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PALAEOENVIRONMENT AND PALAEOGEOGRAPHY OF LAMETA GROUP SEDIMENTS (LATE CRETACEOUS) IN JABALPUR AREA, INDIA

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ABSTRACT

Lameta Group sediments (Late Cretaceous) in Jabalpur area are investigated for reconstruction of their palaeoenvironment. These sediments represent deposits of an estuarine complex, exclusively by marine processes. The Green Sandstone represents deposits of an estuarine channel with rather strong tidal currents (ca. 0.50—1.50 m/sec), and exhibits dominantly bipolar large-scale cross-bedding and rare *Thalassinoides* type burrows. Bioturbated carbonates and marls (Lower Limestone, Mottled Nodular Marl, Upper Limestone, Upper Sandstone) denote deposits of estuarine tidal flats with rich benthonic community (mostly crabs), and exhibit extensive churning of sediments and dense, complex network of burrows of various dimensions and running in different directions. Depending upon the variation in the proportion of carbonate and terrigenous clastic material and its grain size, different facies and lithounits are developed. The Bagh and Lameta sediments are synchronous and are only the facies variants; they are product of deposition of a short-lived marine transgression in Narbada Valley of Late Cretaceous in age which started during Turonian and may have lasted until Senonian. The use of term NARBADA GROUP of Singh and Srivastava is extended to include all the deposits of Late Cretaceous transgression in Narbada Valley and their facies variants (e.g. Nimar Sandstone, Bagh beds, and ameta beds).

INTRODUCTION

In Jabalpur area, thin, scattered patches of sedimentary rocks occur overlying the Precambrian metamorphic and granitic rocks and underlying the Deccan Traps. These sedimentary rocks belong to two different groups, namely Jabalpur Group and Lameta Group. Medlicot (1872) made a few remarks about these sediments of Jabalpur area ; while Matley (1921) mapped part of these sediments systematically and proposed a detailed stratigraphy.

Jabalpur Group sediments are represented by immature sandstones and shales with coal bands yielding plant fossils of Upper Gondwana affinity.

Lameta Group sediments are made up of carbonates, sandstones, marls and overlie the Jabalpur Group sediments. Traditionally, the Lameta Group sediments were considered to be fresh water (fluvial) deposits, mainly because of the absence of marine fauna and presence of remains of dinosaurs and some fresh water molluscs (Matley, 1921 ; Pascoe, 1964). However, Chanda (1963 a, b, 1965, 1967) and Chanda and Bhattacharyya (1966) suggested a shallow marine environment of deposition for Lameta sediments mainly on the basis of petrological criteria, i.e. maturity of terrigenous clastic material, presence of glauconite, presence of algal textures in the carbonates and lithological association. Sahni and Mehrotra (1974) again asserted a fresh water origin for the major part of the Lameta sediments. Later, Kumar and Tandon (1977, 1978 1979) demonstrated a marine environment of deposition for most of the Lameta sediments (especially the mottled nodular bed), mainly because of the presence of extensive crab burrows in these sediments. But Chiplonkar (1980) casts doubts on the marine environment of deposition for Lameta sediments, containing crab burrows.

In the present paper environment of deposition of Lameta Group sediments in Jabalpur area is discussed mainly on the basis of primary sedimentary structures and their sequential arrangement, and a palaeogeographic model is proposed. Fig. 1 shows the distribution of Lameta and Bagh Group sediments in Narbada Valley.

STRATIGRAPHY OF LAMETA SEDIMENTS IN JABALPUR

Lameta sediments in Jabalpur area are somewhat thick and show most differentiated development and is divisible into a number of lithostratigraphic units, while in other areas of Lameta sediments persistent sequence is not observable (Pascoe, 1964).

The Lameta sediments in Jabalpur area occur in scattered patches, the different outcrops ranging in thickness from 7-50 m. The name Lameta was given by J. G. Medlicott in 1860 after the Lameta Ghat on the Narbada River, a few kilometres southwest of Jabalpur where sandy carbonates of Lameta Group rest upon the metamorphics. The Lameta succession at Lameta Ghat is somewhat less developed ; while it shows good sections in Jabalpur cantonment area.

Matley (1921) prepared a detailed geological map of the Lameta sediments exposed in Jabalpur cantonment area on a 8" = 1 mile scale and proposed a detailed

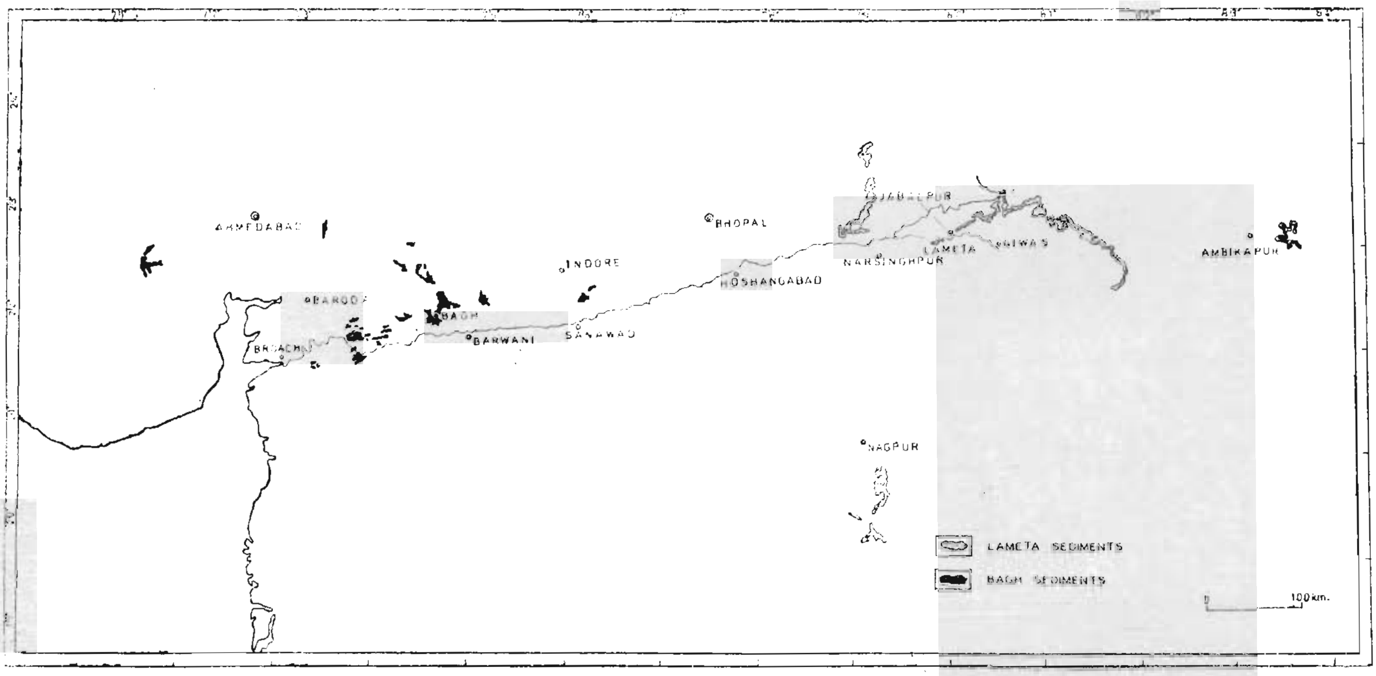

Fig. 1. Location map showing distribution of Lameta and Bagh Group sediments in Narbada Valley and adjacent areas.

lithostratigraphy (see Table 1). The mottled nodular bed is the most distinctive unit all over the Jabalpur area including the Lameta Ghat.

Investigations of Matley (1921) in NE of Jabalpur show that the same type of Lameta succession is present up to about 12 kilometres from Jabalpur. About 30 km NE of Jabalpur Lameta sediments are well-developed except for the Green Sandstone unit. About 60 km NE of Jabalpur, above the Jabalpur Sandstone limestone of Lameta with gravelly bed is present.

Unfortunately, ignoring the excellent map of Matley (1921) clearly demonstrating the mappability of his lithounits, Chanda and Bhattacharyya (1966, p. 63) state that "facies variations are erratic and inconsistent to deserve recognition in any practical stratigraphic classification". This statement is baseless, as the lithounits proposed by Matley are recognizable and mappable in the Jabalpur cantonment area (see map of Matley, 1921). No doubt, the lithounits of Matley are not well-developed at Lameta Ghat; but denying existence of these units in Jabalpur cantonment area amounts to ignoring of facts.

Chanda and Bhattacharyya (1966) proposed a modified stratigraphy (Table 1), grouping the upper three divisions of Matley into a single unit and gave just a sketch map in support of their new stratigraphy. Consequently, the modified stratigraphic scheme of Chanda and Bhattacharyya (1966) has no relevance until supported by detailed map, systematic lithologs etc.

In the present paper the terminology of Matley (1921) has been essentially followed with slight modifications (Table 1).

Table 1. Stratigraphy of Lameta sediments in Jabalpur area.

MATLEY (1921)		CHANDA and BHATTACHARYYA (1966)	Present Paper
Deccan Trap		Deccan Trap	Deccan Trap
Lameta Group	(e) Upper Sands		e. Upper Sandstone
	(d) Upper Limestone (a local zone)		d. Upper Limestone
	(c) Mottled Nodular Beds	1. Upper Sandy Limestone	c. Mottled Nodular Marl
	(b) Main or Lower Limestone	2. Lower Limestone	b. Lower Limestone
	(a) Green Sand	3. Green Sand	a. Green Sandstone
		Unconformity	Unconformity
Jabalpur Group		1. White Clay	
	(b) White Clays	2. Sandstone grading into a basal white silty clay in the west.	b. Jabalpur Clay
	(a) Sandstones		a. Jabalpur Sandstone

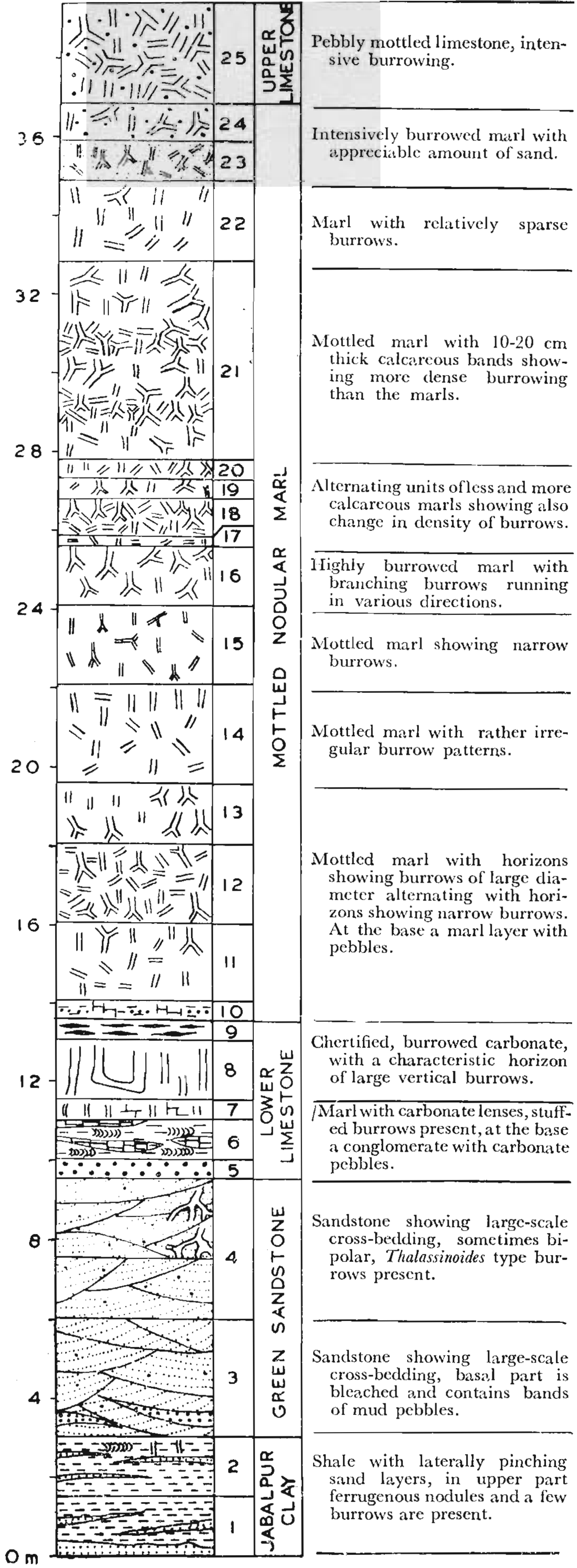

Fig. 2. Litholog of Lameta succession exposed at Chui Hill showing distribution of inorganic sedimentary structures and burrows (see also table 2).

In the present study, Lameta sediments exposed in Jabalpur cantonment, Lameta Ghat, and a small outcrop near Madan Mahal have been investigated. Three sections ; namely Chui Hill, Bara Simla Hill, and Lameta Ghat are described in detail. :

CHUI HILL SECTION

In the Chui Hill a rather thick, well-developed succession of Lameta Group sediments is exposed. The lithounits exhibit rather differentiated facies development and exposures are good. This section can be taken as a reference section. A detailed litholog of the succession is shown in fig. 2, while lithological details are given in Table 2.

In this section Jabalpur Sandstone is not exposed, and the succession starts with about 3 m thick succession of Jabalpur Clay containing sandy intercalations. Some thin sand layers show graded bedding. In this unit burrows are scattered, and a few are horizontal stuffed burrows with spreites.

The Jabalpur clay is followed by Green Sandstone. The contact between the two is variable. At places Green Sandstone unit is placed over the clays with a smooth but sharp contact. At other points, lower part of Green Sandstone is bleached and may contain channel and layers rich in mud pebbles. (see Singh *et al.*, in preparation).

Lower Limestone is basically a cherty limestone, highly bioturbated and shows no primary bedding, but a distinct horizon of large burrows.

The Mottled Nodular Marl is well-developed and can be distinguished into a number of smaller units depending upon content of carbonate and sand, abundance and nature of burrows. The Upper Limestone unit is rather sandy with high content of pebbles, while the Upper Sandstone is not visible, and is probably covered under the scree of overlying Deccan Traps.

BARA SIMLA HILL SECTION

In the Bara Simla Hill too, well-developed succession of Lameta sediments is present and exposed along the newly constructed road. The litholog is shown in fig. 3, while lithological details are given in Table 3.

An important feature in this section is the presence of a ca. 30 cm thick unit of chertified conglomerate with pebbles of underlying Green Sandstone at the base of Lower Limestone. The Lower Limestone in this section is rather marly, showing alternating bands of marl and shaly carbonate. Burrows are common ; but the large burrow of the type seen in Chui Hill are not seen.

The Mottled Nodular Marl shows well-developed extensive and dense burrows, where burrows of different sizes are closely packed and running in different directions.

Table 2. Lithologic succession of Lameta sediments exposed at Chui hill, Jabalpur.

	Covered by Trap debris	
Upper Limestone	2.50 m (25)	Pebbly mottled limestone with pebbles upto 2 cm diameter of jasper and quartzite, intensively burrowed, locally horizontal *Thalassinoides* type burrows common, otherwise burrow patterns indistinct.
	1.00 m (24)	Mottled marl with coarse sand, burrows about 2 cm in diameter, pattern of burrows not clear.
	1.00 m (23)	Sandy marl showing extensive small burrows of ca. 1 cm diameter and on weathered surface appear as honeycomb structure.
	2.00 m (22)	Alternating hard and soft marl layers with burrows.
	5.00 m (21)	Marl with 10-20 cm thick calcareous bands. Calcareous bands show more burrows.
Mottled Nodular Marl	0.50 m (20)	Calcareous marls with abundant burrows.
	0.50 m (19)	Marl layer with burrows.
	1.00 m (18)	Calcareous marls with abundant burrows.
	0.20 m (17)	Marl layer.
	1.50 m (16)	Extensively burrowed marls, burrows running in horizontal, vertical or inclined directions, some show *Thalassinoides* type branching.
	2.00 m (15)	Shaly marl with narrow burrows.
	2.50 m (14)	Mottled marls with rather irregular burrow patterns.
	........Section disturbed due to fault........	
	1.50 m (13)	Mottled marls showing patchy calcareous bands, burrows present, mostly 1 cm in diameter.
	2.00 m (12)	Mottled marls showing abundant burrows, most of them about 2 cm or more in diameter running in all directions.
	2.00 m (11)	Hard calcareous marls, often sandy with horizons of intense, burrowing. Burrows of several sizes occur together running in horizontal, vertical or inclined directions.
	0.50 m (10)	Soft marls with local concentration of pebbles.
	0.50 m (9)	Highly chertified carbonate with irregular chert layers.
	1.50 m (8)	Sandy, chertified carbonate with horizontal chert stringers. Abundant large burrows of 5-8 cm diameter and almost 50 cm in length.
Lower Limestone	0.50 m (7)	Sandy cherty carbonate showing only small burrows.
	1.00 m (6)	Greyish nodular marl, soft and silty with carbonate lenses showing, stuffed burrows with spreites.
	0.50 m (5)	Conglomerate made up of mostly carbonate pebbles, and a few pebbles of chert, jasper, and quartzite.
	3.50 m (4)	Green sandstone showing large-scale cross-bedding, sometimes bipolar. At one point *Thalassinoides* type burrows are present.
Green Sandstone	3.00 m (3)	Green sandstone showing large-scale cross-bedding, basal part is often bleached and enriched in mud pebbles. At the base a 20 cm thick band of mud pebbles seen. A 2 m thick unit in the form of a channel is present, filled with mud pebbles and grit.
	1.50 m (2)	Ferruginous shale, thinly laminated with abundant ferrugenous nodules. Thin sandy intercalations present decreasing upwards, a few burrows are seen.
Jabalpur Clay	1.50 m (1)	Sandstone and shale intercalations, 20-50 cm thick sand layers are seen pinching out laterally, shales contain a few iron concretions.

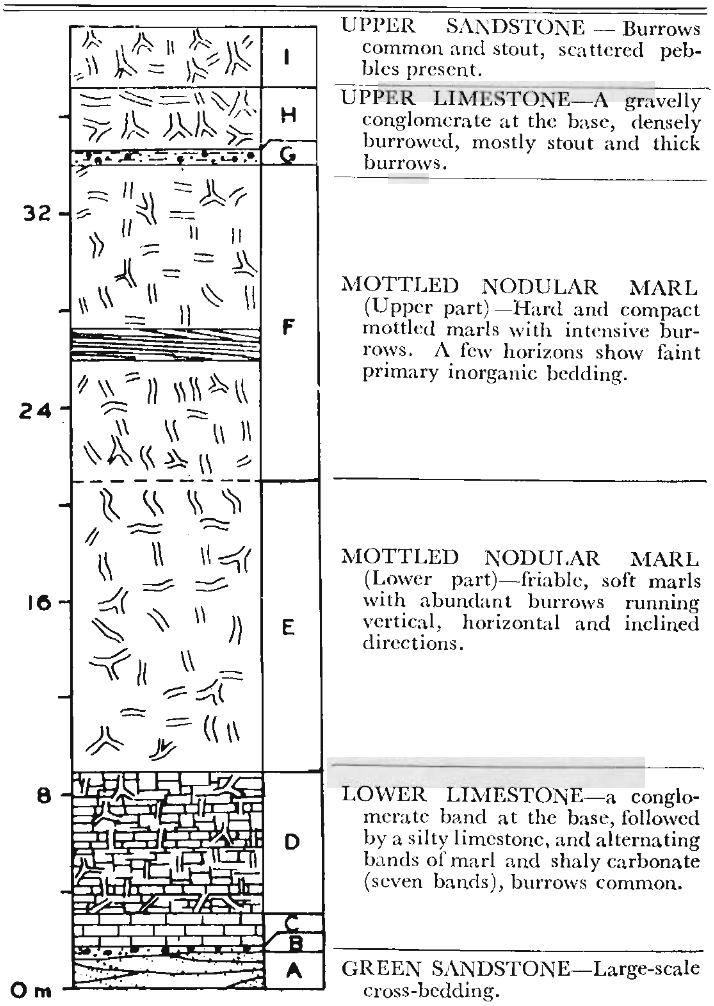

Fig. 3. Litholog of Lameta sediments exposed in Bara Simla Hill (see also table 3).

Table 3. Lithologic succession of Lameta sediments exposed at Bara Simla road section, Jabalpur.

	............Deccan	Trap............
Upper Sandstone	2.70 m (I)	Sandy limestone with scattered pebbles, burrowing common, mostly stout burrows.
Upper Limestone	2.70 m (H)	Limestone, densely burrowed, mostly thick and stout burrows.
	0.60 m (G)	Gravelly conglomerate band with marls.
Mottled Nodular Marl	13.0 m (F)	Hard and compact mottled marls with intensive burrows. A few horizons show faint primary bedding.
	11.0 m (E)	Friable, soft mottled marls with abundant burrows running in vertical, horizontal and other directions.
	5.50 m (D)	Alternating bands of marl and shaly carbonate (seven bands), burrows common, bioturbation is higher in carbonates than in the marl bands.
Lower Limestone	1.20 m (C)	Silty limestone.
	0.30 m (B)	Conglomerate band with pebbles of green sandstone, chertified.
Green Sandstone	16 m (A)	Medium-grained, friable green sandstone showing large-scale cross-bedding.

The Upper Limestone differs from Mottled Nodular Marl in being hard and compact and with thick and stout burrows. The topmost part of the succession becomes extremely sand rich and corresponds to the Upper Sandstone.

LAMETA GHAT SECTION

The Lameta sediments exposed at the *Locus Typicus*, do not exhibit as much differentiated facies as in the case of Chui Hill or Bara Simla Hill (Fig. 4, Table 4).

The lower part (about 5 m) is a hard, sandy limestone with extensive burrows of different sizes. Two horizons deserve special mention, namely a horizon of tiny burrows appearing as protuberances (Plate II-4), and another horizon of faint cross-bedding with low-angle discordances (Plate I-1). The Lower Limestone is separated from the overlying Mottled Nodular Marl by a unit containing layers of mud pebble conglomerates. The Mottled Nodular Marl shows variability in the size of terrigenous clastic material. Burrows are extremely dense.

Matley (1921) recorded a cross-bedded Sandstone at the base of the sequence on the top of Jabalpur Sandstone which he considered to be equivalent to Green Sandstone ; while a fine-grained quartzite was recorded making the top of the succession at Lameta Ghat. Both these lithounits were not observed in the present study.

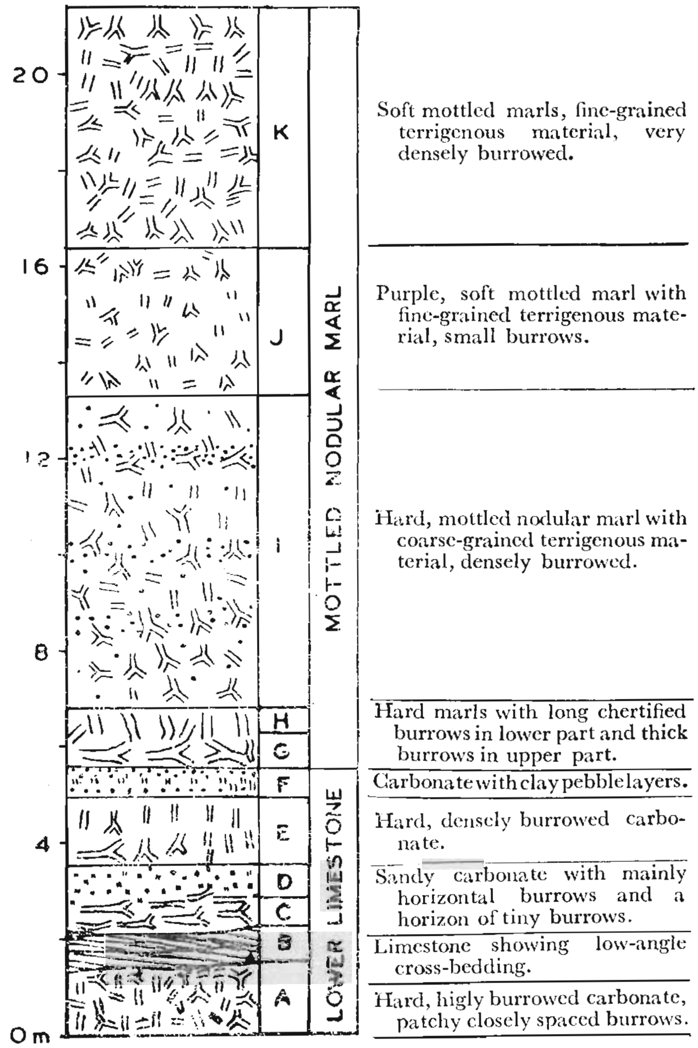

Fig. 4. Litholog of Lameta sediments exposed at Lameta Ghat (see also table 4).

CHARACTERISTICS OF THE LITHOSTRATIGRAPHIC UNITS OF THE LAMETA SEDIMENTS

Green Sandstone : Green Sandstone is a distinct unit in the Jabalpur cantonment area and ranges in thickness from 2 to 16 m. It is a friable, cross-bedded, green-coloured sandstone. Scattered and rounded pebbles of quartz and clay pebbles of green colour are found within the sandstone. The sandstone is friable and mostly of medium-sand size.

In the NE direction of Jabalpur, this unit disappears, and is probably also absent at Lameta Ghat. Singh *et al.*, (in preparation) discuss in detail the palaeoenvironment and stratigraphy of Green Sandstone.

The mature hard sandstone exposed in an abandoned quarry near Madan Mahal belong to Lameta sediments

Table 4. Lithologic succession in Lameta sediments exposed at Lameta Ghat—*Locus Typicus*, Jabalpur.

	............Top not visible............	
	5.0 m (K)	Soft marls, mottled, very densely burrowed, fine-grained.
Mottled Nodular Marl	3.0 m (J)	Soft, purplish, mottled sediments with small burrows and fine grained terrigenous material.
	5.0 m (I)	Hard, mottled, nodular marls with coarse-grained terrigenous material, a few granule and pebble horizons present.
	..........Continuity not seen..........	
	0.50 m (H)	Hard marls with thick burrows.
	1.00 m (G)	Sandy calcareous marls with long branching burrows, partly chertified.
	0.50 m (F)	Burrowed carbonate layer showing a 5 cm thick clay pebble layer at the base, and a 15 cm thick clay pebble layer near the top.
	1.50 m (E)	Hard, intensively burrowed carbonates, burrows smaller than in unit (A).
Lower Limestone	0.20 m (D)	Sandy carbonate layer showing tiny burrows, visible as protuberances, No crab burrows seen.
	1.00 m (C)	Massive looking carbonate with intense horizontal burrow systems, and a few vertical and horizontal shafts.
	0.30 m (B)	Carbonate band showing faint cross-bedding and low-angle discordances.
	2.0 m (A)	Hard, highly burrowed carbonate, patchy greenish in colour, patchy closely-spaced burrows.

and may be equated to Green Sandstone although this sandstone does not show any green colouration. Another possibility is that this sandstone corresponds to the Upper Sandstone. It is quite probable, that at several places sandstone of Lameta Group (when it is not of green colour) has been confused with the Jabalpur Sandstone of Gondwana Group. However, the nature of sedimentary structures, texture, and mineralogy of the both are different, and as such it should be possible to distinguish them from each other.

Green Sandstone in Chui Hill shows pronounced large-scale cross-bedding of low festoon type with 20-50 cm thick sets (Plate II-9). Presence of mud pebble filled channels and layers at the base of Green Sandstone signifies that some erosion did take place, at least locally, at the onset of Green Sandstone sedimentation. A systematic palaeo-current analysis at Chui Hill quarry face, where due to quarrying three-dimensional shape of the cross-bedded units is clearly visible shows that the pattern is mostly bimodal with a stronger current in southern direction, and the other mode in NW direction (fig. 5) (For details see Singh *et al.*, in preparation). At one point in Chui Hill a complex system of Thalassinoides type burrows is rather evident (Plate II—7). There are no mud layers or mud drapes within the sandstone. The green colour of the Green Sandstone is ascribed to the presence of glauconite (Chanda and Bhattacharyya 1966), which is an authigenic mineral known only from the marine environments.

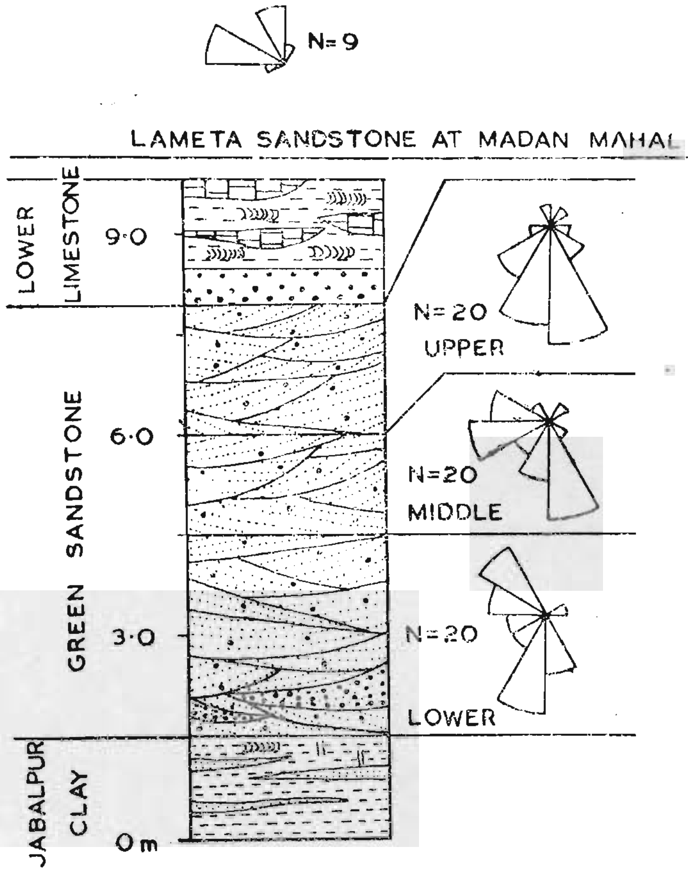

Fig. 5. Palaeocurrent patterns in Green Sandstone. The column refers to Chui Hill Section. The single rose diagram refers to the outcrop near Madan Mahal (after Singh et al., in preparation).

The deposition of Green Sandstone took place in an estuarine channel with rather strong currents (about 1-1.50 m/sec) mostly in subtidal position. The large-scale cross-beds are related to migrating undulatory or lunate type megaripples. The estuary was in the effective zone of tidal activity which caused a reversal in the movement direction of megaripples during ebb and flood phases. The stronger current in southern direction must correspond to the ebb-current, as in the estuaries and tidal embayments ebb is almost always stronger than the flood current, e.g. Jade bay in North Sea (Dörjes *et al.*, 1969).

Nature of cross-bedding, pattern of palaeocurrent, presence of *Thalassinoides* type burrows, and the presence of glauconite point to a marine environment of deposition. The interpretation of Kumar and Tandon (1979) that Green Sandstone represent fluvial point bar deposits is not tenable.

Lower Limestone : The most important lithology of the Lameta sediment is considered to be the limestone, which is sometimes the only lithology present in the Lameta succession. The limestone unit near the base of the Lameta succession is light-grey, cream or bluish in colour, usually containing sandy material, pebbles of jasper, quartz and other rock fragments, and often shows irregular stringers, lenticular masses or nodules of chert.

The Lower Limestone in Chui Hill section shows well-developed sandy, chertified limestone. In Bara Simla Hill this unit is more like calcareous marls, while in Lameta Ghat the Lower Limestone is rather sandy.

Chanda (1963a, b ; 1967) made a detailed petrological study of these carbonates at Lameta Ghat. Chanda (1963a) discusses that the quartz grains of Lower Limestone show rounding and have been derived from metamorphic and igneous rocks and partly from Jabalpur Sandstone (especially those quartz grains which show abraded secondary overgrowth). The carbonate is mainly fine-grained micrite. These carbonates show evidence of algal textures, algal tubes, bird's eye structure, and one grain of oolite (Chanda, 1967). Kumar and Tandon (1979) record penecontemporaneous conglomerate and fenestrae structure (bird's eye structure) from these carbonates.

The most evident and characteristic feature of the Lower Limestone, overlooked by earlier workers, is the extensive organic churning of the sediments producing patchy structure as well as well-defined burrow systems (Plate II-5). On a freshly broken surface irregular, branching system of burrows is seen (Plate II-6). On weathered surface of Lower Limestone in Chui Hill, vertical burrows of large dimensions are rather abundant in a horizon (Plate I—2). These burrows often show a funnel-like opening, branching is common. Whether the horizontal chert layers represent horizontal tunnels connecting the burrows is not clear (Fig. 6). These large burrow systems are certainly dwelling structures of crabs, though they do not show typical *Thalassinoides* characteristics.

At the Chui Hill section, in the lower part of the Lower Limestone some marly intercalations are present which are full of stuffed horizontal burrows, showing prominent spreites of about 0.5 cm in diameter ; these resemble *Zoophycus* (Plate II-3).

In Lameta Ghat section, burrows are very abundant and show characteristics of *Thalassinoides* type burrows. Some of them are exceptionally long (up to 50 cm or more) ; one horizon in Lower Limestone shows small, closely-spaced burrows occurring as protuberances of about 2 mm diameter (Plate II-4). The burrowing and

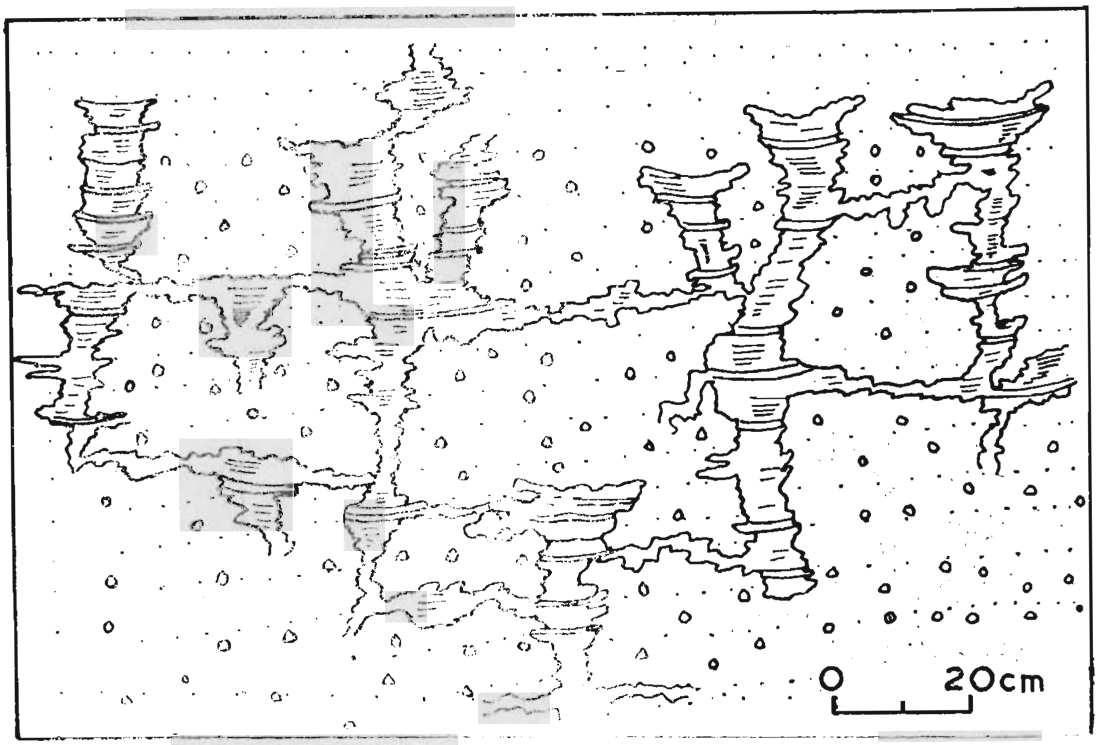

Fig. 6. Sketch of the burrow patterns in Lower Limestone exposed in Chui Hill. The large, vertical burrows may show a funnel-like opening, minor branches of the main burrow show constriction near the point of junction. It seems that the vertical burrows are also connected by horizontal tunnels, which sometimes show swollen areas (see also Plate I—2).

churning of the sediments (predominantly by crabs) is so intense that usually no primary bedding is visible.

In one rare example at Lameta Ghat, a 50 cm thick unit shows low-angle cross-bedding with minor discordances. This feature looks like a wave-built structure during periods of increased energy (Plate I-1).

Chanda (1963, 1967) and Kumar and Tandon (1979) advocated a shallow marine environment of deposition, basically in the tidal flats. Additional evidence in this paper of extensive burrows and wave-built structure support a tidal flat complex as environment of deposition.

Mottled Nodular Marl : In Jabalpur cantonment area, Mottled Nodular Marl makes the most characteristic part of the Lameta succession and is about 15 m thick. This succession is made up of red, green, violet coloured mottled sandy and clayey marls with apparently abundant concretions, which upon weathering produce coarse rubble. Few bands of sandy carbonates are present. Small pebbles are scattered in certain horizons. No bedding is visible except in rare cases when faint lamination can be seen (Plate III-10). Depending upon the carbonate content, nature and size of burrows, content of sand and clay and pebbles, the succession can be identified into a number of smaller units.

Mottled Nodular Marl is extensively bioturbated leading to total destruction of primary bedding and development of well-defined extensive burrow systems filled with more carbonate rich material. Upon weathering, burrows are broken down into rubble producing characteristic nodular appearance of this unit. The explanation put forward by Sahni and Mehrotra (1974) that nodules of Mottled Nodular Marl represent clay balls in a fluvial environment do not conform to the observed facts, as the nodules are of sandy carbonate and not clay and as such, they are certainly broken pieces of burrow systems. Kumar and Tandon (1977, 1978, 1979) were first to note that the Mottled Nodular Marl is extensively bioturbated and show *Thalassinoides* and some *Ophiomorpha* burrows. Within the burrows a few oolites were also recorded (Kumar and Tandon, 1977).

A description and discussion on the burrows in the Mottled Nodular Marls is available in Kumar and Tandon (1977, 1978, 1979), and here a few additional remarks are made.

The burrows in Mottled Nodular Marl are very abundant and usually overlap and coalesce together, often making it difficult to decipher the individual burrow systems (Plate II-8, Plate III-12). Preliminary examination of these burrows reveals that despite different sizes they possess the same basic pattern and thus can be tentatively assigned to crab burrows—*Thalassinoides* burrows. The narrow burrows may belong to the juvenile crabs (Plate III-12). Frey and Howard (1975) discuss the relationship of larger *Thalassinoides* burrows to smaller *Thalassinoides* burrows both in modern and ancient sediments and suggest that the larger ones are made by adult crabs while the smaller ones by small juveniles. It is quite likely that these burrows have been made by only two or three species. Such dense burrowing of sediment by crabs is known only in the marine environment. For the deposition of Mottled Nodular Marl an intertidal zone area of mostly moderate to low energy and with dense population of benthonic community (dominated by crabs) is visualized. Kumar and Tandon (1979) also assigned a shallow marine environment of deposition to the Mottled Nodular Marl, possibly a coastal sand deposit (Kumar and Tandon, 1977, p. 137).

Upper Limestone : This is a rather inconsistent unit of the Lameta succession and Matley (1921) has named it as a local zone. Near the top of Mottled Nodular Marl carbonate content increases and a succession of somewhat hard carbonate is present (Upper Limestone). It is rather sandy and is referrable as calcareous sandstone. Upper Limestone is also intensively burrowed, but the burrows are larger and stout (see Table 3, Plate III-13). Pebble size material is commonly present. Kumar and Tandon (1979) record Thalassinoides type burrows and assign coastal complex, as environment of deposition.

Chanda (1967) discusses petrography of the Upper Sandy Limestone (which includes Mottled Nodular Marl, Upper Limestone and Upper Sandstone) and shows that algal textures are present but are not very evident due to extensive recrystallization.

The depositional environment of Upper Limestone is like that of Mottled Nodular Marl, i.e. an intertidal flat, but with increased carbonate production and increased supply of coarse-grained clastics.

Upper Sandstone : This unit is not well-developed or exposed in the sections studied. Mostly the topmost part of Upper Limestone becomes sandier and may correspond to Upper Sandstone (see Table 3). Usually this unit is covered under the debris of rolled pieces of overlying basalt. According to Matley (1921) this unit at Lameta Ghat is present as fine-grained quartzite ; though in the present study it was not observed.

In Bara Simla Hill topmost part of Upper Limestone gets further enriched in sand content and changes to Upper Sandstone. It shows abundant scattered pebbles and is also dominated by stout burrows (Plate III-14). Kumar and Tandon (1979) assign a coastal complex as an environment of deposition for this unit.

The environment of deposition of Upper Sandstone (as exposed at Bara Simla Hill) is also an intertidal flat, which was under the influence of increased sand supply.

FOSSIL RECORD IN LAMETA SEDIMENTS

Lameta sediments are mostly devoid of body fossils. However, they are well-known for the occurrence of dinosaur bones. In Jabalpur area Matley (1921) recovered a good collection of dinosaur bones from Bara Simla Hill which were later described by Matley and Huene (1933) and assigned a Turonian age for the Lameta sediments. One band of dinosaur bones is located just above the Lower Limestone in a conglomeratic band with pebbles and boulders. Another band is about 1 m above the conglomerate in the red, green marls. A band at the top of Green Sandstone also yielded few bones, while some bone pieces were found in Green Sandstone but with pebble layer (Matley, 1921). It is important to note that bones show evidences of washing, damage and breaking before fossilisation (Matley, 1921) indicating that they have been transported before being fossilized. It is significant to note that bone pieces are associated with pebble or conglomerate horizons, thereby implying that bones along with larger pebbles were flushed into the area of deposition (an estuarine tidal flat) by inflowing small rivers after sudden rains.

Sahni and Mehrotra (1974) point out that carnivorous dinosaur dominate over the herbivorous dinosaur in the Jabalpur fauna. Normally in a *in-situ* community herbivores are always more than carnivores. Consequently, Jabalpur dinosaur assemblage represents a transported assemblage.

Chatterjee (1978) provides a recent survey of the dinosaurs from Lameta sediments of Jabalpur and expresses the opinion that due to the presence of tyrannosaurs the lower third part of the Lameta succession is at least younger than Turonian and may extend up to Santonian, and postulates that the upper age limit may extend up to Maestrichtian.

Sahni and Mehrotra (1974) record a thin band within the Mottled Nodular Marl yielding abundant small shells of *Vivipara normalis*, a fresh water gastropod. However, occurrence of these shells in a single layer itself indicates transportation and concentration of shells during deposition—a case of allochthonous taphocoenosis. It seems that the small rivers occasionally bringing the material into the tidal flat were also responsible for carrying fresh water gastropods to the site of deposition.

It is significant to note that Kumar and Tandon (1977) reported presence of foraminifers, i.e. *Jaculella* sp., *Psammosphaera* sp. and *Saccammina* sp., which clearly suggest a marine environment during deposition of Mottled Nodular Marl. It is unfortunate that due to untimely death of Dr. K. K. Tandon a detailed report of the foraminiferal assemblage could not be published.

There are a few more reports of body fossils from the Lameta sediments of other areas. Fermor (1913) reports one specimen resembling *Turritella*, and numerous *Paludina* from Chhindwara district. In Pijdura in Chanda district, about 200 miles from Jabalpur a rich fauna was collected which unfortunately got lost. This includes *Bullinus*, *Paludina*, and dinosaur bones. Age of Pijdura fauna is supposed to be Santonian (see Pascoe, 1964).

As already discussed, the Lameta sediments are full of trace fossils, amongst them crab burrows of *Thalassinoides* type dominate. The *Thalassinoides* burrows are essentially dwelling burrows of suspension feeding or scavenging crabs. Such abundance of burrows as observed in Lameta sediments indicate a dense and good population of benthonic organisms, probably dominated by one or two species of crabs. Such dense populations are known only in the shallow marine environments. Bromley and Frey (1974) provide a good review on the *Thalassinoides*-type burrows and evidently show their strong variability in shape, size, branching behaviour etc. and that these burrows can be formed by various types of crabs, i.e. decapods, ocypodes and others. The interpretation of Lameta sediments to be marine on the basis of presence of *Thalassinoides* type burrows has been doubted by Chiplonkar (1980). No doubt, individual crab burrows may be present in the fluvial environment (see Singh, 1978) but dense population of crabs causing complete bioturbation of sediment is possible only in the marine realm. Thus, the trace fossils of Lameta sediments in Jabalpur area clearly suggest a shallow marine environment of deposition.

PALAEOENVIRONMENTAL RECONSTRUCTION

The various lithounits and facies of the Lameta Group sediments can be put into two broad categories :

(1) *Deposits of high-energy conditions* (cross-bedded sandstone), e.g. Green Sandstone which are dominated by primary inorganic sedimentary structures.

(2) *Deposits of low-energy conditions* (Bioturbated carbonates and marls), e.g. Lower Limestone, Mottled Nodular Marl, Upper Limestone, Upper Sandstone which are characterized by dominance of primary biogenic structures and almost total absence of primary inorganic structures. The difference within the different litho-units of second category lies only in the relative proportions of carbonate and the nature of terrigenous clastic material.

In Lameta sediments, volumetric proportions of deposits of low-energy conditions (bioturbated carbonates and marls) are much higher than the deposits of high-energy conditions (cross-bedded sandstone). It is already discussed that the nature of primary sedimentary structures, both inorganic and organic, in the Lameta Group sediments demands deposition by essentially marine processes.

It may be stressed here that in Jabalpur area, none of the lithounits of Lameta sediments show any evidence of deposition by fluvial processes.

To fulfill these requirements an estuarine complex has been visualized as the model for deposition of Lameta sediments (Fig. 7). This model is based on information of estuarine sediments in present day environments (Van Beek and Koster, 1972 ; Howard, 1975 ; Greer, 1975 ; Reineck and Singh, 1980).

The palaeolandscape consisted of an estuarine channel varying in depth from ca. 5-20 m with extensive estuarine tidal flats (mostly intertidal) on both sides of the estuarine channel. These estuarine tidal flats were several kilometre broad, and a few small shallow subtidal channels might have been present within the tidal flats. Laterally, these tidal flats changed into plains of somewhat higher gradient where numerous small rivers were essentially draining the Precambrian basement and parts of the older Jabalpur Group sediments.

The estuarine channel (site of deposition of Green Sandstone) was under the influence of tidal currents (ebb and flood) and developed small bar-like features which migrated. In the channel, because of medium sand size of the sediment and high current velocities (ca. 0.50-1.50 m/sec) larger bed forms, i.e. megaripples up to 1 m height and mostly with undulatory or lunate forms were present. Migration of these bedforms produced large-scale cross-bedding. Reversing current directions are reflected in the bipolar nature of cross-bedding data, though one direction (southerly) is dominant and must correspond to the local ebb-current. Some mud deposited on the bars within the channel and on the margins during slack water periods were reworked into mud pebbles which occur distributed within the Green Sandstone.

The sand of the channel was also inhabited by benthonic organisms, e.g. chiefly crabs which produced biogenic structures including burrows. However, the density of population was low and due to continuous reworking of these sediments biogenic structures are rarely preserved. Presence of glauconite in these sands also point to a marine environment as this mineral is known to form only under marine conditions.

The extensive estuarine tidal flats on the sides of the main channel were several kilometre wide and characterized by gentle relief. The small rivers of the adjacent plains were draining into the tidal flats, some of them ending into the flats, while others cutting through the

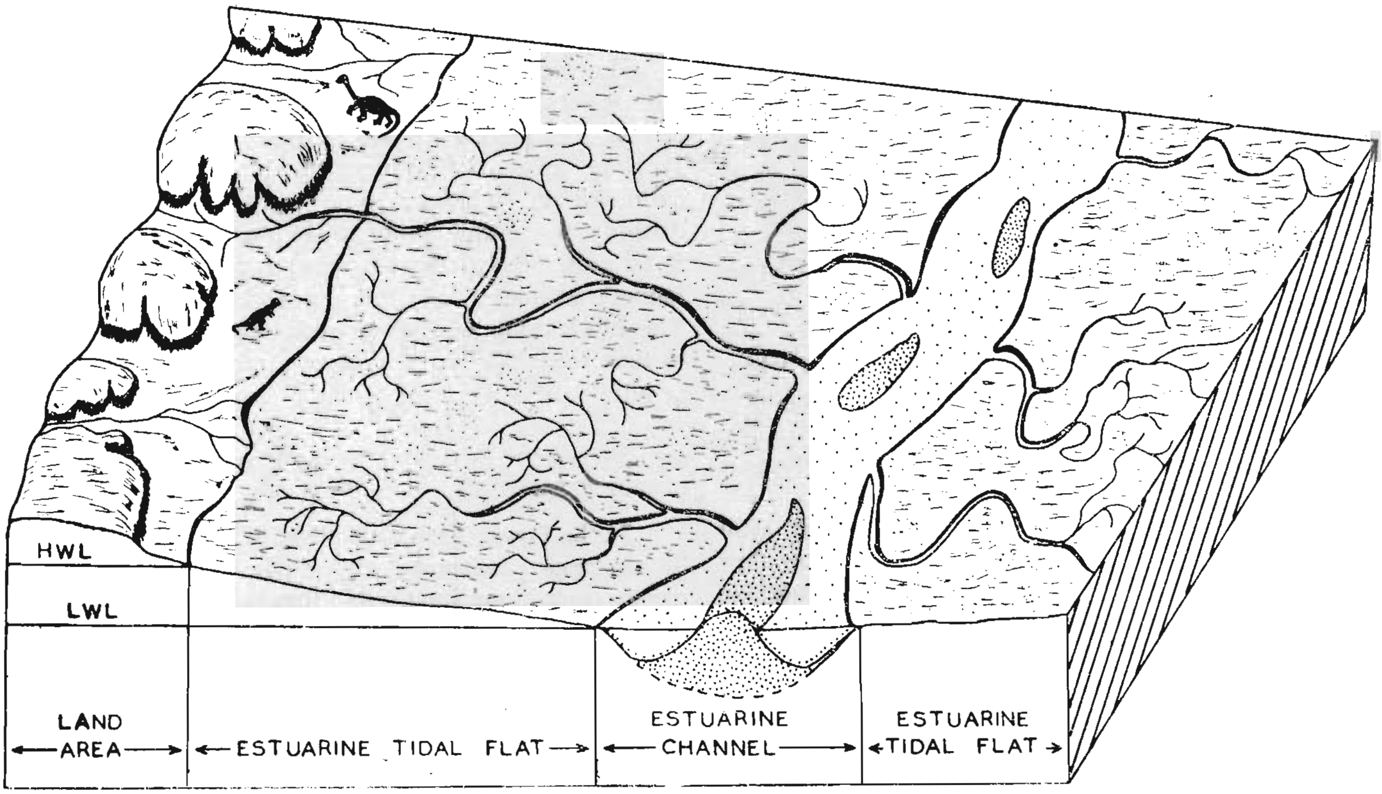

Fig. 7. Schematic palaeoenvironmental model of Lameta sediments depicting palaeolandscape of Jabalpur area during Late Cretaceous. Green Sandstone represent deposition in estuarine channel, while the bioturbated carbonate and marls (Lower Limestone, Mottled Nodular Marl, Upper Limestone, Upper Sandstone) represent deposition on estuarine tidal flats where dense population of crabs was present. The small rivers from adjacent higher landscape provided the terrigenous clastic material. On the land area dinosaurs roamed around. Upon death their bones were transported and deposited in the estuarine sediments. Only the sediments of estuarine channel and estuarine tidal flats are preserved in Lameta sediments. No fluvial facies is preserved.

flats and meeting the main estuarine channel. These small rivers brought in terrigenous material to the tidal flats to be reworked by currents and minor wave activity.

On the tidal flats conditions were favourable for the precipitation of carbonates, and algae were also growing, thus helping in binding and precipitation of carbonates. These estuarine tidal flats had a dense population of benthonic organisms, most of them crabs, may be a few annelids and some molluscs. The rate of sedimentation and mechanical reworking of sediments was slow which led to complete churning of the sediments producing a totally bioturbated mottled sediment with dense network of crab-burrows. The body fossils of crabs, molluscs etc. were dissolved and destroyed during diagenesis.

The various facies of the estuarine tidal flat complex (bioturbated carbonates and marls) were produced in different geomorphological setting, causing changes in the proportions of carbonate and terrigenous clastic material, and lateral shifting of different depositional areas resulted in a complex facies relationship, and also development of penecontemporaneous conglomerates which are present at different stratigraphic levels in different sections.

Lower Limestone : Content of terrigenous clastic material, especially the clay is low, while sand content is often high. It seems that area of its deposition was located more near the low-water line—low sandy flats.

Mottled Nodular Marl : Content of clay material is high and bioturbation is most intense. The area of its deposition was located in mud flats with low energies, or within the influence zone of mud bringing rivers.

Upper Limestone and Upper Sandstone : Content of larger terrigenous clastic grains (pebbles etc.) is high, content of clay is low leading to good lithification. The area of deposition was more near the high-water line where occasionally coarser clastic material from the adjacent landscape was washed in or the area was within the influence zone of rivers bringing coarse terrigenous material.

However, these facies within the estuarine tidal flat are complexly related and in different areas they may show much variation. At present, it is not possible to assign these facies a precise bathymetry within the tidal flat complex, and the above suggestions about their position within the estuarine tidal flat complex are rather speculative and have been given only to emphasize that it should be possible in future, to assign their more precise situation within the tidal flat succession.

DISTRIBUTION OF LAMETA SEDIMENTS

Lameta Group sediments are considered to have a wide distribution in central and western India and consist of limestone, sandstone and shales of pale colour and fresh water origin (Pascoe, 1964). Beside Jabalpur where they show best and thickest development Lameta sediments are supposed to be present in Chanda, Chhindwara, Nagpur, Seoni, Mandla, Narsinghpur, and Saugor districts (see fig. 1).

The Lameta sediments in Nagpur and Bhandara area are made up of carbonates and red green clays and have yielded remains of dinosaurs, chelonian plates and some lamellibranchs, i.e. *Unio* (Pascoe, 1964).

Lameta sediments are also known to occur in Western Narbada Valley in association with Bagh sediments, and exhibit two basic facies: (*a*) upper—sandstone associated with shales and calcareous bands, (*b*) lower—conglomerate with well-rounded pebbles embedded in clay and sand with carbonate cement. These Lameta sediments have yielded *Bullinus prinsepii* and laterally grade into Bagh sediments (Pascoe, 1959, 1964).

In Jhabua area, the northern exposures are of calcareous grit and sandstone with rounded pebbles of Jasper, quartz etc., but without body fossils and seem to represent Lameta sediments ; southwards these are followed by conglomerate and grits along with fossiliferous limestone of Bagh sediments.

A thin unit of cherty sandstone above the Wadhwan Sandstone and below the trap in Saurashtra is also referred to as Lameta (Chiplonkar and Borkar, 1975).

However, no information is available in the literature about the facies characteristics and details of succession of Lameta sediments in different areas, other than Jabalpur area. It is discussed elsewhere that Lameta sediments in Jabalpur area represent deposition exclusively by marine processes in an estuarine complex. It is quite likely that in some areas farther esatward Lameta sediments may show fluvial sequences as well. The relationship of Lameta sediments of Jabalpur area to those near Nagpur and near Ambikapur is not clear at all.

RELATIONSHIP BETWEEN BAGH GROUP AND LAMETA GROUP SEDIMENTS

In the Lower Narbada Valley, thin scattered outcrops of sandstone, carbonate and shale are present, which mostly contain marine fossils ; they stretch from Rajpipla in west to Barwai (Barwaha) in the east. According to Chiplonkar and Borkar (1975) the Wadhwan Sandstone of Saurashtra contains similar fossils as Bagh sediments and represents NW extension of latter. These sediments are referred to as Bagh Group sediments. The basal part of Bagh Group sediments mostly consist of a sandstone unit, namely Nimar Sandstone. Earlier workers considered Nimar Sandstone to be independent unit and a fresh water deposit (see Pascoe, 1959). However, later work clearly demonstrated that at least upper part of Nimar Sandstone is marine (Chiplonkar *et al.*, 1977, Singh and Srivastava, 1981) and it can be grouped together with Bagh sediments (see Chiplonkar, 1980). Thus Bagh sediments are made up of a number of units, namely Nimar Sandstone, Nodular Limestone, Deola Marl, and Coralline Limestone.

The Nimar Sandstone exhibits an increase in thickness from east towards west. Near Rajpipla, it is about 170 m thick while in the east, it can be only a few metres thick or even absent, as is the case in the Man River section.

The oyster beds and Nodular Limestone units extend far in the west ; while Coralline Limestone and Deola Marl do not go so far in the west. Nodular Limestone is most extensive unit of Bagh sediments and its thickness increases towards West (Pascoe, 1959).

No outcrops of Bagh sediments are recorded east of Barwai town where supposedly change from Bagh sediments of Lower Narbada Valley to Lameta sediments of Upper Narbada Valley takes place (Fig. 1). Around the town of Barwai a thick bedded rather soft, whitish sandstone is exposed with layers of oysters (Bagh sediment). This sandstone is separated from the Trap by Lameta sediments with fresh water molluscan shells (see Pascoe, 1959).

Blanford (1869) and Vredenberg (1907) consider that marine Bagh sediments pass laterally into Lameta sediments, which they regarded to be of fresh water origin. However, Bose (1884) proposed that the Lameta sediments, where they are in contact with Bagh sediments, are younger and overlie them unconformably.

Raiverman (1975) studied the Nimar Sandstone, Bagh sediments and Lameta sediments in Gujarat state and is of the opinion that these three Group of sediments are facies variants of the same age. This raises a very relevant point in that the terms Nimar Sandstone, Bagh sediments and Lameta sediments have been basically used on lithological grounds, but also carry stratigraphic implications. Nimar Sandstone represents a sand-dominant succession which may contain marine fossils and make the basal part of the Bagh sediments. Bagh sediments are basically limestone, marls and shales and full of marine invertebrates ; while Lameta sediments are cherty sandy limestones with marls and sandstones, and devoid of marine invertebrate fauna. Within the Lower Narbada Valley, the sandstone facies making the basal part of the Bagh sediments are referred to as Nimar Sandstone. And if an unfossiliferous cherty carbonate is found at the top of the Bagh sequence it is referred to as Lameta sediment. However, there are cases where Bagh succession is represented only by sandy sediments (Nimar Sandstone) but with marine fossils. In other cases, basal sandy facies (Nimar Sandstone) may be absent and the sequence is only made up of carbonates and marls.

Singh and Srivastava (1981) discusses that the Lameta sediments in Jabalpur area are lateral facies equivalents of Bagh sediments (including Nimar Sandstone). He emphasizes that the Nodular Limestone of Bagh sediments are almost identical with the Mottled Nodular Marl of Lameta sediments—both showing extensive crab burrows of *Thalassinoides* type. The only difference being, that in Nodular Limestone occasional remains of marine invertebrates are found, while the Mottled Nodular Marl is barren of them. In present author's opinions, most probably both of them represent deposits of estuarine tidal flats.

The Bagh sediments have yielded a rich assemblage of marine invertebrates and various workers studying different group of fossils have suggested slightly differing ages. Recently, Chiplonkar (1980) has made a good review of the fauna and stratigraphy of Bagh sediments. Probably the most reliable of these ages is the one based on ammonoids, and Spath considered them to suggest a Turonian age for the Bagh sediments (Pascoe, 1959).

Jafar (1981) has been able to obtain a rich assemblage of nannofossils from two samples, one from the top of Nimar Sandstone and the other from the base of Nodular Limestone of two different sections. This assemblage according to Jafar (1981) clearly points out that these sediments are not older than upper Turonian.

Thus, the age of Bagh sediments can be tentatively taken as Turonian and younger (at the most extending into Senonian). As already discussed the age of Lameta sediments is also tentatively Turonian and younger (may be into Maestrichian). Consequently, the Bagh and Lameta Group sediments are synchronous in age and represent shallow marine deposits of a short-lived marine transgression in Narbada Valley during Late Cretaceous.

Singh and Srivastava (1981) proposed that Nimar Sandstone and Bagh beds should be grouped together under a newly proposed name—the NARBADA GROUP consisting of Nimar Sandstone (Formation), and Bagh Formation. It is proposed here that the Lameta sediments should also be included within the Narbada Group as they are only an easterly facies variant of Bagh sediments. Thus, the term NARBADA GROUP of Singh and Srivastava (1981) should be widened in scope to include all the rock units of Late Cretaceous marine transgression in Narbada Valley and their facies equivalents.

PALAEOGEOGRAPHIC MODEL OF NARBADA VALLEY DURING LATE CRETACEOUS

In the western part of Narbada Valley and adjoining areas, i.e. in Pachmarhi, Jabalpur and further east, active fresh water deposition of Gondwana type was taking place during Jurassic and also extending in some areas into Lower Cretaceous. This fresh-water sedimentation came to halt at different times in different areas. The youngest sediments are exposed in Jabalpur area (Jabalpur Group) and its flora are correlated with the Umia flora of Kachchh. The Umia beds seem to be of Lower Cretaceous age, so the Jabalpur Group sediments should be of same age (Pascoe, 1959). Recent studies of pollen and spores of Jabalpur Group in Jabalpur area, also support Lower Cretaceous affinity (pers. Comm. Pramod Kumar, BSIP, Lucknow). However, there is certainly an unconformity and representing a time gap between the fresh water Jabalpur and marine Lameta Group sediments (see Medlicott, 1872; Chanda and Bhattacharyya, 1966).

Based on the palaeoenvironmental reconstruction of the Lameta sediments in Jabalpur area and their synchronous relationship with the Bagh sediments, following palaeogeographic model for the Narbada Valley during Late Cretaceous is proposed.

The Narbada Valley represents an old rift-valley like structure and was reactivated during Late Cretaceous, probably during Turonian time, a marine embayment developed in this valley. The embayment was an elongated structure following roughly the course of Narbada River and Narbada lineament (fig. 8). Towards west this embayment opened up in a broad shallow sea, the area of Wadhwan Sandstone in Saurashtra was also connected to this embayment and sea. Eastward the embayment became narrower. A number of small rivers debouched in this embayment, making small estuaries and creeks. Some small bay like features also existed as part of the major embayment. This embayment was under the influence of strong tidal currents and possessed extensive tidal flats on the margins. Towards west in the broader part of the embayment, shoals and sand bars must have been developed. Within the embayment sandy shoals rising up to intertidal zone were present. In the channels of the embayment and the estuaries mainly sandy sediments were deposited under the influence of tidal currents which are represented by Nimar Sandstone.

On the marginal tidal flats, mainly in the intertidal zone Nodular Limestone was deposited. In the shallow subtidal-intertidal areas Deola Marl and Coralline Limestone were laid down.

Some of the bays of the main Narbada embayment had negligible supply of any terrigenous material from the adjacent land. As these bays were somewhat protected from too strong wave and current energy, mainly fossil-rich carbonate facies was deposited. Sandy facies, e.g. Nimar Sandstone in such bays are absent to poorly developed. Bagh sediments of Man River section were probably deposited in such a bay.

Towards east the embayment became narrower and had several elongated estuaries, creeks etc. At least until Jabalpur marine conditions were prevalent in the Narbada Valley embayment, and under the influence of pronounced tidal currents and large tidal ranges extensive tidal flats were present.

However, it seems likely that east of Barwai (the supposed eastern limit of Bagh-type sediments) due to

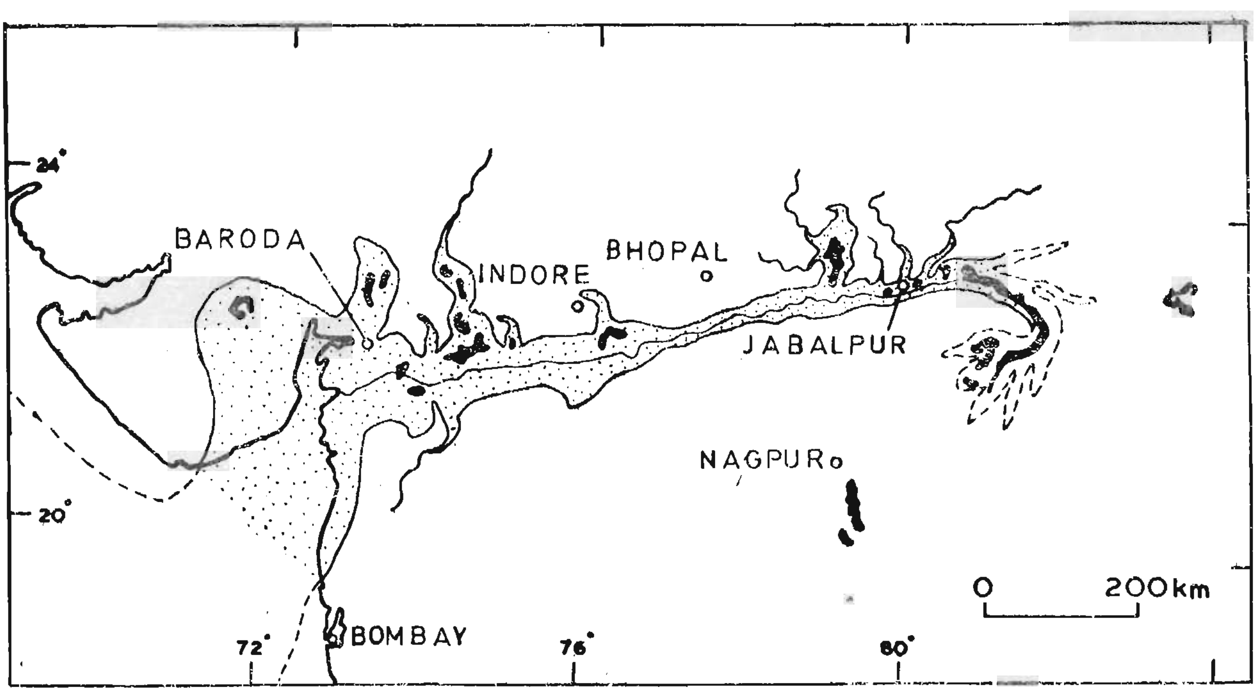

Fig. 8. Palaeogeography of Narbada Valley during Late Cretaceous times (Turonian) showing extention of an marine embayment from the west upto Jabalpur and beyond. A number of small and large estuaries and bays developed in this embayment where deposition essentially by marine processes took place producing Bagh and Lameta sediments. Black patches are outcrops of Bagh and Lameta sediments.

heavy influx of fresh water in the embayment the salinity level dropped down and turbidity of water increased. It looks probable that around Jabalpur area where Lameta sediments were deposited the salinity of water was slightly lower than normal, influencing the nature of benthonic community of the estuarine tidal flats. Probably, more susceptible fauna, e.g. corals, bryozoans, and molluscs did not inhabit this area. Only the sturdy crabs and a few molluscs made dense population to produce totally bioturbated sediments. However, diagenesis might have also caused destruction of shells.

The extension and nature of Narbada embayment east of Jabalpur is not clear as almost no information on the facies of Lameta sediments east of Jabalpur area is yet available.

The total E-W extension of Narbada embayment—estuarine complex was at least 1000 km, and at least until Jabalpur, about 800 km from western coast, the marine processes were prevalent.

In the present-day environments we have an embayment---Bay of Fundy, North America, extending about 300 km from the sea coast, having smaller inlets within the embayment with prominent tidal flat sedimentation (see de Vries Klein, 1963).

As already discussed the time of marine transgression in the Narbada Valley was sometimes in Turonian. The duration of this transgression is not clearly known. However, the transgression was short-lived and might have lasted until Senonian.

A point worth consideration here is that during Albian period a major regression took place in Western India, namely in Kachchh and Rajasthan where shallow marine sedimentation was taking place since Bathonian or even earlier. However, in the western part of Rajasthan basin, in the sub-surface, Mesozoic sedimentation continued until Coniacian (Dasgupta, 1975). The renewed transgression during Turonian did not reach the Kachchh and eastern Rajasthan areas (which became positive land areas) but inundated an entirely new area—Narbada Valley, where there was no earlier record of marine deposition during Mesozoic. The Narbada Valley also has an earlier record of a short-lived marine transgression during Lower Permian leading to deposition of Umaria marine bed. Evidences of a short-lived Late Cretaceous transgression (most probably synchronous to that of Narbada Valley) are also present in Lesser Himalaya—Subathu-Dogadda Zone in the form of Shell Limestone in Garhwal (Singh, 1981).

CONCLUSIONS

1. The Lameta sediments exposed in Jabalpur area show two major type of facies : (*a*) cross-bedded sandstone facies (Green Sandstone), (*b*) Bioturbated carbonates and marls facies (Lower Limestone, Mottled Nodular Marl, Upper Limestone, and Upper Sandstone).

2. Deposition of Lameta sediments took place essentially in an estuarine complex by exclusively marine processes. The cross-bedded sandstone facies is characterized by dominance of inorganic primary structures, e.g. bipolar large-scale cross-bedding, and a few burrows, and denotes deposition in high-energy conditions within the estuarine channel by the action of tidal currents. The bioturbated carbonates and marls facies are characterised by the dominance of biogenic structures, mainly dense network of crab burrows, and represents deposition in low-energy conditions on the estuarine tidal flats. No lithounit of Lameta sediments in Jabalpur area shows any signs of deposition by fluvial processes.

3. Burrows in the Green Sandstone and Lower Limestone are being reported for the first time. In Green Sandstone branched *Thalassinoides* type burrows are recorded ; while the Lower Limestone exhibits a variety of burrows, namely large vertical burrows with horizontal tunnels, small protuberances like burrows, *Zoophycus* like burrows, and usual *Thalassinoides*-type burrows.

4. The Lameta sediments represent a facies variant of Bagh sediments, the former developed mainly in the eastern (upper) part of Narbada Valley. Some lithounits, like Nodular Limestone (Bagh sediments) and Mottled Nodular Marl (Lameta sediments) show striking resemblance and are deposits of similar environmental setting. Both Bagh and Lameta sediments represent deposits of a short-lived marine transgression in the Narbada Valley during Late Cretaceous time.

5. The beginning of this marine transgression in Narbada Valley was sometimes in Turonian, the upper limit may extend into Senonian, though no precise information is yet available.

6. The use of name Narbada Group (proposed by Singh and Srivastava 1981) should be extended to include all the deposits of Late Cretaceous marine transgression in Narbada Valley and their facies variants (Nimar Sandstone, Bagh beds, Lameta beds, etc.).

7. Detailed facies analyses of Bagh and Lameta sediments in different sections is urgently needed to obtain a more precise picture of Late Cretaceous transgression in Narbada Valley. Especially, no information is yet available about the Lameta sediments east of Jabalpur.

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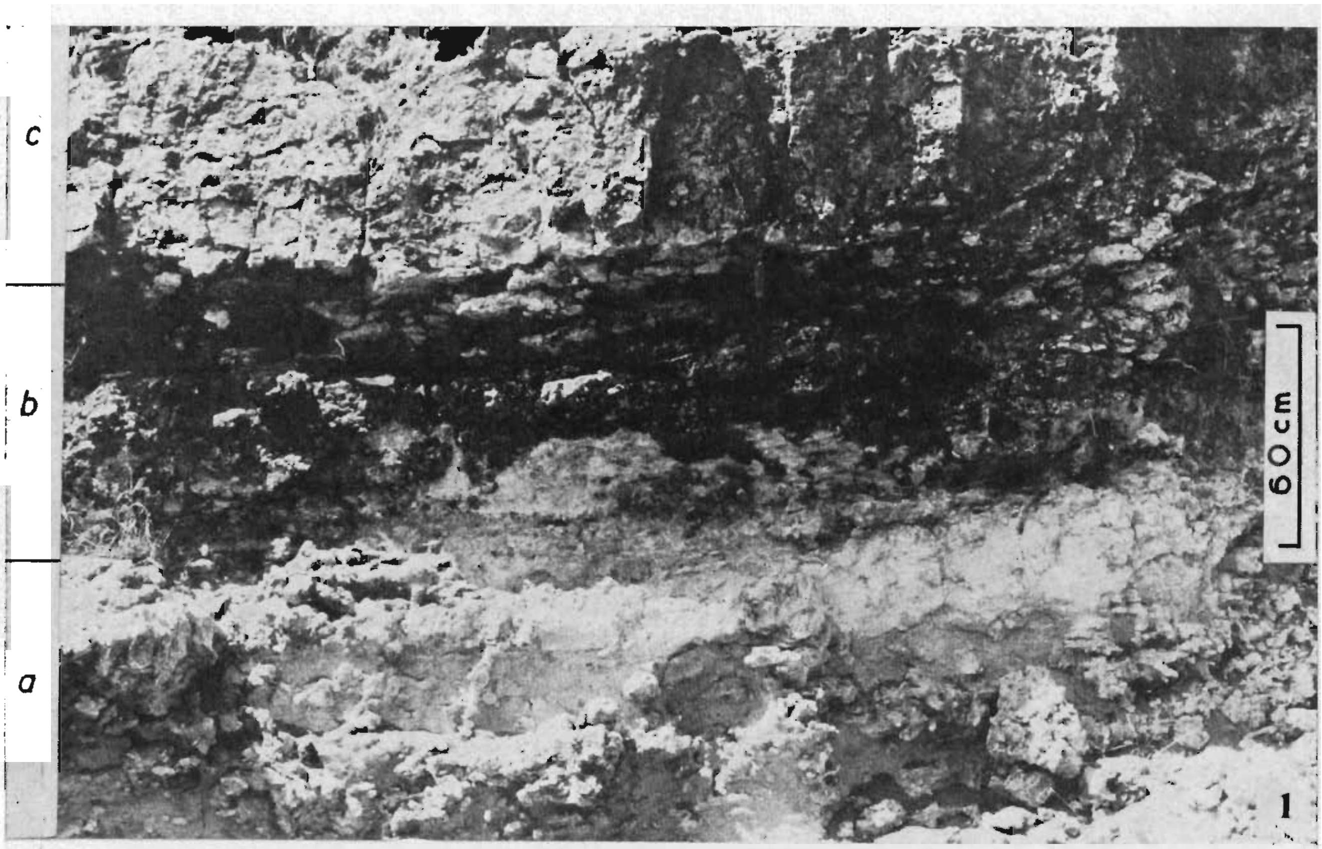
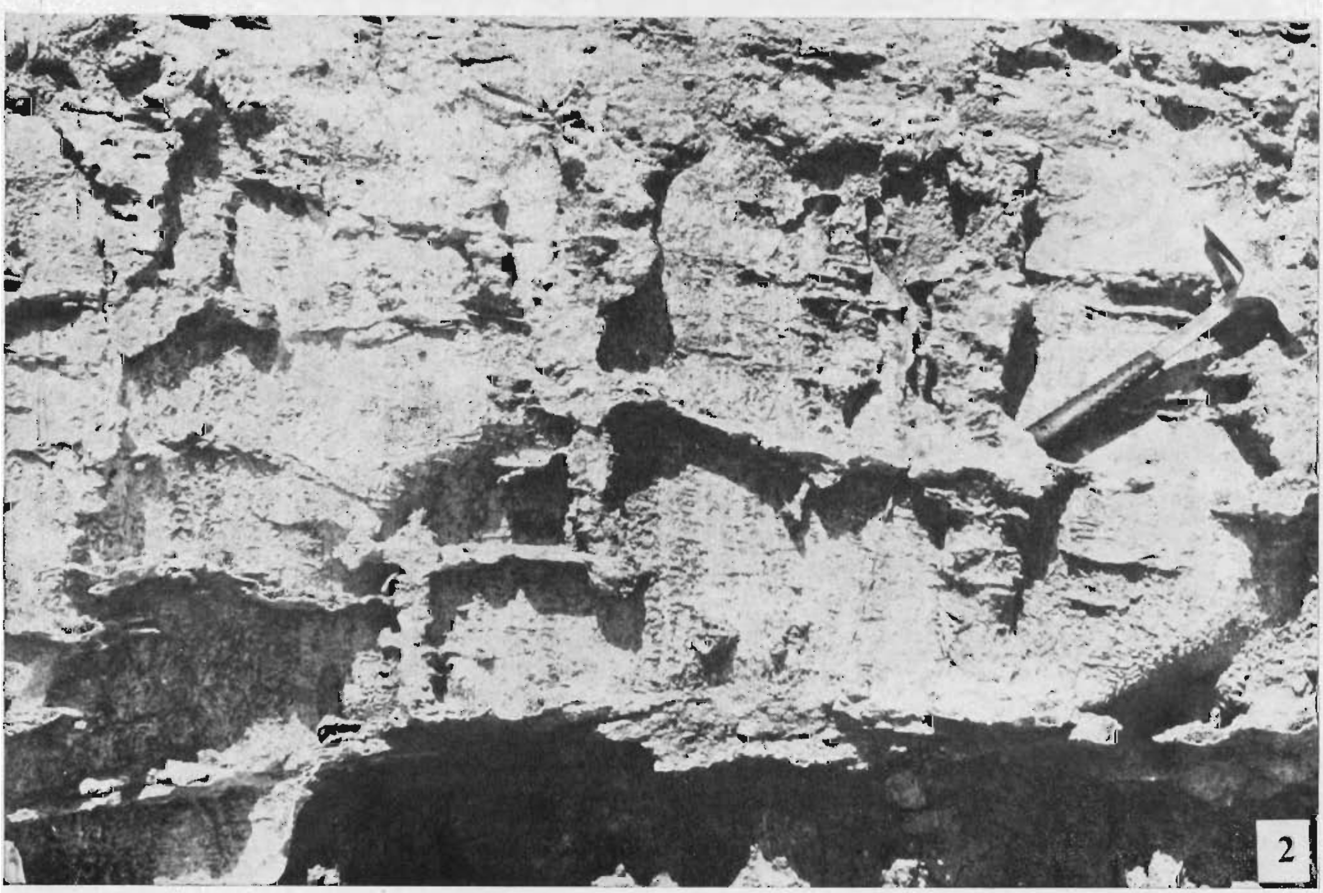
EXPLANATION OF PLATES

Plate I

1. Succession exposed in Lower Limestone at Lameta Ghat. In the lower part (a) large, thick *Thalacssinoides* type burrows are present, (b)—shows a succession with low angle cross-bedding, (c)—burrowed carbonate showing very faint low-angle dipping lamination. Length of the Hammer=30 cm.
2. System of large burrows in Lower Limestone of Chui Hill. Large vertical burrows may possess a funnel-shaped opening and show branching. There are horizontal levels where many burrows may terminate. Some of the vertical burrows seem to be connected by horizontal tunnels. Length of hammer=30 cm.





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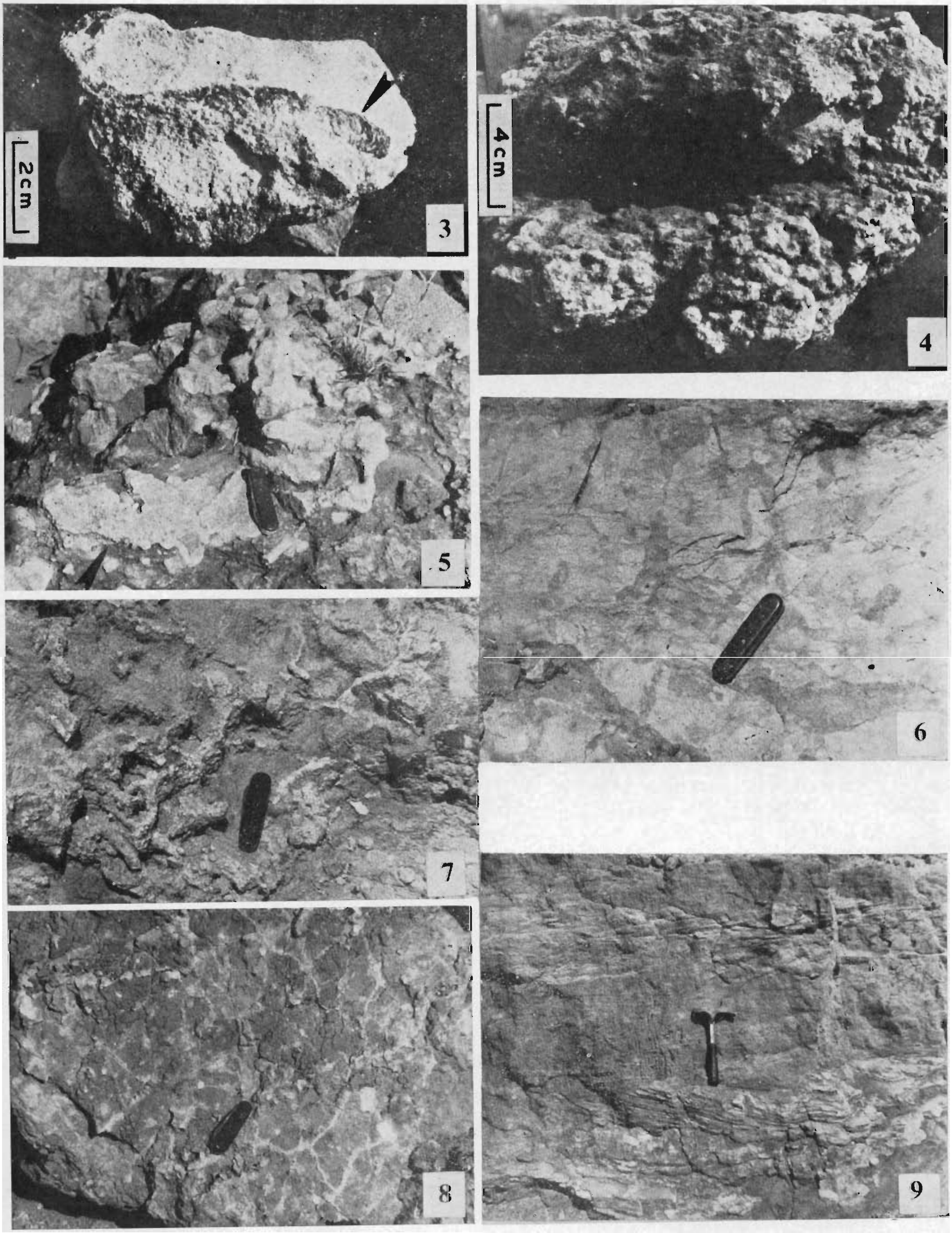
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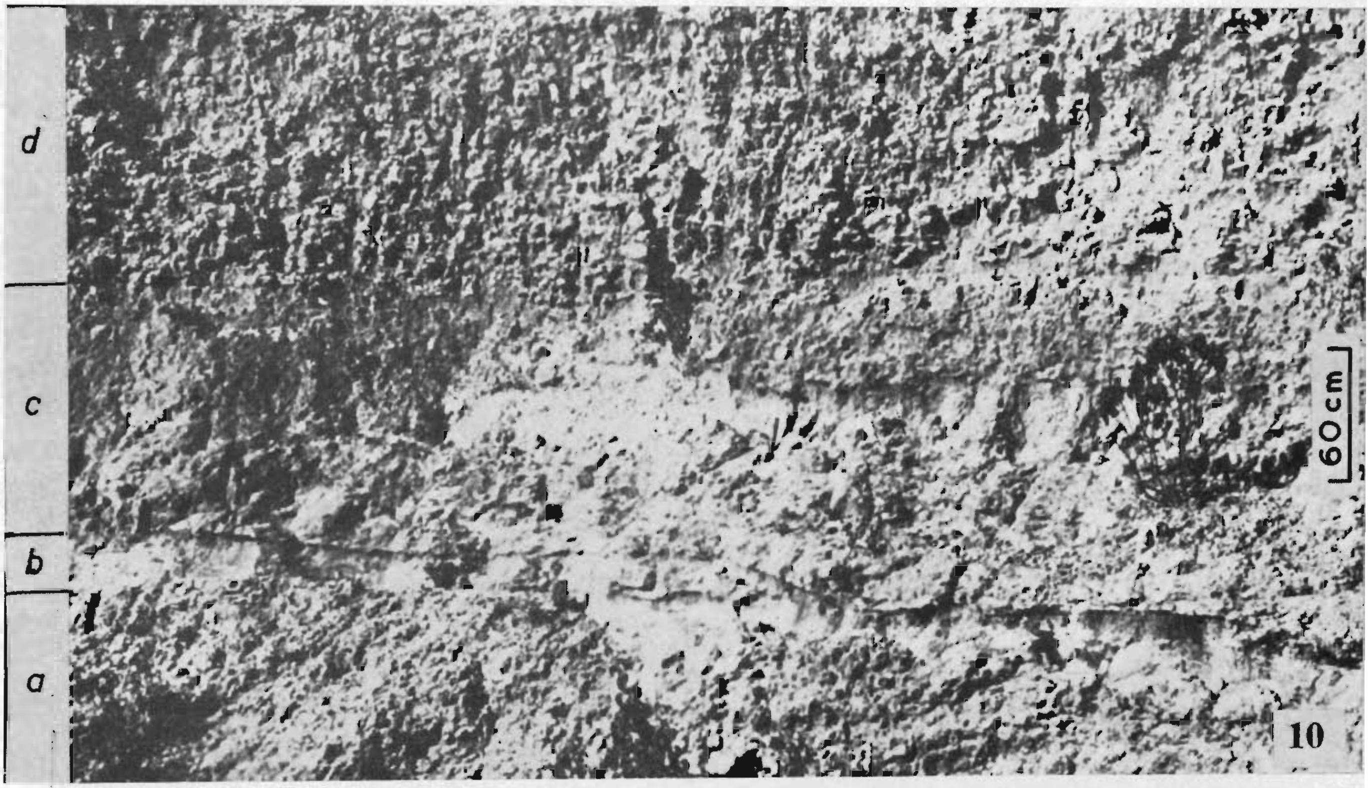

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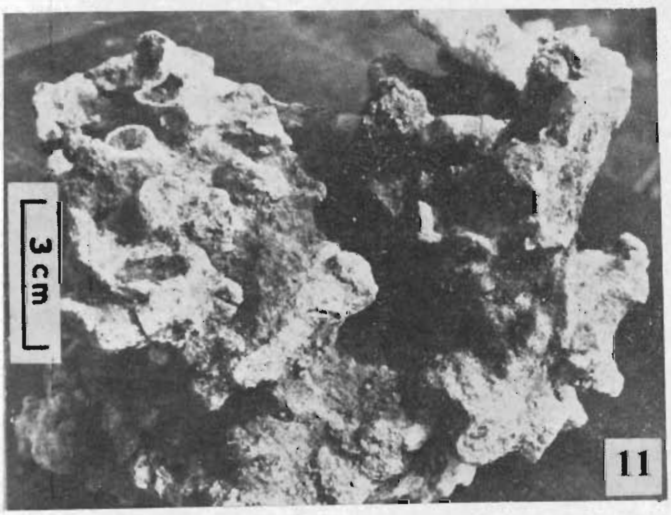

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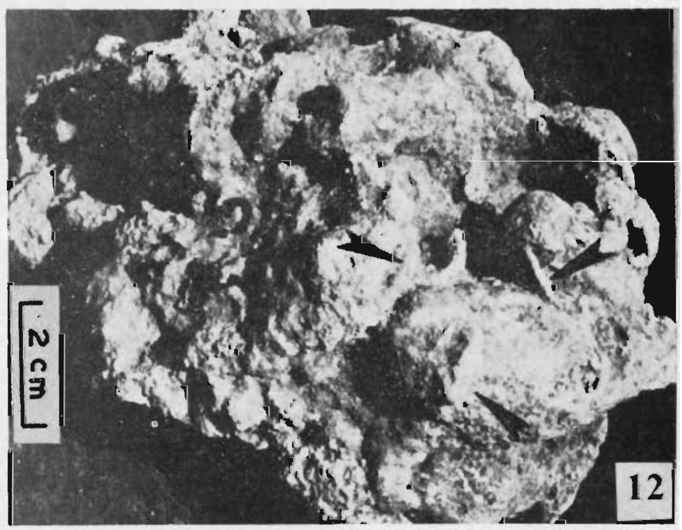

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Plate II

3. Stuffed burrows showing spreites resembling *Zoophycus*. Lower Limestone (Unit 6) in Chui Hill.
4. Small burrows appearing as minute protuberances. Lower Limestone, Lameta Ghat.
5. Horizonal, flat burrow patterns along with a few well-developed cylindrical burrows. Lower Limestone, Lameta Ghat. Length of knife =8 cm.
6. Irregular, branching system of burrows on the freshly broken surface of Lower Limestone, Chui Hill. Length of knife=8 cm.
7. *Thalassinoides*—type burrows, showing prominent branching in the Green Sandstone, Chui Hill. Length of knife=8 cm.
8. Complex burrow patterns in the Mottled Nodular Marl. These burrows are not lithified. Chui Hill. Length of knife=8 cm.
9. Large-scale cross-bedding in the form of low-festoons. Green Sandstone, Chui Hill. Length of hammer=30 cm.

Plate III

10. Succession of Mottled Nodular Marl, Bara Simla Hill. Several units are identifiable depending upon the degree of burrowing. In the upper and lower part intensity of burrowing is very high (a, d), in the middle part burrowing is less (c); there is a prominent unit showing low-angled cross-bedding without any apparent burrows (b).
11. A broken Chunk of Mottled Nodular Marl showing complex pattern of branching *Thalassinoides* burrows, Chui Hill.
12. A piece of Mottled Nodular Marl showing *Thalassinoides* burrows of larger and smaller dimensions. The smaller burrows are marked by arrows. Chui Hill.
13. Stout burrows in the Upper Sandstone, Bara Simla Hill. Width of hammer handle=3.5 cm.
14. Thick, stout burrow systems showing branching in the Upper Limestone, Bara Simla Hill.