CHAPTER - IV

LITHOSTRATIGRAPHY AND FIELD DESCRIPTION

GENERAL

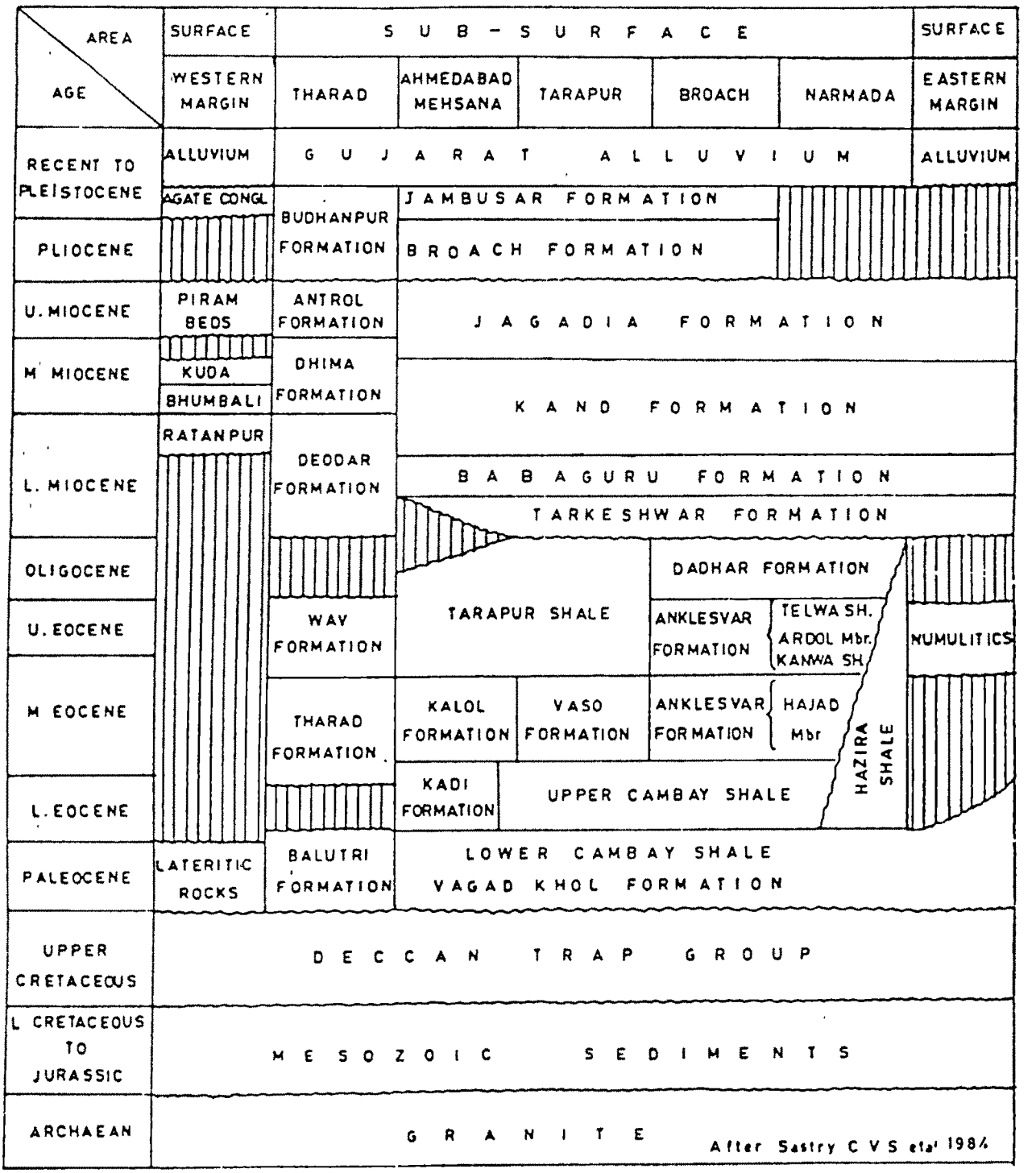
The Quaternary continental deposits of the study area form the northern half of the Mainland succession and as already stated consists of layered sediments of marine, aeolian and fluvial origin. The various depositional and sedimentological features, textures and mineralogy typically reflect the influence of related depositional processes and the factors controlling them. A total thickness of over 300 m of Quaternary sediments has been computed on the basis

of exposed sequence and sub-surface bore hole data. As such the nature of the base of Quaternary deposits is not fully understood and little information is available to delineate the boundary between the Quaternary and the Tertiary. The author has therefore relied mainly on the published and unpublished information generated by the O.N.G.C. and C.G.W.B.

The Quaternary deposition on Mainland and east coast of Saurashtra comprises part and parcel of the Cambay Basin sedimentation and a synoptic view of the Cambay Basin sequences consisting both Tertiary and Quaternary as given by Sastry *et al.* (1984) is presented in Table 4.1.

It may be pointed out that the lower part of the Quaternary sequence remains uninvestigated and the only available information is that provided by Chandra and Chowdhary (1969). These workers of the O.N.G.C. have given a Pleistocene age to their Jambusar formation of Ahmedabad - Mehsana, Cambay - Tarapur and Jambusar - Broach tectonic blocks of Cambay basin. In the Tharad - Serau block further north, the upper part of Budhanpur formation has been considered to comprise Lower Pleistocene; or in this formation Pliocene is perhaps gradually changing over to Pleistocene, the entire sequence mostly being fluviatile. In the sub-surface on the western margin of the Cambay basin in the Dhanduka block, a conglomerate resting directly over Deccan Trap perhaps represents Lower Pleistocene. In the Viramgam section an undifferentiated sequence resting over the Oligocene Khora formation could also in part be of Lower Pleistocene age. In the coastal areas of Saurashtra the agate bearing conglomerates and the conglomeratic horizons of the Jhagadia formation exposed on the Mainland along

TABLE 4.1 GENERALIZED STRATIGRAPHIC SUCCESSION OF CAMBAY BASIN



After Sastry C V S etal 1984

the eastern Margin of the Cambay basin have been considered as Lower Pleistocene (Merh, 1993).

The sequence that overlies these Lower Pleistocene rocks and referred to as Gujarat alluvium by most workers and Narmada formation by Agarwal (1986), range in age from Middle Pleistocene to Recent. The sequence Middle Pleistocene upward has been better investigated and is conspicuously exposed in the major river sections and provides ideal exposures on the basis of which a dependable sequential stratigraphy has been constructed. Taking into account the exposed Quaternary sequences in Narmada, Mahi and Sabarmati rivers, Chamyal and Merh (1992) have given an outline of the lithostratigraphy of exposed Quaternary deposits (Table 2.2). Sareen *et al.* (1992) also dwelt upon the sediment succession of the Sabarmati valley which has been reproduced in Table 2.3. Merh and Chamyal (1993) have correlated the sediment profiles in the various rivers and suggested a composite sequential stratigraphy.

While describing the drainage characteristics of the north Gujarat, it has been quite clearly established that the present day rivers including Sabarmati do not exactly conform to their original courses. What we see today is a picture which comprises a combination of evidences of two drainage systems. The earlier one which was more powerful and mainly responsible for the main bulk of the deposits, stands considerably disrupted and modified by a later superimposed river system. This phenomena is responsible for a very complex network of relict channels co-existing with some deeper river courses. The river Sabarmati perhaps provides the best example of the superimposition of a new drainage direction on the older fluvial system. As it has already been pointed out earlier the present

study has adequately established that the development of new river courses was essentially a phenomenon related to the development of fractures cutting the fluvial sequence. The factor of tectonism has been discussed in Chapter-V. One of the most stiking fact related to this late fracturing especially in respect of the Sabarmati river is that the new channel course provides excellent vertical sections of the earlier deposited sediments by the river which was an ancestor of the Sabarmati. At present the river neither carries significant sediment load nor it is depositing much except as localised flood plains. Obviously the stratigraphic sequence seen in the cliffs of the Sabarmati river belong to the depositional phases prior to the development of the new Sabarmati river course (Sridhar et al., 1994).

STRATIGRAPHIC SEQUENCE IN THE STUDY AREA

Whereas the Sabarmati river provides very good cliff sections incorporating almost the total exposed stratigraphic sequence, the other rivers further north show only the upper part of the sequence. The author has worked out a detailed lithostratigraphy of the exposed Quaternary sediments comprising a sequence of continental deposits of alternating fluvial and aeolian sediments. On the basis of a critical examination of various exposed sections in the Sabarmati, Banas and Luni, supported by sub-surface bore hole data, it has been possible to work out a composite sequential stratigraphy (Fig. 4.1) (Table 4.2). The author has been able to reconstruct the entire depositional model which has been shown schematically in Fig. 4.2. It has been further observed that the entire sequence has been subjected to post-depositional faulting which has been responsible for obvious lateral discontinuity of a number of lithological units. The author has

FORMATION	MEMBER	LITHOLOGY	DEPOSITIONAL ENVIRONMENT	AVERAGE THICKNESS (M)
Mahudi formation	Ogadpura member	Dunal sands, fine grained with quartz and mica flakes. No sedimentary structures	Aeolian	3
	Deesa member	Fine to medium grained silt, loess-like, structureless, porous, homogenised and stabilised	Aeolian	4
Saroli formation		Coarse sand and mud with lenses of gravel, chiefly comprising quartz grains, felspar and rock fragments with interlayering of silt, sand and mud. Gravel lenses show cross bedding.	Fluvial	10
Hirpura formation		Red, reddish brown silt, unconsolidated, composed of sub-angular quartz grains. Calcareous nodules present in the basal part, concentration increasing downwards.	Fluvial	8-10
Lakroda formation	Sindari member	Gravel, consolidated comprising quartz, felspar in a calcium carbonate matrix. Stratification well preserved. Cross bedding visible. Overlain by laminated mud, chiefly comprising fine grained quartz.	Fluvial	8-10
	Valasana member	Gravel, consolidated with clasts of quartzite, quartz, granite, agate, chert, jasper and other rock fragments. Overlain by fractured mud, chiefly made up of quartz and mica flakes.	Fluvial	5-8
		Bluish green clay mottled, with carbonate tubes, veins and strings.	Marine	

Table 4.2 : Stratigraphic sequence of the exposed Quaternary sediments in the study area.

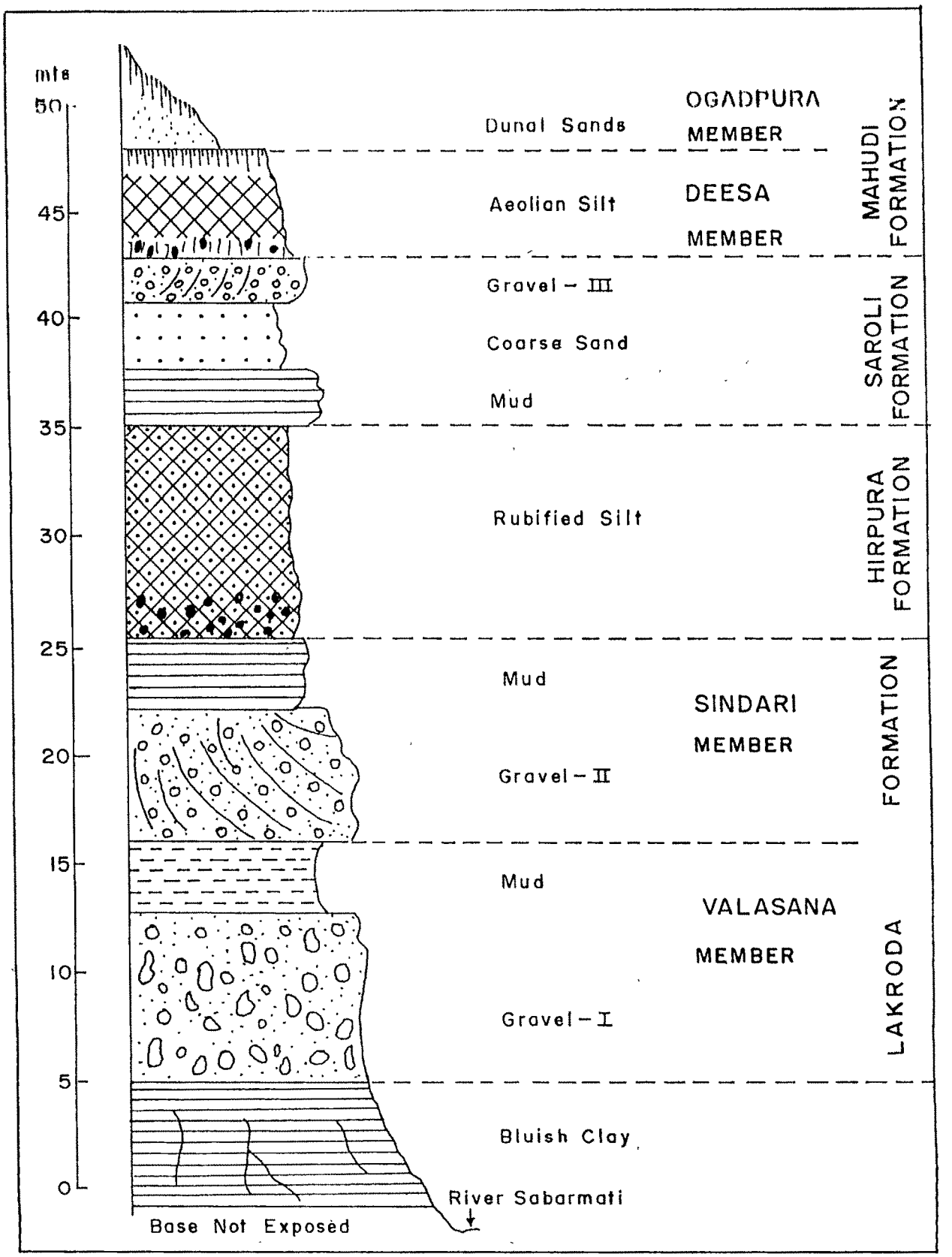


Fig. 4·1 COMPOSITE EXPOSED QUATERNARY SUCCESSION OF THE STUDY AREA

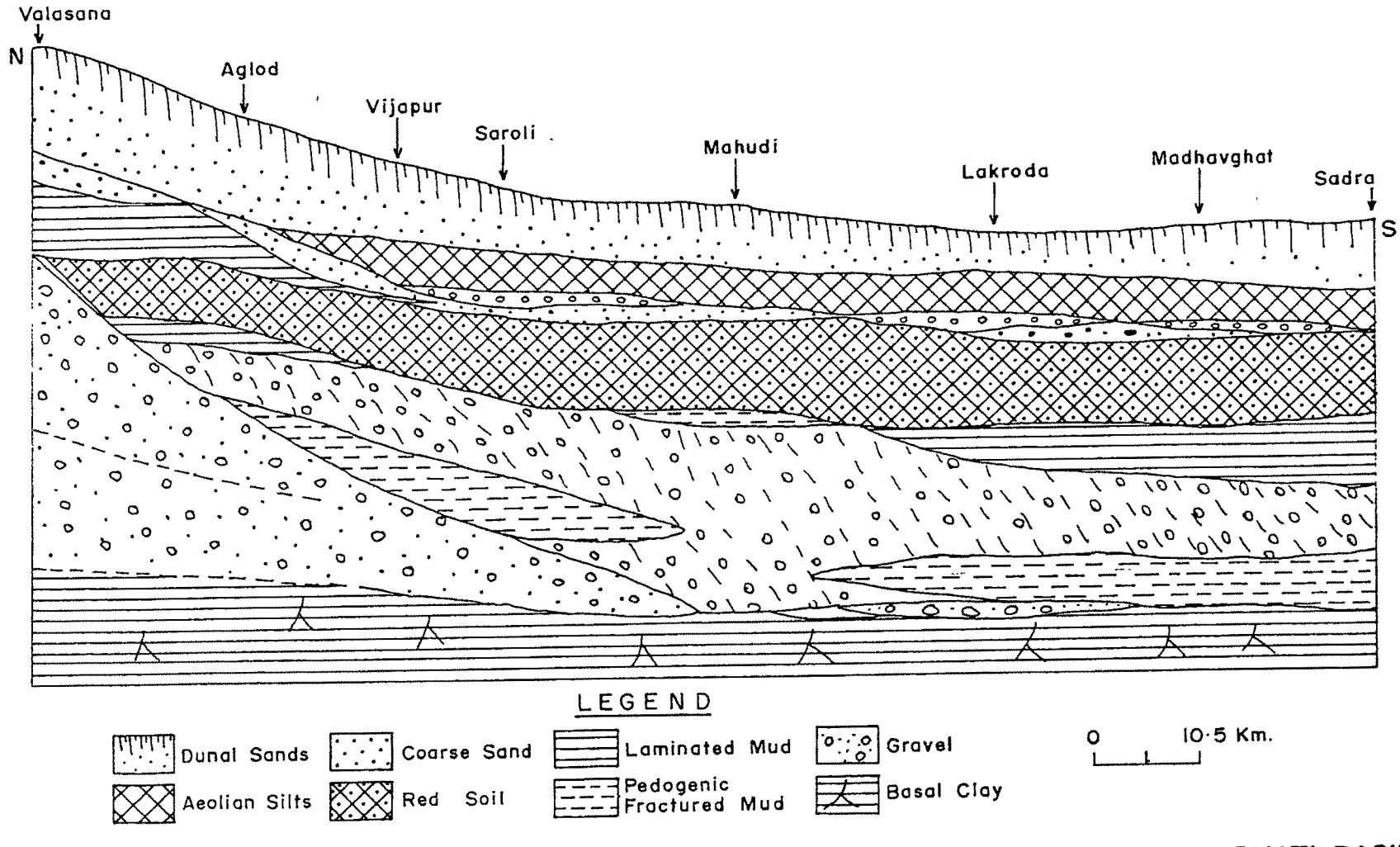


Fig. 4·2 SCHEMATIC DEPOSITIONAL MODEL OF QUATERNARY SEDIMENTS IN SABARMATI BASIN

diagrammatically shown in Fig. 4.3, the present day picture of the entire sequence revealing

(i) Lateral facies variation

(ii) Lensoid nature of certain horizons and

(iii) abrupt truncations and vertical displacements along a number of faults.

SYSTEMATIC FIELD DESCRIPTION

BASAL BLUISH CLAY

The base of the exposed sequence in the Sabarmati river consists of a clayey silt horizon of bluish green to grey colour (Plate 4.1). A characteristic feature is a typical mottled appearance with numerous carbonate tubes, pipes and strings with veins intruding this horizon (Plate 4.2). These calcrete structures abruptly terminate against the overlying gravels suggesting that they pre-dated the overlying gravels. This horizon is restricted only to the middle reaches of the Sabarmati river. The exposed thickness of this horizon ranges from 1.5 to ~ 5 m (base not seen).

This horizon has been reported by other workers, Pant and Chamyal (1990), Chamyal (1995), Chamyal and Merh (1992) and Merh and Chamyal (1993) from southern rivers viz, Mahi and Narmada. In the subsurface bore hole data, the Irrigation Department of the Government of Gujarat has shown this horizon at the base of the sand silt gravel horizon and called them as Tertiary marine clays. Merh (1992, 1993) has described them as clays of marine origin deposited during the Middle Pleistocene transgression, stratigraphically comparable with the Miliolites of Saurashtra. As this clay horizon typically shows development of calcretes, it

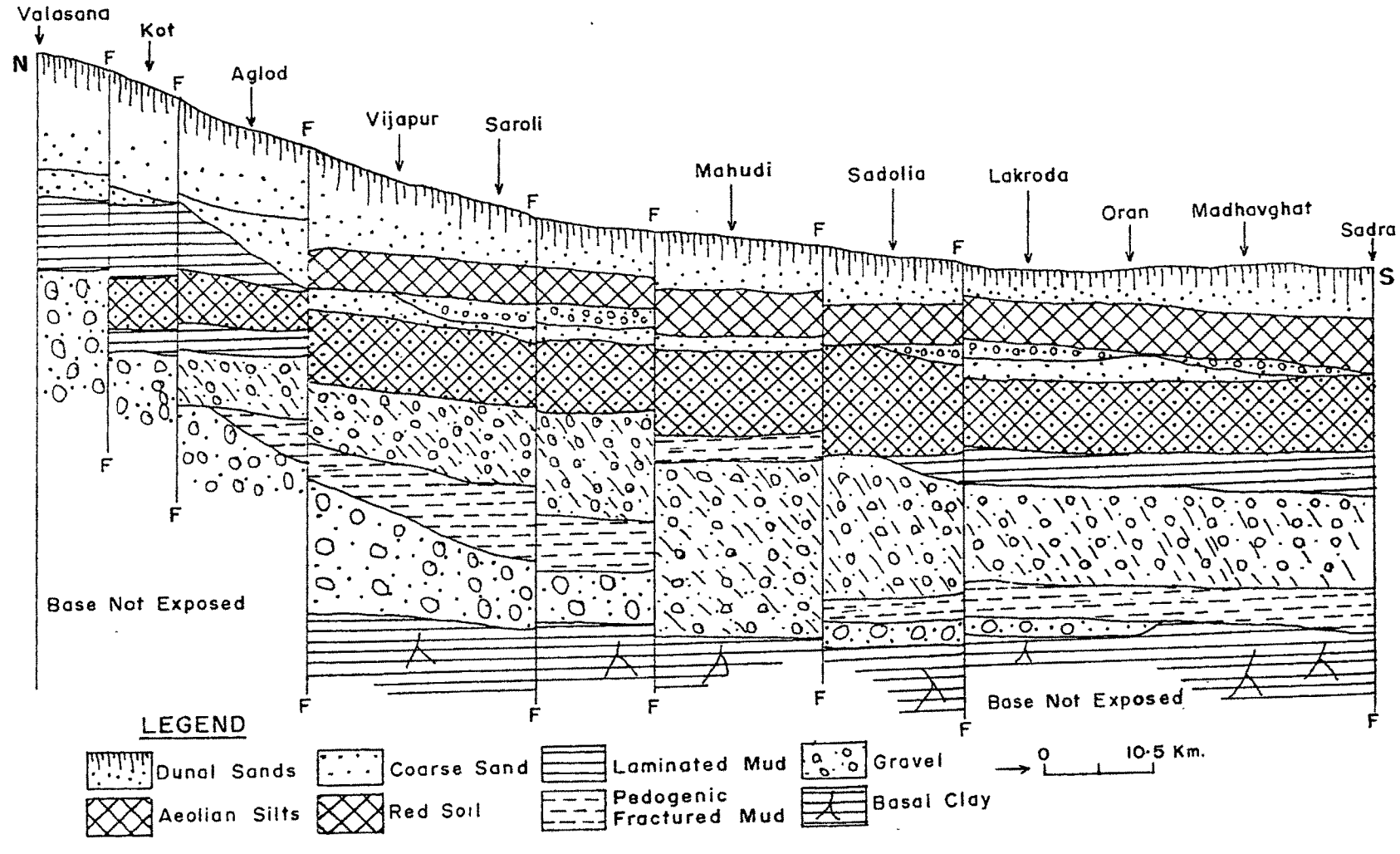


Fig. 4·3 SCHEMATIC CROSS-SECTION OF EXPOSED QUATERNARY SEDIMENTS IN SABARMATI VALLEY

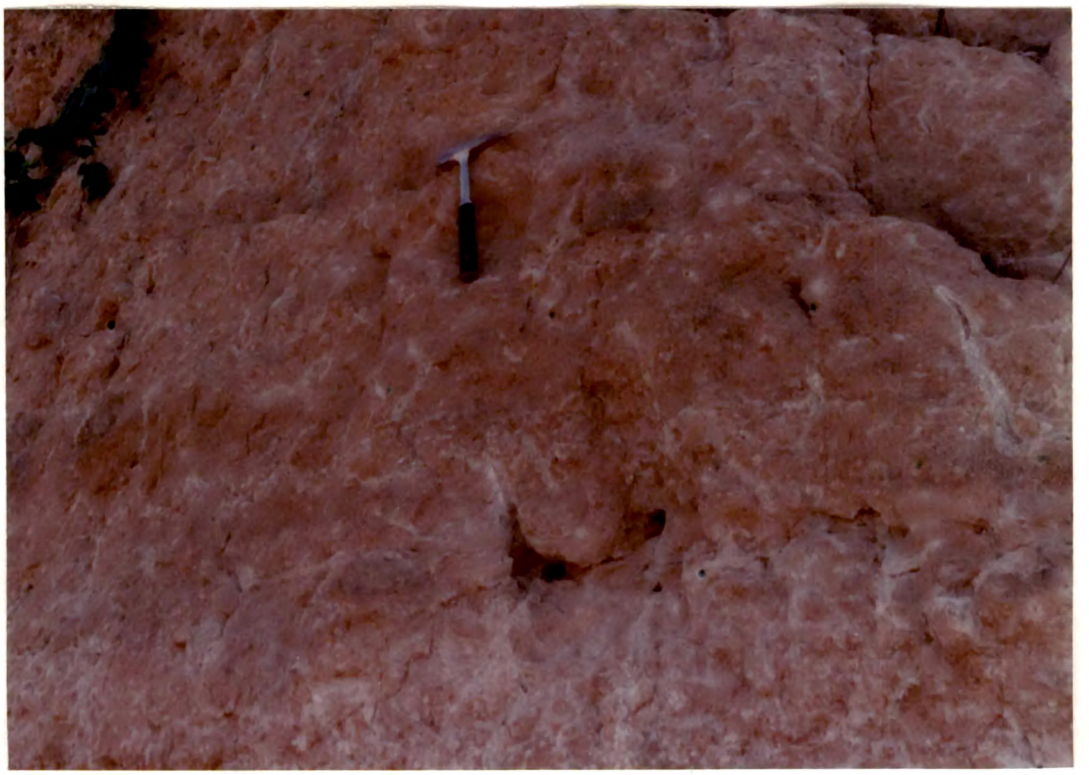


Plate 4.1 Well developed basal bluish clays (Loc. Lakroda).

Plate 4.2 Calcrete vein intruding into basal clay (Loc. Lakroda).

has to be envisaged that considerable time gap prevailed between the deposition of these clays and that of the overlying gravel, the intervening period gave rise to pedogenetic calcretisation. Along the Sabarmati river these clays are very well exposed from Sadra in the downstream through to Madhavghat, Mahudi and Vijapur. Their occurrence at variable heights at these locations is on account of subsequent faulting.

LAKRODA FORMATION

Lakroda formation which at most places is seen to rest directly over the blue clays has a total thickness of about 15 to 20 m and consists exclusively of fluvial sediments. Although it is encountered at several localities along the river course. it is best exposed at Lakroda. hence it has been designated as Lakroda formation. It is also well exposed at Oran. Saroli and Vijapur. At Lakroda. the formation attains a thickness of 18 m and is represented by all the lithological units.

On the basis of the lithology of the constituent strata. this formation has been sub-divided into two members viz,

(a) SINDARI MEMBER,

(b) VALASANA MEMBER.

Though both the members are fluvial in origin but are clearly divisible into two well defined fluvial depositional cycles. These two members are well developed throughout the Sabarmati basin and occur at similar stratigraphic levels. In the Sabarmati river basin, the gravels of the Valasana member are better

developed and can be traced from Valasana (upstream of Sabarmati) in the north to Sadra (downstream) in the south (Fig. 4.4). However, the gravels of Sindari member are noticed all throughout the study area.

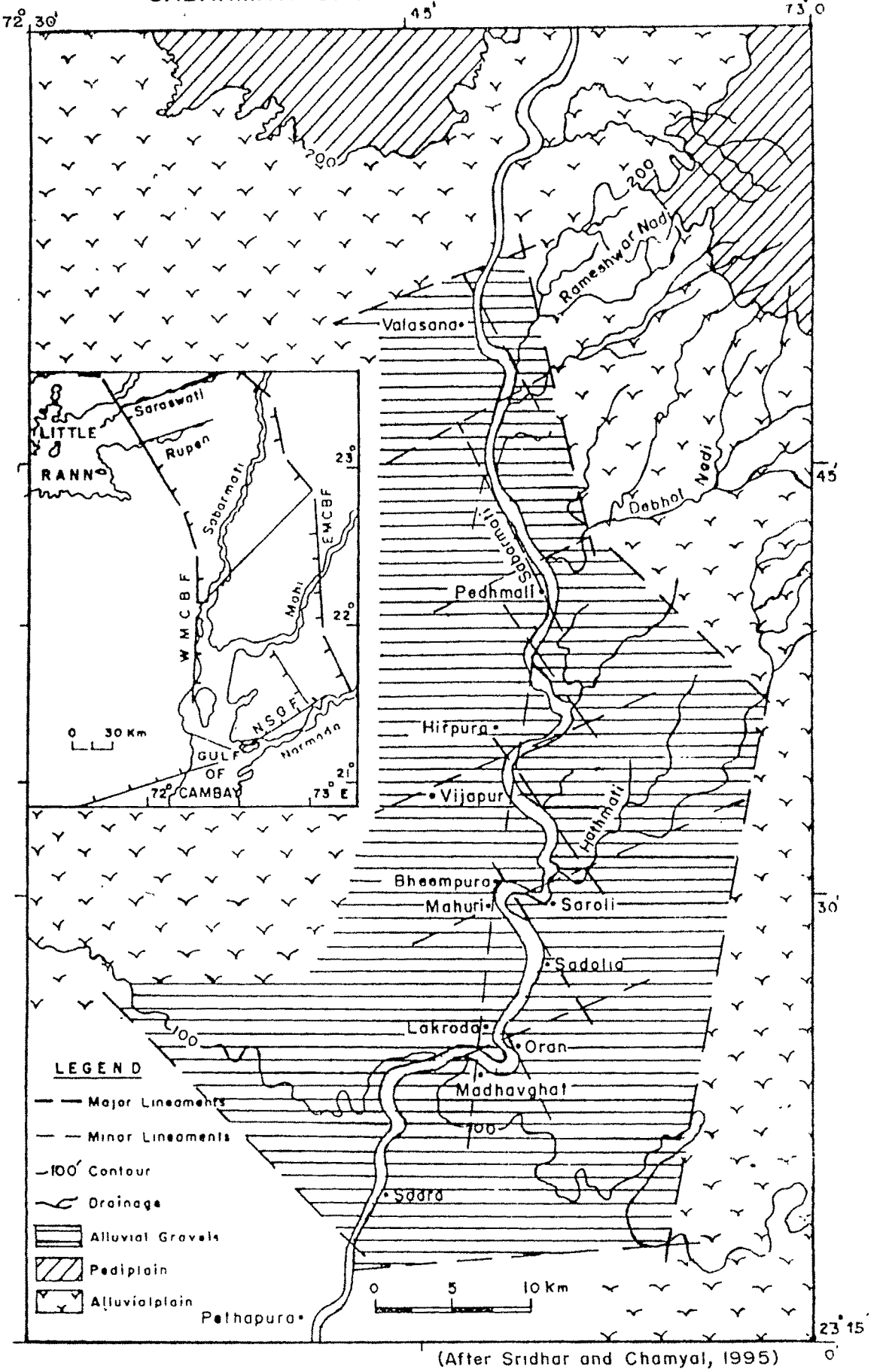
Valasana Member

The Valasana member has a very conspicuous gravelly basal horizon (Plate 4.3) overlain by a fractured mud horizon. The transition is gradual and the gravel upwards changes over to a gravelly grit and sand with clasts of varying sizes. The clasts are distributed in a very haphazard fashion, either in a cluster, individuals or in some instances, spread all along the length of the horizon (Plate 4.3). The pebbles and cobbles of the gravelly horizon are of quartzite, granite and other rock fragments together with those of quartz, agate, chert and jasper.

The member is well exposed at Valasana, Aglod, Vijapur, Saroli and Bheempura before it disappears against the blue clays and the overlying fractured mud horizon and is seen directly resting over the blue clays (Fig. 4.1) at Mahudi. This unit is best developed in the proximal end near Valasana where it shows a maximum development of 8 m which progressively decreases downstream. At Lakroda, this horizon again appears as a lense with a maximum thickness of 5 m before finally terminating downstream near Oran. This lensoid occurrence tends to contain clasts of constituent particles and the clastic grains being of smaller size almost sands with reasonably consolidated.

The topmost part of this member is a 3 m thick layer of mud. Its contact with the underlying gravelly horizon is rather sharp. The layer of mud does not

Fig. 4·4 DISTRIBUTION OF GRAVELS WITHIN THE SABARMATI BASIN



(After Sridhar and Chamyal, 1995)

Plate 4.3 Closeup view of lower gravel of Valasana member (Loc. Valasana).

Plate 4.4 Closeup view of well stratified gravel of Sindari member around Sindari.

show much of lamination, but is characteristically fractured both horizontally as well as vertically. This horizon which represents fine fluvial sediments deposited under tranquil conditions shows weak pedogenesis and is dark brown in colour. Obviously there was a gap in deposition during which the mud was exposed to subaerial process. The next fluvial cycle is represented by the overlying Sindari Member, which is quite distinctly recognised in the field by the abrupt appearance of a gravelly rock above the fractured mud horizon.

Sindari member

The gravelly rocks of this member whose thickness varies from 8 to 10 m are quite distinct from those of Valasana member in being slightly finer grained. the clasts are mostly pebbles of smaller size and the entire member is compacted by a calcareous cement and at some localities appears rock like (Plate 4.4). This member shows well defined cross stratification (Plate 4.5) and individual layers consist of pebbles and the matrix in variable proportions and grain size. It comprises chiefly of sub-angular to sub-rounded pebbles of quartz, feldspars, jasper, granite, chert and agate fragments.

Ideal exposures of this member are observed at Sindari in the Lower Luni river section; this has been taken as the type area. Comparable rocks are also seen in the Banas and Sabarmati rivers. While in Sabarmati, good exposures are met all along the cliff sections from Aglod, downstream and continue till Sadra. The constituent material in the Sabarmati section broadly identical to that of Luni and Banas in terms of lithology and grain size. The cross-stratification is quite

Plate 4.5 Closeup of cross stratified Sindari Gravel (Loc. Sindari).

Plate 4.6 View of gravel bed of Sindari member occurring as horizontal sheets (Loc. Madhavghat).

pronounced in the upper reaches of the study area and in the downstream beyond Sadolia, this structure tends to change over to almost horizontal sheets (Plates 4.6).

The top portion of this member is again a muddy layer, light yellow in colour and shows quite distinct lamination. This mud does not show any signs of pedogenesis. The presence of lamination within this horizon clearly indicates the changing velocity of the currents depositing the mud resulting in the fine layering (Plate 4.7). This mud is not seen in Luni and Banas rivers where the gravels directly underlie the dunal sands of Mahudi formation. In Sabarmati river it shows a conspicuous development and is seen as a 3 m thick almost continuous horizon between Mahudi to Sadra downstream. Upstream of Mahudi it gradually tapers off such that the silts of Hirpura formation directly overlie the gravels between Mahudi and Aglod. Interestingly at the proximal end, the mud reappears as a 2 m thick lens extending upto Kot.

HIRPURA FORMATION

This one member formation overlying the Sindari member all throughout comprises an important and very conspicuous sandy silt horizon. In the Sabarmati valley, it is exposed all along its course forming a 8-10 m thick band. This formation derives its name from the village Hirpura in the Sabarmati valley where it has attained a thickness of 10 m and is very conspicuous by its red coloration (Plate 4.8). Its most striking feature being its red to reddish brown colour, unconsolidated nature and shows layering or lamination (Plate 4.9). The presence of layering or lamination is an indication of its being part of a fluvial cycle.

Plate 4.7 Laminated mud horizon (Loc. Sadolia).

Plate 4.8 View of alluvial cliff near Hirpura showing a distinct red soil horizon.

Plate 4.9 View of the upper part of cliff at Mahudi with a well developed red soil horizon.

Plate 4.10 The red soil as seen in the Banas river cliff at Deesa.

The red coloration is perhaps due to coating of iron oxides. This red horizon is fully exposed in Banas river (Deesa section; Plate 4.10) and has been partly exposed in the smaller rivers viz, Rupen, Pushpavati; its presence is also recorded in the bore hole data as well. The formation has considerable paleoclimatic significance and has been reported to occur southward also in the rivers Narmada and Mahi by Chamyal and his associates (Pant and Chamyal, 1990, Chamyal and Merh, 1992; and Merh and Chamyal, 1993). Obviously subsequent to the deposition of these sediments they were subjected to pedogenetic changes which are indicated by the extensive development of calcretes.

It is however not very clear whether the reddening phenomena is due to pedogenetic changes or could be attributed to reworking of older red alluvial sediments during an arid phase (Pye, 1983). The original sediments possibly fluvial material reworked by aeolian agency during a period of aridity or semi-aridity. However if the latter alternative of reworking of older sediments is valid, then the redness forms part and parcel of the original sediments, but otherwise the rubification has to be attributed to pedogenetic changes subsequent to the deposition, a possibility which is most probable in view of the widespread calcretisation of the silts.

SAROLI FORMATION

The Saroli formation again marks the onset of fluvial depositional cycle as it rests with a very distinct non-conformity indicated by a sharp contact and sudden change in sediment nature. The formation has been taken to comprise one

single member, a product of more or less continuous fluvial deposition coarsening upward. Based on the grain size and lithology the sequence is divisible into three units. The lowermost mud layer rests over the Hirpura formation. There is upward coarsening which changes the mud layer into a horizon of coarse sand. The mud horizon occurs as lensoid bodies and is seen only near Valasana and again around Saroli. No traces of this horizon are found downstream of Saroli. The coarse sand horizon which overlies the mud unit is also lensoid in nature and occurs in the proximal end at Valasana, again appears as a lense at Kot before disappearing at Vijapur. The transition of mud to coarse sand is rather gradual and with the disappearance of mud, the sands come in direct contact with the underlying formation. The sands merge upward into a gravelly unit (Plate 4.11). Within the sands occur thin lenses of gravel. The entire sequence points to a progressive increase in the depositional energy, the grain size progressively coarsening upward. This formation is best exposed in the cliffs of Sabarmati river at Saroli, where all the units of this formation are encountered attaining a thickness of 10 m.

The unit is best exposed other than at Saroli at Mahudi, Lakroda, Oran and Madhavghat, downstream in the Sabarmati valley. The discontinuous sandy horizon which occurs above this mud unit occurs with an average thickness of 2-3 m. It is dominantly made up of coarse sand size grains of quartz, feldspars and rock fragments. The locations of Madhavghat, Oran, Lakroda, Saroli, Vijapur and Hirpura,Phudera and Kot reveal good exposures of this unit.

The gravels occur predominantly between Saroli and Sadra. It is a sandy gravel, the pebble sized clasts of quartz, felspar, agate, chert, jasper and rock

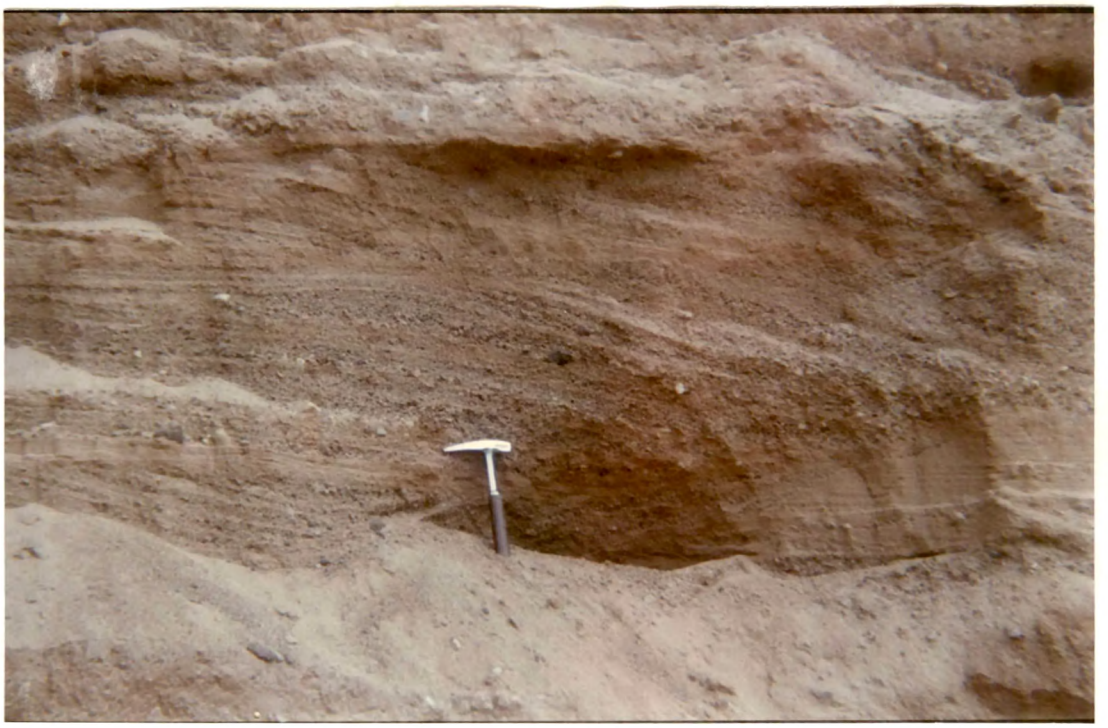


Plate 4.11 Closeup view of sandy gravel. (Loc. Saroli).

Plate 4.12 View of the aeolian silts occuring as vertical bluffs in the ravines around Oran.

fragments are embedded in a coarse gritty matrix. Whereas the quartz, agate chalcedony pebbles are fairly well rounded, those of felspar and rock fragments have relatively sharper edges. The entire unit could have derived its material from two sources. Cross-stratification is prominently developed (Plate 4.11). The entire sequence shows much less consolidation and is quite friable. With the sudden appearance of aeolian silts of the overlying formations a distinct and abrupt climatic change is visualised. A near total absence of pedogenetic features in this formation indicates the sudden onset of aridity and deposition of wind blown material without any time interval.

MAHUDI FORMATION

This formation is the youngest one in the sequence and overlies the older fluvial sediments and by and large points to an arid climatic phase. In the Sabarmati river section, it shows good exposures at Mahudi and has therefore been named Mahudi formation. It may however be pointed out that the Banas river section and the area to its NW upto Luni and beyond shows a much better development of this formation. Its subdivision into two members is therefore based on exposed sequences other than at Mahudi.

Although its entire thickness typically indicates aeolian deposition it has been possible to divide the formation into two members viz the lower Deesa member and the upper Ogadpura member. The basis for this demarcation is the slight amelioration in the climate which brought about stabilisation of the earlier deposited aeolian material and led to quite distinct pedogenic changes. The

overlying member points to a return to aridity which with minor climatic fluctuation continuous to prevail to this day.

Deesa member

This member essentially consists of wind blown fine sand and silt deposited (Plate 4.12) during the major arid phase that set in during the Terminal Pleistocene. Seen practically all over Central and North Gujarat from Narmada to Luni, this aeolian member shows an almost continuous blanket. Characterised by a dunal or hummocky land surface. Equivalents of this member have been described by Chamyal and Merh (1992) from Mahi and Narmada sections referred to as Timba and Broach formations respectively.

In the study area, the member shows quite a prominent development. It forms a sheet like body of variable thickness the maximum 5 m, but is characterised by a very well defined dunal topography some of the dunes rising as high as 25 m above the ground level. A diagnostic feature of this formation is their distinct stabilisation, pedogenesis and calcretisation. In the study area, the member is ideally exposed in the Banas river at Deesa hence the name (Plate 4.10). Around Sabarmati, the stabilised dunal material of this member is encountered all over Ahmedabad and Mehsana. At Mahudi, the Deesa member makes up a major part of the Formation and the overlying Ogadpura member is represented only by a thin veneer of loose sand of about 2 m forming the top cover (Plate 4.13).

Plate 4.13 Dunes as seen around Ogadpura.

Plate 4.14 Closeup view of Ogadpura dunal member (Loc. Ogadpura).

Further north the environs of Banas also typically comprise a landscape made up of this member. Beyond Banas towards Luni the topography is a reflection of this member the entire landscape providing an undulating hummocky surface with occasional clusters of higher dunes (Diodhar, Δ 73 m, Tharad Δ 59 m, Khundala Δ 63 m and Vav Δ 43 m). A common feature of this member is a distinct stabilised nature with a clear vegetal cover.

The constituent material which makes up this member is a fine sand showing uniform grain size laterally as well as vertically (Plate 4.14). The entire accumulation is structure less, devoid of any bedding/stratification pale yellow in colour, porous homogenised and considerably consolidated. Laboratory studies have revealed that most of the sand grains comprise well sorted quartz grains, mica flakes and a small percentage of abraded foraminiferal tests. The lithological details granulometric characteristics and presence of foraminiferal shells are indicative of the sediments from two sources viz. reworked fluvial sediments and coastal marine material. A distinct development of paleosol and formation of calcretes, phenomena indicative of the factor of stabilisation point to a humid interval during which these changes took place in the aeolian sediments. Khundala on the Luni river offers a very good example of where the development of calcretes in the form of layers after layers is seen (Plate 4.15). They represent carbonates which have leached downward and precipitated in this horizon forming layers of petrocalcic horizons. A coarse sand separates these within the climatic regime then prevailing.

Plate 4.15 Calcretes occuring as distinct layers at Khundala.

Plate 4.16 Recent sands deposited over older dunes (Loc. Near Tharad).

Ogadpura member

This member represents the unconsolidated recent material spread unequally over the Deesa member (Plate 4.16). At many places it is seen resting directly over the gravels and sands of the Saroli formation. It is best developed in the area between Banas and Luni. Further north it merges into the unconsolidated sands of the Thar Desert. Occurring as discontinuous sheets of unconsolidated to weakly consolidated sand sheets as well as dunes and ridges. it provides a good example of the present day desert topography. By and large the deposits do not show any pedogenetic changes except due to the seasonal rainfalls. locally some vegetation has grown and provided stabilisation to some extent. The constituent material of this member is more or less identical to that of the Deesa member except that it tends to be slightly coarser, more friable and devoid of any calcretes.

LOCALITY WISE DESCRIPTION

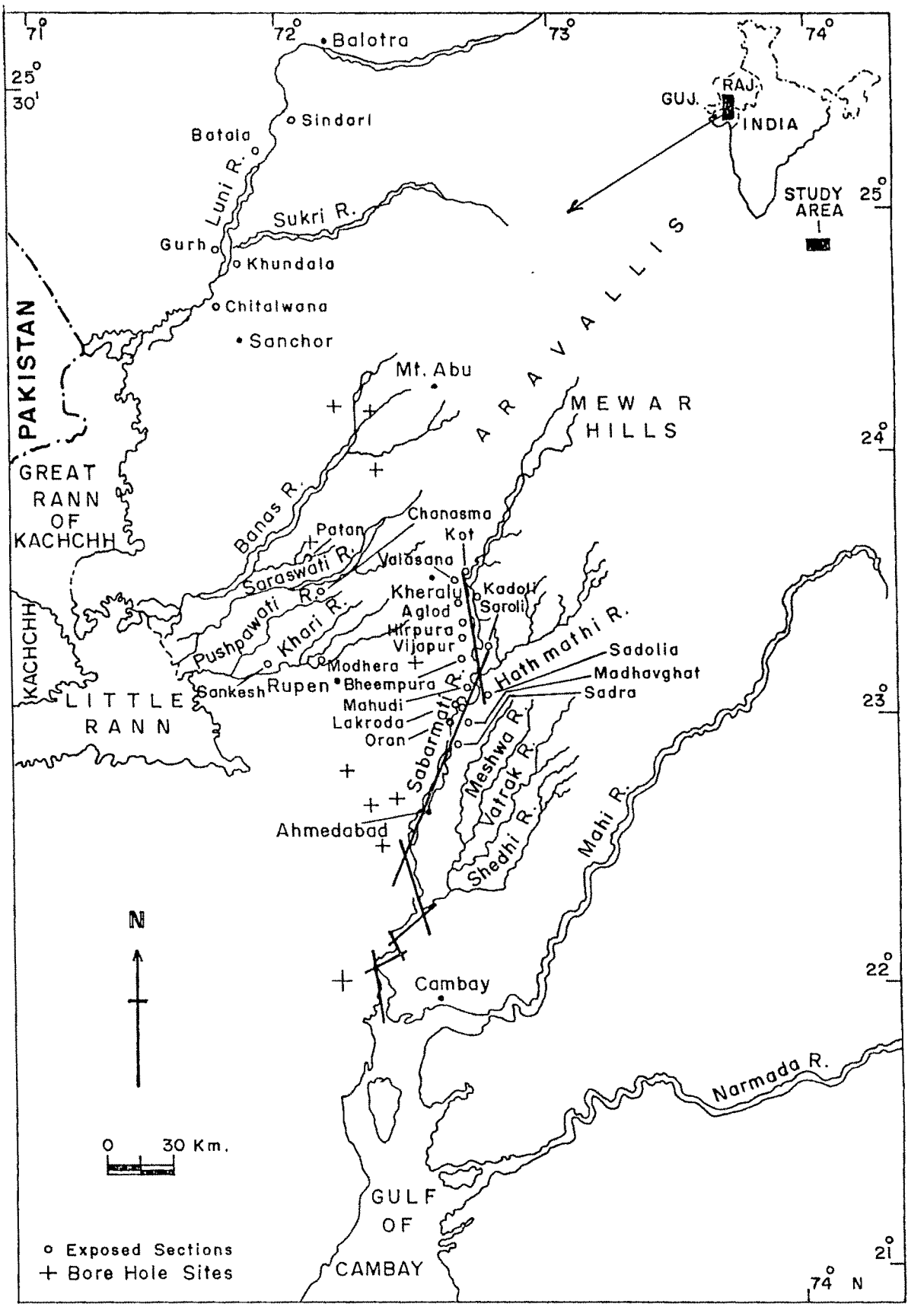
SURFACE EXPOSURES

In the course of the present study, the author has investigated sections in the Sabarmati, Rupen, Khari. Saraswati, Banas and Luni rivers. Locations of which are shown in Figure 4.5.

SABARMATI RIVER

In the Sabarmati river. fourteen sections were studied along its cliffs from Valasana to Sadra. The details of the various cliff sections are as follows.

Fig. 4·5 LOCATION OF EXPOSED SECTIONS & BORE HOLE SITES

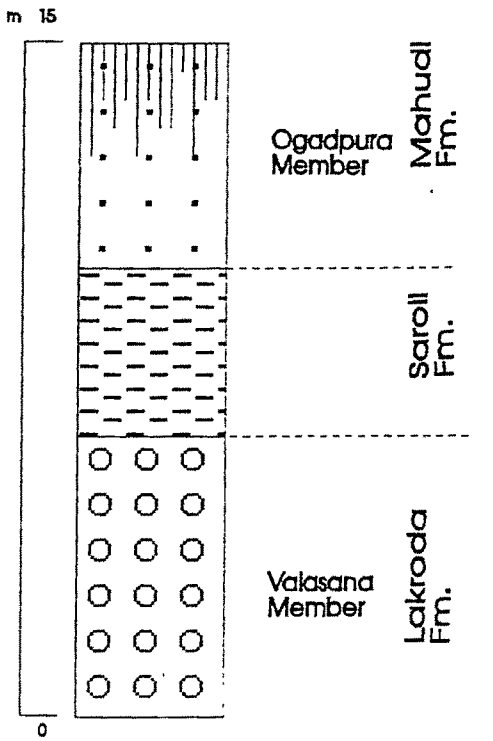


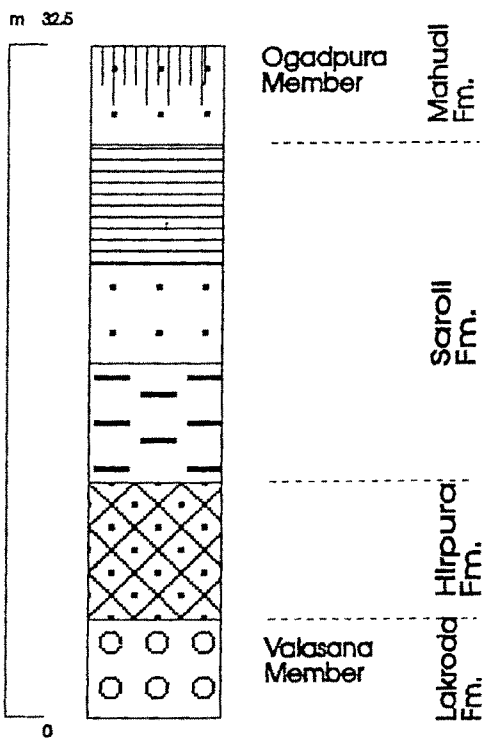
VALASANA SECTION

The Valasana section has been considered as the type section for the Valasana member of the lowermost Lakroda formation. Valasana is located south of Dharoi and has an exposed cliff section of 15 m. It offers the first best exposed Quaternary sequence in the Sabarmati river. This section is noted for the absence of the entire Hirpura formation, the Deesa member of the Mahudi formation and Sindari member of Lakroda formation. Lakroda formation is represented here by the Valasana member where the gravel-I unit forms the base of the exposed sequence.

KOT SECTION

Located 25 km downstream of Valasana, the Hirpura formation is first exposed at this location in the Sabarmati basin. The Deesa member and Sindari member of Mahudi and Lakroda formations are not

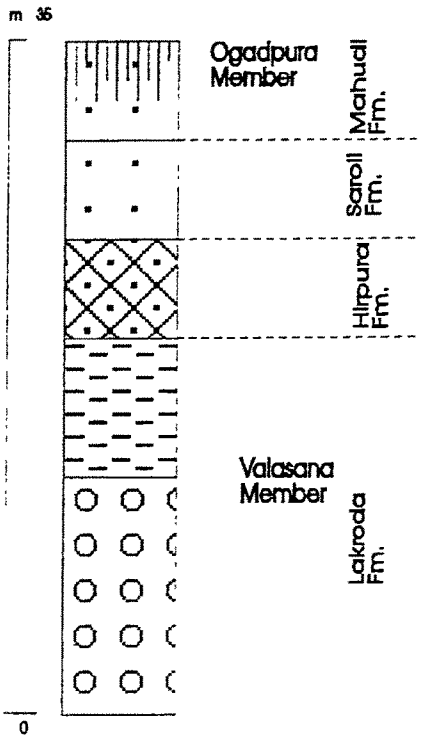




exposed. The Valasana member (Gravel-I unit) forms the base.

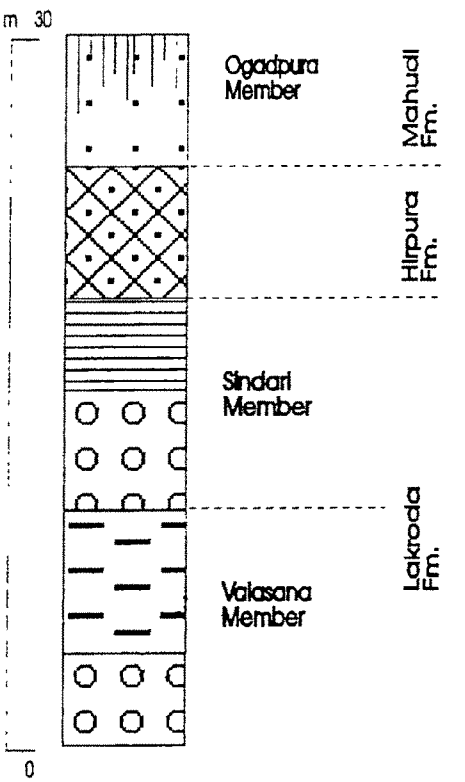
KADOLI SECTION

This section shows a sequence similar to that at Kot except that the Valasana formation is fully represented with both the units of fractured mud and gravel-I. The gravel is highly compacted, with streaks of red colouration and has a thickness of 7 m.



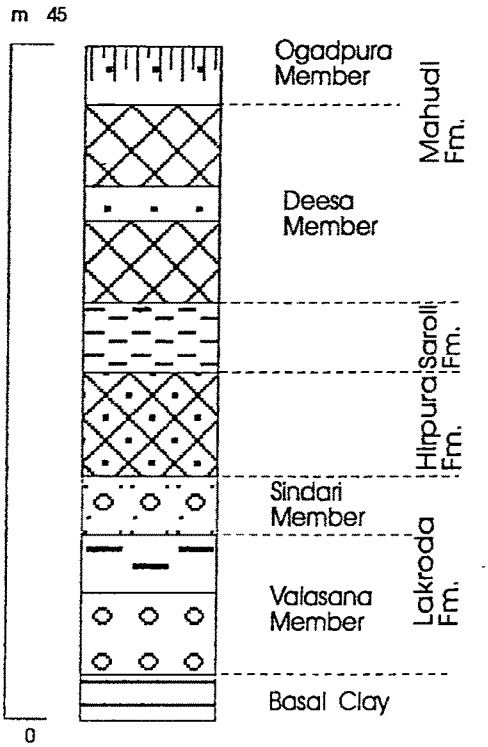
AGLOD SECTION

The Aglod section, 33 km from Vijapur is conspicuous for the first exposures of the cross stratified gravel-II unit of the Sindari member which is fully exposed. Valasana member forms the base while the rubified silts of Hirpura formation are seen directly underlying the top dunal sands.



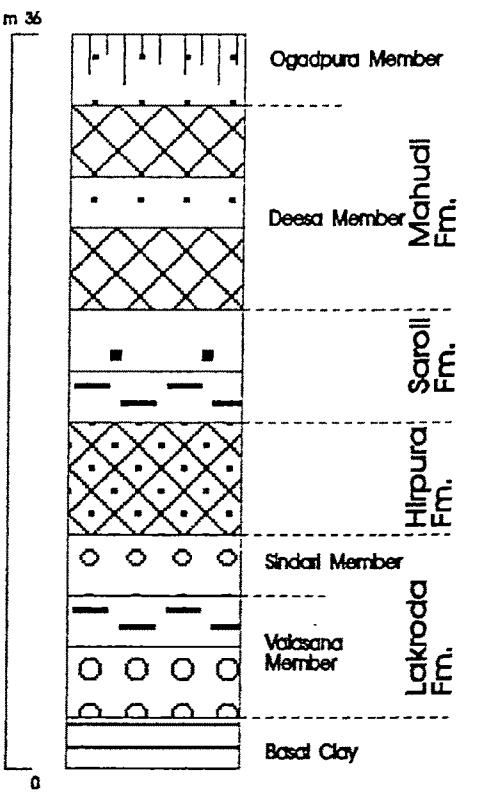
HIRPURA SECTION

The type section of Hirpura formation is located 17 km from Vijapur. Needless to say, the most conspicuous feature of this section is the massive horizon of the Hirpura formation of rubified silts. This section represents a comparatively better developed Sabarmati Quaternary sequence where all the formations are exposed.



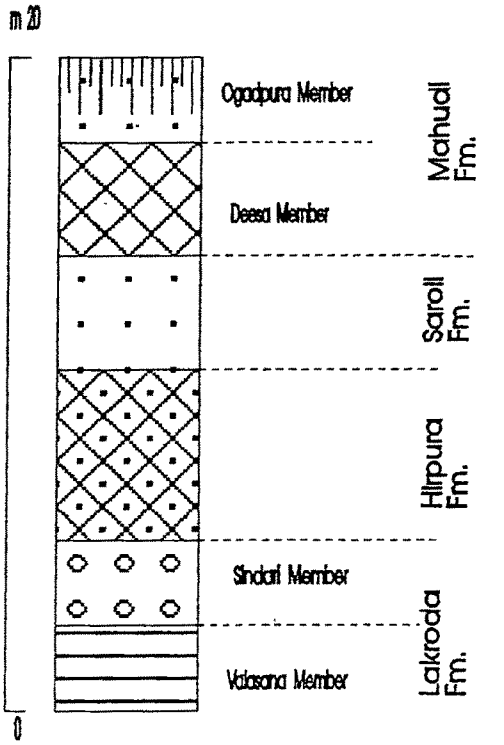
VIJAPUR SECTION

The Hirpura section continues downstream in the Vijapur area also, and the cliff sections except for the disappearance of the laminated mud unit of Sindari member is unchanged. The base of the sequence at Vijapur though is a clay horizon.



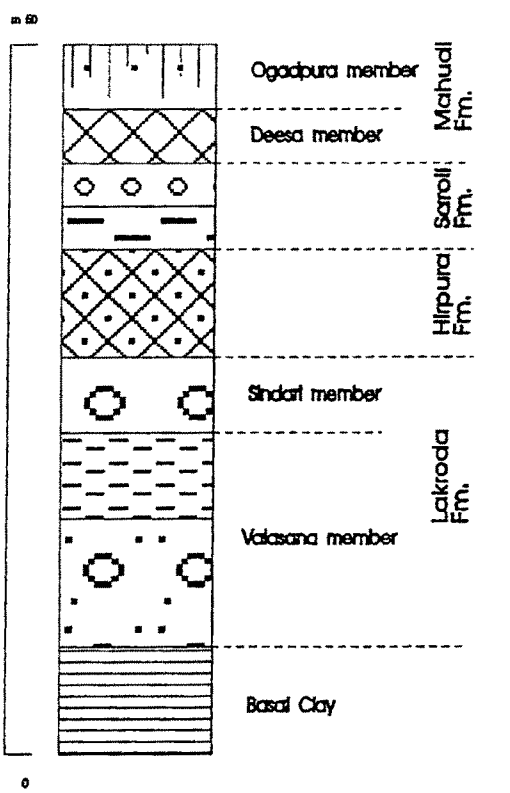
BHEEMPURA SECTION

The Bheempura section located in the ravines of the area around the village Bheempura has the Valasana member (mud unit) of the Lakroda formation exposed in the lower part. The Saroli formation is poorly represented, while both the members of the Mahudi formation are exposed at this section.



SAROLI SECTION

The type section of the Saroli formation, the cliffs here present a breathtaking view of the Sabarmati river with heights of over 55 m representing probably the best and most complete sequence of the Quaternary deposits in the entire course of the river. The base of the section is a bluish green mottled clay horizon. The coarse sandy cross bedded gravel, (Gravel-III) of Saroli formation is exposed here. The laminated mud unit of Sindari member and the Lakroda



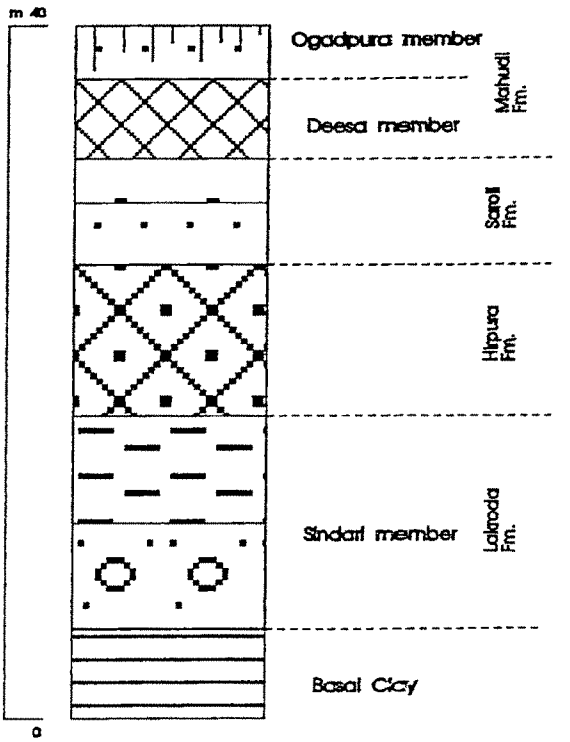
formation is not exposed here suggesting its appearance at Kot and Aglod only as a lensoid body.

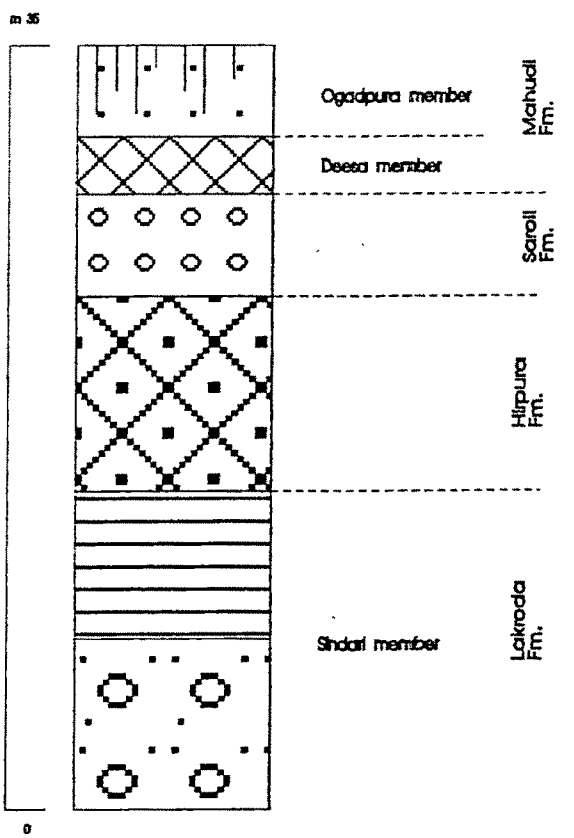
MAHUDI SECTION

The type section of the Mahudi formation, it is located 32 km from Gandhinagar and represents a massive cliff section. The Mahudi section is noticeable for the disappearance of the entire Valasana member due to which the gravel-II unit of Sindari member is seen directly resting over the basal clay horizon.

SADOLIA SECTION

Located downstream of Mahudi, the only notable aspect of this formation apart from its continuity of the Mahudi sequence is that the gravel-II unit of Saroli formation is seen directly overlying the rubified silts of the Hirpura

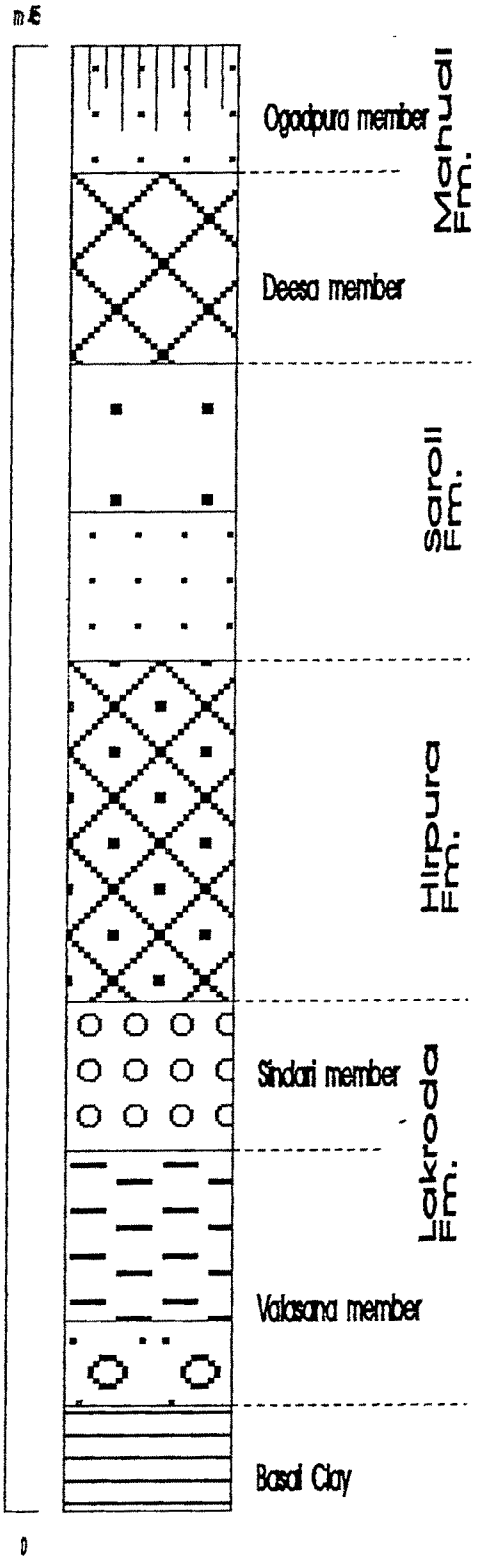




formation. The Deesa member is also not exposed at this section.

LAKRODA SECTION

Lakroda offers a cliff section which along with the Saroli section represent the two best exposed sequences of the Sabarmati river cliffs. The most important feature of the Lakroda section is the reappearance of the Valasana member here though its nature is quite different from its earlier counterparts upstream in the proximal source of the river. The gravel-I unit is highly compacted, massive and has a very fine grain size unlike the pebbly coarse compacted gravel upstream. Apart for the absence of the mud unit of Saroli formation, this section represents the most complete exposed sequence of the entire Sabarmati river. The name of Lakroda formation is given to the basal formation due to the best developed



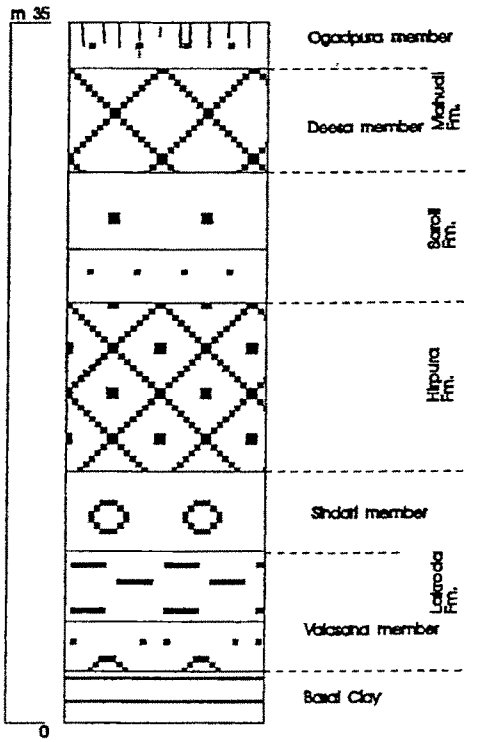
exposures of the Valasana and Sindari members at this locality.

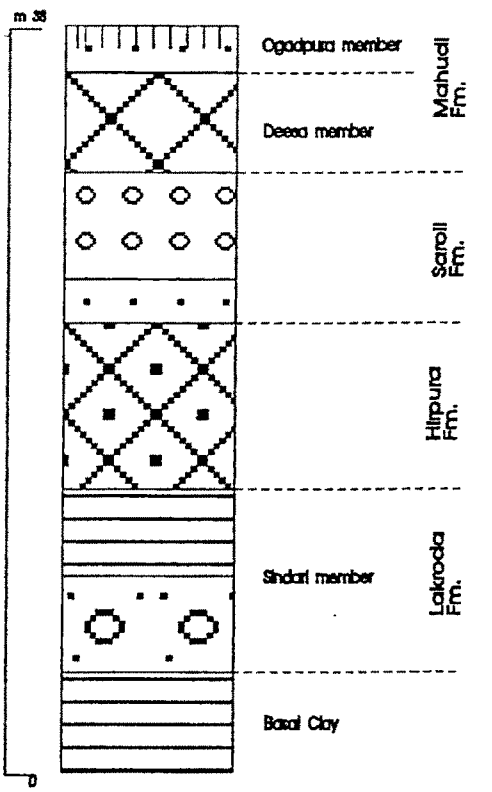
ORAN SECTION

At this locality, 20 km from Prantij, the gravel-I unit of the Valasana member has a sheet like appearance and is quite thick. All the other formations are present here, though not complete. The Hirpura formation is very prominent at this location and is visible from a long distance.

MADHAVGHAT SECTION

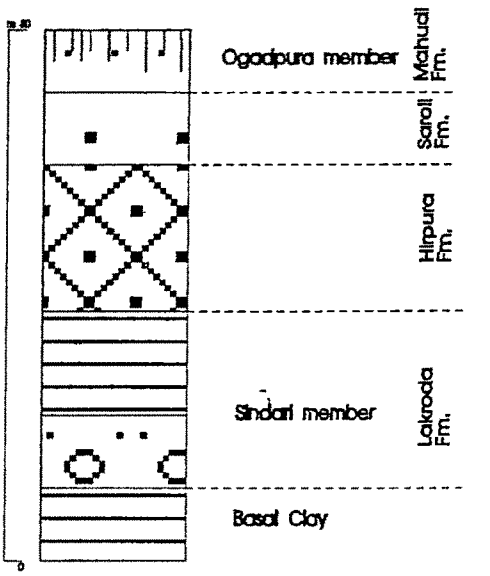
At Madhavghat, upstream of Sadra, the Valasana member is absent, the gravel of the Sindari member directly rests over the basal clay horizon. Its appearance at Oran and Lakroda indicate its reappearance only as a lensoid body in the downstream channel of the Sabarmati.





SADRA SECTION

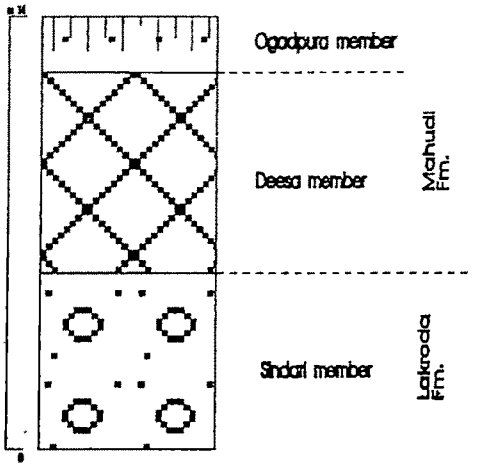
Sadra represents the last exposed section clearly showing good exposure of the Sabarmati sequence. The aeolian silts of Deesa member and the Valasana member of Mahudi and Lakroda formations are absent. The Sindari member is seen directly resting over the basal clay horizons.



RUPEN RIVER

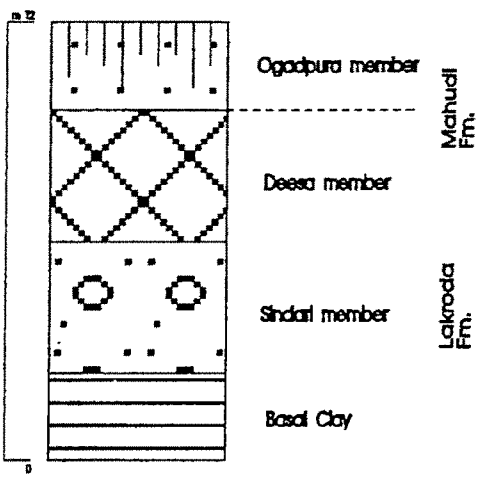
MODHERA SECTION

At Modhera 25 km from Bechraji, the section shows the gravels of Sindari member at the base over which lies the Deesa member, capped by the Ogadpura member of Mahudi formation.



SANKESH SECTION

Sankesh, east of Modhera has an exposed cliff of 12 m. The sequence is similar to that of the Modhera except that the

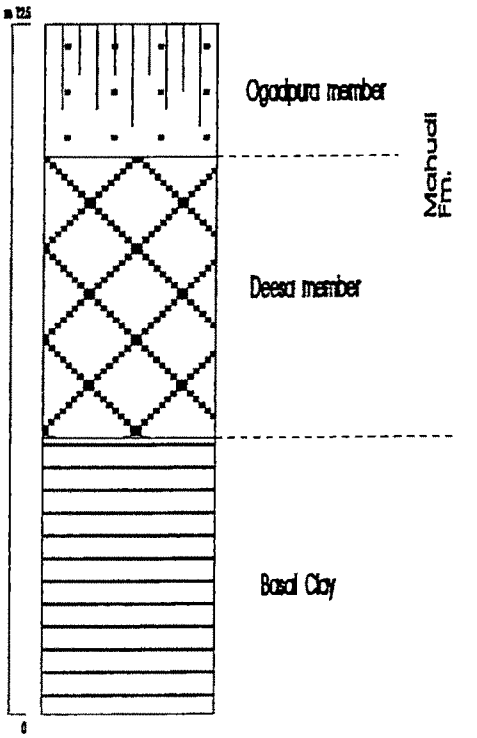


Sindari member is seen resting over the basal clay horizon.

KHARI RIVER

CHANASMA SECTION

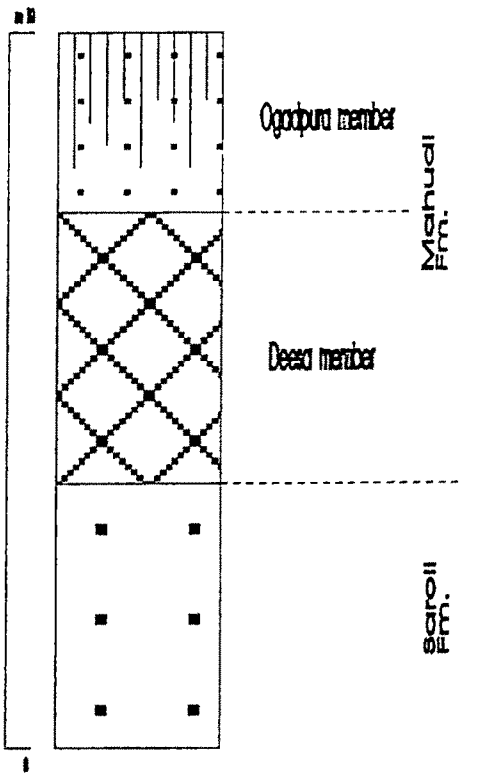
Khari river at Chanasma has an exposed cliff of 12.5 m where the basal clay horizon forms the base. Overlying it are the two members of Mahudi formation.



SARASWATI RIVER

PATAN SECTION

The Saraswati river at Patan shows very nondescriptive cliffs with only parts of the Saroli formation and the Ogadpura member of the Mahudi formation exposed.

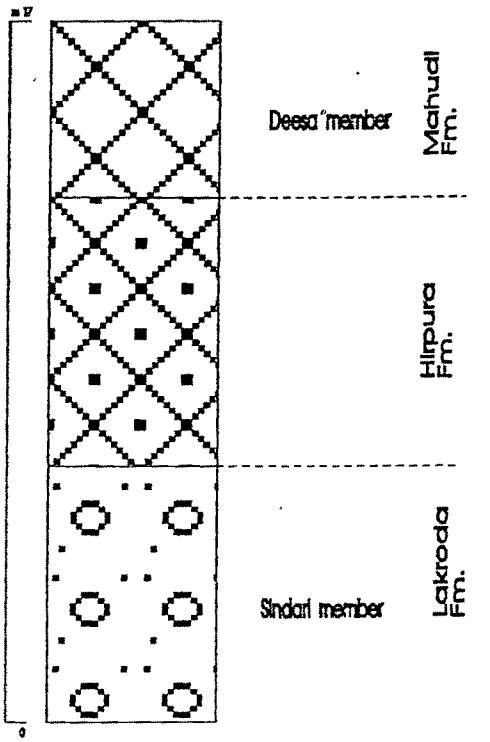


BANAS RIVER

DEESA SECTION

The Deesa section forms the type area for the Deesa member of the Mahudi

formation where the stabilised dunal sands provide a very good exposure of this member. The gravels of Sindari member are exposed at the base over which lie the rubified silts of Hirpura formation capped by the Deesa member.

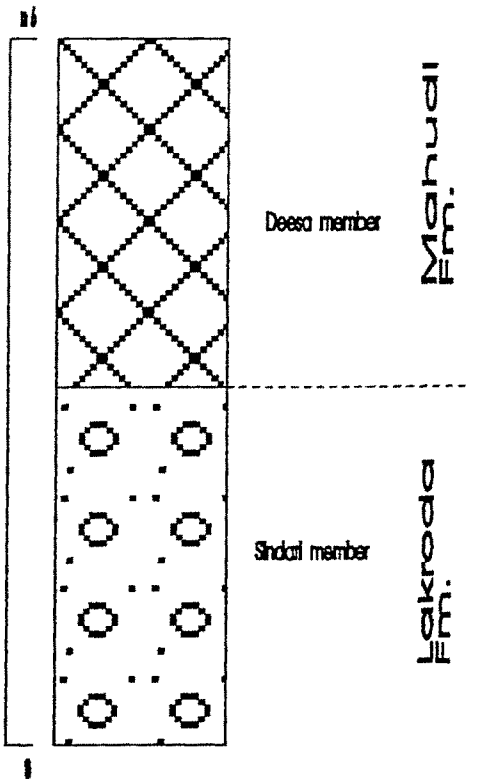


LUNI RIVER

The Luni river bordering Gujarat and Rajasthan exposes the upper part of the sequence seen in the Sabarmati river.

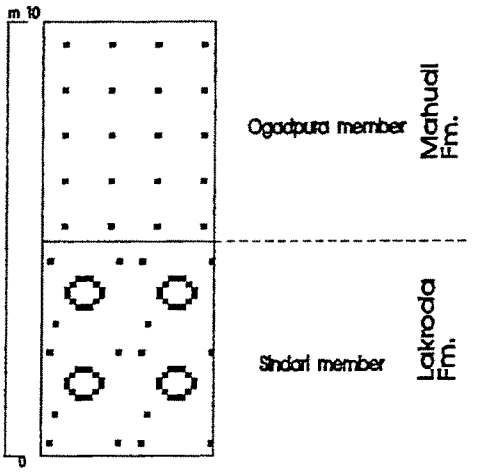
SINDARI SECTION

This section located south of Balotra provides the type area for the Sindari member of the lowermost Lakroda formation. Needless to say it is the most prominent feature of this section. The dunal sands of Deesa member overlie the Sindari member in a cliff of 15 m.



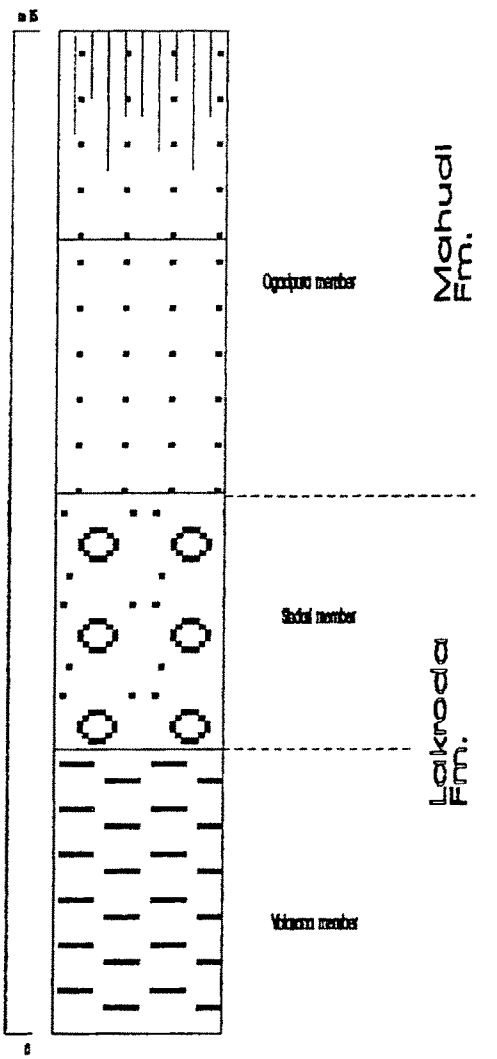
BATALA SECTION

Batala located downstream of Sindari has a cliff of 7 m. The base is the Sindari member over which lie the dunal sands of Ogadpura member.



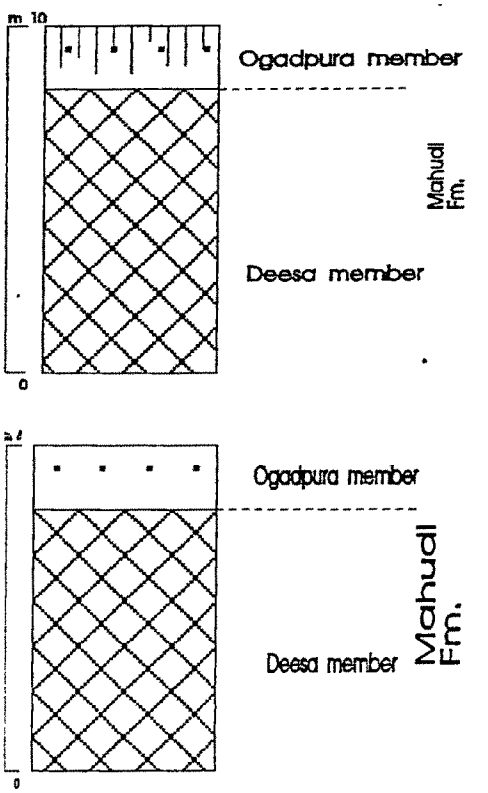
KHUNDALA SECTION

Khundala near Chitalwana has a 15 m thick exposed sequence where the gravels of Sindari member are the most conspicuous feature, overlying the muds of Valasana member. A noteworthy feature of this section is that the overlying Deesa member which is exposed here shows very distinct layering of calcretes. Ogadpura member caps the top of the section, though at nearby areas present day shifting dunes overlie this member.



GURH SECTION

This locality is conspicuous only for the continued pedogenetic changes seen in the Deesa member which shows calcrete layers. Ogadpura member makes up the present day topography.



CHITALWANA SECTION

The aeolian silts of Deesa member and the Ogadpura member dunal sands form a cliff of around 10 m exposed all along the Lower Luni.

SUB-SURFACE SECTIONS

Bore hole data from the vicinity of the Sabarmati river, to the area in the north, encompassing the Banas and Saraswati, reveal a thickness of more than 300 m all through out the region. The sequences revealed are similar to that exposed by the Sabarmati in its cliff sections and the top 50 m of either sections are comparable. Figure 4.3 shows the distribution of the bore hole sites. In all ten bore hole sites were studied and their lithologs are as follows.

JANALI (24° 36' - 72° 09')

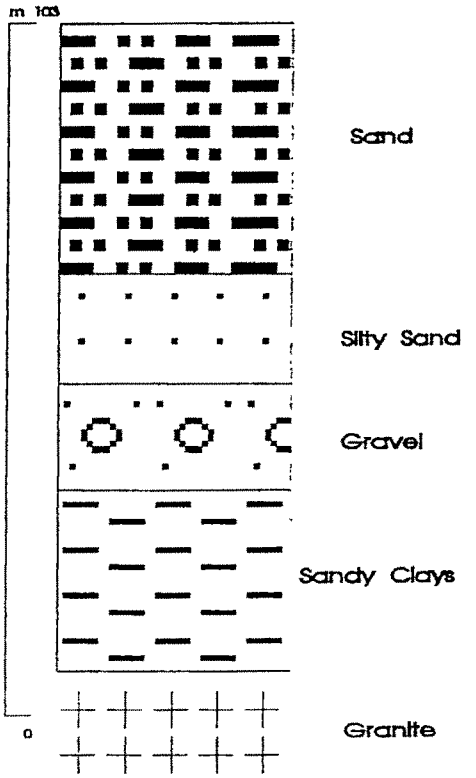
Janali (Banaskantha District)

Height - 200 m amsl

Depth of drilling - 103 m

Basement - Granite

The sequence revealed by the bore hole is quite similar to that of the exposed sections. The gravel unit being comparable to the Sindari member, the silty sand (Hirpura Formation ?) and the sand belonging to the Mahudi Formation.



RASANA (24° 13' - 72° 15')

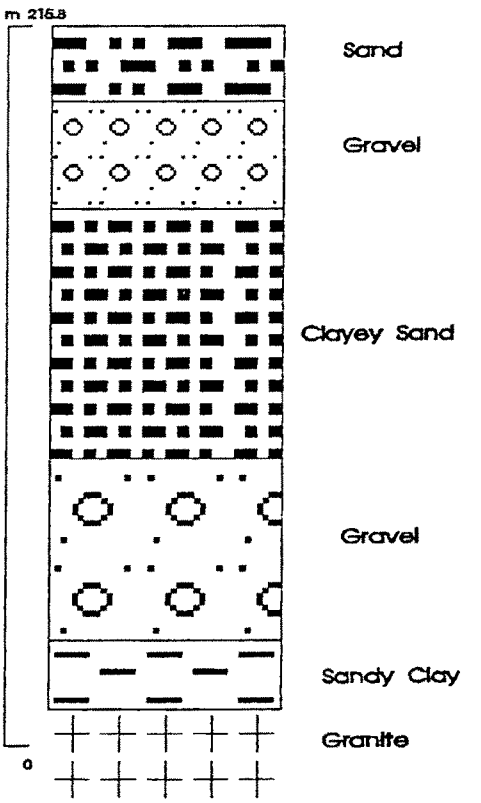
Rasana (Banaskantha district)

Height - 162 m amsl

Depth of Drilling - 215.8 m

Basement - Granite

The sequence revealed by the drill hole shows two gravels (Valasana and Sindari member) resting over sandy clays.



BHATSAN (24° 07' - 72° 10')

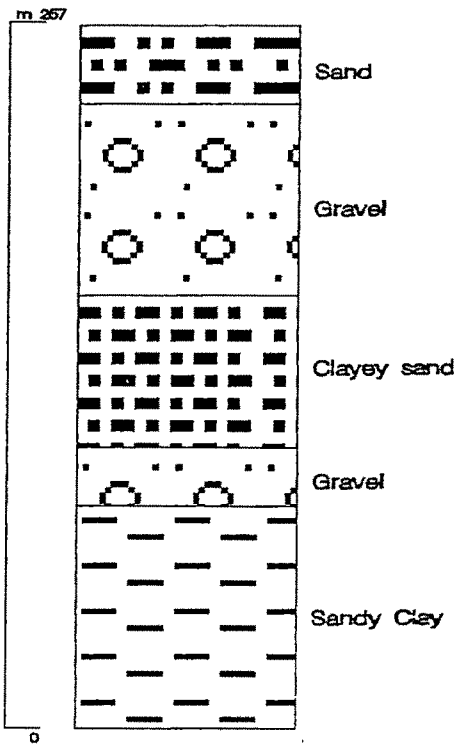
Bhatsan - Mehsana District

Height - 125 m amsl

Depth of drilling - 257 m

Basement - Sandy Clay (Granite not encountered)

The sandy clay which form the base of the bore hole is overlain by two gravel units (Valasana and Sindari member) seperated by a clayey sand of Valasana member covered by the sand (Mahudi formation).



VASNA (23° 55' - 72° 06')

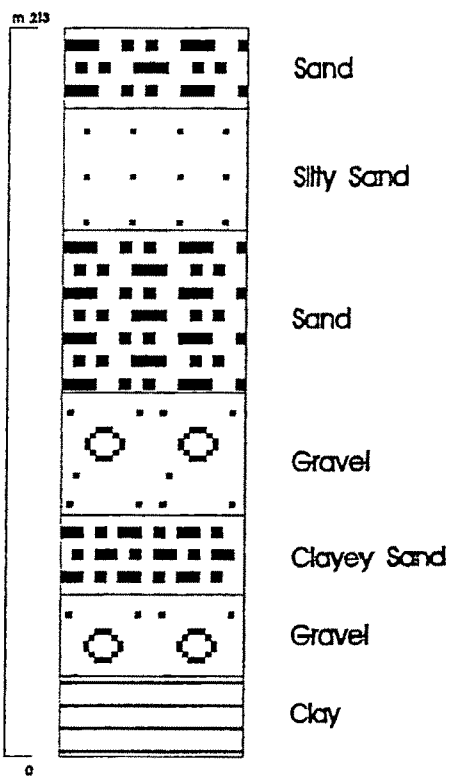
Vasna - Mehsana District

Height - 89 m amsl

Depth of drilling - 213 m

Basement - Clay (Granite not encountered)

Representing a more complete equivalent of the exposed sequence of the gravels

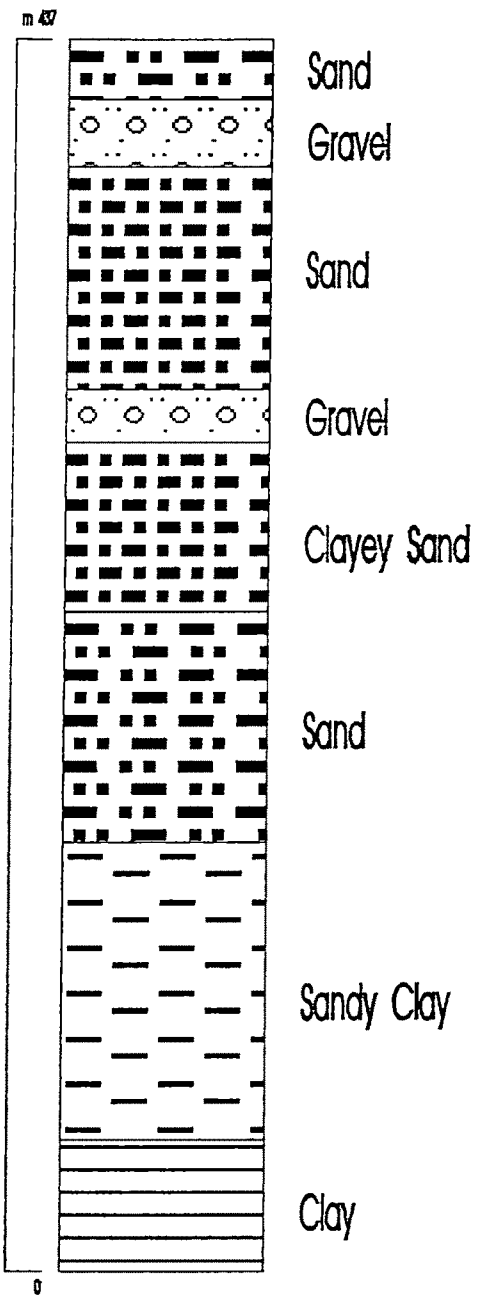


(Valasana and Sindari members of Lakroda formation) are overlain by the coarse sand (Saroli formation), capped by the sands (Mahudi Formation).

MEWAD (23° 32' - 72° 23')

Mewad - Mehsana District
Height - 83 m amsl
Depth of drilling - 440 m
Basement - Clay (Granite not encountered)

At Mewad, the gravels (Sindari and Valasana members of Lakroda formation) are seen in the subsurface litholog under lain by a clayey sand, changing downwards into a sandy clay and finally clay whose base in not reached. The sands of Mahudi formation are seen at the top.



WADSAR (23° 10' - 72° 28')

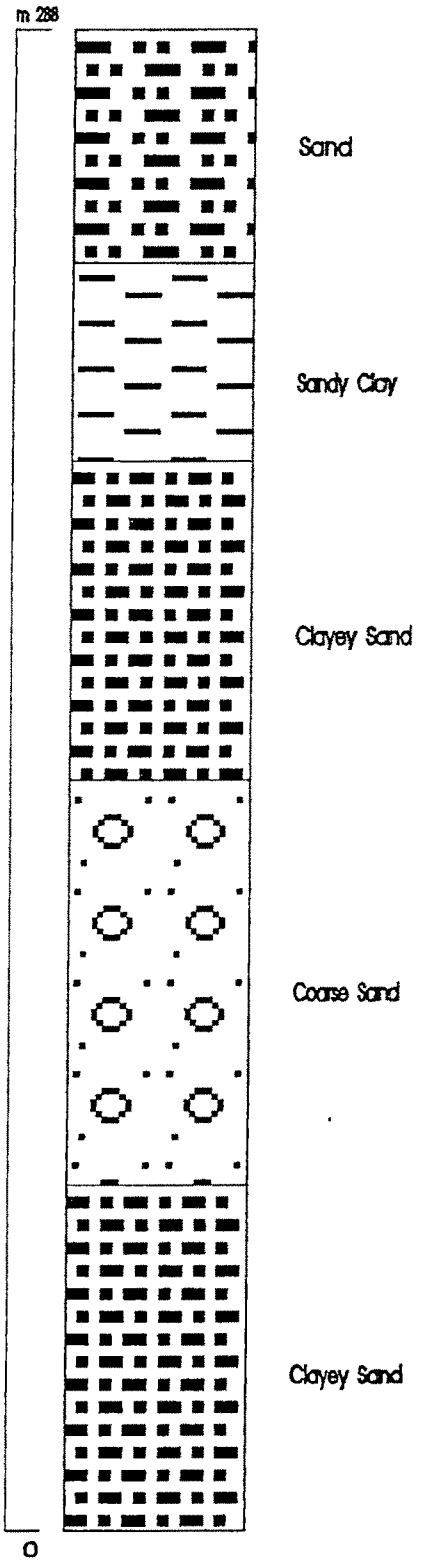
Wadsar - Mehsana District

Height - 64 m amsl

Depth of drilling - 288 m

Basement - Clayey sand (Granite not reached)

Wadsar located at the distal end of the study area is marked by the complete absence of the gravels (Lakroda formation). The coarse sands (Saroli formation) are underlain by the clayey sands (basal clay ?). Top is made up by the sands (Mahudi formation).



AHMEDABAD (23° 03' - 72° 36')

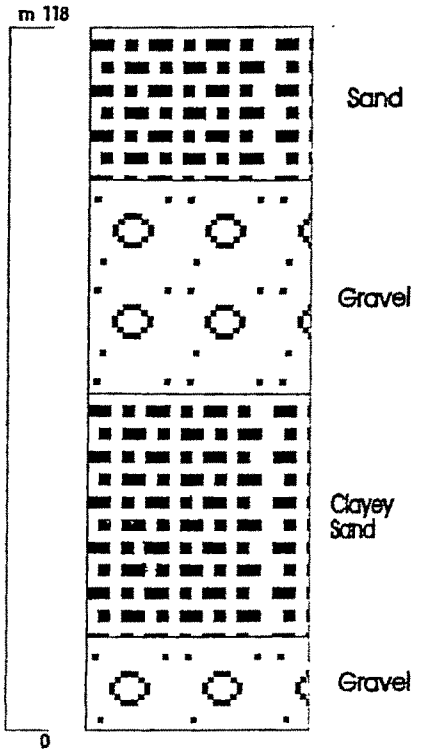
Ahmedabad - Ahmedabad District

Height - 40 m

Depth of drilling - 118 m amsl

Basement - Gravel

The gravel units of Lakroda formation (Valasana member and Sindari member) are present in this litholog separated by a clayey sand. The sands of Mahudi formation unit form the top.



SOYALA (22° 57' - 72° 22')

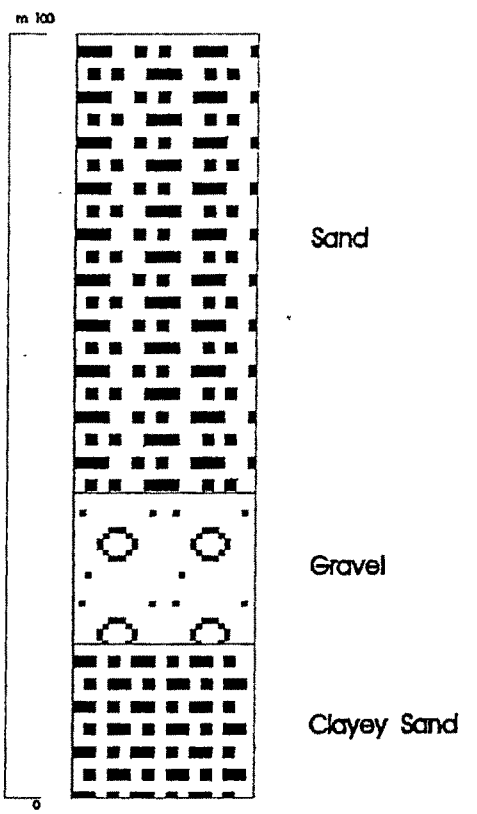
Soyala - Ahmedabad District

Height - 33 m

Depth of drilling - 248 m

Basement - Clay

Shows the same continuity of the Ahmedabad bore hole data, the gravel (Sindari member), underlain by the clayey sands (Bluish clays).



PHANGADI (22°55' - 72° 19')

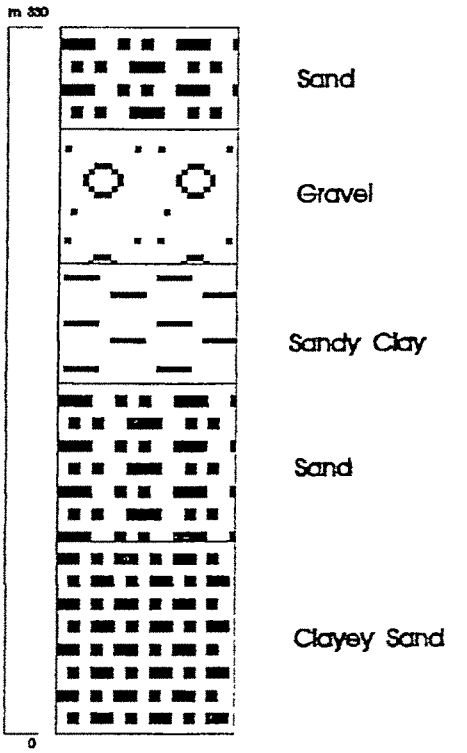
Phangadi - Ahmedabad District

Height - 28 m

Depth of drilling - 337 m

Basement - Clayey sand

Clayey sands, sand and sandy clays (basal clay) comprise a major part of this sub-surface location, overlain by gravel (Lakroda formation) capped by sand (Mahudi formation).



MANKOL (22° 53' - 72° 18')

Mankol - Ahmedabad District

Height - 24 m

Depth of drilling - 296 m

Basement - Clay

At Mankol, sandy clay and clayey sand (basal clay) form the base of the sequence similar to Phangadi overlain by gravel and sand (Lakroda and Mahudi formation respectively).