CHAPTER 2
PREVIOUS WORK

2. PREVIOUS STUDIES

2.1 INTODUCTION

The rocks of Gujarat belong to formations ranging in age from the oldest Precambrian to the Recent. Stratigraphically however, the record is incomplete, as the rocks of Palaeozoic Era are totally absent. The sedimentary and volcanic rocks rest over the southwesterly extended Proterozoic rocks of Rajasthan and these sequences are post-Triassic in age. The major geological events of Gujarat thus are confined to Mesozoic and Cenozoic Eras. The geological evolution of Gujarat was initiated sometime in Triassic with the breaking up of Gondwanaland. The subsequent geological history is related to northward drift of the Indian sub-continent, which has mainly controlled the geological evolution of Gujarat. The depositional history and Deccan volcanism are part and parcel of this major tectonic phenomenon. Except the pre-cambrian basement rocks, the other rocks are seen present in Kachchh.

In the past a number of workers have worked on various aspects of the region of which, Stratigraphy and Palaeontology were given importance because of plausible exposures of Mesozoic and Tertiary formations. Some notable work also exists on Structure and tectonics. Although the region falls in the seismic zone 'V' (Jai Krishna, 1992), a very little work has been carried out on seismicity in this region. A considerable literature is available on various aspects of great and little Ranns of Kachchh. Although, the author does not propose to go into details of the work concerning the studies related to Palaeontology, Stratigraphy and evolution of Ranns, some eminent works related to the above fields which have direct or indirect relevance to the present studies have been described.

In this chapter an elaborate resume of the work concerning regional geology, structure and tectonics, geomorphology and seismicity is presented with a view to provide a substantial background for the present investigation. Kachchh region has attracted a number of geologists from early 19th century and the Palaeontological aspects of the Mesozoic and Tertiary rocks of the region attracted most of these. Besides, many workers have dealt with, a) the general stratigraphy, b) structure and tectonics, c) geomorphology and aspects related to seismicity.

2.2 GEOLOGY AND STRUCTURE OF GUJARAT IN GENERAL

The structural setting of Gujarat (Fig 2.1) is controlled by two major Precambrian orogenic trends i.e. NE-SW Aravalli trend and ENE-WSW Satpura trend. The tectonic boundary dividing the Indian shield into a southern peninsular block and the northern foreland block, is the Narmada-Son lineament. A series of parallel extension faults opened up the Cambay basin and the Western Continental Shelf. The Aravalli trend in its SW extremity splays out into three branched components. The main NE-SW trend continues across the Cambay graben into Saurashtra as a south-westerly plunging arch. Further it extends across the continental shelf and divides into the northern Kachchh-Saurashtra and southern Bombay-Kerala shelves. The northern branch of Aravalli-Delhi trend swings E-W and resumes into the Kachchh region across the Cambay basin (Biswas, 1982; 1987). The third southernmost component swings anticlockwise and tends to merge with the Satpura trend. Reactivated movements along these trends gave rise to three important basins; Kachchh, Cambay and Narmada, and according to Biswas, (1982, 1987) the Precambrian tectonic trends control the tectonic styles of these basins. These peri-continental rift basins in the western margin of Indian craton provided ideal sites for the Mesozoic and Cenozoic

sedimentation. The Saurashtra peninsula remained as a horst, flanked by three intersecting rift trends.

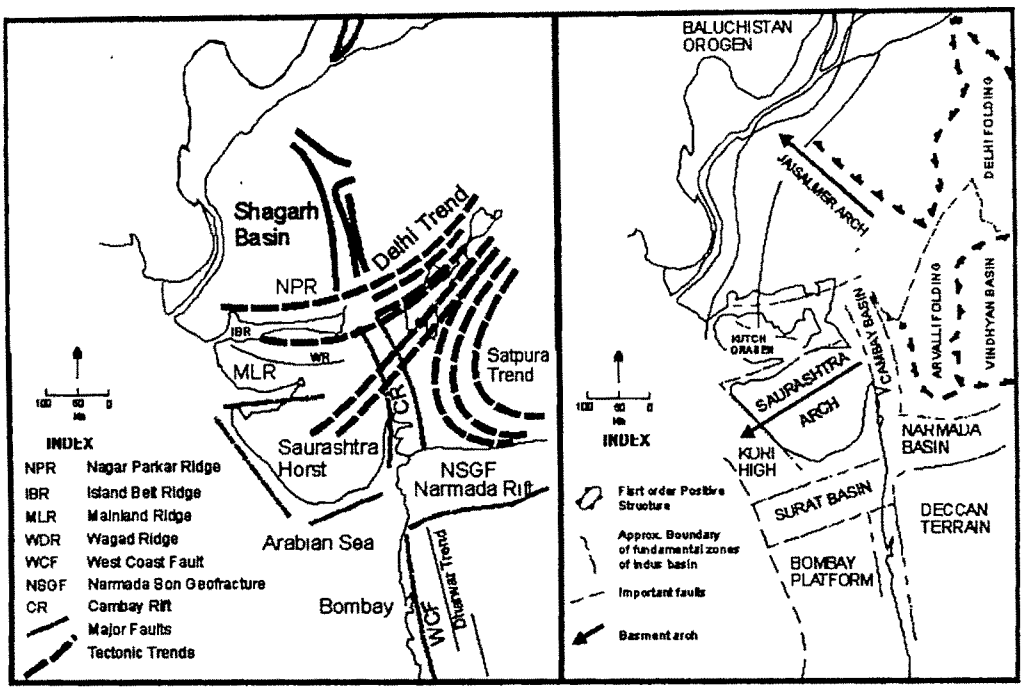

Fig 2.1 Tectonic and structural set-up of Gujarat (after, Biswas, 1987 and Merh, 1995)

The three basins evolved during different phases are geologically quite distinct from each other. According to Biswas (1982), the basins of Kachchh, Cambay and Narmada have rifted during Triassic-early Jurassic, early Cretaceous and late Cretaceous times respectively. The Kachchh basin opened up along the Delhi trend while the Cambay and the Narmada basins follow Dharwar and Satpura trends. The three basins originating at different periods during Mesozoic, have varying thickness of Mesozoic sediments. Though the Cambay basin originated in the late Mesozoic, it has mainly evolved during Tertiary as revealed by the huge thickness of Cenozoic sediments.

The geological diversity is reflected in three major physiographic divisions; each is characterised by diverse structure, stratigraphy and lithology. Each has its own evolutionary history. The geology of Gujarat comprises a Precambrian basement over which younger

rocks commencing with Jurassic, continuing through Cretaceous, Tertiary and Quaternary have given rise to varying sequences in its different parts. The sedimentary sequences are mainly Jurassic, Tertiary and Quaternary in age. These show considerable diversity in respect of depositional processes and environments. A large part of Gujarat is occupied by the Deccan Trap, with intervening Cretaceous and Tertiary rocks at many places. Stratigraphically the Mainland Gujarat is represented by Precambrian crystallines, sedimentary rocks of Cretaceous, Tertiary and Quaternary periods and the Deccan Trap. The Saurashtra peninsula shows a sedimentary sequence as old as Upper Jurassic with extensive area occupied by the basalts. A good development of Mesozoic and Tertiary sequence (the oldest rocks being the Upper Triassic ?) is represented in Kachchh.

2.3 GEOLOGY AND STRUCTURE OF KACHCHH

Grant (1837) was the first to provide an account on the regional geology of Kachchh province. This report was of preliminary nature and was accompanied by different maps and list of fossils. Although the report was too generalised this provided a suitable basis and framework for further investigations.

Blanford (1869) was the first to present proper ideas about the geological architecture of the region. He envisaged presence of E-W trending faults along the northern margin of major uplifted ranges of the basin. Wynne (1869) in his preliminary note on geology of Kachchh correlated the plant beds of Kachchh with Rajmahal series (Upper Gondwana) on the basis of a few forms of ptillophyllum found common in both the formations. He believed that plant bearing beds in marine Jurassic have probably been drifted into these localities from shores adjoining the seas in which the mollusca, now found fossilised in these beds, then existed. However, Oldham (1869) suggested that these are

younger than those containing the truly Jurassic ammonite and other characteristic fossils but belonging to Jurassic period.

Wynne and Fedden (1872) gave a detailed geological account of the area which, consists of detailed descriptions of some important sections. In fact, this has laid the foundations on which the later works were based. Table 2.1 presents the succession for the Kachchh rocks after his work. The existing classification of Mesozoic rocks of Kachchh was put forth by Waagen (1871). This is based on detailed studies of fossil ammonites and field notes of Stoliczka. Accordingly, the Pachham, Chari, Katrol and lower part of Umia correspond with the 'lower series' and the upper part of Umia with the 'upper series, of Wynne (1869). However, Oldham (1893) modified Waagen's classification and included the beds of Ukra hills into the Umia series. The other important studies in this regard were done by Kitchin (1903) and Vredenburg (1910).

Rajnath (1932, 1934a, 1934b, 1942) further divided the Umia series of Waagen into three units on the basis of detailed biostratigraphic work on some of the best exposed sections in Kachchh Mainland. A fairly good presentation of structural features and pattern is given by Auden (1949); this account was mainly based on his work on economic minerals and hydrogeologic aspects.

A revised stratigraphic terminology was given by Agarwal (1961). He proposed the name 'Habo series' in place of 'Chari series' and 'Mebha Oolite' instead of Dhosa Oolite' beds. The geology of Kachchh as a whole was published by Poddar (1959). He revised the Tertiary stratigraphy as was given by Wynne (1872) and others. After Poddar (1959) several aspects of the Kachchh region were investigated by different workers; some worth mentioning are Berburg and Schott (1963) and Prasad (1964).

Merh and Hardas (1968) initiated work on different aspects of Geology in Kachchh, other than stratigraphy and Palaeontology. They gave a brief account of the Miliolitic rocks

of Kachchh Mainland thereby laying a foundation to study these in detail. This followed by a notable work by Hardas (1969) who gave a detailed account of sedimentology and structure of the area to the south of Bhuj. The most recent Palaeontological and Biostratigraphic studies must be credited to the workers of ONGC (Ghosh and Ghosh, 1959; Sengupta, 1959; Sen and Satyanarayan, 1953; Guha, 1961; Madan Mohan, 1965; Poddar, 1963; Biswas, 1965, 1971; Biswas and Raju, 1973).

Biswas and Deshpande (1970) gave the best geological presentation of Kachchh geology. One of the important discoveries made by these workers is that of Syenitic Pre-Cambrian basement outcrop of Maruda Takkar Hill in the Great Rann. On the basis of this finding these workers have postulated that the Mesozoic rocks of Kachchh directly rest over the Pre-Cambrian basement. However, the precise dating of these rocks would be the concluding evidence.

Although many people have worked in Kachchh region the foremost credit must go to Biswas (1980, 1982, 1987) for his comprehensive contribution towards the stratigraphy, structure and tectonics of Kachchh region. Biswas and Deshpande (1970) published geological and tectonic maps of Kachchh region. These maps may be considered as the basic maps towards all future work to follow. The geological map presents the rock stratigraphy for the Mesozoic rocks and time stratigraphy for the Tertiaries. The tectonic map shows all the major tectonic elements of the region. Biswas (1974) also takes the credit of correlating different geomorphic landforms and geology. According to him differential denudation cycles were on account of major tectonic disturbances in the region. He suggested that several periodic unidirectional movements and a very late uplift is responsible for the present day youthful topography.

Biswas (1982, 1987) gave an outline of the structural and tectonic evolution of Kachchh basin. He has described the presence of monoclinal flexures and domes aligned

along the margin of all the major faults of the region i.e. Nagar Parkar Fault (NPF), Island belt Fault (IBF), Kachchh Mainland Fault (KMF) and Katrol Hill Fault (KHF). According to him the structure of Kachchh region can be correlated with that of Laramide structures of Colorado plateau and Central Montana Rockies of North America. He attributed the genesis of these chains to the vertical uplift along almost straight Master Faults.

According to him the marginal folding along all the major faults is on account of gravity sliding. To arrive at this conclusion he followed the Bellousov (1969) and Prucha et al (1965) models of vertical uplift. Besides this, Gopala Rao (1988) described structural features of the Gulf of Kachchh. Apart from this no other remarkable work in terms of geology, structure and tectonics is done in the last decade.

2.3 MORPHOTECTONICS

Although the work on morphotectonics was initiated long back when Biswas (1974) studied the geomorphic attributes of Kachchh Mainland but in last ten years, greater attention is being paid on these aspects of Kachchh. Sharma (1990) gave a detailed account of the geomorphology of Kachchh coastline. Through his work he presented some salient geomorphological attributes of Kachchh coast. Kar (1993a, 1993b, 1993c) gave a detailed account of neotectonic influences on Kachchh coastline and Banni tract. On the basis of morphology he divided the Kachchh coast into five major segments and concluded that tectonism is the major cause for the evolution of these coastal segments. Of late Merh (1995) in his book 'Geology of Gujarat' gave a comprehensive account of all the major geological aspects.

2.4 SEISMOTECTONICS AND PALAEOSEISMICITY

A number of earthquakes have struck in the region of Kachchh in recent and historic times. However, but for a few reports an adequate documentation is lacking. MacMurdo

(1824), a British Army Officer posted at Bhuj who was an eyewitness has given an excellent account of the earthquake of 1819. He observed that river valley with sandy beds, which generally remained dry, got filled with water for a period ranging from a few minutes to half an hour. At many places "spots of ground in circle of from twelve to twenty feet diameter threw out water to considerable height, and subsided in a slough". He found that the earthquake had raised an earthen mound about 50 miles long in an east-west direction and a mile wide, with a steep face on the south side but no perceptible slope on the north. This elevated portion in the Rann, he called Allah Bund, the Mound of God. Burnes (1839) has also given some details of the 1819 earthquake. According to him, this earthquake spewed up great quantities of mud and water and pieces of iron and ship nails along the edges of the Rann. He has written that a large lake formed on the south side of the Allah Bund completely submerging the small village of Sindree under about 18 feet of saline water. In the Railway report of Mangrulkar (1948) some more details of the Burnes's description are available. He has given the account of an earthquake that followed the 1819 earthquake and was perhaps referring to the one that shook Kachchh in 1845. He has stated that the bunds built across the Kori Creek were burst and water started flowing through the old established channel cutting for itself a passage through Allah Bund which, formed during the earthquake of 1819 described by MacMurdo (1824). Burnes (1839), travelled up the channel from Lakhpat to Allah Bund and reported that rivers at Lakhpat upto twelve miles upstream were two to three fathoms deep. On going further up for two miles, the depth increased and he entered in a vast inland lake amidst which the remaining tower of Sindree stood like a rock. At Allah Bund, the channel was about 35 yards wide and 3 fathoms deep and fresh water was flowing.

Wynne, (1872), Oldham, (1883); and Davison, (1936) explicitly stated subsidence of the southern side thereby causing complete submergence of Sindree fort (some 10-15 km south of Allah Bund dislocation which was a few feet above the MSL (and raised upto ~ 4.2

m). Several other reports deal with different aspects of earthquakes of Kachchh region, some of the worth mentioning are of that of Frere (1870) and Oldham (1926). Apart from this Quittmayer and Jacob (1979) gave a comprehensive compilation of earthquake data for whole of the Indian shield. This work presents some aspects of the seismicity of Kachchh region, however, no good description concerning the great earthquakes is presented.

In the recent times several workers (e.g. Johnston and Kanter, 1990; Bilham et al, 1996; Rajendran et al, 1998) have attempted to model out a possible driving mechanism of the the 1819 Allah Bund Earthquake. All these workers believe that the fault, which ruptured in 1819 was of the reverse nature. However, a lot of ambiguity exists in the models presented by these workers. Most recently Thakkar, et al, (1999) presented a geomorphological account of Kachchh.