CHAPTER

III

GEOLOGICAL FRAMEWORK

REGIONAL GEOLOGICAL SETUP
STRUCTURAL CONTROL OF GULF CONFIGURATION
STRATIGRAPHIC SETUP OF THE GULF

CHAPTER III

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

REGIONAL GEOLOGICAL SET UP

The geological diversity of Gujarat, though not directly related to the present study has considerable indirect relevance so far as the nature of the offshore and onshore sediments of tne Gulf of Khambhat are concerned. It is therefore, very necessary that an outline of the geological framework is given. After all the sediments added to the Gulf of Khambhat in the Late Quaternary are derived from provenances comprising rock formations of different ages and lithologies.

On the basis of geology and geomorphology Gujarat can be divided into following three main units:

i) The Mainland Gujarat

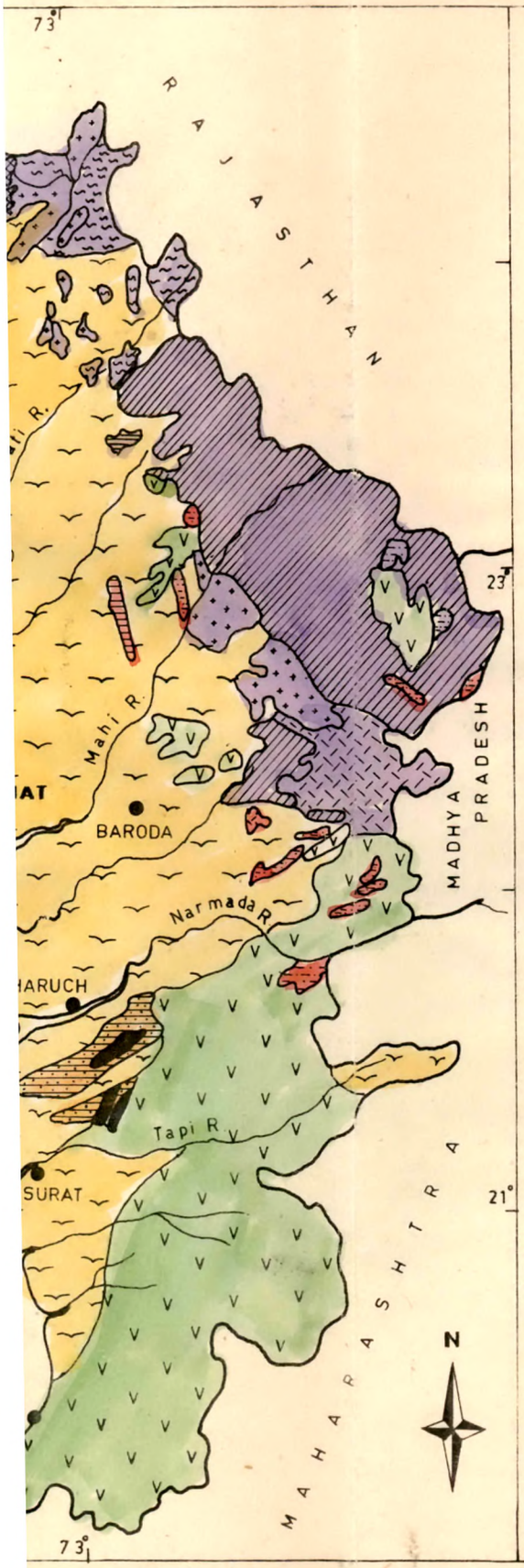
ii) The Saurashtra Peninsula, and

iii) The Kutch.

The Mainland Gujarat extends from Ambaji in the north to Umbargaon in the south and comprises rocks ranging from Precambrian Banded Gneissic Complex to Recent deposits. The Saurashtra Peninsula is bound on three sides by sea, except in the northeast, where it is flanked by the alluvial plains of the Mainland Gujarat; its rocks range from Juro-Cretaceous (sedimentary and volcanic) to Recent coastal deposits. The Kutch region forms the northwestern part of the Gujarat State, its northern limit is marked by the international border with Pakistan. To the south and west of Kutch lies the Arabian sea, while in the east it is bounded by the Rann of Kutch. The rocks of Kutch show a fairly wide geological range. Over a Precambrian basement rests a striking and almost unbroken Mesozoic (Jurassic-Cretaceous) and Cenozoic sedimentary sequence.

The details of the various formations occurring in the three units (Fig. III.1) are summarized in the accompanying table (Table 3.1). It is interesting to observe that within a relatively small areal extent comprising the state of Gujarat, its three main constituent units show considerable geological and structural diversity, pointing to quite distinct evolutionary histories for each unit.

FIG. III. 1



GEOLOGICAL MAP OF GUJARAT

RANN SOILS (SALT ENCRASTED)	RECENT AND SUBRECENT
ALLUVIUM AND BLOWN SANDS	
MILIOLITE	PLEISTOCNE
LATERITE	
DWARKA MANCHHAR BEDS	TERTIARY
GAJ SERIES	
KIRTHAR-LAKI BEDS	
DECCAN TRAP	CRETACEO-EOCENE (EFFUSIVE ROCKS)
BAGH BEDS LAMETA BEDS WADHAWAN SANDSTONE	CRETACEOUS
HIMATNAGAR SANDSTONE NIMAR SANDSTONE UMIA AND BHUJ BEDS DHRANGADRA SANDSTONE	
KATROL SERIES CHARI SERIES PATCHAM SERIES	JURASSIC
BASIC INTRUSIVES	PRE-CAMBRIAN
ACID INTRUSIVES	
DELHI SYSTEM	
ARAVALLI SYSTEM	
GRANITES AND GNEISSES	

0 40 80
km

Modified after ONGC and GSI


69°
71°
P A K I S T A N
THARAD
PALANPUR
GREAT RANN OF KUTCH
LAKHPAT
MAHESANA
LITTLE RANN
BHUJ
JAKHAU
AHMEDABA
23°
MANDVI
LAKHTAR
GULF OF KUTCH
JAMNAGAR
KHAMB
RAJKOT
DWARKA
GULF OF KHAMBHAT
BHAVNAGAR
PORBANDAR
JUNAGADH
Shetrunji R.
TALAJA
21°
DIU
DAMA
A R A B I A N S E A
69°
71°

TABLE - 3 1 GENERALISED STRATIGRAPHIC SUCCESSION OF GUJARAT

GEOCHRONOLOGIC UNIT		MAINLAND GUJARAT		SAURASHTRA		KUTCH	
PERIOD	EPOCH	FORMATION	LITHOLOGY	FORMATION	LITHOLOGY	FORMATION	LITHOLOGY
QUATERNARY	HOLOCENE	ALLUVIUM	NEOALLUVIUM, MUDFLATS, BEACHES DUNE SANDS & SOILS	ALLUVIUM	ALLUVIUM, MUDFLATS, BEACHES AND DUNESANDS SOILS	ALLUVIUM	ALLUVIUM, SANDS & CLAY, SOILS RANNCLAYS ETC
	PLEISTOCENE	OLDER ALLUVIUM & LATERITIC ROCKS	SANDS & CLAYS, ALLUVIUM, LATERITES	AGATE CONG AND SANDSTONE MILIOLITE	AGATE CONGLOMERATE AND ASSOCIATED SANDSTONES CALCARENITE, CALCRUDITE WITH INTERCALATION OF CLAYS	MILIOLITE FORMATION	CLAY ARENITE AND OOMICRITES
TERTIARY	PLIOCENE			DWARKA FORMATION	SILTY CLAYS, GYPSIOUS CALCAREOUS CLAYS & MARLS, ARENACEOUS LIMESTONE FOSSILIFEROUS CONGLOMERATES,	KANKAWATI SERIES	SANDSTONES, FOSSILIFEROUS CALC - GRITS AND CONGLOMERATES WITH SHALES
		JAGADIA FORMATION	CALCAREOUS AND MICACEOUS SANDSTONES AND SANDS	PIRAM BEDS	GRITS AND SANDY CLAYS SANDSTONE & CONGLOMERATES		
	MIOCENE	KHAND FORMATION	LIMESTONES & FERRUGINOUS AGATE CONGLOMERATES	GAJ FORMATION	FOSSILIFEROUS GRITS, GYPSEOUS CLAYS WITH THIN BANDS OF LST	KHARI SERIES	GRAY CLAY WITH FOSSILIFEROUS MARL, VARIAGATED SILTSTONES
		TARAKESWAR FORMATION	SILTY CLAYS WITH LENSES OF LATERITES				
	OLIGOCENE					BERMOTI SERIES	SILTY SHALE, MARL, SANDS, LIMESTONES, CALC-CLAYS & SHALES
	EOCENE	NUMMULITIC FORMATION	FERRUGINOUS CLAYS & LIMESTONE WITH BENTONITIC BANDS			BERWALI SERIES	LIMESTONES CLAYS, LATERITES, LIGNITE AND BLACK SHALE
		VAGAD-KHOL FORMATION	TRAP WASH, FERRUGINOUS SANDSTONE	LATERITIC ROCKS	RED BROWNLATERITES, BAUXITE TUFFACIOUS MATERIAL	MAD SERIES	LATERITES, TUFFACIOUS SHALES, BENTONITIC CLAYS VOLCANIC ASHES
	PALEOCENE	DECCAN TRAP	BASALTS WITH ALL ALKALINE VARIETIES & DYKES	DECCAN TRAP	BASALTS, PLUTONIC MASSES AND DYKES, THIN INTERTRAPPEAN BANDS	DECCAN TRAP	MASSIVE BASALTS & AMYGDOLOIDAL BASALTS WITH INTERTRAPPEAN BEDS
CRETACEOUS		INFRATRAPPEAN LAMETA BEDS	SANDSTONE	WADHWAN SANDSTONE	SANDSTONE WITH INTERCALATION OF CLAYS		
		BAGH BEDS	LIMESTONES & SANDSTONE				
		HIMATNAGAR SANSTONE	SANDSTONES	DHRAGADHRA FORMATION	SANDSTONE GRITS CARBONACEOUS SHALES WITH COAL & PLANT REMAINS	BHUJ FORMATION	SANDSTONES CONGLOMERATES AND SHALES
JURASSIC						JHURAN F M	SANDSTONES AND SHALES
						JUMARA F M	SHALES & LIMESTONES WITH OOLITIC BANDS
						JHURIO F M	LIMESTONES
PRE CAMBRIAN		ERINPURA GRANITE	ULTRABASIC, BASIC AND ACIDIC INTRUSIVES				
		DELHI SYSTEM	QUARTZITES, PHYLLITES AND SCHISTS				
ARCHEAN		CHAMPANER SERIES (ARAVALLI SYSTEM)	GRANITES, PHYLLITES, SCHISTS, DOLOMITES, QUARTZITES				
		BANDED GNEISSIC COMPLEX	GRANITIC GNEISSES AND MICA SCHISTS				

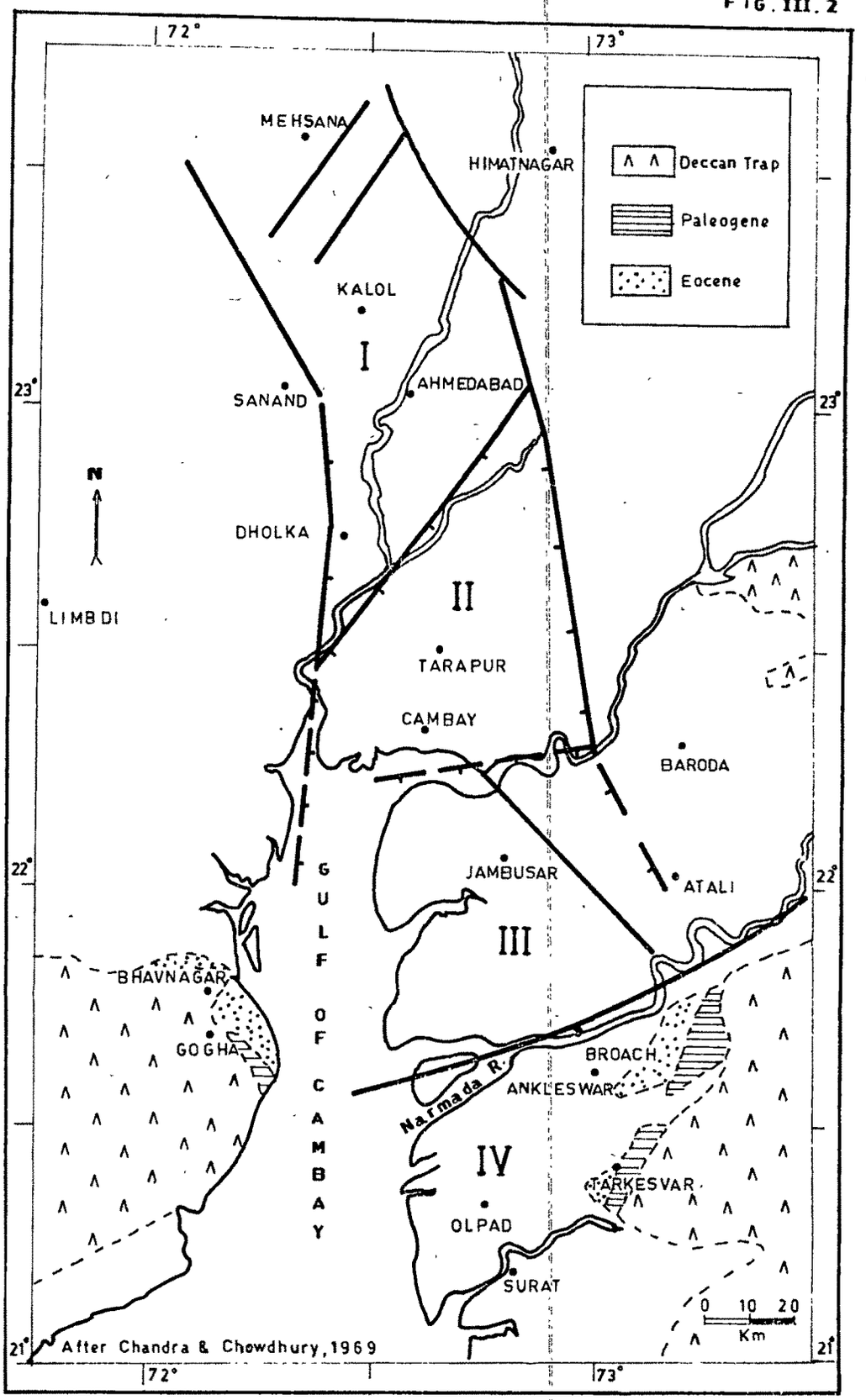
(Compiled after Krishnan, 1968 Shrivastava, 1968, Biswas 1971)

STRUCTURAL CONTROL OF GULF CONFIGURATION

The Gulf of Khambhat reflects the control exercised by the numerous major and minor faults related to the Cambay Basin. The tectonic framework of the Cambay Basin which has been investigated by the various workers of the ONGC (Raju, 1968; Mathur & Evans, 1964), Mathur et al., 1968; Chandra & and Chowdhary, 1969) differs in details but in a broad sense the major lineaments of the east and west basin-bounding faults as well as a number of cross cutting faults have been found responsible for the existing configuration and geological and geomorphological evolution of the Gulf of Khambhat and the coastal areas facing the Gulf. It is obvious that the tectonic evolution of Cambay Tertiary Basin is closely related to that of the Gulf. Whereas the Cambay Basin comprises Tertiary deposition, the present day Gulf is the Quaternary manifestation of the same tectonic set up.

Mathur et al. (1966, 1968) and Chandra & Chowdhary (1969) divided the Cambay Basin into four tectonic blocks namely; Narmada block, Jambusar-Broach block, Cambay-Tarapur block, and Ahmedabad-Mehsana block (Fig.III2). Subsequent workers have somewhat modified the tectonic picture visualized by Mathur et al. (1966) and found that the basin to the east and west was bounded by step faults which were discontinuous in nature. The two basin bounding faults have been shown to continue southward as en'echelon step faults (Fig.III.3). Out of the

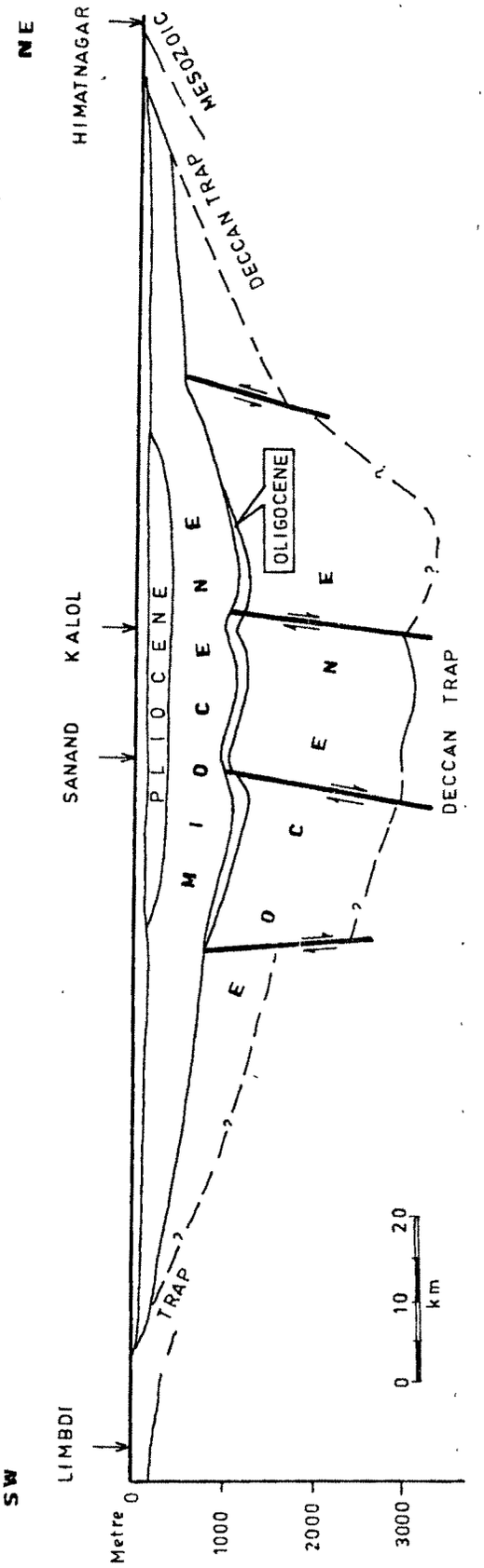
FIG. III. 2



TECTONIC MAP OF CAMBAY BASIN

I. AHMEDABAD-MEHSANA BLOCK
II CAMBAY-TARAPUR BLOCK
III. JAMBUSAR-BROACH BLOCK
IV NARMADA BLOCK

FIG. III. 3



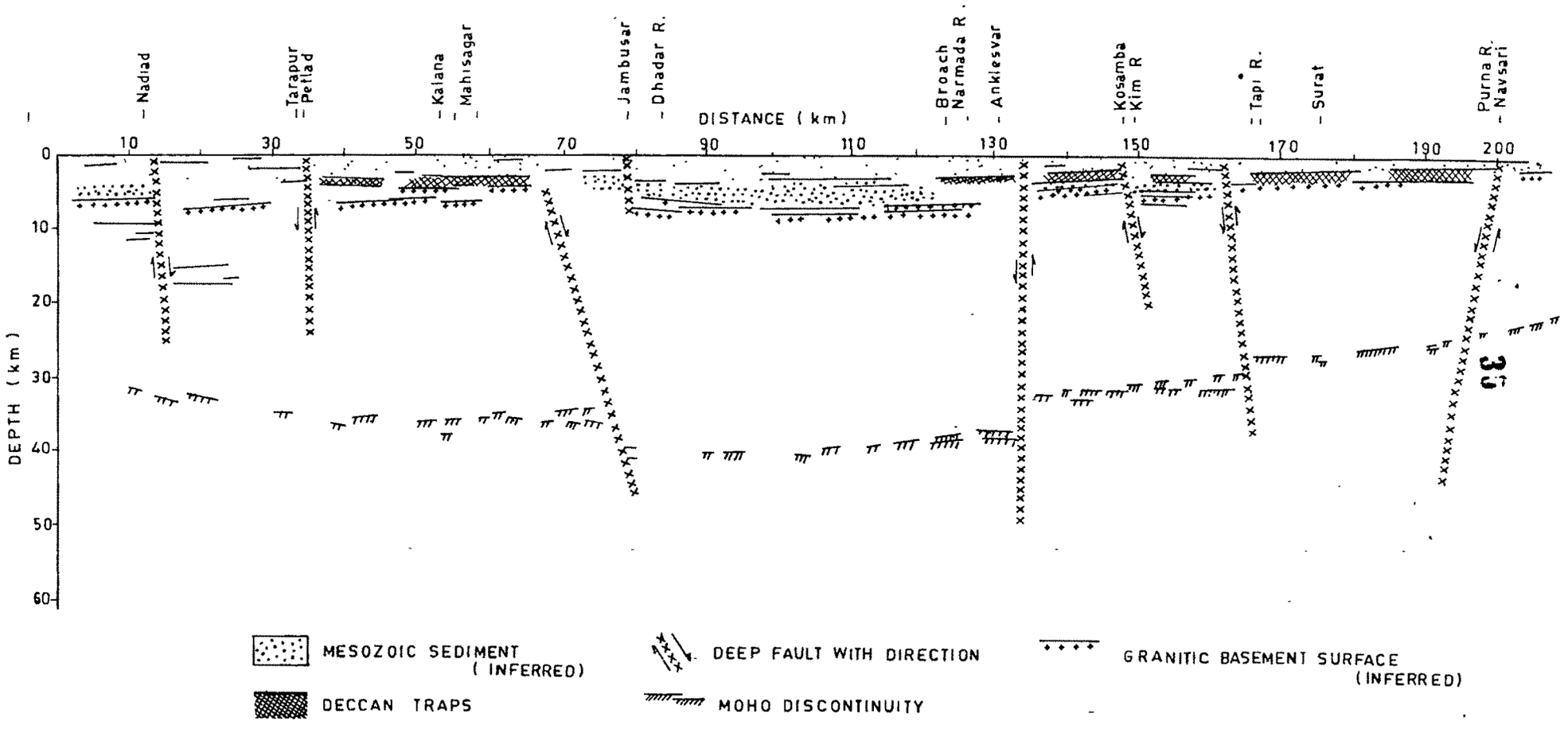
DIAGRAMATIC SECTION ACROSS CAMBAY BASIN (AFTER MATHUR & EVANS, 1964)

different tectonic models available for the Cambay Basin (Raju, 1968; Mathur et al.,1968; Markevich et al., 1976; Rao & Talukdar, 1980; Biswas, 1982) the present author is more inclined to agree with Raju & Srinivasan (1983), who have described the Cambay Basin as an intracratonic rift graben between Saurashtra uplift and Aravalli ranges extending in a roughly north-south alignment from north Gujarat through the Gulf of Khambhat to as far south as Ratnagiri offshore. The partly inland and partly offshore Cambay Basin opens to southwest into the Bombay Offshore Basin.

Tectonically viewed the Gulf of Khambhat can be divided into three parts. The north-south Saurashtra coast overlooking the Gulf marks the site of a major lineament known as Western Cambay Basin Boundary Fault (WCBBF). Ganapathi (1981) has referred to the southern extension of this fault as Ghogha-Sanand fault. This author (Ganapathi, 1981) has also shown a NW-SE fault along the river Shetrunji which possibly meets the N-S bounding fault. The two faults together have considerably influenced the Quaternary history of the Saurashtra side of the Gulf coast. The northern tip of the Gulf which is marked by a narrow east west extending muddy coast almost forms the meeting point of Sabarmati and Mahi and most probably follows a fault line (Mathur et al. (1968). Though on the basis of LANDSAT-1 imagery studies Powar (1981) has shown a lineament along Mahi-Narmada coast, existence of such a fault is doubtful. No fault line has been

reported along the Mainland coast extending in a north south direction by any one else but according to the ONGC workers it certainly forms a partly submerged graben of Jambusar and Narmada blocks South of Narmada however, a fault has been shown by Biswas (1982) a little inland and parallel to the Dharwar trend. An interesting tectonic feature of the Gujarat Mainland coast is the presence of numerous transverse faults broadly coinciding with the major river trends namely those of Mahi, Narmada and Tapti. On the basis of Deep Seismic Sounding, Kaila et al., (1981) have delineated some more basement lineamnets which have cut even the Moho boundary. (Fig.III.4). This cross cutting lineaments are reflected in the depositional history of the Cambay Basin during Tertiary and Quarternary periods.

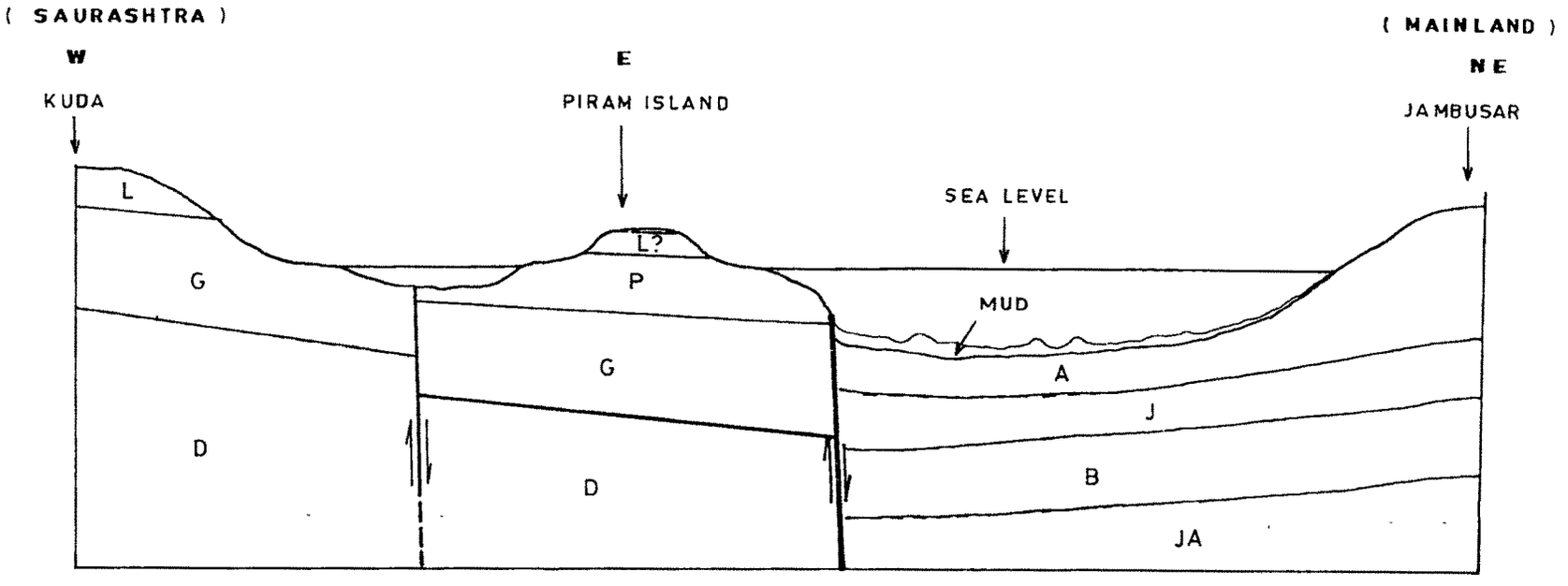
The existing coastal and bathymetric features, especially on the Saurashtra side reveal well marked fault control. The present author is very much inclined to invoke a N-S trending fault bordering the eastern side of the Piram Island. It is quite possible that the Ghogha-Sanand Fault which Ganapathi (1981) has shown to pass from inbetween Ghogha and Piram, in fact, lies to the east of Piram Island. Of-course, the possibility of a smaller N-S fault inbetween Ghogha and Piram cannot be ruled out. Considering the various evidences, the present author has schematically visualized a section (Fig.III.5) across the Gulf to show the relative positions of the various formations.



MAJOR BASEMENT LINEAMENTS CUTTING MOHO BOUNDARY

(Based on Kaila et al, 1981)

FIG. III.4



SCHEMATIC SECTION ACROSS THE GULF

L	LAKHANKA FORMATION	A	ALLUVIUM
P	PIRAM BEDS	J	JAMBUSAR FORMATION
G	GAJ FORMATION	B	BROACH FORMATION
D	DECCAN TRAP	JA	JAGADIA FORMATION

FIG. III.5

STRATIGRAPHIC SET UP OF THE GULF

From the stratigraphy point of view, the Gulf of Khambhat and its environs, comprise mostly post-Mesozoic depositional sequences, dominantly marine. Resting unconformably over the basalts of the Deccan Trap, the Tertiary rocks constitute the Cambay Basin, Although a large part of the Gulf of Khambhat does not show any significant outcrops of the Tertiary rocks in its coastal areas, their presence, stratigraphy and lithology have been thoroughly investigated by the ONGC (Raju, 1968; Chandra & Chowdhary, 1969; Rao, 1969; Sudhakar & Basu, 1973; Raju and Srinivasan, 1983; Biswas & Deshpande, 1983; Sastry et al., 1984). Table 3.2, gives the stratigraphy of the Cambay basin as summarised by Sastry et al. (1984).

As already stated, a large part of the coast is exclusively made up of Quaternary deposits. However, the various coastal blocks of the Gulf, viz. Saurashtra, Bhal and Mainland show much geological diversity. Along the Saurashtra coast within a distance of 15 km inlandward successively Tertiary and Quaternary formations over a trappean basement are met with. Ganapathi (1981) has given the details of the stratigraphy of the Saurashtra coastal block which has been reproduced here in Table 3.3.

In the Bhal area, the raised mudflats several meters' thick, rest over an older alluvium pointing to the overrunning of the alluvial area by a transgressive sea. Though

TABLE-3.2 GENERALIZED STRATIGRAPHIC SUCCESSION OF CAMBAY BASIN

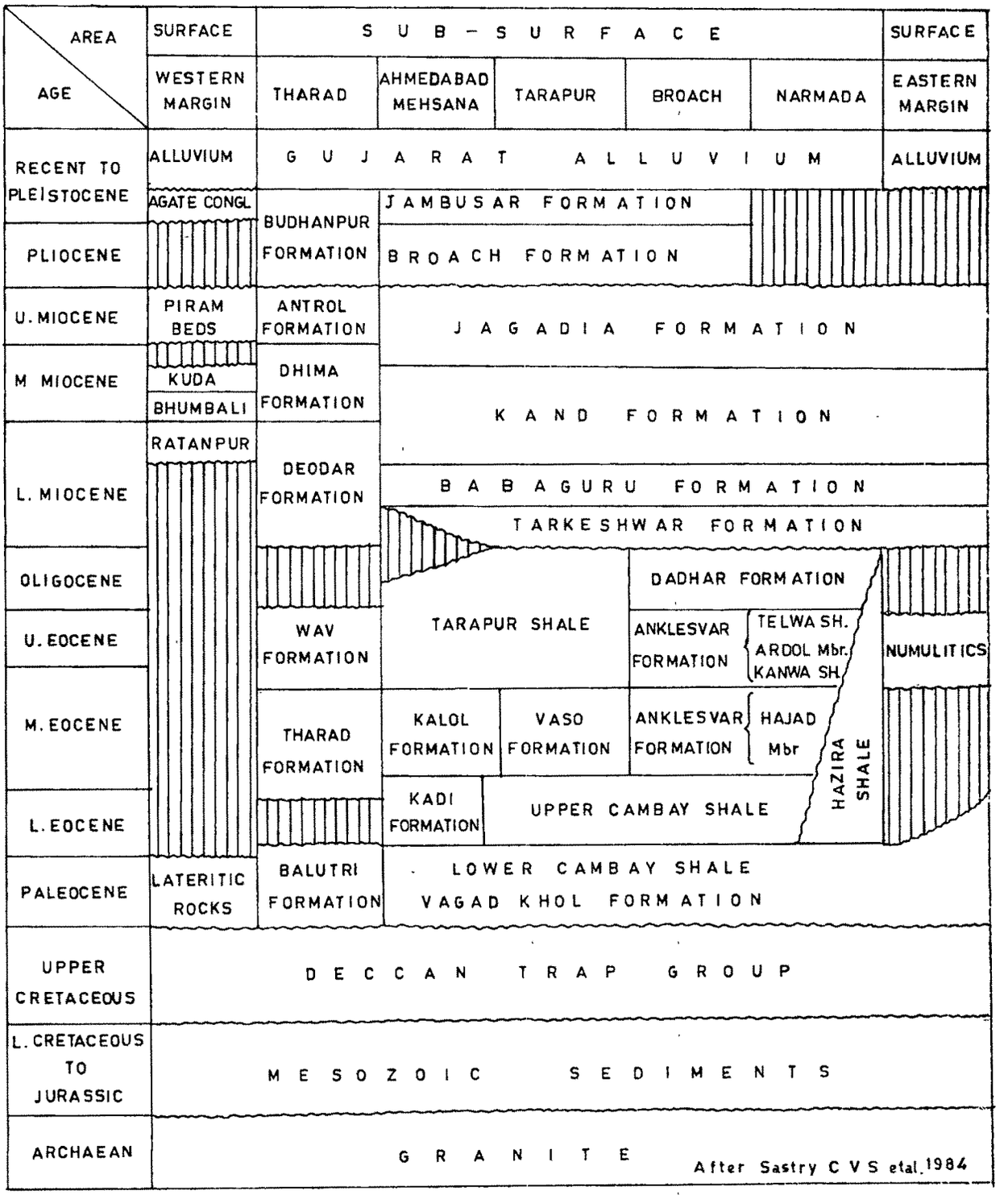


TABLE - 3.3 STRATIGRAPHIC SUCCESSION OF SAURASHTRA COASTAL BLOCK

PERIOD / EPOCH		THE AREA NORTH OF SHETRUNJI RIVER		THE AREA SOUTH OF SHETRUNJI RIVER	
		FORMATION	LITHOLOGY	FORMATION	LITHOLOGY
QUATERNARY	HOLOCENE	RECENT DEPOSITS	ALLUVIUM, BEACH AND DUNE	RECENT DEPOSITS	ALLUVIUM, BEACH AND DUNE SANDS MUDFLATS AND SOILS
QUATERNARY	PLEISTOCENE TO EARLY HOLOCENE	LAKHANKA FORMATION	SOFT FRIABLE FERRUGINOUS SANDSTONES AND SANDS WITH LAYERS RICH IN AGATE PEBBLES AND INTERCALATIONS OF GRAY COLOURED CLAYS	MILIOLITE FORMATION	BIOSPARITES WITH INTERCALATIONS OF RED COLOURED CLAYS
			UNCONFORMITY		
TERTIARY	MIO-PLIOCENE	PIRAM BEDS	HARD AND WELL CEMENTED FOSSILIFEROUS CONGLOMERATES WITH ALTERATION OF SAND STONES AND CLAYSTONES		
			DISCONFORMITY		
TERTIARY	LOWER MIOCENE	GAJ FORMATION — BHUMBHLI CONGLOMERATE MEMBER	FOSSILIFEROUS CONGLOMERATES, GRITS AND ARGILLACIOUS SANDSTONES WITH INTERCALATIONS OF CLAYS		? ? ? ?
			UNCONFORMITY		
TERTIARY	LOWER MIOCENE	GAJ FORMATION — RATANPUR CLAY MEMBER	GRAY AND YELLOW COLOURED CLAYS AND MARLS WITH GYPSUM LAYERS AT THE BASE, BASAL CONGLOMERATES AND ARGILLACEOUS SANDSTONES WITH CROSS LAMINATION	GAJ FORMATION	YELLOW AND GRAY COLOURED CLAYS WITH BIOSPARITES.
			UNCONFORMITY		
	PALEOCENE	LATERITIC ROCKS	UNSTRATIFIED RED, BROWN AND YELLOWISH BROWN HARD LATERITES WITH CLAY POCKETS	LATERITC ROCKS	RED, BROWN, YELLOWISH, BROWN HARD LATERITES WITH CLAY POCKETS
CRETACEOUS		DECCAN TRAP	VARIETY OF BASALITIC LAVA AS WELL AS FELSITE AND RHYOLITE WITH DOLERITE DYKES	DECCAN TRAP	VARIETY OF BASALTIC LAVA FLOWS, FEISITE AND RHYOLITC WITH DOLERITE DYKES.

(Ganapathi, 1981)

the exact thickness of the underlying alluvium is not known, it may be varying from 100 to 200 meters gradually merging into the marine clays. Geologically, the Bhal presents a good example of Late Quaternary sea level fluctuations.

The Mainland Gujarat coast is stratigraphically quite different. Here Recent to Sub-Recent mudflats and sporadic beach sands are seen resting over an older alluvium. This alluvium is almost 150 to 200 meters thick north of Narmada and nowhere Tertiary rocks are encountered. To the south of Narmada, mudflats and sandy beaches rest over alluvium. Here the alluvial cover has been reported to be relatively thin, of the 100 meters or less.