Chapter VIII

DISCUSSION AND CONCLUSION

The Lower Tapi River Basin (LTRB) constitute an important segment of the south Cambay basin and provides a classic example of a complex interplay of geomorphic diversity, neotectonic activities, eustatic changes and sedimentological aspects. Keeping in mind the proposed objectives of the present investigations, this basin has been investigated in detail in order to achieve the above objectives and to understand the influence of geological processes in bringing about the evolution of this basin. Based on the studies adopted in the present investigation, an overall understanding of the complexities pertaining to the LTRB are envisaged and further discussed in the following text.

The study area in particular and south Gujarat alluvial plains in general, occupies an important position on the passive western margin of the Indian sub-continent and is bounded by two well-established major peri-continental rift basins, i.e., the Cambay (NNW – SSE) and the Narmada – Tapi (ENE – WSW). These rift basins have developed along the pre-existing major basement fractures and have undergone reactivations periodically from time to time. The sub-surface studies carried out by the earlier workers have revealed the presence of deep-seated faults between Narmada and Tapi rivers. This system of faults, along with the other structural elements such as the West Coast Fault and Eastern Cambay Basin Marginal Fault has divided the south Gujarat plains in several crustal blocks. The periodic reactivations of these basement faults have resulted in block movements thereby giving rise to horst and graben configuration, wherein the LTRB forms an integral segment.

The study area 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. The study area apports the tectonic domains of Narmada – Tapi and Cambay basins, thereby indicating the control of basement lineaments along the ENE – WSW (Satpura trend), N – S (Cambay trend) and NNE – SSW (Aravalli trend) directions. This clearly suggests that the evolution of LTRB in particular and the complete Tapi river basin in general, needs to be viewed in the light of the tectonic events that seem to have modified the basin configuration during post-Deccan Trap activities.

The geology of the study area comprises a complete assemblage of lithological formations, ranging in age from upper Cretaceous to Recent. Within this assemblage, the exposed continental Quaternary sediments, on which the present study dwells, constitutes a very important and integral part of the south Gujarat alluvial plains.

These Quaternary sediments accord an exhaustive record of the events that occurred since the middle Pleistocene times right up to the Holocene. The Quaternary sediments are widely distributed within the study area, rest unconformably over the eroded surfaces of Deccan Traps (upper Cretaceous to Eocene) and the Tertiary sediments belonging to Kand Formation (middle to upper Miocene). Compositionally the Quaternary sediments indicate a proximal source and seem to have been derived from the erosion and denudation of the trappean rocks and Tertiary sediments.

The studies carried out on the geomorphic aspects of the study area have pointed out the presence of diverse geomorphological features that exhibit the complex interplay of surficial as well as tectonic processes. The landform features widely distributed in the study area, have been identified to be of fluvial, fluvio-marine, aeolian and tectonic in nature. Interestingly, the study area also exhibits the presence of palaeo-landforms in terms of river dominated deltaic lobes, channels, mouth-bars and raised mud flats. The presence of these features has been attributed to the varying strandline positions during the Quaternary times and reflects the key role played by tectono-eustatic changes in governing the course of Tapi and its tributary channels.

Along with the diversity in landforms, the study area is also adorned by the presence of an inter-locking drainage network of the important rivers, which includes the Kim, Tapi and Mindhola rivers along with their tributary streams. The major trunk streams as well as their tributaries show an overall orientation in the ENE – WSW, NW – SE, NE – SW and N – S directions indicating a strong control of the prevailing fracture and joint systems. The detail investigation of the drainage network of the study area has clearly pointed out its formation on two contrasting lithological domains i.e., the Deccan Traps and alluvium and ideally reflects the influence of geomorphic processes, hydrodynamic factors and tectono-eustatic changes.

The drainage network of the study area reflects dendritic to sub-dendritic patterns along with the trellis, rectangular and pinnate patterns observed at places. Particularly northeast portion of the area comprising Deccan Trap outcrops is characterized by fine drainage textures with a dense network of streams. Contrastingly, the southwest portion, comprising alluvium reflects coarse drainage texture and comparatively less dense network of streams. These observations clearly point to the fact that the overall nature of the drainage system and their patterns points to a strong control of lithology and structure. The role of structure and its influence on the drainage is further substantiated by the presence of tight winding loops and contortions observed in Tapi and Mindhola rivers and abrupt change in the course of Tapi river near its mouth portion. Although the longitudinal profiles of Kim, Tapi and Mindhola rivers do not persistently reflect the control of tectonism, however, field observations at several locations along these river channels have indicated the presence of tectonically related features such as rapids, knick points and cascades, aptly confirming the structural control.

The study area and its environs have been observed by earlier workers by virtue of its potential as far as signatures of neotectonic activities are concerned. During the present investigation, ample evidences of neotectonic activities, which are well impregnated in the geological and geomorphological expressions, have been observed and critically studied. 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 the river profiles; presence of geo-thermal springs and seismicity. Taking

into account the above observations, it is clear that the study area has experienced neotectonic activities persistently during the Quaternary period, which further continued throughout the Holocene and Recent times, and is glaringly manifested by the historical records of seismic events of varying magnitudes.

The continental Quaternary successions observed at various locations through out the study area represents continuous cycles of sedimentation without any appreciable break however, they do show changes in energy conditions during the deposition. The cyclic sedimentation is demarcated by the repetition of lithological units exhibiting a gradual decrease in the grain size, from bottom to top of the succession. This clearly indicates the fining upward nature of the sediments, which points to their deposition by fluvial agencies under channel fill – point bar – floodplain conditions. The nature of the primary structures, which includes the planar as well as trough cross-stratifications, aptly points to their formation under fluvial processes. The absence of the organic remains of marine forms within these sediments also points to their formation under fresh water conditions. The variation in the thickness of these deposits and their relative number of cycles of sedimentation at different locations is attributed to the nature of the sub-stratum vis-à-vis tectonism and the intensity of the geological processes.

The results obtained from the laboratory investigations of the representative samples of the Quaternary sediments of the study area, also convincingly supports the field interpretations and strongly points to their deposition under fresh water conditions on account of fluvial processes. The details of granulometric analyses, in terms of the computed statistical parameters and the scatter plots strongly suggest their transportation by riverine processes and their deposition in fluvial environments. The freshwater nature of the sediments, low salinity of the depositing medium and the

fluvial environment of the deposition is also supported by the mineralogical details obtained from X-ray diffraction studies. These studies have also further indicated the source of the clay minerals identified in the sediments to be the result of weathering of basaltic rocks (Deccan Traps) under a humid tropical climate with intense rainfall. The studies of the surface textures of the quartz grains representing various lithological units under scanning electron microscope have provided very interesting results supporting the above observations. These surface features include conchoidal fractures, coalescing irregular impact pits, straight and arcuate steps, straight and curved scratches, friction features and mechanically formed "V" marks, clearly pointing to the high energy conditions and strong influence of fluviatile processes.

The geochemical estimations pertaining to the trace element concentrations of the representative samples have provided results, which are in accordance with the interpretations generated from the other data, particularly the absence of elements such as boron and the minor traces of other elements such as copper, nickel and chromium, strongly indicates low salinity of the depositing medium, pointing to the fresh water conditions of the deposition.

The configuration of LTRB during the Quaternary times has been envisaged on the basis of the structure contour and isopach maps. These maps have clearly pointed out a significant change in the basinal slope and the depocenter of the basin during these times, which is attributed to the differential block movements along E – W transverse fault systems.

The observations made during the present investigation on the exposed continental Quaternary sediments of the study area have clearly indicated that the sedimentation initiated during the middle Pleistocene onwards mainly on account of fluvial processes representing fresh water deposition. The marked absence of surficial

evidences of early Pleistocene deposits in and around the study area is attributed to the active subsidence and sedimentation persisted during that time. Based on the lithological correlation, wide lateral extension and mappable nature of the Quaternary deposits of the study area, they have been formally designated as "Tapi Formation" and are further sub-divided into four members such as Dhatwa member, Kholeshwar member, Puna member and Palsana member.

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 successions, nature of sediments, tectonic signatures and seismic evidences, a systematic account of the evolution of the LTRB and its Quaternary sedimentation history has been envisaged, the details of which are given below.

(1) The evolution of the LTRB has been strongly controlled by the basin configuration that existed during Mio – Pliocene times and which provided room for the Quaternary sediments accumulation. 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, particularly the overall regression of sea, during early Pleistocene times.

(2) During the middle Pleistocene times, the transgressive nature of the sea caused a significant change in the land – sea boundary resulting in 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, which have been described in the earlier pages of this

dissertation. 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 Quaternary sedimentation history of the LTRB is initiated from the middle Pleistocene onwards and is characterized by the continental deposits exposed along the Kim, Tapi and Mindhola river valleys. These deposits have been laterally correlated and they represent a continuous cyclic sedimentation formed under fluvial conditions. Based on the litho-stratigraphic nomenclature these deposits have been assigned the rank of the formation and formally designated as "Tapi Formation".

The preceding chapters of this dissertation have described in detail the various aspects pertaining to the Quaternary evolution, sedimentation history and neotectonic signatures observed within the LTRB of south Gujarat. The field as well as laboratory investigations carried out during the present investigation along with the other relevant information, have convincingly pointed out that the continental Quaternary sedimentation history commenced from middle Pleistocene onwards. The significant absence of lower Pleistocene deposits in the surficial data is an enigmatic problem, which needs to be investigated in terms of the sub-surface details and bore-hole records and becomes a part of future studies.