CHAPTER III

AREA BETWEEN CHITROD AND MANFARA : GENERAL GEOLOGY AND DESCRIPTIVE STRATIGRAPHY.

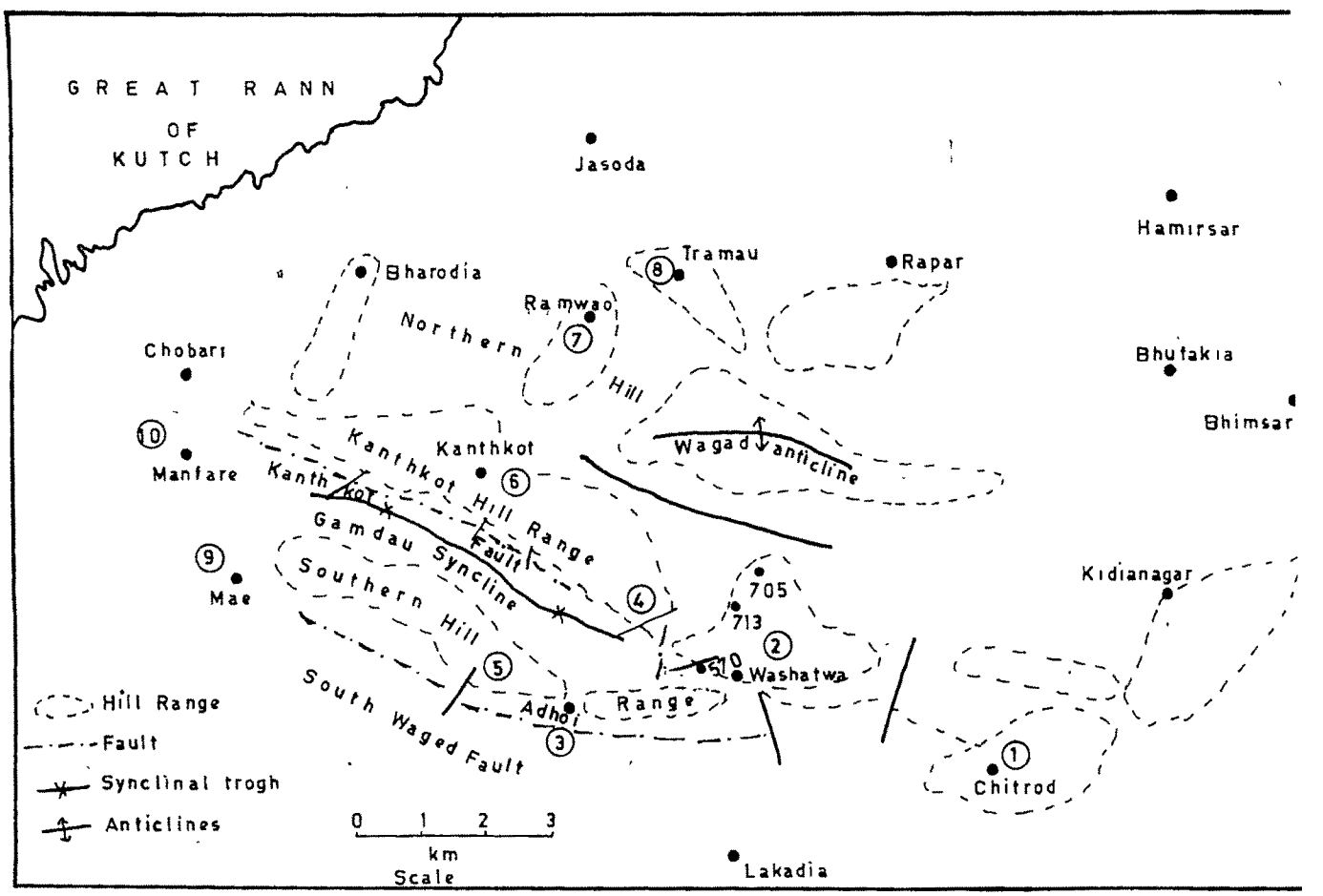
GENERAL:

The Wagad region of eastern Kutch (Latitude, 23°21' & 23°40' east and longitude, 70°21' & 70°0' north) exposes a unique sequence of Mesozoic rocks ranging in age between Callovian and Neocomoan. The main outcrops of these rocks are located between Chitrod (Latitude 23°24' & Lontitude 80°43') in the east, and Manfara (Latitude 23°29' & Longitude 70°21') in the west. The author has also considered the areas lying to the north, the northeast, and the northwest of this main Chitrod-Manfara region in order to gain additional evidences to support his investigations. The total area is approximately 480 Sq. kilometers and is covered in the survey of India topo sheets number 41 1/7, 41 2/10 and 41 1/11, and partly in 41 I/2+6, 41 I/3+7 and 41 I/15. The area as a whole comprises series of isolated and detached ranges of hills of Mesozoic rocks that maintain a persistent east-west strike probably reflecting the Precambrian basement trend characteristic of the entire region of Kutch.

STRUCTURE AND TECTONICS:

The structure and tectonics of the Wagad region has been studied in detail by Biswas and Deshpande (1970), and Deshpande (1972). Important observations of these workers are summarised as under:

FIG.-6. Physiographic and Tectonic map of Wagad. Distribution of Domes and locations of measured sections. (Modified after Deshpande, 1972)



Index to measured sections :

1	CHITROD	6.	KANTHKOT
2	WASHATWA	7	RAMWAO
3	ADHOI	8.	TRAMAU
4	NARA	9.	MAE
5.	HALRAE	10.	MANFARA

(1) The Mesozoic sediments in eastern Kutch are exposed in three parallel ranges viz. The northern range, the central range and the southern range (Fig. 6).

(2) The southern limit of the Mesozoic outcrop in Wagad is bounded by an east-west trending fault known as the south Wagad fault. It is a high angled normal fault having downthrow towards south. This fault has resulted in exposing the younger Tertiary rocks in south.

(3) In the south-western part of the area, another prominent fault having WNW-ESE strike, extends from Manfara in the west to Washatwa in the central Wagad. This fault known as the Kanthkot fault almost merges with the south Wagad fault south of Washatwa (Fig. 7).

(4) The interrelated faulting and folding in Wagad appears to have resulted into interesting and striking structural features of a number of anticlines and domal structures with intervening synclines.

(5) The important structural features in the northern half of the area include the Chobari nose, the Ramwao syncline, the Wagad anticline, the Tramau nose, the Narada dome, the Dabunda dome, the Sonawala dome, the Hamirpur dome, and the Bhimsar anticline. These structures are gentle and are of symmetrical types.

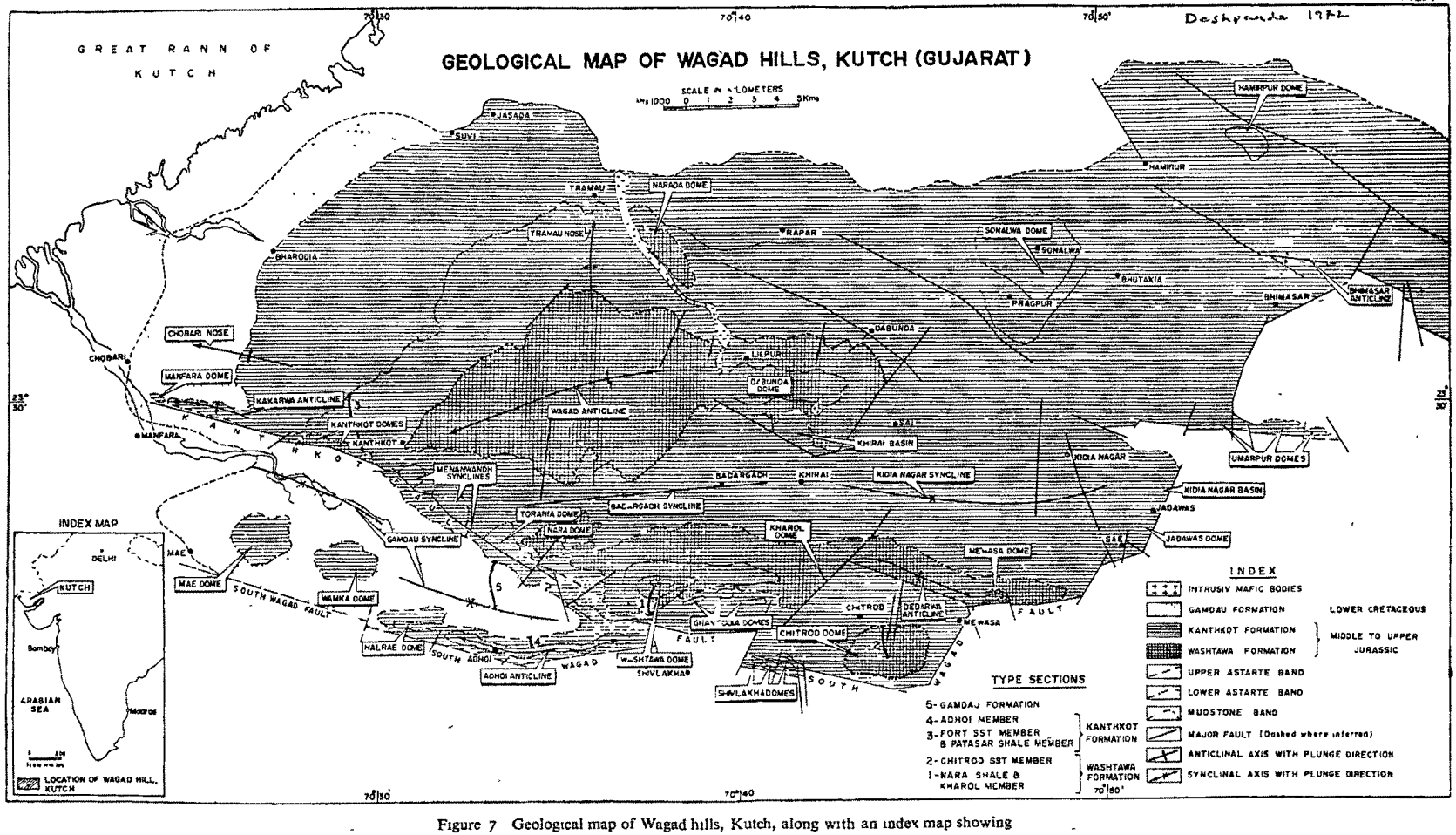


Figure 7 Geological map of Wagad hills, Kutch, along with an index map showing location of the area within Indian Peninsula

(6) The structures occuring to the north of the Kanthkot fault are asymetric and with steep southerly limbs. These include the Manfara dome, the Kakarwa anticline, the Kanthkot dome, the Nara dome, the Mae dome, the Hairé dome, the Adhoi dome, the Washatwa dome, the Chitrod dome, the Dedwara dome and the Mewasa dome (Fig. 8).

(7) The southern chain of domes and anticlines according to Deshpande (1972) exhibit much structural complexity and the Washatwa dome as claimed by him has experienced highest degree of uplift correspondingly exposing the oldest rocks in the area.

(8) The area is intruded by several dolerite dykes, the chief amongst these being the Badargarh dyke, the Tramau-Lilpur dyke and the Kirai dyke.

STRATIGRAPHY - (General Concepts)

Published work on the stratigraphy of eastern Kutch is rather limited. The reference to the earliest work of Spath (1935) and Cox (1940) is found in the book of Pascoe (1959, p. 1147).

Pascoe (p.1146) writes, "the greater part of Wagur (eastern Kutch) is occupied by beds which have been assigned to the base of the Khatrol but which might equally well be given to place to themselves; intermediate between Chari and

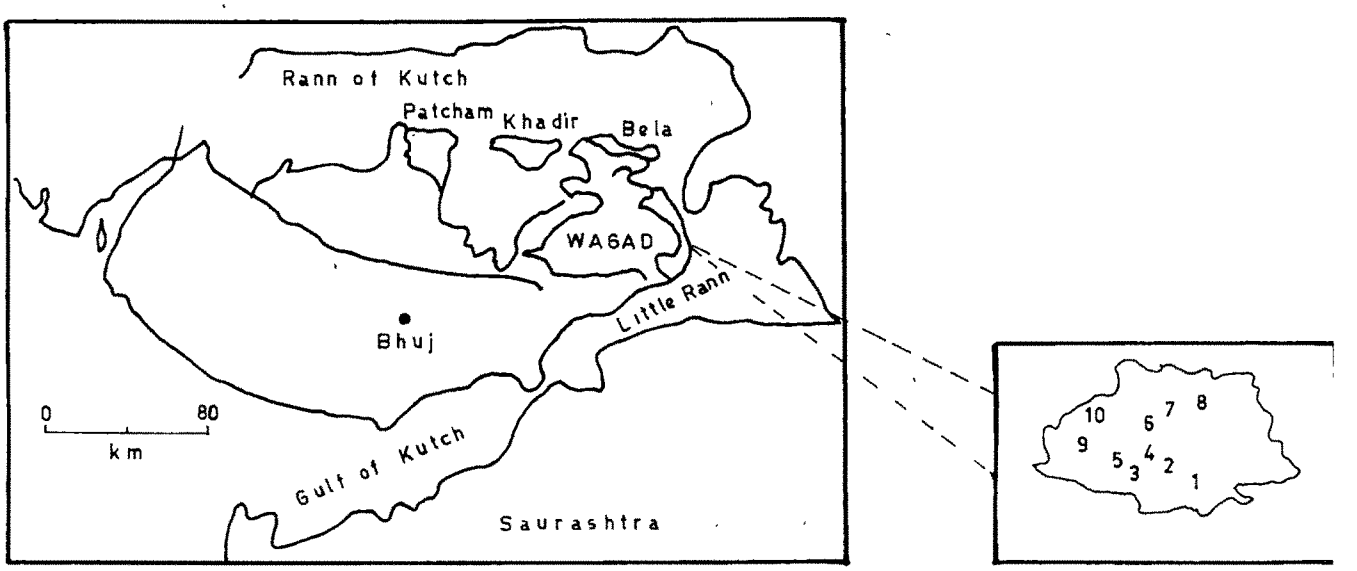


FIG. 8 Distribution of important domes in eastern Kutch where trace fossils are investigated.

1. CHITROD
2. WASHATWA
3. ADHOI
4. NARA
5. HALRAE
6. KANTHKO
7. RAMNCAO
8. TRAMAU
9. MAE
10. MANFARA

Katrol. From their development around the town of Kanthkot, these Wagur beds have received the name of Kanthkot sandstone; they are composed of grey or yellowish shales below, and of white, grey and pinkish sandstones, both coarse and fine above. Although the Wagur rocks are very similar in mineral character to Khatrol rocks of the Kutch main area, their cephalopods are almost all distinct and indicate a lower horizon".

A number of cephaloped species and genera belonging to Balemnoidea, Phylloceratidae, Oppelidae, Mayaitidae, Perisphinctidae, Aspidoceratidae, probably indicating Kanthkot sandstone to be Argovian in age are reported by Pascoe. Further according to him (p. 1148), Spath recorded Trigonia smeei and Astarte major from Kanthkot, but whether from the Kanthkot sandstone or from some other horizon at Kanthkot is not stated by Spath. Cox (1940) recorded Grammotodon (Indogrammatodon) Kantkotensis from the Argovian of Kanthkot; Mytilus tramauensis from the Argovian of the Tramau river; and Oxytoma inaequivalva from the Upper Argovian of Barodia.

Recently, Biswas (1977, p. 21-27) made some important observations pertaining the Wagad rocks of eastern Kutch and those of the Khadir, Bela and Chorar Islands. The stratigraphy of the eastern Kutch according to him is represented by interrelated rock units exposed in the unconnected outcrops of Wagad, Khadir, Bela and Chorar. He recognizes three mapable rock

TABLE 4: VERTICAL ENVIRONMENTAL PROFILE OF EASTERN KUTCH

Formation	Sed. process	Member	Environment	Lithology	Grain size	Sorting	Sed. structure	Geometry	Biota	Visher's Model
Wagad Sandstone	Deltaic Process	Gamdau	Deltaic plain	Sandstone	Coarse to Medium	Good	X-bed, planar & festoon	Blanket	Plant	Festoon X-bed
(Kimmeridgian to Lower Cretaceous)		Kanthkot	Pro-delta and Delta fringe	Basal shale, and sandstone	Medium to fine	Good	X-bed in sandstone, Ripple marks.	Sheet Sandstone & Wedge shale.	Fauna Abundant in Lower shale	Pro-delta and Delta fringe (Sandstone
Washtawa (Argovian)		—	Lagoonal	Shales	Clay-silt	Poor	Laminated	?	Abundant limited Taxa, Fewer eastward	Bays & Lagoons
Khadir (Bathonian to Argovian	Transgressive Marine	Bambhanka and Gangta	Sublittoral below wave base.	Shales	Clay-silt	Poor	Laminated	Blanket	Abundant and diverse	Distal prodelta
	Regressive Marine	Gadhada	Tidal flat & delta front	Sandstone and shale	Medium to fine	Good	X-bedded	Blanket Sand	Few	Tidal flat & passes
	Transgressive Marine	Hadibhadang Sandstone	Sublittoral near wave zone	Sandstone and Limestones	Medium to fine	Good	X-bedded	Blanket Sand	Limited fauna	Littoral
		Hadibhadang Shale	Lagoonal	Shales & sandstone	Coarse to Medium	Moderate	X-bedded	Lenticular	Limited	Bays & Lagoons
		Cheriyabet Conglomerate	Alluvial fan (piedmont)	Conglomerate & Arkose	Pebble to boulder	Poor	—	Wedge	Nil	—

units formally named by him as the Khadir Formation, the Washatwa formation and the Wagad Sandstone (Table 4). According to him the Khadir Formation includes the oldest beds of the sequence, while the Washatwa Formation exposed only in Wagad, appears to be equivalent of the uppermost part of the former because both are conformably overlain by the Wagad sandstone. Base of the Khadir Formation and top of Wagad Sandstone are not exposed in Wagad region. The Wagad sandstone of Biswas is represented by two distinct members, the lower marine, known as the Kanthkot Member and an upper, the non-marine. The Kanthkot Member passes laterally into non-marine sandstone in eastern Wagad where it is named as Gamdau Member.

The age of the Washatwa Formation as supported by the ammonite fauna from the Kanthkot ammonite band according to Biswas is Argovian while that of the Wagad sandstone ranges from Upper Oxfordian to Lower Cretaceous -(Pre-Aptian) (Table 4).

Another important contribution to the stratigraphy of eastern Kutch where the rocks between Chitrod and Manfara find an appropriate reference is that of Deshpande (1972). Deshpande has delt the stratigraphy and structure of the Wagad hills of eastern Kutch in great detail in his unpublished doctoral work at the M.S.University of Baroda. The following Table 5, gives classification of Wagad Group of rocks in eastern Kutch as given by Deshpande (1972).

STRATIGRAPHIC CLASSIFICATION OF WAGAD GROUP OF ROCKS

After Deshpande, 1972.

Age	Group	Formation	Western Part Members & Lithology	Eastern part Members & Lithology
Tertiary		Lakadiya Formation	Varigated clays, Shales and Sandstones	Varigated clays, Shales and Sandstones
			unconformity	
Lower Cretaceous		Gamdau Formation	Sandstone, grey to buff, massive with minor Shales	
			Disconformity	
Middle to Upper Jurassic		Kanthkot Formation	Adhoi Member Sandstone and Shale alternations	Non-deposition
			Disconformity	
			Fort Sandstone Member	Fort Sandstone Member
			Sandstone, massive grey to pink	Sandstone, massive, grey to brown and brick red
			Patasar Shale Member	Patasar Shale Member
			Shale, grey to dark grey & khaki	Shale, grey, Khaki silty.
			Disconformity	
	WAGAD GROUP	Washatwa Formation	Nara Shale Member	Chitrod Sandstones Member.
			Shale grey, Khaki and Silty	Sandstone, flaggy to bedded grey to brown
			Kharol Member Shale and Sandstone alternations	Kharol Member Sandstone and Shale alternations
			Base not exposed	

According to Deshpande the entire Mesozoic sequence in Wagad ranges from Middle Jurassic to Lower Cretaceous i.e. from Callovian to Neocomian. The "Kanthkot sandstones" as observed by the earlier workers (Pascoe, 1959, p. 1147) represent Argovian age. Below the "Kanthkot sandstone" the succession of thick sediments has an Oxfordian or Callovian age. The rocks above the "Kanthkot sandstone" on the basis of their lamellibranch fauna as suggested by Biswas (1977) could be correlated with the Umia series which comes at the top of the Jurassic sequence of Kutch. Spath as referred by Pascoe (1959, p. 1148) recognized the lamellibranch assemblage zone above the Kanthkot sandstone very similar to the one of the Umia series and thus this lamellibranch assemblage zone of the Wagad has been assigned by him the Tithonian or the Uppermost Jurassic age. Considering the normal order of superposition as suggested by Deshpande (1972) the rocks above the lamellibranch zone have to be assigned to Neocomian or the Lower Cretaceous age.

From amongst the earlier stratigraphic classifications Deshpande's (1972) classification finds maximum utility in the field and as such for the ichnological investigations the present author has broadly adopted this classification.

DESCRIPTIVE STRATIGRAPHY:

Washatwa Formation:

The oldest Mesozoic formation present in the study area is the Washatwa Formation (Fig. 5). The formation as a whole comprises alternations of shales, silty shales and sandstones. The base of the formation is not exposed any where in the area, while its top is marked by a fossiliferous, cherry coloured conglomeritic mudstone band.

The definition of the Washatwa Formation used in this study is that one proposed by Biswas and Deshpande (1970), and Deshpande (1972) for the lowermost of the three lithologic subdivisions of the Wagad Group of rocks exposed in eastern Kutch. The Washatwa Formation is well documented in the central and southern part of the present area of study (Fig. 5). The southern flank of the Washatwa dome (Lat. 23° 24' 35" & Long. 70° 37' 09", sheet no. 41 I/11+15) is the type section of this formation. Good exposures of the formation can be located along the Wagad anticline, Dabunda dome, Narada dome, Ramwav, Tramau, Nara dome, Washatwa dome, Manfara dome and Chitrod dome. The thickness and extent of the Washatwa Formation can be known from figure 9. This figure also illustrates gross thickness variations, including six prominent closures, one each in the central and nothern part and four in the southern part possibly representing individual uplifts

along the structures occurring in Wagad. Regional trend of WNW-ESE of the Washatwa Formation is very well indicated by this illustration. The least thickness of 300' is in the north-east part near Bhutakia while the southern areas situated near Nara, Washatwa, Mewasa and Chitrod represent maximum thickness between 700'-800'. This rapid increase in thickness as suggested by Deshpande (1972) is because of subsidence and correspondingly large accumulation of sediments.

The mean grain-size in the eastern part as computed from Deshpande, around Dabunda-Dedwara-Mewasa is about 2 phi, i.e. average grain size is of finer to medium grade; around Rapar-Chitrod in the central part it is 2.5 phi; while in the south-western part, south of Kanthkot-Chitrod axis it is around 3.0 phi, i.e. very fine grained. Tendency of coarsening upward is found in the vertical sections of a number of domes.

The Washatwa Formation is divisible into three members, viz. the Kharol Member, the Nara Shale Member and the Chitrod Sandstone Member.

The Kharol Member:

The shale and silstone alternations comprising the lower part of the Washatwa Formation have been termed as Kharol Member. The member is well exposed in the Washatwa and Chitrod domes and can be traced in the east towards the village of Kharol,

Dabunda, Mewasa and Narada in the north. In Washatwa dome this member is exceptionally well developed and is represented by two sedimentary facies the arenaceous and the argillaceous facies. The arenaceous facies consists of sandstones grey to brown in colour with fine to medium grained sands. The argillaceous facies is thickly developed, and at places exhibits gypsum layers in it. It comprises yellowish coloured fine to medium grained sandstone and siltstone layers. Change is facies from arenaceous to argiallaceous appears to be gradual. Sedimentary structures are represented by tabular cross-beddings and current ripples. The microfossils include species of Tintina, few pollen grains, plant strands, and rootlets of microplants (Shringarpure et al. 1976).

The Nara Shale and the Chitrod Sandstone Member:

The Nara Shale Member in the west and the Chitrod Sandstone Member in the east both overlie the Kharol Member and are considered to be facies varient of each other. These members are well exposed in Washatwa, Kanthkot, Mewasa and Chitrod domes.

The Nara Shale derives its name from the Nara dome (Lat. 23° 20' & Long. 70° 35') which exposes its complete sequence. This member is characterized by its grey and Khaki coloured shales with alternations of grey flaggy sandstones.

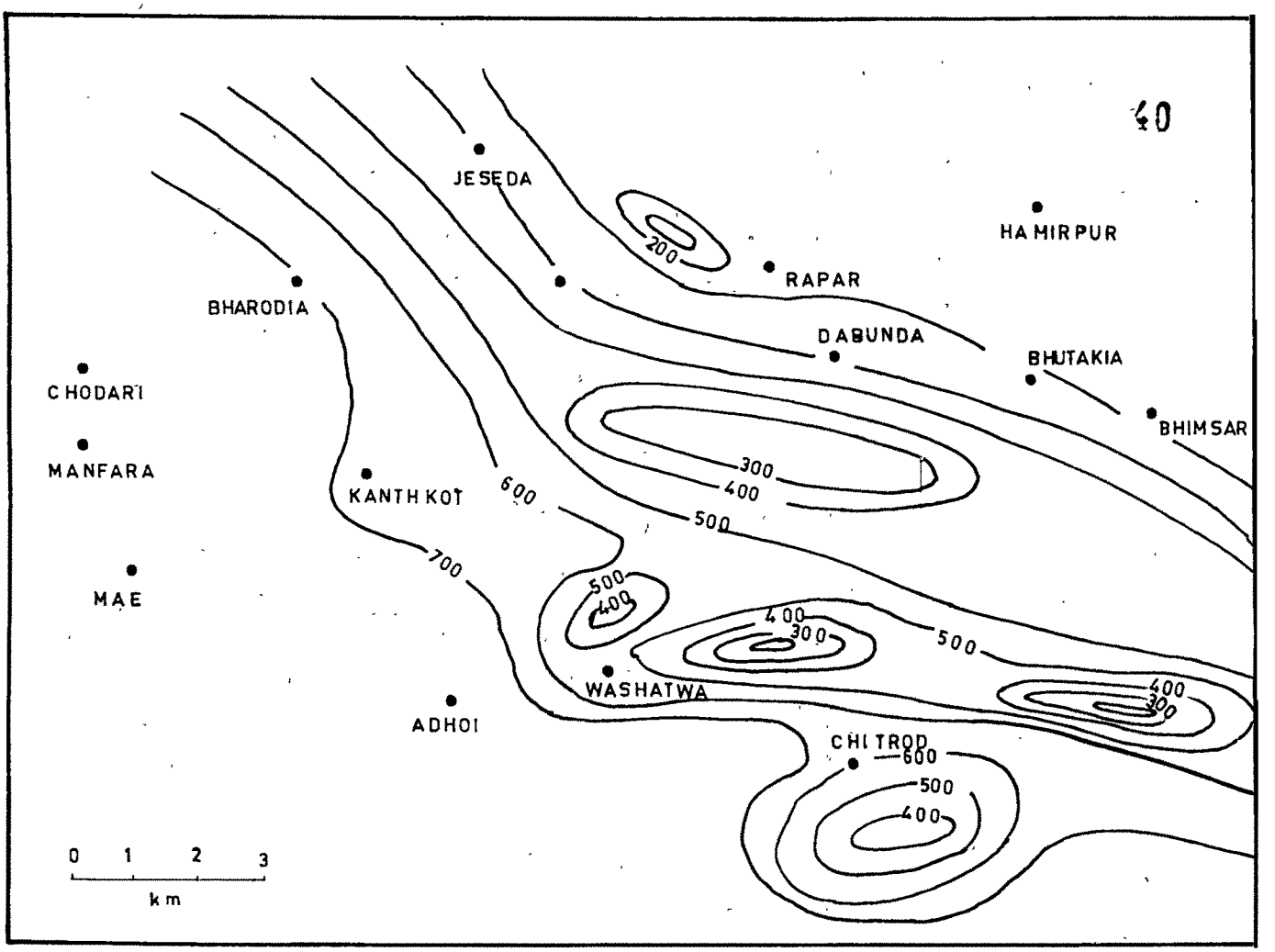


FIG. 9 Isopach Map of WASHATWA Formation (after Deshpande, 1972

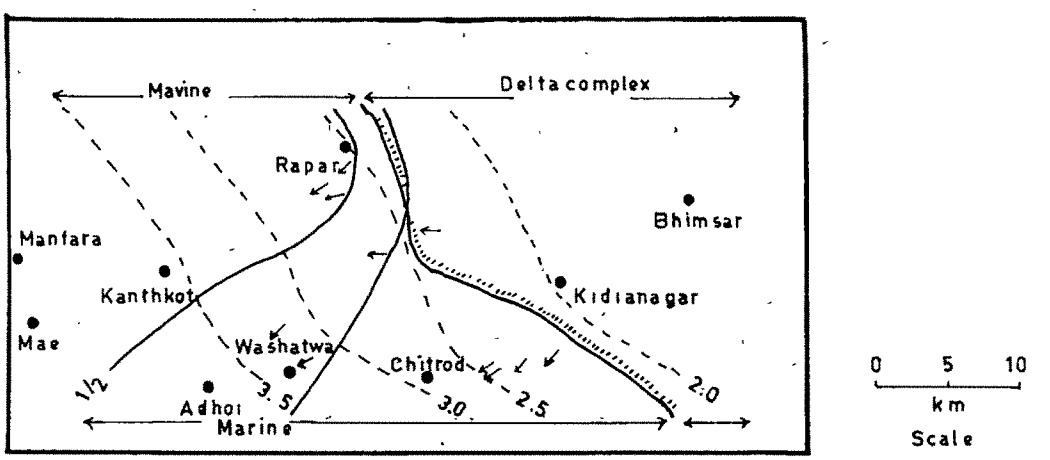


FIG. 10. WASHATWA Formation depositional pattens (after S.V.D. 1972)

Cross beding direction

2.0 Mean grain size of Sandstone in Phi

Strand line with delta to east and marine deposition to west

The Chitrod sandstones which occur in the eastern part receives its name from its exposures around Chitrod town. (Lat. 23° 24' & Long. 70° 43'). It is represented by yellowish, brown to grey micaceous sandstone and brown coloured highly bioturbated sandstones.

As a whole the measured stratigraphic sections of the Nara Shale Member and the Chitrod Sandstone Member indicate an increase in thickness as one traverses from east to west.

A fossiliferous red coloured mudstone band marks the top of the Nara Shale Member. This bed is important because it marks a time parallel plane denoting top of the Washatwa Formation. This bed can be located in Kanthkot, Nara, Narada, Dabunda and Tramau sections. The fossils occurring in this bed are ammonites, belemnites lamellibranchia, and occassionally gastropods. The fossil content and thickness of this band decreases towards east.

Deposition of Washatwa Formation is generally considered to have taken place in a shallow marine regressive cycle in the south west and delta mouth bar environment in the north-east with Rapar-Mewasa axis forming a lobate shoreline in relation to the delta (Fig. 10).

The age of the Washatwa Formation has not been definately established because of lack of diagnostic fossils.

Biswas (1977) suggested it as equivalent to the Gangta Member which is Argovian in age.

The Kanthkot Formation:

This formation disconformably overlie the Washatwa Formation and consists of a thick sequence of sandstone and shale alternations. The defination of the Kanthkot Formation used in this study is that of Deshpande (1972) which includes its two subdivisions in Lower Kanthkot Formation and the Upper Kanthkot Formation. The Lower Kanthkot Formation includes two members, viz. the Patasar Shale Member and the Fort Sandstone Member. The Upper Kanthkot Formation includes only one member called the Adhoi Member. The Kanthkot dome section (N. flank, Lat. 23° 29' & Long. 70° 27') has been the type section for the Upper Kanthkot Formation. The top of the Kanthkot Formation forms a distinct disconformity over which rests the Gamdau Formation.

The Kanthkot Formation is well exposed around the Chitrod Nara, Kanthkot, Washatwa, Adhoi, Halrae, Wamka, Mae, and Manfara section.

The thickness and extent of the Kanthkot Formation is shown in figure 11. This figure also indicates that the base of the Kanthkot Formation is exposed in the central and south central parts of the area and is indicated by the zero contour

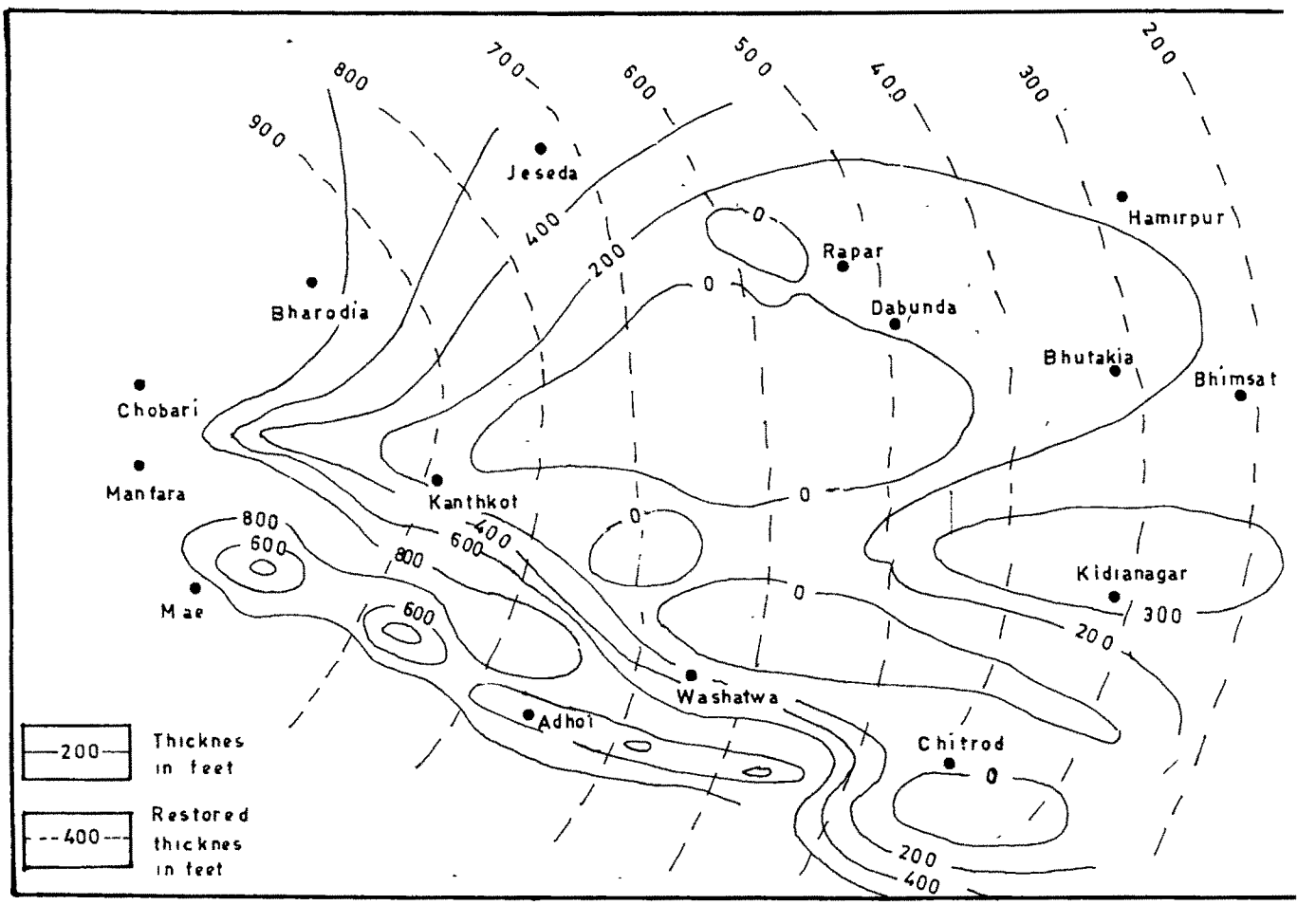


FIG. 11 Isopach Map of Kanthkot Formation.
(after Deshpanda, 1972)

line. The minimum isopach value is 200' in the north-east towards Bhimsar and Hamirpur. This value gradually increases towards SW and the maximum thickness over 800' is recorded near Wamka and Mae. The low values and the closures in the southern area is thought to be indicative of removal of sediments due to erosion. The pattern as a whole show a regional E-W strike that becomes roughly WNW-ESE in the south-western part and NE-SW in the north-western part.

The mean grain size as indicated by Deshpande (1972) for the Lower Kanthkot Formation in Bhimsar-Mewasa-Chitrod averaged between 1.0 to 2.0 Phi. In Adhoi-Washatwa it is about 2.5 phi, further westward around Nara-Adhoi, Kanthkot-Mae it varies between 2.0 to 2.5 phi. Thus the variation in mean grain size is from medium to fine from east to west.

The average mean grain size values for the Upper Kanthkot Formation varies from 2.0 phi in the Narada-Chitrod parts in the east to nearly 3.0 phi in west around Mae-Manfara. Thus the Kanthkot Formation as a whole shows a general decrease in the mean grain size from east to west as medium to fine sands.

The Lower Kanthkot Formation:

As mentioned earlier the Lower Kanthkot Formation is divisible into two members - the lower one known as the Patasar Shale Member, the upper one known as the Fort Sandstone

Patasar Shale Member:

The type section of this member is at Patasar tank near Kanthkot. Good exposures of this member can be located in Kanthkot, Nara, Kakarwa, Washatwa, Dedwara, Mewasa and Chitrod domes. The shales are mostly light grey to dark grey in colour with gypsum intercalations in the lower part and are grey to khaki and silty in the upper part. The upper part is often marked by brown siltstone gradually grading into friable sandstones. The Patasar Shale occur above the fossiliferous mudstone band of the Washatwa Formation and below the Fort Sandstone Member.

The Fort Sandstone Member:

The Fort Sandstone Member receives its defination from the Kanthkot Fort (Lat. 23° 26' & Long. 70° 26') which is built on this sandstone member. It comprises purple and ferruginous fine to coarse grained, friable sandstones. Good exposures can be located in the Chitrod, Washatwa, Nara, Kanthkot, Adhoi, Halrae, Wamka and Mae sections. The Fort Sandstone Member contains a variety of physical and biogenic structures. The physical structure include cross-beddings, ripple marks, sole marks, flute casts, scour and fill structures, etc. Tabular and cross trough bedding being more common. No significant microfossils are reported from this

member. The top of this member is marked with a conspicuous fossiliferous band known as the Lower Astarte band. It includes fossils of Astarte, Trigonia, Ostrea, Modiola, Gryphaea besides Belemnites and pieces of fossil wood. A few illpreserved ammonites were also found in this bed.

THE UPPER KANTHKOT FORMATION:

The Adhoi Member:

A complete succession of Adhoi Member deposited between the two prominent Astarte bands, viz. the Lower Astarte band and the Upper Astarte band is found in Adhoi, Washatwa, Halrae, Wamka, Kakarwa, Mae and Manfara sections. It is also reported from the flanks of the Chitrod dome. This member comprises grey to pinkish grey alternations of shales, siltstones and friable fine to medium grained sandstones. The sandstones are often cross-bedded with occassionaly gritty and ferruginous layers. Top of this member is marked by the Upper Astarte bed containing large sized lamellibranch fossils. The shales and siltstones of this member have yielded the following formainiferal forms indicating a Callovian-Oxfordain age (Shringarpure & Desai, 1975).

Robulus sp.; R. carinocordatus (Subottina & Srivastava); R. stepphensoni (Cushman); Lenticulina dilectaformis (Subottina & Srivastava), L. navicula (d'Orbigny), Palmula sp.,

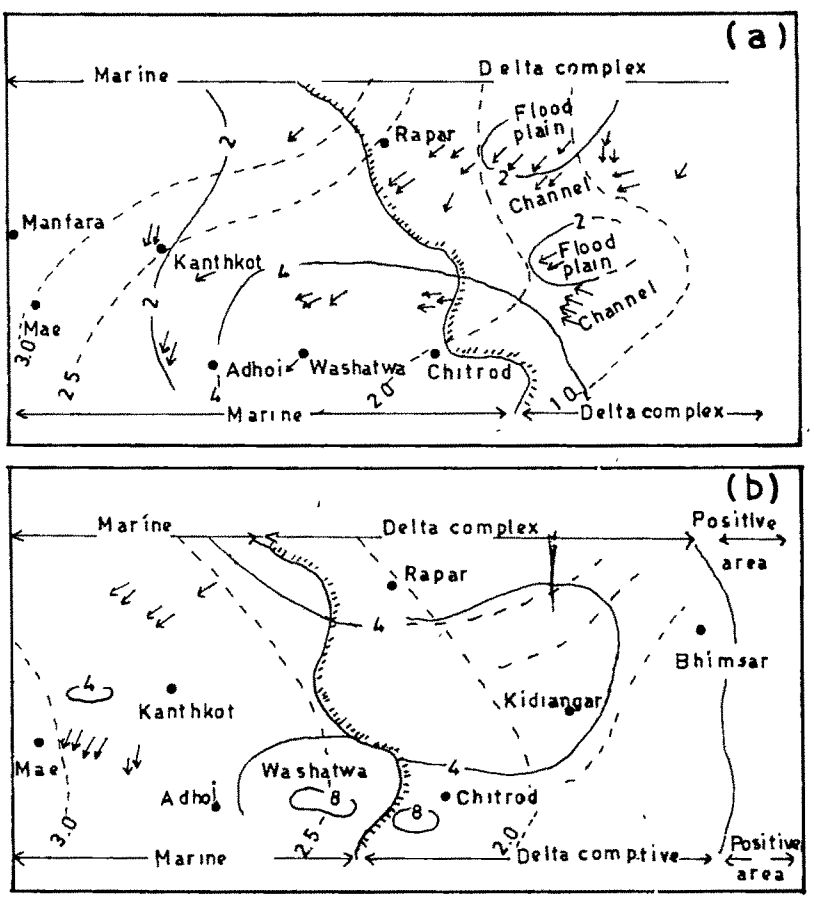


FIG. 12 - Depositional patterns of Lower Kanthkot (a) and Upper Kanthkot (b) Formation (after S.V.D. 1972) Legend as in fig. 10

Astacolus calliopsis (Reuss). A. renominata (Schwager), A centrogyrata (Terquem), Saracenaria sp., Marginylina? sp., Vaginulopsis hybrida (Terquem), Dentalina gracilis (d'Orbigny), Nodosaria sp., Nodosaria affinis (Ruess), Rectoglandulina oviformis (Terquem), Pseudoglandulina sp., Lagena sp., Lagena hispidi (Reuss).

The generalised pattern of deposition of the Kanthkot rocks is given in the figure 12.

Gamdau Formation:

Rocks of Gamdau Formation are restricted to the Manfara, Mae, Wamka, Halrae, and Adhoi dome sections and comprise Khaki to grey silty shales and flaggy yellowish brown fine to medium grained sandstone alternations. The name of this Formation is proposed by Deshpande (1972) from its type section in the Gamdau village. These rocks unconformably overlie the Upper Astarte bed of the Kanthkot Formation. Top of the Formation is, nowhere exposed since these rocks gradually dip subsurface beneath the alluvial or the Rann cover. The sedimentary structures developed in these rocks include asymmetrical ripples, flute casts and slump structures. The total thickness of this formation in Adhoi is 200' while at Halrae and Wamka it is about 310' & 160' respectively (Deshpande, 1972). In Mae, where the syncline opens out it is around 550' (Fig. 13). The formation as a whole occupies the

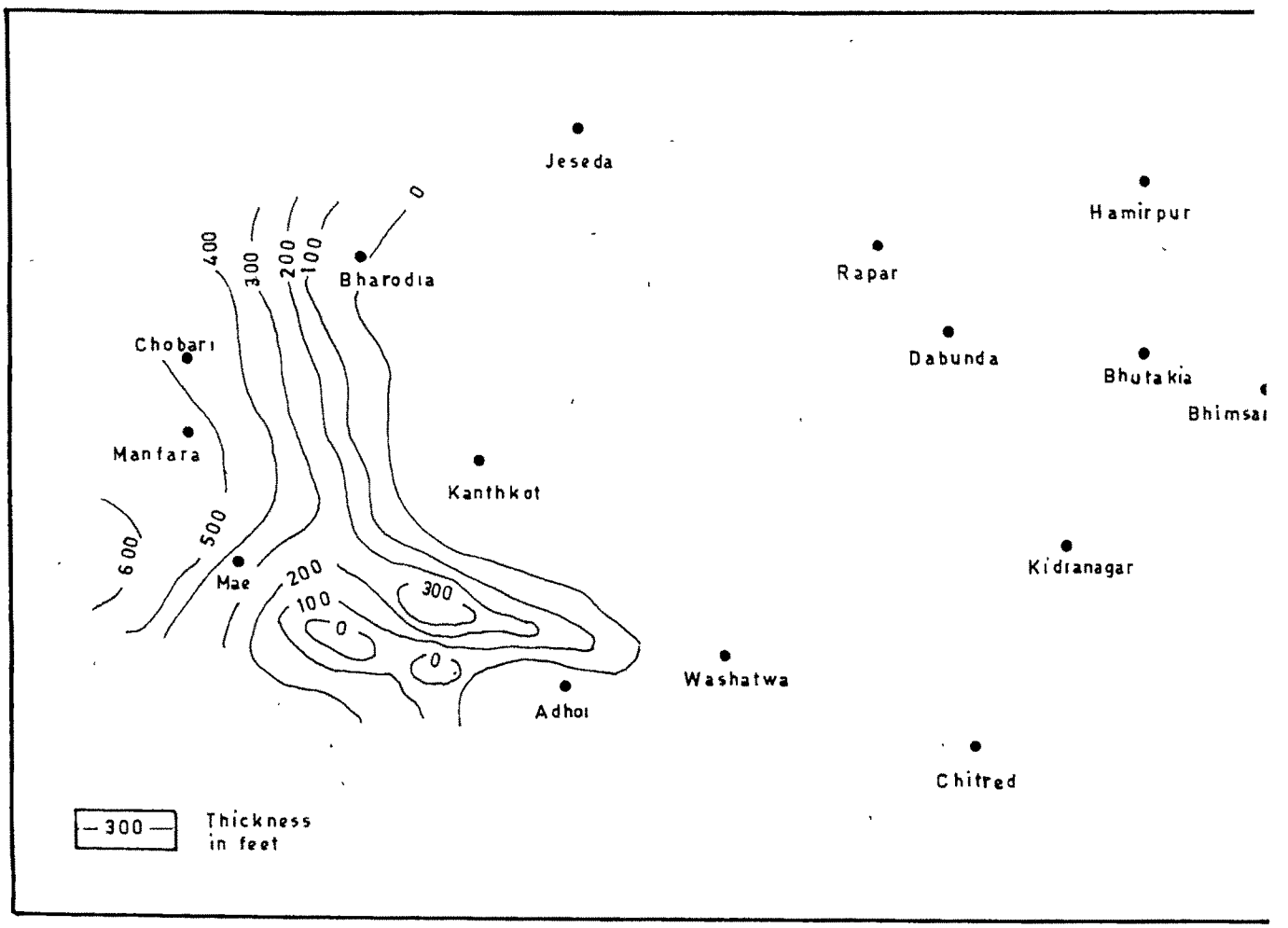


FIG. 13 Isopach Map of the Gamdau Formation
(after Deshpande, 1972)

southwestern and western part of the Kanthkot range and the southern range of hills in the form of a narrow north-south strip fringing the older rock formations. The Gamdau Formation as a whole is characterized by its "fining up" cycle. The microfauna includes the following foraminiferal species and is restricted to the lower part of the formation.

Lenticulina dilectaformis (Subottina and Srivastava); L. navicula (d' Orbigny); Palmula sp.; Astacolus callopsis (Reuss) Marginulina sp; Vaginulopsis sp.; Nodosaria sp.; Lagena sp.