CHAPTER - IV

F I E L D D I S T R I B U T I O N

GENERAL

The miliolite rocks of Kutch are exposed over the Mainland in its eastern and central inland areas in the form of isolated and scattered outcrops, extending from Bhachau in the east upto Nakhatrana in the west, and from the southern foothills of Central Highland upto northern foothills of Northern Hill Range, bordering the Banni Plains. These rocks are white to dirty white in color, occupying (i) low ground at the base of the hills, (ii) topographic depressions in hilly areas like valleys and plains surrounded by ridges and (iii) hollows on the slopes of the big hills and ridges, and show considerable diversity in their nature and modes of

occurrences. Most of these occurrences are characterised by dune-type current-bedding and alternate coarse and fine grained laminations (Plate IV. 1 & 2). The coarse laminae sometimes contain subrounded polished quartz grains in addition to the biogenic sand particles.

The author has mapped and recorded more than seventy exposures scattered over the study area (Fig. IV.1). They are seen resting over the older Pre-Quaternary rocks, right from Mesozoic upto Tertiary (Fig.IV.2). Almost all the occurrences can be clubbed together into SW-NE zones overlooking the sandy beaches of South Kutch coast; these zones comprised major topographic gaps which provided easy avenues for sand-laden southwesterly coastal winds to blow inlandward (Fig.III.1). Based on the mode of occurrence in different exposures, they have been categorised as under:

1 - Category - A : Obstacle deposits
2 - Category - B : sheet deposits

In the following pages of this chapter, the present author has described the various exposures as observed in the field. He has given all possible details recorded by him for the various occurrences. His description tends to be repetitive but this has been deliberately done to provide first hand data obtained by this author for the benefit and reference of all future workers.

Plate IV. 1

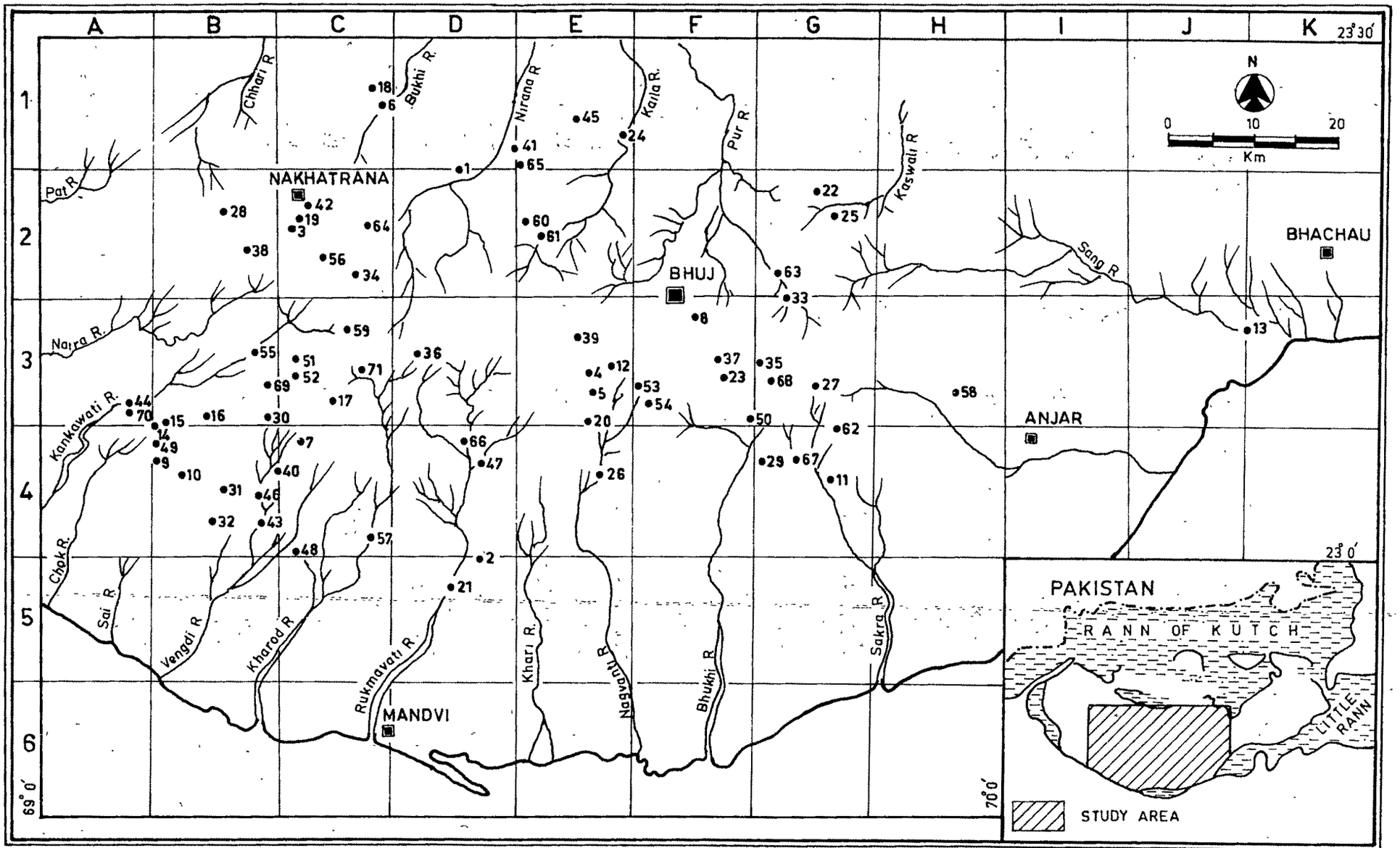
Field photograph of quarry face showing planar wedge type cross bedding
(Loc. Miliolite quarry, Bhopha Dongar)

Plate IV. 2

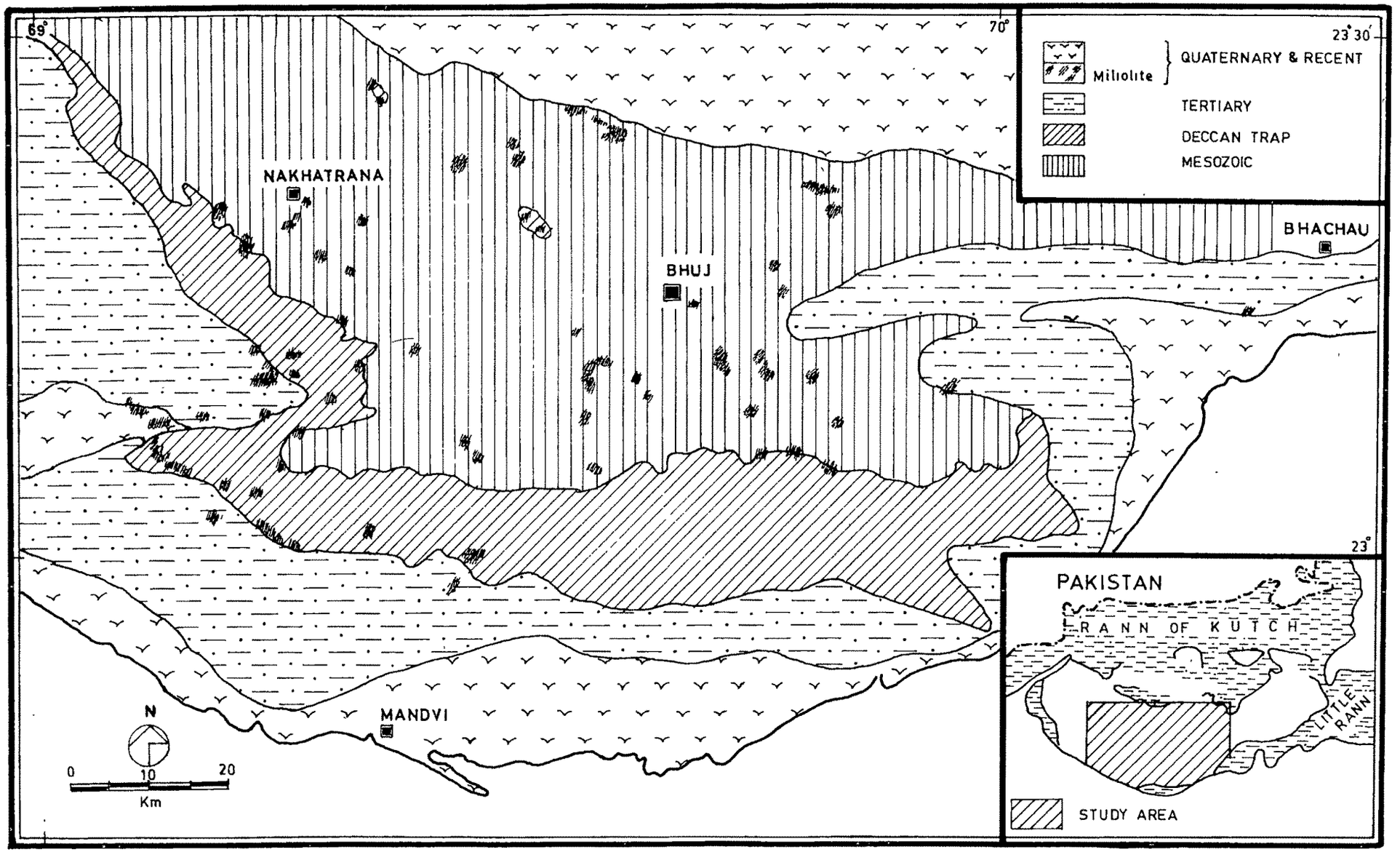
Miliolite sample showing alternate fine and coarse laminae
(Loc. Chirai Moti)

List of Miliolite Occurrences

Loc.No.	Reference	Locality	Loc.No.	Reference	Locality
1.	D_1	Arada Dongar	37.	F_3	Madhapar
2.	D_4	Asambia Nana	38.	D_2	Manki Dongar
3.	C_2	Boru	39.	E_3	Mankua
4.	E_3	Bharasar	40.	C_4	Maun Moti
5.	E_3	Dharasar	41.	E_1	Modisar
6.	C_1	Dhimasar	42.	C_2	Nakhatrana
7.	C_4	Dhopha Dongar	43.	B_4	Nangrecha
8.	F_3	Dhujia Hill	44.	A_3	Nundhatar
9.	B_4	Doha	45.	E_1	Palanpur
10.	B_4	Doha	46.	B_4	Poldiya
11.	C_4	Chandala	47.	D_4	Rampar
12.	E_3	Chaduva Dongar	48.	C_4	Ratadia Nana
13.	J_3	Chirai Mota	49.	B_4	Raydhonjar
14.	B_3	Chitrani Dongar	50.	F_3	Rehn Mota
15.	B_3	Chiyasar	51.	C_3	Roha
16.	B_3	Chiyasar	52.	C_3	Sanatorium
17.	C_3	Devpar	53.	F_3	Sanatorium
18.	C_1	Dhinodhar Dongar	54.	F_3	Sanatorium
19.	C_2	Dhodam Dongar	55.	B_3	Sanosra
20.	E_3	Godpar	56.	C_2	Shangnara
21.	D_5	Goniasar Mota	57.	C_4	Sherdi
22.	C_2	Habe Hill	58.	H_3	Sugaria
23.	F_3	Jadura Mota	59.	C_3	Sukhpur
24.	E_1	Jhura hills	60.	E_2	Sumrasar
25.	C_2	Jikadi	61.	E_2	Sumrasar
26.	E_4	Kera	62.	G_3	Tharauda
27.	G_3	Khatrod Hill	63.	G_2	Traya
28.	B_2	Kotada	64.	C_2	Vithon
29.	G_4	Kotada	65.	E_1	Wadasar
30.	B_3	Kotada	66.	D_4	Wadasar
31.	D_4	Kotadi	67.	G_4	Wadli
32.	B_4	Kotadi	68.	G_3	Wadli
33.	G_2	Lakhand	69.	B_3	Wandh
34.	C_2	Lakharia Dongar	70.	A_3	Wandh
35.	G_3	Lex Village	71.	C_3	Waramseda
36.	D_3	Madhapar			



Fig·IV.1 MILIOLITE OCCURRENCES (KUTCH)



Fig·IV·2 GEOLOGICAL MAP OF THE STUDY AREA WITH MILIOLITE EXPOSURES.

OBSTACLE DEPOSITS (A)

These rest against hollows and depressions on the hill slopes. The shape, thickness and extent of these deposits depends on the depth and shape of the hill slope hollows that they have occupied. They are usually triangular in shape and taper towards the upper margins of the dunes, the lower margins merge into the sheet miliolites. The thickness of such deposits varies from outcrop to outcrop ranging from few meters to as much as 30 m in their middle portion. For the purpose of description, on the basis of their median thickness, the author has classified these deposits as :

(i) Small sized deposits - thickness less than 2 m
(ii) Moderate sized deposits - thickness between 2 to 8m.
(iii) Large sized deposits - thickness more than 8 m.

These deposits usually show corss-stratification that consists dominantly of tabular and wedge planar sets. Cross laminations are commonly inclined at an angle of 5°-10° to the horizontal plane. The dip of forest varies from very gentle (< 5°) to quite steep (20°-35°). Abrupt reversal of the direction of dip are not uncommon. Presumably, the direction of dip within each cross-set reflects the orientation of of effective winds. In most cases, the

wedge-type cross-bedding is observed in the quarry faces on the southern slopes of the hills and ridges and indicates the wind direction (southwest and west-southwest). The deposits on the northern sides of the hills are characterised by tabular planar type of dune bedding following the slope of the obstacle, dipping gently (5°-20°) towards north and northeast. This type of dune structure developed in miliolite deposits is a product of a unidirectional wind regime (Mckee, 1966).

The obstacle deposits have been observed to comprise two distinct types as (i) windward face deposits (A_1) and (ii) leeward (slip-face) face deposits (A_2).

i) Windward Face Deposits (A_1)

These represent the accumulation of wind-borne material in the notches and depressions on the windward (southwestern and west-southwestern) slopes of the hills and ridges. These deposits are triangular in shape, thickest in middle part, ranging from few metre to as thick as 30 metre, and gradually thinning out at their upper limits. The lower limits usually merge into the sheet deposits at the foothills. They are commonly characterised by the wedge-type current-bedding with dips of foreset varying from 5° to as steep as 35°.

ii) Leeward (Slip-face) Face Deposits (A_2)

These rest on the leeward (northern and northeastern) slopes of the hills and ridges. The accumulations usually

follow the slopes of the obstacle, are in general, Pinch out in thickness as compared to the windward face obstacle deposits, and accumulate at different heights of the slope. The thickness of this type of deposit also varies from one exposure to another and range from few cm to as thick as 10 m. These deposits are commonly characterised by tabular planar sets of dune bedding with dips of foreset varying from 5° to 20° towards north and northeast. At most places, they are seen occurring on the leeward slope of ridges wherein the summit is marked by saddles across which the wind-borne material sails through and accumulates in hollows and depressions on the other side, as well as at the base. They also merge into sheet deposits at their lower margin and thin out at their upper margin towards the peak of the hill.

SHEET DEPOSITS (B)

These deposits occupy areas like older river valleys, rocky amphitheatres, flat-topped hills and pedeplains and occur at various elevations. On a cursory look they show a deceptive horizontality, but on a closer examination, these outcrops show a gentle dip varying from 2°-5° either due NE or SW, depending on the site of deposition i.e. the sheet deposits overlooking the southern and northern slopes of the hills and ridges reveal dips due SW and NE respectively. These types of deposits also show diversity in their thickness,

mode of occurrence and extent, from outcrop to outcrop. Considering their sites of accumulation and thickness, this category has been divided into following four types:

(i) Valley-fill deposits (B_1)
(ii) Sheets at the base of obstacle deposits (B_2)
(iii) Sheets as thin veneers within the hilly terrain (B_3)
(iv) Sheets resting on the flat-topped hills (B_4)

i) Valley-fill Deposits (B_1)

These deposits comprise accumulations of miliolite material in broad river valleys and in 'intermontane' depressions. These are sub-horizontal showing an imperceptible dip varying from 2°-5° due either SW or NE, and their mode of occurrence points to some interesting facts. Some of the valley filling sheets show distinct cross-lamination, pointing to their deposition by aeolian processes, while there are others which appear to have been deposited at their present sites by fluvial transport-miliolite sands having been carried from nearby areas during flash floods. Such deposits occasionally contain layers of pebbles and cobbles locally concentrated along the bedding plane. Today these sheet deposits are observed as well-defined cliffy banks of the order of few cm to as thick as 10 m. Obviously, they were

first deposited and subsequently dissected by the present day streams that flow along the valleys. Such cliffy miliolite sheets occur on either or both banks. Some of the larger valley-fill sheets are observed to occur at progressively increasing altitudes from SW to NE, though maintaining a broad horizontality.

ii) Sheets at the base of the obstacle deposits (B_2)

These comprise miliolite sheets associated with obstacle dunes, representing their base. The lower margin of most of the obstacle deposits are seen to merge gradually into 1/2 to 2 m thick sheets towards the foothill, which in turn thin out towards the low ground facing the hill ranges and gradually pass into peneplain ground.

iii) Sheets as thin veneers within the hilly terrain (B_3)

These types are quite common but, sometimes difficult to observe and record. These consist of discrete patches never exceeding a metre or two in thickness and forming discontinuous and sporadic veneers over older rocks of palaeosoil . This type of miliolite is recorded at many places in front of or at the back of ridges providing sheltered sites. The more conspicuous occurrences of such thin sheets are observed in amphitheatre-like low grounds and pedeplains.

iv) Sheets resting on the flat-topped hills (B_4)

These also comprise sheets of miliolite that rest over flat-topped isolated hills protected by higher hill ranges in the background, and represent accumulations at varying levels depending on the heights of the hill tops. Such occurrences are not very common but provide a striking example of the accumulation of wind-borne material on the flat tops at different heights. These miliolite outcrops could be very deceptive and to a casual observer, may look like marine deposits. It was perhaps such occurrences that led Merh (1980) to invoke marine sheets of miliolite at various levels.

The mode of occurrence of various miliolite exposure of Kutch Mainland described above, indicates that there is a close relation between these two wind-borne miliolite categories, viz. obstacle deposits (A) and sheet deposits (B). The genetic relationship between the various types of miliolite occurrences within the two categories has also been schematically shown in Fig.IV.3.

The mode of occurrence and distribution of various miliolite exposures of the study area which have been fitted into the above categories have been summarized in Table IV.1 & 2.

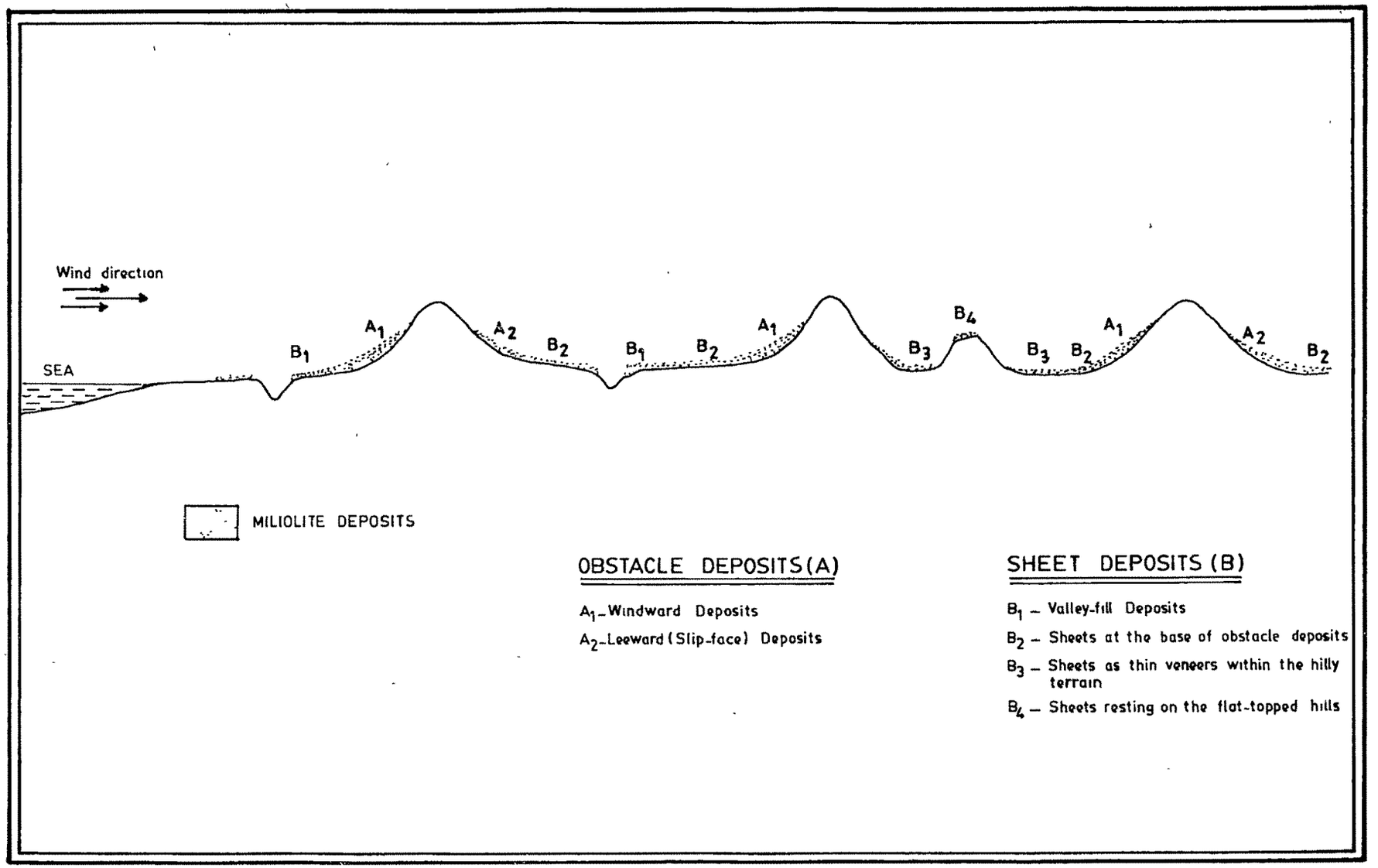


Fig.Ⅳ 3 Schematic diagram showing the relation between various types of Kutch miliolites.

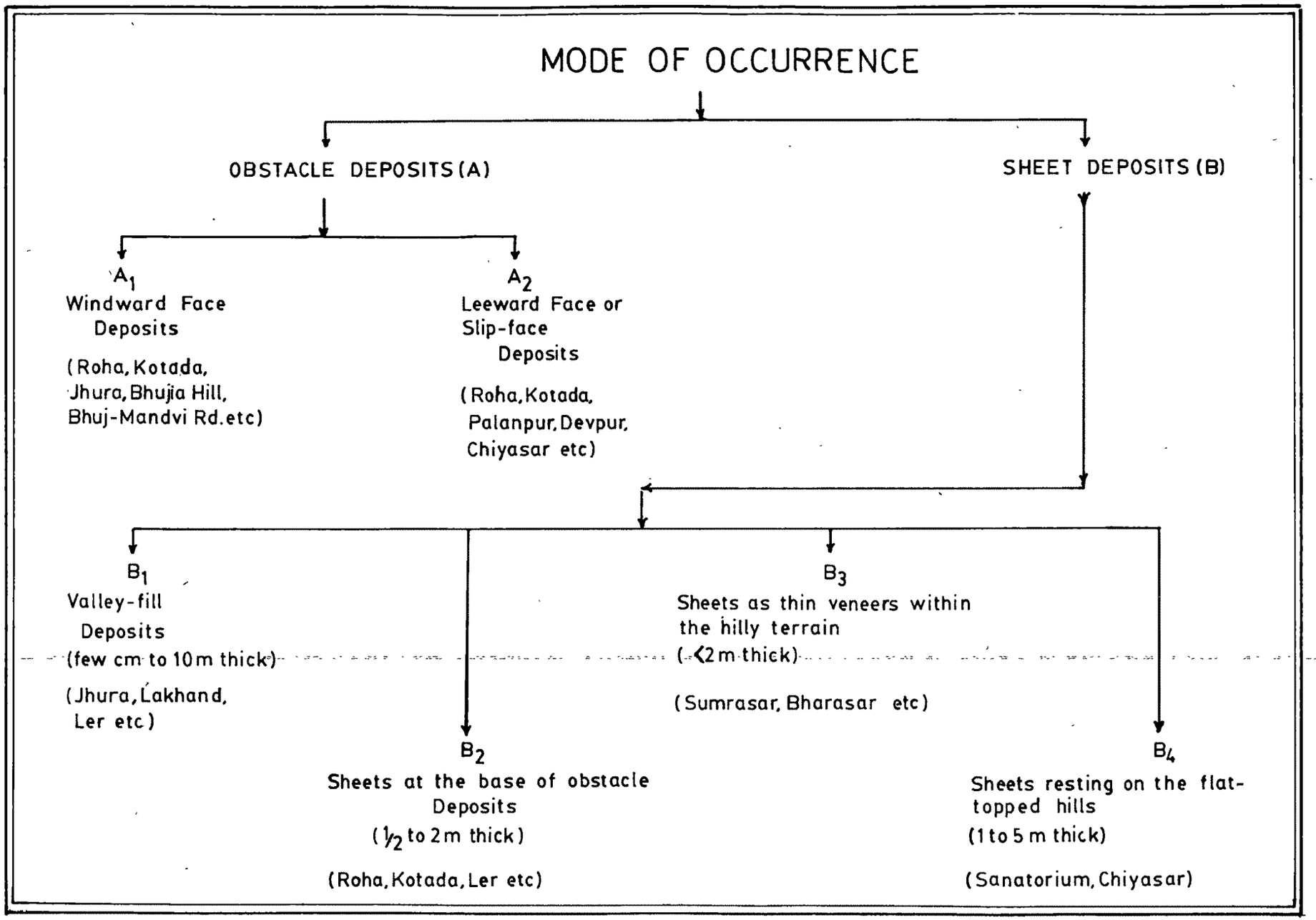


Table IV-1 MODE OF OCCURRENE OF KUTCH MILIOLITES

Table IV. 2 Distribution and occurrences of miliolite rocks of Mainland Kutch.

Miliolite Loc.Nos.	Locality	Location reference (Fig.IV.1)	Miliolite categories					
			Obstacle (A)		Sheet (B)			
			A_1	A_2	B_1	B_2	B_3	B_4
1	Arada Dongar (312 m) (N. of Tharawada)	D_1	*			*		
2	Asambia Nana(1.5 km NE) (Bhuj-Mandvi Road)	D_4			*		*	
3	Beru (2 km N) (S. of 254 m hill)	C_2	*			*	*	
4	Bharasar (3.5 km SE)	E_3	*	*	*	*	*	
5	Bharasar (3 km SSE) (N of 251 m hill)	E_3	*			*	*	
6	Bhimasar (2 km W) (In Bhukhi River)	C_1				*		
7	Bhopha Dongar (227 m) (2 km NW of Ratnapar)	C_4	*		*	*		
8	Bhujia Hill (SE of Bhuj)	F_3	*			*		
9	Boha (NW) (Between Boha and Raydhanjar)	B_4	*			*		
10	Boha (SE) (Between Boha and Kotadi)	B_4				*	*	
11	Chandala (1 km S)	G_4		*		*	*	
12	Chaduva Dongar (258 m) (Bhuj-Mandvi Road)	E_3	*	*	*	*	*	

* Types present

Table IV.2 (contd)

Miliolite Loc.Nos.	Locality	Location reference (Fig.IV.1)	Miliolite categories					
			Obstacle (A)		Sheet (B)			
			A_1	A_2	B_1	B_2	B_3	B_4
13	Chirai Mota (8 km SW of Bhachau)	J_3	*					
14	Chitrani Dongar (188 m)	B_3	*	*		*		
15	Chiyasar (4 km W) (on 169 m Hill)	B_3	*			*		*
16	Chiyasar (3 km E)	B_3	*	*	*	*		
17	Devpar (3.5 km N) (274 m Hill)	C_3	*					
18	Dhinodhar Dongar (388 m)	C_1	*		*	*		
19	Dhodam Dongar (271 m)	C_2	*	*		*	*	
20	Godpar (7 km NE) (Bhuj-Mandvi Road)	E_3			*		*	
21	Goniasar Mota	D_5			*		*	
22	Habo Hill (N of Baladia)	G_2	*		*	*	*	
23	Jadura Mota (3 km N)	F_3	*			*	*	
24	Jhura Hills	E_1	*	*	*	*	*	
25	Jikadi (3 km E)	G_2		*	*	*		
26	Kera (2 km NW)	E_4	*	*	*	*	*	
27	Khatrod Hill (349 m)	G_3	*	*	*	*	*	
28	Kotada (on 230 m hill) (Near Nakhatrana)	B_2	*	*		*		

* Types present

Table IV.2 (contd)

Miliolite Loc.Nos.	Locality	Location reference (Fig.IV.1)	Miliolite categories					
			Obstacle(A)		Sheet (B)			
			A_1	A_2	B_1	B_2	B_3	B_4
29	Kotada (Near Reha Mota)	G_4		*		*	*	
30	Kotada (Near Roha)	B_3	*	*	*	*	*	
31	Kotadi (3 km NNE)	B_4	*	*	*	*		
32	Kotadi (½ km S) (In tributary of Vengdi River)	B_4			*			
33	Lakhand	G_2	*	*	*	*	*	
34	Lakharia Dongar (363 m)	C_2		*				
35	Ler Village	G_3	*	*	*	*	*	
36	Madhapar (2 km SW) (on 348 m Hill)	D_3	*	*		*	*	
37	Madhapar (5 km S) (on 259 m Hill)	F_3		*		*	*	
38	Manki Dongar (311 m)	B_2	*	*		*	*	
39	Mankua (In Ratia Nala)	E_3			*			
40	Maun Moti (2 km SW) (In Khadkawali Nadi)	C_4			*		*	
41	Medisar	E_1	*	*	*	*	*	
42	Nakhatrana	C_2	*	*				
43	Nangrecha (1 km N) (In Vengdi River)	B_4			*			

* Types present

Table IV.2 (contd)

Miliolite Loc.Nos.	Locality	Location reference (Fig.IV.1)	Miliolite categories					
			Obstacle (A)		Sheet (B)			
			A_1	A_2	B_1	B_2	B_3	B_4
44	Nundhatar	A_3	*	*	*	*		
45	Palanpur (2 km S)	E_1		*		*	*	
46	Poldiya (2.5 km S)	B_4	*		*	*		
47	Rampar (In tributary of Rukmavati River)	D_4			*			
48	Ratadia Nana	C_4	*		*	*		
49	Raydhanjar (2 km NE)	B_4	*	*		*		
50	Reha Mota (In Bhukhi Nadi)	F_3			*			
51	Roha	C_3	*	*	*	*		
52	Roha (3 km SW) (on Roha-Kotada Road)	C_3					*	
53	Sanatorium (2 km NE)	F_3						*
54	Sanatorium (2 km S)	F_3	*		*	*	*	
55	Sanosra (Nandra Fort)	B_3			*		*	
56	Shangnara (1.5 km S)	C_2	*	*		*	*	
57	Sherdi (In Kharod Nadi)	C_4			*			
58	Sugaria (3 km SE)	H_3					*	
59	Sukhpur (1.5 km N) (on 350 m Hill)	C_3	*					

* Types present

Table IV.2 (contd)

Miliolite Loc.Nos.	Locality	Location reference (Fiv.IV.1)	Miliolite categories					
			Obstacle (A)		Sheet (B)			
			A_1	A_2	B_1	B_2	B_3	B_4
60	Sumrasar (2 km NW) (on 249 m Hill)	E_2	*	*		*	*	
61	Sumrasar (1.5 km SW) (In Bharod Nadi)	E_2			*		*	
62	Tharauda (1.5 km NW)	G_3	*		*		*	
63	Traya (on 257 m Hill)	G_2	*	*	*	*	*	
64	Vithon (S of 281 m Hill)	C_2	*					
65	Wadasar (2.5 km N) (S. of Medisar)	E_1	*		*	*		
66	Wadasar (1 km S) (NW of Rampar, in Rukmavati River)	D_4			*		*	
67	Wadli	G_4	*	*	*	*	*	
68	Wadwa (1 km NE)	G_3	*			*	*	
69	Wandh (Near Bhojraj)	B_3					*	
70	Wandh (Near Nundhatar)	A_3				*		
71	Waramseda	C_3	*	*		*		

* Types present

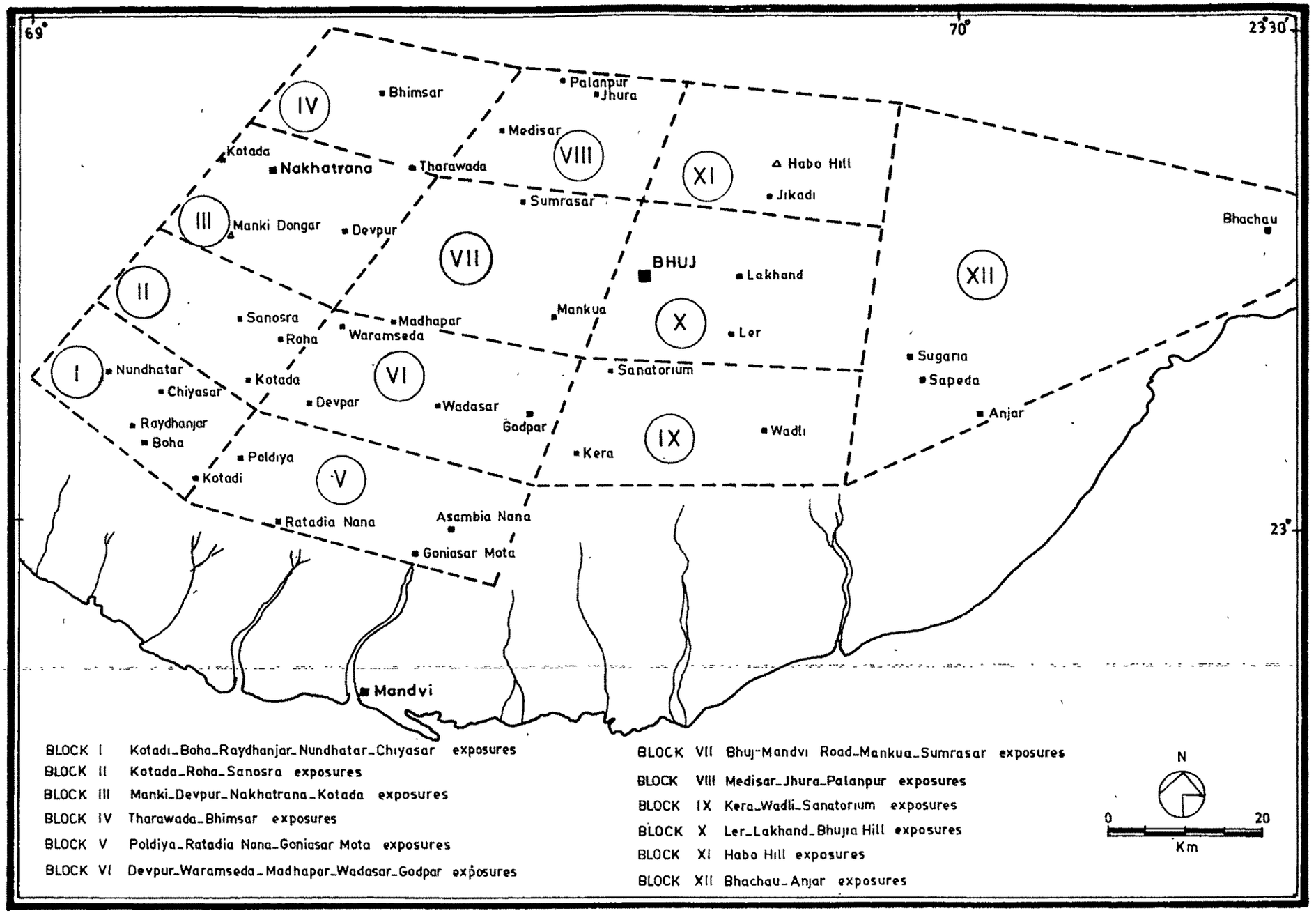
BLOCKWISE DESCRIPTION

In order to understand the relationship between the adjoining miliolite exposures, the author has, for the purpose of convenience grouped the various miliolite exposures spread over the study area into twelve blocks as shown in Fig.IV.4 and have described them in the following text.

Block I: Kotadi-Boha-Raydhanjar-Nundhatar-Chiyasar exposures

Between Raydhanjar and Kotadi the drainage is southwesterly and all the low order streams originating from the trappean highland, meet the chok, Sai and Vengdi rivers. Between the altitude range of 80 to 120 m, sheets of miliolite occur on the two flanks of these streams forming cliffy bank deposits (Plate IV.3). The thickness of miliolite increases in the upstream direction, to as much as 4 m, and finally the dunes abut against the rocky slopes giving rise to moderate sized windward obstacle deposits. Between Boha and Kotadi almost 2 to 3 m thick horizontal sheet miliolites occupy the low ground and rest on the older Tertiary rocks showing 2° to 5° dip due south.

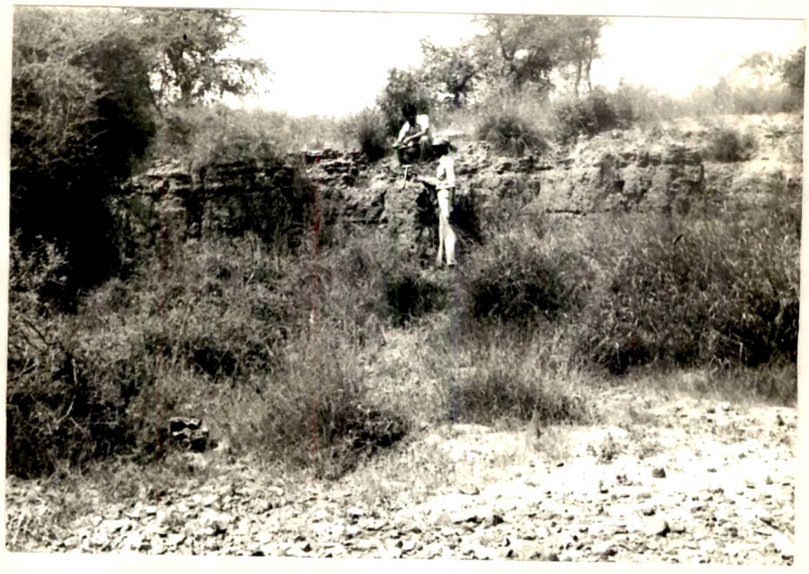
A moderate sized windward face obstacle deposit occurs on the southern slope of Chitrani Dongar (188 m), located NE of Raydhanjar village. The aeolian cross-beddings are



BLOCK I Kotadi_Boha_Raydhanjar_Nundhatar_Chiyasar exposures
BLOCK II Kotada_Roha_Sanosra exposures
BLOCK III Manki_Devpur_Nakhatrana_Kotada exposures
BLOCK IV Tharawada_Bhimsar exposures
BLOCK V Poldiya_Ratadia Nana_Goniasar Mota exposures
BLOCK VI Devpur_Waramseda_Madhapar_Wadasar_Godpar exposures
BLOCK VII Bhuj-Mandvi Road_Mankua_Sumrasar exposures
BLOCK VIII Medisar_Jhura_Palanpur exposures
BLOCK IX Kera_Wadli_Sanatorium exposures
BLOCK X Ler_Lakhand_Bhujia Hill exposures
BLOCK XI Habo Hill exposures
BLOCK XII Bhachau_Anjar exposures

Fig·IV·4 BLOCKWISE DISTRIBUTION OF MILIOLITE.

Plate IV. 3



Sheet miliolite forming cliffy banks (Loc: Chok River, SE of Raydhanjar village)

present, but not well developed. To the east of Chiyasar, all along the northern and southern foothill of the narrow E.W elongated hill (175 m), small patches (sheets) of 30-40 m long miliolite deposits of 30 cm to1 m thickness are recorded. The miliolite is also seen to occur along the southern slope of the E.W trending hill (169 m) and northern slope of Chitrani Dongar (188 m) occupying the rain gullies, and form windward and slip-face deposits respectively.

The sheet miliolites are also seen to occur at the base and over the flat-topped trappean hill (169 m), located to the NE of Chitrani Dongar (188 m) and west of Chiyasar. The latter deposit thickness range from a few cm to as much as a metre and show a gentle dip of 2°-5° due south; on a careful observation, they reveal aeolian cross-beddings. The sheet miliolites occurring at the base of the hill, and the one resting on the top of the hill, show a height difference of about 40 m, and give an erroneous impression of faulting. As a matter of fact, there are no indications of any faulting, and in reality the two occurrences represent accumulations of wind-borne material over a pre-miliolite topography having this height difference.

On the southern and northern slopes of an E-W elongated trappean hill (164 m), situated to SE of Nundhatar village moderate sized miliolites occur as windward and leeward

deposits respectively. These deposits extend Southward and northward in the foothill areas and merge into sheet deposits; later vertical cutting of these sheets by the streams that join the Kankawati river, has given rise to cliffy banks of about 2 metre thick miliolite (Plate IV.4).

Block II: Kotada-Roha-Sanosra exposures

The Kotada exposures located 43 km WSW of Bhuj city and 7 km SSW of Roha village, occur within an approximate area of 10 sq.km. and dominantly comprise obstacle deposits and sheet miliolites, resting over Deccan Trap. Physiographically, the trap hill range shows a WNW-ESE trend and varies from 1.5 to 4 km in width. The southern and northern slopes of the range support a number of rain gullies and 1st order channels, that meet the Vengdi and Kankawati Nadi respectively. The hollows excavated by these streamlets have provided ideal sites for the accumulation of wind blown material and formation of obstacle dunes. These obstacle deposits are large in size and support numerous quarries (Plate IV.5). The quarry faces reveal well-developed wedge-type cross-beddings. These deposits occur at the altitude between 160 to 180 m. It is also observed that the wind-borne miliolite material has crossed over the summit through a gap between the two high peaks (259 m and 240 m), and has been dumped on the leeward side (northern side), giving rise to slip-face deposits.

Plate IV. 4

Cliffy miliolite sheet deposits
(Loc: Tributary of Kankawati river
near Nundhatar village)

Plate IV. 5

Patchy occurrences of slip-face miliolite
deposits facing the saddle opening
(Loc: Kotada hills)

Farther downslope, these extend upto the foothills, merging into thin sheets (Plate IV.6). To the south of this range, the sheet miliolites occur as 2-4 m thick cliffy banks in the various tributary streams of vengdi river. A few obstacle dunes are also recorded on the southern and southwestern slopes of 281 m high conical trappean hill, located to the north of the Kotada hill range and southeast of Roha village. These deposits are large in size supporting a few quarries and show dune cross bedding; on an average individual set of cross strata dip 20°-30° (Plate IV.7).

Roha village is located 7 km NE of Kotada and about 40 km inland from south Kutch coast. Here also the miliolite occur as obstacle and sheet deposits. The conspicuous dunes are located on the southern and northern slopes of the E-W Roha Fort trappean hill (266 m), just to the north of Roha village. These dunes occupy the rain excavated gullies and depressions (Plate IV.8). On the southern slope windward accumulations of miliolite show conspicuous wedge-type aeolian cross-bedding with foreset dip varying from 15° to 20°. These dunes contain numerous angular fragments of locally derived trap fragments rolled down from the hill top. At the base of the hill, these deposits have merged into horizontal sheets and extend for about 200 m and gradually thining out south-ward (Plate IV.9). Altitudewise, these sheet miliolites are seen to occur at the levels between

Plate IV. 6

Slip face miliolite deposits facing the saddle opening
(Loc: Kotada hills)

Plate IV. 7

Field photograph showing windward obstacle deposits merging into sheet miliolites
(Loc: 3 km E of Kotada village)

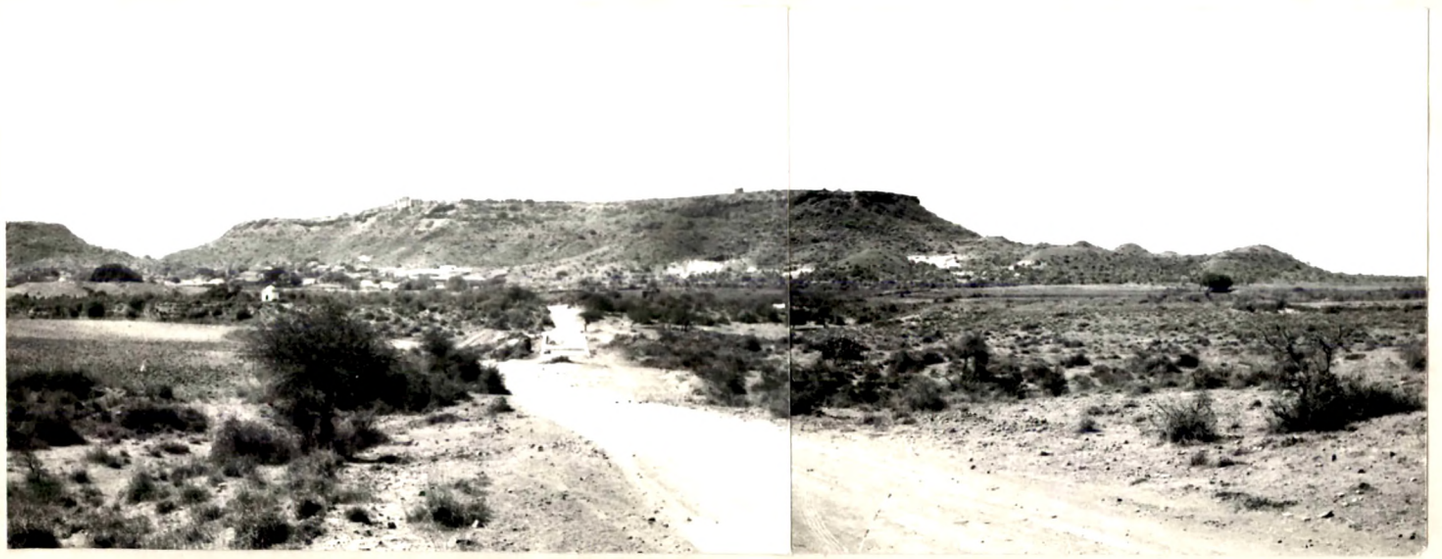


Plate IV. 8 Panoramic view of Roha hill showing windward obstacle deposits

160 and 180 m, and are quite often cut by subsequent stream channels, giving rise to 1 to 1.5,m thick cliffy banks (Plate IV.9). On the northern slope of the hill small sized slip-face deposits of miliolite occur behind the saddle openings. These deposits show foreset dips ranging from 8° to 10° which coincides with the slope of the hill (Plate IV.10). The northward extension of these deposits has finally merged into a thin sheet of miliolite, at the foot hill. In fact, the low lying ground on the northern side of this hill is covered with about 1/2 m thick veneer of miliolite. Slip-face dunes also occur on the northeastern and eastern slopes of the 220 m high NNE-SSW trending hill located just to the west of the Roha village. They are small in size and show 5°-10° foreset dip due N, and NE (Plate IV.11 & 12). All these deposits gradually pass into low ground forming sheet deposits.

Between Kotada and Roha near Wandh Bhojraj village, the amphitheatre-like low ground has been covered with a thin veneer of miliolite, ranging in thickness from few cm to 1 m.

At Sanosra village, on the left bank of Kankawati river, a thin impure sheet of almost horizontally bedded miliolite is recorded. This deposit shows imperceptible dips of 2°-5° due SW. Significantly, the terrain between Sanosra, Naredi, Bhittar and Chiyasar villages that forms the intervening

Plate IV. 9

Windward obstacle deposits merging into sheet miliolites (Loc: Eastern fringe of Roha hill)

Plate IV. 10

Slip-face deposits behind the saddle opening (Loc: Roha hill)

Plate IV. 11

Miliolites forming slip face obstacle deposits (Loc: hill ranges, W of Roha village)

Plate IV. 12

Leeward miliolite deposits (Loc: W of Roha village)

region between the various tributaries of Kankawati river, is devoid of miliolite deposits.

Block III: Devpur-Nakhatrana-Kotada exposures

On the southern, northern and northeastern slopes of the trappean Manki Dongar (311 m), near the village Wehar, the miliolite deposits occupy the hill slope depressions and show a gentle foreset dips of 10° to 15°. This deposit is moderate in size and tapers upward and passes into sheet miliolite at the base of the hill.

Near the village Kotada, 7 km SW of Nakhatrana, numerous moderate sized (windward as well as leeward) obstacle dunes are present. These deposits also show horizontality at the foothills.

12 km east of Manki Dongar (311 m) and 3 km SW of Devpur, a striking large sized miliolite deposit occupies the northern flanks of the Lakhadia Dongar (363 m). This deposit typically comprises a slip-face dunes representing aeolian material accumulated in the notches and depressions deveral metres above ground level (Plate IV.13). The author has been tempted to designate this rather unusual mode of occurrence, as a 'perched dune'.

A moderate sized slip-face deposit is located about one km south of the village Shangnara, (Plate IV. 14) and

Plate IV. 13

Field photograph showing a typical slip-face deposit (perched dune) in the Lakhadia Dongar (Loc: 3 km SW of Devpur)

Plate IV. 14

Slip-face deposits showing tabular dune bedding (Loc: 1 km S of Shangnara village)

shows foreset dip ranging from 15° to 20°. The low ground to the north of the hill range shows sporadic occurrences of thin miliolite veneer of varying thicknesses ranging from few cm to as thick as a metre. On the southern slope of this hill range the usual windward face deposits which are large in size and extend to the foot of the hill forming sheet miliolites, occupy the various topographic hollows.

The miliolite occurrences around and to the SE of Nakhatrana are spread within an area of several sq.km. and comprise obstacle dunes of both varieties; good exposures are recorded from the northern, southwestern and southeastern slopes of 280, 334, 246 and 288 m high hills. The dunes on the SW slopes, typically consist of windward aeolian accumulations, ranging from moderate to small in sizes, depending on the hollows they occupy. The hill slopes are characterised by ruggedness on all sides, and at the crest, a number of saddles provided the gaps for the wind-borne material to cross over the summits and accumulate on the northern slope as slip-face dunes.

The moderately sized miliolite is also seen to occupy the western, southern and northern slopes of the trappean Dhodam Dongar (271 m), as windward and leeward face deposits. The slip-face deposits extension to the foothill form sheets

of about a metre thick exposure.

The northern as well as southern slopes of the various isolated hills and small ridges (220 m, 254 m), lying to the east and south of Nakhatrana, are replete with moderately sized obstacle deposits.

Block IV : Tharawada - Bhimsar exposures

The hollows on the southern slopes of Arada Dongar (312 m), located 4 km north of Tharawada village, have been filled with numerous moderate sized obstacle dunes, characterised by aeolian wedge-type current-beddings, and support numerous small quarries. Here also the sheet miliolite of about a metre thick, cover the base of the hill.

Exposures of triangular shaped miliolite deposits are also met with on the southern, southwestern and southeastern slopes of the trappean Dhinodhar Dongar (388 m), located 3 km NW of the village Bhimsar. These deposits are characterised by a distinct alternate coarse and fine laminae, showing a gentle foreset dip ranging from 10 to 15° due south. Locally derived scree debris is seen embedded in them. The sheet deposits at the base of the dune have been cut across by Bukhi Nadi (presently a dry seasonal stream) forming striking cliffy banks.

Block V : Poldiya-Ratadia Nana-Goniasar Mota exposures

Between Poldiya-Ratadia Nana and Goniasar Mota the drainage is southerly. All the various low order streams originate from the trappean highlands and meet Vengdi, Kharod and Khadkawali rivers. Between the altitude range of 80 and 120 m, sheets of miliolite occur on both the sides of these streams, forming cliffy outcrops. The thickness of miliolite is observed to increase from a few cm at lower altitudes to as much as 2 to 4 m at higher altitudes. At higher levels, the sheet miliolites abut against the rocky slopes and form as moderately sized windward face obstacle deposits (Plate IV.15). Similar exposures are again encountered in the south and southwest flowing streams located about 3 km northeast of Kotadi.

Between Kotadi and Poldiya, large sized miliolite accumulations are seen to occupy hollows on the windward and leeward slopes of 197 m high hill range. Here also the deposits are seen extending towards the low ground and gradually merging into horizontally bedded sheet miliolites. The vertical cutting of these sheet deposits by Vengdi river has given rise to 3 to 4 m thick banks of miliolite (Plate IV.16).

Near Nangrecha village a very interesting exposure of miliolite, about a km long is observed to occur on both the banks of Vengdi river. Here the constituents are somewhat coarser in nature and show very well developed dune

Plate IV. 15

Thin veneers facing the windward obstacle deposits (Loc: W of Poldiya village)

Plate IV. 16

Sheet miliolite deposits showing cliffy banks in the vengadi river section (Loc: W of Poldiya)

cross-beddings with numerous intercalations of coarse fluvial material. This interbedding of aeolian layers with gravelly beds could be considered comparable with what Glennie (1970) has described as "wadis and desert fluviatile sediments". These are a very good indication of the alternating dry and wet phase during the deposition of miliolite. The presence of gravelly beds points to the rapid flow of water due to flash flooding concomitant with concentration of pebbles during the wet phase; the cross-bedding is indicative of a dry phase during which the aeolian transportation of miliolitic sands took place (Plate IV.17). Another very interesting structure which is observed in this miliolite outcrop is that of plant-root moulds. Glennie & Evamy (1968) have used the term 'dikaka' for this type of structure, and have stated that "the few small burrows must not be confused with similar phenomena occurring in, say, estuarine sands and formed by burrowing animals". On going away from the banks, this sheet is seen extending for a few metres and there gradually thinning out, merging into the rocky pedeplain (Plate IV.18).

Occurrence of sheet miliolite is observed at Ratadia Nana, along the left banks of Khaḍkawali Nadi, a tributary of Kharod Nadi. Here also the miliolite forms a cliffy bank of 3 to 4 m thick; it gradually thins out after a few hundred metres in the downstream direction (Plate IV.19).

Plate IV. 17

Wedge-type cross beddings and gravally laminations in the sheet miliolites in the vengdi river section (Loc. NE of Nangrecha village)

Plate IV. 18

Cliffy miliolite deposits merging with rocky pedeplain (Loc: Vengadi river near Nangrecha village)

Plate IV. 12

Miliolite showing cliffy banks in
Khadkawali river section
(Loc: Near Ratadia Nana village)

Near Goniasar Mota and Asambia Nana villages, on the left bank of river Rukmavati, semi-consolidated miliolite deposits of about a metre thickness is seen resting on the lateritic rocks. These horizontal-looking sheet deposits, on a careful observation show cross-laminations (Plate IV.20).

Block VI : Waramseda-Madhapar-Wadasar-Godpar exposures

These miliolite outcrops are located further north of the above group of exposures. Near Devpar, 9 km NE of Poldiya, the miliolite is seen to occur as large sized windward face deposits, occupying the hollows and depression on the southern and western slopes of the trappean 274 m and 227 m (Bhopha Dongar) high hills (Plate IV.21). These dune deposits show a well defined wedge-type current-bedding, with overall steep foreset dip varying from 20° to 25°. These deposits contain angular pebbles and fragments of trap, obviously representing the scree debris fallen from the hill top into the bedding surface of the deposit on the lower slopes. (Plate IV.22). As usual, the base of these dunes which form sheets has been dissected by a number of seasonal streams.

A few km north of Bhopha Dongar (227 m), in the vicinity of Waramseda village scattered exposures of miliolites are encountered on the southern as well as northern slopes of trap hill of Nana Dongar (433 m); these

Plate IV. 20

Field photograph showing cross stratification in sheet deposits (Loc: Rukmavati river near Asambia Nana)

Plate IV. 21

Quarry face section of windward deposits showing cross stratification (Loc: Bhopha Dongar)

Plate IV. 22

how do you explain this?

Presence of trap fragments in obstacle deposits (Loc: Miliolite Quarry, Bhopha Dongar)

deposits support a few workable quarries (Plate IV.23). The foot hill areas of this hill also are covered with thin sheets of miliolite.

About 2 km SW of Madhapar and 6 km E of Waramseda the hollows on the southern, southwestern and northwestern slopes of 348 m high trappean hill (Dhrubya Dongar) have been occupied by large size miliolite deposits. The windward face obstacle deposits show well developed wedge-type current-bedding with foreset dip ranging from 20° to 30°. The lower margin of this deposit also shows the occurrence of sheet miliolites (which is at the altitude of almost 200 m above M.S.L.). On the northeastern side of the hill, facing the saddle opening miliolites occur as leeward face deposits (Plate IV. 24 & 25). The northern foot of the hill is characterised by the occurrence of thin sheet miliolites.

In the tributaries of Rukmavati river, near Wadasar and Godpar villages, about a metre thick horizontally bedded miliolite deposits is seen to occur. This deposit is impure and contain pebbly layer at its lower portion.

Plate IV. 23

Leeward miliolite deposits showing tabular dune bedding (Loc: Nana Dongar near Waramseda village)

Plate IV. 24

Field photograph showing a slip-face aeolianites (Loc: Dhrubya Dongar near Madhapar)

Plate IV. 25

Slip face miliolite deposits facing saddle opening in Dhrubya Dongar (Loc: SW of Madhapar village)

Block VII: Bhuj-Mandvi Road-Mankuva-Sumrasar exposures

These are the northern extension of Wadasar- Godpar deposits and rests on the northern slopes of the Samtiya Dongar (293 m) and Chadwa Dongar and also on the southern slopes of 258 m high hill. The various E-W hill ranges of these Dongars are made up of Jurassic rocks. The miliolites occupy the hollows and notches formed prior to miliolite deposition. Most of the quarries are situated on both side of the west flowing streams that joins the Wandhay Talav and also on the southern slope of the 258 m high E-W trending hill. All these deposits have been described as Bhuj-Mandvi road exposures as they are located on either side of the Bhuj-Mandvi road.

The Bhuj-Mandvi road cuts, across the valley-fill sheet miliolites in Wandhay Talav and provides very good sections wherein the deposits on the either side, form cliffy banks. These deposits contain the angular fragments of older rocks. Aeolian wedge-type cross-beddings with high angle of foreset (20°-25°) are very well developed in these deposits. Here the sheets of miliolite are very thick and seen to occur at-least at two different levels, resting on the pre-miliolite rocky terraces situated to the southern side of the E-W trending 258 m high hill (Plate IV.26). The deposit on the upper terrace is thicker (15-20 m) than the lower one and the former merges into obstacle deposits against the southern

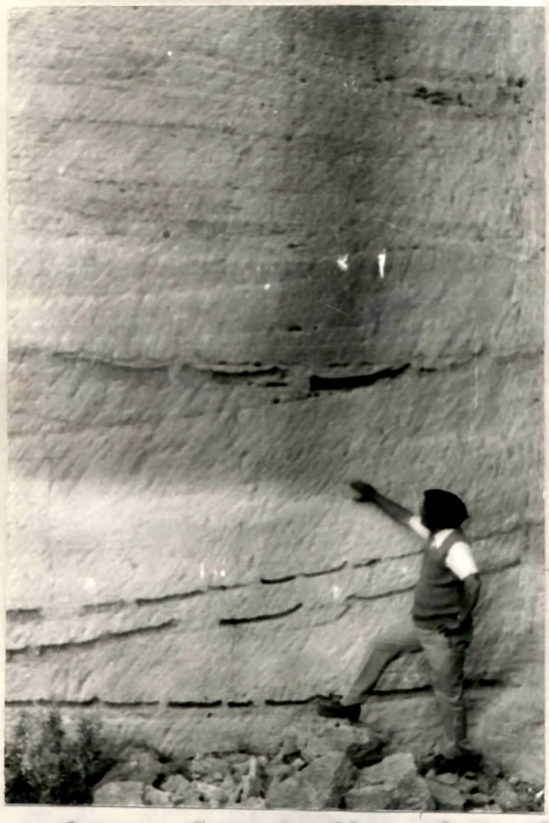
Plate IV. 26 Field photograph showing the occurrence of miliolites at two different levels (Loc: Bhuj-Mandvi Road)

slope of the above hill and supports a few quarries of considerable sizes. (Plate IV. 27). The lower terrace deposit is about 2 m in thickness and thins out in upstream and downstream direction. Numerous windward face accumulations of miliolite are also seen to occupy the hollows and depressions excavated by rain water on the southwestern slopes of this hill range. These large sized triangular windward obstacle deposits provide a good quality building material and supports number of quarries. The quarry faces show truncated aeolian cross stratification with foreset dips ranging from 20° to 30°. In general, each cross set dips towards SW. At the junction of each set of beddings, the wind-borne ripples are seen to occur (Plate IV. 28). The scattered outcrops of miliolites are also seen to occupy the hollows and notches on the northern and southern slopes of Samtiya and Chadwa Dongar. These deposits are moderate to large in size and are characterised by truncated dune cross-beddings. The lower margin of these exposures are marked by sheet deposits occurring as cliffy outcrops on either side of the streams originated from these hill ranges. Practically all the hill gaps and intermontane areas are seen filled with the dunal material.

Near Mankua village, 12 km WSW of Bhuj city, sheets of about a metre thick miliolites are seen to occur on both the banks of Ratiya Nala.

Plate IV. 27 Field photograph showing the miliolite quarry in the upper rocky terrace (Loc: Bhuj-Mandvi Road)

Plate IV. 28



Quarry face section of an obstacle dune with wind-borne ripples at the junction of each set of bedding (Loc: Bhuj-Mandvi Road)

All along the southern, southeastern and northeastern slopes of 249 m, 353 m, 209 m and 344 m isolated trappean hills located to the NW and NE of Sumrasar village, moderately sized miliolite are seen to have accumulated as windward and leeward face deposits (Plate IV. 29). In the main Sumrasar quarry miliolite is cross stratified, the lower strata is steeply dipping whereas the upper one is gentle (Plate IV. 30). This exposure contain numerous angular fragments of Trap rolled down from the hill top and embedded within it (Plate IV. 31). As usual these deposits also occupy the topographic hollows and extend to the base of the hill as sheet miliolite. Aeolian material is not only deposited on the slopes, but appear to have spread over the surrounding low ground all around the hill as thin sheets. The seasonal streamlets (tributary of Bharod Nadi) that flow south-eastward in the ground between 353 m and 249 m high hill have dissected these deposits, forming miliolite banks.

Block VIII : Medisar-Jhura-Palanpur exposures

In the areas surrounding Medisar, 8 km north of Sumrasar, numerous small and scattered exposures of miliolites occupying the heart of hilly terrain and the low lying areas are recorded. They rest over the Bhuj Sandstone, and are almost horizontally bedded with 1 to 2 m thickness (Plate IV. 32). The vertical cutting of such exposures by the tributaries of Nirona river has given rise to steep terraced

Plate IV. 29

Field photograph showing obstacle deposits (windward and Leeward type) near Sumarasar village.

Plate IV. 30

Closer view of Sumarasar miliolite Quarry showing variable dips.

Plate IV. 31

Presence of trap fragments embedded in miliolites (Loc: Sumarasar Quarry)

Plate IV. 32

Subhorizontally bedded sheet miliolites at the base of the hilly terrain (Loc: Medisar village)

banks of miliolite. On the hill slopes, they form small obstacle dunes of windward and leeward sides. The windward face deposits are relatively coarser and more in number than the finer leeward ones.

Near the northernmost fringe of the Kutch and the southern most fringe of the Banni, the miliolite deposits occupy relatively large areas in the Northern Hilly Range. Majority of these deposits are situated south of Jhura and Palanpur village and occur either as windward and leeward face obstacle deposits or as sub-horizontally bedded sheet deposits. The miliolite deposite at these localities are observed to rest over Jurassic rocks.

About 1.5 km south of Palanpur village, the miliolite deposits form the western extension of Jhura outcrops and occur all along the northern foot of 237 m, 298 m and 147 m hills, especially in the ephemeral streamlet courses originating from these hills. These slipface deposits are characterised by tabular planar dune bedding showing a gentle foreset dip of about 10° towards N (Plate IV. 33). They extend northward towards the lowground (Banni plains) as sheet deposits which gradually thin out northward. It is interesting to observe that these deposits have been covered by 1 to 2 m thick layer of the scree material derived from the older rocks.

The miliolite exposures at the southern part of Jhura village are interesting from the point of view of their mode

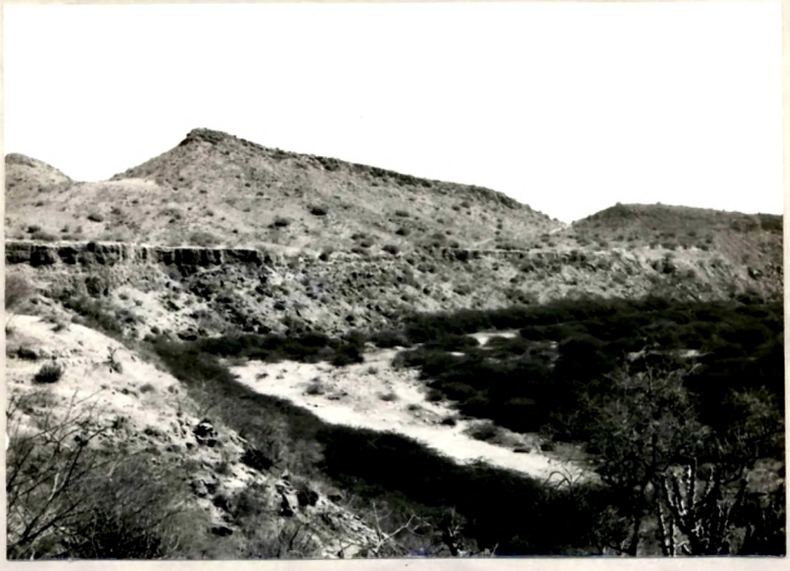
Plate IV. 33

Slip-face deposits showing tabular planar bedding (Loc: 1.5 km S of Palanpur village)

of occurrence. These occur almost at the eastern end of the E-W trending ridge as obstacle dunes and sub-horizontally bedded sheet deposits (Plate IV.34). Here the sheet deposits are conspicuously developed and restricted mostly to the left bank of the north flowing Kaila river and on the both the banks of the various seasonal streamlets that flow down from the eastern slopes of 277 m hill and cutting the left bank of this river.

Miliolites on the banks of Kaila river and its tributary gives a clear picture of the modes of occurrence of various types of sheet deposits. Sheet miliolite at this locality shows an altitude range between 40 to 80 m above M.S.L. at Kaila river bank and at the base of the 227 m hill respectively. These sub-horizontally bedded sheet miliolites form steep cliffy banks of about 6 to 8 m thick showing alternate fine and coarse laminae with an imperceptible dip of 2° to 5° due NE, and are seen resting over an older pebbly alluvial material which contains the boulders and pebbles of Mesozoic rocks (Plate IV.35). A typical miliolite exposure is observed to occur at the point where the left bank of the Kaila river cut by a tributary; here the horizontal layer is resting on the steeply dipping miolilite (Plate IV.36). The lower dipping strata comprises tabular planar dune bedding, whereas horizontal beds probably form flat surfaces bounding cross-strata sets, a feature similar

Plate IV. 34



Horizontally bedded sheet deposits showing cliffy banks (Loc: Kaila river, 2.5 km S of Jhura village)

Plate IV. 35

A closer view of miliolites showing
a) lower cross bedded strata and
b) upper horizontally bedded sheets
(Loc: Tributary of Kaila river)

Plate IV. 35 Panaromic view showing the 'valley fill' deposits in Kaila River (Loc: 2.5 km S of Jhura village)

to the dune structure described by Mckee (1966). The northeastern and eastern slopes of 124 m and 160 m hills located at the left bank of Kaila river show good slip-face miliolite deposits. These are small in size and comprise tabular planar dune beds whose laminae dip at angles of 15° to 20° due NE. Prominent large sized wind-ward obstacle dunes resting over the Kaila river sheet miliolite, is recorded in the hollows and gullies on the southern slopes of 120 m hill. These show well developed tabular dune beddings with foreset dip ranging from 20°-25°. (Plate IV.37). Practically in all the gullies and depression on the northern slopes of the E-W trending Jhura hill range miliolite is observed to occur as leeward deposits (Plate IV.38). Along the base of these hill ranges these deposits occur as sheets with gentle dips towards north.

Block IX : Kera-Wadli-Sanatorium exposures

From Kera in the west upto Wadli in the east thin veneers of miliolite are sporadically seen to occur all along the E-W trending Jurassic hills. Near Kera on the two flanks of the Nagvanti river almost horizontally bedded miliolite sheets of about ½ m thick are recorded. Away from the river bank no miliolite is encountered. These deposits are impure and full of layers of cobbles and pebbles derived from older rocks, and are loosely compacted.

Plate IV. 37

Windward obstacle deposits of the Main Jhura Quarry showing planar dune bedding

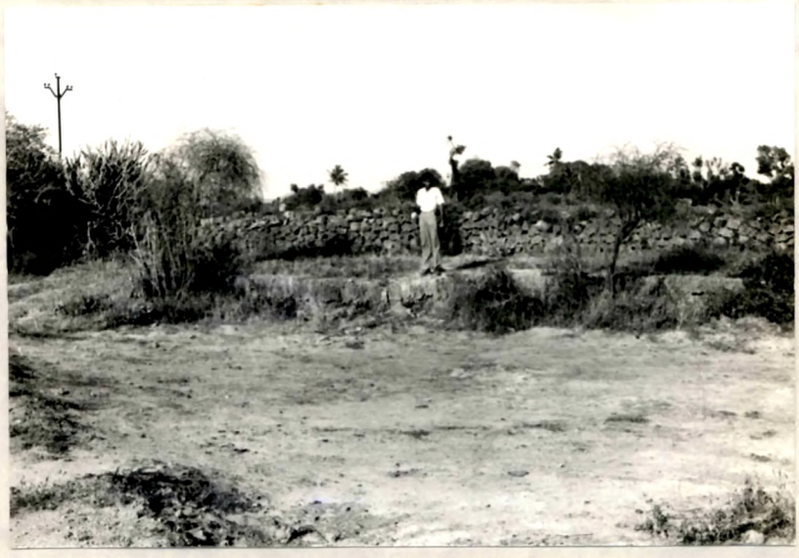
Plate IV. 38

Thin veneers of slip-face deposits of Jhura hills overlooking 'Banni'

On the bank of Bhukhi river near the village Jambudi a ½ metre thick miliolite sheet is seen resting over Bhuj sandstone (Plate IV.39). Similarly 2 km west of Wadli on the northern and southern slopes of 225 m hills, slip-face and windward face deposits are observed (Plate IV.40). Thin sheets of miliolite are also found on the flanks of Ruparel, Lerakh and Bhukhi rivers (Plate IV.41). These deposits show an altitude of about 70 m above M.S.L. with varying thicknesses, but not exceeding 3 m. The 349 m (Khatrod Hill) and 225 m, 220 m, 198 m E-W Jurassic hill ranges, are characterised by the obstacle deposits, comprising the material dumped on the windward and leeward slopes. These dunes merge into sheets ranging from few cm to 1½ m in thickness. Altitudewise, these dunes are restricted upto 180 m, whereas the sheet deposits are at 120 m altitude above M.S.L.

About 11 km SSW of Bhuj city, occurrences of sheet miliolites are recorded 2 km NE of the Sanatorium village. Here about 2 m thick friable miliolites, are seen capping three flat topped small isolated hillocks of almost horizontally bedded Bhuj sandstone, the deposition having been brought about by the break in wind velocity by the higher hill ranges to the NE and SW (Plate IV.42). The altitude of these occurrences is around 240 m above the

Plate IV. 39



Thin sheets of miliolite on Bhukhi river bank (Loc: Near Jambudi Village)

Plate IV. 40

Quarry face of a slip-face deposit showing planar dune bedding (Loc: W of Wadli village)

Plate IV. 41

Sheet miliolites forming cliffy banks (Loc: Lerakh River section near village Wadli)

Plate IV. 42

Miliolites capping the flat-topped hills (Loc: 2 km NW of Sanatorium village)

M.S.L. From a distance these appear to be made up of horizontal layers, but on a closer examination planar aeolian cross-bedding sets are distinctly observed that dip gently (2° to 5°) due N (Plate IV.43).

About 1 km south of Sanatorium village, in a small south flowing stream that meets Nagvanti river, the miliolite accumulations are again recorded. These deposits are about 3 m thick, occupying the hollows provided by the south flowing streams, and extend in downstream direction as sheet deposits. The later carving of these sheet deposits by rain water, has given rise to vertical banks (Plate IV.44). These deposits on both the sides of the river apparently look horizontal but on a careful observation they show gentle downstream dip of 5° to 10°.

Block X : Ler-Lakhand-Bhujia Hill exposures

15 km SE of Bhuj city around Ler village, the occurrences of miliolite rock are observed to rest over the older Jurassics. The hilly terrain to the immediate S, SW and SE of this village is marked by numerous miliolite occurrences. To the SW of the village, the hollows on the southern and the northern slopes of the two E-W trending parallel ridges (262 m, 225 m and 263 m), separated by Gunawari Nadi; a seasonal tributary of Dharawa Nadi, are seen filled with wind-borne miliolitic sands (Plate IV.45).

Plate IV. 43

A closer view of Sanatorium miliolite exposures showing cross bedding

Plate IV. 44

Sheet miliolite occupying the topographic depressional areas (Loc: 1 km S of Sanatorium village)

Plate IV. 45

Windward deposits cut by local stream (Gunawari Nadi) giving rise to cliffy banks (Loc: SW of Lex village)

In most of the occurrences, aeolian cross beddings are well developed; the accumulations are moderately thick and support a few small quarries. These miliolite exposures ideally show the gradual merging of the triangular steeply dipping accumulations into almost horizontal sheet deposits at their base extending over the low ground (Plate IV.46). The sheets are of the order of a metre or two in thickness with gentle dips (2°-5°) due N, and are as usual dissected by the channels of local ephemeral streams that flow at the base of these ridges (Plate IV.47).

To the ESE of Ler, another cluster of dunes are encountered on the northern and southern slopes of the Khatrod range (349 m). Near the western end of this ridge (3 km SE of the village) an interesting aeolian phenomenon is observed on the leeward side of the hill. Here the older rocks are dipping gently due south and the slope of the ground coincides with the dip of the strata. On account of the gentleness of the southern slope the aeolian material has completely blown over across the ridge to the northern slopes and has accumulated as slip-face deposits. As a result their windward counterparts accumulations have not developed.

6 km north of Ler village and 11 km east of Bhuj city, near Lakhand village, miliolite rocks are extensively

Plate IV. 46

Slip-face miliolite deposits with gently dipping strata (Loc: SW of Ler village)

Plate IV. 47

Sheet miliolite showing cliffy banks (Loc: Ler village)

encountered in the terrain bounded by the E-W trending ridge (190 m) and two NW-SE aligned hills (257 m and 190 m). The intervening areas are seen to comprise sheet deposits. The Pur Nadi that flows from SE to NW has carved out such accumulations and form a very distinct cliffs of sheet miliolites of about 4 to 5 m thick. (Plate IV.48). These sheets are more or less horizontal, but show an almost negligible dip of 2° to 5° due NE. It is observed that the miliolite material rests over a 2 m thick unconsolidated palaeosoil that overlies the Bhuj sandstone. These deposits do not show uniform thickness along the river bank, after a kilometre or so they taper out. The hills 257 m and 188 m, that mark the northern limit of such sheet miliolites are seen to support both windward and slip-face dunes on their slopes. In most windward dune occurrences aeolian cross-beddings are well developed.

Further NE, about 6 km from Lakhand, another occurrence of miliolite is seen along the southern slope of the hill (230 m), occupying the topographic hollows and gully depressions. These occurrences ideally show wedge-type cross-beddings. All these exposures show an altitude range between 90 m and 160 m above M.S.L.

Just to the southeast of Bhuj city, miliolite occurs on the southern slopes of the crescent shaped Bhujia hill.

Plate IV. 48

Miliolites resting over palaeosole
(Loc: Puz river section near Lakhand village)

Here it forms a typical windward obstacle dunes resting over the basalts. The concave (southern) slope is characterised by at least 6 gullies or hollows which have provided sites for windward miliolite accumulations (Plate IV.49). These deposits are small in size, their upper and lower limits fall within an altitude range of 160 m and 120 m respectively. No miliolites are encountered on the northern slope of this hill.

Block XI : Habo Hill exposures

These comprises the northeastern extension of Ler-Lakhand exposures and form the northernmost limit of miliolites of Mainland Kutch. The exposures occupy an extensive E-W linear tract bounded by Habo hills in the north and small hill ranges lying to the south of Jikadi, Baladia and Habai villages. In fact, in terms of linear extent and number of outcrops, this group is one of the largest one and include both the obstacle varieties and also the sheet deposits. They rest over the hill slopes and the intervening broad valley of the Kaswali Nadi. The leeward miliolite accumulations are encountered on the northern slopes of small hill range with peaks 171 m and 172 m located south of Jikadi and Baladia village. These deposits are fairly large in size, resting over Jurassic rocks and exhibit planar dune bedding showing 25° to 30° foreset dips due ENE.

Plate IV. 49

Panoramic view of Bhujia hill with occurrence of miliolites on the southern slope (Loc: Bhujia Hill)

On the gently sloping southern flank of the Habo hill (Jurassic), miliolite deposits, occupy almost all the hollows and gullies excavated by the seasonal streams flowing southward down the slope (Plate IV.50). These deposits are characterised by alternate fine and coarse laminae (Plate IV.51). These deposits occur at an altitude of upto 220 m above M.S.L. and show planar dune beddings with a gentle foreset dip ranging from 5° to 10° (Plate IV.52).

All these windward and leeward (slip-face) deposits gradually extend to the foothill pedeplain between the two hill ranges forming an almost horizontal sheet deposit . The Kaswali Nadi and its tributaries that originate in the western part near the village Jikadi and flows NE towards the Banni plains have dissected these sheet deposits giving rise to 2 to 3 m high cliffs of miliolite (Plate IV.53). These sheet deposits in this part of the terrain occur at an altitude of about 60-80 m above M.S.L.

Block XII : Bhachau-Anjar exposures

These form the easternmost limit of the miliolite exposures of the Kutch Mainland. Miliolite occurrences are recorded from Chirai Moti 8 km SW of Bhachau towards Anjar. They comprise wind blown accumulation resting against an obstacle provided by a triangular and SW facing topographic hollow (Plate IV.54). The miliolites are almost horizontal,

Plate IV. 50 Windward miliolites occupying the topographic hollows of the Habo hills

Plate IV. 51

Windward miliolite deposits of Habo hills showing alternate fine and coarse laminae

Trough-bed

Plate IV. 52

Habo hill miliolites showing tabular planar dune bedding.

Plate IV. 53

Sheet miliolite showing cliffy banks in Kaswali River (Loc: Jikadi village)

Plate IV. 54

Sub-horizontally bedded miliolite deposits showing alternate fine and coarse laminae. (Loc: Chirai Moti village)

1 to 2 m thick with very gentle dips (2° to 5°) due SW. This exposure is significant in the sense that it occurs almost uniterruptedly for about 1.5 km in a N-S direction, which on the map is seen to be just above 30 m contour line. The other striking feature is that it shows a distinct lamination of alternating shelly and sub-rounded polished coarse quartz grains, which is indicative of deposits of these material by winds of varying velocities, an aeolian process invoked by Glennie (1970).

Another interesting miliolite occurrence is recorded near Sapeda, 8 km from Anjar, on Anjar-Bhuj road. Here it is seen to form an elongated NE-SW trending longitudinal dune, cut by the road. Obviously, the miliolite material has been transported from the southwest by strong winds and dumped at this locality. The miliolite rock here shows a crude sub-horizontal layering. The terrain around this exposure is covered with recently blown quartzose sands. The possibility of southward extension of miliolite beneath the blown sands towards the present day coast of Kutch Mainland can not be ruled out.