Chapter - 3

PREVIOUS WORK

III. 1. INTRODUCTION:

A large literature is available on the cultural, geographic and economic as well as political aspects of the former princely state of Kutch covering a duration of nearly 200 years. Geological work of real insight, for Kutch, in fact commenced more than a century ago and included the palaeontological and lithological descriptions, and stratigraphical classification based upon the same, for Mesozoic and Tertiary sediments in general. It will thus be interesting to take a brief review of this background before the author concentrate on the results of his investigations.

III. 2. THE MESOZOIC SEQUENCE:

Geologically Kutch is a widely explored region. The earliest work on geology of Kutch was made by Fox (1828), followed by Grant (1840); Blanford (1867); Wynne (1869, 1872); Oldham (1962); Waagen (after Stoliczka, 1871); Meddlicott and Blanford (1879); Gregory (1893, 1900); Kitchin (1900); Vredenburg (1910); Spath (1924, 1933); Rajnath (1932, 1933, 1942); Cox (1940). There after officers of Geological Survey of India [including Poddar (1950, 1954); Desican, Kulkarni and Thothathiri (1963, 1967, 1970, 1976); Sahastrabudde (1960); Vyas (1968-69); Mehra, Verma and Srivastava (1978); Ghevaria (1978-91); Raksit and Bandopadhyay (1986) etc.] have carried out systematic geological mapping in different parts of Kutch.

In addition to these, Rao (1957); Sahni and Prasad (1957); Agrawal (1956, 1957); Poddar (1959, 1964); Singh et al (1963); Ritchter

Bernberg and Schott (1963); Mitra and Ghose (1964); Ghose (1969); Roy (1967); Mathur et al (1970); Biswas and Deshpande (1968, 1970b); Patil (1971); Balagopal (1975); Venkat Raman and Patil (1975); Badve and Ghare (1978); Biswas (1978, 1980, 1981, 1982, 1987, 1991); Kanjilal (1978); Agrawal and Kachhara (1979); Mitra et al (1979); Kumar et al (1982); Singh et al (1982); Casshyap et al (1983); Jaitly and Singh (1983); Jaikrishna (1983); Jaikrishna et. al. (1983); Shringarpure (1984, 1986); Koshal (1984); Howard and Singh (1985); Bose (1986); Ghare and Kulkarni (1986); Krishna (1987); Krishna and Pathak (1989); Singh (1989); Kulkarni and Ghare (1989, 1991); Ghevaria and Srikarni (1990); Shukla and Singh (1991); Singh and Singh (1992); Fursich et al (1991, 1992), have carried out significant work.

As mentioned earlier, the Mesozoic sedimentary sequence of Kutch is well known in the Indian stratigraphy for its fabulous faunal contents. The sediments as such are extensively investigated by a number of workers for their mega and micro fossils. The stratigraphic classification of these rocks have also been constantly reviewed or modified or refined with the advancement of the code of stratigraphic nomenclature.

Blanford (1867) published a structural account of the region of Kutch. He for the first time recognised the E-W trending master faults.

The most important and pioneering work on geology of Kutch is by Wynne (1872). The lithostratigraphic classification as suggested by Wynne is reproduced in Table. 1. A detailed account of geology of Kutch along with classification of Mesozoic and Tertiary rocks including

TABLE - 1: LITHOSTRATIGRAPHIC CLASSIFICATION OF WYNNE, 1872.

Recent	Alluvial, blown sand and sub-Recent deposits	Pleistocene
	Upper Tertiary	
	Unconformity	
Tertiary	Argillaceous group (Fossiliferous)	Miocene to Upper Eocene
	Nummulitic Group	
	Gypseous Shale	
	Arenaceous Group	
	Nummulitic Group	
	Gypseous Group	
Volcanic	Sub-Nummulite	Eocene
	Stratified Traps and Intertrappean beds	
	Infra-trappean beds	
	Unconformity	
Jurassic	Upper Jurassic Group	Oolitic
	Lower Jurassic Group	
Metamorphic Crystalline	Syenite	

a geological map [1 inch = 4 Miles Scale] was published by him in 1872. He divided the Mesozoic sequence into two subdivisions lower Jurassic and upper Jurassic, and denoted it as equivalent to the Oolites of England. The map proposed by him is quite accurate and has provided basis of reference to all the subsequent geological work in Kutch.

Immediately following Wynne the stratigraphic subdivisions of the Mesozoic rocks of Kutch were suggested by Stoliczka on the basis of mineralogical and palaeontological characters. He put forward a four fold classification which includes Patcham, Chari, Katrol and Umia 'Groups' in ascending order.

The fossils of *ammonites* from these rocks were studied in great detail by Waagen (1871, 1873-1876), and on the basis of ''*ammonite* assemblage zone'', he for the first time correlated fourfold classification of Stoliczka with the European zones. In this way a chronostratigraphic classification came into existence. Such a classification has been followed till now with various modifications by later workers particularly depending on palaeontological observations. The classification is as follows : (Table 2)

Chronostratigraphic Classification of Waagen (1875) after Stoliczka

Series	Age
Umia	Portlandian to Neocomian
Katrol	Portlandian
Chari	Oxfordian
Patcham	Bathonian

On the basis of fossils - *corals* Gregory (1893, 1900) and *brachiopods* Kitchen (1900, 1903) - assigned Patcham series to the European Bathonian and Chari to lower Callovian. Spath (1924, 1927, 1933) subdivided the Mesozoic sequence of Kutch into Bathonian, Callovian, Oxfordian, Kimmeridgian, Tithonian and Neocomian stages in ascending order. He established detailed biozones of the Mesozoic stratigraphic units on the basis of his studies of *Cephalopods*.

Rajnath (1932, 1933, 1942) defined the stratigraphic boundaries on the basis of megafossils except the Patcham-Chari boundary, which he recognized on lithological characteristics. He suggested the extension of the upper age limit of the Mesozoic rocks in Kutch. He further carried out detailed biostratigraphic work of some of the best exposed Mesozoic sections of the western Kutch mainland, and proposed several fossil assemblage zones mentioning 26 lithological units for the Patcham and Chari of the Jumara dome section. Moreover, he divided the Katrol into four parts - lower Katrol (mainly shales), middle Katrol (mainly sandstones), upper Katrol (mainly shales) and uppermost Katrol (mainly hard sandstones); and the Umia of Waagen into three units - lower green oolitic rocks containing Tithonian fauna as Umia stage; middle calcareous fossiliferous beds as Ukra stage; and upper plant fossil bearing beds as Bhuj stage assigning middle Cretaceous age. He also divided Umia stage into five beds. Furthermore, Rajnath also pointed out several unconformities and suggested fluctuations in the sea level during deposition.

Cox (1940, 1952) recorded species of *Trigonia*, which he claimed were similar to those found in Europe, Somalia, South Africa and Tanganyika.

Tiwari (1948) assigned Bathonian to Argovian age to the Jurassic sequence of Habo hills on *Gasteropod* and *Lamellibranch* fossil evidence.

Arkell (1956) has published a brief summary of the Kutch geology in his book the ''Jurassic Geology of the World'' and given revised age for Patcham, Chari, Katrol and Umia series.

Agrawal (1957) was the first to doubt the validity of the existing stratigraphic terminology. He proposed the name ''Habo series'' after Habo hills to replace the name ''Chari series''. From the palaeontological work in Jura hills, he concluded that all the three *Macrocephalus* beds are of Callovian age, and assigned Callovian to Oxfordian age for the same and divided it into lower, middle and upper parts. He studied the faunal assemblages of the Jhura dome in the mainland and differentiated 18 beds in the Chari series.

On the basis of lithological and palaeontological characteristics, Pascoe (1959) compiled a classification which is more systematic with respect to the usage of stratigraphic terms like series, stages, substages and zones (Table 3). Further, he has given detailed lists of fossil assemblages occurring in different horizons.

Poddar (1959, 1963) prepared a short and regional account of the geology of Kutch, synthesizing the salient stratigraphic and structural aspects. He considered Patcham series to be Bathonian or slightly older, Chari series to be Callovian Oxfordian, Katrol series to be Kimmeridgian Tithonian and Umia series to be Neocomian - Aptian in age.

Table 3: CLASSIFICATION OF MESOZOIC SUCCESSION OF KUTCH AS COMPILED BY PASCOE (1959).

SERIES	STAGE	AGE
Ukra beds		Aptian
	Sandstones and shales with plant remains and a few marine fossils	?Purbeckian Neocomian.
Umia series	Unfossiliferous shales Trigonia sandstones Oolitic sandstones, shales and conglomerates, with marine fossils	Portlandian
Katrol series	5. Katrol sandstone (unfossiliferous), Gudjinsir bed (marine fossils), Zamia shales.	
	4. Brown and red ironstones — Upper 3. Basal Ammonite bed — Middle 2. Jurun Belemnite marls — Lower	Kimmeridgian.
	1. Kantkot sandstone	Argovian
Chari series	5. Dhosa Oolite — Upper, Lower	Divesian
	4. Athleta stage — Upper, Lower	
	3. Anceps stage — Upper, Lower	Callovian
	2. Rehmanni stage	
	1. Golden Oolite — Upper Macrocephalus beds; Middle Macrocephalus beds	
Pachhim series	2. Upper stage, or Lower Macrocephalus beds	Bathonian
	1. Lower stage.	

Bernberg and Schott (1963) investigated a few sections in the island belt and Katrol hill section in the Mainland. On the basis of palaeontological criteria, they assigned Bathonian age to Kuar bet beds, Callovian age to the Khavada nala section of Patcham island and upper Oxfordian age to Dhosa oolite band of the mainland. According to them, the Katrol series belongs to Kimmeridgian age and the *Trigonia* beds of the lower Umia to lower Cretaceous age.

Mitra and Ghosh (1964) were first to recognize the importance of environment and facies changes in the shallow marine shelf deposits of Kutch. Mitra and Ghosh (1964) at the same time stressed that individual *ammonite* fauna were being over emphasized by the earlier stratigraphers, and advocated the use of assemblage zones instead of *ammonite* index fossils in correlation and classification.

According to Rao (1964) the faunal evidences in Kutch suggest a Bathonian or lowest Callovian to post-Aptian age of deposition.

Krishnan (1968) in his text book, adopted the classification of Rajnath (1932, 1942) with modifications of age according to Arkell (1956) (Table 4). He followed the original four fold classification with little modification of Bhuj series as `Bhuj stage' within his Umia series.

A detailed sedimentological study of the area South and South-West of Bhuj, in the mainland was carried out by Hardas (1968). He suggested a complete sequence of depositional environments varying from infralittoral to fluvial for the Mesozoic rocks of this area.

TABLE - 4:

CHRONOSTRATIGRAPHIC CLASSIFICATION OF RAJNATH (1932, 1942) WITH AGE MODIFICATIONS AFTER ARKELL (1956), AS ADOPTED BY KRISHNAN (1968).

	AGE	SUB-DIVISIONS
U	Post-Aptian	Bhuj beds (Umia Plant beds) Sandstones and shales
M	Aptian	Ukra beds - Marine calcareous shales
I	Upper Neocomian	*Umia beds*: Barren sandstones and shales
A	Valanginian	Trigonia beds Barren sandstones
	Upper Tithonian	Umia ammonite bed
K	Middle Tithonian	Upper Katrol Shales
A	Middle Tithonian	Gajansar beds
T	Lower Tithonian	Upper Katrol (barren) Sandstone
R	Middle Kimmeridgian	Middle Katrol (red sandstones)
O	Middle Kimmeridgian	Lower Katrol (sandstones, shales, marls)
L	Upper Oxfordian	Kantkote Sandstone (Bimammatum zone)
C	Upper to Lower Oxfordian	Dhosa Oolite (green and brown oolites) (Transversarium zone)
H	Upper Callovian	Athleta beds (marls and gypseous shales)
A	Middle Callovian	Anceps beds (limestones and shales)
R	Middle Callovian	Rehmanni beds (yellow limestone)
I	Lower Callovian	Macrocephalus beds (shales with calcareous bands, with golden oolite - diadematus zone - in the upper part)
P A T C H A M	Lower Callovian	Patcham coral bed
	Lower Callovian to Bathonian	Patcham shell limestone
		Patcham basal beds (Kuar Bet Beds)

As suggested by Ghosh (1969a), the mega-fossil assemblage of Kutch shows more affinity to the East and South African assemblage than those of Himalayas or European Jurassic, and ranges in age from middle Bathonian to Argovian (Ghosh, 1969b).

A concise version of all the above work and their European equivalents are summarized in table 5, following Bhalla and Abbas (1976).

Table 5: MESOZOIC SUCCESSION IN KUTCH

Series	Thickness (in meters)	European stratigraphic equivalents
Bhuj	450	Post-Aptian
Umia	900	Upper Tithonian to Aptian
Katrol	300	Upper Oxfordian to middle Tithonian
Chari	366	Lower Callovian to lower-upper Oxfordian(part)
Patcham	300	Upper Bathonian to lower Callovian(part)
Archaean granites and gneisses		

Guha and Pandey (1973) carried out microbiozonation and lithostratigraphy of well section for oil exploration and divided the sequence into eight biozones on the basis of *foraminifers* and *ostracodes* range in age from Bathonian to Albian (?). They have also classified the sequence into Kaladungar, Patcham, Chari, Katrol, Umia and Bhuj formations. According to Pratap Singh (1973a,b), basal beds of this sequence were deposited in the brackish to marine environments,

whereas, the rest of the sequence was deposited in the inner neritic environments. Koshal (1973) carried out microspore analysis of these subsurface sediments of Banni, Kutch, and established four assemblages ranging in age from Rhaetic to lower Cretaceous. This seems to be the first record of the sediments of Rhaetic age in Kutch.

In the time span between 1875 to 1971, as such, many geological contributions were made, mostly based on the stratigraphic classification of Waagen (1875) and its modifications made by Rajnath (1932). This long gap saw major changes in the concept of stratigraphy and stratigraphic nomenclature. It seems that no attempts have been made to revise and redefine the earlier classification till 1971. At that time, through a series of important publications, Biswas (1971, 1977) proposed for the first time a rock stratigraphic classification considering recommendations of the International Code of Stratigraphic Nomenclature [Hedburg, 1972]. The work contains description of units, proposed stratigraphic sections and a geological map. As further claimed by Biswas (1977), the variations in lithofacies from one part of the basin to the other, make it difficult to trace a set of rock units recognised in one area, strike wise to the other areas.

Biswas and Deshpande, at the same time, 1970 & 1982, published comprehensive and detailed geological and tectonic maps of the entire region of Kutch. These are reproduced in fig. 2, 3 & 4. In these maps the lithostratigraphic classification was used for the first time and later on was defined, discussed and described by Biswas (1971, 1977).

The lithostratigraphic classification of Biswas (1971, 1977) is given in table 6.

TABLE - 6: LITHOSTRATIGRAPHIC CLASSIFICATION OF KUTCH

AGE	MAIN LAND		PACHHAM ISLAND		E.KUTCH-KHADIR-BELA-WAGAD	
	FORMATION	MEMBER	FORMATION	MEMBER	FORMATION	MEMBER
NEOCOMIAN-ALBIAN	BHUJ 815m	UPPER 260m +				
		UKRA 30m				
		GHUNERI(W) OR LOWER(E) 525m			WAGAD SANDSTONE 365m	GAMDAU 165m +
KIMMERIDGIAN TO THONIAN	JHURAN 760m	KATESAR 100m				KANTHKOT 200m
		UPPER 300m				
		MIDDLE 160m				
		LOWER 120m				
OXFORDIAN	JUMARA 275m	DHOSA OOLITE 115m			WASHTAWA (WAGAD)	BAMBHANKA SHALES 160m
		MIDDLE 75m				GADHADA 185m
CALLOVIAN		LOWER 35m	GORADONGAR 154m	MODAR HILL 130m +	KHADIR (KHADIR ISLAND) 650m	HADIBHADANG 280m
	JHURIO 290m	UPPER 70m		RAIMALRO 9m		
				GADAPUTA 6m		CHARIYABET 25m
BATHONIAN		MIDDLE 85m		FLAGSTONE 5m		
		LOWER 135m	KALA-DONGAR 470m	KALA-DONGAR SANDSTONE		
				KUARBET 290m		
					PRECAMBRIAN	

(AFTER BISWAS, 1971, 1977)

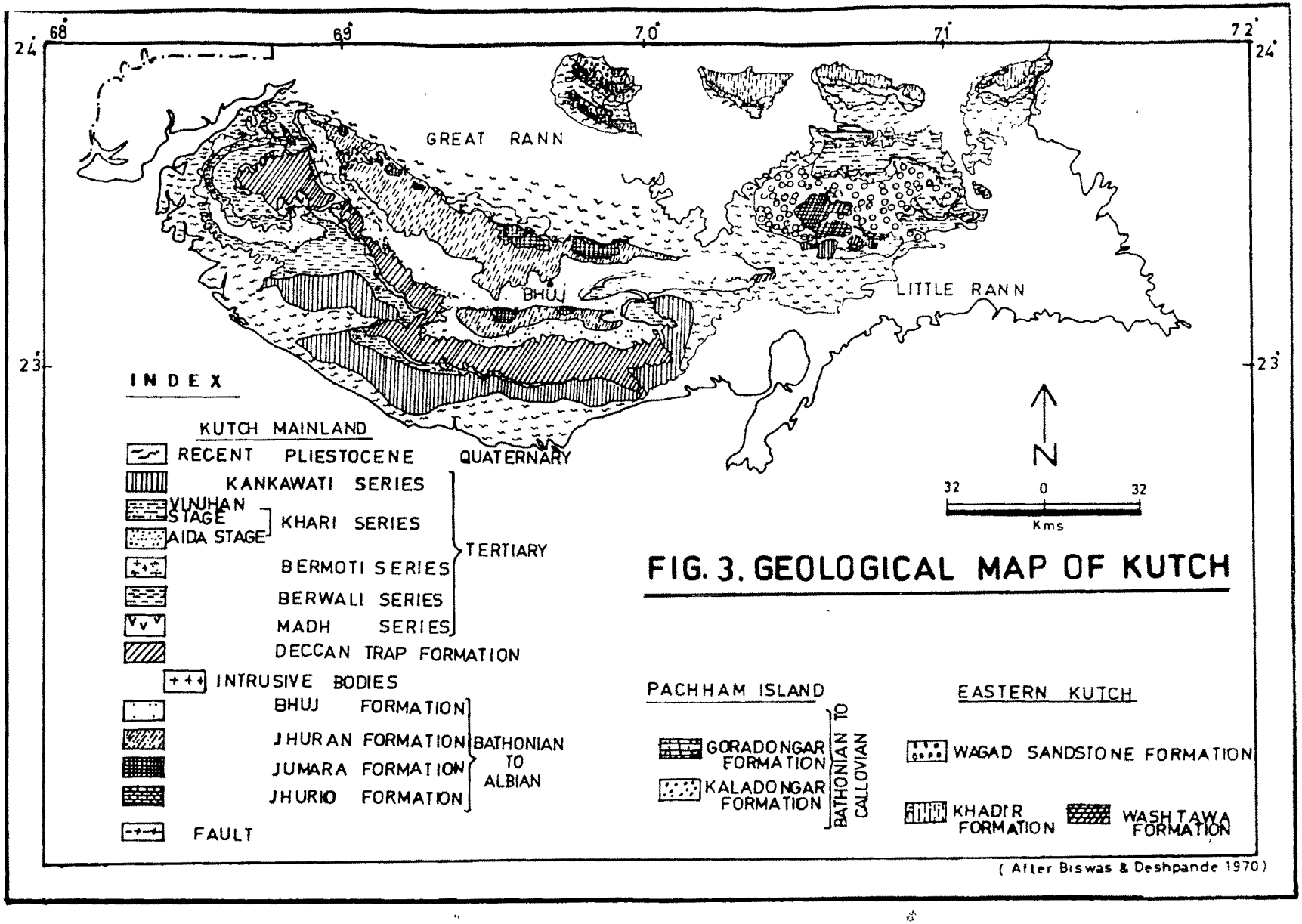
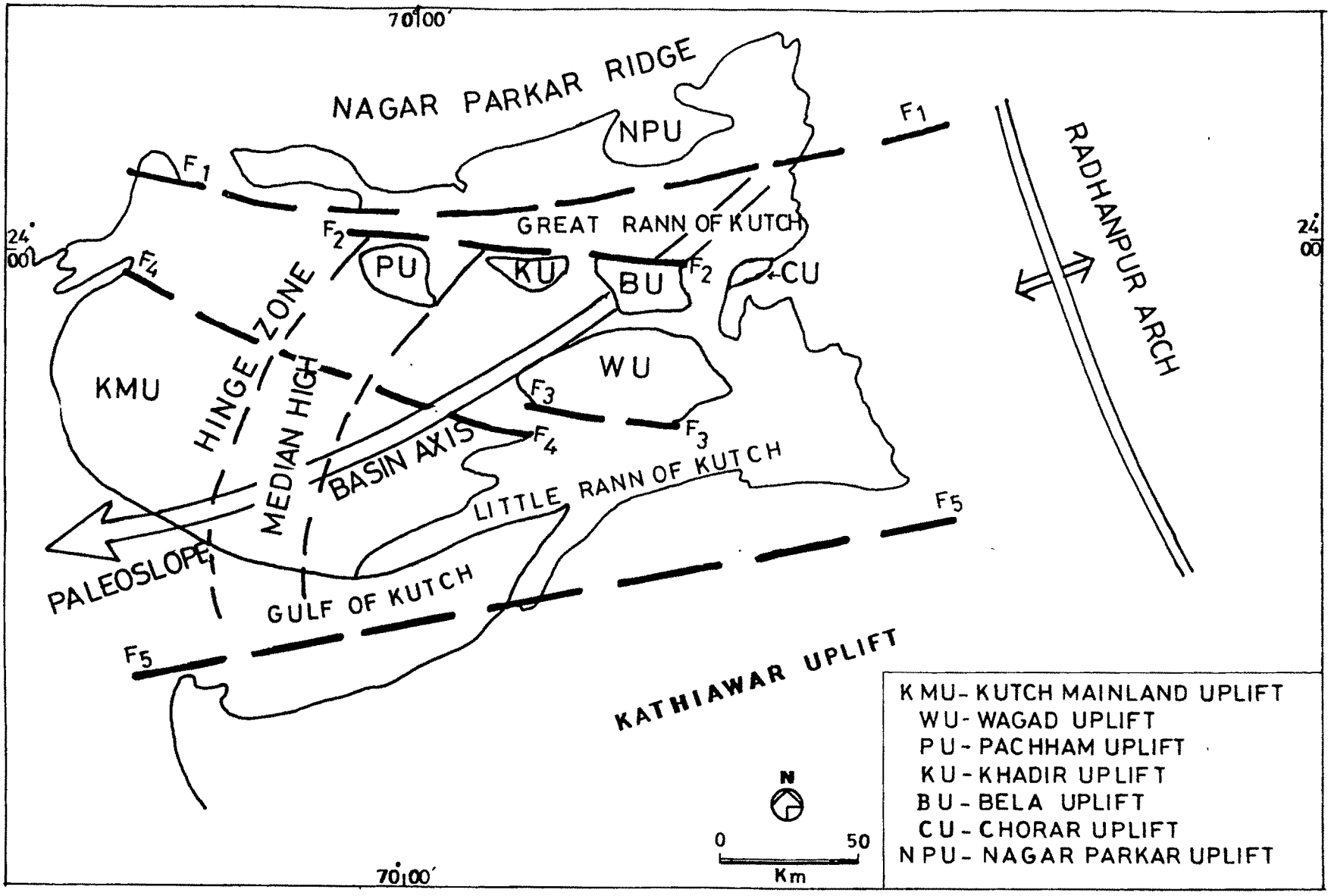


FIG. 3. GEOLOGICAL MAP OF KUTCH

(After Biswas & Deshpande 1970)



(After Biswas, 1982)

FIG. 4. REGIONAL TECTONIC MAP

Except a few, majority of the workers have continued to use older four fold chronostratigraphic classification of Waagen and Rajnath, which is widely followed in the text books of Indian Geology. However, the lithostratigraphic classification of Biswas (1977) provided the basic framework for the study of the depositional model of the basin and its evolution (Biswas, 1981).

A few workers later opposed this classification (Howard and Singh, 1985; Jaikrishna, 1983; Jaikrishna et.al., 1983; Mitra et.al., 1979), considering the units of the old classification of Waagen and Rajnath and those of lithostratigraphic classification of Biswas as identical, they argued for the retention of the old nomenclature, since it is the priority of usage. In response to these, Biswas (1991) has argued that the nomenclature of one category of stratigraphic classification can not be changed or used into another by changing the rank terms without proper justification, definition and reference to stratotype. As to him, question of priority does not arise when categories of classification are different. Furthermore, he states that units of the earlier classification - Patcham, Chari, Katrol, Umia series do not correspond to the four lithostratigraphic units - Jhurio, Jumara, Jhuran and Bhuj formations of Biswas (1977), as boundaries of older classification are defined by time planes indicated by ammonite index/assemblage zones, while lithostratigraphic boundaries are strictly defined on the basis of major lithological breaks, unconformities and change over from one environment to another. As to him, the stratigraphy of a basin remains incomplete, if, it is not studied in the three main aspects - lithological, biological and chronological, with their interrelationship. Moreover, Pandey

and Dave (1993), have put forward revised and redefined chronostratigraphic classification on the basis of original work of Waagen (1871) and Rajnath (1932), with reference to the stratotypes identified. Their chronostratigraphic classification, mainly based on refined microfauna with relation to the already established megafaunal zones, is represented in table 7.

Furthermore, through a series of papers Biswas (1978, 1980, 1981, 1982, 1983, 1987, 1991) has discussed stratigraphy, structure, basin framework, palaeo-environment and depositional history, tectonic framework and its evolution and sedimentary evolution of Mesozoic rock sequences of Kutch on a regional scale.

Kanjilal (1978) carried out geological and stratigraphical work on the Jurassic rocks of Habo hills.

Agrawal and Kachhara (1979) given detailed biostratigraphy of the Habo (Chari) beds exposed in the eastern part of Ler.

Koshal (1984) has differentiated subsurface Rhaetic sediments of Kutch on the basis of palynofossils. These sediments are mainly continental to paralic valley fill clastics (Biswas, 1991).

Shringarpure (1984, 1986) investigated the rocks of the Wagad region of Eastern Kutch, from ichnological point of view and for the first time interpreted these structures in terms of their ethology, palaeoecology, animal sediment relationship, event stratigraphy and depositional environments. He has for the first time recorded, in detail, more than 45 ichnogenera and 73 ichnospecies.

TABLE - 7 : REVISED CHRONOSTRATIGRAPHIC CLASSIFICATION (AFTER PANDEY AND DAVE, 1993).

AGE		STAGE		KUTCH BENTHIC FORAMINIFERAL ZONES
		EUROPEAN	KUTCH	
CRETACEOUS		APTIAN-ALBIAN	NOT CLASSIFIED	
	LOWER	NEOCOMIAN	MUNDHANIAN	DOROTHIA KUMMI HAPLOPHRAGMOIDES PACILIS RANGE ZONE
JURASSIC	UPPER (MALM)	TITHONIAN	UMIAN	EPISTOMINA VENTRICOSA RANGE ZONE
		KIMMERIDGIAN	KATROLIAN	LENTICULINA BULLA-EPISTOMINA VENTRICOSA INTER BIOHORIZON (BARREN) ZONE
				LENTICULINA BULLA PARTIAL RANGE ZONE
		OXFORDIAN	DHOSAIAN	EPISTOMINA MAJUNGAENSIS-LENTICULINA BULLA INTER BIO-HORIZON (POORLY FOSSILIFEROUS) ZONE
				EPISTOMINA MAJUNGAENSIS RANGE ZONE
	MIDDLE (DOGGER)	CALLOVIAN	CHARIAN	PROTEONINA DIFFLUGIFORMIS-ASTACOLUS ANCEPS ASSEMBLAGE ZONE
				TEWARIA KUTCHENSIS PARTIAL-RANGE ZONE
				LENTICULINA DISCIPIENS ZONE
		BATHONIAN	BADIAN	DOBROGELINA RAJNATHI RANGE ZONE
				LENTICULINA DILECTAFORMIS PARTIAL RANGE ZONE
				EPISTOMINA REGULARIS-EPISTOMINA GHOSHI ASSEMBLAGE ZONE
		BAJOCIAN	PATCHAMIAN	LENTICULINA-EPISTOMINA ASSEMBLAGE ZONE
				NOT ESTABLISHED
		AALENIAN	BANNIAN	MAINLY NON MARINE
TRIASSIC PRE-CAMBRIAN BASEMENT				

Singh (1989) discussed Dhosa oolite member of Chari series in relation to sedimentological, ichnological and palaeontological aspects and proposed that, it is a transgressive condensation horizon of Oxfordian age.

Lately, Fursich et.al. (1991, 1992) discussed palaeoecological and palaeoenvironmental conditions of Chari rocks covering various exposures in the Kutch mainland.