Chapter - 2

STRUCTURE AND STRATIGRAPHY OF KACHCHH

THE KACHCHH BASIN

The Kachchh rift basin is located at the western continental margin of India. The basin opened during the Early Jurassic, and became fully marine in Middle Jurassic which resulted in the deposition of more than 2000-3000 m thick Mesozoic and Cenozoic sediment succession (Biswas, 1977, 1982). A major part of the Kachchh is occupied by the Pre-Quaternary rocks, which show good conformity with the tectonic framework. The sediments were deposited in Kachchh rift basin in sublittoral to deltaic environment in two major cycle: a transgressive cycle of Middle Jurassic age and a regressive cycle of Late Jurassic-Early Cretaceous age (Biswas, 1981). Mainly the carbonate rich sediments and shales were deposited during the transgression period, while the deltaic clastic deposits represent to regression period (Biswas, 1982).

The dominant E-W tectonic fabric is clearly reflected in the geomorphic setup of the Kachchh. The area exhibits first order topography where the structural highs and lows correspond respectively to the geomorphic highs and lows (Biswas, 1974). The first order topography and a long history of devastating earthquakes in recent past indicate continuous rejuvenation of the region. The structure of the present fault-controlled geomorphic configuration of Kachchh is attributed to inversion of the basin in the late Cretaceous (Biswas, 1982). In general, the post-rift (inversion phase) geological evolution of the basin is marked by periodic reactivation of various E-W trending intrabasinal faults, which are also responsible for recurrent seismic activity in the region. Several medium to high magnitude earthquakes in the last 300 years indicate active coseismic deformation of the basin under an overall compressive stress regime (Biswas and Khattri, 2002). Documentary evidence show that the region has been greatly affected by several minor and a few major earthquakes during historic time. The well known Allah bund earthquake of 1819 produced profound changes in the landscape particularly in the Great Rann of Kachchh and caused large-scale devastation (Mcmurdo, 1824; Bilham, 1998). The earthquake of 1956 completely demolished the old town of Anjar. The earthquake of 26th January, 2001 caused devastation not only in Kachchh but also in adjacent areas (Rajendran et al., 2001).

PHYSIOGRAPHIC DIVISIONS OF THE KACHCHH

The Kachchh region is divisible into five main geomorphic units- the Great Ranns and the Banni plain, the Island belt, the Wagad highland, the Mainland

Kachchh and the Coastal zone of Kachchh. The Mainland Kachchh is further divisible into the northern part and southern part (Figure 2.1). The overall geomorphic set up of the southern Mainland Kachchh is strongly influenced by the structural and tectonic set up.

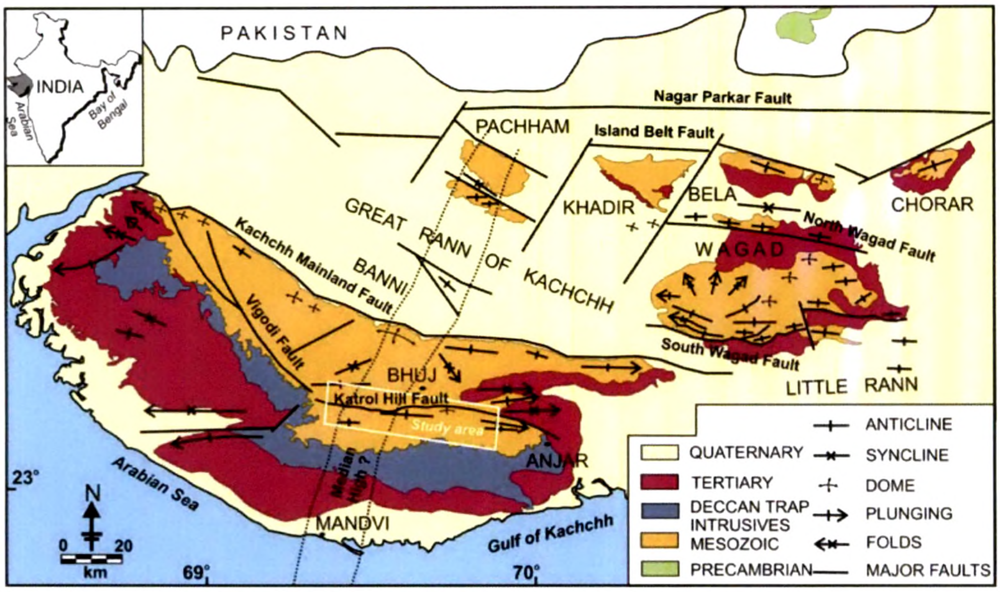

Figure 2.1 Tectonic map of Kachchh (after Biswas and Deshpande, 1970). The area enclosed in box shows the study area.

The Great Rann of Kachchh and the Banni plain

The flat terrain of the Great Rann and Banni plain (Figure 2.1) together comprise a vast barren landscape that is hostile and almost unnavigable (Glennie and Evans, 1976). These contiguous terrains occur a few meters above sea level and are believed to be part of a former gulf occupying an E-W trending tectonic depression. The Ranns, which, constitute a flat terrain with no surface exposures, are the product of marine deposition (Biswas, 1974; Glennie and Evans, 1976; Roy and Merh, 1981). The evolution of the Great Rann of Kachchh has been linked to tectonic activity in recent times (Roy and Merh, 1981). The basin was filled up by sediments supplied from the Indus drainage basin while the surface has been smoothened by the frequent earthquake. The Ranns are therefore the most promising area of the Kachchh for neotectonic and palaeoseismic investigations. These unique geomorphic features occupy eastern and northern parts and have a total area of 22000 sq km. The Great Rann of Kachchh has been the site of the 1819 earthquake which produced surface rupture known as 'Allah Bund' resulting in the upliftment of the northern part of the

Rann. The Little Rann is an extension of the Gulf of Kachchh when the sea level was high during the Holocene transgression. This vast wasteland is about 4 m above high water line. The Great Rann and Little Rann comprise unique example of Holocene sedimentation (Biswas and Deshpande, 1970). The two Ranns mark the site of sediment accumulation in a shallow gulf that was marked by a fluctuating strandline since the beginning of the Holocene (Merh and Patel, 1988). Because of extensive salinity and long dry spells, the Rann sediments show poor development of organic life (Glennie and Evans, 1976). The plain of Banni is regarded as a raised mudflat between the Mainland Kachchh and the Great Rann (Kar, 1995). It occurs 3-10 m above the level of the Great Rann. It is more or less flat and almost gradientless saline grassland covering an area about 3000 sq km. The Banni plain is only flooded by Rivers from the south and monsoon precipitation (Glennie and Evans, 1976). The presence of gullies and incised fluvial channels on the elevated eastern part of the Banni plain are indicative of the latest phase of uplift (Biswas, 1974). Extensive liquefaction occurs in the Rann area during the large magnitude earthquakes that have occurred several times in the past.

The Island belt

The Island belt comprises a E-W trending linear series of four islands within the Great Rann located to the north of Wagad and Mainland Kachchh. These islands from west to east are the Pachchham, the Khadir, the Bela and the Chorar islands (Figure 2.1). Of these the Pachchham island is the largest and Chorar is the smallest in size. The highest elevation in the entire Kachchh is recorded in the Pachchham island. All the islands display rugged hilly topography and exposed Mesozoic rocks with Tertiary rocks at the fringes of the Pachchham and Khadir islands. The northern margin of all the islands is marked by north facing escarpments which mark the Island Belt Fault.

The Wagad highland

The Wagad highland is situated between Mainland and the Island Belt. The area exposes Mesozoic rocks with Tertiary rocks around it. Pysiographically, Wagad is a table land whose northern margin is marked by the North Wagad Fault (NWF), while the southern margin is delimited by the South Wagad Fault (SWF) (Figure 2.1).

Both the faults are associated with a flexure zone along them. The Mesozoic rocks are criss-crossed by several dykes.

The Mainland Kachchh

The Mainland form the largest geographic entity in the Kachchh basin. It displays the most rugged and most well developed sequence of Mesozoic and Cenozoic rocks. The northern margin of the mainland is bounded by the Kachchh Mainland Fault (KMF) with the domal hilly region, the Northern Hill Range to its south. In the part, the Katrol Hill Fault (KHF) divides the mainland into southern mainland and northern mainland Kachchh (Figure 2.1). The Vigodi Fault and the Naira River fault are the other major fault located in the west and south western part of the mainland. The mainland outcrop exposes a continuous succession from Bathonian to Santhonian. The oldest sequence from Bathonian to Callovian is exposed in the northernmost part of the Kachchh.

The Coastal zone of Kachchh

The coastal alluvial plain is a narrow gently sloping plain comprising unconsolidated Quaternary sediments to the south of the mountainous topography of the Katrol Hill Range (Figure 2.1). The change of topography is rather abrupt and sharply defined. The width of the alluvial plain varies from 10-25 kms. The monotonous occurrence of alluvium is interrupted by the presence of Tertiary rocks between the Kharod and Kankawati Rivers. The stretch of alluvial plain to the east of the Kharod River is termed as the eastern alluvial plain while to the one to the west of the Kankawati River is termed as the western alluvial plain. The alluvial plain comprises one of the few cultivable areas in Kachchh. The alluvial plain in overlapped by the coastal sediments near the shoreline.

STRUCTURAL SETUP OF KACHCHH

The evolution of all the three rift basin of western India (Kachchh, Narmada and Cambay) is related to the breakup of Gondwanaland in the Late Triassic/Early Jurassic and the subsequent spreading history of the Eastern Indian Ocean (Biswas, 1982, 1987). The Saurashtra block remained as a horst while the Kachchh, Cambay and Surat basins subsided around it for the deposition of Cenozoic sediments. The Kachchh rift was initiated in the Late Triassic along the Delhi trend as evidenced by continental Rhaetic sediments in the northern part of the basin (Kosal, 1984). The Kachchh rift basin was formed by subsidence of a block between the Nagarparkar Hills (Figure 2.2) and the southwest extention of the Aravalli Range (Biswas, 1982, 1987). The Kachchh graben became a fully marine basin during the Middle Jurassic period (Biswas, 1981). The present fault-controlled geomorphic configuration of the Kachchh (Figure 2.2) is attributed to inversion (uplift of the Jurassic sediments) in the late Cretaceous (Biswas, 1987). In general, the post-rift (inversion phase) geological evolution of the basin is marked by periodic reactivation of various E-W trending intrabasinal faults like, the Island Belt Fault (IBF), Kachhh Mainland Fault (KMF), South Wagad Fault (SWF), Katrol Hill Fault (KHF) and others (Figure 2.2), which are also responsible for recurrent seismic activity in the region.

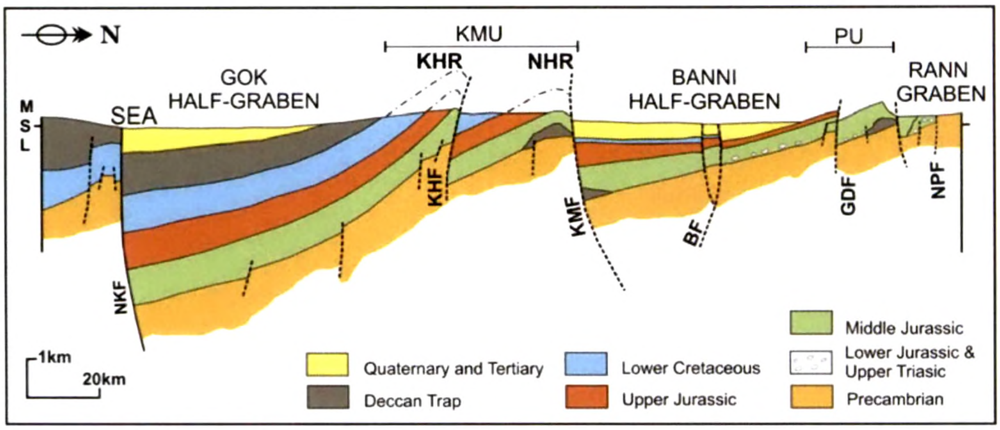

Figure 2.2 Cross section along the Median High showing structural setup of the Kachchh basin (after Biswas and Khattri, 2002). NPU-Nagar Parkar Uplift; NPF-Nagar Parkar Fault; IBF-Island Belt Fault; PU-Pachchham Uplift; GDF-Gora Dongar Fault; BF-Banni Fault; KMF-Kachchh Mainland Fault; KHF-Katrol Hill Fault; NKF-North Kathiawar Fault; GOK-Gulf of Kachchh; KHFL-Katrol Hill Flexure Zone; NRFL-Northern Range Flexure Zone; KMU-Kachchh Mainland Uplift.

The KMF and the KHF are the two major E-W trending faults of Mainland Kachchh which show numerous evidence of neotectonic reactivations and differential uplift of the area (Maurya et al., 2003a). A NW-SE to NE-SW and NNE-SSW to NNW-SSE directed transverse fault system also exists which cuts across the E-W tectonic fabric of Kachchh (Thakkar et al., 1999; Maurya et al., 2003a). Role of transverse faults in the tectonic evolution of Kachchh is obvious as these faults laterally displace the master E-W trending faults and the domal structures associated with them (Patidar et al., 2007, 2008). Regional scale geomorphic studies have helped in delineating the role of these transverse faults in pre-Quaternary and Quaternary tectonic evolution of southern Mainland Kachchh (Patidar et al., 2007, 2008). The role of transverse faults in the tectonic evolution of Kachchh is obvious as they laterally displace the large E-W faults and the domal structures associated with them. Geomorphic evidence of strike slip movements along the transverse faults affecting the KMF and KHF are seen in the form of major fault scarps, beheaded/deflected or offset drainage, sags, shutter ridges and pressure ridges (Maurya et al., 2003a). The offset along the transverse faults ranges from a few hundreds of meters to several kilometers, which includes a pre-Quaternary as well as Quaternary component. The stresses accumulating on the E-W trending faults are possibly transmitted to the NW-SE to NE-SW transverse faults, which account for the present seismic phenomenon in Kachchh. Determining these is important as faults with a long geological history in millions of years may also be responsible for their recent dynamic state (Coltorti et al., 1996). The present study has been carried out along these lines and is intended to serve as a stepping stone for further seismotectonic and palaeoseismic studies in the Kachchh region.

STRATIGRAPHY OF KACHCHH

Kachchh is a pericratonic palaeo-rift graben located at the western continental margin of the Indian plate (Biswas, 1987). The Kachchh basin preserves about 2000 to 3000 m of Mesozoic and 1000 m of Cenozoic sediments (Biswas, 1977, 1982). The Tertiary rocks are exposed along the coastal belt of southern and western Kachchh bordering the Mesozoic rocks (Figure 2.3). The pre-Quaternary evolutionary history of the Kachchh basin is dwelt at length by Biswas (1982; 1987; 1993) which has implications for the recurrent seismic activity (Biswas and Khattri, 2002). The present chapter provides a brief summary of the stratigraphic set up of Mainland Kachchh with emphasis on the southern Mainland Kachchh, where the area of present study is located.

Mesozoic rocks

Mesozoic rocks of the Kachchh were first mapped by Wynne (1872) who classified the sequence into upper and lower Jurassic Groups. Waagen (1875) proposed the popular four-fold subdivisions, namely, Pachchham, Chari, Katrol and Umia Series. Rajnath (1942) restricted the term 'Umia' only to the lower Umia of the Waggen; the upper Umia made up of non-marine beds with plant fossils was called by him as Bhuj Series of Middle Cretaceous or even slightly younger age. Biswas (1977) recognized three main lithologic provinces within the basin and rocks of each province were classified separately and named the units according to their stratotypes (Biswas, 1977). The lithostratigraphic sequence of Mainland is divided into four Formations named as the Jhurio (Jhura), Jumara, Jhuran and Bhuj Formations (Biswas, 1977, 1981). The major lithological characteristics of these formations worked out mainly by Biswas (1974; 1977; 1982; 1987), is briefly described below.

Jhurio Formation: A thick sequence of limestone and shales with bands of 'golden oolites' has been named as the Jhurio Formation after the type section in Jhurio hill, in North-Central Mainalnd (Figure 2.3). The Formation is well exposed along another two domes Habo and Jumara located towards the northern margin of the Mainland of Kachchh. The entire Jhurio hill is composed of this formation. The upper part of the formation is made up of thinly bedded white to cream coloured limestones (pelmicrite and biomicrite) with thin bands of 'golden oolite' (Balgopal, 1973). The middle part is composed of thick beds of grey yellow weathered shales alternated with thick beds of golden oolitic limestones and the lower part comrpises thin beds of yellow and grey limestones (Agarwal, 1957; Balgopal, 1973). This formation in Jumara dome is highly fossiliferrous where the corals, brachiopods and ammonites are present. The maximum thickness estimated in the type section is 955 ft, while in Habo and Jumara hill it is 50-250 ft thick. The physical and biological aspects of the formation indicates littoral to infra-littoral environment. The formation ranges from Bathonian to lower Callovian.

Jumara Formation: A thick argillaceous formation conformably overlying the Jhurio Formation has been named after its type section in Jumara hill near the Rann, north of Jumara village (Figure 2.3). The formation is characterised by monotonous olive-grey gypseous laminated shales with thin red ferrugenous bands. The Jhurio and Habo dome sections are the important reference sections for this formation. More sandstone beds appear in these sections and the outcrop present in Katrol (Charwar) range. This formation is the richest of all in fossil content. Varieties of ammonites, belemnites, brachiopods, corals and gastropods are found throughout the formation (Biswas, 1977). The ~900 ft thickness of the Formation is uniform throughout the area. Local disconformity is observed at places where the Jhuran shales are seen resting over the

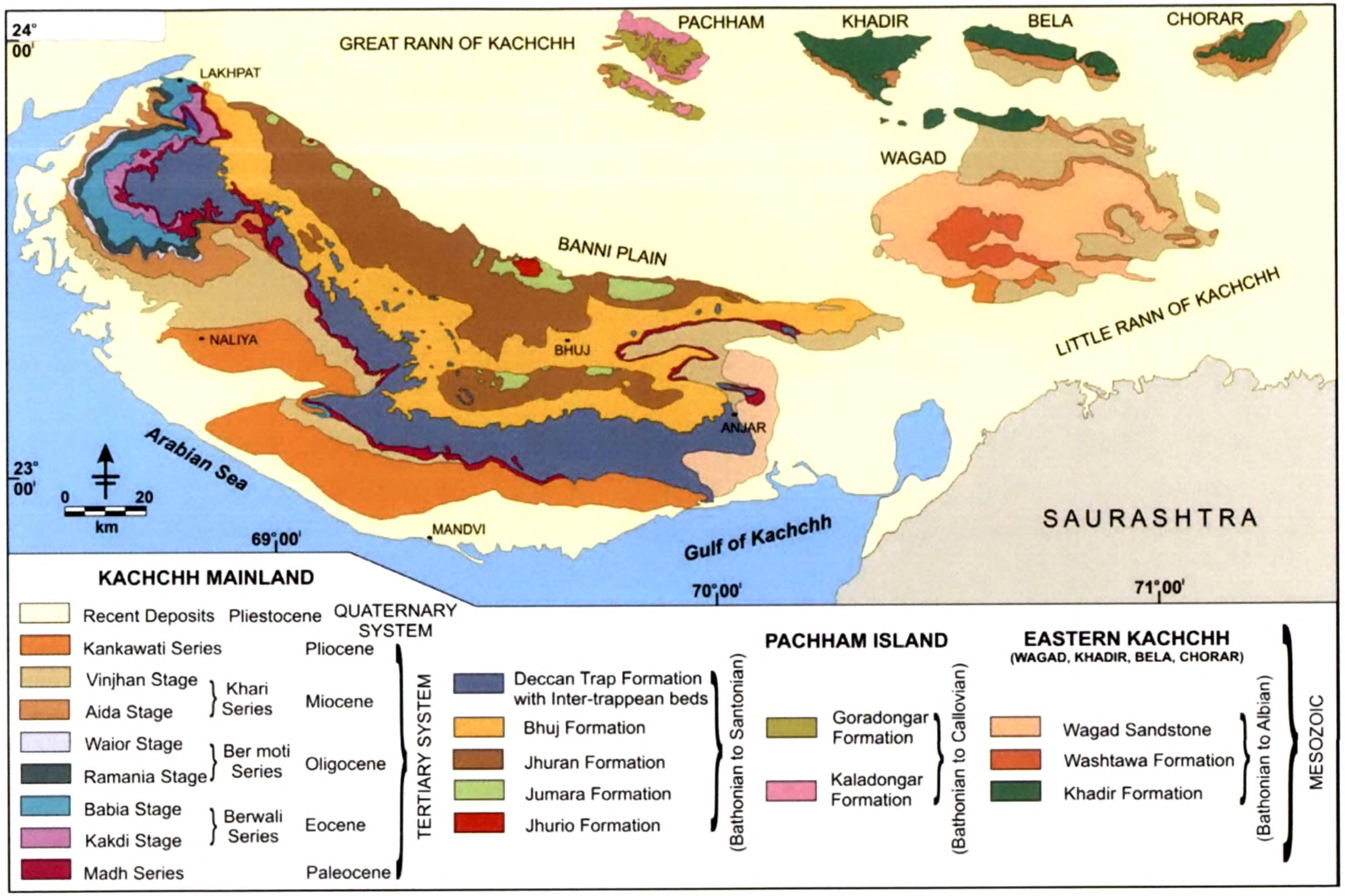

Figure 2.3 Geological map of the Kachchh basin (after Biswas and Deshpande, 1970).

eroded Dhosa oolite member. The lithological and biological aspects suggest circa-littoral environment of deposition. The Jumara Formation ranges between Callovian to Oxfordian.

Jhuran Formation: It comprises a thick sequence of alternating beds of sandstones and shales. The boundaries of the formation are defined by the Dhosa Oolite member below and non-marine sandstones of Bhuj Formation above. The formation is divided into four members-lower, middle (Rudramata shale), upper and Katesar member (Biswas, 1977). The formation is extensively exposed along the southern flanks of the northern and central hill ranges in two wide east-west strips. In the central and western parts of the Mainland, the lower, middle and the lower part of the upper members are exposed (Figure 2.3). The lower member consists of alternating red and yellow sandstone and shale. The middle member is mostly shaly comprising dark grey to black laminated gypseous shales. The upper member is predominantly arenaceous and composed of red and yellow massive current bedded sandstones with intercalations of shale, siltstone and calcareous sandstone. The alternations of hard and soft rocks rise to cuestas and valleys. The impressive Jara and Kas scarps are the some good examples. The formation is richly fossiliferous in the Western Mainland then the eastern part. The common fossils are ammonites, belemnites, gastropods and corals (Biswas, 1977). The irregular occurrence of plant fossils are also noted in this formation. In the NW Mainland the Formation is ~2600 ft thick and is thinner down towards east up to 1200 ft. The physical and biological characters of the sediments tend to indicate the sub-littoral to supra-littoral depositional environment. Kimmeridgian to Valanginian age is fixed for this Formation.

Bhuj Formation: Named after its type locality around Bhuj, this formation is characterised by a huge thickness of non-marine sandstones of uniform character. These rocks occupy about 3/4th of the total area of the Mesozoic outcrop in Mainland Kachchh (Figure 2.3). The lower member is characterised by cyclic repetition of ferruginous or lateritic bands, shales and sandstones. The upper member consists of wheatish to pale brown, massive, current bedded, coarse grained, well sorted sandstones. The formation is bounded by the plains of disconformity. In the south, Deccan trap flows rest on the eroded undulating surface of this formation. The sediments represent deltaic deposits with distal part (delta front) towards the west and the proximal part (fluvial) to the east in the direction of the land. Lower Cretaceous (Valenginian) to Santonian time range is fixed for this formation (Biswas, 1977).

Deccan Trap

The Deccan Traps form a more or less linear outcrop extending across the Mainland with a maximum width of about 10 km in the east near the town of Anjar and gradually tapering westward. Lava flows are dominantly tholeiitic basalts occupying the southern and soutwestern slopes of the Central Highland (Figure 2.3). The trappean flows shows gentle southerly dips and are believed to be of pahoe-hoe type (Biswas and Deshpande, 1973). Six major flows have been reported at the eastern extremity (Dhola hills near Anjar) where they show alternations of columnar and amygdaloidal basalts, occassionally separted by inter-trappean beds. Associated with the trapppean flows are a number of long narrow dykes that occur to the N, NW and NE of the lava flow occurrences. Most of the dykes occur along transverse faults extending N-S, NNE-SSW and NNW-SSE. An interesting aspect of the Deccan volcanism in Kachchh is the occurrence of alkaline basalt and its derivatives as plugs, laccoliths and sills within the domal structures in the Mesozoic rocks. The inter-trappeans were deposited in shallow basins and depressions over trappen surfaces, fed by simultaneously formed rivulets. An uppermost Cretaceous (Maastrichian age) is inferred for these inter-trappeans. The laterites form a narrow elongate Paleocene belt, a few hundred meters wide and several hundred kilometers long sandwiched between the basalts of the Deccan Trap and the Tertiaries, and forms a terrain that is characterized by 10 to 15 m high elongated ridges separated by broad intermittent valleys.

Tertiary Rocks

Wynne and Fedden (1872) studied these rocks for the first time. Biswas (1974) proposed a revised stratigraphy and established that the Tertiary sediments in Kachchh were deposited on the eroded surface of the Deccan Trap and the Mesozoic sedimentaries and deposition started with a marine transgression during Lower Eocene and ended in Pliocene (Figure 2.3). During Paleogene, deposition was restricted to the western part of the Kachchh Mainland, the thickest parts being exposed in the southwestern coastal plain which was the deepest part of the basin. The following is a brief summary of the Tertiary rocks as described by Biswas (1973).

Madh Series: The type area of the rocks of this series is the well known village of Mata-No-Madh in western Kachchh (Figure 2.3). It consists of volcanoclastic sediments deposited in variable environments, ranging from fluviatile to littoral. The sediments were mainly derived from the Deccan Trap and the pyroclastics ejected during the waning phase of the volcanism. The Madh series overlies the basalt but underlies the Kakadi Stage of Lower Ecoene. On the basis of plant fossils, the rocks of Madh Series have been assigned a Paleocene to Lower Eocene age (Biswas, 1974).

Berwali Series: The type section of this series is exposed along the Berewali Nadi in southwestern Kachchh, between the villages Baranda and Ber-Nana (Figure 2.3). The series is divisible into two stages, the lower consisting of gypseous and ochreous clays and marl containing several varieties of molluscs and foraminifers, and is seen in Kakdi Nadi section (Kakdi Stage), and the upper stage is well exposed in Babia hill in western Kachchh comprising a fossiliferous fragmental limestone with a basal calcareous clay bed (Babia Stage). The base of Kakdi Stage indicates an unconformity with the underlying volcanoclastic rocks of the Madh Series.

Bermoti Series: This series forms a well exposed continuous belt south of Lakhpat in northwestern Kachchh (Figure 2.3). It is divisible into two stages, the lower Ramania Stage consists of greenish-grey marl and argillaceous limestone with a basal bouldary clayey marl bed deposited in an epineritic environment of a slowly regressive sea. Named after the village Waior, the constituent rocks of the upper stage are banded fossiliferous marl, the base comprising of rusty oolitic marl. Biswas (1974) has assigned an Oligocene age to the Ramania Stage. The Waior Stage has been considered as Aquitanian.

Khari Series: This series overlies unconformably the Bermoti Series and is well exposed in the cliffy banks of the Khari River in southwestern Kachchh (Figure 2.3). The Khari Series is made up of two distinct stages distinguishable. The lower Aida Stage is composed of variegated siltstone, the lower 16 m of which is barren, but the upper part contains Lower Burdigalian fossil assemblage. The upper part of the series, the Vinjhan Stage consists of grey to khakhi-coloured gypseous clay with hard marl bands packed with fossils. This stage forms the main bulk of the Lower Miocene of

Kachchh. The clays of this stage contain a rich assemblage of Upper Burdingalian fossils. As the Khari series is seen overlapping the Deccan Trap directly, it suggests that this marine transgression was the most powerful one in the history of the Tertiary sedimentation in Kachchh.

Kankawati Series: Well exposed around Kankawati River between Sandhan and Vinjhan (Figure 2.3), this series consists of grey micaceous and calcareous sandstone, lenticular bands of conglomerate and Khakhi grey clay. The upper part is mainly pinkish hard calcareous grit and conglomerate containing abundant foraminifers. This series has been tentatively assigned a Pliocene age and has been correlated with the Manchhar Series of Sindh-Baluchistan.

PREVIOUS QUATERNARY GEOLOGICAL AND NEOTECTONIC STUDIES IN KACHCHH

The region of Kachchh falls in an arid zone, which is the southwestern continuation of the arid belt of northwestern India that includes the Thar Desert in Rajasthan. However, very little information exists on the Quaternary sediments of these areas, which has great relevance in understanding the neotectonic and the climatic changes in western India. There are two principal areas in Kachchh, which have witnessed significant Quaternary sedimentation. One is the flat saline wasteland of the Ranns which includes the Great Rann of Kachchh and the Little Rann of Kachchh (Figure 2.3). The second area is the narrow E-W trending plains of southern Mainland Kachchh along the Gulf of Kachchh coastline.

The salt-encrusted surficial Rann sediments are underlain by light grey and bluish micaceous non-calcareous clay, which turns yellowish brown on exposure (Srivastava, 1971). The clays are laminated with medium to coarse poorly sorted sand and are about 15 m thick to the south and east of Pachham Island (Srivastava, 1971). The oldest Holocene sediments are believed to merge downward into fluviomarine to fluvial sediments of Late Pleistocene age (Merh, 1995). Gupta (1975) identified four distinct horizons dating back to the earliest Holocene. He has suggested an average sedimentation rate of 2 mm per year and that the Rann was inundated throughout the year as late as 2,000 years ago.

The coastline has been broadly divided into five segments based on geomorphologic variations and present day coastal processes (Kar, 1993; Maurya et al., 2008) -the deltaic coast to the west of Kori Creek, the irregular drowned prograded coast between Kori Creek and Jakhau, the straightened coast between Jakhau and Bhada, the spits and cuspate foreland complex between Bhada, Mandvi and Mundra and the wide mudflat coast to the east of Mundra up to the Little Rann. Neotectonic movements have been found responsible for the varied coastal geomorphology and evolution of various coastal segments (Kar, 1993; Maurya et al., 2008; Shukla et al., 2008). The geomorphic diversity with features indicating submergence as well as emergence suggests a complicated geomorphic history.

The narrow coastal alluvial plain is made of Late Pleistocene and Holocene fluvial sediments (Maurya et al. 2003b; 2008). These sediments are exposed along the cliffs of various rivers flowing towards south. Based on geomorphic criteria two phases of neotectonic uplift during early Holocene and late Holocene has been discerned. The uplift has been to inferred have occurred with southward tilt as indicated by decreasing incision by the rivers in the same direction.

In other parts of Kachchh, the occurrences of Quaternary deposits are scaterred and patchy. These sediments occur in the form of intermittently occurring alluvial deposits along the rivers, alluvial fans along faults, expecially along the Kachchh Mainland Fault (KMF), colluvial deposits and aeolian and fluvial miliolites. The miliolites occur as small inliers within the rocky areas. Biswas (1971) compared these deposits with the miliolites of Saurashtra and described them as aeolian deposits with Saurashtra as their provenance. The valley fill miliolites occurring extensively in the area are studded with cobbles and pebbles suggesting a fluvial component in the origin of these deposits (Maurya et al., 2003a; Patidar et al., 2007, 2008). The sheet deposits mostly occur as steep vertical scarps along the banks of the various Rivers. $^{230}Th/^{234}U$ ages of the Kachchh miliolites range from about 30 ka to 130 ka (Baskaran et al., 1989; Chakraborti et al., 1993; Somayajulu, 1993).

Within the Katrol Hill Range, the alluvial deposits occur in patches within the various stream channels incising through pre-Quaternary rocks. At places, these occupy the valleys bounded by cliffs of sheet miliolites indicating that these deposits represent the post-aeolian miliolite depositional phase which can be roughly correlated with the alluvial depositional phase in the southern coastal plain (Maurya et al., 2003a; Maurya et al., 2008). The sediments comprise mainly sandy alluvium deposited as channel deposits. In Gunawari River near Marutonk Dungar, near Bhata

Talav and to the south of Bharasar village these deposits show faulted contact with the pre-Quaternary rocks (Thakkar et al., 1999, 2006).

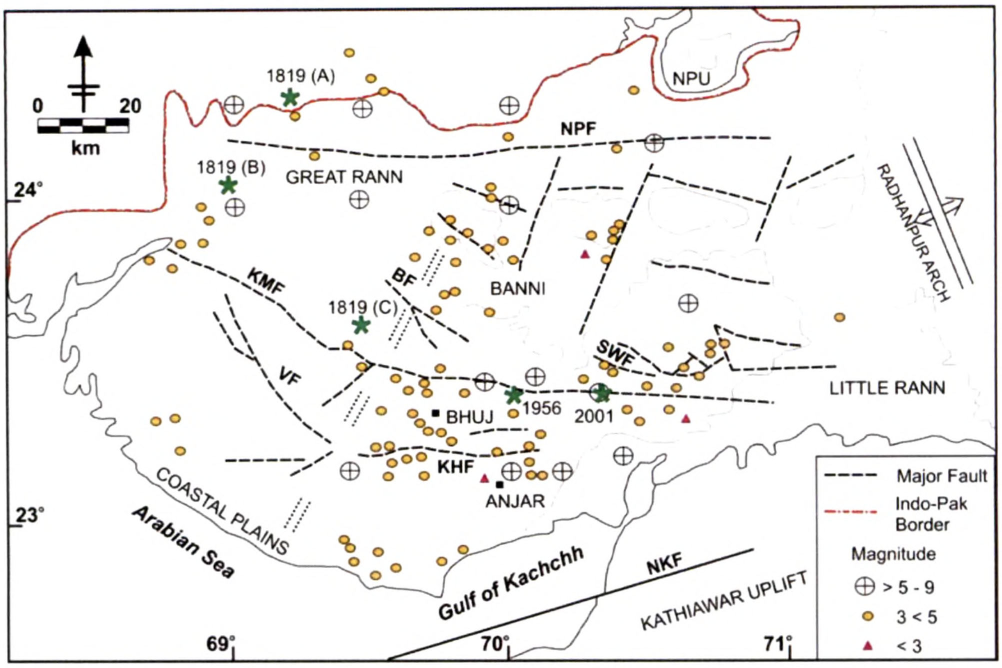

Figure 2.4 Seismo-tectonic map of Kachchh showing epicenters of recent seismic activity (after Biswas and Khattri, 2002). Location of epicenters of major earthquake are shown by stars. Abbreviations are same as in Figure 2.2.

The Kachchh basin has received lot of attention as far as paleoseismology is concerned, specially after the devastating 2001 Bhuj earthquake. The region of Kachchh is placed in Zone V of the Seimic Zoning map of India. Several small and large earthquakes have affected the region during historic and pre-historic times (Figure 2.4). The most well known are the 1819 Allahbund earthquake, the 1956 Anjar earthquake and the 2001 event. Liquefaction features related to past earthquakes in historic times have been reported from the Great Rann of Kachchh. Notable palaeoseismic studies have been carried out by Rajendran and Rajendran (2001, 2003) and Rajendran et al. (2001; 2002; 2008). However, detailed documentation of these features, categorisation of these into chronologically well constrained seismic events and relating them to movements along specific subsurface faults remains to be done. This essentially requires a chronologically well constrained subsurface stratigraphy and delineation of buried structural features within the sediments along the fault zones. Maurya et al (2003a) based on their studies in the Mainland Kachchh, postulated that the transverse faults are perhaps responsible for the present day seismic activity in Kachchh and they have distinctive role in shaping the present day landscape. This needs to be further substantiated by more detailed studies.

In general, several medium to high magnitude earthquakes in the last 300 years indicate active coseismic deformation of the basin under an overall compressive stress regime (Biswas and Khattri, 2002). The region of Kachchh is known to have had a long history of tectonic movements and is identified as an area possessing high seismic risk (Biswas and Khattri, 2002). In view of the seismically active nature of the area, there is a need for generating data on the impact of structure on landscape and drainage configuration. It is also essential to delineate evidence of tectonic activity during Quaternary times and interpret them in terms of movement along faults.