its subsidence rate increased during the Tertiary (Kaila et al., 1990). The basin is bound on either sides by step faults that are discontinuous. It should be noted that the basin bounding faults are those for the Tertiary sedimentation phase. Although deposition during the Quaternary period extended beyond the structural confines and continues even today, the Tertiary fault controlled basement topography has been instrumental in giving rise to the unequal thickness of Quaternary sediments in Mainland Gujarat (Merh & Chamyal, 1997). The Cambay basin faults follow the deep seated PreCambrian faults which have been demonstrated to extend till the Moho (Kaila et al., 1990; Shanker, 1991). The Cambay Basin region is an area of increased heat flow and shallow Moho (Shanker, 1991). Some authors believe that structural disturbances extended a prominent allocyclic control on depositional patterns (Maurya et al., 1997). Field evidences of lineament control on river courses include the presence of slickensides along the banks of the river Mahi north of Kadana which points to the control of strike-slip faults on the river paths (Maurya et al., 1997). A similar control of earthquake related fissures in generating river courses is observed for the Rupen river at the Sidhpur road crossing north of Mahesana. At this site the river bed consists of calcrete-conglomerates that are intensely jointed. The channel has a width of 50 m and bankfull depth of 8 m (Gibling and Tandon, 1997), and flows across a very low gradient surface. The control of lineaments on the Sabarmati river has also been demonstrated by Sareen et al., (1993).

The area is covered by Quaternary sediments and isolated Deccan Trap basalt exposures towards the northeast (Fig. 2.8). Beyond the area defined by the Gujarat Alluvial Plains, the mountainous hinterland forms a significant sediment source. This hinterland formed due to two Precambrian orogenies : the Aravalli and the Delhi orgeny. Compositionally the Precambrians are a complex assemblage of quartzites, gneisses, schists, marbles, granites and basalts belonging to the Aravalli and Delhi Supergroups (Merh and Chamyal, 1997).

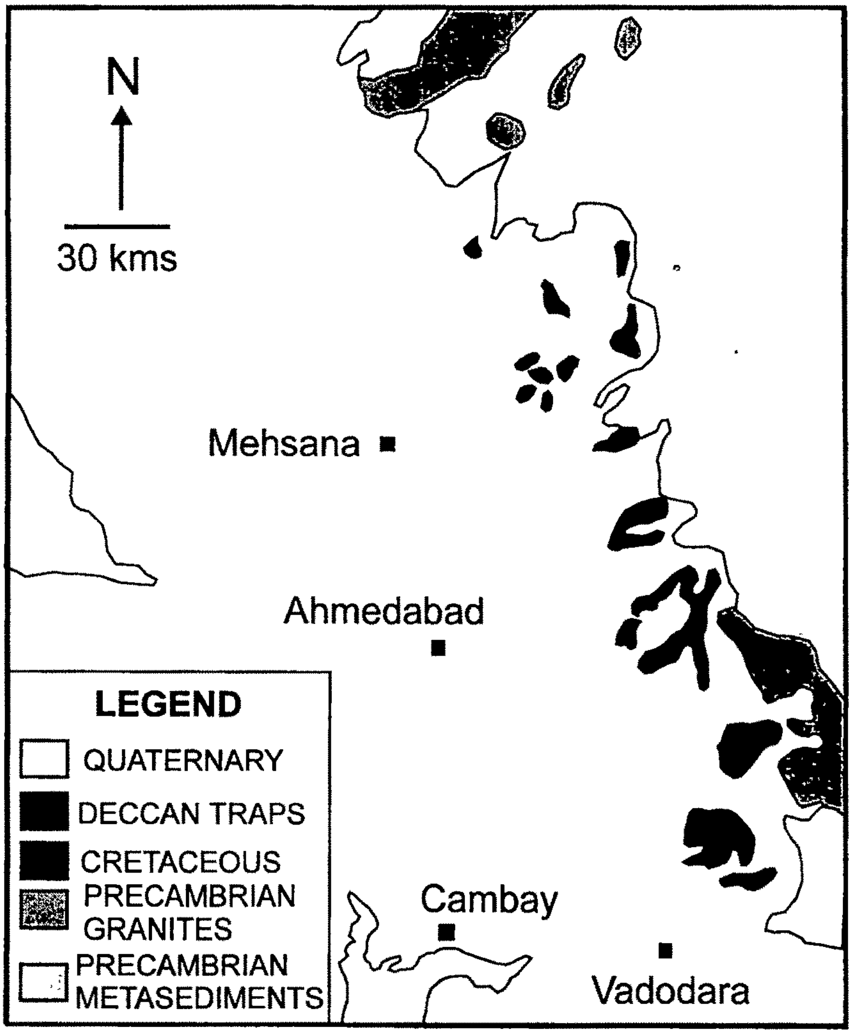

Figure 2.8: Geological map of the study area (from Merh & Chamyal, 1997)

2.5 Geomorphology

It is possible to recognize broadly two geomorphic entities in the region on the basis of topography and slope gradient. Towards north and north-east the terrain is mostly mountainous. Some hard rocks also occur as inselbergs. This area forms the hinterland from which sediment is sourced. The mean elevation of this region is 350 m Within the alluvial plains two geomorphic surfaces may be recognized and are termed as S1 and S2 (Maurya et al., 1997). The older S1 surface is flat with gradients towards south-west in the Mahi valley area and mostly west in the Sabarmati valley area. These slopes exert maximal control over the preferential location of tributaries along the eastern banks of both rivers. The trunk channels in both cases cut across the regional slope. Within the box shaped channels there occur inset terraces that are unaffected by gullying. These terraces are asymmetric, bank-attached and formed between 2 ka to 4 ka BP (Kusumgar et al., 1998). The surfaces of these terraces make up S2. The terraces originated when discharges were much higher than present. While the terraces are narrow and elongated in the medial reaches of the Mahi river they become much more extensive towards the mouth. This increase is almost linear (Fig. 2.9).

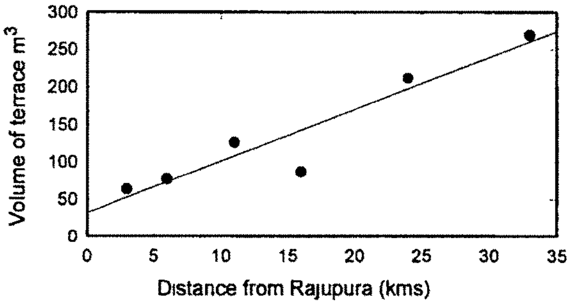

Figure 2.9: Linear relationship between distance from Rajupura and the volume of terrace material in the Mahi river. Volume was calculated using area and height from toposheets. This increase reflects the incremental influence of the sea at the mouth of the Mahi river.

Sedimentary structures such as herringbone cross-stratification, laminated clay sediments, ripple laminations within the mouth-proximal terraces suggest an estuarine origin. A microfaunal assemblage comprising benthic foraminifers such as *Nonion, Nonionella, Brizalina, Bolivina, Florilus* and planktonic foraminifers (*Globogerinoides, Globogerina*) have been recently recorded in them (Rachna & Chamyal, 1998).

Sareen et al., (1995) divided the Sabarmati basin into three subdivisions. The first-the upper reaches had erosive tributaries and flowed on steeper slopes; the middle reaches in which the tributaries joined the trunk channel from the eastern side and the lower reaches an area which comes under the influence of estuarine conditions. Like the Mahi basin the Sabarmati basin is also divided into three geomorphic zones. The Eastern Rocky Highlands towards the northeast, followed southwards by the alluvial plains and coastal mud flats (Merh & Chamyal, 1997) which forms a gradientless terrain.

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