CHAPTER - X

RESUME

1. The alluvial plains of north Gujarat and southwest Rajasthan constitute an important segment of the Quaternary terrain of Western India. The author carried out investigations in these areas with a view to collect maximum available information through detailed on the spot studies of the various river sections; gave maximum emphasis on the Sabarmati river as it was found to provide an almost unbroken exposed sequence of the Quaternary sediments. The data obtained from this river as well as some of the shallower rivers further north viz, Rupen,

Pushpavati, Khari, Saraswati, Banas and Luni, bore-hole information from the unexposed intervening areas, were synthesized.

2. The studies thus carried out throw light on (i) pre-Quaternary configuration of the depositional basin, a feature related to Cambay Basin tectonics, (ii) the complex fluvial history and deposition of sediments varying in thickness from 100 to 300 m, (iii) the influence of climatic changes and tectonic movements, both in the provenance as well as within the depositional sites (iv) and the depositional history comprising an ancient major fluvial system, subsequently disrupted by the tectonic movements and climatic changes.

3. The Quaternary continental deposits of north Gujarat and southwest Rajasthan have attracted attention of geologists, archaeologists and pedologists for almost a century. Although considerable information has been generated by the previous workers, a coherent picture of the various Quaternary events detailing the evolution of this part of western India has remained fragmentary and somewhat sketchy.

4. Essentially comprising unconsolidated continental sediments deposited by fluvial and aeolian agencies under varying climatic conditions, the terrain is replete with a wide variety of physiographic features. The area shows the reflections of the various tectonic, erosional and depositional processes of the late Quaternary. An indepth appraisal of the terrain have revealed very interesting details.

5. From the geomorphic point of view the study area could be broadly, categorized into 3 main NNW-SSE running divisions; the easternmost division mainly comprising the rocky provenance whereas in the westernmost division the rivers tend to end their journeys. The central part is cut across by the various rivers that constitutes the portion on which this study dwells upon.

6. The area is traversed by a number of major rivers originating in the rocky highlands to the east, beyond the limits of the Gujarat state. The drainage characteristics vis-a-vis significant thickness of continental deposits exposed in various river sections characteristically points to a protracted fluvial history comprising two major drainage systems. The present day drainage mainly cuts across the material deposited by the older river system. The author has been able to recognise the existence of an ancient super fluvial system. It was this ancient fluvial system which was mainly responsible for the deposition of the entire bulk of the sediments in the various post Tertiary depressions. The present day rivers which are observed to have been superimposed at a later date dominantly follow numerous tectonic lineaments and faults, but they do reveal relicts of the earlier fluvial system.

7. The present day Sabarmati river which flows south southwestward with an entrenched channel follows a major fracture which has been responsible for capturing the waters of the Rupen river and it has been concluded that the Rupen with its accompanying depositional features and relict tributary system represents the original course of Sabarmati river.

8. The Quaternary continental deposits of the study area form the northern half of the Mainland succession and consists of layered sediments of marine, aeolian and fluvial origin. The various depositional and sedimentological features, textures and mineralogy typically reflect the influence of related depositional processes and the factors controlling them. A total thickness of over 300 m of Quaternary sediments has been computed on the basis of exposed sequence and sub-surface bore hole data.

9. The vast thickness of the unconsolidated Quaternary sediments and their lateral expanse along the alluvial plains of Mainland Gujarat clearly indicate that the sedimentation took place in a depression of phenomenal dimension. This depression was formed during the beginning of the Quaternary due to reactivation of the pre-Quaternary basement faults which comprised part and parcel of the tectonic framework of the Cambay Basin.

10. The basin which received the Quaternary sediments thus had a bottom topography reflecting uplifts and subsidences along numerous faults related to the Cambay Basin tectonics. Tectonic features of significance which have affected the Quaternary sedimentation are (i) NW-SE trending fault parallel to the border of the Little Rann and (ii) N-S fault marking the limit of the Great Rann, both more or less parallel to the WMCBF, comprise faults related to the Cambay Basin tectonics, but representing features delimiting the Quaternary deposition. The faults parallel to the two Ranns typically illustrate an uplift subsequent to the deposition of major part of fluvial sequences. Perhaps these faults were

responsible for the drainage disruption leaving only the relicts of the older fluvial system.

11. The tectonic features of the study area belong to more than one ages and they can be broadly categorized as (i) pre-depositional, (ii) Syn-depositional and (iii) post-depositional structural features. Of these three categories (i) and (iii) are better recognised whereas the syn-depositional tectonism has been only indirectly inferred. Lineament map prepared on the basis of drainage characteristics, geomorphic features and IRS imagery clearly shows the control exercised by tectonism over to the fluvial depositional sequence.

12. On the basis of field studies in the various river sections, bore-hole data and depositional and erosional landforms in the study area, a very well defined sequence of continental deposition has emerged. On the basis of a critical examination of various exposed sections in the Sabarmati, Banas and Luni, supported by sub-surface bore hole data, it has been possible to work out a sequential stratigraphy and reconstruct the depositional model. It has been further observed that the entire sequence has been subjected to post-depositional faulting. The entire exposed succession is divisible into four formations viz, Lakroda, Hirpura, Saroli and Mahudi in ascending order.

13. The oldest exposed Quaternary horizon in the study area, the basal bluish clay appears to have been deposited under marine conditions during the Middle Pleistocene high sea, This horizon comprises 70 - 75 % of clay and is rich in illite, chlorite and montmorillonite. Subsequent to their deposition the clays were

exposed to subaerial weathering processes, during which it underwent pedogenisation. This is evidenced by the development of calcrete veins, strings and tubes. The high CaO content is also attributed to this phenomena. The overall geomorphic setting of the Valasana member of Lakroda formation marks the onset of fluvial sedimentation. The depositional direction was southwesterly. The mean direction of the longest axes of the gravels is also NE-SW; the original flow direction was quite oblique to the present day river flow. The gravel characteristics point to their formation by the process of a low viscosity debris flow. Fractured mud horizon which overlies this gravel indicates that the energy conditions of the depositing streams progressively weakened and finally the deposition stopped and exposed to weathering. The pedogenisation of this mud points to the period of non-deposition before the onset of the next fluvial cycle. The Sindari member overlying the Valasana member is characterised by the second gravel. The various characteristics point to their being a product of stream flow deposits. The rubified sediments of Hirpura formation are typically fluvial; this is revealed by the textural characteristics. These sediments are reddened by a subsequent pedogenetic process; the red colouration is due to the presence of finely divided ferric oxides, chiefly hematite, magnetite and goethite. The Saroli formation that again consists of riverine sediments belongs to the third fluvial cycle. It however, points to a reduced energy system as compared to the processes responsible for the formation of the underlying gravelly deposits. The absence of coarse gravel units, the presence of sand, silt and mud reveals that the sedimentation took place through a fluvial form of intermittent flood deposits loosing energy after debouching from the pediment zone of the foothills. The absence of pedogenetic features in the Saroli formation indicates a rapid onset of

aridity, leading to deposition of the overlying windblown material without any time gap of appropriate climatic conditions that would have brought about pedogenesis. The overlying Mahudi formation made up of aeolian silt and sand that forms a blanket like cover over the fluvial sedimentation is characterised by near total absence of layering or lamination. This feature is supported by appropriate grain size parameters and provide clear indications of aeolian processes being responsible for the deposition of this formation. Interestingly, a break in deposition and pedogenisation between the two aeolian members points to a brief somewhat wet spell intervening the two dry phases.

14. The exposed sediment successions in the valleys of the various north Gujarat rivers are intercalated with the various types of soils. The textural, clay mineralogical and chemical data which throw some light on the paleoenvironmental conditions. Two major and one poorly developed surface soil types which evidently follow the geomorphic features are recognised. In general, there are two well defined buried soils in the region, amongst the two, the red soil (rubified) is the most conspicuous by its colour and spatial spread. The soil has developed on fine sandy silt of fluvial origin and has a well developed carbonate crust at the base. The reddening is quite deep. The soil profiles show presence of smectite, illite, kaolinite, and chlorite. Smectite and illite dominate over others. It appears that they are partly formed during soil genesis otherwise they have to be products of the parent material. Overall, not only the Brown Forest type of surface soil in the Sabarmati and Banas river basins are typologically similar but the buried soils are also similar to recent soils because their properties refer to the similar climatic conditions. The element distribution in the surface and buried

soils indicate similar characteristics. However, Cu and Zn are found more in the A-horizon of the surface soils probably due to plant activity and in the buried soil profiles Cu and Sr have leached further down in the Cca horizon. The dominance of Fe, Ti, Rb, K and Mn and presence of Cu and Zn in the B- horizon of buried soils indicate that these elements are related to the process of soil formation.

15. The characteristics of the continental sequence reveal an interesting late Quaternary paleoclimatic history. The successive events of deposition, both fluvial and aeolian, punctuated by periods of non-deposition and pedogenetic changes, throw considerable light on the climatic changes that played their due roles in depositional processes and pedogenesis. Climates ranging from humid through semi-arid to arid have left their imprints in the sediments at various stratigraphic levels.

16. The author has reconstructed the paleoclimatic events on the basis of the nature of the sediments, variation in the grain size upward, repetitive events of pedogenic changes comprising development of calcretes, rubification of silts and stabilisation of dunal sands. Considering the various climatic and sea-level curves given by numerous workers, the rise and fall of the level reflecting the climatic changes in terms of warm and cold periods, the sequence of the study area can be considered to fall broadly within the last interglacial and the last glacial stage. In the absence of precise radiometric dates, it is only possible to suggest an approximate time framework to correlate the various events of alluvial deposition, periods of non-deposition and pedogenesis and periods of aeolian activity. The interglacial stage which broadly has a time span from around 240 K.Y. to 120

K.Y. and it was during this time interval the two fluvial cycles appear to have been deposited. The climatic conditions perhaps fluctuated between sub-humid to semi-arid and whereas the two major cycles of deposition might be representing wet spell with augmented streams action, the periods of non-deposition and pedogenesis indicate a more or less humid to sub-humid climate operating over subaerially exposed fluvial sediments lying up perhaps by some tectonism . The climatic conditions were just wet enough to weakly pedogenise the uplifted sediments. Absence of a well developed soil profile and calcretes is indicative of such climatic conditions.

17. It has been concluded that a powerful ancient drainage system filled up the tectonic basins, giving rise to the existing thickness of the sediments. The deposition was not continuous, punctuated by spells of non-deposition and pedogenisation. Late tectonic fracturing modified the old drainage lines and resulted into the existing river system. Whereas several phenomena have been understood, many more remain to be further investigated.