JOURNAL OF THE PALAEONTOLOGICAL SOCIETY OF INDIA
VOLS. 21 & 22, 1978 pp. 33—43. (*For* 1976-77).

STROMATOLITES AND ENVIRONMENT OF DEPOSITION OF THE VINDHYAN SUPERGROUP OF CENTRAL INDIA

S. KUMAR

GEOLOGY DEPARTMENT, LUCKNOW UNIVERSITY, LUCKNOW—226007

ABSTRACT

Stromatolites forms of the Vindhyan Supergroup of Central India are studied in the light of depositional sedimentary environment. Representing deposits of a tidal flat-lagoon complex the Vindhyan Supergroup is divisible into two lithostratigraphic groups : the older is the Semri Group (Lower Vindhyan) and the younger is the Upper Vindhyan. The stromatolite assemblages of both the lithostratigraphic groups differ from each other and are of much help in the intra-regional and inter-regional correlation. In the Semi Group, the forms of *Kussiella, Colonella. Conophyton* and some domal stromatolites are present. And in the Upper Vindhyan, the forms of *Baicalia,*? *Tungussia* along with some domal stromatolites are well developed.

The Vindhyan stromatolites are environment sensitive and variations due to environmental factors are noticeable in the stromatolite morphology in the different stratigraphic horizons. Nevertheless, the different stratigraphic horizons of the Vindhyan succession show assemblages of stromatolites which are nonrepetitive through the passage of time. This implies that the different sets of microbiological groups were responsible for constructing different morphological forms as there is a broad similarity in the environmental settings for the various stromatolite bearing horizons. Thus, a definite evolutionary trend in stromatolite morphology is evident in the rocks of the Vindhyan Supergroup.

INTRODUCTION

Stromatolites are widely distributed in areas of modern carbonate sedimentation. They are recorded from the Shark Bay, the Persian Gulf, the Bahamas, the Great Salt Lake and the Coorong Lagoon from the environments ranging from subtidal to supratidal zone (Logan, 1961 ; Kendall and Skipwith, 1968 ; Kinsman *et al.*, 1971). Walter *et al.*, (1976) have recorded *Conophyton* from the hot springs of Yellowstone Park, U.S.A. Fresh water stromatolitic structures are reported by Egglestone and Dean (1976). These modern examples offer an opportunity to study stromatolite morphogenesis in the process of formation and development which give rise to a better understanding of the various factors affecting the stromatolite morphology and the fabric of the stromatolite laminae (Hoffman, 1976 ; Walter *et al.*, 1976).

The stromatolites show most extensive and luxuriant growth in the Precambrian rocks throughout the world. When Precambrian stromatolites are compared with the Recent stromatolites the following points are not well understood :

(1) On comparison with the Precambrian carbonate, it is apparent that the stromatolites are rare in modern carbonates (Von der Borch, 1976).
(2) The morphological forms till now recorded in the Precambrian are much more varied than the forms recorded in the modern carbonate sedimentation areas.
(3) In the Precambrians sequences, on the basis of the different morphological forms, both intra-regional and inter-regional correlation has been done quite successfully in the different parts of the world, specially in USSR, Australia and India, though some workers now begin to question such correlation (Preies, 1977). The correlation on stromatolite morphology is based on the presumption that it shows evolutionary trends. However, the studies in the modern sediments indicate quite convincingly that the stromatolite morphology is environment sensitive. Naturally, this raises doubts to the feasibility of correlation on the basis of stromatolite morphology.

A thorough investigation is required in the different Precambrian terrains with reference to the effects of environments on stromatolite morphology to clarify these points. The present paper presents a study of stromatolite morphology with reference to the environment of deposition of the Vindhyan Supergroup. The Vindhyan succession of Central India is selected for the following reasons :—

(1) The age of the Vindhyan Supergroup ranges from Lower Riphean to Upper Riphean (Kumar, 1976) during which there had been extensive development of stromatolites. Even some radiometeric age determinations are available for the different horizons of the Vindhyan Supergroup (Misra, 1969), which help in giving the precise age to the various lithostratigraphic formations a definite age.

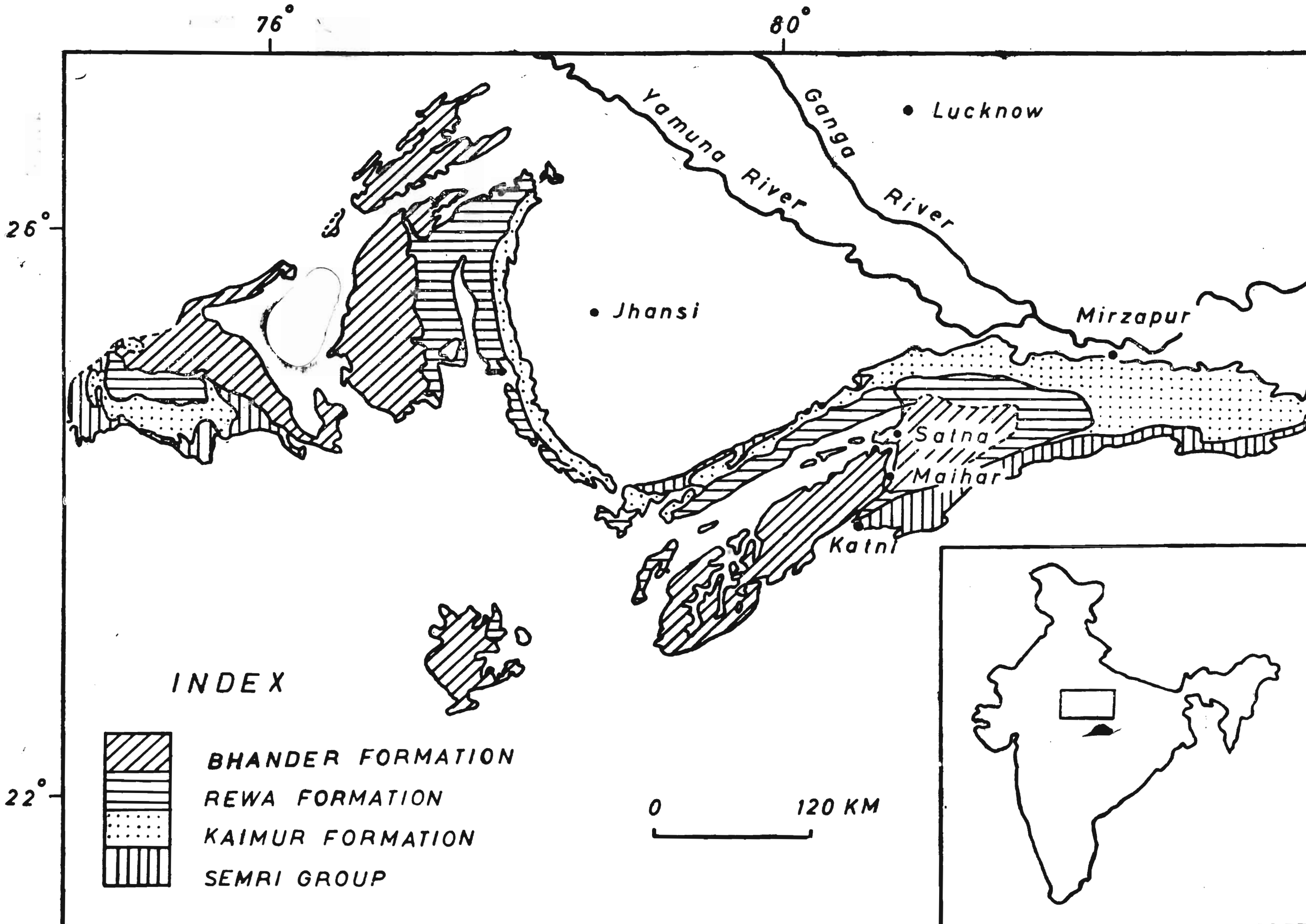


Fig. 1. Geological map of the Vindhyan Supergroup (after Krishnan and Swaminath, 1959).

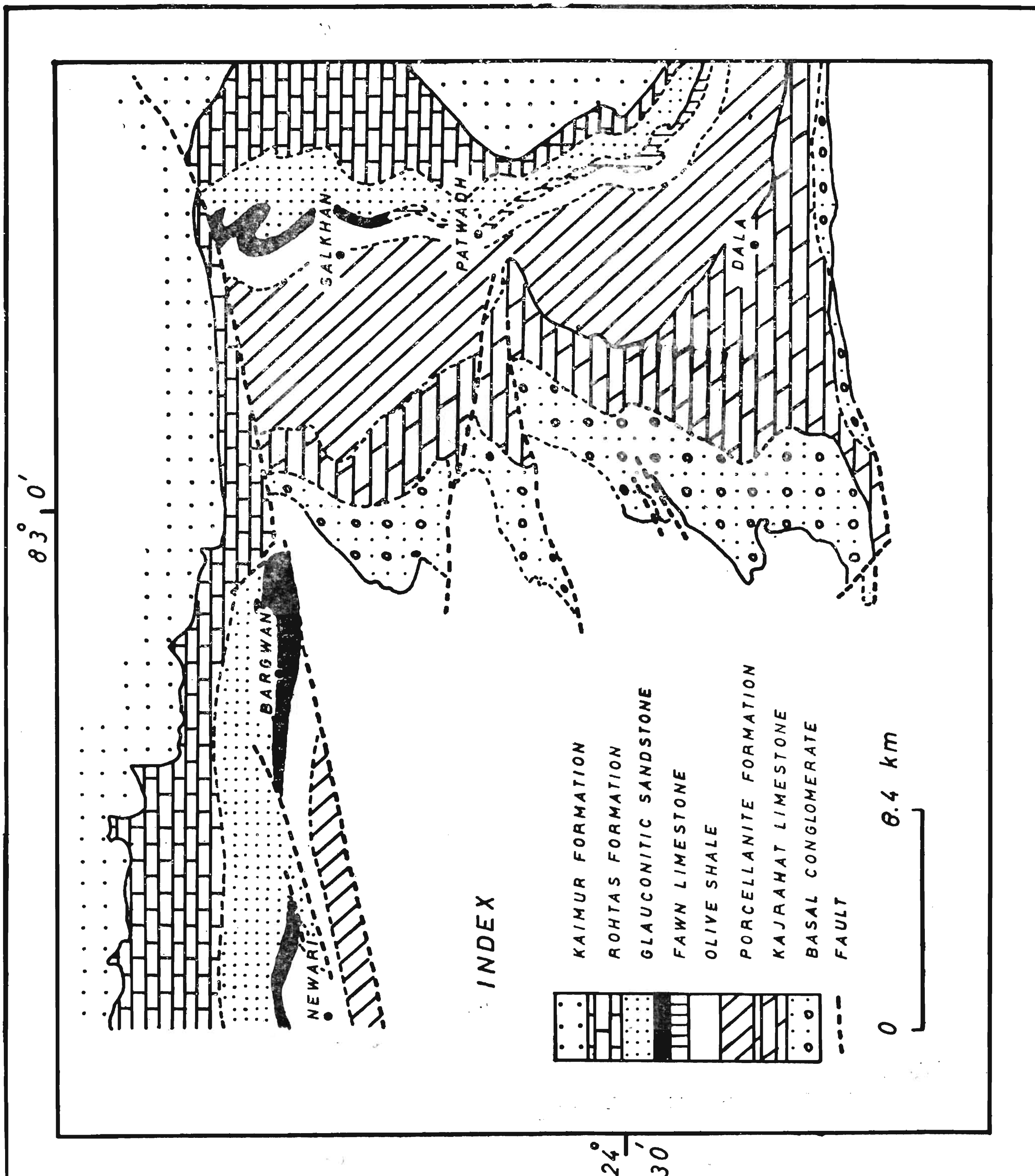


Fig. 2. Geological map of the Son Valley area, Mirzapur district U. P. In the Fawn Limestone, the black portion represents open sea facies and the lined portion represents lagoonal facies (Modified after Auden, 1933).

(2) There are a number of stromatolite forms, which are recorded from the Vindhyan rocks.
(3) Most of the morphological forms of the present area are studied and described.
(4) A tangible evolutionary trend is purported to have taken place in the stromatolites of the Vindhyan rocks (Valdiya, 1969 ; Kumar, 1976).
(5) The Vindhyan rocks are undeformed and show no sign of metamorphism.
(6) The environment of deposition of the Vindhyan Supergroup is more or less established (Singh, 1974, 1976 ; Singh and Kumar, 1978).

The present work is based on the exposures of the Vindhyan rocks in the Son Valley, Mirzapur district, Uttar Pradesh, and Satna district, Madhya Pradesh.

GEOLOGICAL SETTING

The rocks of the Vindhyan Supergroup are well developed in Central India and attain a thickness of about 4,000 meters (Fig. 1). It is divisible into two lithostratigraphic groups ; the Lower Vindhyan and the Upper Vindhyan. The Lower Vindhyan is represented by the Semri Group (Semri Series of Auden, 1933), and is best developed in the Son Valley, Mirzapur district, Uttar Pradesh (Fig. 2). The Upper Vindhyan is represented by the Kaimur Formation, the Rewa Formation, and the Bhander Formation. The Kaimur Formation attains maximum thickness in the Son Valley area, while the Rewa and Bhander formations show maximum development around Maihar township, Satna district, Madhya Pradesh (Fig. 3). The stratigraphic succession of the Vindhyan rocks is given in Table 1. (After Auden, 1933).

Table 1—Stratigraphic Succession of Vindhyan Supergroup

	Bhander Formation	Maihar Sandstone Sirbu Shale Bhander Limestone
Upper Vindhyan	Rewa Formation	Upper Rewa Sandstone Jhiri Shales Lower Rewa Sandstone Panna Shales
	Kaimur Formation	Dhandhraul Quartizites Scarp Sandstone Bijaigarh Shales Upper Quartzite Silicified Shales Lower Quartzite
....	Unconformity	....
	Rohtas Formation	Limestone and Shales
Semri Group Lower Vindhyan	Kheinjua Formation	Glauconitic Sandstone Fawn Limestone Olive Shale
	Porcellanite Formation	Porcellanites
	Basal Formation	Kajrahat Limestone Basal Conglomerate
....	Unconformity	....
	Bijawar Formation	Phyllites

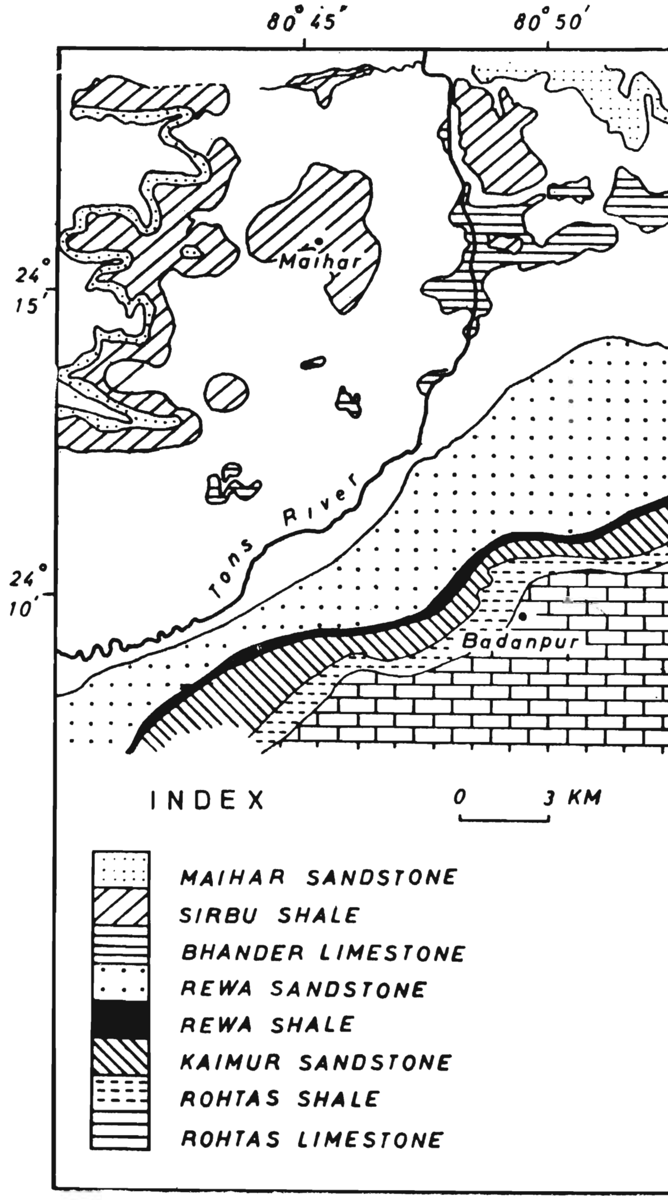


Fig. 3. Geological map of Maihar area, Satna district, M. P. (after Rao, 1949 in Awasthi, 1964).

In general, the entire sequence of Vindhyan Supergroup represents deposits of a very shallow marine environment (Singh, 1976). It is a complex mosaic of subtidal, intertidal, supratidal and lagoon deposition.

STROMATOLITES

Auden (1933) was the first to mention the algal structures from the Vindhyan rocks. Mathur, Narain and Srivastava (1958, 1962) recorded *Collenia* from the Fawn Limestone of the Son Valley area. Later Mathur (1965) described a new stromatolite group *Indophyton* from this horizon, which was later identified as *Conophyton* (Valdiya, 1969 ; Kumar, 1976). Mohan (1967) also studied the stromatolites of the Semri Group of the

Son Valley area. Valdiya (1969) described the stromatolites of both Vindhyans and carbonates of the Lesser Himalaya and on this basis attempted an inter regional correlation of the different Precambrian formations. Recently, Kumar (1976 a, b) gave a detailed account of the Vindhyan stromatolites.

The Basal Conglomerate, the older member of the Basal Formation, shows development of only *Kussiella kussiensis*. The stromatolite bearing horizon is quite thin and the development is poor. However, in the Kajrahat Limestone, the younger member of the Basal Formation (Table 1), there is an extensive development of *Kussiella kussiensis*, *Kussiella dalaensis*, *Conophyton vindhyaensis*, *Colonella kajrahatensis* and *Collenia symmetrica*. These are seen near the contact of the Kajrahat limestone with the Porcellenite Formation. The next carbonate horizon in the stratigraphic succession is the Fawn Limestone of the Kheinjua Formation which is characterised by the presence of *Conophyton garganicus*, *Colonella columnaris* and *Collenia clappii*. In the Rohtas Limestone, the youngest formation of the Semri Group, only oncolites and poorly developed columnar stromatolites have been reported by Kumar (1976, 77).

In the Upper Vindhyan Group there are only two calcareous horizons and stromatolites have been recorded in both of them. Both the horizons belong to the Bhander Formation (Table 1). In the Bhander Limestone member the *Baicalia baicalica* and *Baicalia satnaensis* (*? Tungussia*) are extensively developed. The domal stromatolite *Maiharia maiharensis* has been described from the Sirbu Shale (Table 1).

STROMATOLITES OF KAJRAHAT LIMESTONE (MEMBER)

The stromatolites are developed only in the upper part of the Kajrahat Limestone member and are best seen near Bari, 2 km north of Dala on Dala-Chopan road. Here a sequence, about 35 meter thick, outcrops on a hillock in which *Colonella kajrahatensis*, *Collenia symmetrica*, *Conophyton vindhyaensis*, *Kussiella kussiensis* and *Kussiella dalaensis* are recorded (Kumar, 1976a, b).

A generalised litholog is given in Fig. 4.

About 4 meter thick sequence of dolomitic limestone (lime mud) at the base of the hillock shows parallel bedding with low angle discordances which suggests environment of deposition with very low energy conditions. Overlying this is a 2 meter thick algal mat horizon with very poor development of columnar stromatolite. This horizon ultimately grades into 20 meter thick succession of dolomitic limestone with abundant development of *Colonella kajrahatensis* (Plate I—2, 3). With this are associated two other stromatolite forms *Conophyton vindhyaensis* (Plate I—2) and *Collenia symmetrica*. The former is in the form of small biostromes and can be traced for a few tens of meters while the latter occurs as isolated colonies and is quite sparingly seen. All three forms show quite low relief of the stromatolite columns. The maximum height recorded is 15 cms. The infilling material between the columns is generally lime mud but occasionally oolites are also noted. The dolomites show parallel lamination with low angle discordances. Mud cracks have also been recorded.

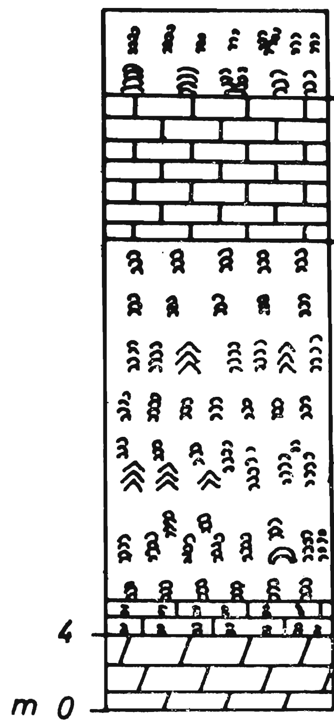


Fig. 4. Generalised litholog of the Kajrahat Limestone, near Bari, Mirzapur district, U. P.

All these suggest deposition in a low energy area which was subjected to aerial exposure also i.e., a supratidal zone of a carbonate tidal flat in which the wave/current activity was quite low. According to Hoffman (1976) the relief of the columnar stromatolites is proportional to the intensity of the wave/current action which undoubtedly depends on both velocity of wave/current and the volume of water. However, the oolites must have been brought from the open inter-tidal zone by storms and redeposited in the supratidal zone.

The 20 m thick stromatolite bearing horizon is succeeded by about 8 meters thick dolomitic limestone horizon. The sedimentary structures associated with this horizon are parallel bedding with low angle discordances, small scale ripple bedding, small scale cross bedding, penecontemporaneous breccia and fenestrae structure. These structures suggest that this part of the succession was deposited in a supratidal to high intertidal zone of a low to moderate energy tidal flat. The dolomitic limestone horizon is overlain by a 5 meters thick stromatolite bearing unit showing development of *Kussiella kussiensis* and *Kussiella dalaensis* (Plate I—3, 4, 6). The former is developed in the lower and the latter is seen in the upper horizon. The maximum relief of the two forms is 40 and 75 cms respectively. The relief of the stromatolite laminae is also moderate to high. Moreover, the columns of the *Kussiella dalaensis* are elongated in N 10° E—S 10° W direction. The elonagtion is so conspicuous that the bedding surface resembles ripple marks (Plate I—3, 4). An individual stretched column on the bedding surface can be traced for a distance of more than 2 meters. The infilling material between the columns is lime mud. Just overlying this is a meter thick sandy dolomitic limestone horizon showing development of lenticular bedding. Poorly developed current bedding in this horizon shows bipolar current directions towards north and south. It may be suggested that this horizon of the Kajrahat Limestone must have been deposited in the intertidal zone where the current and tidal scour was moderate to high. This is manifested both by the relief of the stromatolites and also by the elongation of the *Kussiella dalaensis* which can be ascribed to the unidirectional or bipolar tidal currents. Such elongation of stromatolite columns has been observed in both the recent carbonate sedimentation areas as well as in the older rocks. (Playford and Cockbain, 1976 ; Gebelein, 1976 ; Hofmann, 1976 ; Hyrodyski, 1976).

The activity of current or wave is also confirmed by the presence of limestone breccia and conglomerate, flaser and lenticular bedding and also by the presence of pellet limestone. It appears that there is a gradual increase in the wave or tidal scour from the base to top in the Kajrahat limestone exposed at Bari, and it is reflected by the stromatolite morphology in size and elongation of the stromatolite columns.

STROMATOLITES OF THE FAWN LIMESTONE (member)

The Fawn limestone is a conspicuous lithological horizon of the Kheinjua Formation developed between Olive Shale and Glauconitic Sandstone members in the Son Valley area, Mirzapur district, U. P. (Fig. 2). The Fawn limestone shows development of three stromatolite forms *Conophyton garganicus*, *Colonella columnaris* and *Collenia clappii* (Valdiya, 1969 ; Kumar, 1976). Lateral distribution of these forms has been studied by Kumar and Srivastava (1977). They have traced them for a strike distance of about 50 kms and have reached on the conclusion that the *Conophyton* shows extensive development only north and west of Patwadh (Fig. 2).

It appears that there are two carbonate facies within the Fawn Limestone member. The open sea supratidal-intertidal dolomitic limestone facies is developed north and north-west of Patwadh in which parallel laminataon with low angle discordances, small scale ripple lamination, mud cracks, penecontemporaneous breccia, imbrication structure, and interference ripple marks have been recorded. And at Patwadh and beyond in southward and further eastward extension of the Fawn Limestone a restricted lagoonal facies is developed in which dolomite and dolomitic limestone are developed. These are characterised by parallel lamination, and fenestrae structure.

At the western end of the Vindhyan Basin in the Son Valley the stromatolites are not developed. They appear for the first time near Newari where *Conophyton garganicus* (Plate I—1 ; III—1) and domal stromatolite *Collenia clappii* (Plate II—4) are recorded in which the former is restricted only in the lower horizon (Fig. 2 & 5). The stromatolite columns are almost at right angle to the bedding and the maximum relief of the stromatolites is 110 cms. The relief of the stromatolite laminae is low to moderate. The sedimentary structures associated with this horizon are parallel bedding with low angle discordances, small scale cross bedding, and penecontemporaneous breccia with imbrication structure. This horizon appear to have been deposited in a moderate energy intertidal zone of a carbonate tidal flat. In the upper part of the Fawn Limestone only the domal stromatolite *Collenia clappii* is developed.

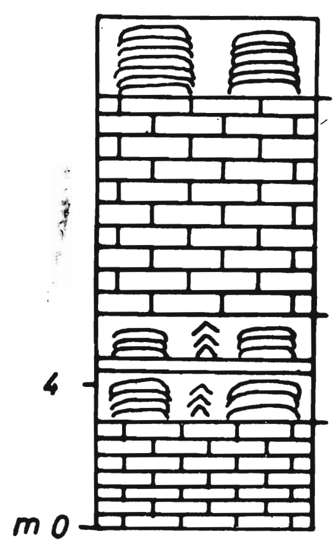


Fig. 5. Generalised litholog of the Fawn limestone, Newari area, Mirzapur district, U. P.

With this horizon the sedimentary stuctures associated are parallel bedding with low angler discordances and mud cracks suggesting a supratidal environment.

Eastward the domal stromatolite *Collenia clappii* gradually disappears and *Conophyton garganicus* is gradually developed to a maximum near Salkhan, about 25 kms east of Newari. At Salkhan only *Conophyton garganicus* is profusely developed and it attains maximum height of 160 cms (Fig. 6). The columns are not vertical with respect to the bedding and are generally inclined in N 60°E direction. The angle of inclination ranges from

30° to 90° with the bedding plane. In some of the columns in the lower part the inclination is 60° while it gradually decreases to only 30°. Associated sedimentary structures include parallel bedding with low angle discordances, small scale ripple bedding, asymmetrical ripple marks and penecontemporaneous breccia. This must have been deposited in the moderate energy intertidal zone of a carbonate tidal flat of an open sea.

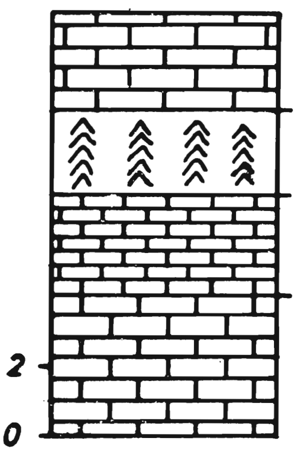


Fig. 6. Generalised litholog of the Fawn Limestone, Salkhan hill, Mirzapur district, U. P.

About 5 kms south of Salkhan, at Patwadh hillock, an altogether differeni carbonate facies represented by dolomitic limestone is developed, which is characterised by parallel lamination and fenestrae structure (Fig. 7). The other sedimentary structures recorded are parallel lamination with low angle discordances and flat bebble dolomitic limestone breccia. Safaya and Singh (1975) have also recorded abundant occurrences of birds eye structure (fenestral structures) in these dolomites. Evidences of current and tidal scour are almost absent. The environment of deposition of these dolomitic limestone appears to have been in superatidal flat of a restricted lagoon or an embayment. In the upper part of this member at Patwadh *Colonella columnaris* is recorded (Fig. 7, Plate II—5). The columns attain maximum height of 50 cms and are at right angle to the bedding plane. Penecontemporaneous breccia also occurs there. The relief of the laminae of the *Colonella columnaris* is moderate to high. The infilling material between the columns is lime mud. The stromatolitic horizon, however, might have developed in a zone effected by wave/current scour i.e., the upper intertidal zone of a lagoon.

Thus, it can be concluded that *Colonella columnaris* is restricted in the lagoonal facies. The *Conophyton garganicus* is developed only in the open intertidal zone where current/tidal scour was moderate to high. With the increase in current and tidal scour the size of the *Conophyton* columns also increased and the columns became

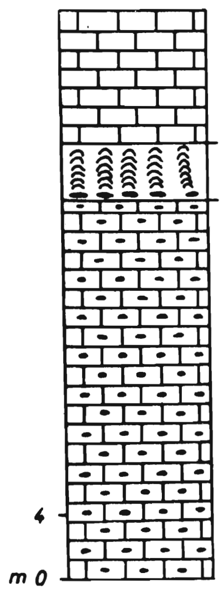


Fig. 7. Generalised litholog of the Fawn Limestone, Patwadh hill, Mirzapur district, U. P.

inclined. The domal form *Collenia clappii* is restricted to the high intertidal to supratidal facies where current and tidal scour was quite low or was almost absent.

STROMATOLITES OF THE BHANDER LIMESTONE (MEMBER)

The Bhander Limestone is developed around Maihar and Satna townships in the low lying areas. The upper part of the member is dolomitic with evaporite facies developed near Satna (Singh, 1976).

In the upper part, two forms *Baicalia baicalica* (Plate III-2) and *Baicalia satnaensis* (Plate II-1) (*Baicalia satnaensis* has some resemblance with *Tungussia*) are extensively developed throughout Satna district, M. P. Only two sections will be described here.

TONS RIVER, SECTION, MAIHAR AREA

The *Baicalia baicalica* is best seen in the Tons River section. The litholog of Tons River section is given in Fig. 8. The lower 4 m thick succession is made up of parallel laminated and ripple laminated limestone. A thin siliceous oolitic horizon is also recorded. Overlying it is a ½ meter thick cryptalgalaminate horizon in which the stromatolite colonies are poorly developed. With this are associated shales which show mud cracks. Intraclast breccia is also present.

It is succeeded by a 1½ meters thick horizon showing very well developed *Baicalia baicalica*. In this horizon in the lower part the stromatolite colonies are vertical with respect to bedding. But towards the top their inclination in NE direction becomes increasingly conspicuous and ultimately they make an angle as low as 3°- with the bedding plane. The maximum lengt h of the

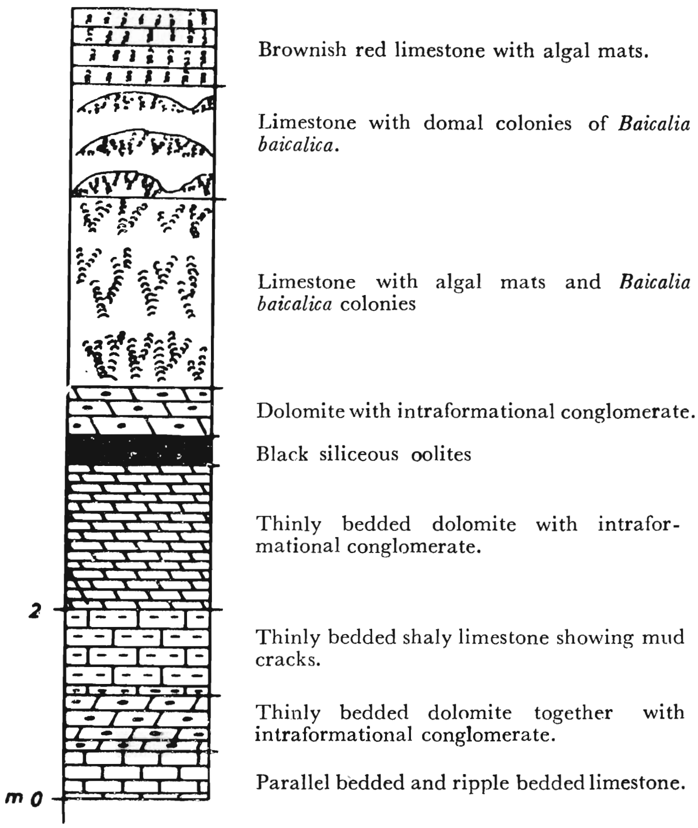


Fig. 8. Generalised litholog of the Bhander Limestone, Tons River section, Maihar area, M. P.

stromatolite column is 80 cms. Subsequently this is followed by a horizon in which the *Baicalia* columns form large domal colonies which are circular in plane view (Plate IV—1) with a maximum diameter of 5 m. The height of the *Baicalia* columns which form domal colonies is less in comparison to the *Baicalia* columns in the underlying horizon. Ultimately it is succeeded by a few centimeter thick algal mat horizon in which the individual columns are quite small and often nonramifying, resembling *Colonella columnaris* (Plate II—2). The columns in the upper part are at right angles to the bedding plane. This horizon also shows mud cracks suggesting subaerial exposure.

Thus, it can be inferred that the deposition of the sedimentary sequence in the Tons River Section has taken place in the intertidal zone of a carbonate tidal flat in which initially the wave/current scour was low, but subsequently its intensity increased considerably due to which *Baicalia baicalica* columns became inclined in NE direction. Later on, the environment again changed to supratidal with a resultant decrease in current or tidal scour in which the formation of large domal colonies and algal mats took place.

SAJJANPUR SECTION, SATNA AREA

Around Satna township in the low lying areas, the upper part of the Bhander Limestone is exposed. A good section of the Bhander Limestone is seen in the Sajjanpur Quarry about 15 kms from Satna on the Satna—Rewa Road and in the nearby Pathare nala cutting. In this area two facies of the Bhander limestone are developed (Fig. 9). One is the supratidal-intertidal facies seen in Pathare nala cutting and Sajjanpur Quarry, and the other is an evaporatic facies developed at about ½ km south of Pathare nala. However the stromatolites are developed only in the supratidal-intertidal facies in the upper part of the dolomitic limestone succession. In this facies *Baicalia satnaensis* (*? Tungussia*) is developed (Plate II—1, III—3). It occurs both as bioherms as well as biostromes.

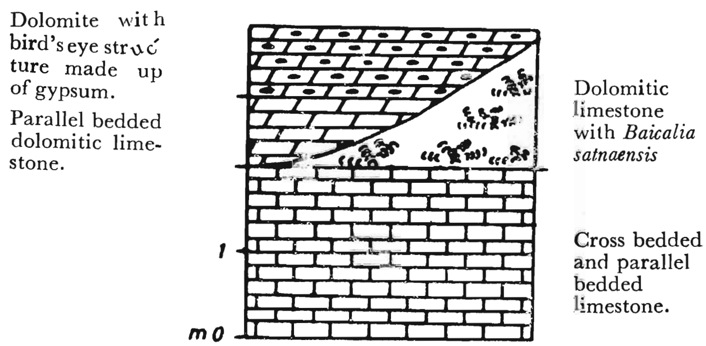
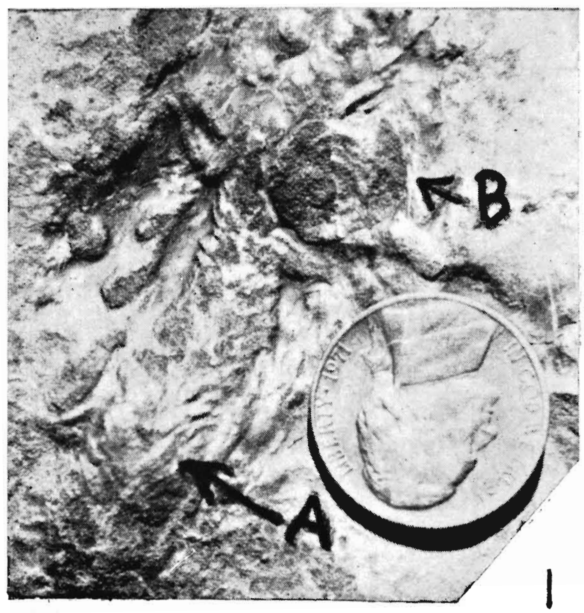


Fig. 9. Generalised litholog of the Bhander Limestone Pathare, nala section, Sajjanpur, Satna district, M. P. Horizontal scale is about 1 km.

Near Sajjanpur Quarry the *Baicalia satnaensis* (*? Tungussia*) forms bioherms of small dimensions. In these the daughter columns are seen to grow more in the horizontal direction than in the vertical. This means that the columns are often parallel to the bedding plane. Even the downward convexity of the columns is also recorded in a few columns. In the central part of the bioherm, the columns are vertical while in the margin these are horizontal and are even inclined in the downward direction. Mud cracks of a very small scale are also seen in the stromatolite columns. The infilling material between the different colonies is made up of penecontemporaneous breccia (Plate II—6), which is often oolitic. Well preserved mud cracks are also seen in the dolomitic limestones. It is suggested that the environment of deposition of these stromatolite bearing dolomitic limestones is in the supratidal zone (Singh, 1976).

In the Pathare nala cutting *Baicalia satnaensis* (*? Tungussia*) forms biostromes and south of it the upper part of the Bhander Limestone succession becomes dolomitic in which bird's eye structure is seen due to the development of gypsum (Singh, 1976) but no stromatolite is recorded.



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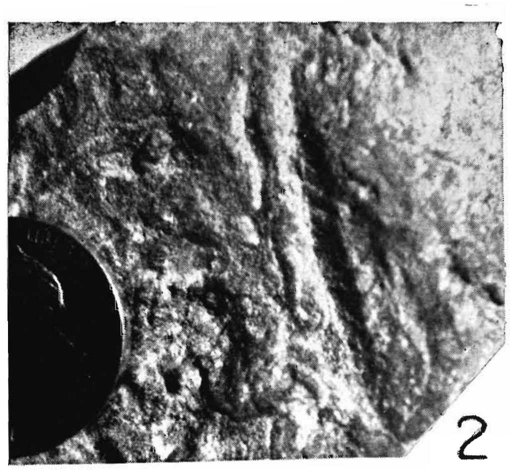

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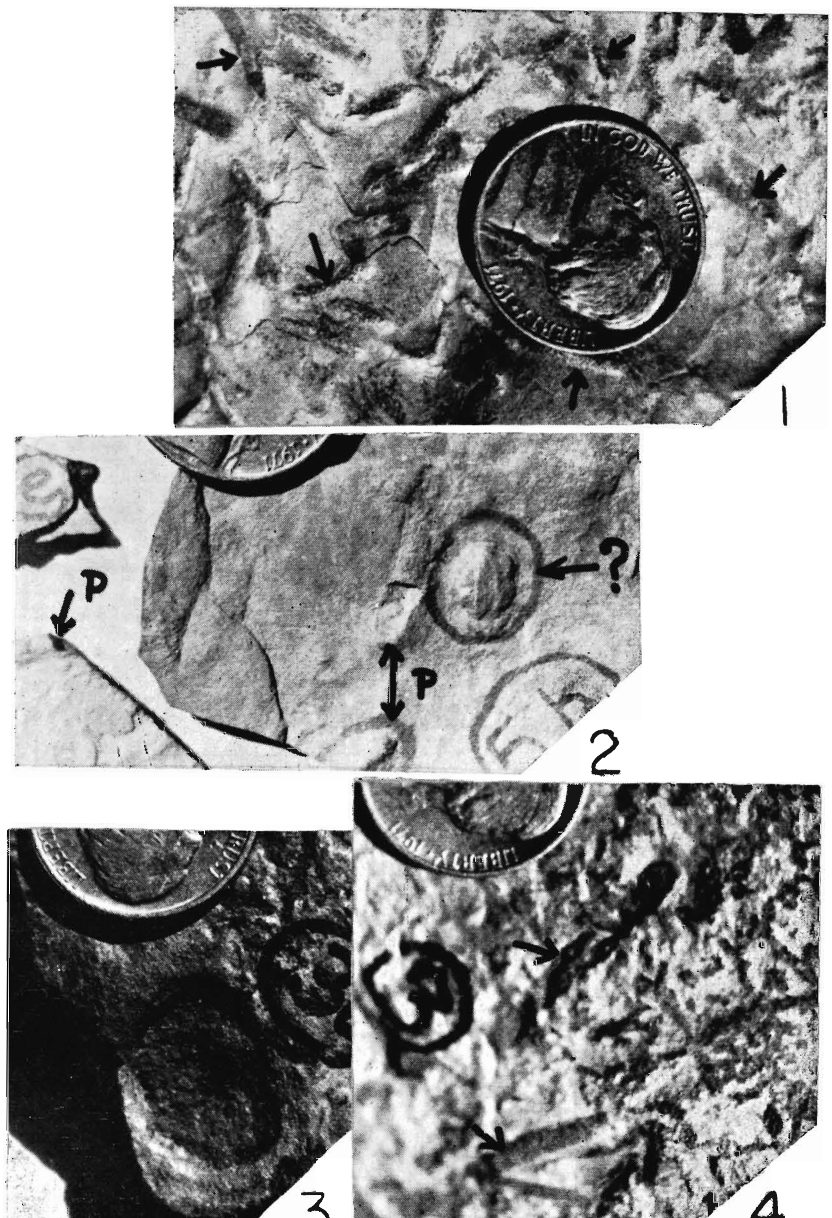

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The presence of gypsum suggests that this part of the succession represents supratidal to slightly restricted lagoonal deposition in which evaporatic conditions developed in hypersaline conditions.

Thus, in this section two types of morphological setting is seen in *Baicalia satnaensis* (*? Tungussia*). It is suggested that where the wave energy and water depth were comparatively less the biohermal colonies developed and where the wave energy and water depth were comparatively much more the biostromal colonies were formed. However where the evaporitic conditions developed in the basin no stromatolite could be formed.

STROMATOLITES OF THE SIRBU SHALE (MEMBER)

In the Pathna nala section, about 5 kms from Maihar on Maihar-Satna road, a good section of Sirbu Shale is exposed (Fig. 3). Chandra and Bhattacharya (1974) have included the Pathna nala succession in Sirbu Shale, while Rao (1949, in Awasthi, 1964), Kumar (1976) and Singh (1976) have included it in the Bhander Limestone. In the present work Pathna nala exposures are included in the Sirbu Shale of the Bhander Formation because of the fact that these dolomites are seen as lenticular horizons within the shales. The environment of deposition of the Sirbu Shale is taken as having been lagoonal in which occasionally hypersaline conditions developed resulting in the development of salt crystals (Singh, 1976). This member is basically a silt/shale succession. The sedimentary structures recorded are salt-pseudomorph, wave and current ripple marks, mud cracks, parallel bedding, small scale ripple bedding and mud pebble breccia. In the lower part, there are intercalations of calcareous horizons with the development of oncolites and stromatolitic horizon (Fig. 10). The succession appears to having originated in the supratidal zone of a lagoon or a tidal mud flat.

In the lower part of the Pathna nala section small bun shaped domal stromatolites are developed (oncolites?), which are seen within the silty shale horizon and are not attached to substrate (Plate II—3). These have not yet been described. These are coevally formed with non-calcareous siltstone and shales. Overlying this is the well developed domal stromatolite *Maiharia maiharensis* (Plate IV—3), In *Maiharia maiharensis* very small columns of about 2 cms high are recorded. In the central part of the dome the columns are vertical, while in the margin these are inclined and even horizontal. Overlying this horizon, the domal colonies are linked together (Plate IV—2). Monty (1972) in describing the biostromatolitic aeposits from the mud flats bordering fresh water lakes of Andros observed that one factor which controls the morphology of the stromatolite is the time to which the algal structures are subjected to drying. Areas which remained dry for longer periods show isolated domes

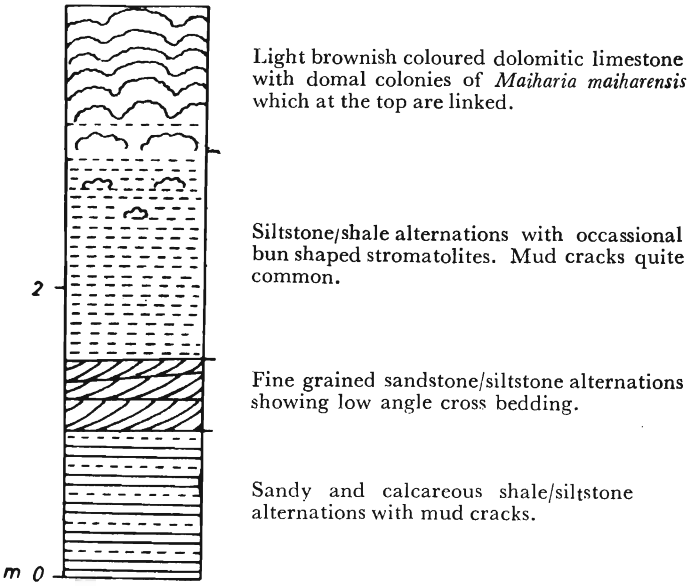

Fig. 10. Generalised litholog of the Sirbu Shale. Pathna nala section, Maihar, M. P.

and pancake types of stromatolites, while those which remained wet form contiguous laminated algal heads. Similar reason can be ascribed to this feature in the Pathnd nala section. The lower supratidal region show very well developed mud cracks and isolated pan caked stromatolite. This is followed by bigger domal colonies of *Maiharia maiharensis*. A meter thick horizon succeeds this horizon which show laminated domal colonies, which are laterally linked. In this nala section, three types of the morphological forms are developed in response of environmental differences. The pan cake stromatolites developed where the area was subjected to longer period of drying with moderate supply of clastic sediments in the supratidal zone of a mud flat or lagoon. Overlying this horizon the isolated domal colonies are developed in the similar environment as pan cake stromatolite with little or no supply of clastic material. The upper most horizon shows linked domal colonies. This must have been deposited in the region where the sediments remained wet for longer periods.

CONCLUSIONS

(1) The stromatolites of the Vindhyan Supergroup indicate that the stromatolite morphology is environment sensitive and definite variations are noticeable in the morphology of the stromatolite. However, at the same time in the different stratigraphic horizons, i.e., in both the lower and upper Vindhyan groups, there is a definite assemblage of stromatolites which is non repetitive. This suggests that the different set of microbiological groups were responsible for constructing various morphological forms, as the environment

of deposition for the different stromatolite bearing horizons of the Vindhyan Supergroup is more or less same.

(2) The stromatolites show unidirectional elongation in response to current and tidal scour.

(3) In the restricted environment with weak wave and tidal scour the stromatolites attain biohermal and domal disposition.

ACKNOWLEDGEMENT

The author is indebted to Dr. P. G. Haslett of the Broken Hill Proprietary Company Limited, Perth, Australia, for critically reviewing the earlier draft of the paper. He is also thankful to Dr. M. R. Walter of the Bureau of Mineral Resources, Canberra, Australia, for encouraging comments and to Prof. S. N. Singh, Dr. I. B. Singh and Dr. S. K. Singh for the help during course of investigation. Financial assistance from the State Council of Science and Technology, Lucknow is thankfully acknowledged.

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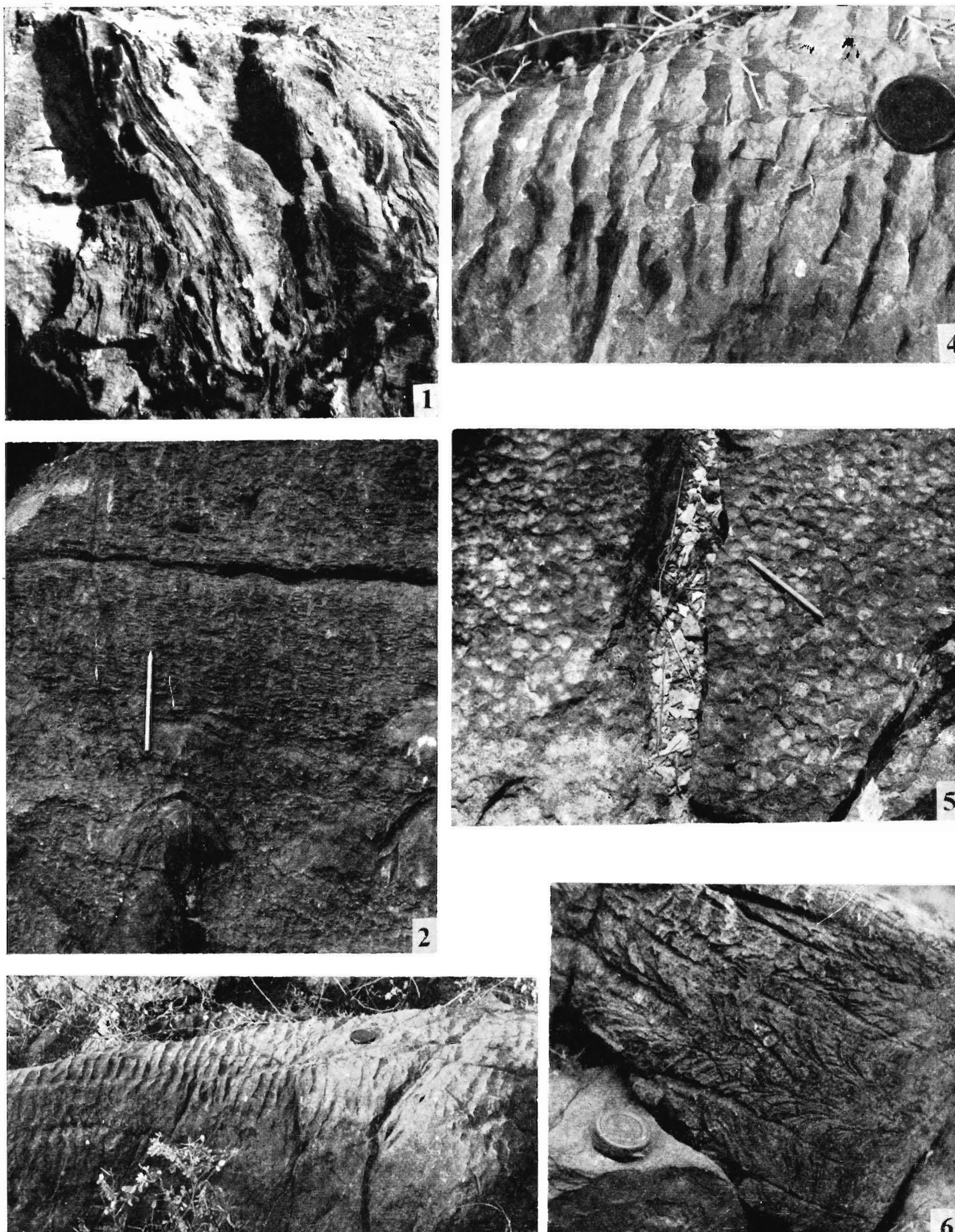
EXPLANATION OF PLATES

PLATE I

1. *Conophyton garganicus.* Longitudinal section. The columns are inclined with respect to the bedding plane. Fawn Limestone, Salkhan hill.
2. *Colonella kajrahatensis* in the upper part, and *Collenia symmetrica* in the lower part. Kajrahat Limestone, Bari area. Longitudinal section.
3. 4. *Kussiella dalaensis.* Transverse section. Uppermost part of the Kajrahat Limestone, Bari area.
5. *Colonella kajrahatensis.* Kajrahat Limestone, Bari area. Transverse section.
6. *Kussiella kussiensis* in the upper part of the Kajrahat Limestone, Bari area. Longitudinal section.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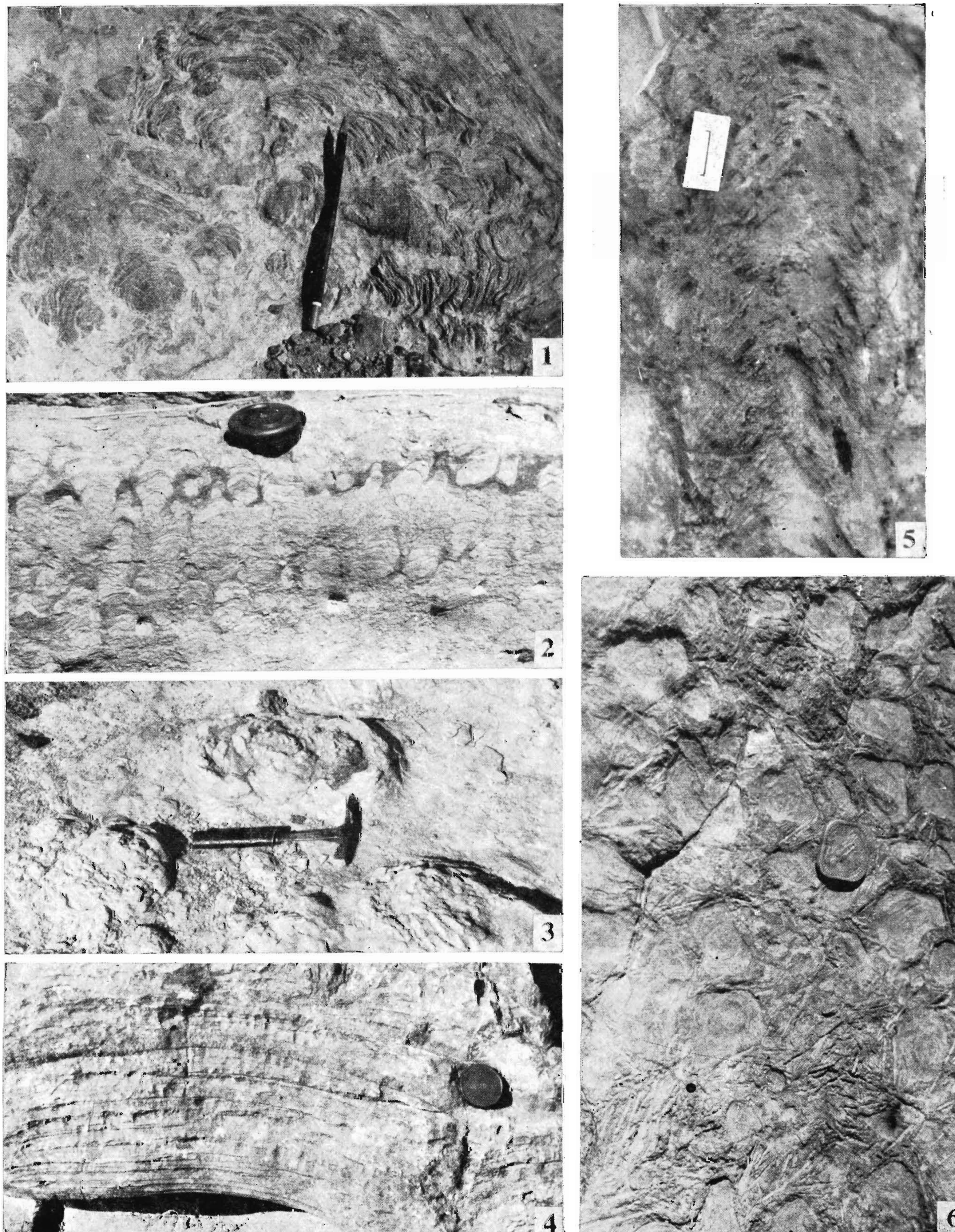

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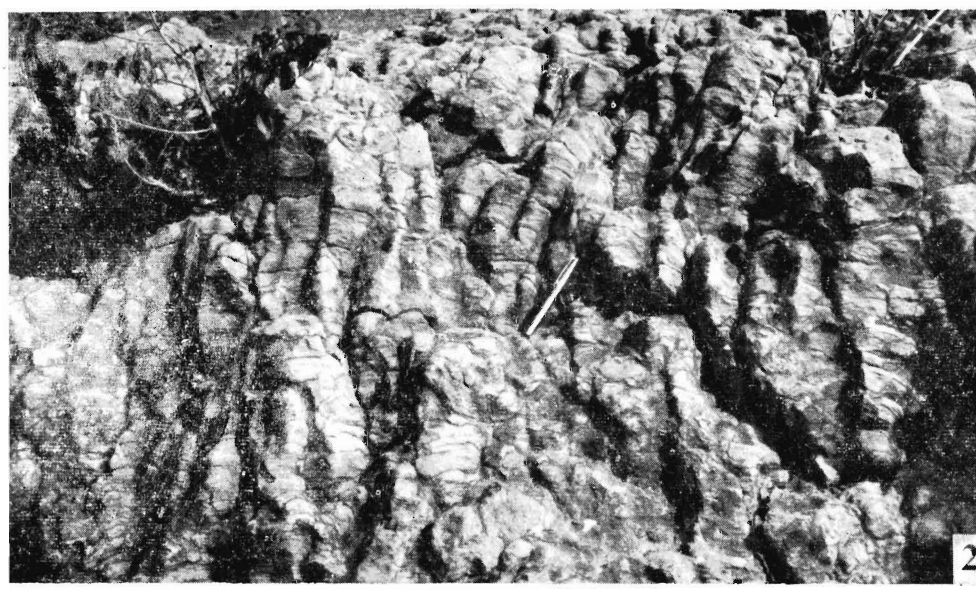

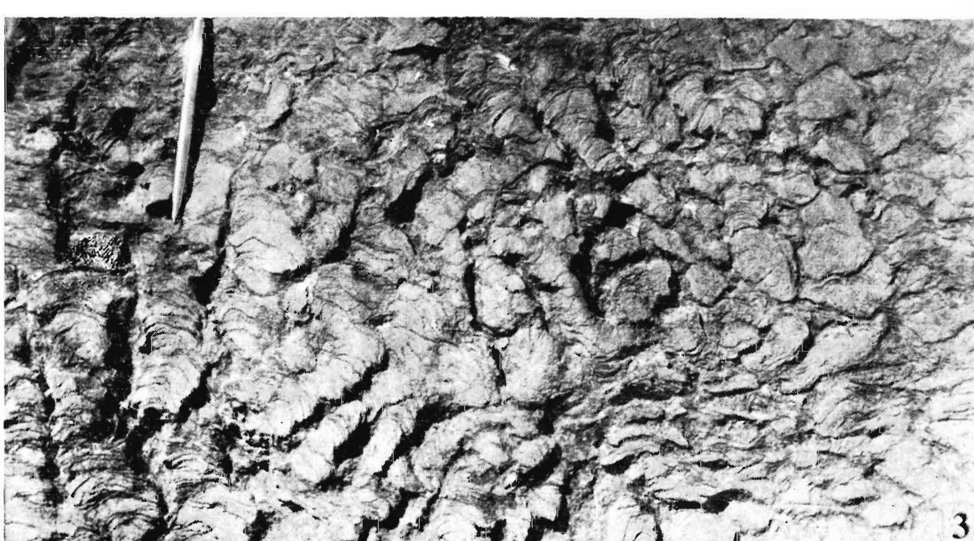

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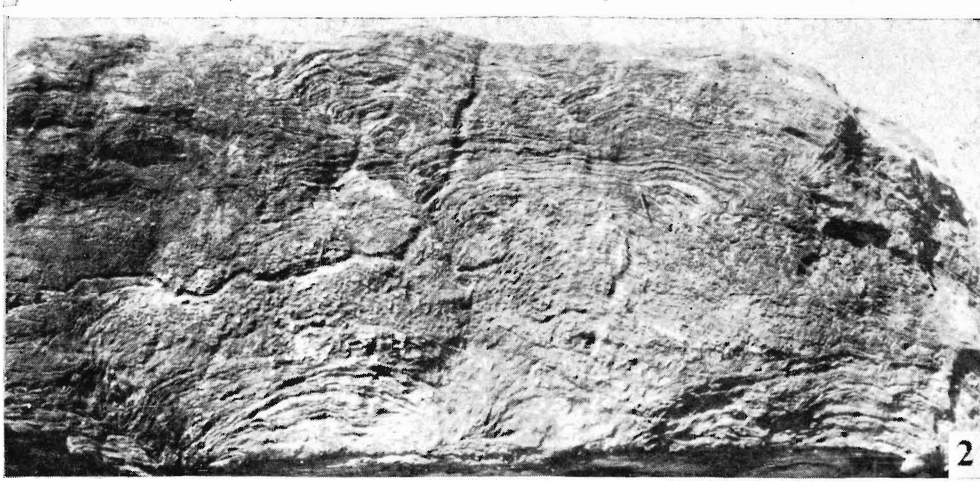

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PLATE II

1. *Baicalia satnaensis* (?*Tungussia*). Longitudinal section. Bhander Limestone. Satna area.
2. *Colonella columnaris* like stromatolites in the uppermost part of the Bhander Limestone. Longitudinal section. Tons River section, Maihar.
3. Bun shaped domal stromatolites, lower part of the Sirbu shale. Maihar area.
4. *Collenia clappii*. Longitudinal section. Fawn Limestone, Newri area.
5. *Colonella columnaris*. Longitudinal section. Patwadh hill. Mark is equal to 1 cm.
6. Limestone breccia as infilling material between *Baicalia satnaensis* columns.

PLATE III

1. *Conophyton garganicus*. Transverse section, Fawn Limestone. Salkhan hill.
2. *Baicalia baicalica*. Longitudinal section. Bhander Limestone Maihar area.
3. Domal colonies of *Baicalia satnaensis* (? *Tungusssia*). Longitudinal section. Bhander Limestone, Satna area.

PLATE IV

1. Domal structure made up of *Baicalia baicalica*. Upper part of the Bhander Limestone. Tons River section, Maihar.
2. Linked domal stromatolite *Maiharia maiharensis*. Sirbu shale. Maihar area.
3. Domal stromatolites of *Maiharia maiharensis*, Sirbu shale. Maihar area.