# *Chapter - 1*

# CHAPTER - I

# GENERAL INTRODUCTION

Evidences of Cretaceous/Tertiary (K/T) boundary sequence are very well located in the region of Kutch. The Cretaceous sedimentary rock sequence comprises various sub-units of the Bhuj Formation deposited more or less continuously. This depositional phase continued till the commencement of the Deccan volcanics, that marks alternately quiet and eruptive phases. It is further important to note that during such quiet periods, the fossiliferous intertrappean sedimentary strata were deposited. This alternating sequence of lava flows and sedimentary deposition continued till the uppermost Cretaceous (Mastrichitinian) time as is revealed by the flora and fauna found in the rocks of Anjar, Dayapar, Matanomadh and some other places in Kutch. This sequence therefore bears great potential to trace the transitional Cretaceous/Tertiary boundary characteristics in the region of Kutch. The problem of identifying and demarcating the K/T boundary sequence in Kutch is thus unique and challenging.

## I.1. AREA OF STUDY:

The author has mainly concentrated his studies in the southern and western parts of Anjar (Toposheet nos. 41 I/4, 41 E/16); Bhachau (41 I/7); Dayapar (41 A/14); Matanomadh (41 A/14); Ukra (41 A/13); and Roha (41 A/14; Fig-1). Important localities where outcrops either were freshly exposed for detail investigations or where potential stratigraphic sections were located and measured for systematic sample collections are given in the following Table-I:

| Locality | Lat./Long. | Toposheet no. | Rock Formation | Geological age |
|---|---|---|---|---|
| 1. Around Anjar | - | 41 I/4 & E/16 | K/T transition | - |
| i) Shinugra | | | sequence | |
| ii) Viri | | | " | |
| iii) Shinaya | | | " | |
| iv) Pakhara | | | " | |
| v) Tharauda | | | " | |
| 2. Fatehgarh | | 41 I/14 | " | Cretaceous |
| 3. Bhachau | | 41 I/7 | " | Cret./Tert. |
| 4. Kera | | 41 E/12 | " | Cret./Tert. |
| 5. Matanomadh | | 41 I/14 | " | Cret./Tert. |
| 6. Dayapar | | 41 A/14 | " | Cret./Tert. |
| 7. Ukra | | 41 A/13 | " | Cret./Tert. |

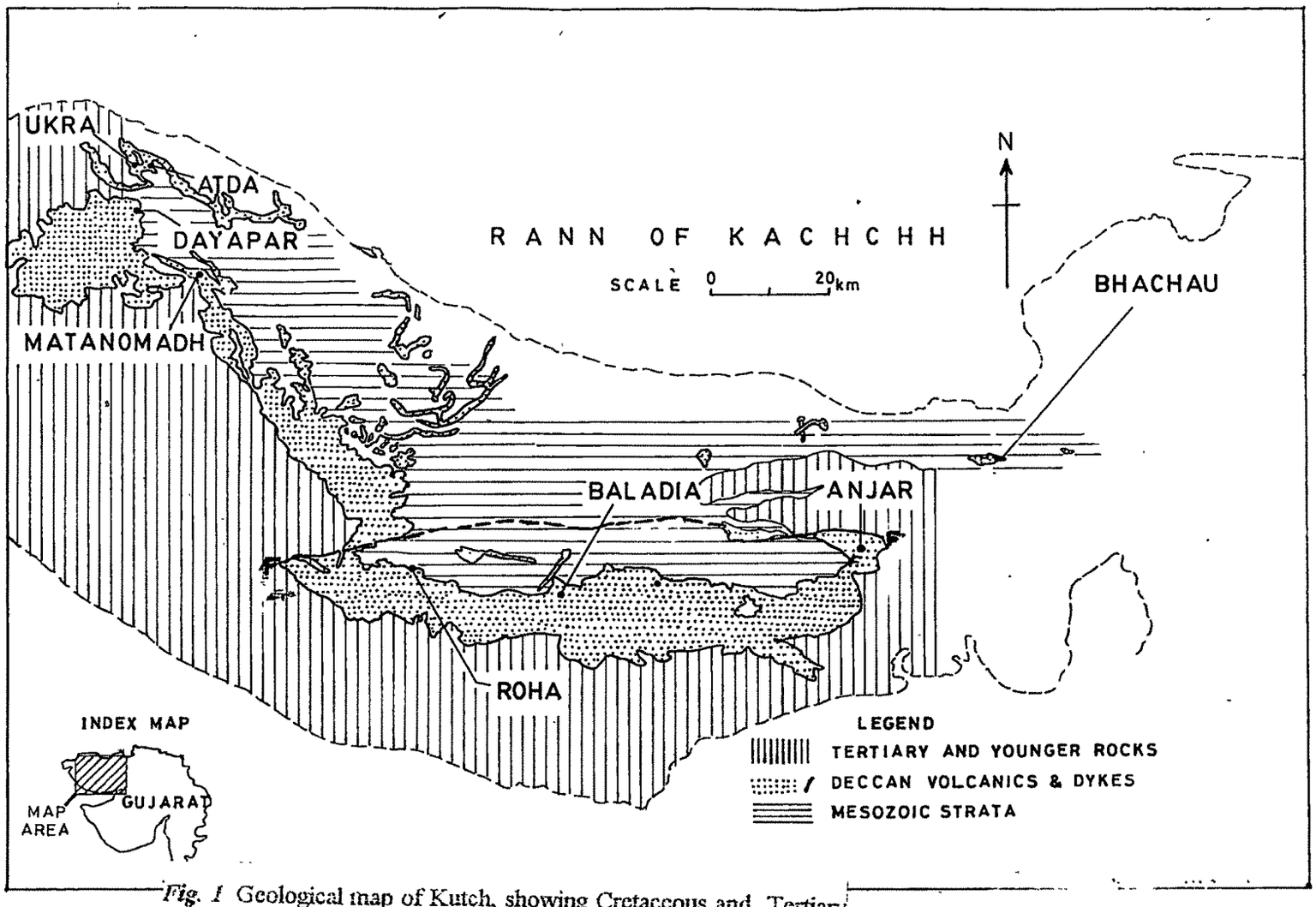
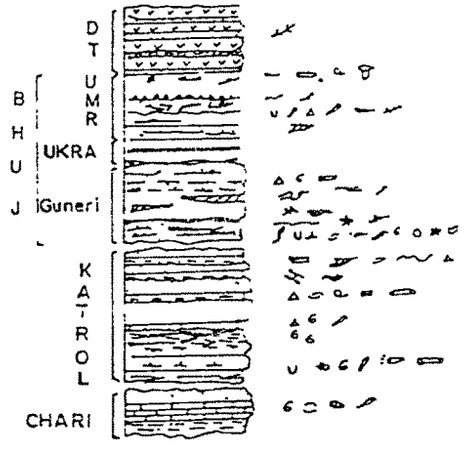


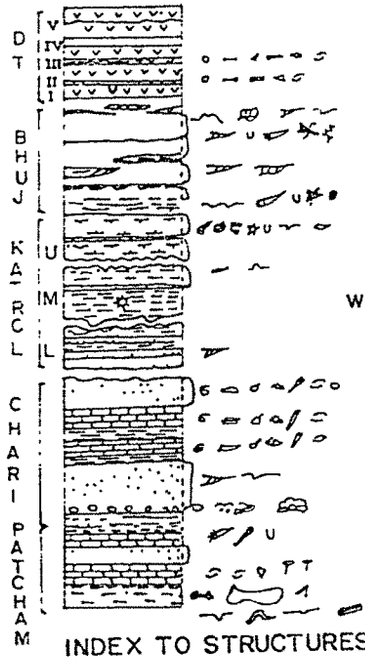

*Fig. 1* Geological map of Kutch, showing Cretaceous and Tertiary rocks and important Deccantrap sections.

# COMPOSITE LITHOSTRATIGRAPHIC SECTIONS OF MESOZOIC ROCKS KUTCH

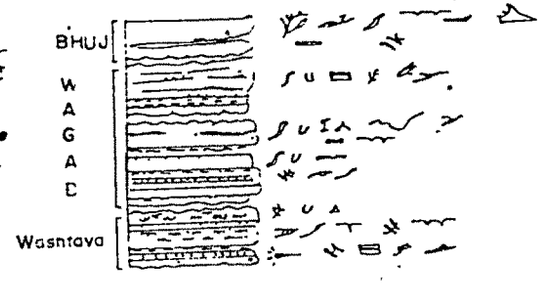
## WESTERN KUTCH




## CENTRAL KUTCH

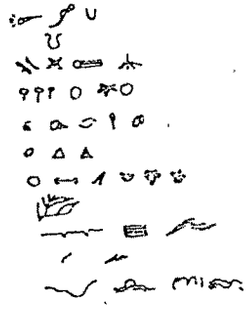



## EASTERN KUTCH




### LEGEND TO LITHOLOGY

- Sandstone
- Shale
- Siltstone / sandy clay in case of intertrappean beds.
- Ferruginous sandstone
- Limestone / oolitic limestone
- Lava flows.
- Calcareous sandstone
- Conglomerate / Trap pebble Conglomerate.



### INDEX TO STRUCTURES/BIOTA

Horizontal burrows / inclined, irregular / vertical burrows
Cones / Fruits of cycades
Fossil plant leaves / fossil wood / Rhyosomes
Corals / Crinoid Stem / crinoids / oscicle plates
Ammonites / gastropods / Lamelli branches / Belemnites /
Brachiopods / Trigonia / Astrate
Dinosaurian eggs / Bones / tooth / Foot Prints
Sedimentary / igneous dykes
Suncracks / Finely laminated Shale / Loadcasts
Ripple marks / Cross bedding (trough type)
Channel structure / contorted cross bedding / algal bedding

TABLE - I

| ERA | PERIOD | STAGE | KACHCHH | SAURASHTRA | HIMMATNAGAR & EASTRN GUJARAT | Balasinor & S.E. Gujarat. | West NarmadaValley |
|---|---|---|---|---|---|---|---|
| MESOZOIC | CRETACEOUS | DANIAN | R→ 61 → Flow – 7<br>→ Flow – 4<br>65 → Int.bed – III with D.F.<br>Flow – 3<br>Int.bed – II with D.F.<br>N→ 66.6 → Flow – 2<br>Int. bed – I<br>66.7 → Flow – 1 | Lava flows and red bole beds. | Lava flows and Intertraps<br>Ratanpar Intertraps.<br>Lava flows<br>Fatehgarh Intertraps.<br>Lava flows | Lava flows Intertraps<br>Sandhasal Intertraps<br>Lava flows<br>Othwad Intertraps<br>Lava flows. | Lava flows Intertr--aps. |
| | | Maestrich-tian. | BHUJ FORMATION | Botad Intertraps Angiosperm plants. | Hathmati Formation:– Mohanpur banded chert, Conglomerat, clays with Spore pollens and micro fossils. | Rahioli & Balasinor beds:– Cherty sandstone conglomerate & Limestone with D.F. | Cherty limestone & Sandstone. |
| | | Campanian | →DINOSAUR FOSSIL<br>Upper Member:– (Sandstones, Shales, Clays with two trigonia bands 300m) Upper Gondwana plant Fossils. | Lava flows and Intertraps. | | Gondwana plant fossil, quartzitic sandstone, silt and conglomerate. | Navagam group 140m. limestone oyster bed. Songir group 305m. fossiliferous, sand--stone, flagstone. |
| | | Senonian | | Wadhwan Formation:–(sand--stone cherty limestone with corals, echinoides, fish & molluses. 200m. | | | |
| | | Turonian | | Ranipat Formation:– (Sandstone, quartzite, grit and conglomerate). | | | |
| | | Cenomanian | 110 | | Non-deposition<br>Erosional unconformity | | Older sediments. |
| | | Albian | DINOSAURIAN HISTORY<br>BHUJ FORMATION<br>UKRA MEMBER<br>→DINOSAURIAN BON--ES. (Vertebrate bones Dinosaurian bones Ammonite beds and bivalves. 60m.) | | Maherpur intrusives<br>Digenetic changes<br>Pedhamali sandstone shale, glass sand, soja shales, clays, sandstone with inverte-shell casts and plant fossils. | | |
| | | Aptian | | Surajdeval Formation:– (Glass-sand horizon). | | | |
| | | Barrenian | →DINOSAUR FOSSIL<br>Guneri / Lower Member:– (Burrowed Sandstone, Shales, Coal seams, plant beds. 625m) Gondwana plant Fossil. | Than Formation:– (Felspathic sandstone grey carbonaceous shale, coal seams with plant fossils, china clay) Upper Gondwana plant Fossils. | Laxmi Narayan grit, conglomerate china clay. | | |
| | | Hauterivian | | | Arsodia flagstones with plants and worm burrows Ranasan conglomerate and cherty sandstone with plants Gondwana type. | | |
| | | Valengian | | | | | |
| | | Tithonian | 145 →DINOSAUR FOSSIL<br>KATROL FORMATION (Gondwana plant fossil.) | Base not exposed | Older Rocks | | |
| | | Callovian | CHARI FORMATION<br>PATCHAM FORMATION Gondwana plant Fossil | | | N=Normal palaeomagnetic polarity.<br>R=Reversed palaeomagnetic polarity. | |
| | | Bathonian | 185 →DINOSAUR BONES<br>Stegosaurus, Antarc to | →saurus, (?) Titanosaurus. | | | |

DHRANGADHRA GROUP 625 m.

HIMMATNAGAR GROUP 130 m.

SABARMATI FORMATION 80 m.

TABLE – II

## I.2. AIMS AND OBJECTIVES:

The major aim of the author in investigating the K/T boundary sequence in Kutch has been to establish and demarcate the characteristic transitional zones in space and time, particularly in relation to the Upper Bhuj stratigraphic units and the Intertrappean beds. The author further intends to view this problem in regional and global perspective and in relation to the breakage of the Gondwana Supercontinent and the migration of the Indian Subcontinent. For this purpose the range of studies to be dealt by the author include the following:

(1) Detailed multi-disciplinary approach on litho-, bio-, and chrono-stratigraphy, besides palaeomagnetic, geochemical and geochronological studies.

(2) Petrographic, microscopic, micropalaeontological, palaeodendrological, and palaeohistological and bone histological studies.

(3) Identification of sedimentological, lithological and biostratigraphical characters in order to demarcate and establish correlation of litho-, chrono-, bio-, palaeomagneto-, geochrono-, and chemo-stratigraphy in respect to at least a few sections in detail.

(4) Studies concerning the behaviour of different palaeobiological groups in relation to time and space, in order to recognise their relationships with the palaeoecosystems and specific environmental conditions prevailing during the time of their existence.

(5) Studies to establish criterias to recognise possible environmental parameters and to relate these to the causative effects on the biota (viz. palaeoclimatic, volcanic, meteoritic, leading to the floral and faunal extinctions etc.).

(6) Studies relating to the Time-stratigraphic units to recognise major events in space and time. The present investigations are also aimed at tracing the dinosaurian history in time and space and to bringout the factors controlling their proliferation, and final demice. For this, the author has intended to work out details of dinosaurian records in Kutch in relation to their habitat, ecology, social behaviour, etc., in terms of their families, genera and species.

(7) Studies to reconstruct the possible scenario and suggest a geological model that operated at the specific event in context of the migration of the Indian proto-continent in time and space.

(8) Based on the information so gathered, the author finally intends to propose a possible geological model in terms of the migration of the Indian subcontinent especially during the Cretaceous / Tertiary transitional period.

## I.3. METHODOLOGY AND APPROACH:

The geological field work was carried out on the Survey of India Topographical maps nos. 41 I/4, 41 I/7, 41 I/14, 41 E/2, 41 E/12, 41 E/16, 41 A/13, and 41 A/14 with 1:50,000 and 1:63,360 scales. The main work was confined to the toposheet no. 41 I/4 and 41 E/16 and parts of 41 A/14 (figure: 1). Geological traverses and section measurements were carried out in detail at various localities whenever necessary.

The aquisition of data include the following details:

(i) Thickness and geometry of each stratigraphical unit, (ii) Information on contects between major and minor stratigraphic units, (iii) Grain size characters, (iv) Classification of rock types, (v) Sediment colour, (vi) Sedimentary structures, (vii) Trends of directional structures, i.e. palaeocurrent and other such features, (viii) Trace fossils and body fossils, with their mode of occurrence and position in the stratigraphic units, (ix) Their relative abundance with reference to underlying and overlying units, (x) Their total range in sequence.

These details were collected at the time of field investigations and at the time of fresh excavations.

The lithostratigraphic sections at important horizons were studied in detail at all possible places in order to determine the lateral and vertical facies change. These include cliff cuttings, nallah cuttings, quarry faces, foot hills of ridges, pits. Besides these, pits were excavated at some places for detail study of lateral and vertical facies variation. Data on various parameters like detail lithological assemblage, their sedimentary structures and characters, the relative abundance of each constituent unit of gross lithology was also recorded in detail with its lateral and vertical behaviour in time and space.

In case of lithounits with sedimentary structures like bedding, graded bedding, lamination, stratification, bundling and bundling sequences, etc. were also noted in detail as proposed by Lindholm (1987), and Miall (1985). The sedimentary and biogenic structures were photographed. The vertical logs were supplemented with drawings wherever appropriate. Drawing of graphical section (logs) were completed in laboratory. Stratigraphical and other samples for various purposes were collected from different stratigraphical levels covering full sequence of rock units.

Detail tracings of exposures showing various units, their interrelationship, contects and biogenic sedimentary structures were used to evaluate the environmental analysis of the sectional sequences.

The detail lithostratigraphic framework studies and their correlation were used to interpret each sequence in form of depositional regime using various parameters of sedimentation and to further designate the sub-environments on the basis of genetic criteria.

Based on field and laboratory studies, the biozonations for each group of biota were attempted in each section based on the first appearance of the group, its maximum developments / relative abundance and decline in the section in space and time. Different biozonations were plotted for each section/subsection and accordingly based on the group. The biozonations thus obtained were studied in relation to environment/sub-environments, lithounits and stratigraphical units.

The relative sample positions of different samples were plotted in section profiles in vertical range. The analytical results of these samples were also plotted on the previously constructed (biostratigraphical, lithostratigraphical and chronostratigraphical) logs. The

comprehensive logs thus obtained were used to demarcate relative change in major groups of biota along with signatures of other natures (geochemical, geochronological, palaeomagnetic, faunal, floral, palaeoclimatological) to find out possible relationship.

## I.4. OBSERVATION AND RECORDING OF TRACE FOSSILS :

The author located important trace fossils of invertebrate and vertebrate animals during his study. The study and recording of ichnofossils requires different techniques. In the present case, the procedures described by Sarjeant (1975), Lockely et.al. (1986), Lindhalm (1987), were applied depending upon the actual field conditions. Care was taken to understand the conditions and set ups of (mode of) preservation, morphology and structures and process of preservation of the trace marking organisms in relation to their activities on the bedding surfaces and whether the trace mark was produced by the living activity of the animal on the sediment water interface and whether the underlying/overlying sedimentary structures were deformed. The complete morphological details like micro-relief surfaces, depressions, web impressions and relative angles of the depressions, directions and spacings etc. were noted in detail and the detail large scale maps of the trace pattern were prepared for computation of various locomotion parameters. Similarly the *dinosaurian* trace patterns were first observed and studied carefully. Various physical and morphological features were noted. In the subsequent stages, the analysed patterns were actually marked on the outcrops with numbers and directions of progressions, angulation, pace, inter-digital angles, sole morphology, inclinations, inner and outer sides, hind side and front side were also determined. Pace, stride, length and width of the individual foot impression and group of impression (tracks) were determined. Size variations in the impression have bearing on the age groups - and maturity - their social behaviour.

The observations on the trace fossils were used to interpret the ecology and existing scenario at different times in order of their chronological sequences. The plaster casts, detail sketches and drawings were used for further analysis and detail demarcation of the environmental regime.