GEOLOGY AND STRATIGRAPHY OF THE AREA BETWEEN WAGHOPADAR AND CHEROPADI, KUTCH, WESTERN INDIA

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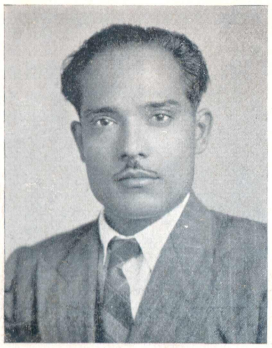
ABSTRACT—The geology and stratigraphy of the region in the neighbourhood of Waghopadar and Cheropadi has been described and an attempt made to correlate the subdivision of the Tertiary rocks of this region with those of other regions of Kutch by means of the larger Foraminifera.

INTRODUCTION

THE highly fossiliferous Tertiary formations of Kutch are known since the early part of the 19th century. These were officially mapped and studied by Fedden during the field seasons of 1867 to 1869. A detailed account of these has been given by Wynne (1872) in his "Memoir on the Geology of Kutch", which is accompanied by a geological map of this area compiled by Wynne and Fedden. Fossil Mollusca and Echinodermata from some of these beds have been studied by Vredenburg (1925–1928), and Duncan and Sladen (1883). But even these need further investigation. The foraminifers of Eocene and Oligocene rocks drew the attention of Vredenburg (1908), and Nuttall (1926), yet nothing is known of the Miocene foraminifera. Moreover the Eocene, Oligocene and Miocene foraminiferal stratigraphy has not yet been worked out so far in detail. This is important from the view point of precise dating of the beds.



In India, the sub-divisions of the Miocene are largely based on the distribution of the several species of Echinodermata and Mollusca—more specially on the species of *Ostrea*. Correlation of the Miocene beds of Western India has been attempted by Rao, Tewari and others (1957) on the basis of the distribution of the larger Foraminifera, so important in the recognition of the Tertiary stages all over the world. They, however, proved that the Foraminiferal fauna of Western India has an important bearing on the correlation of the Indonesian Tertiaries with those of India.

The area was visited by the author in October, 1948, and later in October, 1952. Collections of rocks and fossils were made bed by bed. Apart from the area between Waghopadar (23° 29′: 68°47′) and Cheropadi (23° 22′ : 68° 45′), the author has visited and mapped other Tertiary areas of Kutch such as Vinjhan (23° 6′ : 69° 2′), Miani (23° 7′ : 69° 6′), Waior (23° 25′ : 68° 44′), Rampur 23° 20′: 68°51′), Sitalamata Temple (23°22′ : 68° 46′), Sukhpur (23° 27′ 30″ : 68° 47′), Chhasara (23° 21′ : 68° 48′) and Sanosara (23° 26′ 30″ : 68° 46′).

PREVIOUS WORKERS

Sykes in 1834 reported *Nummularia exponens* —identified by Sowerby, from the Nummulitic beds of Kutch, contained in the collection of Captain Walter Smee.

As early as 1837 Grant attempted to classify the Tertiary rocks of Kutch as follows:

Tertiary.
Nummulitic.

His paper is accompanied by a geological map of Kutch and description of fossils. The plant fossils were described by

J. Morris and the animal fossils were figured and described by J. de Carl Sowerby. Besides descriptions of a large number of molluscs, echinoderms, *Serpula* and *Balanus* from the Tertiary rocks of Kutch his paper contained the descriptions of the following foraminifera:

Nummularia acuta, N. obtusa, Lycophris ephippium, L. dispansus, Fasciolites (Parkinson) elliptica.

D'Archiac and Haime in 1853 studied a few *Nummulites* and mollusca of this region and combined the two sub-divisions of Grant. He considered both of Eocene age. The localities of the fossils described are not known.

Carter's (1853 and 1857) views on the Tertiary stratigraphy of Kutch, expressed in the "Summary of the Geology of India" can be summarised as follows :

Calcareous grit (Porbander limestone)	Pliocene
Argillaceous grit full of fossils Coralline limestone	Miocene
Nummulitic limestone of Grant, and Lower Blue Clay	Eocene

Again Carter (1857, p. 743, in foot-note) revised his opinion regarding the position of the Argillaceous grit and Coralline limestone and referred both of them to the Eocene.

The official survey of Kutch was completed by Wynne in 1872 and he proposed the following classification of the Tertiary beds of Kutch:

			Probable thickness
Up. Tertiary	Pliocene ?	Variable and inconstant deposits including concrete beds of great thickness.	
	Miocene ?	Soft sandstones, shelly, calcareous and quartzose grits, gravels and conglomerates with trap pebbles and agates. Brown sands and sandstones with fossil wood.	200′ to 500′

(Unconformity)

Argillaceous fossiliferous grp.	? U. Eocene or Miocene	A great thickness of clays and shales alternating with sandy shales and harder bands of shelly limestone, or marls a few nodular clay and conglomeratic beds. In the upper part fossils are most abundant, often forming whole beds. The lower part is often rusty brown and sandy, with ferruginous and lateritic bands and some conglomerates. Some of the sands are richly mottled and in part white. Some large bones etc., in one of the lower conglomerates.	800′ to 1,200′ (?)

Eocene	Arenaceous group	Mottled, white, red-stained, streaky, fine silty sandy shales, soft and friable, obliquely laminated, irregularly bedded and often lenticular; containing impressions of leaves . . . 100′ Dun-coloured and blue silt clays and blue shales; contain the carapace of a small crab, etc. . . . . 30′	600′ to 800′
	Nummulitic group	Marly beds with a few fossil casts and Nummulites in the lower part. Nummulitic marls and limestone . . 700′	
	Gypseous shales	(?) *Operculina* gypseous shales with nodular bands and laterite above and below. An oyster bed sometimes on this horizon 100′	
	Sub-Nummulitic	Finely laminated shales, upper part rusty brown and friable; lower argillaceous and bituminous and pyritous, with small lumps of mineral resin, bitumen etc. Small horny plates, possibly belonging to a crustacean, woody fragments and leaf impressions, best preserved in the lower part.	50′ to 100′
			Total 1600–2600 feet

Wynne states (1872, p. 74), "The whole formation is, however, subject to irregularities, very likely to mislead, and not only are whole groups wanting in some parts of the area, but individual beds vary along their extension, or die out altogether, so that the sub-divisions. . . . . are occasionally open to some amount of uncertainty." The Sub-Nummulitic group is considered to be conformable with the underlying Deccan Traps.

Medlicott and Blanford (1879, p. 344) gave the following sequence or beds in the Tertiary succession and compared it with that of Sind.

	Kutch		Sind	European equivalents
	Alluvium, blown sand etc.		Alluvium	Pleistocene or Recent
Tertiary	Upper Tertiary	200′–500′	Manchar	Pliocene & Upper Miocene
	(Unconformity)			
	Argillaceous group	800′–1200′	Gaj	Miocene
	Arenaceous group	130′	Nari (?)	Lower Miocene and Upper Eocene
	Nummulitic group	700′	Kirthar	Eocene
	Gypseous shales	100′	Ranikot	Lower Eocene
	Sub-Nummulitic	100′		
	Stratified traps		Traps	Upper Cretaceous

The sub-divisions of Medlicott and Blanford are the same as those of Wynne. However, they considered the Sub-nummulitic together with Gypseous shales as equivalent to Ranikot (Lower Eocene) of Sind. The Nummulitic group was correlated with the Kirthar of Sind and the Arenaceous group, somewhat doubtfully, with the Nari, which

he considered to be of Lower Miocene to Upper Eocene age. While the Argillaceous group was supposed to be equivalent to the Gaj of Sind and of Miocene age, the Upper Tertiary group was correlated with the Manchar of Sind and regarded as of Upper Miocene and Pliocene age.

Blanford *in* Duncan and Sladen (1883) stated, "It is clear that the Miocene beds of Cutch are allied to the Miocene or Gaj of Sind, some of the fossils, as *Breynia carinata* (the most characteristic species) and *Coelopleurus Forbesi*, being identical." He also considered the Arenaceous group of Wynne equivalent to the Upper Nari (Oligocene) group of Sind.

Duncan and Sladen (1883) identified and described Echinoids from the Tertiary rocks of Kutch. He described 22 species from the Nummulitic series, five from his *Orbitoides* bearing Oligocene strata and sixteen from the Miocene beds of this area.

Vredenbrug (1906) described the megalospheric and microspheric forms of a new species *Nummulites douvillei* from Lakhpat and Noondatur, in Kutch collected by Wynne and Fedden. He identified *Nummulites laevigatus* and *N. gizehensis* var. *obtusus* Sowerby associated along with his new species and referred the new horizon to Middle Khirthar. In the same paper he also discussed the zonal distribution of Indian *Nummulites* and divided the Kirthar beds of India into Lower, Middle and Upper. *Nummulites douvillei* was later (Vredenburg 1908) revised to *N. vredenburgi* on the suggestion of Prever. Later on it was included under *Nummulites acutus* and its megalospheric form under *N. djokdjokartae* by Nuttall (1926).

Nuttal's (1925 and 1926) views on the stratigraphy of Kutch may be summarised as:

Oligocene	Nari Limestone containing *Nummulites intermedius*, *N. clipeus*, *N. subclipeus*, *N. fischteli*.		
Lower part of Middle Kirthar	Well-bedded white limestone containing *Nummulites acutus*, *N. maculatus*, *Assilina exponens*, *Alveolina elliptica*, *Discocyclina dispansa*, *D. javana* var. *indica*, *D. sowerbyi* *Actinocyclina alticostata*, *Dictyoconoides cooki*, *N. djokdjokartae*	500′	Eocene
	Shales	75′	
	- - - - - - - - - - - - - -	Unconformity	
	Laterite		
	Deccan Trap		

Nuttall (1926) for the first time postulates an unconformity between the shales, underlying the lower part of Middle Kirthar, and Deccan Trap associated with laterite. The shales may be representatives of the Sub-Nummulitic and Gypseous shales of Wynne while the well-bedded limestones assigned to the lower part of Middle Kirthar, are probably equivalent to the Nummulitic group of Wynne. Moreover, Nuttall (1925) for the first time established the occurrence of the Nari beds overlying unconformably the lower part of Middle Kirthars. The Nari beds were first postulated from Kutch by Medlicott and Blanford (1879), when they correlated, with some doubt, the Arenaceous group of Wynne to the Nari beds of Sind. Nuttall (1925) states that *Nummulites intermedius* occurs together with *N. clipeus* ".... at the base of the 'Arenaceous Group' of Cutch." Nuttall (1926) mentions the occurrence of *N. obtusus*, one and a half miles north of Waghopadar (23°29′:68°47′), from the base of Lower Kirthar. This seems to be a printing mistake, and he probably means lower part of Middle Kirthar.

Vredenburg (1925–'28) recognises the occurrence of the Nari, Lower Gaj and Upper Gaj in the Post-Eocene Tertiary formations of Kutch. He has described the rich Molluscan fauna from the post-Eocene Tertiary formations of north-western India, and considered the post-Eocene fossil Mollusca

of Kutch of the Lower Nari (Lattorfian or Stampian or both), Lower Gaj and Upper Gaj, approximately equivalent, respectively, to Aquitanian (Rembang series of Java) and Burdigalian (Najlingdung series of Java). The Upper Nari beds of North-western India have not yet yielded any recognisable Mollusca. They frequently contain Lepidocyclines of the group *Lepidocyclina dilatata*.

Wadia (1953)gave the following sequence of beds in the Tertiary system of Kutch:

6. Recent alluvium : blown sand, etc.		Pleistocene and Recent
5. Ferruginous conglomerate, sandstones and clays. (Manchar of Sind)	500′	Pliocene
4. Richly fossiliferous shales, clays and marls with sandstone beds (Gaj series)	1200′	Lower Miocene (Burdigalian).
- - - - - - - - - - - - -		
3. Impure Nummulitic limestone (Kirthar series)	700′	Upper and Middle Eocene.
2. Bituminous and pyritous shales etc. (Laki series)	200′	Middle Eocene
- - - - - - - - - - - - -		
1. Basalts of the Deccan trap		Lower Eocene.

Bed No. 2 of Wadia represents the Sub-Nummulitic group of Wynne. Similarly, his bed No. 3 may be compared with the Gypseous shales and the Nummulitic group of Wynne. The Arenaceous group of Wynne, already assigned to the Nari by Nuttall (1925) has not been recognised by Wadia or included in the overlying bed No. 4, which can be compared with the Argillaceous group of Wynne and Gaj beds of Medlicott and Blanford (1879) and Vredenburg (1925–28). Bed No. 5 of Wadia can be compared with the Upper Tertiary of Wynne and Medlicott and Blanford (1879) and equivalent to the Manchars of Sind.

Krishnan (1943) referred to the occurrence of "Well-developed Tertiary strata including the Laki, Kirthar, Gaj and Manchars." He gave the following sequence of Tertiary strata in Kutch:

4. Conglomerates, sands and clays	Manchars	500′ Pliocene.
3. Shales, marls and sandstones	Gaj	1200′ Burdigalian.
2. Nummulitic limestone	Kirthar	700′ Upper to Middle Eocene.
1. Shales, often bituminous and pyritous	Laki	200′ Middle Eocene.

Bed No. 1 of Krishnan can be compared with the Sub-Nummulitic group of Wynne, and bed No. 2 of Wadia, and shales 75′ thick at the base of the Middle Kirthar beds according to Nuttall (1926). Hence, it is undoubtedly the lowest horizon of sedimentary strata in the Tertiary sequence of Kutch. Although, a majority of workers, in this area, regard it of Laki age this is not yet settled in the absence of any characteristic fossil.

Bed No. 2 of Krishnan can be compared with the Gypseous shales and Nummulitic group of Wynne and bed No. 3 of Wadia. Vredenburg assigned this horizon to Middle Kirthar and Nuttall to lower part of Middle Kirthar (Lutetian). There is no dispute regarding the age of this horizon.

Although Krishnan has not shown the Nari beds in his sequence of the Tertiary rocks of Kutch, he recognises them in the text and states, "The Eocene is overlain by Nari and Gaj strata comprising buff coloured limestone with inter-bedded variegated shales and marls. ....The Lower contains *Nummulites intermedius* and Upper Nari *Lepidocyclina*."

Bed No. 3 of Krishnan can be compared with the Argillaceous group of Wynne, Argillaceous grit and Coralline limestone of Carter (1857) and bed No. 4 of Wadia.

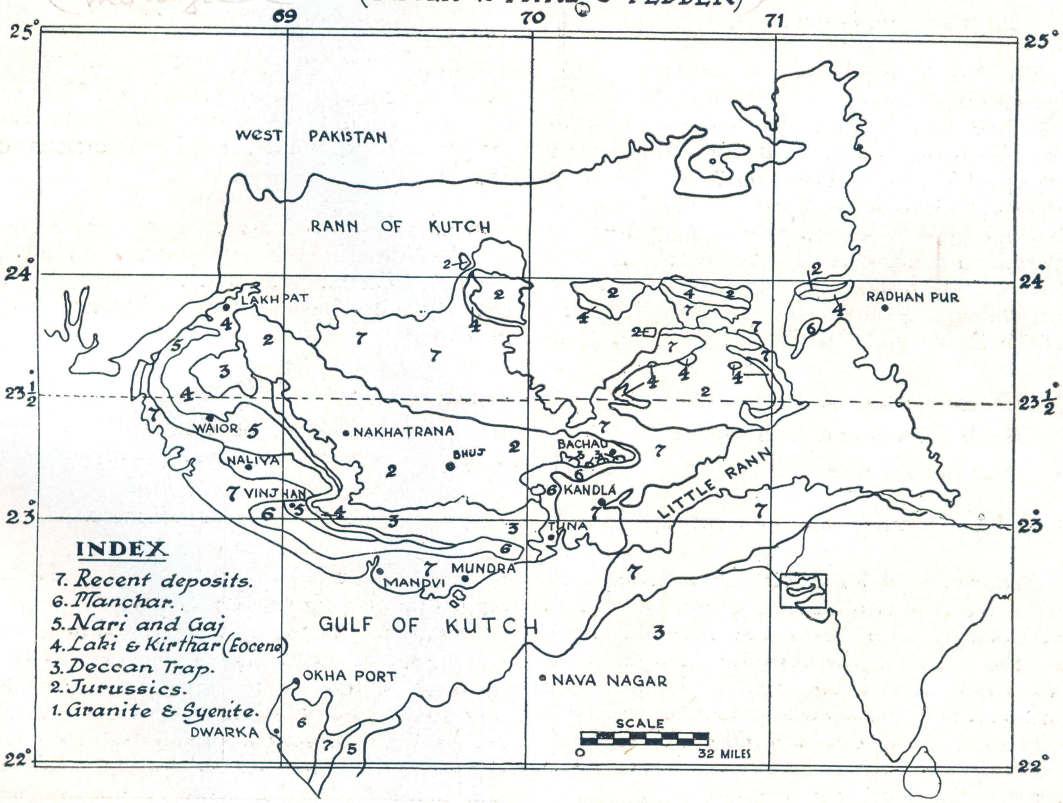
Medlicott and Blanford (1879), Medlicott, *in* Duncan and Sladen (1883), Vredenburg (1925–28) have also recognised this horizon equivalent to Gaj of Sind.

Bed No. 4 of Krishnan can be compared with the Upper Tertiary beds of Wynne and bed No. 5 of Wadia. Medlicott and Blanford (1879) also considered this horizon equivalent to the Manchars of Sind.

However, Reed (1949) recognises the occurrence of the Laki, Kirthar and Gaj groups, being specially well developed, in Kutch.

which nearly correspond to the Sub-Nummulitic, Nummulitic and Arenaceous groups of Wynne, respectively. His bed (4) represents the Gaj and post-Gaj horizons and is equivalent to the Argillaceous group of Wynne. These in turn are overlain unconformably by bed (5), which is correlated to a part of of the Manchars (Middle Miocene to Pliocene) of Western Pakistan. This has been further elucidated by him in his paper published in 1956, wherein he has introduced a horizon called Post-Gaj as it is distinct from Gaj and does not contain any characteristic Gaj fossils such as *Ostrea latimarginata* or

GEOLOGICAL MAP OF KUTCH & A PART OF KATHIAWAR
(AFTER WYNNE & FEDDEN)



Tewari (1952) studied the sequence of the Tertiary rocks as revealed in the sections of the Kankavati river of Vinjhan-Miani area, Kutch. His beds (1), (2) and (3) correspond to the Laki, Kirthar and Nari horizons,

any other Lower Miocene larger foraminifer. He has further clearly demonstrated the presence of definite Aquitanian beds in Kutch and reported a new species of *Spiroclypeus ranjanae* (1956). However, Rao,

Tewari and others (1957) have broadly correlated the Miocene beds of Kutch with those of other regions in India, Ceylon and Middle East.

TERTIARY GEOLOGY OF KUTCH

The Tertiary rocks outcrop in the form of a more or less continuous band all along the western, southern and south-eastern coast of Kutch from Lakhpat (23°49′30″: 68°47′) in the west to as far as Wandh (23°18′: 70°24′) on the eastern side. There are a few isolated patches of the Tertiary rocks on the northern and eastern side of the province. The Tertiary rocks overlie the denuded edges of the Deccan Traps, or, at a few places, on the Jurassic and Cretaceous rocks. The Eocene, Oligocene and Lower Miocene marine formations are more confined to the western and south-western parts of the region, while the fresh-water younger rocks, equivalent to the Manchars of Sind, occur all along the southern coast, eastern side and western side of the province. The width of the Tertiary band is sometimes more than 30 miles.

Exposures of the Tertiary rocks are generally good and can be studied from bed to bed, along the dip of the beds, particularly in stream sections running parallel to dip. The aggregate thickness of these beds is several thousand feet. The beds are occasionally horizontal, but low dip towards the sea-coast is most commonly met with. Folding has been observed in the Vinjhan-Miani and Lakhpat areas. Unconformities and local faulting have also been noticed. The earth movement leading to folding is of post-Middle Miocene age as the rocks of Lower as well as of Middle Miocene age have been found to be affected.

A large spread of the Tertiary rocks in western Kutch, commencing from near Lakhpat (23°49′30″ : 64°47′) and passing through Sehe (23°40′ : 68°35′), Peepar (23°31′30″ : 68°37′), Waior (23°20′ : 68°44′) and Rampur (23°20′ : 68° 51′) merges in the outcrop of Vinjahan-Miani area. Then they extend south-eastward up to Mandvi (23°50′ : 69°21′). The rocks are highly fossiliferous. Some horizons of the Tertiaries are continuous from west to east while others die out and reappear. Lateral changes of facies have also been observed.

WAIOR-CHEROPADI SECTION

A continuous section of Oligocene and Miocene rocks is visible in the stream passing through Waior (23°25′ : 68°44′), Waghot (23°24′ : 68°44′) and Cheropadi (23°22′: 68°45′). The section can be followed down stream from north of Waior up to Cheropadi with some breaks here and there. The rocks have a low dip towards south and the following sequence of beds with their contained fauna has been observed, the oldest beds being exposed north of Waior and youngest near Cheropadi.

16.	Grey shales with thin bands of nodular hard, calcareous sandstones containing *Ostrea latimarginata*, *O. angulata*, *Taberina malabarica*, *Lepidosemicyclina*, *Sorites*, fossil Algae and Mollusca.	
	Break of about 3 furlongs.	
15.	Brown shales and yellow argillaceous limestone in the escarpment containing *Ostrea latimarginata*, *Breynia corinata*, *Taberina malabarica*, *Clypeaster* sp., Lamellibranchs and Gastropds.	Upper Burdigalian.
14.	Green shales.	
13.	Sandy, shelly limestone grey in colour with *Taberina malabarica*, *Archaias angulatus*, *Operculina*, *Austotrillina howchini* and other Milliolines.	

EXPLANATION OF PLATE 14

FIG. 1—A stream section of bed no. 16 of Waior-Cheropadi area. Locality : 1 mile north of Cheropadi.

2—An outcrop of bed No. 2 of Waior-Cheropadi area. Locality : about 3 furlongs northeast of Waior.

3—A good exposure of coarse grained sandstones (Nari beds) showing current bedding. Locality : about 1½ miles northeast of Manjal, Vinjhan-Miani area.

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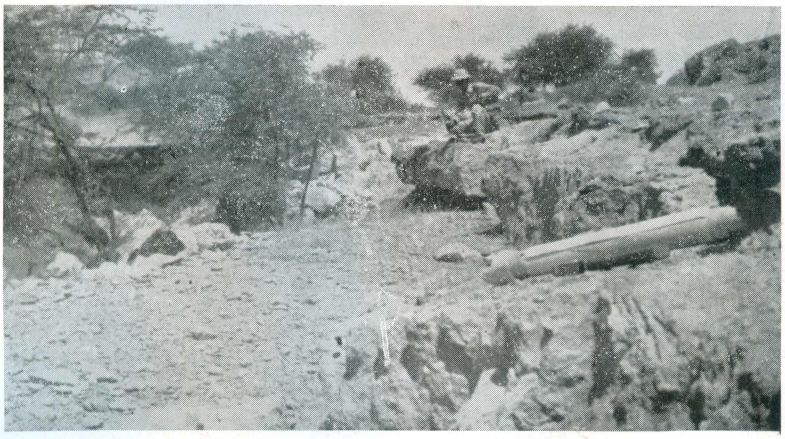

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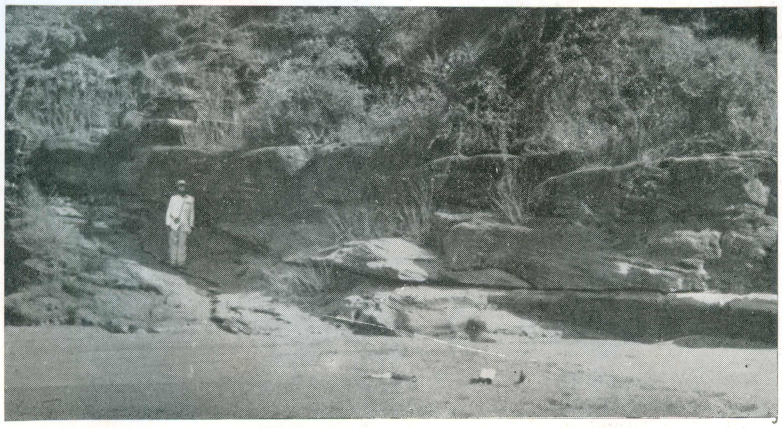


3

TEWARI : GEOLOGICAL SECTIONS IN KUTCH.

1

2

3

4

TEWARI : FOSSILIFEROUS HORIZONS IN KUTCH.

12.	Dark, shelly, impure limestone with *Anomia*, *Streb'us*, *Operculina* and smaller Foraminifers.	
11.	Greenish and yellowish shales with fragmentary shells.	
	Small break.	
10.	Nodular, shelly, yellow, calcareous sandstone with smaller Foraminifers.	
	Break.	
9.	Several bands of limestones and marls alternating with shales containing *Turritella* (*Torculoidella*) *angulata*, *Clypeaster waageni*, *Nephrolepidina borneensis*, *Miogypsina irregularis*, *Austrotrillina howchini*, *Archaias angulatus*, *Sorites marginalis*, *Breynia carinata*, *Ostrea angulata*.	Lower Burdigalian.
8.	Shales and sandy limestones with fragmentary shells just south of Waghot.	
7.	Sandy beds.	
6.	Nodular, compact limestone with *N. borneensis*, *M. irregularis*, *Austrotrillina howchini*, *Sorites marginalis*, *Archaias angulatus*, *Textularia*, *Lithothamnion*, *Corallina*, *Archaeolithothamnium*.	
5.	Shelly, yellow limestone with fragments of Lamellibranchs.	
4.	Grey argillaceous sands with bands of nodular and ferruginous, impure limestones with *Operculina*, *Spiroclypeus* sp. *M. irregularis*, *A. howchini Nephrolepidina*, *Textularia*, *Miogypsinoides dehaarti*, *Turritella*, fossil Algae, and *Hypoprion*.	
3.	Ferruginous sandstones with tubes of worms	Aquitanian
2.	Cream-coloured compact limestone with *Spiroclypeus ranjanea*, *Gypsina globulus*, *Operculina*, *Ostrea*, *Rotalia*, *Eponides*, *Schizaster granti* and rare *Nephropidina* and *Miogypsina* s.l.	
	Break of about 2 furlongs.	
1.	Sandy bed containing *Nummulites intermedius*, *N. clipeus*, *N. subclipeus*.	Latto.fian and/or Rupelian.

The presence of reticulate *Nummulites* in bed in No. 1 of Waior shows that it is definitely younger than the Middle Kirthar (Lutetian) of Miani. Nuttall (1925) reported these forms from the Arenaceous beds of Aida (23°24′ : 68°51′) and Khari (23°27′30″ : 68°44′), Kutch. These beds are well developed representatives of loose, coarse-grained sandstones (? Nari) of Vinjhan-Miani area, where these beds have not yielded any fossils except a species of *Streblus*. The bed is equivalent to the Lower Nari beds of Sind, Western Pakistan.

Bed No. 2 of Waior does not contain any reticulate *Nummulites* but contains *Spiroclypeus ranjanae*, Tewari, *Gypsina globulus* and

EXPLANATION OF PLATE 15

FIG. 1—Close-up of Bed No. 16 of Waior-Cheropadi area studded with fossil shells. A left valve of *O. latimarginata* is seen near the hammer. ×1/5. Locality: about 2 furlongs north of Cheropadi in the stream bed.

2—Close-up of Bed No. 9 of Waior-Cheropadi area studded with white casts of *Turritella* (*Torculiodella*) *augulata*. ×1/5. Locality: about 1 mile south-east of Waghot, in stream bed.

3—Close-up of a cast of a large *Conus* in Bed No. 16 near Cheropadi. ×1/3.

4—Close-up of Bed No. 9 of Waior-Cheropadi area showing *Breynia carinata*, and *Clypeaster waageni*. ×1/5. Locality: about 1 mile south-east of Waghot, in stream bed.

Operculina. Besides these it contains *Schizaster granti*, *Rotalia*, *Eponides*, *Operculina* together with occasional *Nephorlepidina* and *Miogypsina* s.l. along with *Spiroclypeus* indicating Aquitanian (basal part of Lower Miocene) age for this horizon.

Bed No. 3, that is, the ferruginous sandstones, represents unconformity within the Aquitanian.

The presence of *Miogypsina* and *Austrotrillina howchini* in bed No. 4 of this area suggests a post-Oligocene age. However, the prsence of *Spiroclypeus* sp. indicates that the horizon is not younger than Aquitanian.

Spiroclypeus disappears from bed No. 6 of Waior and *Nephrolepidina* becomes abundant. The horizon is also characterised by the profuse development of Calcareous Algae *Corallina*, *Archaeolithothamnium*, *Lithothamniun*. The fauna resembles that of the Agate Conglomerates of Surat. The horizon seems to be of Lower Burdigalian age.

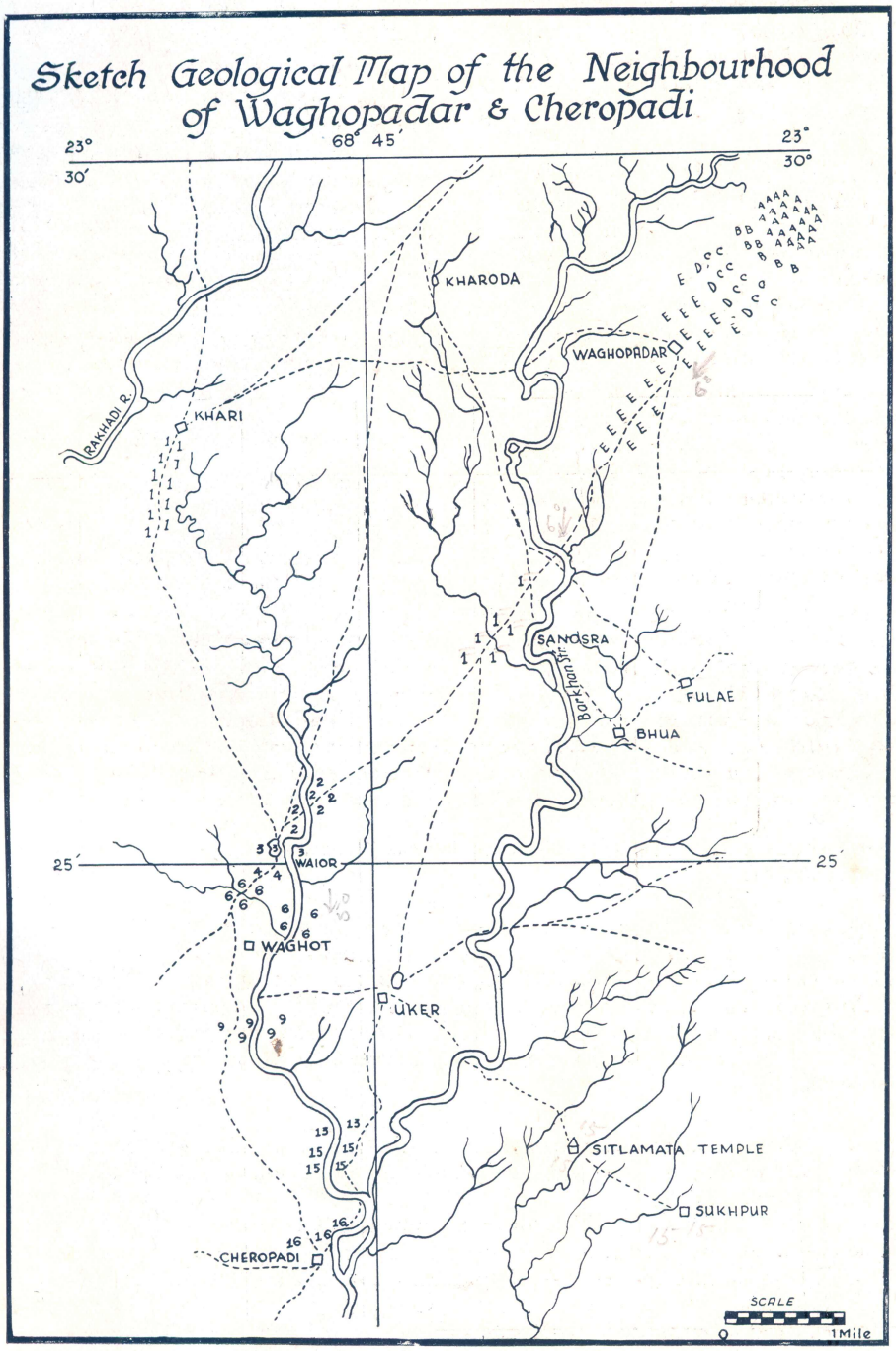
The fauna of bed No. 9 is typical of the Gaj series of Sind. *Ostrea latimarginata* has not yet appeared, although *Breynia carinata* is present together with *Nephrolepidina borneensis*. The absence of *Taberina malabarica*, *Trybliolepidina* and *O. latimarginata* suggests Lower Burdigalian age for these beds. Similar fauna has been reported from the Lower Burdgalian beds by Chatterji and others (1957) from Visawara in Kathiawar, India.

Ostrea latimarginata and *Taberina malabarica* appear first in bed No. 13 of Waior-Chedopadi section and continue upwards in younger rocks. Lepidocyclines are conspicuous by their absence. *Austrotrillina howchini* and *Miogypsina* s.s are present along with *Lepidosemicyclina* in bed No. 16 of this area. This association indicates Upper Burdigalian age for beds numbered 13 to 16 in this locality. However, the presence of *Austrotrillina howchini* suggests that the beds are not younger than Upper Burdigalian.

WAGHOPADAR-SANOSARA SECTION

Eocene rocks are exposed from north of Waghopadar (23°29′ : 68°47′) to Sanosara (23°26′30″ : 68°46′) in the south. The section is not clearly seen between Sanosara and Waior, hence the relationship between the underlying Eocene rocks and Oligocene rocks is not very clear. However, there are some beds south of Sanosara, which are made up of debris from the older Eocene rocks. The Eocene rocks are horizontal. The oldest beds are exposed in the north of Waghopadar in a deep valley. The following sequence of beds is seen in this area:

F. 6.	Sandy beds, containing *Nummulites intermedius*, *Nummulites clypeus*, *N. subclypeus*.	Lattorfian and or Rupelian.
E. 5.	Yellowish white, compact limestone and marl with *Nummulites acutus*, *N. stamineus*, *Discocyclina dispansa*, *D. javana* var. *indica*, *D. sowerbyi*, *Alveolina elliptica*, *Alveolina elliptica* var. *nuttalli*, *Dictyoconoides cooki*, *N. djokdjokartae*, *Halkyardia*, *Assilina exponens Asterocyclina alticostata* (Nuttall), *Actinocyclina kutchensis Asterocyclina wagarensis Ostrea* sp., other Molluscs and Echinoderms.	Middle Eocene.
D. 4.	Brown, yellow and blue shales with a few ferruginous bands and gypsum with *Ostrea flemingii* and other Lamellibranchs and badly preserved bones.	Lower Eocene.
C. 3.	Shales, grey and brown. The lower portion is of carbonaceous shales with lumps of mineral resin and pyrite. Impressions of dicotyledonous leaves and *Botryococcus brauni* are present in this horizon.	
B. 2.	Mottled argillaceous beds with laterite.	
A. 1.	Lavas of the Deccan Trap	Lower Eocene and or Upper Cretaceous.


Sketch Geological Map of the Neighbourhood of Waghopadar & Cheropadi
23° 30′
68° 45′
23° 30′
25′
25′
KHARODA
WAGHOPADAR
KHARI
RAKHADI R.
SANOSRA
Borkhunda
FULAE
BHUA
WAIOR
WAGHOT
UKER
SITLAMATA TEMPLE
SUKHPUR
CHEROPADI
SCALE
0
1 Mile

Text-fig. 2

Bed No. 3 is not represented in the Vinjhan-Miani area. Although, there is no direct evidence regarding the age of beds 2 and 3 Waghopadar-Sanosara area, on the basis of Foraminifers, their stratigraphical position suggests an age earlier than Middle Kirthar (Lutetian). However, *Botryococcus brauni*, which is known from the definite Laki (Lower Eocene) beds of Salt Range and Bikaner, is also met with in these beds. Provisionally, these beds are assigned to Lower Eocene. Bed No. 1 of Vinjhan-Miani area partly represents this horizon.

The fauna of bed No. 5 of this area is typical of the Middle Kirthars of Nuttall. The horizon is equivalent to bed No. 2 of Vinjhan-Miani area. It is also equivalent to the Nummulitic beds of Lakhput (23°49′30″ : 68°47′) western Kutch.

CORRELATION OF THE TERTIARY BEDS OF SOUTH-WESTERN KUTCH

	Waior Cheropadi	Waghopadar Sanosara	Rampur	Sukhpur Chhasra	Sitalamata Temple	Lakhpat
Upper Burdigalian	Beds No. 16, 15, 14, 13 ..	....	....	Present	Present	
Lower Burdigalian	12, 11, 10, 9, 8, 7, 6, 5 ..	....	Present			
Aquitanian	4, 3, 2					
Lattorfian and or Rupelian	1 ..	Present F				
Middle Kirthar, Middle Eocene	..	.. E	....	....	....	Present
Laki, Lower Eocene	..	.. D				
	..	.. C				
		.. B				
Lower Eocene and or Upper Cretaceous	..	.. A				

RAMPUR SECTION

Near the village Rampur (23°20′ : 68°51′) weathered marls and yellowish impure limestones are exposed. The beds are almost horizontal and following Foraminifers have been recorded:

Lepidocyclina (*Nephrolepidina*) *borneensis*
Lepidocyclina (*Nephrolepidina*) *sumatrensis*
Austrotrillina howchini
Sorites marginalis
Archias angulatus

This assemblage is characteristic of Burdigalian. But the absence of *Taberina* and *Trybliolepidina* indicates that the beds are not Upper Burdigalian. However, these beds are referred to lower part of the Upper Gaj that is Lower Burdigalian, and may be equivalent to the Agate Conglomerates of Surat-Broach region.

BETWEEN SUKHPUR AND CHHASRA

On the cart road between Sukhpur (23°27′30″ : 68°47′) and Chhasra (23°21′ : 68°48′) compact yellow foraminiferal limestone is exposed. The bed dips at about 4° towards south. The following Foraminifera have been recorded:

Miogypsina (*Miogypsina*) *irregularis*
Miogypsina (*Lepidosemicyclina*) sp. nov.
Taberina malabarica (Carter)
Sorites marginalis
Archaias sp,
Rotalia
Textularia

Besides these, several Milliolines are also met with. Lepidocyclines are conspicuous by their absence. The presence of *Taberina malabarica* indicates that horizon represents the Upper part of Upper Gaj (Upper Burdigalian). The horizon is equivalent to bed No. 15 of Waior-Cheropadi area.

SITALAMATA TEMPLE

North-west of Sukhpur (23° 22′ : 68° 46′) near Sitalamata Temple brown impure limestone is exposed containing a few large Lamellibranchs, *Archaias*, *Sorites* and *Rotalia*. The presence of a doubtful specimen of *Taberina malabarica* in this horizon suggests an Upper Burdigalian age for these beds.

LAKHPAT

Near Lakhpat (23°49′30″: 68°47′) grey limestones underlain by gypseous shales are exposed. The limestones are highly fossiliferous and contain the following:

Nummulites acutus
Nummulites stamineus
Nummulites djokdjokartae
Discocyclina dispansa
Assilina exponens

The fauna is characteristic of the Middle Kirthars of Nuttall. Grant (1837) recorded a small anticline in this area.

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