CHAPTER-1

INTRODUCTION

Kutch peninsula forms the westernmost part of India and represents a major geologic province in the realm of the Indian stratigraphy. Kutch basin experienced a fairly continuous sedimentation from middle Jurassic to Recent. It exhibits diverse and fascinating geologic phenomena including structural style, bio and litho-stratigraphic variations, tectonics and basin evolution. It has been, therefore, a unique place of attraction for paleontologists, structural geologists, sedimentologists etc.for over a century.

Major outcropping parts of the Kutch basin comprise Mesozoic sediments, whereas Tertiary sediments are developed at the western and peripheral part of the eastern and southern region. Oligocene sequence is deposited in the south - western part of Kutch and has been selected by the author for the present studies (Figures 1.1 and 1.3).

1.1 GENERAL BACK GROUND OF KUTCH

Geomorphologically, Kutch forms several discrete high-lands separated by alluvial and marshy depressions (Figure 1.2). The principal highlands are termed as the Kutch Mainland in the central part, Wagad hills in the east and a chain of "islands" namely

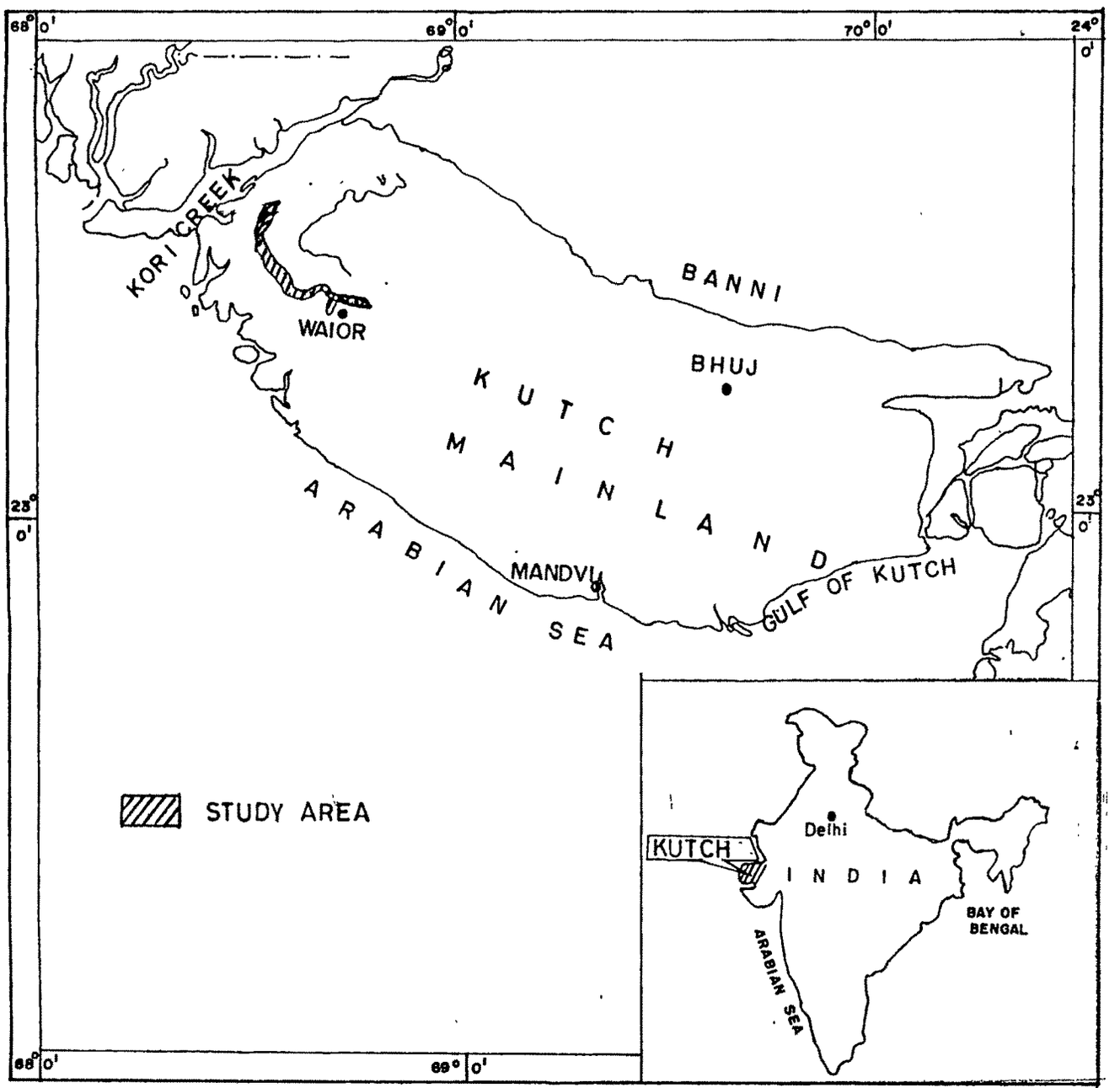
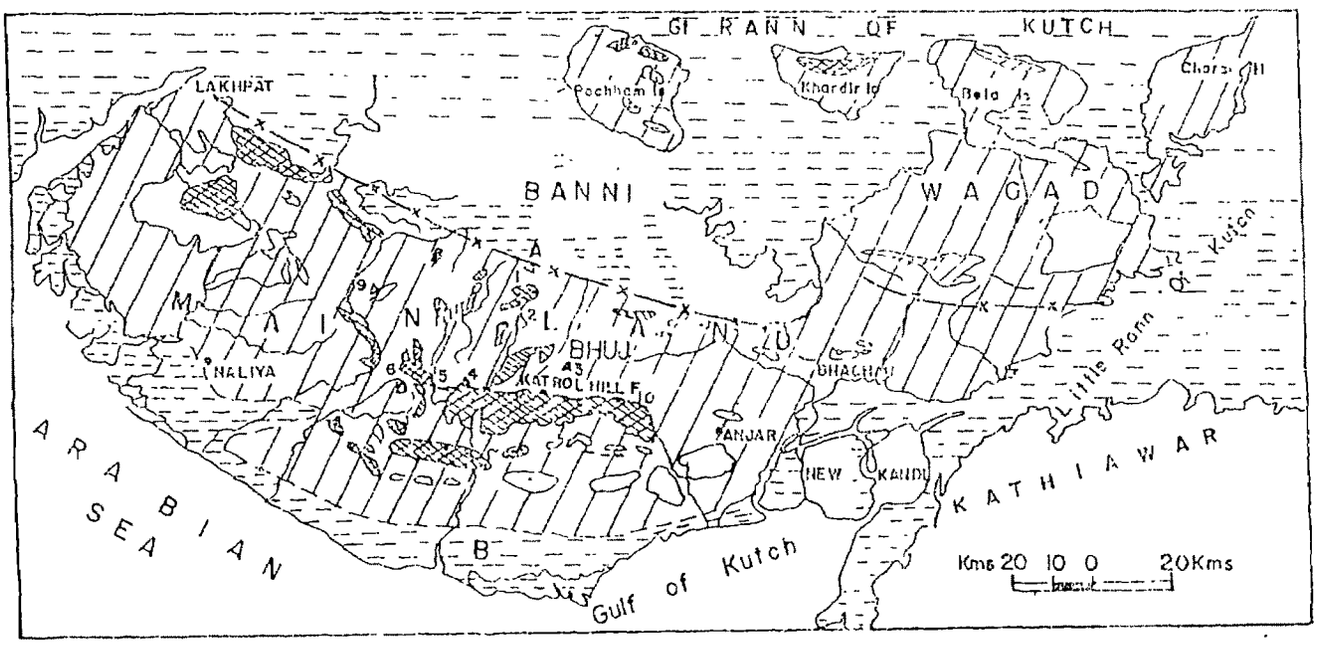


FIG.1.1 LOCATION MAP.



LEGEND

- DEPOSITIONAL PLAINS
- EARLY QUATERNARY LANDSURFACE (KUTCH CYCLE)
- LATE TERTIARY LANDSURFACE
- MID-TERTIARY LAND SURFACE
- RELICS OF UPPER CRETACEOUS/EARLY TERTIARY (INDIAN CYCLE) LANDSCAPE.
- FAULT

HIGH HILLS

1. JHURA HILL
2. VARAR HILL
3. BHUJIA HILL
4. DHRUBIYA HILL
5. NANADONGAR HILL
6. ROHAL HILL
7. BHABAPUR HILL
8. DHINODHAR HILL
9. MANKI HILL
10. KHATROD HILL

FIG. 1.2 GENERALISED MORPHOLOGICAL MAP OF KUTCH (AFTER BISWAS 1974)

Pachham, Khadir, Bela and Chorar in the north. The intervening marshy depressions in the northern and eastern parts are respectively called the Great and Little Rann of Kutch. The Mesozoic sediments which form the major part of the outcropping area exhibit greater degree of uplift and tectonisation in comparison to Tertiary sequence.

Dry and semi-arid climatic conditions prevail round the year over the area and has resulted in sparse vegetation, usually xerophytes, thorny shrubs etc. Recently several irrigation projects have helped better cultivation through localised farming. Because of the paucity of vegetation cover, there is poor growth of wild fauna in the region. However, Kutch is world-famous for its bird-life, particularly the migratory Indian bustard and flamingos.

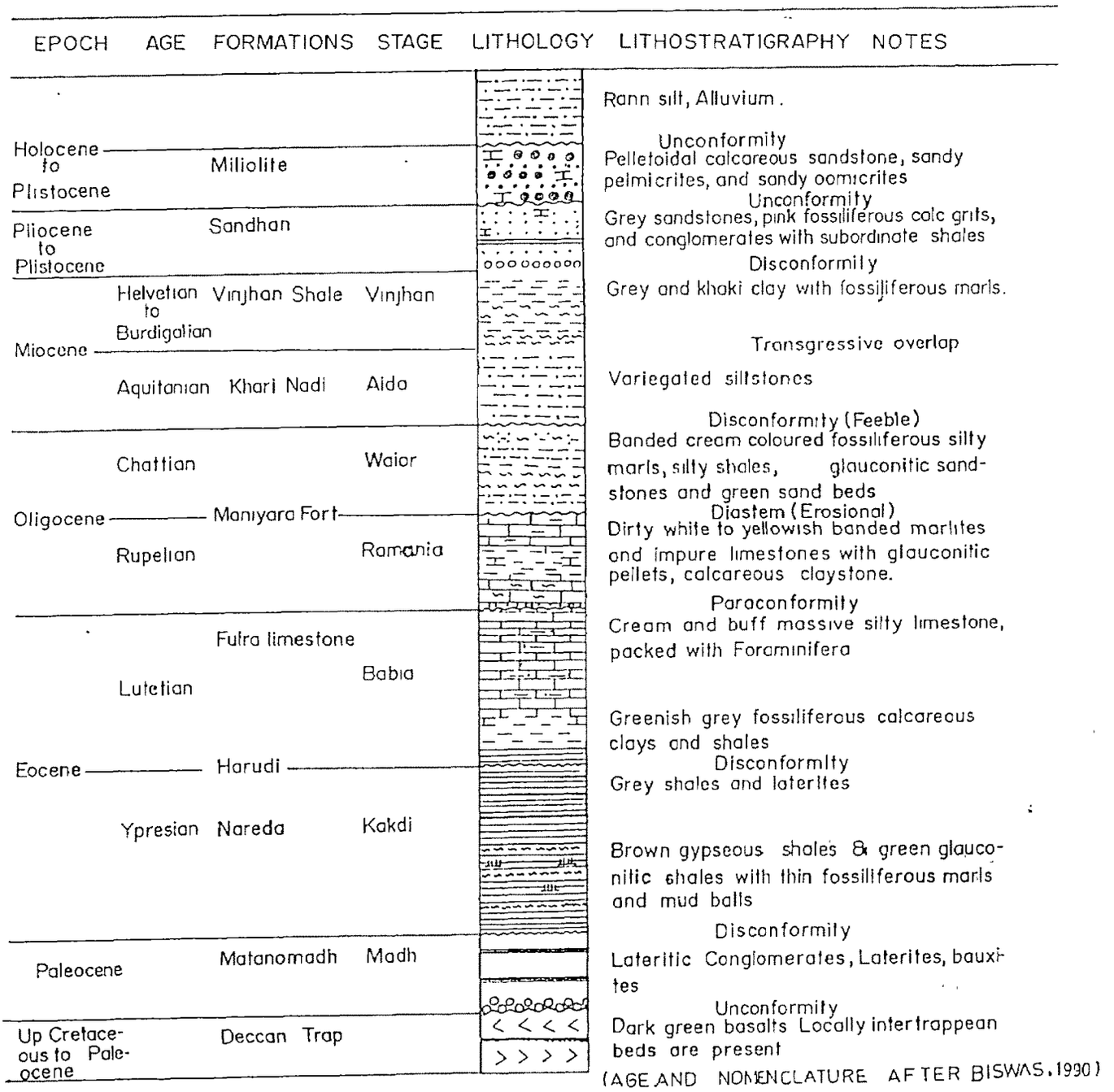
The general population density is very low and most depend on localised farming, cattle breeding, as well as, manufacture of handicrafts and special variety of hand-woven cloth and linens. The population of nomadic tribes is fast dwindling.

The entire area is very well connected by well maintained, all weather roads and good bus services connecting most of the villages to the district town Bhuj. The present area occurs between 100 to 130 km. west and south west of Bhuj. The study area (Figure 1.3) which measures about 220 sq km. exhibits very good outcrops, particularly, along the river and nala cuts, as well as, small discrete mounds. The area is well accessible from Bhuj. However, the camping facilities are poor.

1.2 SELECTION OF THE AREA

The Tertiary deposition in Kutch basin took place in open marine, stable shelf environment, punctuated by mild tectonism and uplifts, represented by unconformities. The entire sequence from Paleocene to middle Miocene is richly fossiliferous both with mega and micro fauna. Oligocene time being generally, a tranquil period, resulting in the development of a comparatively fewer speices, has not mustered enough attention of paleontologists, till now.

The sedimentary basin of Kutch was developed due to break-up of Indian plate from African one and its drift due north-northeast. The basin formed an east-west embayment which opened out and deepened due west towards Arabian sea. The sedimentation commenced from middle Jurassic times and continued till Recent (Figure 1.4). The Mesozoic sediments in the central, northern and southern parts of the basin are severely affected by tectonic activities whereas, Tertiary sequences particularly western and southern part, show only mild disturbances. This has resulted in preservation of good sedimentation records in the south-western part of Kutch. The regional tectonic map of Kutch (Biswas and Deshpande, 1970) indicates a major fault along the northern border of the Mainland as well as Kathiawar. The south-western part of Kutch thus, remained as a stable and shallow platform, ideal for good preservation of geological records. The author has, thus, selected this area to study the depositional history of Oligocene sequence and changes of sea levels in relation to faunal and sedimentological parameters.



(AGE AND NOMENCLATURE AFTER BISWAS, 1980)

FIG. 1·4 TERTIARY CHRONO-STRATIGRAPHY OF KUTCH.

The stratigraphic sequence studied, represents Oligocene age and is roughly equivalent to Maniyara Fort Formation of Kutch basin (Biswas, 1972). The section comprises good faunal assemblages, excellent outcrops and variety of easily identifiable clastic and carbonate facies. Besides,within relatively thin Oligocene stratigraphic interval, a large variety of geologic phenomena could be observed and documented.

1.3 TYPE SECTION AND CLASSIFICATION OF OLIGOCENE

The Oligocene Epoch was proposed by Beyrich (1854) to include the formations between upper Eocene and the lower Miocene as defined by Lyell (1839). Originally, this epoch was classified into three main stratigraphic units namely a lower greensand unit referred to Lattorfian, a middle deeper marine clayey unit comprising the Rupelian stage and an upper shallow marine sandy unit contains the Chattian stage. The three fold division of Oligocene was followed till 1970. Later on it was found that the lower-most unit, the Lattorfian, is age equivalent of Priabonian stage and was placed under Eocene, based on the following findings-

1. Martini (1970), assigned lower Oligocene age (NP-21) to the Lattorfian sands based on the presence of calcareous nannoplankton Ericsonia subdisticha and the absence of rosette shaped late Eocene discoaster, Discoaster barbadoensis and D. saipanensis. The nannoplankton Ericsonia subdisticha is known to occur in the upper part of type area of Priabonian of Italy.

2. Nummulites germanicus which occurs at Latdorf has, according to Blondeau (1969), descended from the upper Lutetian N. anomalus. This is a south European Priabonian species known also in the upper Eocene of Ukraine which reached Germany by way of Poland (Pomerol, 1982).

3. The Neotype of Lattorfian (Martini and Ritzkowski, 1968) exposed in the lignite open mine and clay pits near Helmstedt and at Lehrte, east of Hannover, yielded planktonic foraminferal fauna of P15-P16 zonal assemblage of late Eocene (Marks & Van Veesem, 1971).

4. The basal Silseberg beds of Neotype Lattorfian has been dated as 37.5 + 07 Ma based on Potassium - Argon (glauconite) dating method (Graman et al 1975) and considered as age equivalent of late Eocene.

In view of the above, the lowermost unit of Oligocene, the Lattorfian, is now dropped and is placed under Eocene Epoch. At present, the two fold classification of Oligocene comprising Rupelian and Chattian stage is followed throughout the world, (Figure 1.5).

The Rupelian stage was proposed by Dumont (1849), after Rupel, a tributary of the river Scheldt in Belgium. The main unit of Rupelian consists of Berg sands overlain by Boom clay with septarian nodules. This stage has been taken to include planktonic

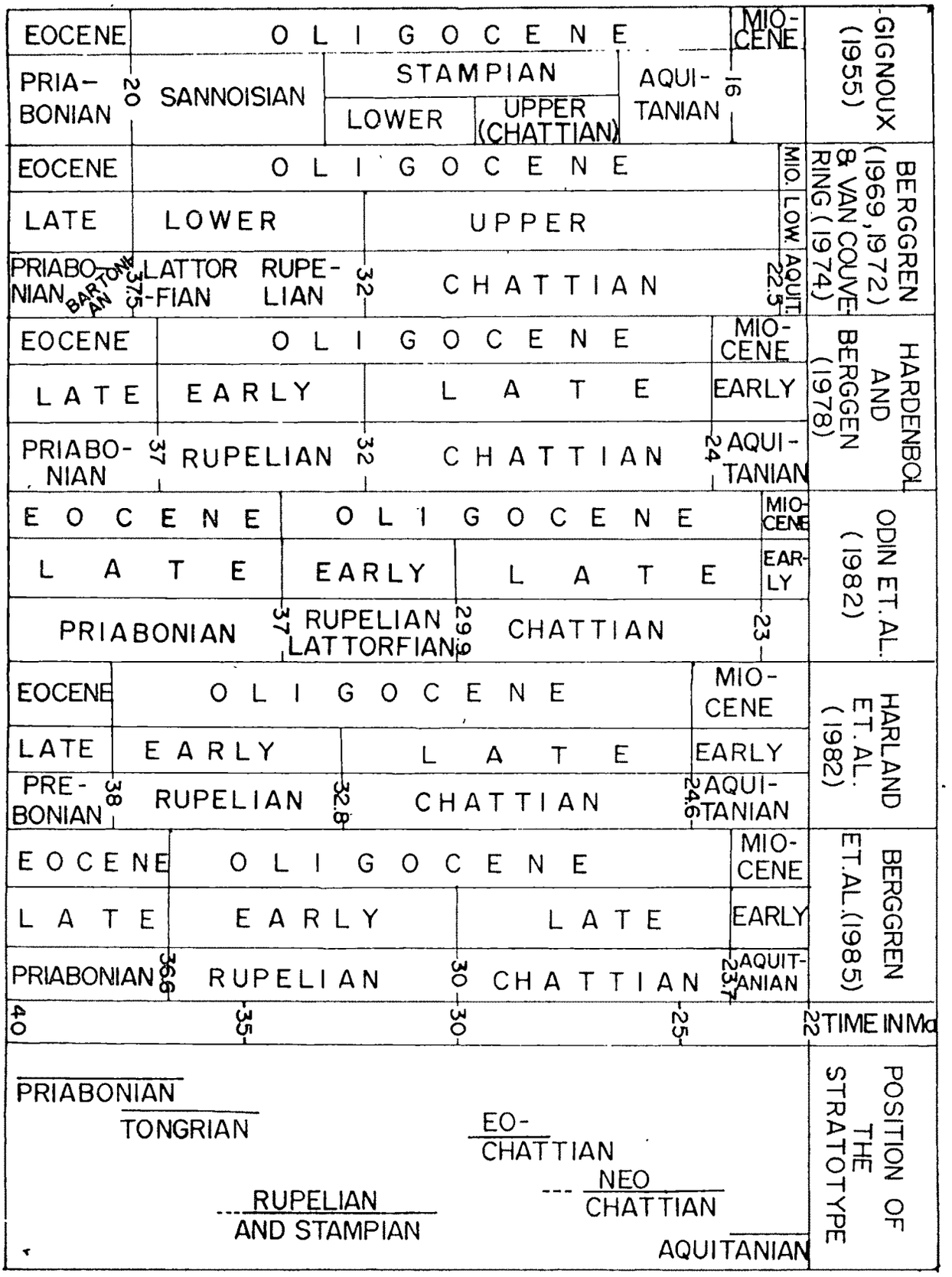


FIG. 1·5 HISTORY OF OLIGOCENE TIME SCALE.

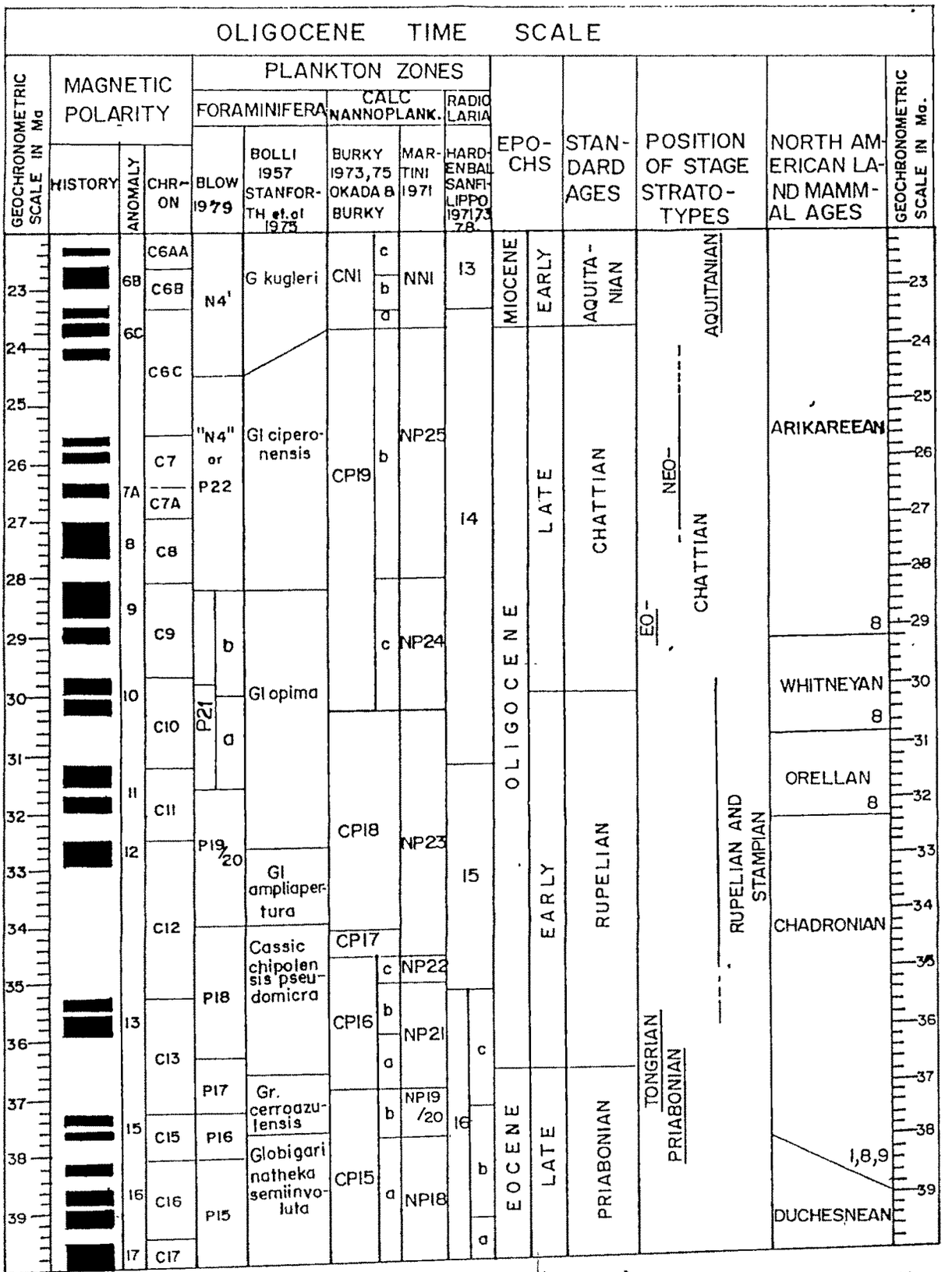


FIG. 1·6 REVISED OLIGOCENE TIME SCALE.

(after Berggren et,al,1985)

foraminiferal zones P-18 to P-21 (part) and corresponding nanno-plankton zones NP 21, 22, 23 and NP 24 (part), (Martini, 1971). The Rupelian stage has a equivalent stage, Stampian in Paris basin, and spans about + 6.6 Ma years between 36.6 Ma and 30 Ma (Berggren et al, 1985).

The Chattian stage proposed by Fuchs (1894) is named after the ancient tribe Chattes or Chatten of the Cassel region, North Germany. The typical lithology in the type section Doberg near Bunde, consists of glauconite sands of shallow marine environments. The stage generally includes planktonic foraminiferal zones P-21 (part) and P-22 (N3) and corresponding nannoplankton zones NP-24 (part) and NP-25 (Martini, 1971). It spans about 6.3 Ma years between 30 Ma and 23.7 Ma, (Figure 1.6).

1.4 OBJECTIVE AND SCOPE OF STUDY

After a short reconnaissance of the area and study of existing literature, the main objectives of the study identified were:

1. to decipher litho and biostratigraphy, as well as microfacies and to study their variations in space and time,

2. to identify detailed paleoenvironments of deposition during Oligocene time in the study area, on the basis of paleontological and sedimentological parameters,

3. to establish unconformities and/or minor breaks in deposition,

4. to understand cyclicity of sedimentation in relation to sea level changes,

5. to decipher eustatic changes and to correlate the same with global sea level changes, and

6. to construct the Oligocene paleogeography of the area.

SCOPE OF STUDY

To achieve the above mentioned objectives, the author has taken the help of both micropaleontological and sedimentological studies. The investigations are based on study of four regionally spread outcrop sections (Figure 1.3). Geological map published by Biswas and Deshpande, (1970) with a few modifications carried out by author was taken as the base. Subsequently, study in greater details was carried out along four traverses namely Ratipal, Bermoti, Bernani and Waior from west to east respectively. Detailed data on macro and microfossils, lithology, sedimentary facies and sedimentary structures were collected along each traverse. A total number of 110 samples representing lithologic variations and faunal richness were collected. These data were subsequently, transformed into various representative logs, as well as maps, representing bio-and micro-facies etc.

The framework was then used to establish bio and litho correlation, spatial and temporal changes in paleoenvironments, cyclicity in sedimentation and eustatic sea level changes. From such studies conclusions were drawn to correlate the local and global sea level changes in relation to sedimentation, as well as, paleogeographic setting.

1.5 METHODOLOGY

The author conducted field studies during two consecutive years. After a general reconnaissance of the area, the best exposed sections were identified for detailed studies. The sections selected across the regional stike are 1) Ratipal 2) Bermoti, 3) Bernani and 4) Waior, respectively from west to east (Figure 1.3). This spread almost entirely covers outcroping Oligocene area.

Bed by bed stratigraphic measurements were carried out along these sections. Samples with precise stratigraphic positions were collected at about 3 feet to 5 feet interval and also as and where lithologic and faunal changes were observed.

Both litho and bio-stratigraphic columns representing each traverse were constructed and correlated.

I. For biostratigraphic studies, the samples were subjected to the following procedure.

1. Distintegration of samples for faunal extraction for subsequent studies,

2. Transverse and axial sectioning of larger foraminifera,

3. Thin sectioning of the hard samples to study the faunal content, and

4. Preparation of smeared slides for nannoplankton studies.

II. Sedimentological investigations carried out were :

1. Quantified facies data from field studies,

2. Thin section petrographic studies for identification of microfacies,

3. Semi-quantitative analysis of carbonate constituents on the basis of thin sections, and

4. Insoluble residue studies by acid treatment.

Thus, data were generated in terms of various paleontological and sedimentological maps and logs, alongwith their correlation across the basin. On the basis of this, interpretative figures such as sedimentation cyclicity, environments of deposition in space and time, sea level changes and paleogeography representing Oligocene sequence were constructed. Figure 1.7 indicates a general flow-chart of sequence of investigations adopted during the course of studies.

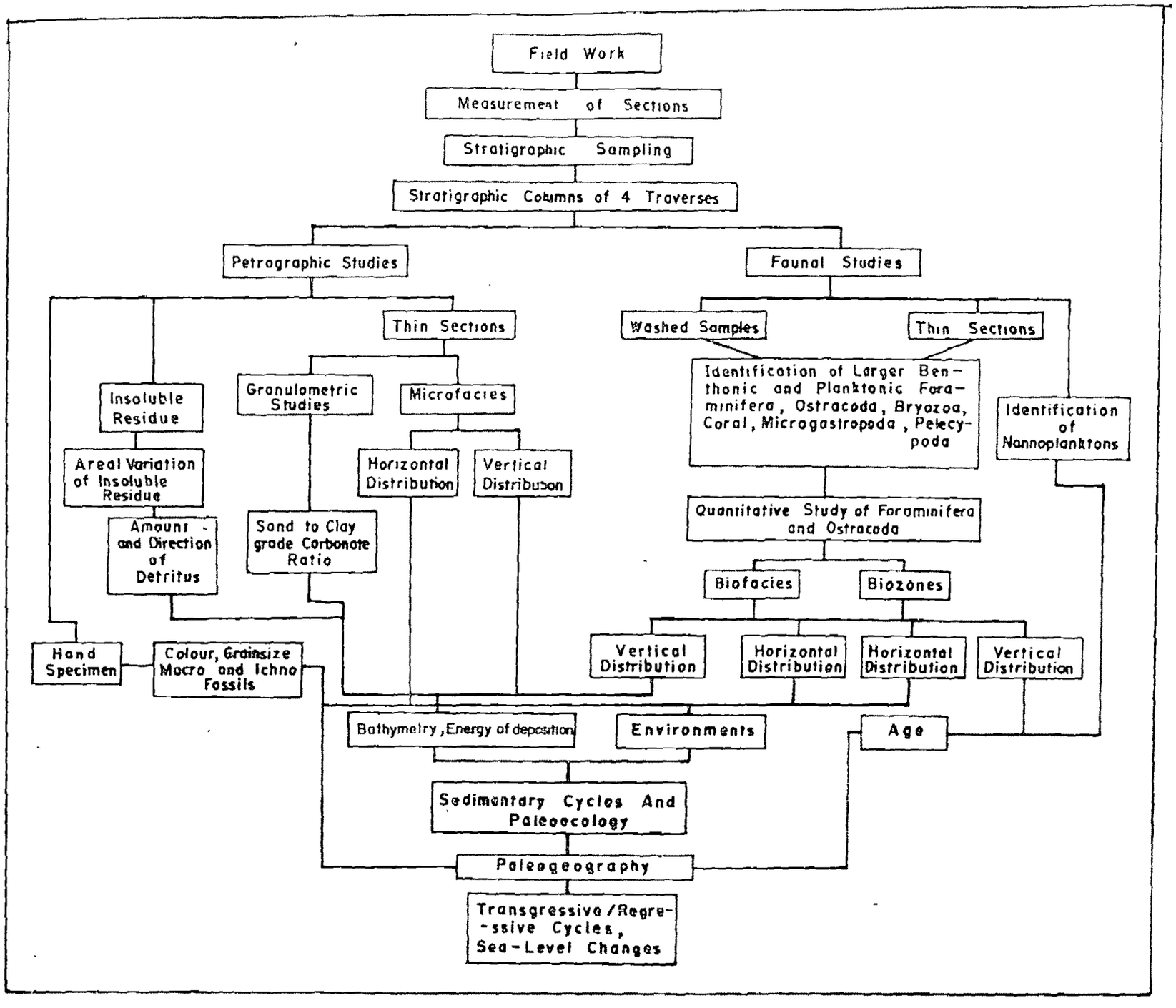


Fig. 1.7 NETWORK DIAGRAM INDICATING INVESTIGATIONS AND INFERENCES

1.6 PREVIOUS WORK

Though, several geological, cultural and ecological accounts of the erstwhile state of Kutch were published since over one and half centuries, first detailed geological investigations were carried out by Wynne and his work was published in a form of memoir of the Geological Survey of India in the year 1872. He was the first to publish Geological map of Kutch on 1" = 4 miles scale. He divided Mesozoic stratigraphy into two as lower and upper Jurassic groups. Overlying the Deccan trap flows, he further subdivided the Tertiary sequence into several groups namely sub-Nummulites, Gypseous shale, Nummulitic group, arenaceous group and argillaceous group.

Waagen (1871, 1873) classified the Mesozoic sequence into Pachham, Chari, Katrol and Umia series. This sequence is still widely followed in the Indian geological literature.

Rajnath (1932, 1934 and 1942) carried out detailed biostratigraphic studies of Mesozoic strata on the basis of mega fossils in the western Kutch Mainland, particularly around the Jhumara dome.

Agarwal, (1957), extended the paleontological studies to Jhurio and Habae domes in the north-central part of Kutch Mainland and assigned Callovian to Oxfordian age to Chari series.

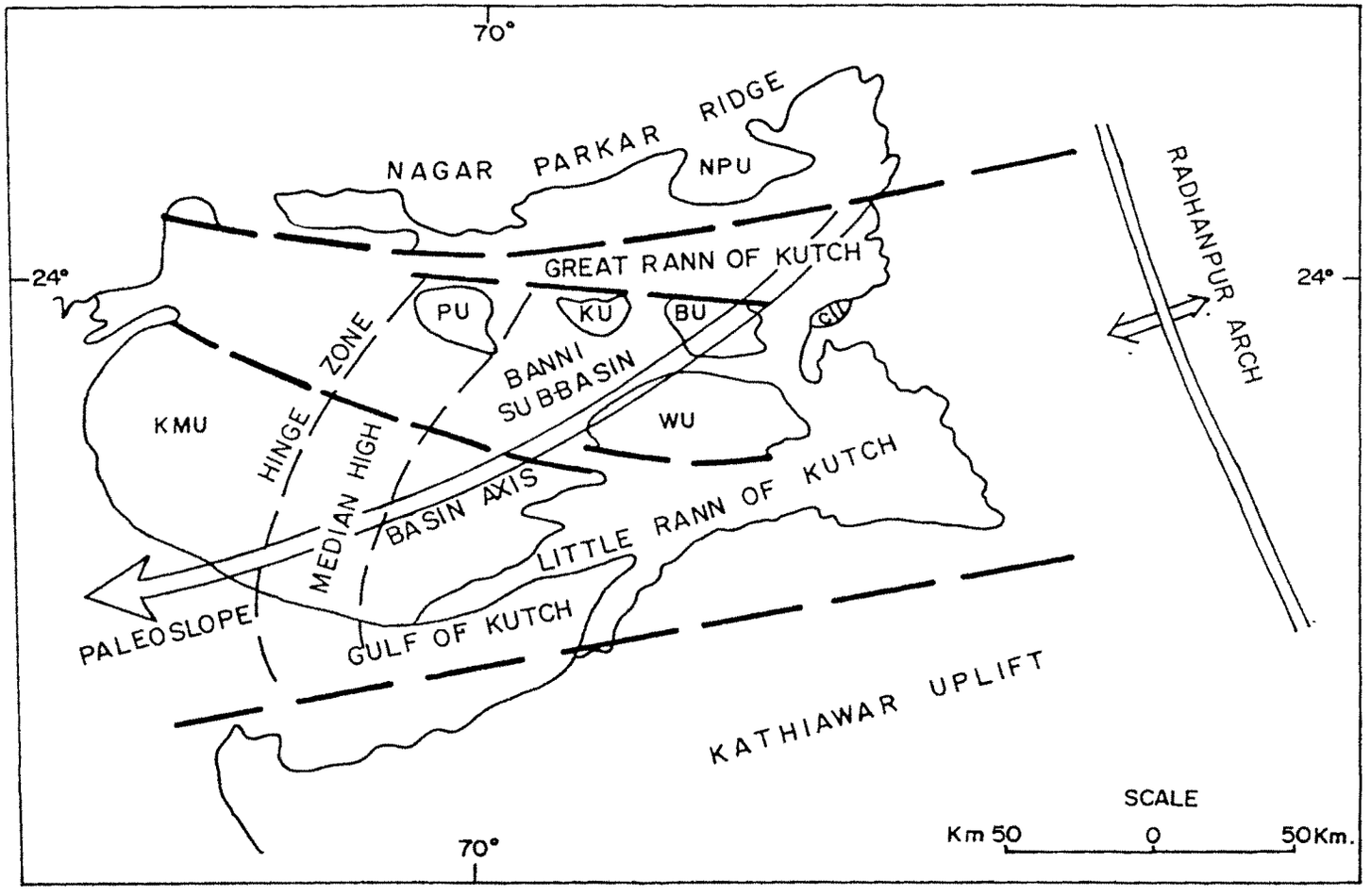
A concise regional account of Kutch geology was published by Poddar in 1959 and 1963.

Several paleontological investigations were carried out, particularly of Tertiary stratigraphy by Tewari (1952, 56, 57, 59, 60). He suggested biostratigraphic zonations for Vinjhan, Waghpadar, Panadro, Babia and Lakhpat area.

Biswas and Deshpande, (1968), discovered Pre-Cambrian syenitic basement outcrops within the great Rann of Kutch and suggested that the Mesozoic sediments were directly overlying the Pre-Cambrians. They further, for the first time, published geological and tectonic maps for entire basin and suggested stratigraphic classification in 1970. Biswas et al (1970, 1971, 1973, 1982) have further described detailed stratigraphy of Kutch for both Tertiary and Mesozoic sequences.

Raju (1973, 74) has published several accounts on the Tertiary paleontology of the western parts of Kutch and their stratigraphic significance. Madan Mohan et al (1965, 68, 70) have also carried out foraminiferal studies of Eocene and Miocene sequence of western Kutch. Samanta (1970) has published an middle Eocene planktonic foraminiferal account for Lakhpat area.

Shringarpure and his co-workers have been carring out detailed trace-fossils and related ichno-faunal investigations for the last two decades and have published several detailed accounts (1985,86,89,90).



KMU – KUTCH MAINLAND UPLIFT. W
WU – WGAD UPLIFT
PU – PACHHAM UPLIFT
KU – KHADIR UPLIFT
BU – BELA UPLIFT
CU – CHORAR UPLIFT
NPU – NAGAR PARKAR UPLIFT

FIG. 1·8 TECTONIC MAP OF KUTCH SHOWING MAJOR ELEMENTS
(after Biswas, 1982)

1.7 TECTONIC AND STRATIGRAPHIC FRAME

Kutch peninsula forms the western most part of Gujarat and is detached to it's east from the Mainland by a narrow marshy depression called a Little Rann of Kutch and from the Saurashtra peninsula to it's south by the intervening Gulf of Kutch.

TECTONICS

The Kutch basin has been developed as a result of pericratonic embayment along the passive continental margin of western India. The basin can be called as a rift since it is bounded to its north by Nagarparkar fault and to south by Kathiawar fault (Figure 1.8). The sedimentation commensed during middle Jurassic and continued till Recent. Major tectonic episode took place during upper Cretaceous resulting in uplift of most of the area and subsequent regression. This has restricted the subsequent Tertiary transgression along the western, southern and eastern peripheral parts only.

The main tectonic activity has caused several discrete uplifts, namely the Kutch Mainland, island belt to the north and Wagad hills to the east. Several asymmetrical anticlines and domes have been associated with the major fault systems of Kutch (Deshpande 1972). The tectonic activity was also coupled with the various intrusives. The Deccan Trap basaltic flows were erupted, possibly during upper Cretaceous. However, the Tertiary outcropping region is relatively free from intense tectonic activity and shows only mild reactivation of existing tectonic elements.

STRATIGRAPHY

Biswas and Deshpande (1970) and Biswas (1965), have suggested the litho and time - stratigraphic classifications of Kutch basin for Mesozoic and Tertiary strata respectively. According to them the oldest rocks of Bathonian age, termed as Kaladongar Formation are exposed in Pachham island (Figure 1.9). The equivalent of this formation is also found in eastern Khadir and Bela islands. The arenaceous Kaladongar Formation is overlain by calcareous Goradongar Formation and is supposed to be the equivalent of the oldest stratigraphic unit of Mainland i.e. Jhurio Formation. The Jhurio Formation is subsequently overlain by upper Jurassic units namely Jumara and Jhuran formations. The Jumara Formation comprises mainly of grey and khaki coloured shales with fossiliferous marl bands. Jhuran Formation is made up of sandstone in the lower and upper parts with an intervening shale member. The Jhuran Formation is in turn overlain by the arnaceous Bhuj Formation, mostly representing deltaic facies.

The Paleocene representing Matanomadh Formation in most of the parts of the Kutch is represented by weathered derivatives of the underlying Deccan Trap of upper Cretaceous age. However, in a few localised areas in south-western parts of Kutch, marine Paleocene shales have been observed directly overlying the Deccan trap flows.

The Tertiary sequence well exposed in southwestern Kutch (Figure 1.10) is characterised by several unconformities. Amongst

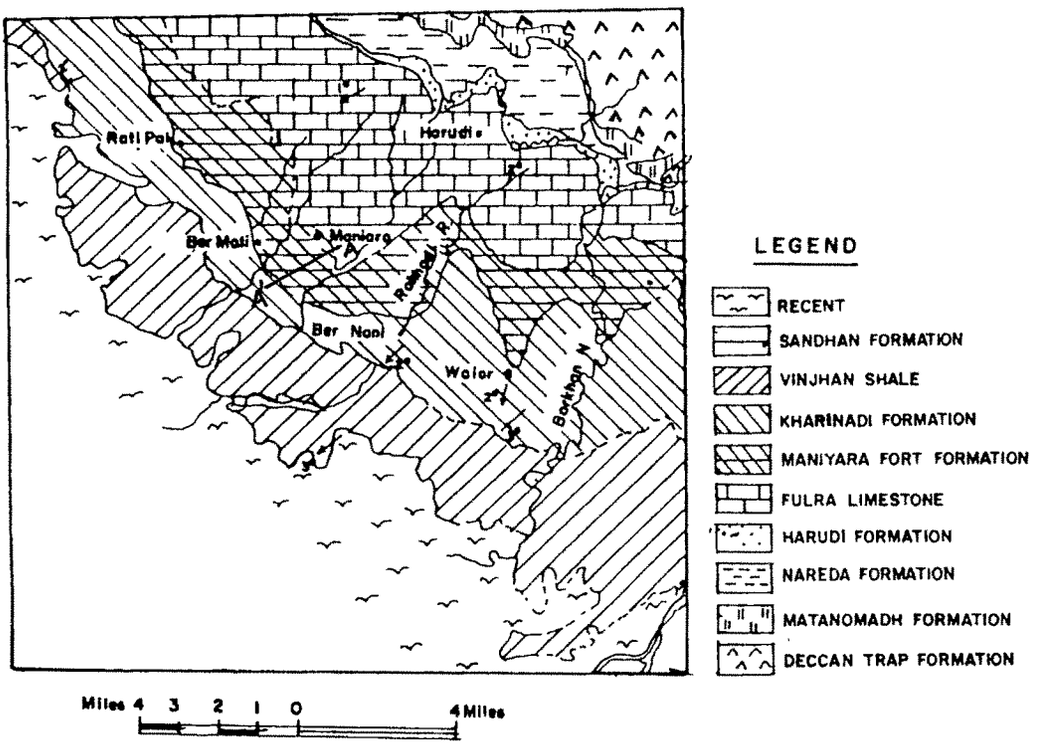


FIG 1:10 GEOLOGICAL MAP OF THE SOUTH-WESTERN KUTCH.

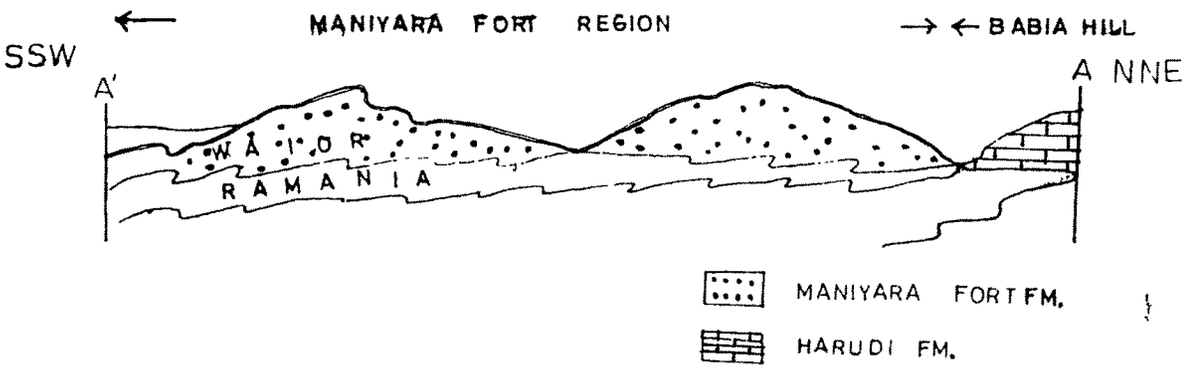


FIG 1:10A GENERALISED NNE-SSW STRUCTURAL CROSS SECTION THROUGH MANIYARA FORT REGION
(NOTE VERY GENTLY DIPPING STRATA)

them, post - middle Eocene para-conformity is the most pronounced one and marks absence of upper Eocene sediments. The other major unconformities are at the top of Oligocene and middle Miocene. A diastem is also observed between lower and upper Oligocene. The generalised stratigraphic column after Biswas (1972) is given in Figure 1.4.

The lower Eocene Nareda Formation is characterised by dark grey fossiliferous gypseous shale overlain by dirty white to yellowish white, highly fossiliferous shales and limestones representing Harudi and Fulra Limestone formations respectively (Figure 1.11). The Maniyara Fort Formation of Oligocene age overlies the middle Eocene sequence with a paraconformity. It is represented by foraminiferal and coralline, light grey to off-white and ochreous grey limestone bands along with greenish grey silty shales and green glauconitic siltstone.

The lower and upper Miocene are represented by the arenaceous Khari Nadi and fossiliferous Vinjhan formations. The Sandhan Formation of Pliocene age is mostly made up of massive and cross-bedded, dark grey, medium to coarse grained, friable sandstones. Sandstones are unfossiliferous and possibly represent continental facies.

The present study is confined to Oligocene sequence, that is strata occurring between upper part of middle Eocene to the basal part of lower Miocene sequence.