CHAPTER - V

TECTONIC SETTING

GENERAL

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. The Cambay Basin comprised two

grabens, Cambay and Narmada, a major tectonic feature related to the rifting of the western margin of the Indian continent and opening up of the Narmada Geo-Fracture. The basin is a product of the tensions created by the northward drift of the Indian plate and its anticlockwise rotation. This phenomena of rifting and drifting at the close of the Mesozoic were accompanied by Deccan Trap volcanism, such that the basalts constituted the Tertiary basement of the Cambay Basin.

The Cambay Basin according to Biswas (1982, 1987) is bounded by a combination of tectonic lineaments and faults which follow three important Precambrian tectonic trends viz. Dharwar, Aravalli and Satpura (Fig. 5.1). The geological history of the basin indicates that they were formed by sequential reactivation of primordial faults. The Cambay Basin opened up in the early Cretaceous, giving rise to the Cambay and the Narmada grabens. This tectonic basin has been a site of continuous deposition all throughout the Cenozoic era. The basin to the east and west is bound by step faults, which are not continuous in nature.

The Cambay Basin sequence is characterised by Tertiary deposits which are mainly marine to fluvio-marine and the overlying Quaternaries indicate dominance of continental conditions. The withdrawal of the Tertiary sea marked the advent of the Quaternary period, as a result sedimentation took place in a number of fault bound sub-basins which represented the different structural blocks of the Cambay Basin. The eastern basin boundary is very well defined and marked by near vertical faults giving rise to a scarp system (Fig. 5.2). These scarps were quite

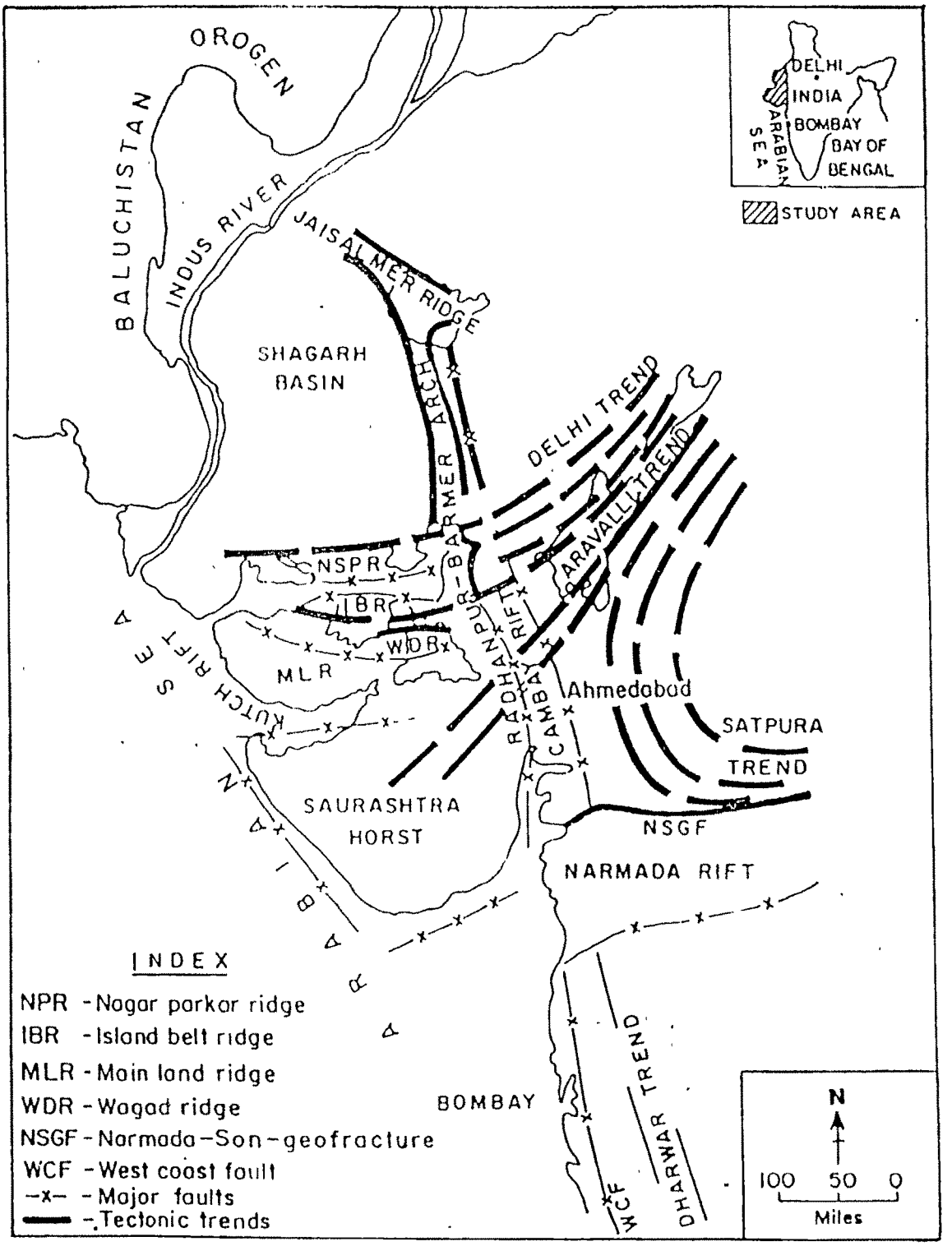
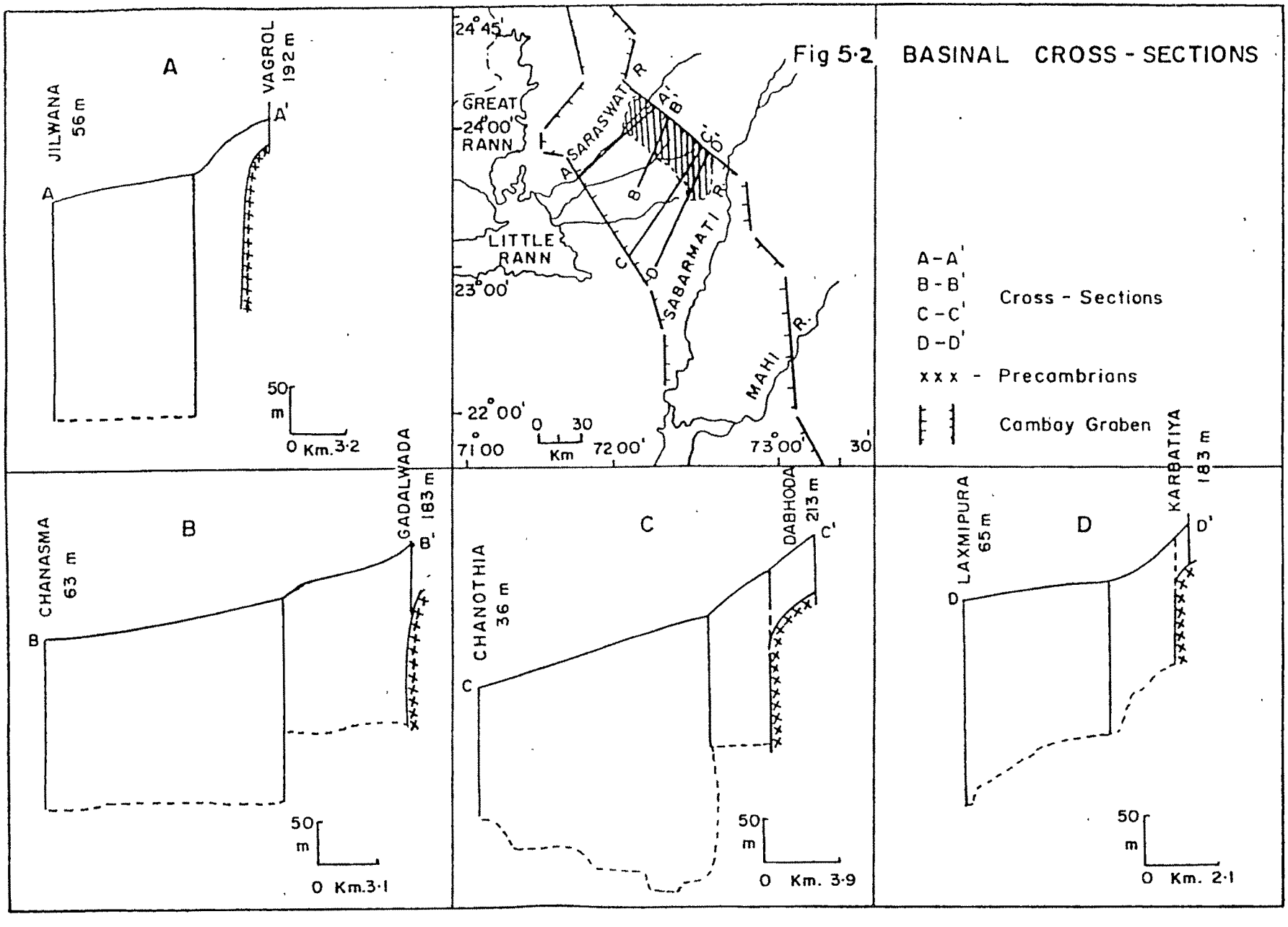


Fig. 5·1 TECTONIC TREND MAP OF WESTERN INDIA
(After Biswas, 1987)


A
JILWANA
56 m
A
VAGROL
192 m
A'
50
m
0 Km.3·2
24°45'
GREAT
RANN
24°00'
LITTLE
RANN
23°00'
22°00'
71°00'
0 30
Km
72°00'
73°00'
30'
SARASWATI R.
SABARMATI R.
MAHI R.
A
A'
B
B'
C
C'
D
D'
Fig 5·2
BASINAL CROSS - SECTIONS
A-A'
B-B'
C-C'
D-D'
Cross - Sections
xxx - Precambrians
Cambay Graben
B
CHANASMA
63 m
B
GADALWADA
183 m
B'
50
m
0 Km.3·1
C
CHANOTHIA
36 m
C
DABHODA
213 m
C'
50
m
0 Km. 3·9
D
LAXMIPURA
65 m
D
KARBATIYA
183 m
D'
50
m
0 Km. 2·1

prominent and marked the limit of the Tertiary and Quaternary seas as well. It was this tectonically controlled topographic feature which significantly influenced the pattern of Quaternary sedimentation especially the accumulation of lower most gravelly horizon. The Quaternary sediments were deposited by an earlier more powerful drainage system which had a larger catchment and in all probability originated further north, perhaps in the Himalaya. The disruption of the former and the formation of the existing drainage is attributed to uplift of Aravallis in the NE coupled with reactivation of NNE-SSW fractures related to the Cambay Basin during the late Quaternary. During the Quaternary sedimentation also, tectonic activity continued to play an important role and this factor is very well reflected in the variable thicknesses and nature of Quaternary sediments in different parts of the Quaternary basin. The tectonic movements are probably still continuing as is evidenced by the various geomorphic features.

The study area located in the northern part of the Cambay Basin, forms a part of Ahmedabad - Mehsana tectonic block (Fig. 5.3) of the Cambay Basin. its northern extremity falls in the Sanchor depression, a northern extension of the Cambay Basin. It is made up of a Quaternary sequence which is comparable to those encountered in the southern part of the basin. The depositional history being somewhat different, whereas the eastern limit of the depositional basin is reasonably well defined and more or less coincides with the Eastern Margin Cambay Basin Fault (EMCBF), the western limit is not yet fully understood. In the southern part of the Cambay Basin, the Western Margin Cambay Basin Fault (WMCBF) marks the limit of the depositional basin but northward, the deposits falling within the study area are found to transgress the WMCBF. Fluvial deposits

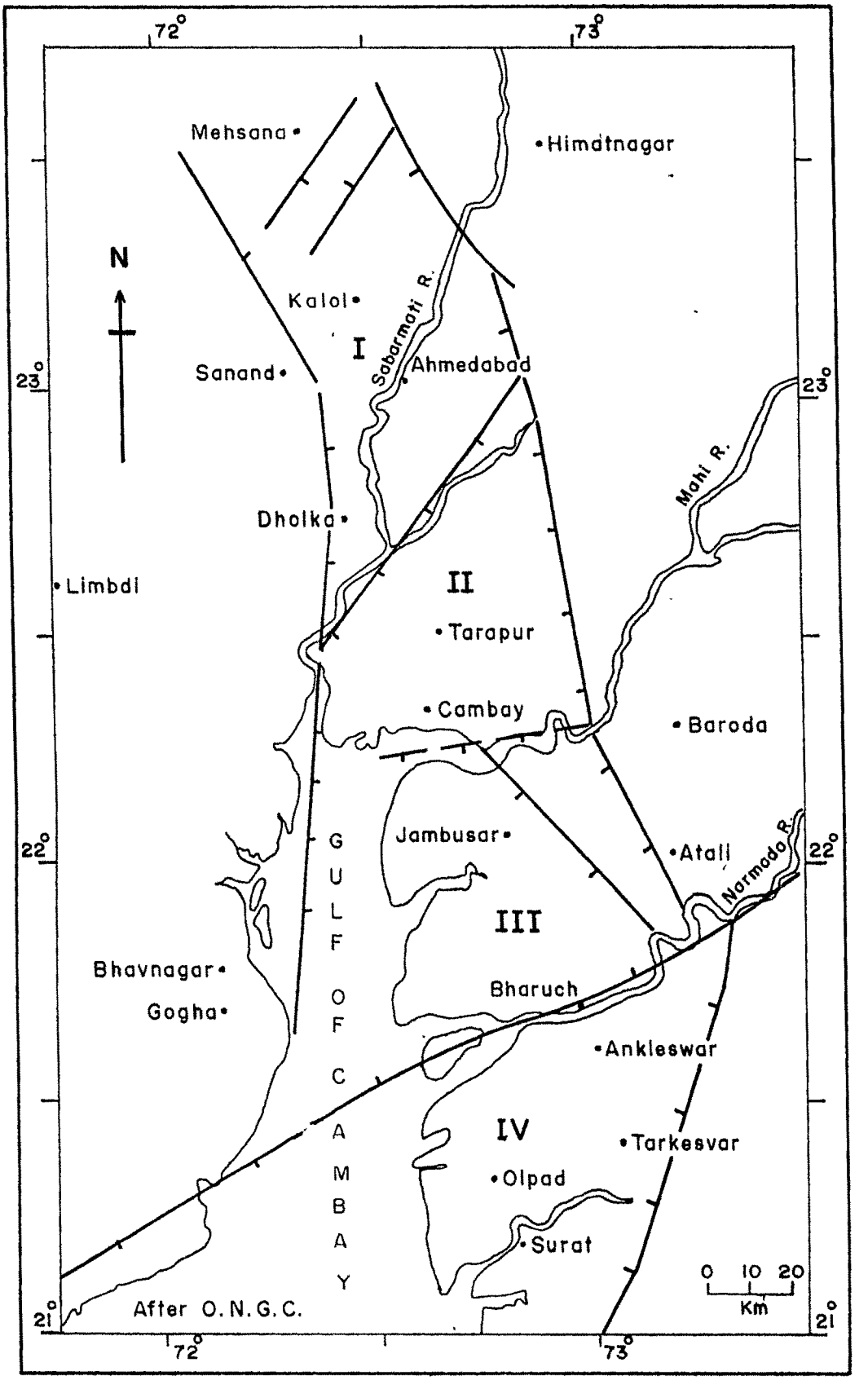


Fig. 5·3 TECTONIC MAP OF CAMBAY BASIN

I Ahmedabad–Mehsana Block II Cambay–Tarapur Block

III Jambusar–Bharuch Block IV Narmada Block

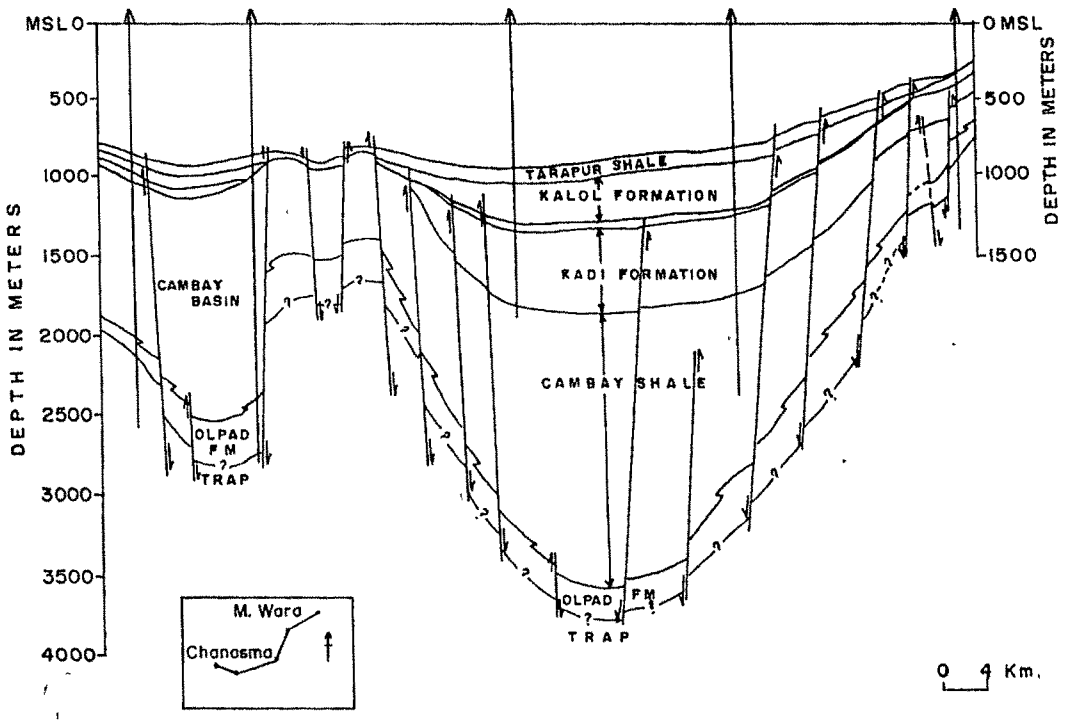
have been reported from the Little Rann (Ghosh, 1982) also and obviously, the western limit of the basin lies somewhere within the Little and the Great Rann.

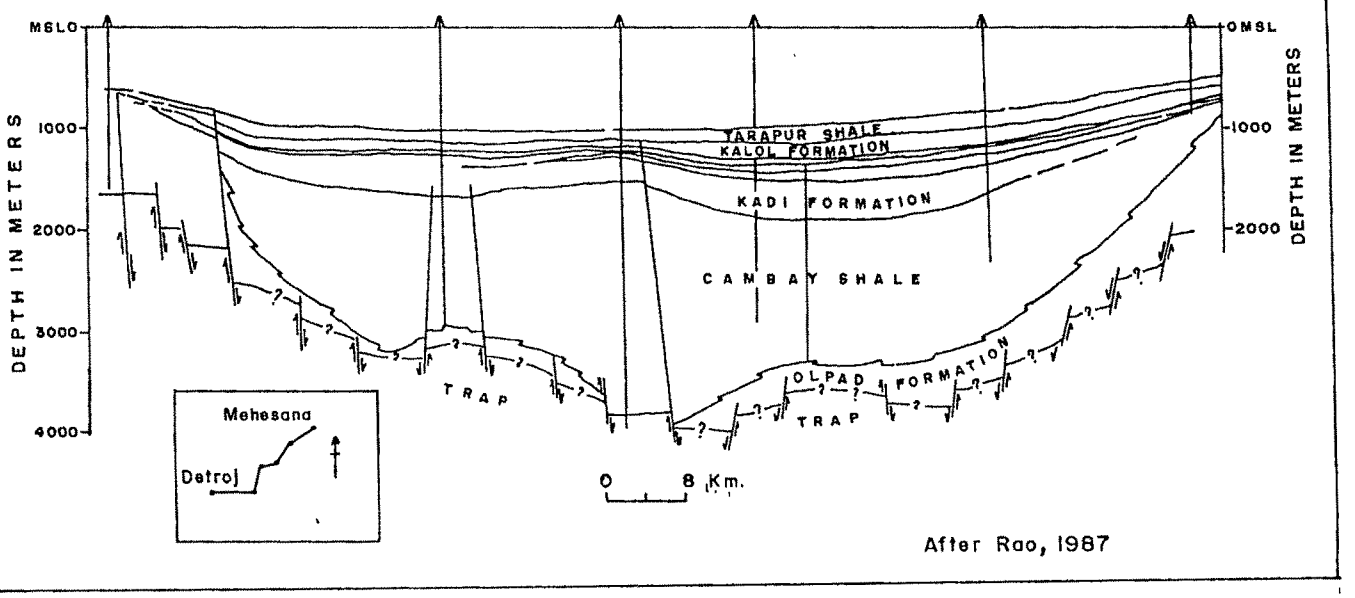
CAMBAY BASIN TECTONICS

The Cambay Basin represents the northward inland extension of the large off-shore west coast basin which marks the site of a major rift along the western margin of the Indian Platform. The basin extends on the land from Bilimora (Valsad district) in the south to Tharad (Banaskantha district) in the north across the Gulf of Cambay upto Ghogha on the Saurashtra coast, on the western side. Its eastern margin abuts against the Precambrians and the Deccan Trap. Raju (1968) has described it as an intracratonic rift basin situated on the western continental margin of India. Biswas (1982) has categorized it to represent an Atlantic type passive margin. Figure 5.1 shows the regional tectonic setting of western India vis-a-vis the Cambay Basin. Three major Precambrian orogenic trends, the NNW-SSE Dharwar trend, the NW-SE Aravalli trend, ENE-WSW Satpura trend control the structural fabric of the basin and provide basis for delimiting the basin boundaries as well as dividing it into the various tectonic blocks. These major tectonic blocks associated with the basin formation appear to have followed somewhat separate depositional history throughout the Cenozoic although all of them have retained a common identity.

The basin which received the Quaternary sediments was tectonically active atleast till the advent of Neogene deposition. Basinal cross-sections (Fig. 5.4) very clearly show active faulting affecting the Neogenes. The basin which received the

Fig. 5·4 GEOLOGICAL CROSS SECTIONS ACROSS CAMBAY BASIN





After Rao, 1987

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.

TECTONISM VIS-A-VIS DEPOSITION

The Quaternary depositional sequence resting over the Tertiaries has preserved numerous evidences of tectonic movements at various stages of the accumulation of vast dominantly continental sequence. As it has been already pointed out, the Cambay Basin depression provided an ideal location for the accumulation of sediments. The basin, essentially a tectonic one appears to have remained active at all stages of the Quaternary deposition. The uplifts and subsidences along various pre-Quaternary faults in the different parts of the basin have not only delineated/ delimited the Quaternary deposits, but appears to have significantly influenced the nature and thickness of various types of deposits in its various segments and also brought about numerous changes in the depositional regimes post-dating the main episode of sediment accumulation. 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 (Fig. 5.5) clearly shows the control exercised by tectonism over to the fluvial depositional sequence.

PRE-DEPOSITIONAL TECTONIC MOVEMENTS

These essentially comprise uplifts and subsidences of the Neogene rocks prior to the initiation of the Quaternary deposition. To this category would also belong the faults at the eastern and the western flanks which marked the limit of the deposition. The eastern limit of the Quaternary basin comprises two parallel step faults extending northwestwards; of these two the fault running NW-SE (Fig. 5.2) and coinciding with the EMCBF demarcates the contact with the Precambrians while the other one a little to the West has been deciphered in the sub-surface which also extends in a direction parallel to the earlier fault. Both these faults are more or less vertical against which abut the Quaternaries.

The western limit of the Quaternary deposition is seen to transgress the Western Margin Cambay Basin Fault (WMCBF) and its limit broadly is demarcated by a N-S fault marking the fringe of the Great Rann and NW-SE fault which limits the Little Rann (Fig. 5.5). These two Quaternary limiting faults though broadly parallel to the WMCBF are obviously related to the latter. The various transverse faults trending NE-SW within the Cambay Basin appear to be

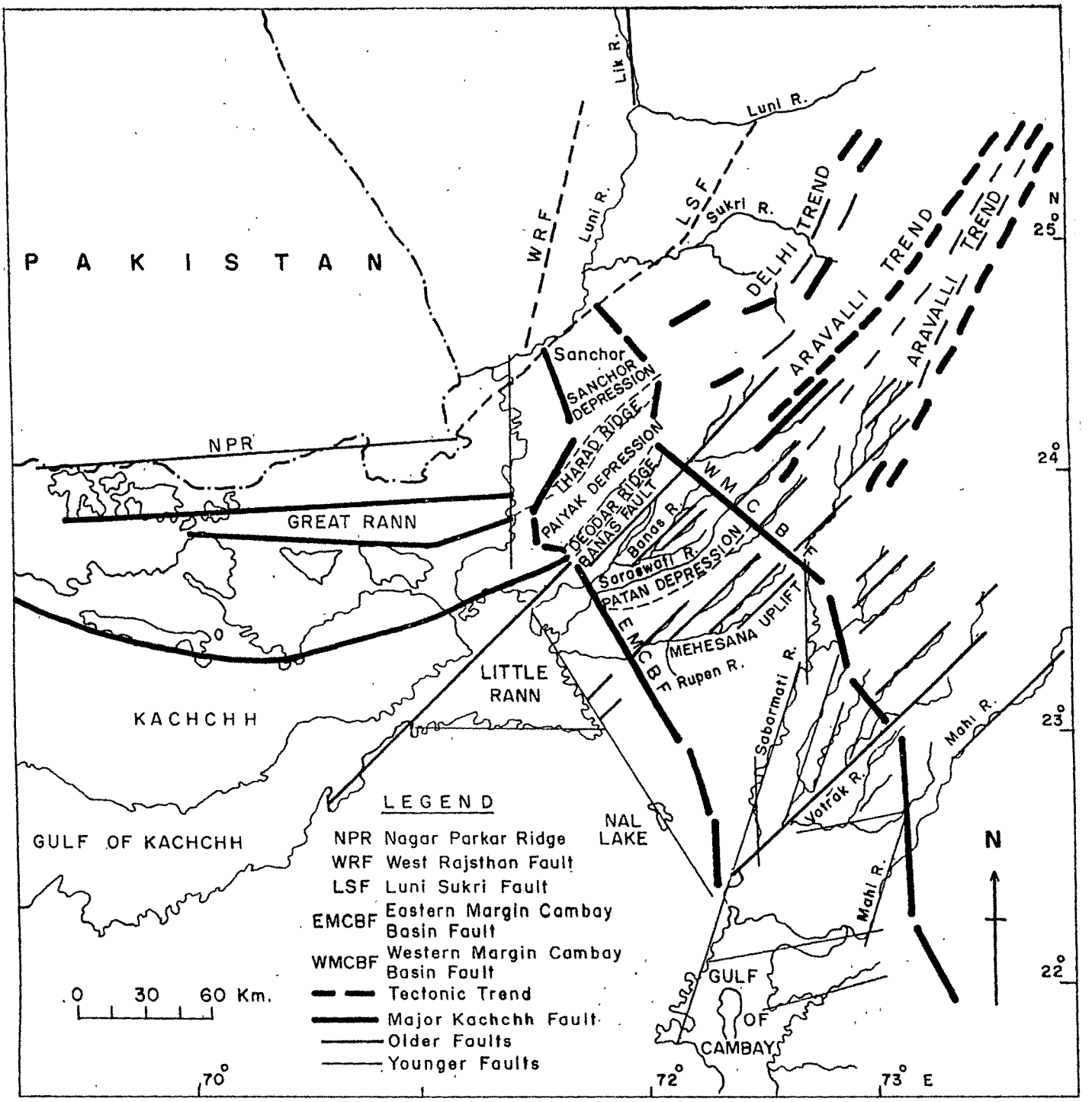


Fig. 5·5 LINEAMENT MAP OF STUDY AREA

responsible for the initial uneven topography of the pre-Quaternary basin marked by linear ridges and depressions. These sub-surface lineaments which were affected by the various basin bounding faults pre-existed the Cambay Basin and can be traced to the east of the eastern bounding fault (EMCBF) and to the west of the western bounding fault (WMCBF). It is not unlikely that the various E-W faults characterizing the Rann of Kachchh landscape, continue in the Cambay Basin sub-surface (Fig. 5.5). This particular phenomena in the regional framework has been very ideally explained by Biswas (1987) (Fig. 5.1).

The present author has on the basis of sub-surface details available in the O.N.G.C. works (Chandra and Chowdhary, 1969; Rao, 1987) supported by his own analysis of drainage and topography has been able to arrive at a reasonably good picture of the tectonically controlled bottom topography. He has recorded a number of controlling lineaments, some seen on the surface by way of drainage lines while others marking the basins highs and lows (Fig. 5.5). It is quite obvious that the Cambay Basin has been divided in the various tectonic blocks on the basis of the transverse faults running NE-SW. The uplifts and subsidences in the Ahmedabad - Mehsana block and the northern extension of the basin towards Sanchor, typically indicate the vertical movement along these parallel faults. The entire fracture pattern of the post - Mesozoic depositional basin thus points to the following sequence of events.

(i) Uplifts and subsidences along NE-SW faults (perhaps prior to the formation of the Cambay Basin). These fault lineaments can be traced towards the Gulf of Kachchh and in the Little and the Great Ranns of Kachchh.

(ii) Development of basin bounding faults on the two flanks broadly trending NNW-SSE. These are seen to comprise the eastern and western bounding faults of the Cambay Basin, ECMBF and WCBMF respectively.

(iii) It is postulated that quite a few smaller faults parallel to these bounding faults developed prior to or during the Tertiary deposition.

(iv) The bottom topography of the Neogenes over which the Quaternary sedimentation rests was thus a reflection of the above tectonic setting.

POST DEPOSITIONAL TECTONISM

The continental deposition comprising the major bulk of the deposits, both fluvial and aeolian, was affected by a very well defined tectonic event. This late post depositional tectonism was responsible for disrupting the previous drainage system and superimposition of few new tectonically controlled drainage lines. The present day drainage of the Gujarat alluvial plains in general and N. Gujarat (study area) thus provides a good example of control exercised by tectonic lineaments over the development of the drainage as also providing good evidences towards proper understanding of the late Quaternary history. The existing landscape when analysed from the point of view of this tectonic factor provides much data on the various manifestations of the post depositional tectonism which can broadly be classified into two categories viz;

(i) features related to the reactivation of the older faults and

(ii) features related to the development of new fracture system

To the former category belong uplifts, subsidences and tilting of pre-existing fault blocks and development of faults parallel to the two main basin bounding faults. To the second category belong a fault system more or less trending NNE-SSW to N-S which have given rise to a few new drainage lines, for example, Lik river a tributary of Luni, new course of lower half of Sabarmati river and parts of Mahi river. Movements along these lineaments of both the categories have brought about significant disruption of older drainage, relicts of which are still preserved.

The salient features of the effects and manifestations of post depositional tectonic events have been discussed below.

Reactivation of Older faults

Post depositional differential vertical movements parallel to the pre-existing NE-SW faults which have divided the Cambay basin into various tectonic blocks and of the faults parallel to the two main boundary faults (WCBMF AND ECBMF) are very clearly seen in the following terrain features.

Topographic variations

Somewhat striking and more or less abrupt rise in the ground level is an indication of reactivation of older faults which at the moment have been deciphered in the sub-surface only. A NNW-SSE trending fault running along more or less parallel to the EMCBF is very clearly reflected in the altitude rise of

the order of 25-30 m (Fig. 5.2) (Based on sub surface information GWRDC reports). The NW-NE-SW trending bounding fault broadly marking the northwestern limit of the Little Rann is very clearly the extension of the Banas fault. This fault cuts across the Cambay Basin both to its east and west and represents reactivated lineaments which perhaps originally pre-dated the Cambay Basin formation. This fault extending south eastward delineates the linear trench like depression extending right upto the Gulf of Cambay. The E-W trending boundary fault marking the southern limit of the Little Rann is also a well defined fault and possibly cut by the other two limiting faults (Fig. 5.5).

The variations in the topography indicative of reactivated faults is also seen in the uplifted areas of Tharad and Diodhar. These comprise linear areas of uplift, reflecting tectonic movements along ENE-WSW, basin faults reactivated after the deposition of the major bulk of the sequence. Differential movement along pre-existing faults mostly trending ENE-WSW have at several places resulted into variations in the altitudes of the main terrace and also the northwestward tilting of the various fault bound blocks. The differential altitudes of terraces are well illustrated in the upper and middle reaches of the Luni river. Within the limits of the study area, this phenomena is not so prominently observed except in the extreme northern part near the state boundary but other workers (Kar, 1988; Ghosh, 1982) have described the terrace heights. Post-depositional tectonism in the neighbouring areas of the Rann of Kachchh have been reported by Biswas (1982, 1987).

The phenomenon of tilting is very much clear in the study area. It is seen that in most rivers (including Mahi and Narmada) the slope controlled tributaries are confined to left bank only (Fig. 1.2). A good example of differential terrace height is seen at Waghpur in the Sabarmati river, but here the uplift appears to be related to the late NNW-SSE trending fracture zone.

These uplifts have to be considered together with the phenomena of tilting. It may be mentioned that the two features viz. differential uplifts and tilting are of the order of a few metres and as such they are only occasionally noticeable. Figure 5.6 provides a schematic and somewhat exaggerated picture of the phenomena of differential uplifts including uplifts and subsidences of tectonic blocks and tilting of the Quaternary deposits.

Development of new faults

The post-depositional tectonism is also manifested in the development of a number of new features which have significantly altered the geomorphic configuration of North Gujarat and Kachchh, and has also brought about disruption of the pre -existing drainage system. The new faults which have cut across the Quaternary sequence are;

(i) N-S (to NNE - SSW) trending faults along which the present day Sabarmati river as well as Lik river a prominent tributary of the Luni flow. Whereas the latter as seen today has a more or less fragmentary course considerably filled up with the recent blown sand, the Sabarmati provides an excellent

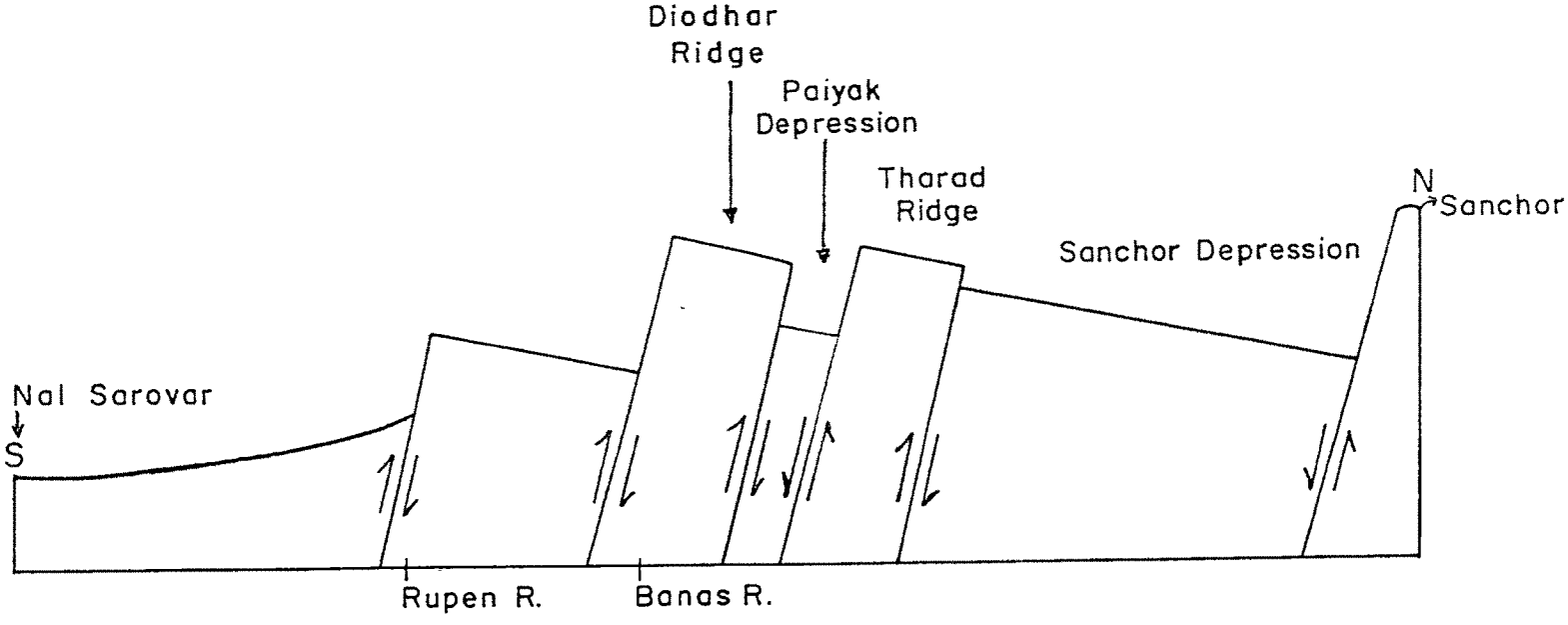


Fig. 5·6 SCHEMATIC DIAGRAM SHOWING TILTING OF FAULT BOUND BLOCKS (Not to Scale)

example of post-depositional fracture revealing ideal sequence of the earlier deposited sediments in the various cliff sections of the river.

(ii) The faults which delimit the Great and the Little Rann to the east also represent post-depositional fracturing. The Great Rann boundary is marked by an almost N-S fault whereas the fault that marks the limit of the Little Rann trends NW-SE. The Little Rann fault though more or less parallel to the West Cambay Basin Bounding Fault (WCBMF) is much younger; it affected the fluvial sediments also and as a result of this faulting within the Little Rann the marine silts overlie the fluvial sands and gravels (Ghosh, 1982; Gupta, 1977). Both these faults indicate relative uplifts of the order of 6-10 m to the east of these two faults. This tectonism appears to have significantly disrupted the then prevailing drainage system. Of all the younger fractures the one running along the Sabarmati is the most prominent and extends southward beyond the river mouth upto Bhavnagar following the Saurashtra coast. Against this Sabarmati fault, perhaps abuts the WMCBF as well as the NW-SE trending Little Rann fault (Fig. 5.5).