QUATERNARY SEDIMENTATION HISTORY AND NEOTECTONISM OF LOWER TAPI BASIN, SOUTH GUJARAT.

Summary of the Thesis

Submitted To

The Maharaja Sayajirao University of Baroda

For the Degree of

Doctor of Philosophy

in

Geology

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VADODARA – 390 002.

MAY, 2005

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S U M M A R Y

The Lower Tapi River Basin (LTRB) i.e., the study area constitutes an integral part of the south Gujarat alluvial plains that represents one of the important portions of the passive western margin of the Indian sub-continent. This basin is bounded by two well-established major peri-continental rift basins i.e., the Cambay (NNW – SSE) and the Narmada – Tapi (ENE – WSW) and provides a unique example of its geomorphic diversity, tectonism, eustatic changes and sedimentological processes. The study area comprises an exhaustive record of the Quaternary sediments, which are found resting on the platforms provided by the rocks of Tertiary and Deccan Trap Formations. Earlier workers have provided cursory information regarding the geomorphological aspects of the study area; however sedimentological investigations and neotectonic studies have remained grey areas of information. Keeping in mind the proposed objectives of the present investigation, the study area has been thoroughly investigated to understand the influence of geological processes during the Quaternary times in bringing about the evolution of LTRB and sedimentation history vis-à-vis neotectonic attributes. The field investigations as well as the laboratory studies have helped to fulfill the precise understanding of the proposed objectives.

The study area is bounded by the latitudes N21^{0}05'; N21^{0}30' and longitudes E72^{0}37.5'; E73^{0}30' (Fig. 1), occupying an area of 4752 sq. km. and is drained by the tributary streams of Kim, Tapi and Mindhola rivers. It is bounded by the watersheds

of Narmada and Purna rivers in the north and south respectively. The Arabian sea delimits the western boundary, while in the east, the area abuts the trappean plateau of Deccan basalts.

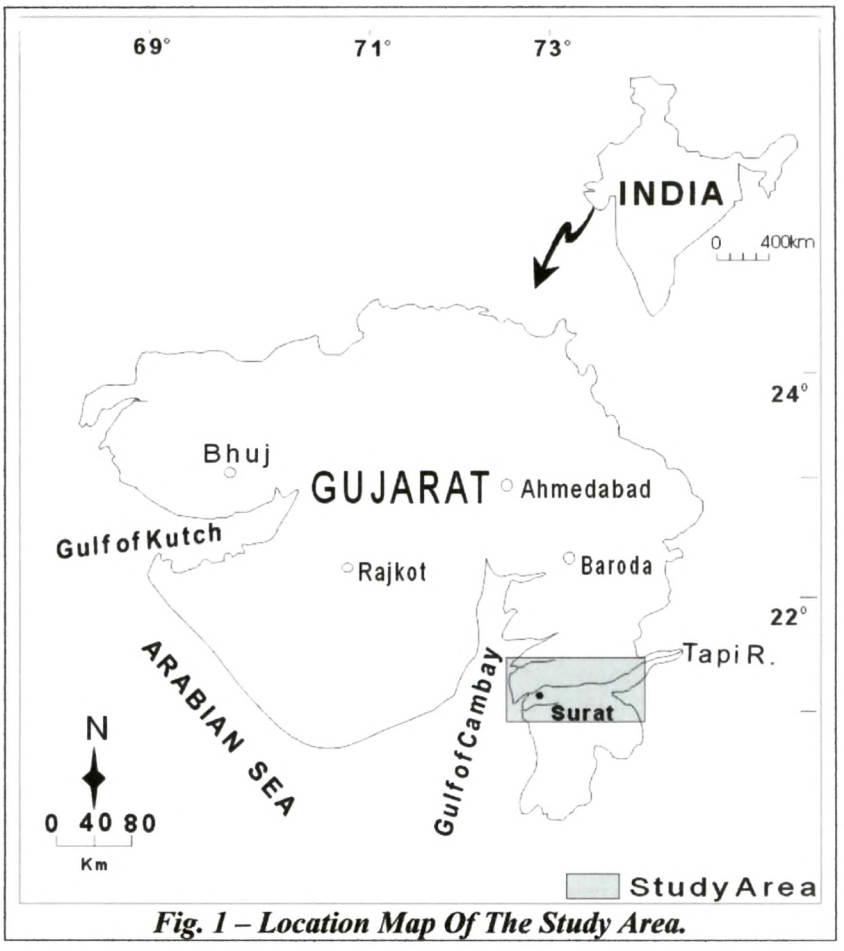

Fig. 1 – Location Map Of The Study Area.

It is bounded by the Narmada – Son lineament in the north, N – S running West Coast Fault in the west, Eastern Cambay Basin Marginal Fault in the east and Purna fault in the south and apports the tectonic domains of Narmada – Tapi and Cambay basins, clearly suggesting the control of basement lineaments along the ENE – WSW (Satpura trend), N – S (Cambay trend) and NNE – SSW (Aravalli trend) directions. The periodic reactivation of these basement faults have resulted in block movements thereby giving rise to horst and graben configuration, wherein the study area forms an important segment of this configuration.

Geologically, the study area comprises rocks belonging to different geological formations ranging in age from upper Cretaceous to Recent (Table 1). The exposed terrestrial Quaternary sediments, on which the present study is focused, constitute a

significant and integral part of south Gujarat alluvial plains and comprise an exhaustive record of events that occurred since the middle Pleistocene times up to the Holocene. The Quaternary sediments have a wide lateral distribution and unconformably overlie the eroded surfaces of Deccan Traps (upper Cretaceous to Eocene) and the Tertiary rocks belonging to Kand Formation (middle Miocene). These formations not only provided the platform for the accumulation of these sediments but also acted as a provenance. The Quaternary sediments through out the study area are well-exposed along the valley portions of Kim, Tapi and Mindhola rivers and also along their tributary streams. The variation in the thickness of these sediments at various locations is attributed to the nature of the pre-topography and sub-stratum.

Age	***Formation***	***Lithology***
Holocene (Sub-recent to Recent)	-	Soil, Clays, Silts, Sands, Gravelly sands, Gravels (Newer Alluvium).
Middle to Late Pleistocene	-	Clays, Silts, Sands, Gravelly sands, Gravels, Siltstones, Conglomerates (Older alluvium).
———	Unconformity	———
Upper to Middle Miocene	Kand	Calcareous sandstones, Shales, Marls and Limestones.
———	Unconformity	———
Upper Cretaceous to Eocene	Deccan Traps	Basaltic rocks and its varieties.

Table 1 – Litho – Stratigraphic Succession Of The Study Area.

Based on the various geomorphic attributes such as, altitude, relief, drainage, land use pattern and the surficial sediment nature, the LTRB has been divided into four distinct physiographic zones viz. Inner Highland Zone (>100m AMSL), Upper Pediment

Zone (50 – 100m AMSL), Middle Alluvium Plains (10 – 50m AMSL) and Lower Coastal Zone (<10m AMSL), each characterized with the presence of unique set of landform features.

Geomorphically, the study area exhibits a variety of landform features that exhibits the complex interplay of surficial as well as tectonic processes. The various landform features identified in the study area represents their fluvial, fluvio-marine, aeolian and tectonic in nature. In addition to the present day landform features the study area is also adorned by the presence of palaeo-landform features in the form of buried channels, mouth-bars and river dominated deltaic lobes. These features have certainly pointed out the variation in the land-sea boundary during the Quaternary times, very well reflecting the role of tectono-eustatic changes.

An interlocking drainage network of the rivers such as Kim, Tapi and Mindhola and their tributaries sprawls within the study area. The orientation of these streams strongly corroborates the control of the existing fracture and joint systems along the ENE – WSW, NW – SE, NE – SW and N – S directions. The presence of dendritic to sub-dendritic and at places trellis, rectangular and pinnate drainage patterns suggests the overall control of lithology and structure on the drainage pattern of the study area. The presence of tight winding loops and contortions observed in Tapi and Mindhola rivers and the abrupt change in the Tapi river course, near its mouth portion also substantiates the role of tectonism on the drainage patterns.

Ample signatures of neotectonic activities, impregnated in the geological and geomorphological expressions within the study area, have been critically recorded and analysed. The observed neotectonic features include subsurface tectonic features; differential tilting of Deccan traps, river cliffs and sedimentary layers; deformation of sediments; shifting and abandonment of river channels; anomalous behavior of river

channels and various tributary streams; variable thicknesses of alluvial deposits; unpaired planation surfaces and river cliffs; development of ravines; break in river profiles; discontinuities along the river channel courses; presence of geo-thermal springs and seismicity. Taking into account the above observations, it is clear that the study area had experienced neotectonic activities persistently during the Quaternary period and also its continuity through out the Holocene, right up to the Recent times.

The exposed Quaternary successions in the study area represent an excellent cyclic sedimentation comprising three to four cycles demarcating a gradual decrease in the grain size from the bottom to top within the individual cycle. This strongly indicates the fining upward nature of the sediments pointing to their deposition by fluvial agencies under channel fill – point bar – floodplain conditions. The sediment characteristics and the primary sedimentary structures present within them strongly support the above observations.

The laboratory investigations carried out for the representative samples of the exposed Quaternary successions of the study area, supports the field interpretations and also indicates the deposition of these sediments under fresh water conditions on account of riverine processes. The granulometric analyses and the computed statistical parameters suggest the dominance of riverine processes and the deposition of these sediments under fluvial regime. The bulk as well as clay mineralogical details obtained from X-ray diffraction analyses have also pointed to the freshwater nature of the sediments and their proximal provenance. The scanning electron microscope studies of the surface textures of the representative quartz grains also supports the earlier observations. The commonly identified features, such as conchoidal fractures, coalescing irregular impact pits, straight and arcuate steps, straight and curved scratches, friction features and mechanically formed "V" marks, have clearly pointed

out high energy conditions and strong influence of fluviatile processes. The data obtained from trace element analysis convincingly supports the fresh water nature of the depositing medium. The absence of trace elements such as boron and negligible traces of other elements such as copper, nickel chromium and manganese indicates low salinity of the depositing medium, pointing to the fresh water conditions.

Based on the field observations, laboratory investigations and palaeo-geographic attributes, the composite litho-stratigraphic successions along the Kim, Tapi and Mindhola rivers have been formulated. The close observation of the composite profiles indicates three cycles of fining upward sequences along the Kim river valley, whereas in case of Tapi and Mindhola river valleys, four such cycles have been noticed. These composite profiles have been taken for lateral correlation based on the lithological similarities (Table 2). Since the exposed continental Quaternary deposits of the LTRB represent a mappable unit having wide lateral as well as vertical extension, they have been formally designated as "Tapi Formation" and have been sub-divided further into four different members such as Dhatwa member, Kholeshwar member, Puna member and Palsana member, based on the exposed thickness and number of representative lithological units of the individual members.

Based on the results obtained from the field observations, laboratory investigations and other parameters, which includes the palaeo-geographic conditions, drainage characteristics, landform features, composite litho-stratigraphic succession, nature of sediments, tectonic signatures and seismic evidences, an attempt has been initiated in the present study to systematically envisage the stages of evolution of the LTRB and its sedimentation history during the Quaternary times, which is described in the following paragraphs.

Age	*Formation*	*Member*	*Kim River Valley*	*Tapi River Valley*	*Mindhola River Valley*
Middle Pleistocene to Holocene	TAPI FORMATION	Palsana	Clays (6.5)	Clays (4.0)	Clays (5.0)
			-	Silts (0.5)	Silts (3.0)
			Sands (1.0)	-	Sands (4.0)
			Gravely Sands (0.5)	-	Gravely Sands (0.5)
		Puna	-	Palaeosol (1.0)	-
			Clays (1.0)	Clays (4.5)	Clays (6.0)
			-	-	Silts (1.0)
			Gravely Sands (0.75)	-	Gravely Sands (1.5)
			Gravels (0.5)	Gravels (0.5)	-
			-	Conglomerate (0.5)	-
		Kholeshwar	Clays (3.5)	Clays (6.0)	Clays (5.5)
			-	Silts (2.0)	Silts (1.5)
			-	Sands (2.5)	Sands (2.0)
			-	Gravely Sands (1.0)	-
		Dhatwa	-	Clays (3.5)	Clays (3.0)
			-	Silts (2.0)	-
			-	Sands (2.0)	-
			-	Gravels (5.5)	-
			-	Conglomerate (1.0)	-
---------- Unconformity ----------					
Middle to Upper Miocene	Kand	-	Limestone	-	-
---------- Unconformity ----------					
Upper Cretaceous to Eocene	Deccan Traps	-	Basalts	Basalts	Basalts

Table 2 – Composite Quaternary Litho-Stratigraphy Of Lower Tapi River Basin
(Numerical Values Indicate Thickness In Meters).

(1) The evolution of the LTRB has been strongly controlled by the basin configuration that existed during Mio – Pliocene times, which further became a site of accumulation for the Quaternary sediments. The structure contour and isopach maps prepared for the Quaternary sediments of the study area, strongly indicates change in the basin configuration acquiring a general basinal slope towards WSW and a shift in the depocenter from northwest to southwest. This is attributed to the differential block movements and tectono-eustatic factors.

(2) The middle Pleistocene times experienced transgression that resulted a significant change in the land – sea boundary causing the shift further eastwards along the pediment zone of the trappean highlands. This is very well justified in terms of the delineated palaeo-lobes (Tapi lobe – I) and palaeo-drainage features. Even though the middle Pleistocene period, represents overall transgression, however within the study area the advancement of sea further east seems to have been restricted on account of huge sediment input contributed by the active drainage network of palaeo-Tapi and its tributaries.

(3) During the late Pleistocene times, the study area experienced a regressive phase due to the differential block movements along the basement lineaments, which resulted into advancements and deflections of the drainages and subsequent shift in the land-say boundary towards the west. It has also been envisaged that the differential block movements have caused the change in the slope of the basin along with the river channel courses abruptly shifting the Tapi river towards northwest and carving out of Mindhola river as an independent channel from the Tapi river. This observation along with the presence of palaeo-depositional features such as Tapi lobe – II, buried distributory channels, sandy ridges and abandoned courses of palaeo-channels, aptly corroborates the active role of tectono-eustatic factors during the late Pleistocene times.

(4) The regressive phase of the sea that was initiated during the upper Pleistocene time continued further in the early Holocene period. The tectonic disturbances that occurred during this time resulted in the differential movements along the Kim and Tapi fault systems. This seems to have resulted in the shift of the Tapi river towards south, enabling the development of Tapi lobe – III and simultaneously caused the formation of an independent Kim river channel.

(5) During the middle Holocene times, the study area experienced a rise in the sea level coeval with the Flandrian transgression (6000 yrs BP, Merh, 1987), which resulted into the shift in the land – sea boundary further eastward. This is well attributed by the presence of raised mud flats along the coastline and associated palaeo-estuarine features. The present-day landscape configuration seems to have been the result of late Holocene regression without any perceived changes in the courses of Kim, Tapi and Mindhola rivers.

(6) The field evidences and laboratory studies of the continental Quaternary deposits of the study area convincingly points to their deposition from middle Pleistocene onwards on account of fluvial processes. The absence of the early Pleistocene sediment record as surficial outcrops in the study area and its environs suggest rapid subsidence of the basin during the early Pleistocene times.