CHAPTER - 2

REGIONAL GEOLOGY AND STRUCTURAL SETUP

The Kim river basin is located in a structurally complex and seismically active zone marking the intersection of the Cambay and Narmada rift systems. Large amount of data exists on the structural style and Tertiary depositional history which is mainly the result of extensive geophysical studies for locating petroleum reserves. The area around Gulf of Cambay is characterized by positive gravity anomalies, high thermal gradients, high heat flow and seismic activity (Kailasam et al. 1972; Quereshy, 1982, Gupta and Gaur, 1984, Ravishankar, 1988). The geophysical anomalies (Biswas, 1987; Arora and Reddy, 1991) have been attributed to various factors like Moho upwarp, large thickness of volcanics in the basin (Kailasam and Qureshi, 1964; Rao, 1968) or upper mantle intrusion in the upper crust (Verma et al. 1968). Detailed geological information of the area to the south of Narmada river is given by Agarwal (1984; 1986), Babu (1984) and Merh (1993; 1995). Described below is a synthesis of the available data on the geological and structural setup as described by previous workers.

REGIONAL TECTONIC FRAMEWORK

The western continental margin of the Indian plate has evolved as a result of rifting along major Precambrian trends (Biswas, 1982). The Kutch, Cambay and Narmada basins are the three major marginal rift basins bounded by intersecting sets of faults whose trends follow the three important Precambrian tectonic trends viz. the Aravalli, Dharwad and Satpura trends (Fig. 2.1). The Narmada and Cambay rift systems cross each other in the Gulf of Cambay region and together with the west coast fault define an area which has been identified by many as a triple junction (Burke and Dewey, 1973; Bose, 1980). Burke and Dewey (1973) have attributed the Mauritius- Reunion plume to be the cause of this junction. The Saurashtra occurs as a horst block between the rifts. The Cambay basin is the northward extension of the Dharwar trend (Biswas, 1982). The NE-SW Aravalli trend splays out into three components at its south-western extremity (Biswas, 1987). The geology of these basins shows that each has its own history of development independent of the others. However, there is a general synchroneity in the tectonic evolution of these basins and the major events of plate teconics (Biswas, 1982). These basins opened up one after another from north to south as the subcontinent drifted northward at an increasing pace and rotated counter-clockwise during the Mesozoic (Biswas, 1987). The basins developed seriatim, starting with the Kutch basin in the early Jurassic, Cambay basin in Early Cretaceous and Narmada basin in late Cretaceous. These three periods of basin formation are correlatable with the three

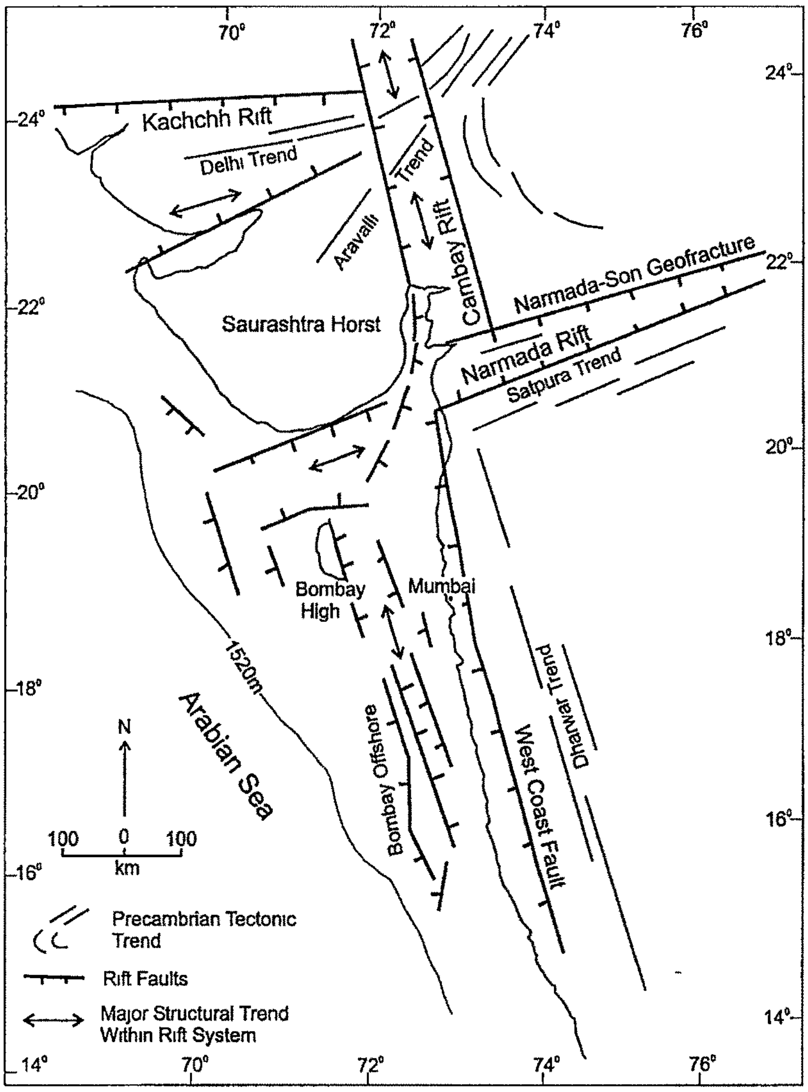

Fig. 2.1 Regional tectonic framework of the western continental margin of India (after Biswas, 1987).

important stages of the drift history of the Indian subcontinent (Biswas, 1982).

The Cambay basin has been subdivided into five structural blocks from north to south (Fig. 2.2). 1. Sanchor- Patan Block, 2. Ahmedabad-Mehsana Block, 3. Cambay-Tarapur Block, 4. Broach-Jambusar Block and 5. Narmada-Ankhleswar block.

The area of present study falls within the Narmada-Ankleshwar block. This block lies to the south of Narmada river and is dominated by ENE-WSW trending structural elements (Ahuja et al. 1990). It is broadly an uplifted region bounded by the Narmada-Son Fault (NSF) in the north and the Tapti Fault in the south. The block contains a

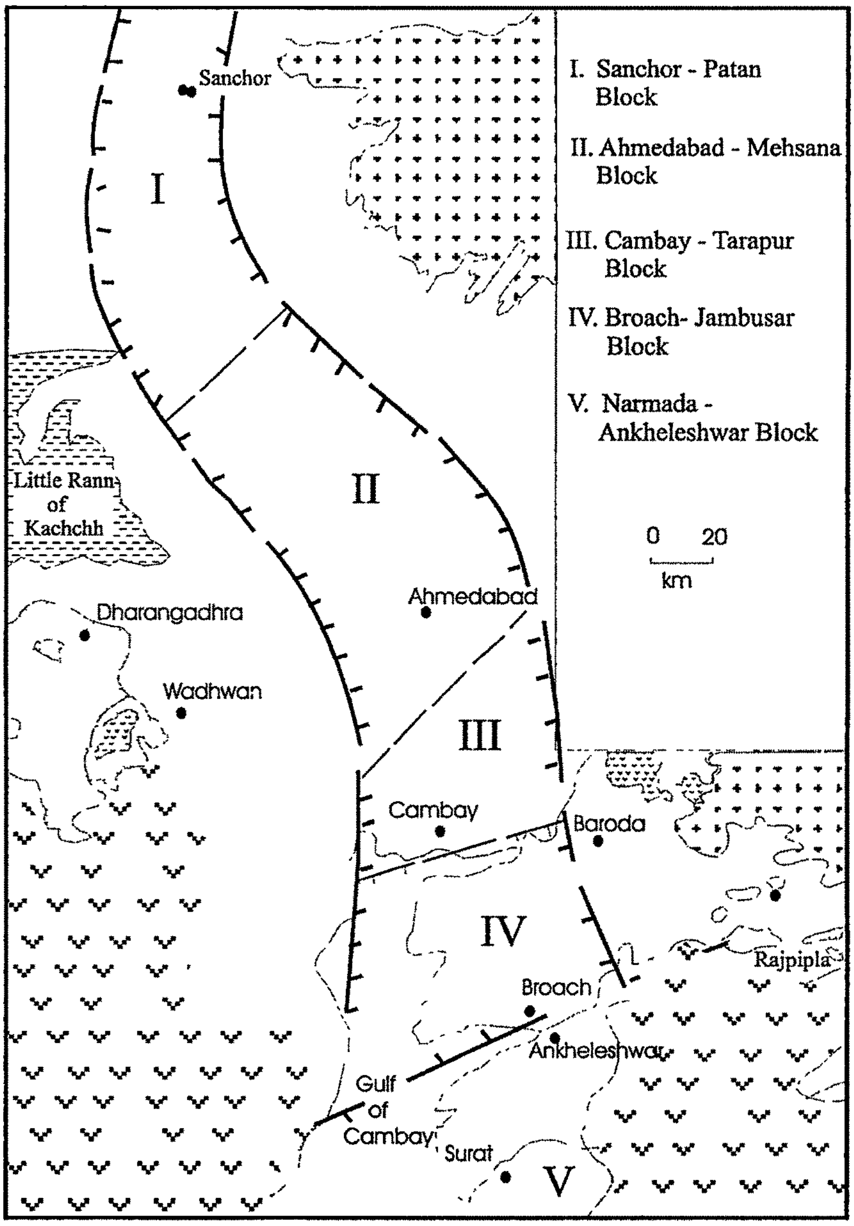

Fig. 2.2 Tectonic map of Cambay basin (after Mathur et al. 1968).

number of smaller blocks or slices which have undergone differential vertical movements (Roy, 1990). The sedimentary cover is relatively thin. The block tilts westward with gradual thickening of sedimentary layers and concurrent changes in the facies of the sediments (Agarwal, 1986). To the east along the fringe of the basin, the Tertiary rocks are exposed on the surface.

GEOLOGY OF THE STUDY AREA

The rocks exposed in the area between Narmada and Tapti rivers belong to Mesozoic and Cenozoic eras (Merh, 1995). The Mesozoic rocks occur in the area around the Narmada valley only further east of the study area. A major part of the study area is occupied by Deccan Traps and Tertiary rocks. The various formations occurring in the Kim basin are shown in Fig. 2.3.

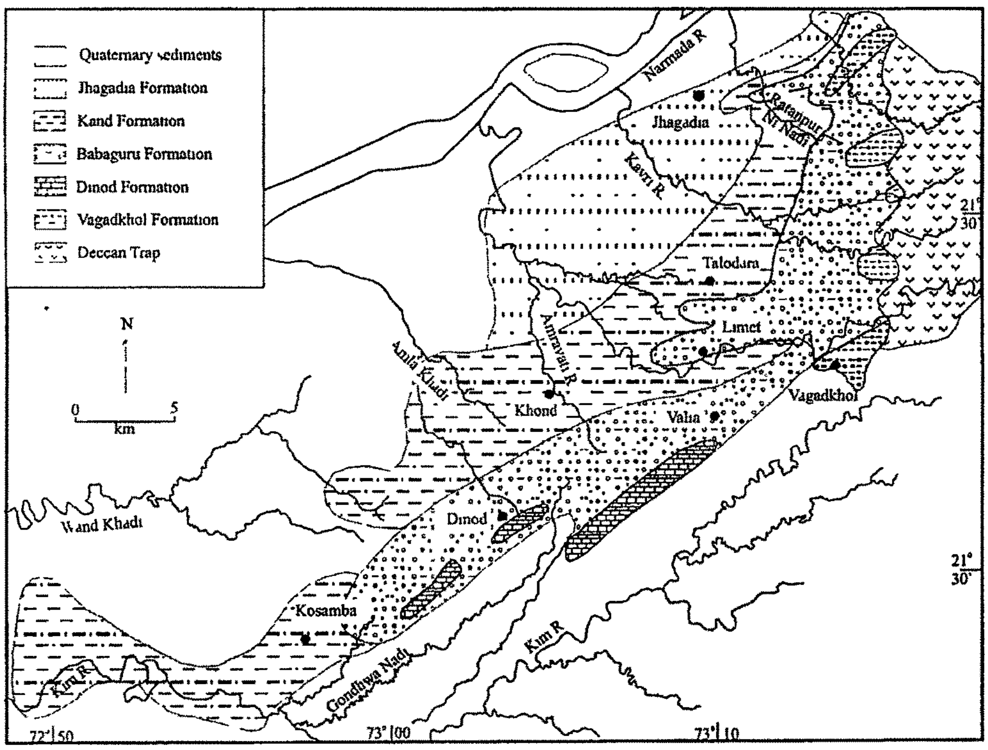

Fig. 2.3 Geological map of the study area (after Agarwal, 1984).

Mesozoic rocks

The Mesozoic rocks unconformably overlie the Precambrian rocks of the Aravalli supergroup (Merh, 1995) and occur as isolated exposures around Narmada valley and trappean upland areas east of the Kim river basin. The constituent rocks are mainly sandstone and fossiliferous limestones which have been designated as the Bagh Formation. Deep Seismic Sounding studies by Kaila et al. (1981) have revealed the presence of Mesozoic rocks below Deccan traps further west.

Deccan Trap

The Deccan Traps form upland areas characterized by E-W trending rows of hills that rise 200-600 msl and continue further east and south into the Maharashtra state. The Deccan trap formation rests uncomfortably over the older rocks. Rifting of the Western Continental Margin and the reactivation of the Narmada Geofracture during the close of the Cretaceous were the prime causes of the Deccan Volcanism, and the outpourings of the huge volume of the basalt marks the Cretaceous-Tertiary boundary (Biswas, 1988; Venkatesan et al. 1986).

The trappean rocks show an interesting assemblage of basaltic differentiates and alkaline derivatives (Merh, 1995). Several plugs of high silica potassic rhyolite are also encountered. A plug of carbonatite with fluorite mineralization at Hingoria near Rajpardi (20 km NW of Netrang) and several carbonatite dykes have also been recorded from the Rajpardi-Netrang area which represent the genetically equivalent counterparts of the Ambadungar Carbonatite Complex across the river Narmada and belongs to the same magmatic phase (Merh, 1995). South of Netrang-Dediapada, the terrain up to Tapti, is dominantly made up of basaltic flows, which have been intruded extensively by younger dykes (Merh, 1995).

Tertiary rocks

The Tertiary rocks occupy the northern and southern fringes of the Kim river basin. To the north of the Narmada-Son Fault (NSF), the Tertiary rocks occur in the subsurface and are overlain by ~800 m thick Quaternary sediments (Maurya et al. 1995). The exposed Tertiary sequence in the study area (Fig. 2.4) comprises Dinod Formation (Late Eocene), Kand and Jhagadia Formations of Miocene to Pliocene age (Table 2.1). Between the Narmada and the Tapti rivers the Tertiary rocks occur in two patches separated by the Kim river alluvium (Merh, 1995).

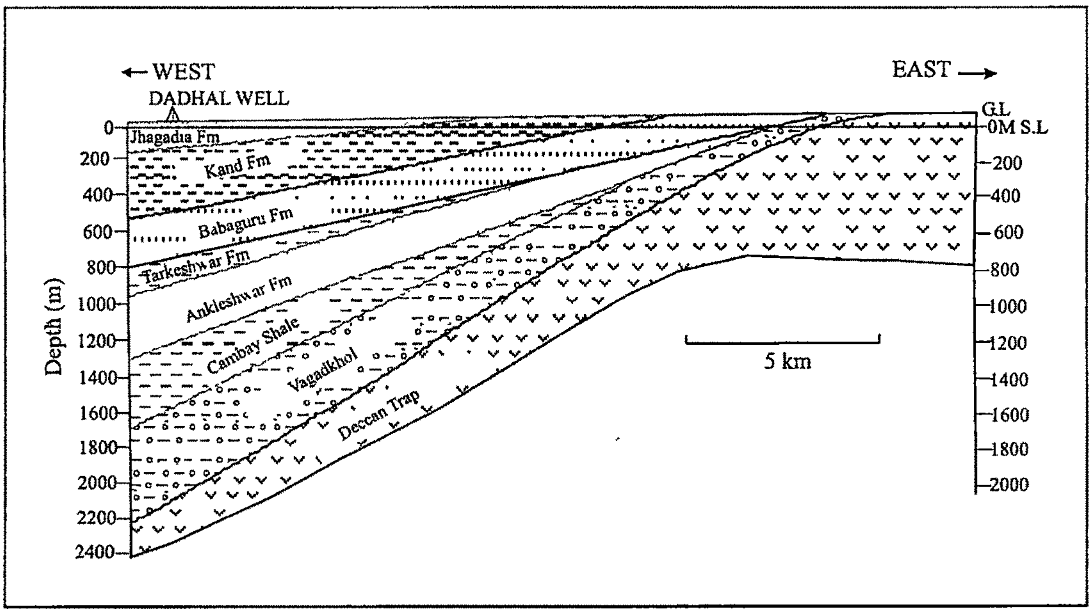

Fig. 2.4 E-W trending subsurface geological section across the Tertiary rocks occurring to the north of Kim river (after Agarwal, 1984).

Table 2.1 Stratigraphy of the exposed Tertiary rock of the study area (after Agarwal, 1984)

AGE	FORMATION	LITHOLOGY
Quaternary to Recent	Narmada	Sands, silts, clays and gravels
Unconformity		
Upper Miocene to Pliocene	Jhagadia	Sandstones, grits, conglomerates and clays
Unconformity in NE part		
Lower Miocene to Mid. Miocene	Kand	Limestone bands, pebbly (fossiliferous), calcareous sandstones and clays and marls
Unconformity in NE part		
Lower Miocene	Babaguru	Ferruginous sandstone and clays, agate conglomerates and silts
Unconformity		
Late Eocene	Dinod	Limestones (fossiliferous) and marls
Unconformity		
Early Eocene	Vagadkhol	Conglomerates, sandstones and pink, red and yellow coloured clays
Unconformity		
Late Cretaceous To Paleocene (?)	Deccan Trap	Basalts
Base unknown		

Vagadkhol Formation

The Vagadkhol Formation overlies the basalts with an erosional unconformity in the subsurface (Merh, 1995). This formation comprises conglomerate and variegated clays, a material mostly derived from the weathering of the basalt (Merh, 1993). The conglomerates consist of subangular pebbles and grits of basalts, claystones and agate in highly ferruginous and calcareous matrix (Agarwal, 1984). Due to low dips of the beds, the outcrops occur as broad distinct patches in some areas near Vagadkhol village. The age of the formation is tentatively shown as Paleocene to Lower Eocene from its general stratigraphic position (Merh, 1995). Lithological characteristics indicate fluvial to shallow marine environment under oxidizing conditions (Agarwal, 1984). The formation is unfossiliferous.

Dinod Formation

Overlying the Vagadkhol Formation is the Dinod Formation. The Dinod Formation appears to have been deposited after a considerable lapse of time as the base of it is marked by an unconformity (Agarwal, 1984). It comprises mostly fossiliferous limestones which are ideally exposed as gentle high grounds in the areas around Nandev, Dinod and Dungri villages (Merh, 1995). The outcrops of Dinod Formation are mostly found along anticlinal axes of Nandev, Dinod and Dungri structures (Merh, 1993). In the subsurface the formation comprises argillaceous shale. The occurrence of Discocyclina dispensa and Discocyclina Sella with Nummulites fabianii in the limestones indicates that the sediments were deposited during the Late Eocene epoch (Agarwal, 1984). A Late Eocene age has been assigned to this formation.

Babaguru Formation

The Dinod Formation is seen unconformably overlain by the highly ferruginous sandstone and agate conglomerate of Babaguru Formation (Merh, 1995). Thus, there is a long period of non-deposition after the deposition of Dinod formation due to regression (Agarwal, 1984). The outcrops of Babaguru Formation are prominently exposed in the area of high topographic relief located between Kosamba and Valia towns. Lithologically, the lower part of the formation consists of cherry and red friable rocks while the upper part is dominated by agate bearing conglomeratic sandstone (Merh, 1993). The deposition of the conglomerate took place near the basin margin in a fluviatile oxidizing environment (Agarwal, 1984). The age of Lower Miocene is assigned based on its stratigraphic position.

Kand Formation

The Kand Formation overlies the Babaguru Formation with an erosional unconforimity (Merh, 1993). The Kand Formation comprises calcareous sandstone with occasional conglomerate, clays, marl and thin fossiliferous limestone bands (Merh, 1995). This formation is made up of fossiliferous limestone with microfossils which indicate a Lower Miocene age for this formation (Agarwal, 1984). The formation is believed to have been deposited under transistional shallow marine inner shelf environments (Agarwal, 1984).

Jhagadia Formation

The Jhagdia Formation is the youngest of the exposed Tertiary sequence and unconformably overlies the Kand Formation. Outcrops of this formation are confined to the northwestern part around Ratanpur and Jhagadia towns (Merh, 1995). Lithologically, it comprises light grey sandstone, greystone and pebble to cobble conglomerates. The conglomerates contain pebbles of marl, sandstone, claystone and agate (Agarwal, 1984). The formation is unfossiliferous and lithologic characters point to a continental fluviatile depositional environment (Merh, 1993). On the basis of its order of superposition and unfossiliferous nature, it has been assigned a tentative age of Middle Miocene to Lower Pliocene (Agarwal, 1984).

Quaternary sediments

The Quaternary sediments comprise mainly alluvial deposits. All the alluvial deposits to the south of the Narmada river and occurring over the exposed Tertiary rocks have been referred to as Narmada alluvium (Agarwal, 1986; Merh, 1995). No geomorphologic, lithologic, sedimentological or stratigraphic details exists on these sediments.

STRUCTURAL SETUP

The Kim River basin is located in the geologically and structurally complex termed as the SONATA Zone. The Son-Narmada-Tapti (SONATA) lineament zone covers about 1600 km long and 150-200 km wide area in the Indian Peninsula between longitude 72^0 and 88^0 and may further extend in either directions (Krishnaswamy, 1981; Radhakrishna, 1989; Ravishankar, 1991). This zone is divisible into several longitudinal fault-bound blocks with episodic history of vertical and lateral movements and magmatism (Ravishankar, 1987). The SONATA zone in the western part in Gujarat State covers the area between and around the Narmada and Tapti rivers. In Gujarat, the Narmada-Son Fault (NSF) occurs as a single crustal scale fault (Chamyal et al. 1992) which is reflected as a reverse fault near the surface (Fig. 2.5). In the Kim river basin, the zone is longitudinally cut across by a N-S trending fault which is traceable from Rajpardi town in the north and Kim river basin in the South. This fault is named as the Rajpardi Fault and marks the sharp contact between the Deccan Traps in the east and the folded, faulted Tertiary rocks to the west (Agarwal, 1986). As is the case with the Narmada-Son Fault (NSF), the Rajpardi fault also presents an excellent geomorphic expression and is well evidenced by the rugged topography of the trappean uplands in the east and the low hummocky topography of the Tertiary rocks to the west of

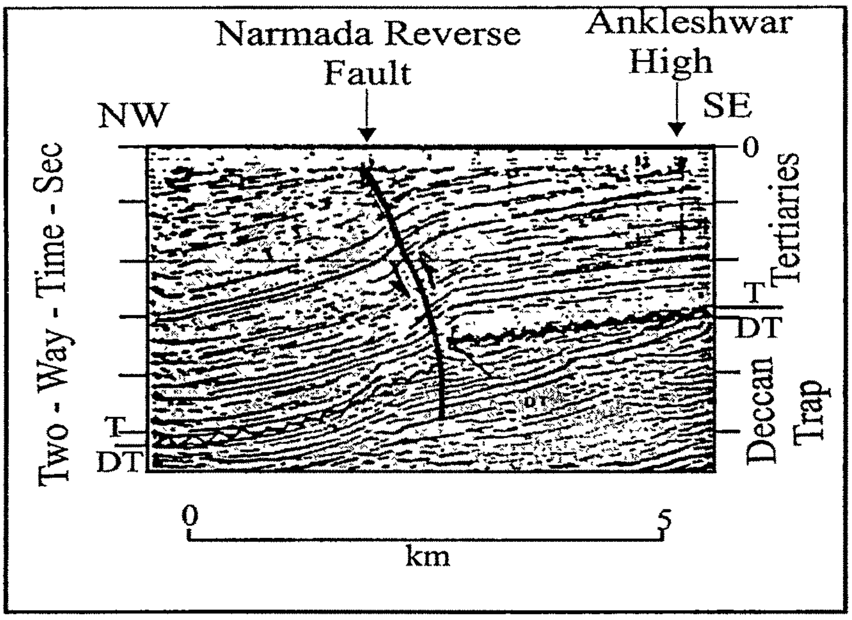

Fig. 2.5 Seismic section showing Narmada reverse fault and folding as a Ankleshwar high (after, Agarwal, 1984).

the fault (Fig. 2.6). The basement section south of Narmada river consists of horsts and grabens in which the area between Kim and Tapti shows a prominent graben which may

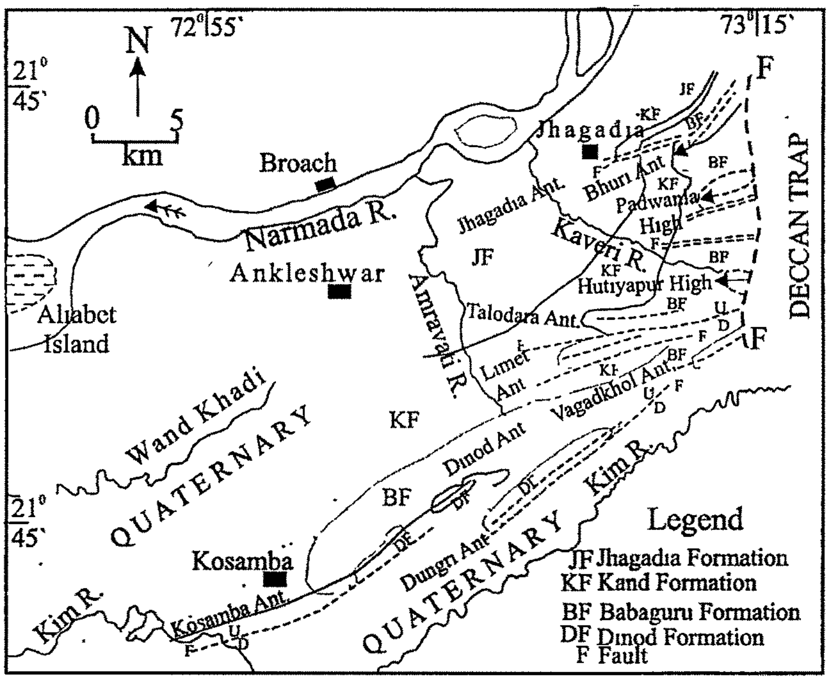

Fig. 2.6 Tectonic map of the study area (after Agarwal, 1986).

be a northeastward extension of the offshore Surat depression (De and Jain 1979).

The exposed Tertiary rocks of the Narmada block have been folded into several narrow anticlinal structures separated by synclinal lows (Fig. 2.6). The abrupt change in the structural style of the Tertiary and Quaternary sequences in the areas to the north and south of the course of Narmada river in Gujarat is significant (Babu, 1984). Agarwal (1986) has delineated a number of anticlinal features within the Tertiary rocks (Fig. 2.6).

The Talodara anticline trends WSW and plunges due WSW (Agarwal, 1986). The NNE limb is gentler than the SSE limb. A fault has been inferred along the SSE limb of the Talodra anticline (Agarwal, 1986). The crestal part of the anticline, is easily identifiable in the field as a geomorphic high. The Limet anticline shows a plunge due WSW and a well marked fault designated as limet fault cuts its SSE limb, south of the Limet village (Agarwal, 1986). The fault is of reverse type, hades due NNW.

The Vagadkhol anticline is located a little north of Vagadkhol village, trending SW (Agarwal, 1986). The Vagadkhol anticline is 4 km long and 1 km wide (Agarwal, 1984). The anticline is in a general structural alignment with that of Dungri anticline to the SW. The Dungri anticline a narrow anticline flanked by the Quaternary sediments to the. SE. It is marked by a distinct water divide forming a pronounced geomorphic high. The anticline plunges due SW and passes beneath the Quaternary sediments and Kim alluvium to the SE (Agarwal, 1986). The Dinod anticline (Fig. 2.7) is a pronounced doubly plunging anticline (Agarwal, 1986).

Considering the general outcrop pattern and the abrupt end of limestone outcrops SE of the anticline, beneath the alluvial cover, the presence of a fault along the south-eastern limit of the anticline outcrop is inferred.

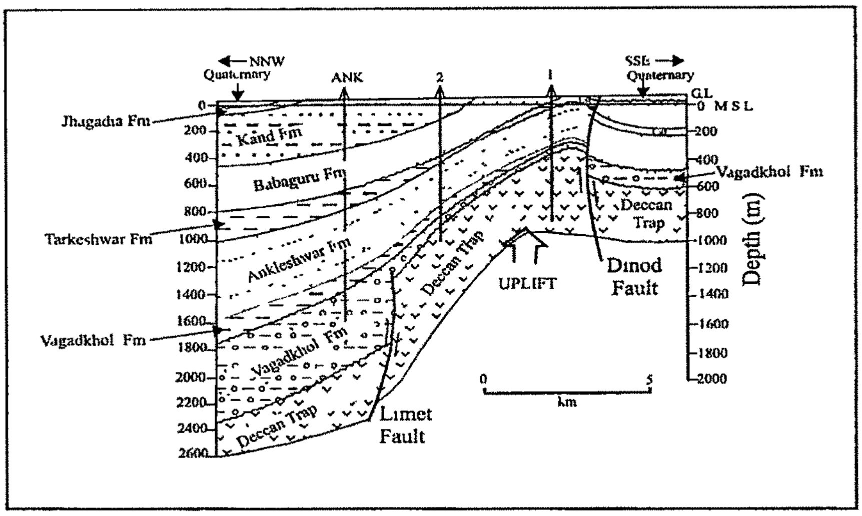

Fig. 2.7 Geological section across Dinod anticline (after Agarwal, 1984).

The Kosamba anticline is a broad and gentle NE-SW trending anticline showing a SW plunge (Agarwal, 1986). The NE-ward axis of the anticline aligns itself with that of Dinod anticline. The SE limb of the anticline is abruptly terminated against the Kim river alluvium due to a SW treading fault along the SE limb of the anticline (Babu, 1984, Agarwal, 1986). This fault designated as the Kosamba fault (Fig. 2.8), which is a reverse fault heading due NW (Agarwal, 1984). NW of Kosamba town, the structure gets concealed under Quaternary sediments.

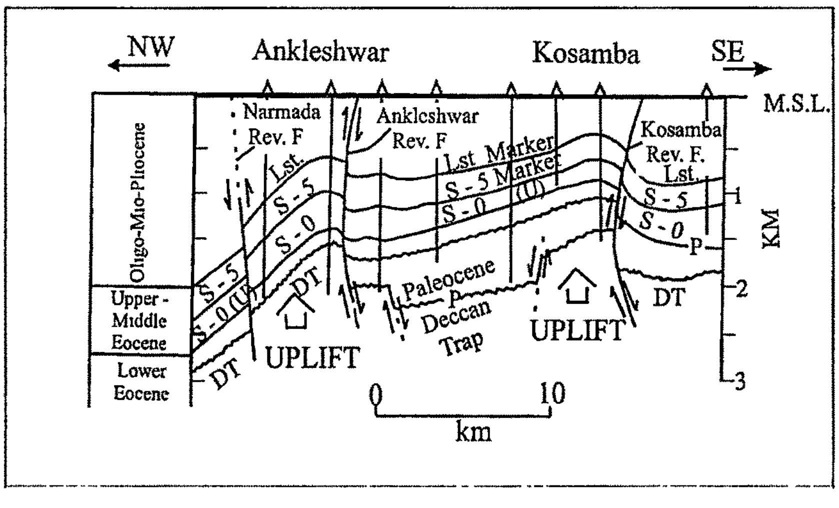

Fig. 2.8 Geological section across Kosamba and Ankleshwar anticlines (Agarwal, 1984) showing various surface and subsurface faults.