Journal of The Palaeontological Society of India
Vol. 48, 2003, pp. 191-214
ISSN 0552-9603

AGE OF VINDHYANS — PALAEOBIOLOGICAL EVIDENCE: A PARADIGM SHIFT (?)

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ABSTRACT

The appearance of metaphyte and metazoan remains is well established in the Terminal Proterozoic strata worldwide. Recent discoveries of megascopic remains (carbonaceous remains, small shelly fossils, sponge spicules, triploblastic animal trace fossils and microstromatolite) in the Vindhyan sediments almost changed the evolutionary clock. New radiometric dates of various horizons of Vindhyans also challenged the established perception of the metaphytic and metazoan evolution in time and space. Collectively, the radiometric datings and palaeobiological remains necessitate an objective review to assess the evolutionary paradigm shifts. Along with the earlier similar exercises (Sharma *et al.*, 1992 and Venkatachala *et al.*, 1996), in the present exercise, 13 reports published between 1990-2000 describing 40 megascopic entities are evaluated. The paradigm shift, based on recent discoveries, is apparent and does not call for any major change in the metaphyte-metazoan evolutionary understanding.

INTRODUCTION

The Vindhyan Supergroup of central India (See Fig. 1 & 2) has long drawn attention of leading geologists and palaeobiologists to find answers about the age of the basin. Geochronologists have provided dates for various horizons, but their efforts could not settle the problem of the age of Vindhyans. Even today, correct age bracket for the deposition of the entire basin eludes the answer and it is still an enigma. Recent age data (Kumar *et al.*, 2001; Rasmussen *et al.*, 2002; Ray *et al.*, 2002) have further compounded this problem. Based on lithostratigraphic correlation, and owing to the absence of recognizable fossils, the Vindhayn Supergroup was considered Precambrian in early twentieth century. Since then palaeobiologists have recovered various evidence in the form of fossils, which evinced keen interest among botanists and zoologists, to trace the evolutionary lineage of various phyla. Such reports generated a great deal of debate about the age of the basin. A few reports even proposed to change the status of theVindhyan basin from Precambrian to Phanerozoic. Many such finds later did not stand the test of time and proved to be either artifacts, or cases of misidentification (Sharma *et al.*, 1992;Venkatachala *et al.*, 1996). The problem of the age of the Vindhyan was further compounded with the recent discoveries that have suggested an apparent paradigm shift to alter the metazoan evolutionary clock altogether (Sarkar *et al.*, 1996; Azmi 1998a; Seilacher *et al.*, 1998; Kumar, 1999a). These discoveries have been widely debated (see Viswakarma, 1998; Sankaran, 1999).

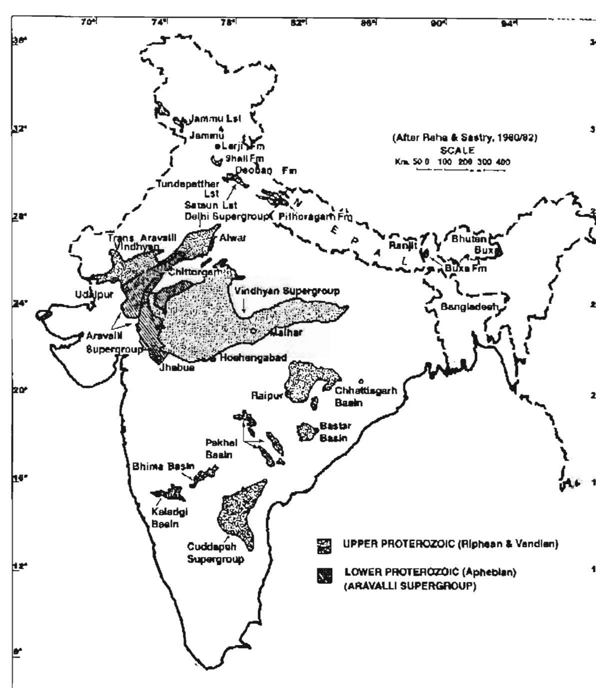

Fig. 1 – Distribution of Proterozoic basins of India (After Raha and Sastry, 1982).

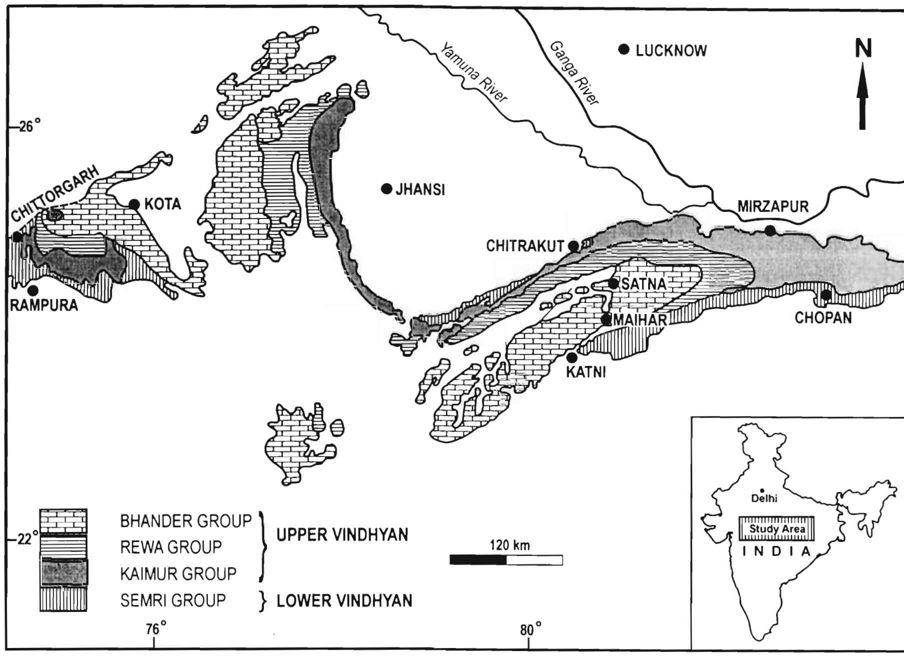

Fig. 2 – Geological Map of the Vindhyan Supergroup (After Krishnan and Swaminath, 1959).

To discuss these finds and other discoveries of the decade 'The Palaeontological Society of India' organized a workshop and field meeting in the year 1999. In light of these findings when I received an invitation from 'The Palaeontological Society of India' to assess the recent discoveries (Sarkar *et al.*, 1996; Seilacher *et al.*, 1998 and Azmi 1998a), I accepted. I had already provided reviews earlier (Sharma *et al.*, 1992, Venkatachala *et al.*, 1996 and Sharma and Shukla, 1999). As our 1992 paper (Sharma *et al.*, 1992) was a comprehensive evaluation of all the Precambrian metaphytic and metazoans finds reported until 1990 in India, I considered this to be a good opportunity to evaluate the subsequent reports, and update the earlier reviews (Venkatachala *et al.*, 1996). The present review covers the metaphytic and metazoan remains recorded from the Vindhyan Supergroup upto 2000 A.D.

It is pertinent to evaluate the new finds in perspective of the latest advancements in the field of Precambrian palaeobiology. My consultation of the post-1990 publications on metaphyte and metazoa in Precambrian sediments of India disillusioned me. In spite of our exhaustive critique (Sharma *et al.*, 1992; Venkatachala *et al.*, 1996), many workers repeated similar mistakes in identification and drew conclusions based on already discarded pseudo- or dubiofossils. Thus, a new review became essential.

In the following pages all the post 1990 publication on megascopic, metaphytic and metazoan remains recorded from Vindhyan basin of India (Fig. 2 and Table-1) are discussed. The megafossils described during the last decade are reviewed individually. An attempt has been made to examine the original specimens wherever possible; otherwise the comments are based on the published account. In each category repository details as provided in the respective paper, author(s) description of the specimens, its general characteristics are given followed by individual attribute, and lastly, the remarks incorporating the discussion leading to categorise as truefossil, dubiofossil or pseudofossil (see Table-2). Primarily, each one has been put into one of the following broad categories, viz. Carbonaceous compressions (*Chuaria*, *Tawuia* and allied forms, *Grypania*), metazoan fossils, trace fossils, and Small Shelly Fossils.

Table 1 : Generalized lithostratigraphy of the Vindhyan Supergroup.

	Group	Soni *et al.*, 1987	Krishnan, 1968	
Vindhyan Supergroup	Bhander Group	Bhavpura Fm.		
		Balwan Limestone Fm.		
		Shikaoda Sandstone Fm.	Upper Bhander Sandstone	
		Sirbu Shale Fm.	Sirbu Shale	
		Bundi Hill Sandstone Fm.	Lower Bhander Sandstone	
		Lower Bhander Limestone Fm.	Lower Bhander Limestone	
		Ganuragarh Shale Fm.		
	Rewa Group	Upper Rewa Sandstone Fm.	Upper Rewa Sandstone	
		Jhiri Shale Fm.	Jhiri Shale	
		Lower Rewa Sandstone Fm.	Lower Rewa Sandstone	
		Panna Shale Fm.	Panna Shale	
	Kaimur Group	Dhandraul Quartzite Fm.	Dhandraul Quartzite	
			Scarp sandstone & conglomerate	
		Bijaigarh Shale Fm.	Bijaigarh Shale	
		Markundi Quartzite Fm.	Upper Quartzite	
		Ghurma Shale Fm.	Silicified Shale/Susnai Breccia	
		Ghaghar Quartzite Fm.	Lower Quartzite	
	Semri Group	Rohtas Limestone Fm.	Rohtas Limestone	Rohtas Stage
		Basuhari Sandstone Fm.	Glauconite bed }	Kheinjua Stage
		Bargawan Limestone Fm.	Fawn Limestone }	
		Kheinjua Shale Fm.	Olive Shale. }	
		Chopan Porcellanite Fm.		Porcellanite Stage
		Kajrahat Limestone Fm.	Kajrahat Limestone }	Basal Stage
		Arangi Fm.	Basal Conglomerate }	
		———— Unconformity ————		
		Bijawar Group		

CARBONACEOUS COMPRESSIONS

Chuaria

Chuaria circularis Walcott 1899 is widely known from Neoproterozoic sedimentary sequences [a few remains assigned to this genus are also known from the Palaeoproterozoic (Hofmann and Chen, 1981) and Lower Cambrian (Brasier *et al.*, 1979)]. It is generally considered to be a large sphaeromorph acritarch. The size range of the *Chuaria* varies considerably. *Chuaria* and *Tawuia* are regarded as colonies of prokaryotes (Steiner, 1994) and as part of multi-cellular plant (Kumar, 2001). Although *Chuaria* could not be recommended as an index fossil, the *Chuaria–Tawuia* assemblage indicates a Neoproterozoic age. Since *Chuaria* and *Tawuia* are all reported from the coeval stratigraphic horizons and therefore they constitute a single biozone (Kumar, 2001).

Chuaria circularis Walcott, 1899 emend. Vidal and Ford, 1985

Repository: Museum of the Geology Department, Lucknow University, Lucknow; Specimens nos. KA45, KA112; Kumar (1995) figs. 4h, and i.

Kumar (1995) reported *Chuaria circularis* from upper part of the Rohtas Formation, Semri Group, the Vindhyan Supergroup exposed in Tikaria, 2 km SE of Katni Railway station area, Madhya Pradesh, India. The reported forms are black circular to elliptical compressions atypical on bedding plane.

Table 2 : Present Status of carbonaceous remains, metazoan fossils, Trace fossils and small Shelly fossils reported between 1990-2000 AD from different stratigraphic levels of the Vindhyan Supergroup of India. (* Represented by latex casts).

S. No.	Reported from	References	Present status
Carbonaceous compressions			
1.	*Chuaria circularis*	Kumar, 1995	True fossils
2.	*Chuaria circularis*	Kumar and Srivastava, 1997	True fossils
3.	*Chuaria circularis*	Rai *et al.*, 1997	True fossils
4.	*Chuaria circularis*	Rai and Gautam, 1998	Organic matter aggregate
5.	*Chuaria gigantia*	Rai and Gautam, 1998	Organic matter aggregate
6.	*Chuaria melanocentricus*	Rai and Gautam, 1998	Organic matter aggregate
7.	*Grypania spiralis*	Kumar, 1995	True fossils
8.	*Grypania spiralis*	Rai and Gautam, 1998	True fossils
9.	*Krishnania multistriata*	Maithy, 1991	Pseudofossils
10.	*Phyllonia bistaria*	Rai and Gautam, 1998	True fossils
11.	*Tawuia dalensis*	Kumar and Srivastava, 1997	True fossils
12.	*Tawuia dalensis*	Rai *et al.*, 1997	True fossils (except fig. 3)
Metazoan Fossils			
13.	*Beltanelliformis brunsae*	Maithy *et al.*, 1992	Pseudofossil
14.	*Cyclomedusa davidi*	Maithy *et al.*, 1992	Pseudofossil
15.	*Medusinites asteroids*	Maithy *et al.*, 1992	Pseudofossil
16.	*Spriggina*	Kathal *et al.*, 2000	Dubiofossil
17.	Sponge spicules	Kumar, 1999	Dubiofossil
Trace fossils			
18.	*Chondrites* sp.	Rastogi and Srivastava, 1992	Pseudofossil
19.	*Cochlichnus anguineus*	Kulkarni and Borkar, 1996a	Pseudofossil
20.	*Hormosiroidea*	Rastogi and Srivastava, 1992	Pseudofossil
21.	*Monomorphichnus* sp.	Rastogi and Srivastava, 1992	Pseudofossil
22.	*Ormathichnus moniliformis*	Rastogi and Srivastava, 1992	Pseudofossil
23.	*Palaeophycus* sp.	Rastogi and Srivastava, 1992	Pseudofossil
24.	*Pelecypodichnus* sp.	Rastogi and Srivastava, 1992	Pseudofossil
25.	*Planolites* sp.	Rastogi and Srivastava, 1992	Pseudofossil
26.	*Rhizocorallium* sp.	Rastogi and Srivastava, 1992	Pseudofossil
27.	*Skolithos linearis*	Kulkarni and Borkar, 1996a	Dubiofossil
28.	Trace fossils	Sarkar *et al.*, 1996	Pseudofossil
29.	Trace fossils	Seilacher *et al.*, 1998	Pseudofossil
Small Shelly fossils			
30.	acrotretid brachiopod*	Azmi 1998a	Pseudofossil
31.	*Camenella* sp. A.	Azmi 1998a	Pseudofossil
32.	*Camenella* sp. B.	Azmi 1998a	Pseudofossil
33.	*Camenella* sp. C.	Azmi 1998a	Pseudofossil
34.	*Codonoconus* sp.	Azmi 1998a	Dubiofossil
35.	*Halkieria* sp.	Azmi 1998a	Pseudofossil
36.	*Lapworthella* sp.	Azmi 1998a	Pseudofossil
37.	obolellid brachiopod*	Azmi 1998a	Pseudofossil
38.	*Olivooides multisulcatus*	Azmi 1998a	Pseudofossil
39.	*Spirellus shankari*	Azmi 1998a	Dubiofossil
40.	*Talliella himalayaica*	Azmi 1998a	Dubiofossil

The size ranges from 0.32 to 4.0 mm, with a mean larger diameter of 1.76 mm (N=107) and a mean shorter diameter of 1.46 mm. One of the peculiar associated structures is two more or less tapering projections recorded by Kumar (1995, fig. 4d and 4g) and considered taphonomic artifacts.

Remarks: Recorded specimens are poorly preserved carbonaceous *Chuaria circularis* with some fragmentary pieces of organic films that could not be attributed to any known organic entity. *Tawuia* sp. is also recorded in the assemblage from the locality. The specimens of *Chuaria circularis* are true fossils.

Chuaria circularis Walcott, 1899 emend. Vidal and Ford, 1985

Repository: Museum of Geology Department, Lucknow University, Lucknow; Specimen nos. D/90, M/42, B, C, D, S/6, M/13; Kumar and Srivastava (1997), pl.1 figs.1, 3, 4, 5, 8, 11, 12.

Kumar and Srivastava (1997) reported *Chuaria circularis* from the Bhander Limestone Formation exposed in the Tamas River Valley near Dulni Village 6 km NE of Maihar, and in a younger formation, the Sirbu Shale exposed 1 km NE of Dulni Village near the 6 km road marked on the Maihar-Rampura Motor Road. The reported forms are circular to elliptical compressions, generally made up of carbonaceous matter or distinct impressions marked by reddish colour. Wrinkles are invariably recorded in all the specimens. The longer diameter ranges from 0.2 to 5.1 mm with a mean of 1.54 mm (N=213), and the shorter diameter varies from 0.2 to 5.0 mm with a mean of 1.36 mm (N=213). Specimens from the Bhander Limestone are larger in size (1.65 mm; N=190) while those of Sirbu Shale Formation are smaller in size (1.20 mm).

Remarks: Specimens described by Kumar and Srivastava (1997; pl.1, figs. 1, 3, 4, 8,11,12) as *Chuaria circularis* are undoubtedly carbonaceous mega fossils. Close examinations of specimens documented in fig. 1 and 4 revealed that these two specimens have some exceptional features, that were not recorded earlier. The specimens documented in Kumar and Srivastava (1997, fig. 1, 4, 5) show a tubular rim around a likely sphere, the other specimen shown in the same photo plate is full of wrinkles, the same is also true for fig. 4 of Kumar and Srivastava (1997). On closer examination, these wrinkles appear to be three-dimensional, with relatively significant penetration in the sediments. These features are neither recorded nor observed in any of the previously described *Chuaria circularis*. Such features are available in plenty in Kumar's collection and cannot be considered taphonomic features. Besides my observations, Kumar independently noticed these features (personal communication) and has erected two independent taxa namely *Suketea ramapuraensis* and *Tawuia khoripensis* (Kumar, 2001). The forms described by Kumar and Srivastava (1997) are true fossils. Some unnamed carbonaceous ribbons subsequently called *Chambalia minor* (Kumar, 2001) are also recorded along with *Chuaria circularis* (Kumar and Srivastava, 1997, pl.1 figs. 6, 9, 10). These are true fossil of indeterminate affinity.

Chuaria circularis Walcott, 1899

Repository: Museum of the Geology Department, Lucknow University, Lucknow; Specimens nos. GDLU/97/VIN 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 18, 20, 23; Rai *et al.* (1997) figs. 3 c, d, e, f, h, j, l-n, p-r, t-v, z.

Rai *et al.* (1997) described the *Chuaria circularis–Tawuia dalensis* assemblage from the Jhiri Shale Formation upper part of the Rewa Group in the vicinity of Sohagi Village, 56 km South of Allahabad on Allahabad-Rewa Road. These forms are recorded as compressed circular to ellipsoidal carbonaceous discs ranging in size from 1.0 mm to 3.7 mm, averaging 2.0 mm. In some of the specimens a cluster of concentric rings in the central part of the compression have also been noted; the Jhiri Shale Formation is considered to be 690±125 m.y. old.

Remarks: The present assemblage comprise "true fossils" *Chuaria circularis* in compression and impression forms.

Chuaria circularis Walcott, 1899

C. gigantia Rai and Gautam, 1998

C. melanocentricus Rai and Gautam, 1998

Repository: Museum of the Geology Department, Lucknow University, Lucknow; *Chuaria circularis* Specimens nos. GDLU/95/V12; Rai and Gautam (1998) pl.1, fig. h; *Chuaria gigantia*, Specimens nos. GDLU/95/V8; Rai and Gautam (1998) figs. a-c; *Chuaria melanocentricus* Specimen no GDLU/95/VT1; Rai and Gautam (1998) pl.1, fig. i.

Rai and Gautam (1998) reported three different species of *Chuaria* from the upper part of the Semri Group, Rohtasgarh Limestone Formation (Rohtas Subgroup) exposed near Bistara Village (lat.23°58'28" N; long. 80° 27' 30"), about 24 km from Katni and 17 km from Kaimur. This assemblage is in addition to what Kumar (1995) described from the Katni area.

Remarks: A comparison of the lithologs published in Kumar (1995 fig. 3A) and Rai and Gautam (1998, fig. 2A and B) suggests that the fossil-yielding horizons are the same; and the locality described in Rai and Gautam (1998) is an extension of the horizon reported by Kumar (1995). Rai and Gautam (1998) reported *Chuaria circularis* as dark, compressed carbonaceous discs preserved on the bedding surface with considerable variation in size ranging from minute specks to 5 mm in diameter. While discussing various other species of *Chuaria*, Rai and Gautam (1998) adhered to the opinion of some authors (Ford and Breed, 1973; Vidal and Ford, 1985; Jankaukas, 1989), by assigning them to *Chuaria circularis*. Surprisingly, later authors went on erecting two new species, based on size and internal structures. The species reported by Rai and Gautam (1998) as *Chuaria gigantia* is based on four specimens. The new species was erected, because of the larger size of the specimens. Their diameter varies from 10 to 11 mm. The diagnostic features of this species are "the large size with circularly arranged very fine network of threads besides abundant small carbonaceous specks bursting out of the main circular discs". The authors have accepted Sun's (1987) interpretation of *Chuaria*, and compared it with modern *Nostoc* balls with thread like circular bodies inside *Chuaria gigantia* (Rai and Gautam, 1998, p.20). But the argument of *Nostoc* ball has been discarded while discussing *Chuaria circularis* in the same paper drawing the support from the works of Vidal (1974, 1976) and considered the filamentous features formed due to mechanical and chemical degradation (Rai and Gautam, 1998, page 18). Observations of Sun (1987) regarding the *Nostoc* ball in *Chuaria* specimens have been interpreted in two different ways in the paper of Rai and Gautam (1998). Size can be a criterion to erect new species, but it is to be supported by biometric analysis and plot, otherwise it is unclear because previously when Ford and Breed (1973) tried to restrict the size range of *Chuaria* from 0.5 to 5 mm, Vidal (1974, 1976) disagreed with the contention, and included the specimens as small as 70 microns in *C. circularis*. When the lower size limit is open the upper size limit should not be criterion for erecting a new species.

Rai and Gautam (1998) argued that the specimens of *Chuaria* in their collection are larger in size in comparison to the known range (0.5 to 5 mm) of *Chuaria* from other parts of the world. But it is not the only instance, Sharma and Shukla (1996) have also reported the size range which exceeds 10 mm. Examination of the specimen of *Chuaria gigantia* shows that what has been interpreted "as small carbonaceous specks bursting out of the main circular disc" that is nothing but derivational features of accumulated organic matter. The structure is poorly aggregated organic mass at different levels of shales and difficult to be considered as *Chuaria*.

Rai and Gautam (1998; pl.1, fig.i) described one specimen with a counterpart as *Chuaria melanocentricus,* whose very large size with a dark circular disc in the central part has been considered as the diagnostic feature. It is reported that the central portion is distinctly separated from the rest of the form by its darker colour, which is about 3 to 4 mm in diameter. Such forms are also known as *Nucellosphareidium*, which is of similar shape. An examination of the specimen confirms that the object is accumulation of organic matter assuming the shape of the *Chuaria* and that the internal feature may be only a taphonomical variation. The three species of *Chuaria* viz. *circularis*, *gigantia* and *melanocentricus* are only variants of regularly/irregularly distributed organic matter and cannot be considered akin to *Chuaria*.

Tawuia and allied forms

Hofmann (in Hofmann and Aitken, 1979) has described *Tawuia* as rod and ribbon like compression of millimetric width and centimetric length with smooth and even outline, the sides are parallel or slightly tapering, the terminal end subcircular. Sun (1987) observed the presence of circular bodies in the *Tawuia*, and the absence of annulations on the surface. There are two views regarding the extinct *Tawuia*. It was originally regarded as probably algal, but possibly metazoan (Hofmann and Aitken, 1979). Hofmann (1992) considers it a cylindrical in shape, whereas Kumar (2001) suggested it to be a siphonaceous thallus or filamentous cell with circular cross section of Chlrophycean/Xanthophycean affinities. It was attached on one end with *C. circularis* and its other end was linked to a holdfast apparatus. *Tawuia* has been found invariably associated with *Chuaria*, while the converse is not true. This led Hofmann (1981 a, b), Duan, (1982) and Sun (1987) to suggest that both genera may be closely related.

Tawuia dalensis Hofmann, in Hofmann and Aitkin, 1979

Repository: Museum of Geology Department, Lucknow University, Lucknow; Specimens nos. D/18, D/38; Kumar and Srivastava, (1997), pl.1, figs. 2, 7

Kumar and Srivastava (1997) reported *Tawuia dalensis* from the Bhander Limestone (Upper Vindhyan). The fossiliferous shales of the Bhander Limestone Formation are exposed in Tamas River Valley near Dulni Village, 6 km NE of Maihar in Madhya Pradesh. The reported forms are "elongated, rod-like carbonaceous compressions, straight parallel sided, ends sub rounded. Occasionally tapering at one end. Width ranges from 0.8 to 1.6 mm with mean as 1.14 mm (N=8). Maximum recorded length is 10.3 mm. Cross walls and annulations are not seen" (after Kumar and Srivastava, 1997).

Remarks: *Tawuia dalensis* described by Kumar and Srivastava (1997) are well-preserved carbonized specimens having smooth surface and nearly all the diagnostic taxonomic characters. These are considered "true-fossils".

Tawuia dalensis Hofmann, 1979 (in Hofmann and Aitkin, 1979)

Repository: Museum of the Geology Department, Lucknow University, Lucknow; Specimens nos. GDLU/97/VIN 1, 5, 9, 15, 19, 21; Rai *et al.* (1997) fig. 3g, k, o, s, w.

Rai *et al.* (1997) reported several specimens of compressed *Tawuia dalensis* from the Jhiri Shale (Rewa Group, Vindhyan Supergroup) from south of Sohagi Village, 57 km from Allahabad on the Allahabad-Rewa Road (National Highway 27). The reported specimens are preserved as compression and impressions and their length varies between 3.3 and 5.0 mm and their width between 1.6 and 2.2 mm.

Remarks: *Chuaria* and *Tawuia* are known from older sediments of the Vindhyan Supergroup (Jones, 1909; Maithy and Shukla, 1984). The present assemblage documents the occurrence of *Chuaria-Tawuia* from still younger sediments of the Vindhyan Supergroup. Examination of the collection reveals that all the described specimen are undoubtedly *T. dalensis*, except the one described by Rai *et al.* , (1997 fig. 3g, GDLU/97/VIN 9); because of its closer affinity with compressed *Chuaria*, it may be combined with *Chuaria circularis* of the same assemblage.

Phyllonia bistaria Rai and Gautam, 1998

Repository: Museum of the Geology Department, Lucknow University, Lucknow; Specimen nos. GDLU/95/V09 and GDLU/95/V10 (counterparts); Rai and Gautam (1998) pl.1, figs. d, g and Text-figure 5.

Rai and Gautam (1998) reported a spatulate carbonaceous form, occurring in clusters assuming a radiating fan-like appearance. Width at broad end ranges between 7 mm to 12 mm and length ranges between 22-31 mm. Terminal ends are not clearly visible, but one specimen shows a tapering rounded terminal end. The authors compared the form with *Longfengshania* Du (1982) and *Lanceoforma* Walter *et al.* (1976). Owing to the absence of a stipe, and the larger size of *P. bistaria*, it was differentiated from these two forms, and argued to a new genus and species of organic film.

Remarks: Rai and Gautam (1998, pl.1, figs. d and g) erected a monospecific genus *Phyllonia*. Among the Proterozoic carbonaceous remains several types of morphologies occur (see Hofmann, 1992). Some of them have been taxonomically dealt, but without correct affinity. Likewise the present form may be considered another addition to the category of carbonaceous remains. Maithy (1991) reinterpreting *Krishnania* Sahni and Shrivastava, (1954) suggested that in reality three specimens were preserved overlapping one another and the central one as having a short stipe-like structure; and presented a text-figure (Maithy 1991, fig. 2A). The possibility that *P. bistaria* is a *Krishnania*-like remnant of an organic film or a cluster of broken *Tawuia* specimens cannot be ruled out, except its size most of the characters are similar to *Krishnania*. The practice of erecting monospecific genera has lately been avoided. The present remains are organic in nature but assignment to new genus and species is inconclusive.

Krishnania multistriata Maithy, 1991

Repository: Birbal Sahni Institute of Palaeobotany, Lucknow; Specimen no. BSIP-35919; Maithy (1991) pl.1, fig.5.

Maithy (1991) erected a new species of genus *Krishnania*, *K. multistriata*. The specimen was collected from the Rohtas Formation, Semri Group, Lower Vindhyan exposed in Baulia Limestone quarry, Rohtas Sasaram District Bihar. *K. multistriata* is an ovate structure, has a surface with fine thickenings, and the attenuated end of the foliate part is drawn into a narrow stout stipe-like structure. Their size varies between 8 x 3 mm to 25 x 12 mm.

Remarks: Sharma *et al.* (1992) showed that the structure considered as *K. multistriata* (specimen no. BSIP-35919) was earlier considered as Krishnanid remains (Maithy 1990, pl.2, fig.3). These structures are present on a thin veneer of fibrous calcite. Conspicuously, all the specimens are aligned in one direction. The fibrous calcite is secondary in origin. Any structure present on subsequently formed (secondary) mineral cannot be considered syngenetic to host lithology. Thus, the structure *K. multistriata* is inorganic and placed in the category of pseudofossils.

Grypania

These are basically impressions of coiled, sausage-shaped, curved and spiraliform ribbons that are several cm long. Individual filaments can be traced up to a few centimeters. Normally no relief is noticed on bedding surfaces and the ribbon/ filaments show smoother surface than the adjoining surface of the matrix.

Grypania spiralis Walcott emend. Walter *et al.*, 1990

Repository: Museum of Geology Department. Lucknow University, Lucknow; Specimens nos. KA9, KA86, KA95, KA100; Kumar, (1995) figs. 6. 7a-7e.

Kumar (1995) reported *Grypania spiralis* from the upper part of the Rohtas Formation, Semri Group. Vindhyan Supergroup, exposed in Tikaria, 2 km SE of Katni Railway station area, Madhya Pradesh. India. Specimens are compressed, curved, spiral. straight, circular and C-shaped filamentous forms ranging between 0.5 and 2.1 mm in width with a maximum mode at 1.6 mm. The filaments show 4-7 septa in 1 mm. The maximum coil diameter is 3.2 cm; some of the filaments have a blunt terminal cell.

Remarks: *Grypania* is a Precambrian genus that has been debated a lot. Its affinity has been attributed to metazoa (Walcott 1899), to megascopic probably eukaryotic alga (Walter *et al.*, 1976. Du *et al.*, 1986, Walter *et al.*, 1990, Han and Runnegar. 1992). Not only has it been recorded from various horizons of the Mesoproterozoic but Han and Runnegar (1992) have reported the oldest record of *Grypania spiralis* specimens from the ~1.9 Ga old Negaunee Iron Formation, Michigan. Kumar (1995. figs. 7f, h, I) illustrated three specimens and considered them possibly as a mould of a *Grypania* like form, and also considered the form described by Beer (1919) to be a mould of *Grypania.* Moreover for getting a mould of *Grypania*-like form with considerable epi-relief, it has to be either of the burrowing nature or three-dimensional object rather than the flat filamentous form. Describing the *G. spiralis*, Kumar (1995, p.178, 180) mentioned that the ribbons show smoother surface in comparison to the adjacent sediment. The author has correctly considered the specimen (Kumar, 1995, figs.7f, h, I) as dubiofossils, but it was not established with sufficient reasons to consider the objects as mould of *Grypania* or *Grypania*-like form. The other elements are true fossils of *Grypania.* Beer's (1919) specimen could not be located in the GSI collections at Kolkata (Calcutta) for consultation during an earlier visit and from whatever published information is available, it appears to be a larger specimen than any other known *Grypania.* So it would be premature to consider it to be a mould of a *Grypania*-like form. Hofamnn (1992 p. 356) considered that since it is not carbonaceous it is possible that it may have quite different affinity. However, Sharma *et al.*(1992), in a previous assessment, have considered it to be a true fossil.

Grypania spiralis Walcott emend. Walter *et al.,* 1990

Repository: Museum of Geology Department, Lucknow University, Lucknow; Specimen no. GDLU/95/V02; Rai and Gautam, 1998, fig.1e; GDLU/95/V01; Rai and Gautam, 1998, fig.1f (*Grypania* sp.).

Rai and Gautam, (1998) recorded specimens of 'C' shaped, compressed, septate filament of width between 1 to 1.5 mm (*G. spiralis* pl., 1 fig. f and *G.* sp. pl.1, fig. e). External diameter of 'C' shape is 15.5 mm, and the terminal end is rounded.

Remarks: Kumar (1995) reported *Grypania spiralis* from the same area. These specimens are larger in size, except for the coil diameter. The occurrence of *Grypania* further corroborates that the present locality is an extension of Kumar's (1995) locality. Those described under *Grypania* sp. are almost of equivalent size to that of Kumar's specimens. Although authors have considered the specimen in their collection as probably the largest specimen being the larger filaments width and the coil diameter but the latter may be preservation factors. The specimens are true fossils.

METAZOAN FOSSILS

Metazoan fossils in Precambrian sediments are known as the Ediacara biota. They are distinct assemblage of soft- bodied organisms that globally occur in Neoproterozoic (Terminal Proterozoic) strata. Some of the Ediacaran organisms are supposed to be the rootstock for the 'Cambrian Explosion' of animals; other bizarre forms are testimony to a failed experiment of nature in the course of evolution. Quite often sedimentary features mimic the Ediacaran fossils, and the literature is replete with such reports. Differentiating between true fossils and sedimentary features is a challenging task.

Spriggina (?) Glaessner, 1959

Repository: Not mentioned; Kathal *et al.* (2000) fig.3, fig. 4 (1-6).

Kathal *et al.* (2000) reported (?) *Spriggina,* from the Chauraiya area, Damoh District, Madhya Pradesh. This specimen was recovered from the Palkawan Shale Formation of Semri Group, the Vindhyan Supergroup. The authors compared the specimen with *Spriggina floundersi* (Glaessner, 1959) from the Ediacara Hills, and further described by Gehling (1991) and Conway Morris (1993a). The Palkawan Shale Formation has been suggested to be 600-544 m.y. old.

Remarks: The lone fragmentary specimen from the Palkawan Shale cannot be confidently considered as belonging to the Ediacara fauna. Kathal *et al.* (2000) are also not confident about the biogencity of the structure, as reflected by the question mark added by them in the title and the systematic description. As emphasized by the authors, the segmentation may be a product of compaction of a high profile body involving internal structures of varying resistance. In spite of the regular segmentation and visualization of lobes/nodes, the present structure cannot be considered unequivocal evidence of metazoan life equivalent to Edicaran elements. In a recent paper Kumar (2001, p.192), who has examined the specimen and visited the field locality, that the *Spriggina floundersi* be considered a pseudofossil for the following reasons: (i) there is only one poorly preserved specimen collected in 1991 which could not be duplicated since then. The specimen has a very superfluous resemblance with appendages of *Spriggina*; (2) Rock from which the sample was recovered is an intraclastic limestone breccia with numerous clasts of varying sizes and not a sandstone as mentioned in the text. Besides, the age of the Palkawan Shale as proposed by the authors (600-544 Ma old) is untenable. So far no radiometric data corroborate this date. For the same reasons, Rai *et al.* (2002, p.134) have questioned the identification. The present find is categorized as a dubiofossil. Recently I have examined the specimen during International Field workshop on the Vindhyan Basin, Central India (3rd – 11th December 2002) and noted that the specimen is intra clastic limestone which has transverse partitions that can be attributed to tensional fractures and not as appendages as described by Kathal *et al.* (2000).

Sponge spicules

Repository: Museum of the Geology Department, Lucknow University, Lucknow; Slide nos. E1/99, 2/99, 5/99, 27/99, 29/99 and 40/99; Kumar (1999a) pl.1 figs. A-G.

Kumar (1999a) reported siliceous sponge spicule-like forms from chert lenses in the Bhander Limestone exposed 5 km East of Maihar in Girgita mine in Central India. The reported forms are of two types: single-rayed spicules (pl.1, B, C, E, F and G) and polyactine spicules (pl.1, A, B and C). The spicules show size variations in both length and width. The maximum reported length is 2.2 mm and width varies from 0.01 to 0.06 mm. The author refrained from assigning any systematic position to these spicules.

Remarks: Among the recent discoveries of fossils from different levels of the Vindhyan Supergroup (Sarkar *et al.,* 1996; Azmi, 1998, and Seilacher *et al.,* 1998), the report by Kumar (1999a) is noteworthy, because of the association of the described structure with microstromatite (microstromatolite). There are only a few recent reports of sponge spicules from the Neoproterozoic (Gehling and Rigby, 1996; Brasier *et al.,* 1997; Li *et al.,* 1998). In India, the previous reports of sponge spicules are from the Lower Tal Formation (Mazumdar and Banerjee, 1998); the Tethyan sequence exposed in Northwestern Kashmir (Tiwari, 1997); and the Gangolihat Dolomite, Lesser Himalaya, India (Tiwari *et al.*, 2000). All these reports indicate the occurrence of sponge spicules in chert clasts. Recent studies (Brasier *et al.*, 1997; Brasier, 1992, fig. 4) suggest that spicules appeared in Neoproterozoic, but true sponge fossils and well-studied spicules are recorded only in the Cambrian and younger sequences. Molecular phylogenetic studies (Christen *et al.,* 1991) also suggest the advent of sponges in Neoproterozoic. Brasier (1992) suggested that demosponge spicules appeared early in comparision to hexactinelids. In Kumar's (1999a) collection, most of the spicules are isolated and broken, and therefore it is difficult to assign them to any of the known classes of the phylum Porifera.

Examination of slides containing the structures described by Kumar (1999a), shows that some of the (?) radiating features can be traced for a considerable distance (e.g. slide no E-2), which exclude the possibility of such structures being the spicules and indicate possibility of their being a lath or ?crystals. In one of the slides (E-27), specimens are preserved in two separate clasts. In one of the clasts the laths are along the bedding plane whereas in the other clast they are fan like radiating structures. In slide (E-3) some of the clasts show radiating laths. Large size single rayed specimens in the rock sections are found in slide E-5. Such variable features, as well as their preferred orientation also negate their possibly being spicules. The structures described by Kumar (1999a) are neither true spicules nor they can be considered entirely abiogenic features. Their attribution to "sponge spicules" has proved inconclusive, and their affinities still remain undetermined, and they are considered to be dubiofossils.

Cyclomedusa davidi Sprigg, 1947

Repository: Museum of the Birbal Sahni Institute of Palaeobotany, Lucknow; Specimen nos. BSIP 36388, 36390 and 36393; Maithy *et al.*(1992) pl.1, figs.1-4.

Maithy *et al.* (1992) recorded (?) Ediacaran biota from the Dholpura Shale, Bhander Group, Vindhyan Supergroup, exposed in a small hillock near Bhavpura, Lakheri, Rajasthan. The fossiliferous horizon is ferruginous siltstone. These remains occur as external moulds, slightly raised from the bedding plane. The assemblage includes *Cyclomedusa davidi*, *Medusinites asteroides* and *Beltanelliformis brunsae*. Maithy *et al.* (1992)

claimed to have twenty specimens of *Cyclomedusa davidi* with diagnostic character "External moulds are preserved either solitary or superimposed upon one another; mould show a raised relief on the rock. The umbrella is radially symmetrical, measuring 20-50 mm in diameter. outline circular to sub circular margin simple, entire; with a distinct central areas, measuring 8-12 mm; surface sculptured, encircled by several concentric thickening at an interval of 5–10 mm, which is only well preserved specimen show fine, simple unbranched radial striae arising from the base of the central area". It is held that the described specimens are closely comparable with the holotype of *Cyclomedusa davidi*, reillustrated by Sun (1986).

Remarks: Though these authors have visualized and noted all the possible diagnostic characters, in their specimens, they seem to be unconvinced about its true Ediacaran affinity/nature, which is why they have put a query in the title of the paper. Examination of the specimens, illustrated by Maithy *et al.* (1992, figs. 1-4), suggests that all the objects described as *Cyclomedusa davidi* are nothing but artifacts formed by weathering. Earlier, Maithy (1990, pl. 1, fig. 7) recorded a specimen with similar features from the Rohtas Limestone exposed in Rohtas District, Bihar as *Rohtasia tandoni* and interpreted as of medusoid affinity. Sharma *et al.* (1992) in a comprehensive review have regarded *R. tandoni* as a 'nonfossil'. The same interpretation applies to the *Cyclomedusa davidi* specimens described from Lakheri, Rajasthan which are considered 'pseudofossils'.

Medusinites asteroides Sprigg emend. Glaessner and Wade, 1966

Repository: Museum of Birbal Sahni Institute of Palaeobotany, Lucknow; Specimen nos. BSIP 36391, 36392 and 36394; Maithy *et al.* (1992) pl.1, figs. 5-7.

Maithy *et al.* (1992) reported *Medusinites asteroides* from the Dholpura Formation (the Bhander Group, Vindhyan Supergroup) exposed in small hillocks near Bhavpura, Lakheri, Rajasthan. The characteristics of the forms are described as "Sub circular, epi relief slightly raised, measuring 5-20 mm in diameter composed of smooth central disc 4-10 mm in diameter separated by a sub circular deep groove from a large outer ring. A narrow marginal flange is occasionally preserved". The specimens are closely comparable with *Medusinites asteroides* Glaessner and Wade (1966).

Remarks: I have noted several weathering features which are similar to *Medusinites asteroides* described by Maithy *et al.* (1992) in the Rohtasgarh locality of Bihar where these structures are present on the top, bottom as well as on the sides margins of the rectangular or square broken pieces of the siltstone. Previously Maithy (1990, pl. 2, figs. 8, 9) photographed *Medusinites* from the same locality. However, the museum numbers assigned to the specimens are those of pollen slide (BSIP-10256) and a petrographic thin section of Infrakrol chert (BSIP-10258). Therefore these are considered to be 'inacessotype specimen' (the specimen that can not be located at its designated place). However, in a subsequent publication, Maithy and Babu (1997) reported that Sharma *et al.* (1992) were biased in calling the *Medusinites* nonfossils and specimens are available in the BSIP repository. A casual approach in assigning the specimen number is further reflected in the paper of Maithy *et al.* (1992) wherein the numbers given in the explanation do not match those of the museum numbers, which makes it difficult to cross check the specimens. The specimens reported from Bhavpura in Rajasthan as *Medusinites asteroides* are similar to weathering features. Therefore the present form is considered pseudofossil.

Beltanelliformis brunsae Menner, 1974

Repository: Museum of Birbal Sahni Institute of Palaeobotany, Lucknow; Specimens nos. BSIP-36395, 36396; Maithy *et al.* (1992) pl. 1, fig. 8-9.

Maithy *et al.* (1992) reported *Beltanelliformis brunsae* from the Dholpura Shale (Bhander Group, the Vindhyan Supergroup) exposed in small hillocks near Bhavpura, Lakheri, Rajasthan. These structures are described as "flat to button-shaped structures preserved along bedding plane, circular to sub circular convex hypo relief and concave epirelief, ranging 3-5 mm in diameter, marking of folds absent".

Remarks: The structures considered as *Beltanelliformis brunsae* by Maithy *et al.* (1992) occur either solitary or in groups of two or three as shown on the photographs. The structures reported by Narbonne and Hofmann, (1987), Fedonkin (1985), and Keller *et al.* (1974) occur in clusters and are distinct by protruding. Such features are absent in the Dholpura (?) Ediacaran remains. Since these structures are present on the same lithology and layer on which *Cyclomedusa davidi* and *Medusinities asteroides* are preserved and considered previously as 'nonfossils', these structures are also considered pseudofossils or 'non fossils'.

TRACE FOSSILS

Trace fossils

Repository: Palaeontological collection of the Agharkar Research Institute, Pune; Specimen no. MACS G 5039; Kulkarni and Borkar (1996a) Figs. 2-5.

Kulkarni and Borkar (1996a) reported the ichnofossil *Cochlichnus anguineus* from Upper Bhander Sandstone (Bhander Group) Vindhyan Supergroup exposed on the western bank of the Moti Nala Tank, near the village Sagoni in Damoh District, Madhya Pradesh India. These authors reported unbranched, smooth, more or less evenly meandering, and sinuous trails, preserved as shallow, broad grooves in negative epirelief. The width varies from 2 mm to 5 mm. Individual trails are seen to run for a distance of more than 1 meter. Interestingly all the individual trails are preserved within troughs and restricted to only one of the flanks of the ripples. *Cochlichnus* has been attributed to annelids lacking well-developed parapodia.

Remarks: The Ichnogenus *Cochlichnus* is a long-ranging form occurring in the sediments of Precambrian to Holocene. In the Precambrian, it has been recorded in Late Vendian strata. In the present case its preservation is confined only to troughs of the ripples. Such preservation may be an event deposition. These features may not be considered mud cracks or syneresis cracks etc. being presreved in the trough region. It is most likely that the crest would be first exposed to the atmosphere and initiate cracks formation and later extending into the trough regions of the ripple. Mathur and Kumar (1997) questioned their assignment to *Manchuriophycus* occurring in similar fashion in Semri Group, Lower Vindhyan rocks exposed in Kota District. *Manchuriophycus* has already been established as a presudofossil. However, Kulkarni and Borkar (1997) rejected this suggestion. The Upper Bhander Sandstone, being youngest is the most likely horizon of the Vindhyan Supergroup in age for such biogenic activities may occur. However it is not conclusively established that these are biogenic structure. Chakrabarti (2001), while evaluating various meandering features in Proterozoic rocks, established the features described by Kulkarni and Borkar (1996a) as nonfossils. Besides in a recent paper Seilacher *et al.* (1999) have shown that such peculiar occurrences are crack patterns resulting from a combination of syneresis cracks with oscillation ripples. In this situation, cracks originate in the ripple troughs, whose contours they follow with a strikingly sinusoidal course. Therefore collective assessments place it in the pseudofossil category.

Trace fossil

Repository: Not mentioned; Specimen nos.— not given; Rastogi and Srivastava (1992) figs. 70-75 as trace fossils and figs. 76-78 inorganic fossil.

Rastogi and Srivastava (1992) reported ichnofossils from various horizons of Vindhyan Supergroup exposed in Rajasthan, and assigned them to various known ichnofossil genera: *Ormathichnus moniliformis* Miller 1880 from Semri Group 2 km ESE of Chechat, Kota District Rajasthan, *Pelecypodichnus* sp. also from Semri Group exposed 1 km of S of Kalyakui, Kota District and *Chondrites* sp. from both the Lower and Upper Vindhyan rocks exposed in Kota and Chittaurgarh districts. *Palaeophycus* sp., *Rhizocorallium* sp., cf. *Hormosiroidea*, *Planolites* sp. and *Monomorphichnus* sp. have been recorded from the Upper Vindhyan rocks exposed in Bundi District. *Palaeophycus* sp. has also been noted in Chittaurgarh District. Besides these ichnofossils, three inorganic forms are also reported from Lower and Upper Vindhyan rocks viz. *Manchuriophycus* sp., *Eophyton* sp. and *Kinneyia* sp.

Remarks: These reports lack the repository details and complete information pertaining to the horizons yielding these ichnofossils. In the absence of this prerequisite information it is not possible to comment on the objects reported under various taxonomic categories. Firstly, at present they are considered Plesiotype specimens (This term is for a specimen illustrated only in a publication. These are not type specimens). Secondly the photographs are of little help in evaluating such structures in absence of morphological details. The quality of photographs are no way different what authors themselves considered as "Inorganic fossil" genera (Rastogi and Srivastava, 1992, page 106) and therefore the other remains may also be considered as 'pseudofossil'.

Trace fossils

Repositroy: Maharastra Association of Cultivation of Sciences, Agharkar Research Institute, Pune; *Skolithos linearis* Specimens nos. MACS G-4333, 4334, 4335, 4336; Kulkarni and Borkar (1996 b, c) figs. 3-7; Kulkarni and Borkar (1996c), figs. 1-3.

Kulkarni and Borkar (1996a, b) reported *Skolithos linearis* Haldemann, 1840 from the Morwan Sandstone of the Kaimur Group, Vindhyan Supergroup exposed near Besla and Rampura, in Mandsaur District of Madhya Pradesh and homotaxial beds exposed in the plateau of Chittaurgarh Fort, near the Kirti Stumbh (Victory Tower), Rajasthan. These ichnofossils are "straight, vertical to steeply inclined, unbranched, cylindrical burrows, ranging in diameter from 3 mm to 7 mm, occur in endo relief. The diameter of the burrows occasionally reaches up to 120 mm. The burrows occur in medium-grained, well sorted, ripple laminated, grey quartz arenite of the Morwan Sandstone Formation. The fill is structureless and resembles host rock material" (Kulkarni and Borkar, 1996a, b).

Remarks: Vertical burrows and surface traces have long been known from Morwan Sandstone (Ghare and Badve, 1977; Sisodiya and Jain, 1984; Shukla and Sharma, 1990). The burrows recorded by Kulkarni and Borkar (1996b, c) as *Skolithos* are also a long ranging ichnogenus form occurring from Late Precambrian to Pleistocene (Fillion and Pickerill, 1990). In the Precambrian, *Skolithos* occurs in the Redkino horizon of the Russian Platform (Fedonkin, 1985) which is of Early Vendian age. The reported occurrence of *Skolithos linearis* is a Plesiotype and therefore their examination is not possible. The photographic representation and description are insufficient to deduce their nature. The occurrence of such large burrows poses the question as to why the originators of the traces are not preserved in these sediments. Until we get suitable creature to suggest forming such burrows it would be advisable to consider it a dubiofossil. Sharma *et al.* (1992) and Venkatachala *et al.* (1996) have considered the traces recorded by Shukla and Sharma (1990) as true fossils. In the light of the above comments I would like to place the previous record (Shukla and Sharma, 1990) also in the category of dubiofossils.

Trace Fossils

Repository: Sedimentological Repository in the Department of Geological Sciences, Jadavpur University, Kolkata (Calcutta); Specimen nos. K834A (i) 1, K834 (ii) 3, K834 (ii) 2, K834 (ii) 5; Sarkar *et al.* (1996) figs. 7-10.

Sarkar *et al.* (1996) reported four types of trace fossils from the Mesoproterozoic Koldaha Shale and the Chorhat Sandstone of the Kheinjua Formation (Semri Group, Vindhyan Supergroup), exposed along a 27 km long stretch parallel to the depositional dip in the area between Chorhat and Sikarganj in Central India. The traces are not assigned any specific names but are described by their distinguishing features. A trace fossil described from the siltstone interbed within the inner shelf facies is a ladder-like form with regularly placed transverse mm-high ridges bounded by two parallel, as negative epirelief on rippled sandstone (Sarkar *et al.*, 1996, fig.7). It is compared with *Scolicia* and *Plagiogmus*. The other form comprises irregular meandering, raised tubes on bedding plane surfaces; these are apparently endogenic structures, formed by vagrant burrowing comparable to *Helminthopsis* (Sarkar *et al.*, 1996, fig.8). As an addendum to the paper, the authors expressed their uncertainty about the biogenic origin of the cited form. The third form represents tubular ridge-like structures with internal median grooves on the top of the fossilized set of ripples, in the upper Chorhat Sandstone; these are considered eolian in nature (Sarkar *et al.,* 1996, fig.9). The structure is compared with *Planolites*-like or *Scoyenia*- like forms. The fourth form is a trail with a median ridge and narrower lateral ridges observed on top of a loose slab in the supratidal-eolian setting, and is regarded as a sliding movement of a "molluscan" foot (Sarkar *et al.,* 1996, fig.10).

Remarks: The four trace fossils reported by Sarkar *et al.* (1996, figs.7-10) deserve close attention because of their antiquity, indicating a paradigm shift in metazoan evolution. As mentioned by the authors the age of the sediments cannot possibly be younger than 1100 Ma (Sarkar *et al.,* 1996, p.428). As per our present day understanding about the metazoan fossils record no definite animal fossil or trace record older than Ediacaran are known except the recent report by Seilacher *et al.* (1998). The first feature, which has been considered comparable to *Scolicia* or *Plagiomus*, is a ladder like structure as also mentioned by the authors. One knows with experience that liquid movement and recrystallization process develops such features in fine-grained lithology. Occurrence of any biogenic features in siltstone, which is a part of faulted Koldaha Shale, as reflected in fig.-2 of Sarkar *et al.* (1996), is doubtful. Similar features were earlier recorded in the Bhander Limestone by Verma and Prasad (1968), Das (1987) and Das *et al.* (1987) as ichnofossils (even considered as 'true fossils' by Sharma *et al.,* 1992; Venkatachala *et al.,* 1996), but other similar fossil, upon slicing were noted to contain either a calcite vein (mineral movements) inside the host rock, or to contain inclusions that were produced on the surface. In most likelihood, Sarkar *et al.,* (1996) ladder like feature is also made in a similar fashion by analogous process. Such features are inorganic in nature, and the structure could not be considered to be a true trace fossil. As far as the tubular endogenic burrows (Sarkar *et al.,* 1996, fig.8) with irregular meanders in the fluvial facies are concerned, the authors themselves have expressed reservations about the biogenicity of the objects (see addendum of the paper). Such features are very common in those sediments. The possibility of such features being syneresis cracks cannot be ruled out. The tubular ridge-like structures with internal median grooves (Sarkar *et al.,* 1996, fig.9) are compared with *Planolites* and *Scoyenia*; another feature is a trail with median ridge and two narrower lateral ridges (Sarkar *et al.,* 1996, fig.10), which are closely comparable with prod and brush marks (see features illustrated in Collinson and Thompson (1983, p. 43-45); Pettijhon and Potter (1964). Thus all the features described by Sarkar *et al.* (1996) fall in category of 'pseudofossils' (The present assessment is based on published photographs).

Triploblastic animal Trace fossil

Repository: Yale University Pea Body Museum, USA; specimen no. YPM 37665: Seilacher *et al.* (1998) figs.2, 3a, b.

Seilacher *et al.* (1998) reported trace fossils attributed to triploblastic animals from the Chorhat Sandstone belonging to the Kheinjua Formation, (Semri Group, Vindhyan Supergroup), exposed in Madhya Pradesh. Authors claimed, these structures are found in considerable numbers on top of sandstone beds along the road east and west of Chorhat village in Madhya Pradesh. The burrows are described as 'too irregular to be syneresis cracks, too sharply delineated to be wrinkles, and too large to be attributed to protists or fungal rhizoids. Based on four reasons, viz. (1) margins of the burrows sometimes elevated above the surrounding surface (2) burrows visible on weathered rock surface (3) one of the burrows is still partly covered by a small remnant of the original sandstone veneer (4) cross sections reveal that this veneer has a larger amount of dark matrix between the sand grains. All this evidence, collectively considered, point towards a burrow origin, but they are in an unusual mode of preservation. A new interpretation is also proposed for the microbial biomat and their association with trace fossils. The thin veneer represents microbially bound biomat, which supposedly served as a food source as well as an oxygen mask for the worm-like animals that were exploiting its decaying mats.

Remarks: Our present understanding of the metazoan evolution suggests that the fossil record of animals goes back to 580 Ma and according to molecular analyses, animals appeared more than 1 billion years ago (Ayala and Rzhetsky, 1998). Traces recorded in younger sediments of the Vindhyan Supergroup are still not accepted (Chakrabarti, 1985, 1988, 1990). Discovery of triploblastic animals' traces pushes the advent of metazoan for 1000 million years back in the earth history. Considering these aspects, Precambrian palaeobiologists are skeptic about the biogenicity of these triploblastic structures. Palaeontologists are divided into two distinct groups of believer and non-believers.

Tony Ekdale of the University of Utah, Salt Lake City; Charles Marshall of UCLA; Mary Draser of University of California, Riverside are convinced about the biogenicity (see, Kerr, 1998a, p.21). Whereas Conway Morris *et al.* (1998, p. 1265) and Bruce Runnegar of UCLA; Andy Knoll of Harvard University (see Kerr, 1998a, b, c; Rai and Gautam 1999, p. 1235a) have grave reservations about the biogenicity and antiquity of the structures. Rai and Gautam (1999) raised several questions, viz. (1) absence of any backfill structure in the burrow tunnel (2) absence of algal-mat impression on the bedding surface (3) non-conducive sedimentary environment for preservation of delicate animals (4) absence of any coprolite etc. It is difficult to agree on the biogenicity of these structures and simultaneously refute the claims. Knoll (in personal communication) expressed his reservations in considering the specimens described by Seilacher *et al.* (1998) as true trace fossils, since algal and perhaps in some cases inorganic origins could not be ruled out. Even if the host rocks are 1600 m.y. old it is difficult to connect the isolated occurrence with the continuous record of animal traces that begins globally some 445 million years later. In recently concluded 'International field Workshop on the Vindhyan Basin, Central India' experts could not locate the (?) triploblastic structures in the field because of insufficient data. When celebrated researcher such as Adolf Seilacher makes a claim such as this we respect the authority. But authorities too need to demonstrate the evidence to support the claims that do not come forward. Recently Kerr (2002) has once again questioned the biogenecity of the features. I am unconvinced about the biogenicity of these structures and until convincing animal remains are found it is considered as a 'pseudofossil'

SMALL SHELLY FOSSILS

Repositroy: Museum of Wadia Institute of Himalayan Geology, Dehra Dun; Specimen nos. WIMF/A 171-188; Azmi (1998a) pl.1, figs. 1-7 latex casts of acrotretid brachiopods; 8 and 12 latex casts of obolellid brachiopods, 9-11 *Lapworthella* sp.; 13-16 *Camenella* sp.A; 17, *Camenella* sp. B; 18-20 *Camenella* sp. C; 21-23. *Halkieria* sp.; 24 *Spirellus shankari*; 25-26; *Codonoconus* sp.; 27 *Olivooides multisulcatus*; 28 *Taliella himalayaica*.

Azmi (1998a) reported a variety of Small Shelly Fossils (SSF) from the topmost part of the Rohtasgarh Limestone and shale (Lower Vindhyan, Semri Group) in two different areas, namely Maihar and Rohtas in the Son Valley. The assemblage comprising of *Spirellus shankari*, *Olivooides multisulcatus*, *Codonoconus* sp. and *Taliella* has been recorded from Maihar area and correlated with the earliest Cambrian Meishucunian Zone 1 assemblage. This zone consists of isolated sclerites as well as their Scleritomes (naturally fused clusters) of tommotiids *Camenella*, *Lapworthella* and halkieriid *Halkieria* along with abundant small size acrotretid (phosphatic) and obolellid (calcareous) inarticulate brachiopods on thinly bedded limestone slabs. The tommotiid and halkieriid genera are diagnostic of Tommotian and early Atdabanian strata of Early Cambrian in several world localities. The acrotretid and obolellid brachiopods, however, had just begun to evolve in the Late Tommotian to early Atdabanian interval before the appearance of the Lower Cambrian trilobite fauna. This assemblage of small shelly fossils and the inarticulate brachiopods therefore clearly indicate that the topmost beds of Rohtasgarh Limestone and shales of Semri Group (Lower Vindhyan) represent a basal Meishucunian/ Tommotian to early Atdabanian interval of Early Cambrian (Azmi, 1998a).

Remarks: No other research paper in the palaeontological field in recent times has drawn such attention (see Viswakarma, 1998; Sankaran, 1999) as the one by Azmi (1998a). Since then, scores of comments have been published on this paper. These comments range from doubting the identification, to questioning the collection, processing and reporting of the samples and data. After publication of the paper, the Geological Survey of India instituted a field investigation team and the Palaeontological Society of India also organized a meeting and field workshop in March 1999. I have nothing more to add to those extensive comments, which are already published. Barring six persons who had an opportunity to see the original specimens (S. Kumar, Ravi Shanker, D.K. Bhatt, Simnon Conway Morris, Sören Jensen and Nicholas, J. Butterfield), all other persons have offered their comments based on the photo illustrations and published material (see Science 1998, vol.282, p.601-602, p.1020, p.1265; Jour. Geol. Soc. India, 1999, vol.53, pp. 120-130, pp.481-500, 717-730; Current Science 1998, vol. 75, pp. 1297-1300; Current Science 1999, vol.76, pp.137-141, Jour. Palaeontological Soc. India, 1999, vol.44, pp.151-153; the deliberations are presented, and abstracts are published in an abstract volume of the Field workshop on Vindhyan Stratigraphy and palaeobiology, March 19-20, 1999). For the convenience of the readers, I will only summarize them in the following paragraphs under two headings : Field data and biogenecity.

Field data: A Major objection on the paper was that the data presented lack credibility because of the absence of a location map and a lithologic description (Bhatia, 1999, p.122, Joshi, 1999, p.125). There is uncertainty as to what are the stratigraphic levels from which two assemblages have been collected. How much thickness of sediments separates them? etc. (Kale, 1999, p.123). Similarly, the reasons advanced (continental environments) by Azmi (1998a) for the absence of Palaeozoic fossils in the Vindhyan is also a gross oversimplification of the facts, and in that situation what would be the fate of small shelly fossils. Are they continental, certainly not (Kale 1999, p.124). Later, Azmi clarified his position regarding the withholding the field data and subsequently published all the necessary details. But he stuck to his position to consider the Vindhyan as fluvial deposits. Bhatt *et al.* (1999) noted that Azmi (1998a) misidentified the grey cherty shale as cherty limestone in the Maihar section (which Azmi accepted in the field), and the Ramdihra Limestone Quarry section given by Azmi (1999, fig.5) also does not correspond to the description given in the literature. Discovery of so-called phosphatized organic remains from grey cherty shale is suspicious (Brasier, 1999), and Banerjee's pers.comm. quoted by Brasier indicates that some minerals do not react to Shapiro's test (an instantaneous check with liquid chemical solution for the presence of phosphate in the sediments).

Biogenecity: Since the beginning i.e., even before publication and after publication experts who had an opportunity to see the original specimens (S. Kumar, Ravi Shanker, D.K. Bhatt, Simnon Conway Morris, Sören Jensen and Nichola, J. Butterfield) did not agree with the biogenicity of many of the reported specimens and considered them inorganic material specially diagenetically produced sedimentary structure "Cone-in-Cone" which has a pointed apex that flares outward with undulatory surface or principally mineral growth or made up of fibrous calcite/secondary calcite vein (Rai, 1999; Conway Morris *et al.*, 1998; Kumar, 1999, Bhatt *et al.*, 1999). Lately even Brasier (1999) who was the referee for Azmi's 1998a paper, has also expressed reservations about the biogenicity. In the light of these comments the forms described by Azmi (1998a) are best regarded as dubio to pseudofossils (see table-2).

DISCUSSION AND CONCLUSIONS

With a little difference in the style of presentation I will enumerate first the present day understanding of the metaphytes and metazoa and afterward follow the thread where Sharma *et al.* left in 1992

1. Metaphytic evidences
2. Metazoan evidences
3. Geochemical evidences

1. Metaphytic evidence: In Precambrian palaeobiology one of the important questions is the timing of metaphytes appearance. The Vindhyans, encompassing an important time span of the earth history, hold promise to this answer. The occurrence of eukaryotes and metaphytes in Vindhyans would help in assessing their advent in a global context. Constituents of the metaphytic organisms, eukaryotes, evolved sometime in the Proterozoic Eon. Size is the most often utilized criterion for recognizing the eukaryotic remains in fossils. However some of the prokaryotic remains can assume large size like spiral–shaped cyanobacteria called *Obruchevella* and *Spirellus*, which are widespread in the Neoproterozoic. In spite of the large size of the leftover sheath of giant sulfide oxidizing bacterium (Beggiatoaceae) they can easily be differentiated from eukaryotic remains.

A variety of metaphytic remains in Proterozoic sediments occur both as compression or impression and are large enough to be recognized in the field with naked eyes. Most of these have distinct morphology, are easily recognizable and are confined to a specific lithology. Thus, there are fewer chances of evading keen and proficient eyes leading to their misidentification. Such remains are specifically widespread in Mesoproterozoic and are also profusely distributed in the Terminal Proterozoic. They are categorized by Hofmann (1992). Most of these remains occur at various stratigraphic levels in the Proterozoic. But they cannot be considered of any major stratigraphical significance, or attributed to index fossils. They are only good indicators of existence of megascopic life in the Proterozoic ocean. The affinities of most of the forms are still not convincingly established; they may be prokaryotic or eukaryotic organisms, or both. Of the several palaeobiological remains of metaphytic evidence, those genera that are morphologically complex, geographically widespread and although not so stratigraphically restricted genera (*sensu* index fossils) and are significant, include *Grypania, Longfengshania, Sinosabellidites, Chuaria—Tawuia* and *Vendotaenia.* Various workers have proposed many groups for such metaphytic remains, which are as follows: Fermoridae (Sahni, 1936), Chuaridae (Wenz, 1938), megasphaeromorphida (Timofeev, 1970), Vendotaenides (Gnilovskaya, 1971), Chuariamorphida (Sokolov, 1976), Chuariacea (Duan, 1982), Huaiyuanelidae (Xing 1984), Longfengshanides (Duan *et al.,* 1985), Cyphomegacritarchs (Fu, 1986) and Vendophyceae (Gnilovskaya, 1988). Many of these forms are considered either eukaryotic remains or multicellular organisms (Hofmann, 1992). In the Vindhyans, the *Chuaria-Tawuia* assemblage was recorded from new levels and horizons during the last decades (Rai *et al.*, 1997; Kumar and Srivastava, 1997; Kumar, 1995; Rai and Gautam, 1998).

Widespread occurrences of coiled algal remains (*Grypania*) have been recorded from 1.1 Ga old sediments in the Vindhyans and elsewhere (see Kumar 1995 and references therein; Rai and Gautam, 1998). The oldest such remains, also considered being the oldest megascopic eukaryotic algae, are recorded from ~1.9 Ga Negaunee Iron Formation, Michigan (Han and Runnegar, 1992). The other older carbonaceous megafossil is from 1.8 billion-years-old sediments near Jixian Northern China (Hofmann and Chen, 1981). If eukaryote evolved around early Proterozoic, the chances of appearance of megascopic metaphytic remains are fairly reasonable in younger sediments (Meso and Neoproterozoic). The occurrence of *Chuaria—Tawuia*, allied remains and *Grypania* at various levels in the Vindhyan in the light of other global records (and assessed above) is testimony to this contention.

One of the interesting forms reported from the Bhander Formation, and reported only in passing, is columnar microstromatite (microstromatolite) (Kumar, 1999). Although it is not an element of metaphytes, it is a conspicuous part of biostratigraphy. Examination of the slides containing sponge spicules described by Kumar (1999) revealed the profuse presence of microstromatolite. As per our present day understanding of microstromatolites, particularly the columnar microstromatolites, those were widespread both in the Palaeoproterozoic and Early Riphean (early Mesoproterozoic), and the Cambrian as well (Raaben, 1998). Most abundant and representative Proterozoic sequences with minicolumellids are confined to two separate time intervals; the Palaeoproterozoic (Middle Aphebian 2.2-2.0 Ga) and the Early Riphean (1.65-1.35 Ga). Kumar (1999) has suggested the age of spicules bearing horizons to ~640 Ma. As no direct radiometric date is available for the Bhander Formation, therefore on the basis of biostratigraphic correlation its age is considered Upper Riphean (Neoproterozoic). But occurrence of microstromatolites suggests that it could either be

Palaeoproterozoic, Middle Riphean or Cambrian. The possibility of the former two can be ruled out on the basis of radiometric dates available for the Semri and Kaimur groups (Vinogradov *et al.,* 1964; Crawford and Compston, 1970; Bansal *et al.,*1998; Kumar, *et al.*, 1991, 2001; Rasmussen *et al.,* 2002; Ray *et al.,* 2002). There is a very distant possibility of this sequence (Bhander Limestone Formation) being Cambrian in age, but Friedman *et al.,* (1996), Friedman and Chakraborty (1997) have indicated, on the basis of $\delta^{13}C$ excursion, that the Precambrian–Cambrian boundary may lie within the Bhander Group. This claim has been refuted by Kumar (1998) and Kumar *et al.* (2002). The occurrence of microstromatolite is another pointer in this direction.

Venkatachala *et al.* (1996), in view of the absence of authentic evidence/global markers of the Terminal Proterozoic, namely glaciation, phosphogenic event, and also the absence of the Ediacaran and Lower Cambrian faunas namely small shelly fossils, archaeocyatha, and rock building algae, ruled out the possibility of a post Precambrian/ Cambrian age for the Vindhyan sediments. The only other possibilty of glacial activity in the Basal Vindhyan Supergroup is the ~1.2 to 1.4 Ga old Gangau tilloid in the Mesoproterozoic Gangau Formation (Mathur and Mani, 1978), which later proved to be a continental debris flow derived mainly from a ferruginous and locally silicified regolith formed on sedimentary rocks (Williams and Schmidt, 1996; and Schmidt and Williams, 1999). So, at present there are no glacial signatures suggesting any chances of Terminal Proterozoic equivalent post Marinoan—Varanger glaciation or younger sedimentary deposits in the Vindhyan Supergroup. The report of microstromatolite (Kumar, 1999a) previously unknown from the Bhander Limestone indicates the only chance of a younger age for the Bhander. Earlier in their conclusion, even Crawford and Compston (1970) also suggested that the Vindhyan Supergroup could transgress into the Cambrian. But the present set of evidence, except for the microstromatolites does not support this contention.

2. *Metazoan evidences*: Metazoans are constituted of specialized group of eukaryotic cells that are differentiated as organs. At what point of time in evolutionary history single eukaryotic cells like protists transformed into an aggregated mass called tissue or organs/metazoans is presently strongly debated. There are two models concerning the timetable for the emergence of multicellular animals (metazoans): one, 'Deep Time' and the other 'Late Arrivals' models (Brasier 1998; Conway-Morris 1989). Tracing the antiquity of fossil record indicates that the diversity of animal fossils dramatically increases as we approach to the Cambrian, and produces what is popularly known as the "Cambrian Explosion" (Conway-Morris, 1989), but they are not the oldest records of animals. A few tens of millions of years before the "Cambrian Explosion" existed a variety of animals called the Ediacaran biota, preserved as impressions, casts and moulds in the Terminal Proterozoic rocks around the world in ~570-543 Ma sediments. But how deep in time their ancestors were present is still not clear.

The body plan (symmetry) of Ediacaran fossils ranges from bilateral to trigonal to tetragonal to pentameral to radial; they thrived in shallow, sunlit shelves to deep seafloors. The oldest occurrence of megascopic Ediacaran-type fossils occurs in the Twitya Formation of north-western Canada, immediately below tillites correlated with the Marinoan-Varanger glaciation and believed to be about 600 m.y. old (Hofmann *et al.,* 1990). Radially symmetrical impressions most probably formed by diploblastic animals occur in the rocks older than 600 Ma. Such animals also dominate the assemblage of younger sediments 570 to 543 Ma, along with varied other morphotypes and trace fossils. The occurrence of the diverse assemblage of body and trace fossils found in Zimnie Gory section of White Sea region which has been dated 555.3±0.3 Ma, is a minimum for the oldest well documented triploblastic bilaterian *Kimberella* (Martin *et al.,* 2000). The only remnants of skeltelized problematic animal fossils *Cloudina* and *Namacalathus* are known to occur in Terminal Proterozoic sediments of Nama Group (Germs, 1972) that was capable of enzymatic precipitation of calcite in an organic matrix (Grotzinger *et al.,* 1995). A recent report of older bilaterian traces (triploblastic animal traces) by Seilacher *et al.* (1998) from Semri Group rocks of Vindhyan basin are yet not unequivocally accepted. Knoll and Carroll (1999) and many others (see remarks section on this find in present paper) have expressed their reservations regarding the age and interpretation of the Seilacher *et al.* (1998) report. Besides the other reports from Vindhyans are also not conclusive (Maithy *et al.*, 1992; Azmi, 1998a; Kathal *et al.*, 2000). At present we know that unambiguous, abundant and continuous record of bilaterian traces begins only at the close of Terminal Proterozoic.

Ediacaran biotas have been found preserved worldwide on the sole of the storm or turbidite beds known as event beds (Narbonne, 1998) with the exception of the Newfoundland (Avalon) biota which is on top of beds (Misra, 1969). It has also been noticed that Ediacaran fossils are not found in beds that lack 'elephant skin' covering (*sensu* Russian palaeontologists) which later identified as microbial mat texture that acted as death mask for the organisms (Gehling, 1987). The trace fossils (Kulkarni and Borkar, 1996 a, b; Rastogi and Srivastava, 1992; Sarkar *et al.* , 1996; Seilacher *et al.*, 1998) and body fossils (Kathal *et al.*, 2000; Maithy *et al.*, 1992; Azmi, 1998) attributed to animal affinity reported from the Vindhyan Supergroup are invariably found on the top of beds negating the chances of their being the Ediacaran remains. Crown group protostomes or deuterosomes may also lurk in Ediacaran-aged rocks but at present, evidence of such animals remains equivocal (Knoll and Carroll, 1999). All diverse Ediacaran fossil assemblages postdate the last major Proterozoic ice age (Knoll and Caroll, 1999).

Yochelson and Fedonkin (2000) and Fedonkin and Yochelson (2002) reported "Problematic bedding-plane marking" resembling a "string of beads", *Horodyskia moniliformis* from the 1.5 billion years old Appenkunny Formation in the eastern part of Glacier National Park Montana and suggested that these may be the oldest animal tissue grade organism. The authors were not very confident of their assignment of beaded structures to animals, but invoked the organic growth as the most plausible mechanism to explain the near proportional uniformity of spacing. Grey and Williams (1990) reported similar beads from Western Australia, which they considered to be algal in nature. In this light (although uncertain), the animal ancestry does not go beyond 1.5 Ga. At present there are no reports of post-glaciation deposits in Vindhyans, therefore the likelihood of an occurrence of Ediacaran elements is feeble.

3. *Geochemical evidences*: Another line of evidence to trace the metazoan antiquity is the molecular phylogeny that can best be understood by integrating the expanding insights of different disciplines (Rosa *et al.*, 1999) and developmental biology with the totality of the palaeontological evidence, including the Ediacaran assemblage, because these assemblages hold the clue for transitions of many of the animal groups (Conway-Morris, 2000). Recent studies in tracing molecular phylogenies are based on 18S ribosomal RNA sequences, suggesting that Bilateria should be divided into three great clades: the deuterostomes, lophotrochozoans, and ecdysozoans, in descending order (Aguinaldo *et al.*, 1997), this phylogenetic study is also independently supported (de Rosa *et al.*, 1999). Now it is believed that acoel flatworms could represent the earliest extant bilateria, before the radiation of the three major clades (Ruiz-Trillo *et al.*, 1999).

Biomarker molecules extracted from protists in the Proterozoic rocks indicate 1.7 billion years to 1.8 billion years old age for the advent of eukaryotes (Summons and Walter, 1990; Doolittle *et al.*, 1989). Later, Brocks *et al.*, (1999) have shown that a key attribute of eukaryotic physiology (sterols) had evolved by 2.7 Ga. Bitumens from the Palaeoproterozoic McArthur Group, Northern Australia, contain sterane, triterpane and extended acyclic isoprenoid alkane biomarkers consistent with inputs from eukaryotes, eubacteria and archaebacteria respectively (Summons *et al.*, 1988; Summons and Walter, 1990). Cytoskeletal and ecological requirements for eukaryotic diversification were established in microorganisms fossilized in nearly 1.5 billion years old shales of the early Mesoproterozoic Roper Group in northern Australia (Javaux *et al.*, 2001). But the framework provided by the molecular data on the early evolution of the metazoans is limited and it cannot provide insight into the anatomical changes and associated changes in ecology that accompanied the emergence of body plans during the Cambrian explosions (Conway-Morris, 2000).

The other line of evidence for eukaryote development and evolution of animal is protein sequence analysis. These analyses indicate that green algae and major lineages of fungi were present by one billion years ago and land plant appeared by 700 Ma; possibly affecting the Earth's atmosphere, climate and evolution of animals in the Precambrian (Heckman *et al.,* 2001). Considering the various factors in fungal phylogeny, Heckman *et al.* (2001) postulated that Glomales originated after chytrids diverged from the other groups, but before Basidiomycota split from Ascomycota about 1.4 Ga to 1.2 Ga. Evidence for such remains are not coming forward, but the large scale of microbial mat occurrences in the Vindhyan indicates the possibility of their presence in these old sediments.

So far no similar biogeochemical studies have been conducted on the Vindhyan sediments. However being less disturbed and unmetamorphosed, the Vindhyan sequence offers a great possibility for such studies. There are good chances for finding occurrences of metaphytic/metazoan signatures in these sediments. Evaluation of the palaeobiological evidence suggests that a paradigm shift is not true in the case of age of the Vindhyan based on palaeobiological remains..

ACKNOWLEDGEMENTS

The paper has benefited by the constructive suggestions of Prof. Hans Hofmann, Prof. S. Kumar and Dr. Manoj Shukla. I am grateful to Prof. S. Kumar who invited me to participate in the workshop on the Vindhyan stratigraphy and palaeobiology and subsequently encouraged to contribute the paper. Permission by Prof. A. K. Sinha to publish the paper is thankfully acknowledged.

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Manuscript Accepted August 2003