CHAPTER - III

G E O L O G I C A L F R A M E W O R K

REGIONAL GEOLOGY

The geology of Gujarat is unique in its diversity. Its various geological formations have imparted a fascinating panorama of landscapes, thereby producing an interesting assemblage of landforms. The northeastern and eastern parts comprise a mountainous terrain made up of Pre-Cambrian metasediments and associated granites. The hilly tracts, along the southeastern boundaries of the state, are marked by dissected lava flows of Deccan basalts. The central parts of the state are made up of vast plains of Quaternary deposits, within which occur Mesozoic and Tertiary rocks.

The southern peninsula is characterised by a basaltic tableland, the coastal fringes of which are overlain by Tertiary and Quaternary rocks. The Kutch peninsula is an important site of Mesozoic rocks, over which the Deccan Trap lava flows occurred. The Deccan basalts, in central Gujarat, though not so widely exposed, provide an ideal basement over which the petroliferous Cambay basin Tertiaries have been deposited.)

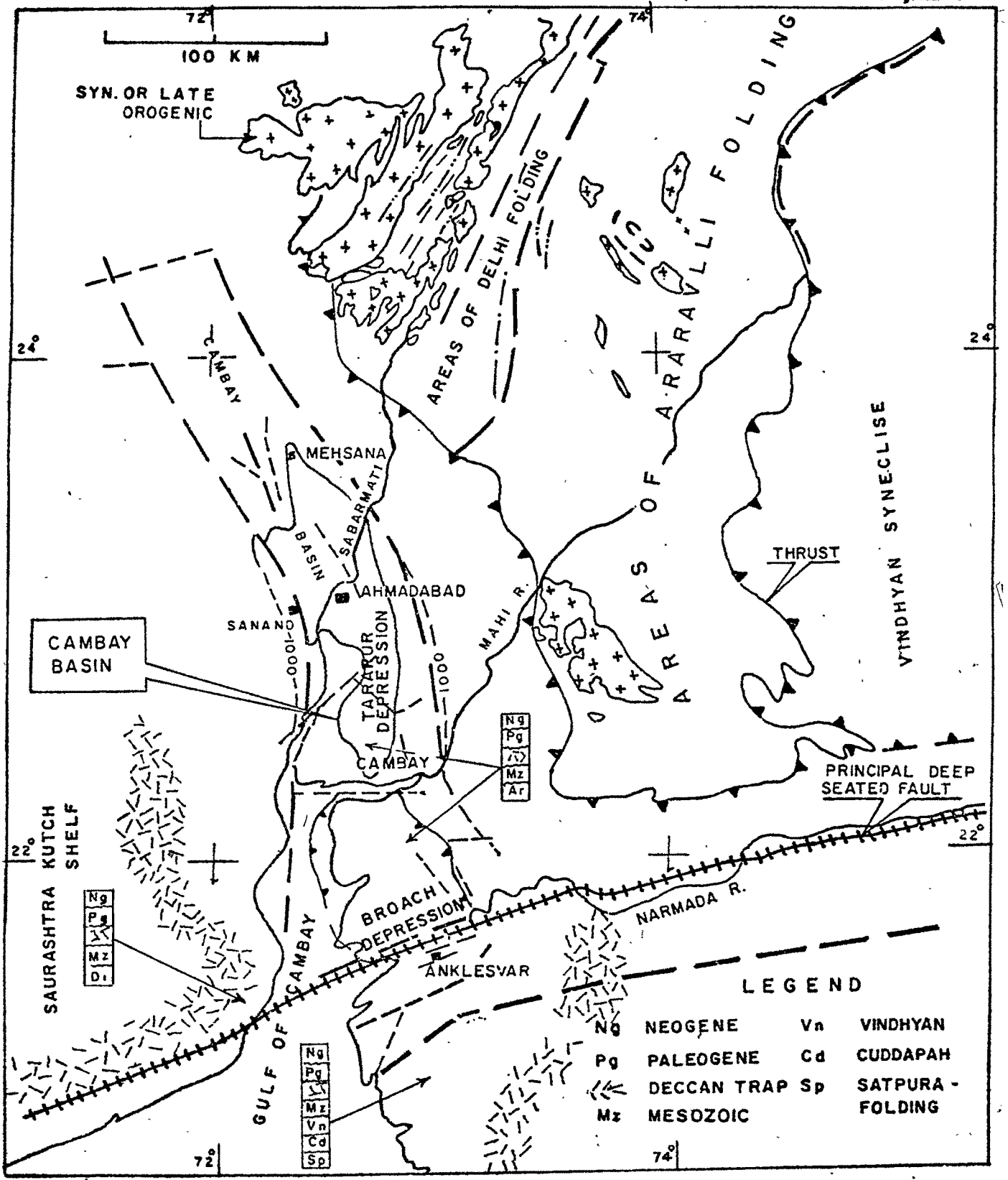
With a view to provide appropriate background to the present investigations, it is relevant to give an outline of the regional geological framework, within which the Tertiaries and Quaternaries have been occurring.

The detailed mapping by various agencies namely the Geological Survey of India, the Geology and Mining Department of Gujarat, the Oil & Natural Gas Commission, and the subsurface geological and geophysical investigations by the ONGC and NGRI have greatly updated and filled-in valuable gaps in the geological knowledge of Gujarat.

Regional structure and tectonics of Gujarat have been depicted in the Tectonic Map of India, Eremenko et.al (1968) and reproduced (Fig.III.1) with a view to elucidate the structural grain of the region. The tectonic features of the area of Gujarat are complex in which various forms of

TECTONIC MAP OF PART OF WESTERN INDIA

Fig. III · 1



positive and negative structures originated during the course of its geological history. The north-eastern part of Gujarat exhibits Delhi and Aravalli folding. Ridges and depressions are shown in the Kutch and Banni areas. Saurashtra-Kutch shelf encompasses a large part of western Gujarat. The north-south trending Cambay graben is located in the central part. A principal deep-seated geofracture is indicated along the trend of the Narmada river extending west-south-west along the southern margin of Saurashtra through the Gulf of Cambay. Various major and minor faults are also indicated trending west-south-west up to Surat.

The older structural trends which cut across the centrally located Cambay graben are of mainly Delhi folding. The younger structural trend of Broach-Surat area consists of west-south-west structural trends of Narmada Tectonic Belt.

These older and younger structural trends cut across in Gujarat area, and give a varied look to the structure and tectonics, and generate interesting geomorphological expressions that reveal evidences of neotectonic activities involving Quaternary sediments.

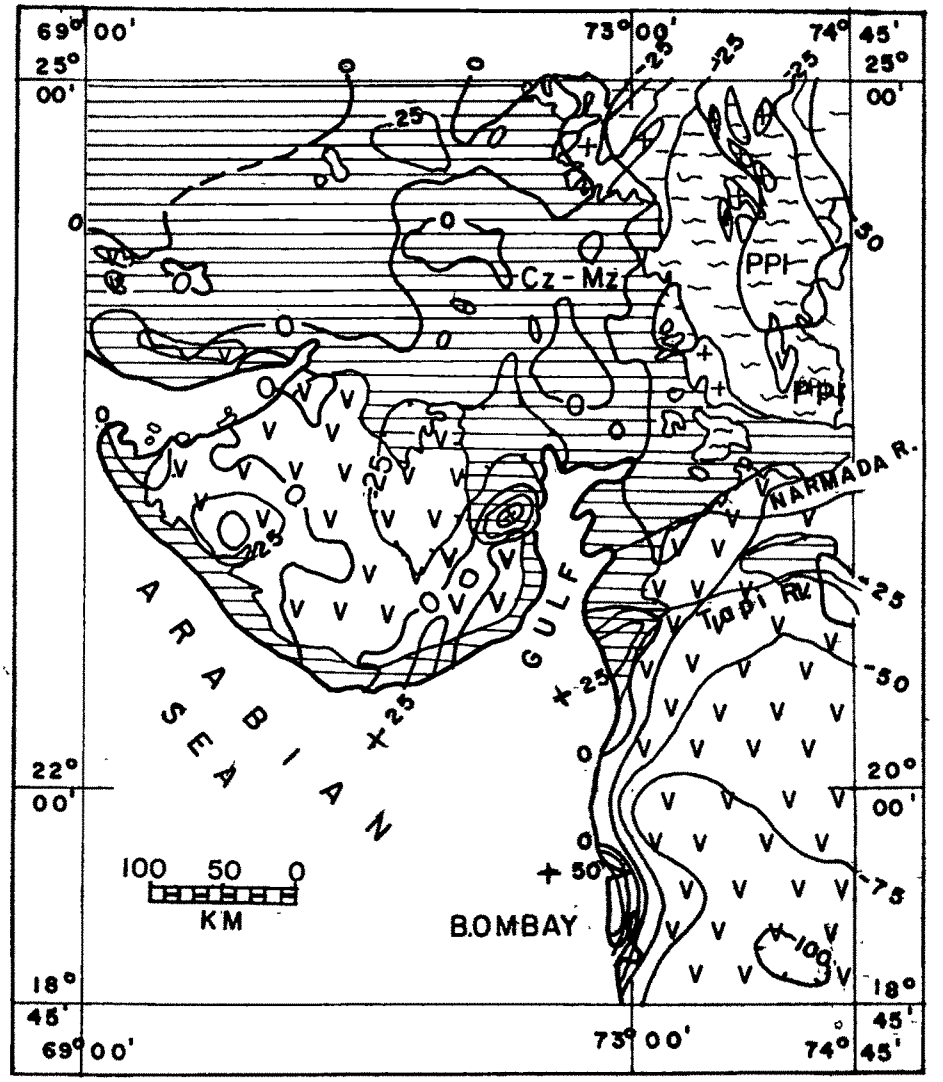
Crustal tectonics caused subsidences, uplifts, tilting of blocks, and these were affected by marine transgressions and regressions. Various older structural trends are traceable superimposed by younger trends in the area.

Gravity surveys have been of great help in understanding the geological framework of the Cambay Basin. Bouguer anomalies reveal deep seated structures and regional tectonics. These have been shown on a map with a simplified version of geology and tectonics of the region (Fig.III.2). The Bouguer anomaly map of western India by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) 1976 depicts most of the major gravity features at 25 milligal intervals. The map is based on the International Gravity Formula of 1930, and a density value of 2.67 gm/cm^3.

The Bouguer anomaly values in the region exhibit a positive maxima of 50 milligal near Bombay on the west coast and south and southwest of Ahmedabad. The positive and negative values have been found to correspond to structural highs and lows in Tertiary sequence underlain by Deccan Traps (Agarwal, 1983) in the areas of south Cambay Basin.

Valuable information from the Deep Seismic Sounding along a N-S profile in Cambay Basin, have been obtained pertaining to deep structures of the crust in general and shallow structural features in particular, and also on the thickness of Deccan trap Kaila (1981). A number of faults are revealed dividing the basin in seven blocks, and in the southern part, the blocks are Jambusar-Broach block (IV), Kosamba block (V) and Surat block (VI). These blocks are displaced up or down, relative to the adjacent blocks due to movement along the faults bounding

BOUGUER ANOMALY SUPERPOSED ON A CONDENSED REGIONAL GEOLOGY MAP OF WESTERN INDIA



L E G E N D

- CENOZOIC MESOZOIC, Cz - Mz
- LOWER GROUP METAMORPHOSED SEDIMENTS & CRYSTALLINES, PPI
- INTRUSIVES
- EXTRUSIVES
- STRUCTURAL TREND
- 50 BOUGUER ANOMALY CONTOURS, 25 MGL. INTERVAL.

AFTER ESCAP, 1976

them, and most of the faults extend deep affecting the Moho boundary. The granite basement is expected at a depth of 5.2 km near Broach, 3.7 km south of Anklesvar, 4 km near Kosamba and 3.5 km near Tapti river (Fig.III.3).

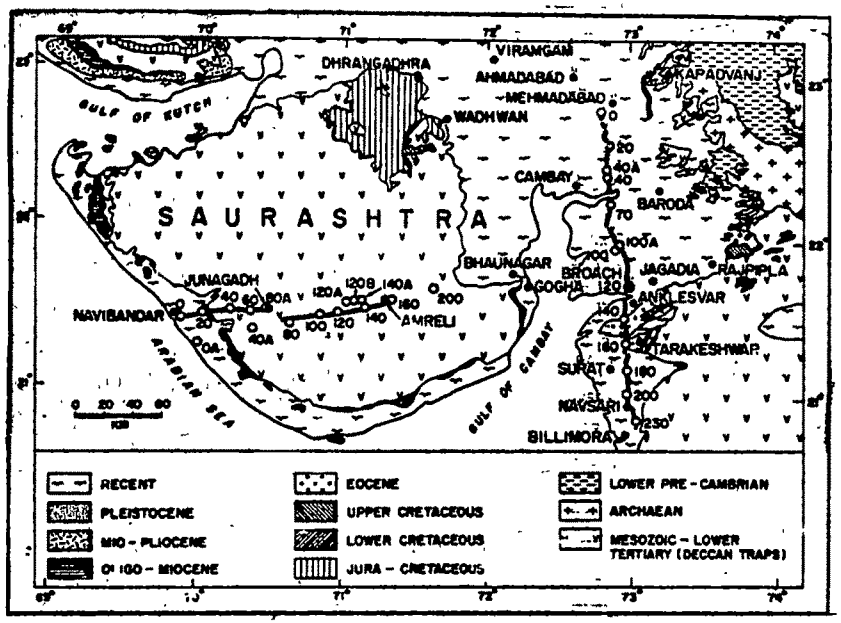
The Deccan Traps underlying the Tertiaries are interpreted to be probably at a depth of 2.2 to 2.3 km in the Broach-Anklesvar area, south of Anklesvar at a depth of 1.7 km, and 1.1 km near Kosamba.

The maximum thickness of Tertiary and Quaternary sediments may be 6 to 7 km in the Jambusar-Broach graben, and rapidly decrease towards Anklesvar and south of it from 1.7 km to 300-400 metres only. Mesozoic sediments below Deccan Traps in the Anklesvar-Kosamba area may be about 1.2 km thick.

The Narmada graben is also controlled by a complex fault system dividing the Indian Peninsula in a sub-latitudinal direction. The area of present study is located over the western part of Narmada graben.

Structures with two different alignments intersect in Gujarat. The two prominent tectonic trends are those of Aravalli and Narmada, and of these, the Narmada trend is younger which is south-westerly, and is manifest on landforms of today.

LOCATION OF DEEP SEISMIC SOUNDING PROFILES IN GUJARAT AND CRUSTAL DEPTH SECTION ALONG CAMBAY BASIN



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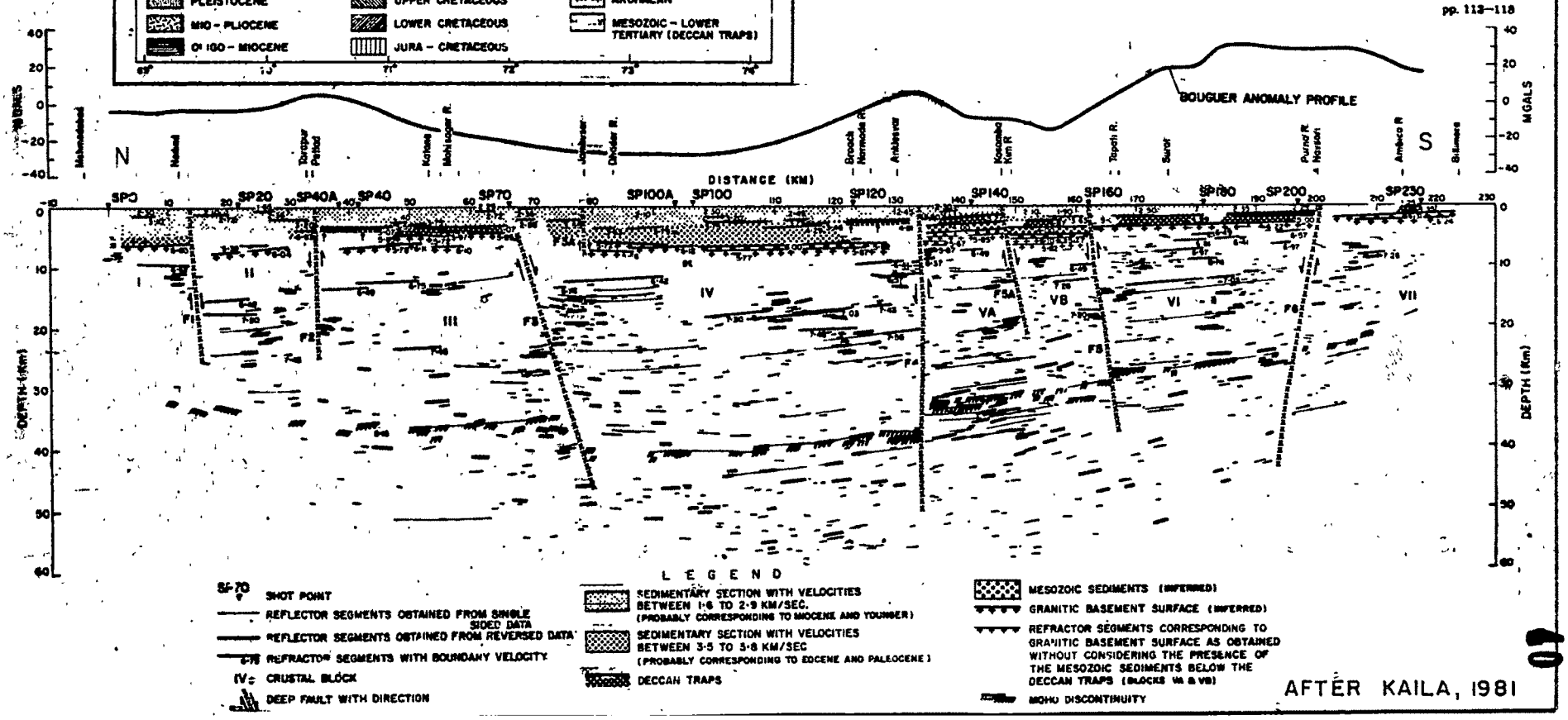

AFTER KAILA, 1981

EVOLUTIONARY HISTORY OF THE CAMBAY BASIN

The popularly known Cambay basin, in the alluvium covered area of Gujarat, is essentially a Cenozoic sedimentary basin. The presence of Cretaceous exposures around it suggests that under the Tertiary and Deccan Trap rocks, Cretaceous rocks might have been present in the central and southern parts of the Cambay basin. The development of Cretaceous basin, encompassing parts of Cambay and Narmada basins, appears to be related to the Cambay and Narmada geofractures. Their origin is attributed to the tension created by the northward drift of the Indian plate, and its counter clock-wise rotation (Biswas,1982). These basins witnessed marine transgressions and regressions. They were, alongwith a vast area of Central India, covered up by basaltic lava flows at the close of Cretaceous. The lava flows are believed to have flowed out along fractures generated on account of the breaking up of the Gondwanaland, and the northward movement of the Indian plate during India's drift in early Cenozoic, when its western margin crossed a fixed source of basaltic magma rising from the earth's upper mantle near the Equator. Molten rocks erupted through the crust and poured onto the Indian subcontinent laying down the basalts of the Deccan Plateau (Dietz & Holden,1970).

The thickness of the Deccan Trap is not precisely known. It is expected to vary in different parts. However, in the Narmada valley and adjoining areas, the Trap thickness is expected

to be upto 700 to 800 metres, and may exceed 2000 m in some parts of the Cambay basin.

The three main tectonic trends, (1) Aravalli, (2) Dharwar, and (3) Satpura influenced the tectonic setup and structural style of the Cambay basin. Reactivation along these tectonic trends, soon after the outpouring of Deccan Trap lava, developed a general north-south rifted basin within which there were faulted blocks marking highs and lows. These lows received the early Tertiary sediments, mainly trapwash, which in due course filled up the irregularity of the basement. At the close of the formative stage of the Cambay basin, when the initial irregularities were levelled up, in the southern part of the Cambay basin falling in the western most part of the Narmada basin, an uplift of the trapwash sediments resulting in their folding and partial erosion occurred. This was followed by a large scale marine transgression during early Eocene to early Middle Eocene. The general southerly tilt of the Cambay basin and the above referred to marine transgression is considered by the present author to have been due to further rifting of the basin as a result of continued northerly movement and counter clockwise movement of the Indian plate. The southerly tilt of the Cambay basin is reflected from the presence of thicker marine shales towards the southern part of the basin. During the Middle Eocene and Oligocene time

shallowing of the basin occurred, and the northern part of the basin had a continental environment. In the southern part there was marine environment but in the eastern margin, where the present area of study is located, regressive phase had developed depositing coquinoidal limestones in a narrow belt of shelf margin. The prevailing drainage in the adjoining area of the basin governed the lithological suites in the basin. The arenaceous input was governed by high energy regime, and in the deeper parts shales were deposited in a low energy regime.

On the Aravalli and Satpura trends, the former seems to have greatly influenced the derivation and distribution of sediments in the basin.

A number of deep wells in the Bombay offshore basin, which is the southern extension of the Cambay basin, penetrated the Tertiary sequence and entered Archaean basement without encountering the Deccan Trap or the Mesozoic. In a few wells Trap was encountered but it appears that trap is thin in the Bombay basin. East of Bombay town the Trap is as much as 2,500 m thick. North of the Narmada river and east of Cambay basin, the trap is comparatively thin and further north absent. It has thus been suggested by Rao & Talukdar (1982) that there are terrains which have thick trap juxtaposed with terrains of thin trap (Saurashtra Peninsula against Bombay Offshore basin, Sahyadris against Cambay basin and the terrains

north of Narmada). It suggests a prominent tectonic element, the Narmada fault which could be a dextral fault.

During the Miocene and post-Miocene times the tectonic activities had nearly ceased excepting in the area between Narmada and Tapti rivers. The tensional faults which had played a major role in forming the structural style of the Cambay basin, in the central and northern parts, ceased to grow any further and no displacement of sediments is observed. The fault traces in seismic sections coupled with subsurface geological data are seen to disappear by the early Miocene and sometimes by late Oligocene times. Whereas in the area of the Cambay basin between the Narmada and the Tapti rivers there had been a development of compressional stresses resulting in the deformation of the entire sedimentary sequence including the Deccan Traps, lying in between the Cretaceous and the Tertiary sequences. This tectonic activity took place during late Cenozoic affecting a large thickness of sequence. The ENE-WSW trending structural features have been mapped by the author not only in the exposed Tertiary and Quaternary sequences but also towards ENE in the Deccan Trap area and in the area of Cretaceous inliers of Narmada valley. The folds trend ENE, exhibiting invariably WSW plunges and occasionally towards ENE. The folds are invariably cut along their SSE limbs by reverse faults hading towards NNW. These are deep seated faults cutting across, in depth, Deccan Traps and Mesozoic sequence also. From the deep seismic

sounding surveys the cross faults of the Cambay basin have been observed to continue upto the Moho boundary(Kaila,1981).

In the last evolutionary phase of the Cambay basin, the Quaternary deposition filled up the remaining lows of the basin consequent upon the withdrawal of sea. The remnants of it can still be seen in the form of numerous land-locked partially saline lakes and ponds northeast of Saurashtra mainland. The alignment of these lakes suggests the connection of the Gulf of Cutch with the Gulf of Cambay in the Late Pliocene time. In the Narmada-Tapti river area of Cambay basin the Quaternary sediments have also been subjected to late Cenozoic tectonic activity.