C H A P T E R - I

INTRODUCTION

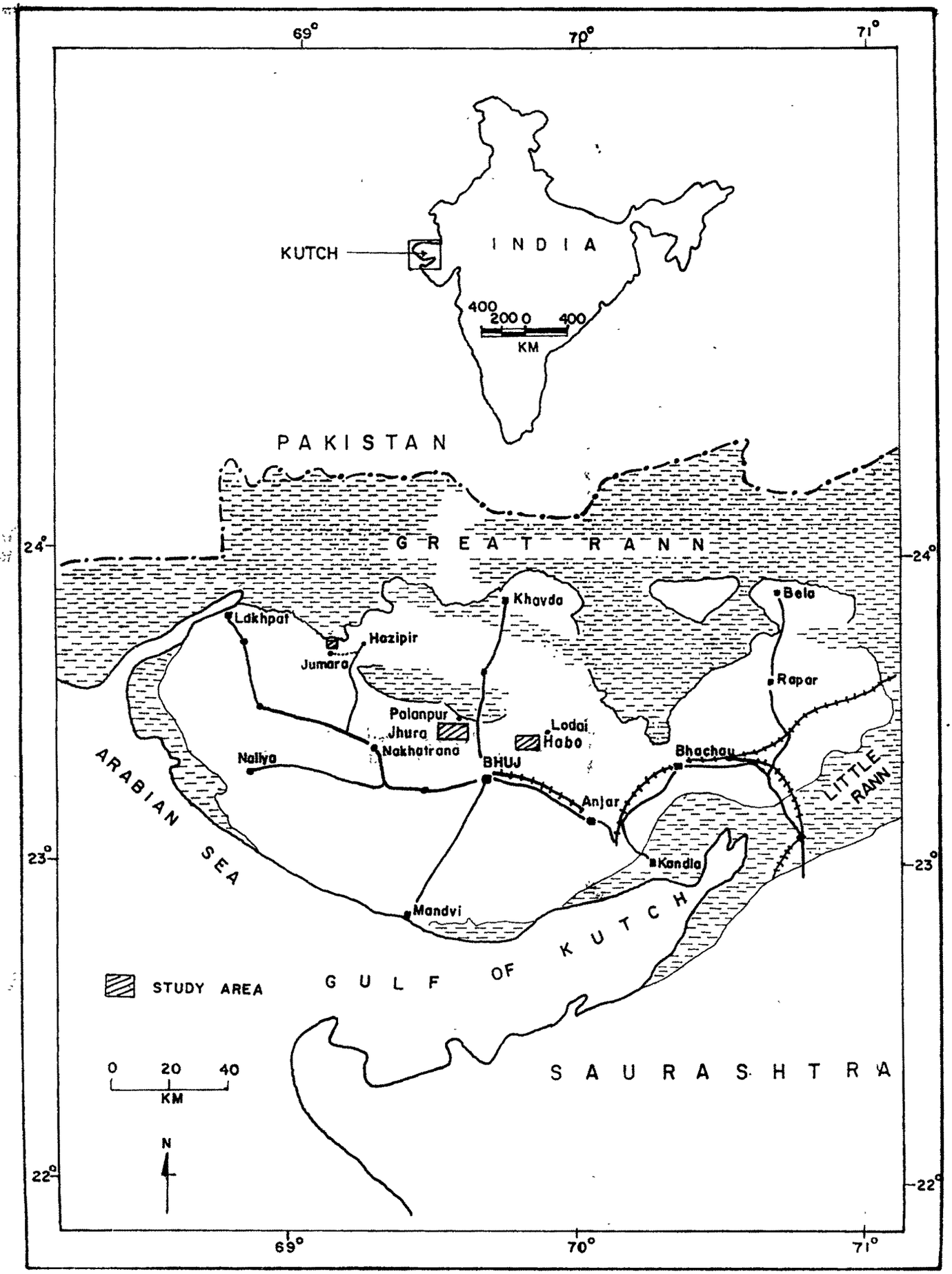
Kutch is a pericratonic basin developed in an east west alignment deepening towards west (Biswas, 1982). It is a discrete basin formed during Gondawanaland rifting in Late Triassic period (Biswas, 1987) and experienced periodic carbonate sedimentation from Middle Jurassic to Neogene time. The total thickness of Mesozoic sediments in Kutch ranges from 1525 to 3050 m. (Biswas & Deshpande, 1983) deposited on a crystalline basement composed of Archean and Proterozoic rocks (Biswas and Deshpande, 1968). The sequences were developed due to repeated marine incursions during the Middle Jurassic to Lower Cretaceous period followed by major tectonic movements and Deccan Trap volcanism in the Late Cretaceous time. These marine Jurassic carbonates of Kutch deposited in an extension of Tethys at the north-western corner of the Indian plate and are particularly well known

for their fossil content. Therefore, most works dealt with the palaeontological aspects. The sediments which hosts the fossils, on the other hand, received only cursory attention.

Except for Biswas (1981,1991), Krishna et al.(1983) and Singh (1989,1992), the sedimentological aspects of the Mesozoic rocks have so far been neglected. While Biswas (op.cit) and Krishna et al. (op.cit) dealt with all the Mesozoic formations in a nutshell, Singh (op.cit) studied only the top most part of Chari Formation i.e. Jumara Formation. Very little work was done on the carbonate sequences of the Mesozoic i.e. the Jhurio and Jumara formations of the Kutch Mainland in terms of lithofacies and microfacies analyses, delineation of diagenetic histories and depositional environments. In the present work, an attempt has been made to achieve the above stated objectives in northern Kutch Mainland. The study was restricted in the outcrops of the Jhurio and Jumara formations in the three domal structures of the Kutch Mainland i.e. Jumara, Jhura and Habo from west to east (**Fig.I.1**).

LOCATION

The Kutch Basin includes the district of Kutch and a part of Banaskantha district (Santalpur Taluka) of Gujarat state lying between latitudes N 24°30′ to N 22°0′ and longitudes E 68°0′ to E 73°0′. Being the biggest district of the state, Kutch occupies a huge area extending from the



LOCATION MAP

FIG. I-I

southern border of Pakistan to the Gulf of Kutch on the south and from the Arabian Sea on the west to the plains of Gujarat on the east. The total area of the basin is 43,097 Sq. Kms. of which 13,633 Sq. Kms. is the outcropping area. Thus, about two third of the total area is covered by recent sediments. This covered area includes the vast plains of the Great and the Little Ranns and the Banni.

The study area

The study area includes Habo, Jhurio and Jumara hills which are also the structural domes bearing the same names. To avoid confusion with the formation name, the author has used the name of Jhura dome for Jhurio dome. The Habo, Jhurio and Jumara hills are located within the Northern Range along the northern margin of the Mainland from east to west. The study area comprising Jumara Dome lies between east longitudes 69^0 02′ 50" and 69^0 05′ 10" and north latitudes 23^0 40′ 50" and 23^0 42′ 00"; the Jhura Dome lies between east longitudes 69^0 30′ 00" and 69^0 40′ 00" and north latitudes 23^0 22′ 20" and 23^0 26′ 00"; and the Habo Dome lies between east longitudes 69^0 45′ 00" and 69^0 54′ 00" and north latitudes 23^0 20′ 20" and 23^0 23′ 30". These form part of Survey of India Toposheet Nos. 41 E/2, 41 E/11 and 41 E/15.

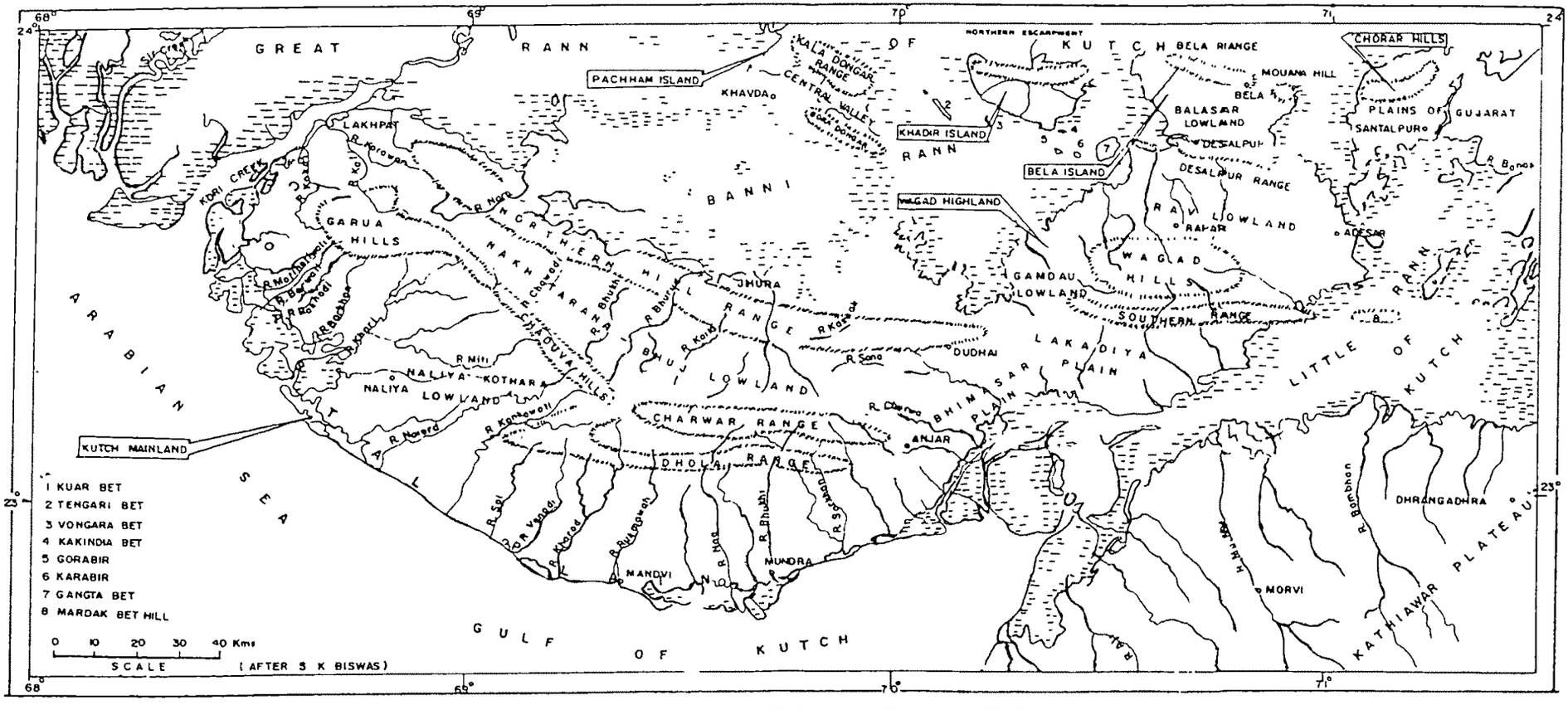
GEOGRAPHIC SETTING

Geographically, the Kutch forms the western most part of India. It is bounded in the north by Sindh plains of

Pakistan, to its east by plains of Gujarat Mainland and to its south and west by Gulf of Kutch and the Arabian Sea respectively. The most remarkable and unique feature of Kutch is the occurrence of a vast desolate terrain known as "Rann" which occupies its northern and eastern parts constituting more than half of the areal extent of Kutch territory (Fig.I.2).

The Rann is divisible into two parts viz.(i) Great Rann occupying the northern part and (ii) Little Rann forming the eastern and southeastern part. The entire Rann area is characterized by a chain of islands comprising mainly Patcham, Khadir, Bela and Chorar islands. The rocky area lying to the south of the Rann and the Island Belt is termed as Kutch Mainland. The Wagad highland occupies an isolated position south of the Island Belt and to the ENE of the Mainland.

The Mainland forms a continuous rocky terrain and consists broadly of two sub-parallel E-W trending hill ranges with intervening low ground and coastal plain to its south. The two hill ranges called as the Northern Range and Katrol Range coincide with the 'Structural Highs' of the area. It is seen that the topography of the entire region is structurally controlled.



GEOGRAPHICAL FEATURES OF KUTCH

FIG. 1·2

GENERAL PHYSIOGRAPHY OF KUTCH

Kutch is an unique area for geomorphological study. The location, elevation, shape, size and orientation of the hill ranges and hills are structurally controlled. The structure of the basin is controlled by block faulting. The highlands which represents principal uplifts are tilted fault blocks. The hill ranges have been formed on the faulted upside of these blocks. The scarp faces or the steep sides of the hills are either the faultline scarp or the steep limbs of asymmetric anticlines.

The dome hills of the Northern Range of the Mainland are in various stages of erosion due to differential uplift during the latest period of rejuvenation. The domes in the western and eastern parts of the range which are at structurally lower level, are maturely dissected.

TRANSPORT AND COMMUNICATION

Bhuj, the district Headquarter of Kutch is connected with Ahmedabad and Bombay by railway and motorable road. Besides, it is also connected by air service from Jamnagar, Rajkot and Bombay. Bhuj as well as Kandla are connected by National Highway No. 8 leading to Delhi and Ahmedabad. The interior villages are connected with numerous tar roads, fair weather jeepable roads, cart tracts and foot tracts. However, common mode of transport is either camel or bullock cart.

Habo hill located to the NE of Bhuj can be approached from Lodai which is approximately 32 km from Bhuj. Kalajar nala, exposing the best section, and located at 23° 22′20"N latitude and 69° 53′20"E longitude can be approached from village Dhrang which is approximately 5 Km west of Lodai.

The Jhurio hill is located to the NNW of Bhuj between villages Palanpur in the north, Kamanguna to the south, Bhakri to the SE and Medisar to the SW. The type section can be approached from Palanpur which is approximately 35 km NNW of Bhuj.

Jumara (N.latitude 23°40′40", E.longitude 69°4′) is a small village lying on the western frontier of Kutch Mainland almost at the center of the dome. Nara is the nearest village about 10 Km east of Jumara. Nara and Jumara are connected only with a seasonal jeepable road, a camel/cart track and also a foot track. Nara is approximately 100 Km from Bhuj and is connected by a bus service along an all weather tar road. It can be approached from Bhuj via Nakhatrana, Kotda, Mathal and Uthangni on Bhuj-Hajipir road. Nara is about 5 Km from Uthangni.

CLIMATE

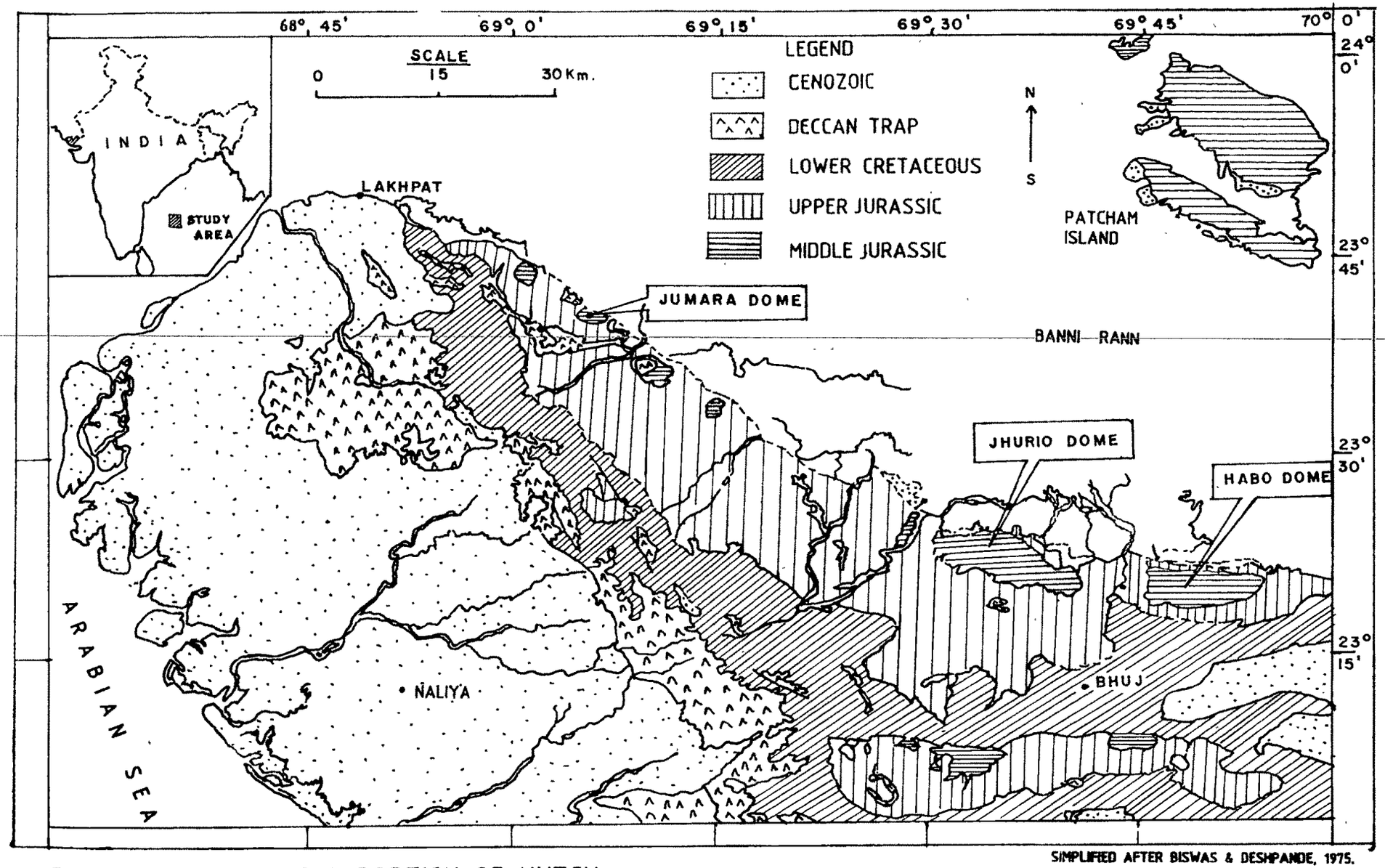
Kutch experiences mainly arid to semiarid climatic conditions. The annual rainfall about 10-12 inches (250-300

mm), spread over the entire monsoon months of June to September is erratic. A season of normal or excess rainfall may be followed by years of drought. The arid climate is characterized by extreme variations of temperature. The minimum temperature falls even below the freezing point during winters while the same touches even 48^{o} C during the summer months of April or May.

REGIONAL GEOLOGICAL SETTING

Marine Jurassic sediments occur on the Indian subcontinent in two regions; predominantly fine-grained siliciclastic rocks of the Himalayan region (e.g. Spiti Shales) record largely outer shelf sediments of the southern margin of the Tethys, whilst the mixed siliciclastics and carbonates of Western India represent largely shallow marine environments of a southerly extending embayment of the Tethys. Sediments of this embayment occur in Rajasthan and Kutch, two sub-basins within the western pericratonic shelf of India.

The Kutch basin, extending offshore and across the continental shelf is typically a continental margin basin embayed into a rifted graben (Biswas 1991). The basin has a thick succession (3000 m.+) of the Mesozoic strata followed by a thin (900m.+) Tertiary sequence. The Mesozoic rocks are exposed extensively in six highland areas of Kutch Mainland, Wagad, Patcham, Khadir, Bela and Chorar; Whereas, the



SIMPLIFIED AFTER BISWAS & DESHPANDE, 1975.

GEOLOGICAL MAP OF A PORTION OF KUTCH

FIG·I·3

Tertiary strata are exposed only in the bordering plainland. **Figure I.3** shows geology of a part of studied area within Kutch Mainland.

MESOZOIC STRATIGRAPHY

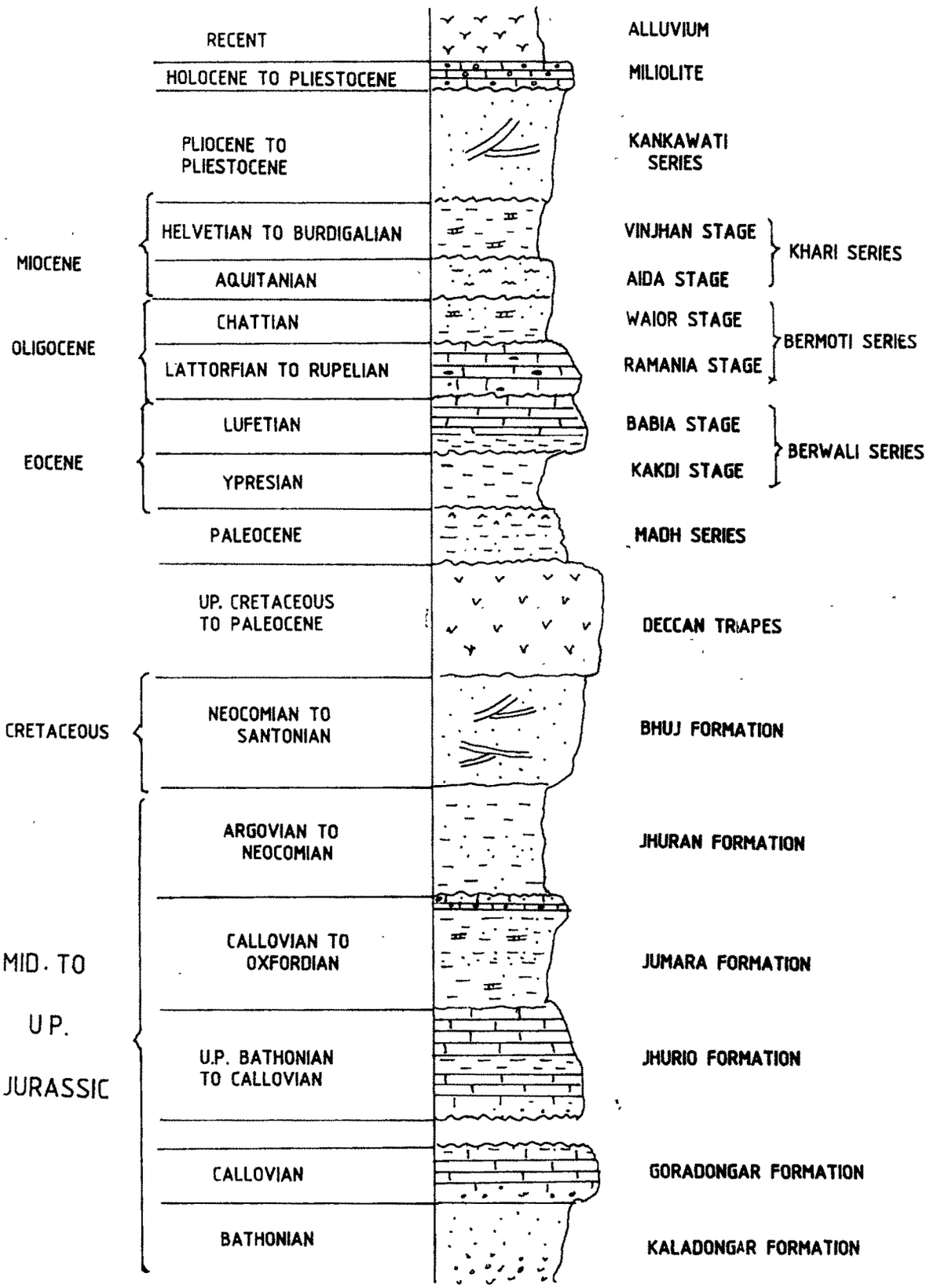
The stratigraphy of Kutch comprises the rocks ranging in age from the Middle Jurassic (Bathonian) to Recent. The complete sequence is exposed only in the Mainland of Kutch. A generalised stratigraphic column of Kutch Mainland is shown in **Figure I.4**. Being highly fossiliferous and lithologically differentiated stratigraphic sequence, the Mesozoic stratigraphy of Kutch can be studied in all the three stratigraphic aspects:

1. Lithostratigraphy
2. Biostratigraphy and
3. Chronostratigraphy.

Lithostratigraphy

Wynne(1872) was the first to suggest a two-fold sub-division of the Mesozoic rocks of Kutch based on general lithological characteristics after extensive mapping of the entire basin. Later, Waagen (1875) divided the stratigraphy of the mainland into four units and Rajnath (1932) divided into five units. Their basis was palaeontological and mineralogical characteristics. A mix up of chrono, bio and lithostratigraphic criteria were used in descriptions of the units.

GENERALISED STRATIGRAPHY OF KUTCH BASIN



NOT TO SCALE

FIG · I · 4

A truly lithostratigraphic classification proposed and published by Biswas (1971, 1977) included full descriptions of the designated holo-stratotypes and intrabasin correlation as required by the International code of stratigraphic nomenclature (1972) for establishing a new classification. It is to be noted that classification of Biswas is not the replacement of the old classification whose priority should be maintained as a chronostratigraphic classification (Biswas, 1991). **Table I.1** gives the lithostratigraphic classification as compared to earlier classifications.

The old classification cannot be regarded as lithostratigraphic as argued by Mitra et al.(1979) and Krishna et al.(1983) since their definition includes mixed criteria and boundaries are defined by time planes indicated by ammonite index/assemblage zones. The lithostratigraphic boundaries defined by Biswas(1977) are strictly on the basis of major lithologic breaks, unconformities and lithofacies variations in response to change over from one environment to another. Besides, this is the only classification where unit nomenclatures are after the fully described designated type sections.

In any basin, units of different categories of classification overlap although their boundaries do not match as they are fixed by different criteria altogether. In one

Table I.1 : ROCK STRATIGRAPHIC CLASSIFICATION AS COMPARED TO EARLIER CLASSIFICATIONS

AGE	BISWAS, 1971			PASCOE ,1959 (MAINLY AFTER SPATH,1933)		KRISHNAN,1969 (MODIFIED FROM RAJNATH, 1932 & ARKELL,1956)	
	E.KUTCH	PACHHAM	MAINLAND				
ALBIAN TO P.SANTHONIAN			BHUJ FORMATION			UMIA SERIES	BHUJ STAGE : PALMOXILON BEDS PTYLOPHYLLUM BEDS ZAMIA BEDS
APTIAN			UKRA MEMBER	UKRA BEDS			UKRA STAGE : MARINE CALCAREOUS SHALE
BERRIASIAN TO BARREMIAN	---NOT EXPOSED---		MAINLAND FORMATION	UMIA SERIES	SANDSTONE & SHALE W/PLANT REMAINS UNFOSSILIFEROUS SHALE TRIGONIA SANDSTONE OOLITIC BANDS WITH MARINE FOSSILS		UMIA STAGE : BARREN SANDSTONE TRIGONIA BEDS BARREN SANDSTONE UMIA AMONITE BEDS BARREN SANDSTONE
TITHONIAN TO KIMMERIDGIAN	WAGED SANDSTONE		JHURAN FORMATION	KATROL SERIES	KATROL SANDSTONE (UNFOSSILIFEROUS) GUDJINSAR BED(MARINE FOSSILS) ZAMIA SHALES,BROWN & RED IRONSTONES BASAL AMMONITE BEDS JURAN BELEMNITE MARLS KANTHKOT SANDSTONE	KATROL SERIES	UPPER KATROL SHALES GAJANAGAR BEDS UPPER KATROL MIDDLE KATROL LOWER KATROL KANTKOTE SANDSTONE
OXFORDIAN	KANTHKOT MEMBER						
TO CALLOVIAN	WAGANA FORMATION		(DHOSA OOLITE MEMBER)	CHARI SERIES	DHOSA OOLITE ATHLETA STAGE ANCEPS STAGE REHMANI STAGE GOLDEN OOLITE STAGE	CHARI SERIES	DHOSA OOLITE ATHLETA BEDS ANCEPS BEDS REHMANI BEDS MACROCEPHALUS BEDS
	KHADIR FORMATION	--NOT EXPOSED--	JUMARA FORMATION				
BATHONIAN	?-?-?-?-?-?-?-?-?-?-	GORADONGAR FORMATION	JHURIO FORMATION	PATCHAM SERIES	UPPER STAGE LOWER STAGE	PATCHAM SERIES	PATCHAM CORAL BED PATCHAM SHELL LIMESTONE PATCHAM BASAL BEDS (RURAL BET BEDS)
	PRECAMBRIAN BASEMENT EXPOSED AT MERUDA HILL.	KALADONGAR FORMATION --NOT EXPOSED--	-NOT EXPOSED-				

part of the basin they may coincide e.g. at major environmental changes or at unconformities, but this does not mean that the units are identical; they may transgress each other in different parts of the basin. In Kutch, though Chari- Katrol boundaries coincide with those of Jumara-Jhuran boundary being at the unconformity, neither the Chari-Patcham boundary coincide with that of the Jhurio-Jumara nor does the Jhuran-Bhuj boundary match with that of the Katrol and Umia (Biswas, 1977, 1986).

Biostratigraphy

Waagen (1871, 1873-76) carried out study of cephalopods from Jurassic of Kutch and on the basis of paleontological evidences substantiated the classification of strata into Patcham, Chari, Katrol and Umia "groups" in ascending order.

Waagen's Patcham, Chari, Katrol and Umia correspond to the "Lower Jurassic Group" and upper part of Umia to the "Upper Jurassic Group" of Wynne (1872).

The massive monograph of Spath (1924, 1934, 1938, 1942) published in Paliadien series gives detailed and original taxonomic descriptions and biostratigraphic accounts. His pioneering work pointed out the relationship of Kutch fauna with that of the Tethyan in the north and Madagascar sea in the south.

According to Pandey and Dave (1992) there was no standard work on biostratigraphic zonations in Kutch duly defined by the stratotypes, which could be cited as a reference for standard zonation of the Jurassic and Cretaceous of Kutch. The biostratigraphic classification including those by Bardhan and Dutta (1987) and Carion and Jaikrishna (1988) remain informal and incomplete in terms of ISSC (1976). This lacunas of biostratigraphic nomenclature has been fulfilled by Pandey & Dave (1992). They attempted a coherent foraminiferal zonation in Kutch correlatable with the global ammonite zones.

Chronostratigraphy

The stratigraphy of a basin remains incomplete if it is not studied in all the three main aspects- lithological, biological and chronological and all the three categories of classification worked out and their interrelationship shown. The biostratigraphic aspect, mainly microfauna with relation to the already established megafaunal zones have been studied by workers in ONGC (Pandey et al. 1992). From their study a basic framework of chronostratigraphy has emerged. Based on this, the original chronostratigraphic units named by earlier workers (Rajnath, 1932; Waagen, 1975) are revised and redefined with reference to the stratotypes identified.

Considering the development of succession in the Jurassic of Kutch, it is noted that only two of its series; Dogger and Malm - develop in the area and these have been classified into seven stages as given in **Table I.2.** A comparison of different views of chronostratigraphic classification has been shown in **Table I.3.**

TECTONIC AND STRUCTURAL FRAMEWORK

The Kutch basin developed primarily due to rifting of Africa and India in the Late Triassic time during the fragmentation of the Gondwana Superplate (Biswas, 1991). The basin is bounded by Nagar Parkar uplift on the north, Radhanpur-Barmer Arch on the east (which separates the Kutch basin and Cambay graben) and Kathiawar uplift on the south (Biswas, 1980, 1982, 1991; Biswas and Deshpande, 1983).

A basement high (Median High) marks the basin hinge zone that came into existence in Post-Oxfordian time during the earliest tectonic movement in the basin (Biswas, 1982) and is considered as an extension of the Indus Shelf hinge (Biswas, 1987). This structural high cuts across the Mainland uplift, Banni Basin and Patcham uplift and seems to be continuing to the north (**Fig.I.5**).

Regional structural elements of Kutch Mainland consist of two parallel fault flexures (brachfallens) along the NW-SE striking master faults (Biswas, 1983). The Jurassic rocks are best developed in the central flexure. A string of

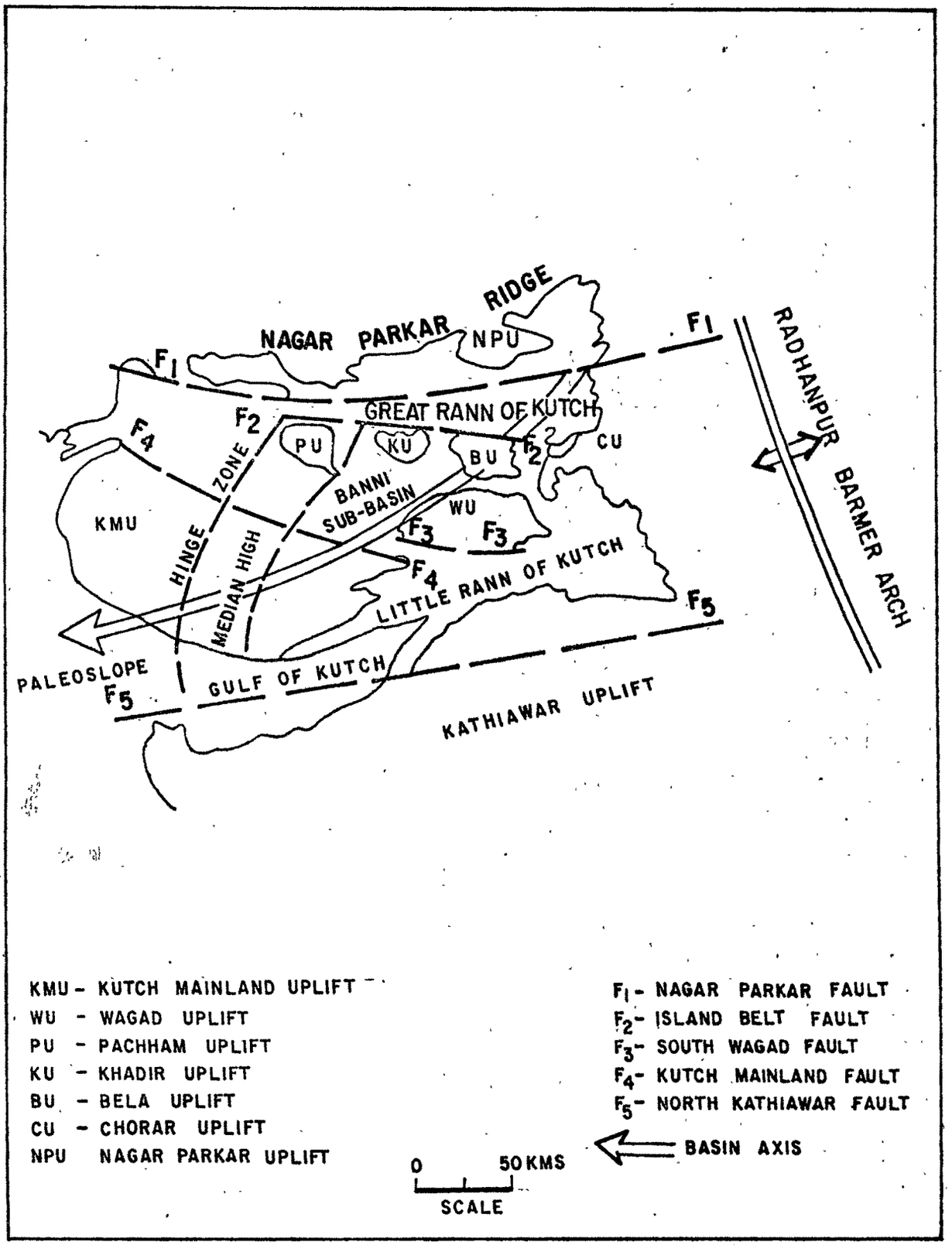
Table I.2 **JURASSIC CHRONOSTRATIGRAPHY OF KUTCH**

(After Pandey and Dave, 1992)

Cretaceous		**Mundhanian Stage**	Neocomian
		----------Major regression----------	
	M	**Umiaian Stage**	Tithonian
J	A	Major transgression	----------
	L	**Katrolian Stage**	Kimmberidgian
U	M	Regression & clastic influx	----------
		Dhosaian Stage	Oxfordian
R		Important transgression	
		----------Major sediments break----------	
A	D	**Charian Stage**	Callovian
	O	Reappearance of calcareous sediments	---------
S	G	**Badian Stage**	Bathonian
	G	Sedimentation break & clastic influx	----------
S	E	**Patchamian Stage**	Bajocian
	R	Beginning of marine lst. sedimentation	--------
I		**Bannian Stage**	Aalenian
		Initiation of Jurassic sedimentation	---------
C			
		----------Major unconformity----------	
		TRIASSIC / PRECAMBRIAN BASEMENT	

Table I.3 JURASSIC CHRONOSTRATIGRAPHY OF KUTCH (DIFFERENT VIEWS)

WAAGEN (and Stoliczka) 1873		RAJNATH, 1932 / 1942		SPATH, 1927-33		PANDEY AND DAVE 1992	
		Bhuj series	Mid.Cretaceous				
Beds with crio-ceras etc.	Cretaceous	Ukra Beds	Aptian	Beds of Ukra Hill with ammonites etc	Aptian	Not classified	Aptian-Albian
Umia Group	Tithonian	Umia Group	Portlandian			Mundhanian Stage	Neocomian
						Umiaian Stage	Tithonian
Katrol Group	Kimmeridgian Oxfordian	Katrol	Kimmeridgian	Katrol Group	Portlandian Kimmeridgian	Katrolian Stage	Kimmeridgian
Chari Group	Callovian	Chari Group	Argovian Callovian	Chari Group	Argovian Callovian	Umasian Stage Charian Stage	Oxfordian Callovian
Patcham Group	Bathonian	Patcham	Bathonian	Patcham Group	Bathonian	Badian Stage	Bathonian



(AFTER S.K. BISWAS) 1987

TECTONIC FRAMEWORK OF KUTCH BASIN

FIG·I·5

culmination is observed along this flexure with depression between them. These zones of culmination stand out in domal forms at Jara, Jumara, Nara, Keera, Jhura and Habo hills, where inliers of relatively older rocks, the Jumara and Jhurio formations occur in the core of the domes.

Though variable in size and shapes, all these folds show uniform structural geometry which follows the form of the flexure zones. The domes are strongly asymmetric with short, steep north limbs, often faulted and gentle south limbs. The origin of these domes may be due to differential movement of subjacent blocks bounded by cross faults within the zone of deformation along the master faults (Biswas, 1987). The folding in the sedimentary rocks has resulted due to the draping of sedimentary strata over the faulted edges of the basement blocks. Besides, syntectonic igneous activity in the marginal deformation zones producing various domes seem to be a possible mechanism of folding.

Other uplifts where Mesozoic rocks are exposed are Wagad and the belt comprising Patcham-Khadir-Bela-Chorar chain of 'islands' in the Rann.