ON THE KHEINJUA FORMATION OF SEMRI GROUP (LOWER VINDHYAN), NEWARI AREA, MIRZAPUR DISTRICT, U.P.

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The Kheinjua Formation (Stage) of the Semri Group (Lower Vindhyan), Newari area, Mirzapur district, U.P., is studied. On the basis of the detailed litholog and the sedimentary structures recorded, it is concluded that the environment of deposition of the Kheinjua Formation is a lagoon-tidal flat complex. The oldest lithostratigraphic member of the Kheinjua Formation, the Olive Shale, is a deposit of a lagoon where wave/current energy was very weak. The Fawn Limestone member represents deposit of the supratidal to intertidal zone of a carbonate tidal flat of an open sea. The contact of the Fawn Limestone and the overlying Glauconitic Sandstone is very sharp. A thin horizon of pebbly sandstone overlying the Fawn limestone is considered to represent a fluvial influence. Rest of the thick sandstone/siltstone succession of Glauconitic Sandstone horizon is a typical tidal flat deposit of moderate energy. This is also borne out by the palaeocurrent study of the Glauconitic sandstone. The rose diagram is polymodal with current distribution in almost all the directions. During the entire period of deposition of the Kheinjua Formation the subsidence kept pace with the sedimentation. A new trace fossil Ichnogenus *Muniaichnus* is recorded from the Glauconitic Sandstone and on this basis the organic life during Kheinjua times is discussed.

INTRODUCTION

THE VINDHYAN rocks show excellent preservation of sedimentary structures. As such, these have been extensively and consistently searched for the evidences of life. Some body fossils were reported but many of them invited much criticism (Misra 1969). However, in recent years well developed stromatolites, microbiota and worm and arthropod remains are recorded from the rocks of the Vindhyan Supergroup (Valdiya 1969; Kumar 1976 *a, b*; Maithi & Shukla 1974; and Tandon & Kumar 1977).

In the sequences which are destitute of body fossils, the correlation and age is largely a matter of speculation. However, the Kheinjua Formation of the Semri Group is the only horizon showing profuse development of both columnar stromatolites and glauconite. These two helped in resolving the age controversy of the Vindhyan succession (Misra 1969; Valdiya 1969; and Kumar 1976 *a, b*). Kumar (1976 *a*) has considered the Fawn Limestone as Middle Riphean in age on the basis of the presence of *Conophyton garganicus*. This accords well with the radiometric age of the Glauconitic sandstones which is given as 1110 $\pm$ 50 million years by Vinogradov and Tugarinov (1964) (See Misra 1969).

In the present paper, a detailed litholog of the Kheinjua Formation is prepared and an attempt has been made to reconstruct the environment of deposition on the basis of the presence of primary sedimentary structures and palaeocurrent study. A new trace fossil is also recorded from the Glauconitic sandstone.

The study is based on the exposures around Muni Ki Pahari near Newari, Son Valley area, Mirzapur district, U.P.

Geological Setting

The geology of Son Valley area was established by Auden (1933) (Fig. 1). The lithostratigraphic succession of the Vindhyan Supergroup is given in Table I. In the area under consideration only Kheinjua Formation is exposed and the older formations are completely missing due to two faults (Fig. 1). All the three members are of the Kheinjua Formation and they are well developed on a small hillock Muni Ki Pahari, near Newari. Nowhere the contact of Olive shales with the underlying Porcellenite formation is exposed. But the contact between the Glauconitic sandstone and the Rohtas limestone can be seen in a nala cutting north of Newari.

Lithologic Succession at Muni Ki Pahari

The Olive shales are exposed in a nala cutting west of Muni Ki Pahari. This is perhaps the best exposure of Olive shales in the entire Son Valley area. The olive green shales show well developed pencil fracture and are generally very friable. The lower one meter thick succession (Fig. 2-*a*) is made up of shale with subordinate siltstone bands. These show papery thin (less than mm) laminations. Textural and colour banding are quite common. They show parallel bedding with very low angle

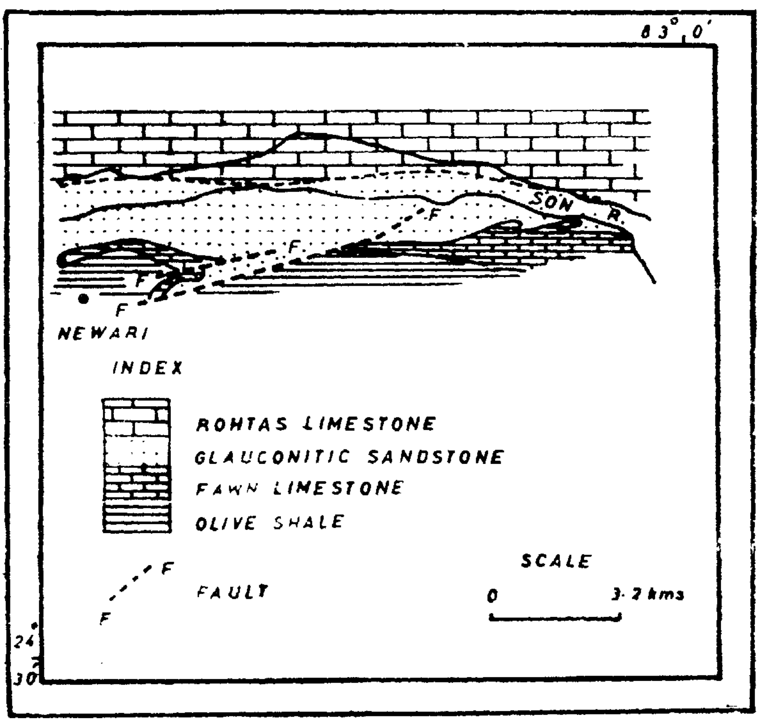

Fig. 1. Geological map of Newari area (after Auden 1933).

TABLE I

Stratigraphic succession of Semri group
(After Auden 1933).

Kaimur Formation		Sandstones and shales
	Unconformity	
	Rohtas Formation (Stage)	Limestone and shales
Semri Group (Series)	Kheinjua Formation (Stage)	Glauconitic Sandstone Fawn Limestone Olive Shale
(Lower Vindhyan)	Porcellanite Formation (Stage)	Porcellanites
	Basal Formation (Stage)	Kajrahat Limestone Basal Conglomerate
	Unconformity	
	Bijawar Formation	Phyllites

discordances. Lenticular bedding is also recorded. This is succeeded by about 15 cm thick lenticular brown weathering grey pelletiferous limestone (Fig. 2-*b*). It also shows presence of mud gals. It is overlain by about 5 meter thick succession (Fig. 2-*c*) of olive shales with silty horizons showing the same sedimentary features as recorded in the shales underlying the pellet limestone horizon.

The entire succession of Olive Shale shows deposition in a very clam water which was least effected by wave/current activity possibly in a protected lagoon. However, a thin lenticle of pellet limestone must have been the deposit of storm generated waves which brought material from open sea and deposited it in lagoon. The presence of mud gals also point to wave activity which eroded thin clay layer and redeposited along with pellet limestone as mud gals.

The olive shales ultimately grade into about a meter thick fine grained light grey orthoquartzitic sandstone (Fig 2-*d*). These show small scale ripple bedding and parallel bedding. Current and wave ripples, and mud gals are also recorded. This horizon indicates both current and wave activity and as such they represent a changed environment of deposition from a protected lagoon to open sea coastal environment where sand was subjected to prolonged abrasion and winnowing.

These orthoquartzitic sandstones in the upper part grade into 1½ meter thick calcareous sandstone with thick cherty bands. Parallel bedding with low angle discordances are the only bedding characters. It is succeeded by 3 meters thick limestone (Fig. 2-*e*) with lenticular cherty bands (Plate 1-2). This horizon also shows parallel bedding with low angle discordances.

This succession shows deposition in an environment in which supply of detrital material was quite scarce but chemical milieu became quite suitable for precipitation of carbonates. The evidences of wave and current activity are lacking and it appears

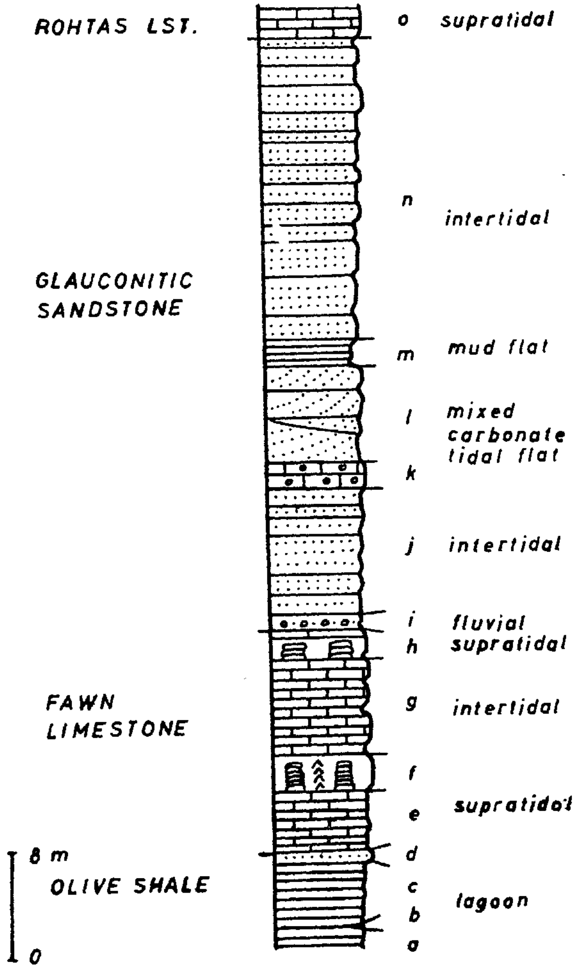

FIG. 2. Litholog of the Kheinjua Formation. (*a*) shales and siltstones; (*b*) pellet limestone; (*c*) shales and siltstone; (*d*) orthoquartzitic sandstone; (*e*) limestone with chert band; (*f*) stromatolitic limestone; (*g*) limestone; (*h*) stromatolitic limestone; (*i*) coarse grained pebbly sandstone; (*j*) sandstone interbedded with shales; (*k*) oolitic limestone with calcareous sandstone; (*l*) calcareous sandstone; (*m*) thinly laminated siltstone and shales; (*n*) Glauconitic sandstone and shales; (*o*) stromatolitic limestone.

that this part of the succession is deposited in a supratidal zone of a carbonate tidal flat.

It is overlain by a 3 meter thick stromatolite bearing fawn coloured limestone in which *Collenia clappii* and *Conophyton garganicus* (Plate II-7) are profusely developed (Fig. 2-*f*). Infilling material between the stromatolite columns is generally made up of lime mud. The stromatolite colonies are making right angle with the bedding plane. The colonies attain maximum height of 110 cm. Studying the recent stromatolites of Shark Bay, Western Australia, Hoffman (1976) has concluded that the relief of the columnar stromatolites depends on the intensity of current/

tidal scour. Thus, it may be concluded that the stromatolite bearing horizon must have been deposited in a high intertidal zone of low to moderate energy.

The succeeding 7 meter thick dolomitic limestone horizon also suggests deposition in a similar environment with low to moderate energy (Fig. 2-*g*). This succession shows parallel bedding with low angle discordances and small scale ripple bedding. Intraformational breccia and conglomerate with imbrication structure and algal mat horizon (Plate II-8) are also recorded. Thin drapes of olive shales are present.

It is succeeded by about 2 meter thick succession (Fig. 2-*h*) of stromatolite bearing dolomitic limestone. In this unit only domal stromatolite *Collenia clappii* and algal mat horizons are developed. The domal colonies attain maximum height of 110 cm and diameter 30 cm. The colonies make right angle with the bedding plane. The infilling material is lime mud. According to Hoffman (1976) the domal stromatolites indicate very weak tidal/current scour. The main bedding structure is parallel bedding with low angle discordances. In this horizon the evidences of current and tidal scour is somewhat lacking. The probable environment of deposition is a supratidal zone of a carbonate tidal flat.

The Fawn limestone is overlain by the Glauconitic Sandstone member with a sharp contact. The limestone is succeeded by about ½ meter thick very coarse grained poorly sorted sandstone (Fig. 2-*i*) with pebbles and cobbles of jasper. This horizon shows parallel bedding and small scale current bedding. The contact of the sandstone with the underlying limestone marks a definite change in the environment of deposition from a carbonate tidal flat in which there was very little supply of clastic material to an environment marked by abundant supply of clastic material which inhibited carbonate sedimentation. Since the clastic material is generally brought by the rivers in the basin of deposition the fluvial influences are not altogether very rare in the coastal facies especially in the supratidal deposits. A thin pebbly coarse grained sandstone with a sharp contact with the limestone might represent a deposit of fluvial regime. The presence of pebbles of jasper suggests the same provenance as that for the conglomerate of the Basal Formation which is also characterised by pebbles and cobbles of jasper. Singh (1973) has suggested a fluvial origin to these conglomerates. For jasper, Pascoe (1959) has suggested the Bijawar Formation as the source rock in which there are thick bands of red jasper. It seems probable that the same source contributed the jasper during the beginning of the deposition of the Glauconitic Sandstone.

The pebbly coarse grained sandstone is succeeded by about 10 meter thick fine to medium grained sandstone with shaly and silty intercalations (Fig. 2-*j*). Flaser and lenticular bedding, and tidal bedding are the most common bedding features. Small scale ripple bedding, small scale current bedding, parallel bedding and herring-bone structures (Plate I-6) are the other important bedding features. Interference, wave and current ripples (Plate I-5,7), mud cracks and falling water marks (Plate II-6) are the most abundant bedding surface features.

This succession marks a transgressive phase. The main deposition took place in the intertidal zone where wave and current activity was present. The area must have been intermittently subjected to aerial exposure as borne out by the abundant mud

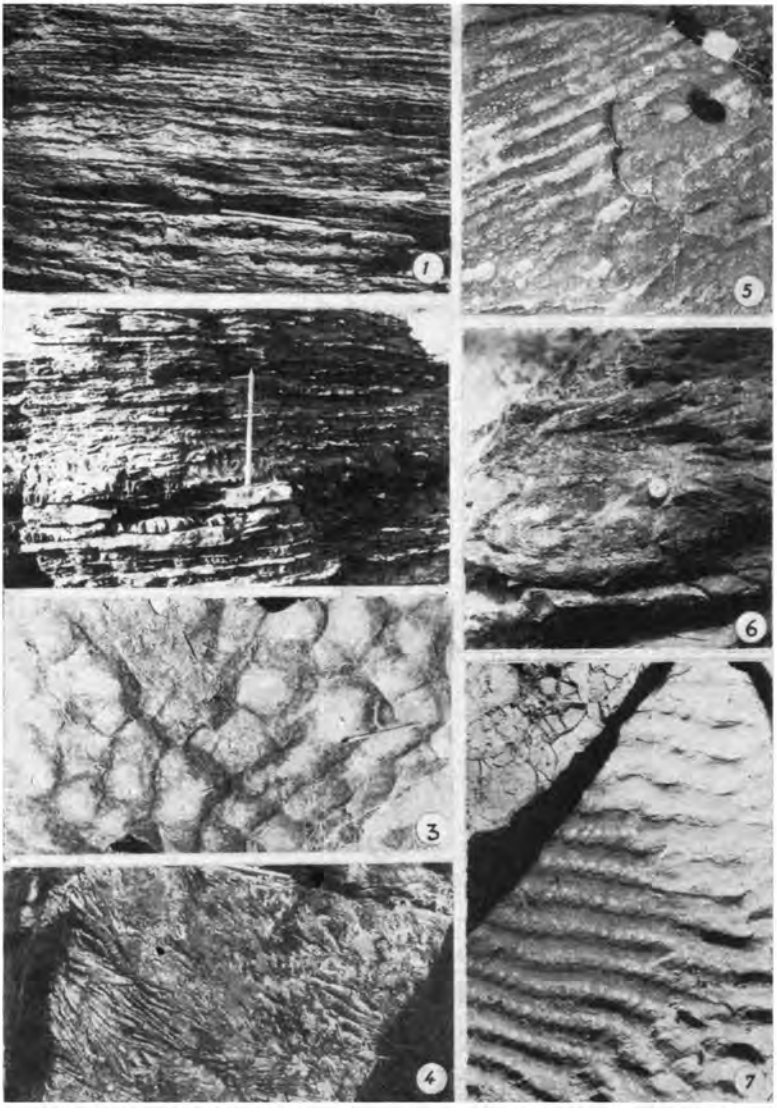

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PLATE 1

1. Parallel bedding and small scale ripple bedding in calcareous sandstone. Middle part of the Glauconitic sandstone (l).2. Chert bands in lower part the Fawn Limestone (e). 3. Interference ripples formed by two sets of wave ripples in the upper part of Glauconitic sandstone (n). 4. Penecontemporaneous limestone breccia. Middle part of Glauconitic sandstone (R). 5. Wave ripples, lower part of Glauconitic sandstone (*j*). 6. Herringbone structure in the lower part of Glauconitic sandstone (*j*). 7. Current ripples partly modified by wave ripples lower part of Glauconitic sandstone (*j*) .*X* 1/.10

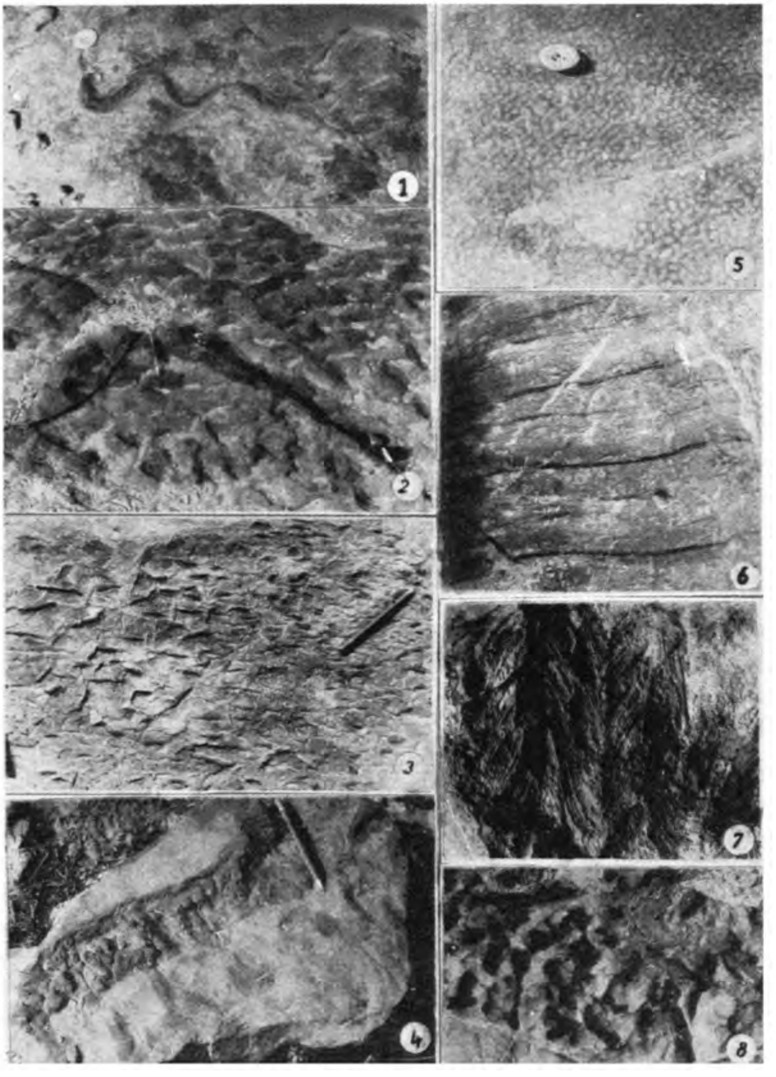

PLATE II

1. Ichnogenus *Muniaichnus* n. gen., Glauconitic sandstones (*n*). 2. Lingoid ripples, upper part of Glauconitic sandstone (*n*). 3. Well developed mud cracks, upper part of Glauconitic sandstones (*n*). 4. Rill marks, upper part of Glauconitic sandstone (*n*). 5. Wrinkle marks in the siltstone, middle horizon of Glauconitic sandstone (*m*). 6. Triple crested wave ripples suggesting falling water level, lower part of the Glauconitic sandstone (*j*). X 1/.4 7. *Conophyton garganicus* in the lower part of Fawn limestone. *X* 1/10. 8. Algal mats in the upper part of the Fawn limestone (*g*).

cracks. The presence of herringbone structure is almost a definite indicator of tidal currents.

The sandstones are overlain by about 2 meter thick mixed calcareous facies (Fig. 2-*k*) represented by oolitic limestone, intraformational breccia (Plate I—4) and calcareous sandstone. It shows parallel bedding and small scale ripple bedding and small scale cross bedding of herringbone type. Penecontemporaneous deformational structures and mud gals are also seen. This succession represents environment of a mixed carbonate tidal flat with little supply of clastic material which resulted in the development of chemical milieu for the precipitation of carbonates. Presence of oolitic limestone and penecontemporaneous breccia suggests a moderate energy tidal flate nvironment.

succeeds a 6 meter thick medium grained calcareous sandstone (Fig. 2-*l*) showing large scale cross bedding, small scale cross bedding, small scale (Plate I—1) ripple bedding and herringbone structure. Primary lineations and intraformational conglomerate are also recorded. Primary lineation suggests deposition in upper flow regime. This succession must have deposited in a mixed high to moderate energy tidal flat environment.

It is succeeded by about 2 meter thick green to black carbonaceous shales (Fig. 2-*m*) interbedded with siltstone. Parallel bedding, lanticular bedding and faintly developed graded bedding are the main bedding types. Mud cracks, wrinkle marks (Plate II—5), small scale interference ripples and rain prints are the important bedding surface features. This shale rich sequence represents low energy mud flat deposit. The area must have been subjected to areal exposures as indicated by mud cracks and rain prints. Wrinkle marks also suggest a very thin water layer of the order of only few cms over the sedimentation surface.

It is succeeded by about 11meter thick glauconitic sandstone horizon (Fig. 2-*n*) with shaly and silty intercalations. Parallel bedding, tidal bedding, small scale ripple bedding, small scale current bedding, flaser and lenticular bedding and herring-bone structureare the main bedding types. Wave and current ripples, interference ripples, lingoid ripples, rill marks, falling water marks and mud cracks are the bedding surface features (Plate I—3; Plate II—2, 3, 4). However, mud cracks and ripples marks are most abundant. These indicate a typical intertidal deposit of moderate energy. Rill marks and mud cracks suggest intermittent aerial exposure. These are succeeded by stromatolitic Rohtas limestone (Fig. 2).

Thus, it may be concluded that the deposition of the Kheinjua Formation took place in two phases. The first is represented by the deposition of Olive shales and Fawn Limestone and the second phase started with the deposition of Glauconitic sandstone. The beginning of the deposition of Glauconitic sandstone marks a transgressive phase. However, the entire deposition took place in a very shallow water environment in which the subsidence kept pace with the deposition.

Palaeocurrent Analysis

An attempt has been made to record and interpret the vectorial attributes in the Glauconitic sandstone in order to know the current system prevailing during the deposition of Glauconitic sandstone. For this only cross bedding is considered. In all 50 readings have been taken and are plotted in the form of a rose diagram with

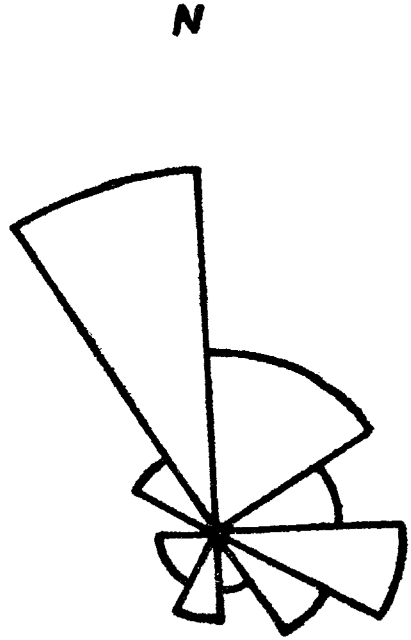

FIG. 3. Rose diagram for paleocurrents of the Glauconitic Sandstone (50 readings).

30° class interval. The rose diagram (Fig. 3) is polymodal with current in almost all the directions. However, the main current is in northerly direction. With coast line trending E–W this direction may be taken as ebb current direction. The rose diagram with very wide scatter confirms tidal flat environment of deposition since in this environment the current system is quite complex (Reineck & Singh 1973) as it is influenced by tides, wind direction, morphology and trend of the coast line etc.

LIFE DURING KHEINJUA FORMATION

Till now except for stromatolites no other fossil is known from the Kheinjua Formation. The *Conophyton garganicus, Colonella columnaris* and *Collenia clappii* are recorded from the Fawn Limestone, and on this basis Kumar (1976*a*) has assigned it Middle Riphean age which accords well with the radiometric age of Glauconitic sandstone.

The Fawn limestone at Muni Ki Pahari has yielded well developed complete pyramidal crystals of quartz which suggests that the crystals must have formed just after the deposition of limestone but before lithification. Chert is also abundantly developed in these limestone. With this view in mind that the silica associated with this limestone is due to primary precipitation, the chert has been searched for possible evidences of organic remains. For this, chert has been cut along the bedding planes and thin sections are prepared. These thin sections have been studied under high magnification. The preliminary investigations are quite encouraging and some micro-structures have been recorded. A detailed paper on the micro organism of the Fawn limestone is in preparation.

However, a well preserved trace fossil resembling *Gordia* Emmons 1844 and *Cochlichnus* Hitchcock 1859 is recorded from the upper part of the Glauconitic sandstone. It is seen on the upper surface of the fine grained sandstone showing well developed mud cracks.

Description

Genus *Muniaichnus* New genus
(Plate II—1)

It is long slender, meandering raised smooth surface with broader one end and tapering other end resembling sine curve. The central part shows uniform thickness. The length is 16 cm and breadth in the central part is 0.6 cm. The thickest part is 1 cm wide.

Remarks

The form resembles *Gordia* Emmons 1844 and *Cochlichnus* Hitchcock 1858 in physical form but instead of trails the present form shows raised surface.

Etymology

The genus is named after the first word of the hillock *Muni Ki Pahari.*

The *Gordia* Emmons 1844 has been reported by Glaessner (1966) from Arumbera Formation which must have been produced by worm like creatures. According to him such trace fossils prove that at some period of the earths history worm like creatures existed which fed on detrital material including decaying organic material, bacteria and protesta. They existed at least one billion years ago.

The recent discovery of arthropod and worm remains from the Rohtas Formation of Katni area by Tandon & Kumar (1977) is quite significant and confirms this fact that prior to the deposition of the Rohtas Formation i.e., in the Kheinjua period, the organic life was evolved enough to be able to give rise well developed arthropod

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