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Full Length Research Paper

Discovery of carbonaceous remains from the Neoproterozoic shales of Vindhyan Supergroup, India

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Neoproterozoic gray to dark gray carbonaceous shales belonging to the Bhander Group exposed in and around Maihar and Nagod areas, Satna district, Madhya Pradesh, contains an exceptionally well preserved, diversified fossils represented by both planktic and benthic meso-megascopic (millimeter to centimeter in dimension) and multicellular metaphytes. The fossils are of varied shape viz., leaf like thalloid films, palmate, straight to curve, with/without holdfast. Some of them are dichotomously branched and compactly entangled thin filaments, including possible reproductive structures. Out of eighteen algal taxa described assemblage includes fifteen genera and sixteen species belong to known metaphytes interpretable as multicellular eukaryotes. The assemblage comprises thalloid algae referable to *Aggregatosphaera miaoheensis*, *Baculiphyca taeniata*, *Doushantuophyton lineare*, *Doushantuophyton cometa*, *Enteromorphites siniansis*, *Eopalmaria pristina*, *Flabellophyton lantianensis*, *Glomulus filamentum*, *Huangshanophyton fluticulosum*, *Jiangchuania taeniphylla*, *Konglingiphyton erecta*, *Palaeochorda vindhyansis*, *Sitaulia minor* and discoidal carbonaceous films of *Churaria circularis, Longfengshania ovalis, Protoarenicola baiguashanensis, Protoconites minor* and *Tawuia dalensis.* Amongst these two taxa viz. *S. minor* gen. et. sp. nov. and *P. vindhyansis* gen. et. sp. nov. Presence of holdfasts and branches indicates advent of complexity in Neoproterozoic life. It is assumed that they preferred shallow water where dissolved nutrients and congenial stable environment. The multicellular metaphytes are comparable to modern algae belonging to Rhodophyta, Phaeophyta, Xanthophyta and Chlorophyta. This assemblage closely resembles the known assemblages of the equivalent sediments (Cryogenian to Early Ediacaran age) of Miaohe biota (China) and White Sea Biota, central Ural (Russia).

Key words: Multicellular, eukaryotes, metaphytes, Bhander group, Vindhyan Supergroup.

INTRODUCTION

Transitional organization from unicellular to multicellular in Proterozoic microorganisms was a turning point in the earth's earliest biosphere (Schopf and Klein, 1992). Prokaryotes to eukaryote (metaphytes and metazoans) diversification is considered as a key evolutionary step in the history life (Schopf et al., 1973; Woese et al., 1990; Knoll, 1992, Knoll et al., 2006; Narbonne, 2005). In the Proterozoic ocean chemistry (Anabar and Knoll, 2002), developments of eukaryotes represents a supporting testimony to the chemo-signatures hopanes and steranes (Brocks et al., 1999). The large numbers of Precambrian-Cambrian sphaeromorphic, vaneer carbonaceous and branched macro-algal fossils have been studied throughout the world since 1889. In the last five decade's, macro-algal (*Chuaria-Tawuia* assemblage) and multicellular meta-phytic fossils have been accumulated as a testimony to establish the evolutionary history from Late Palaeo-proterozoic to Late Neoproterozoic time interval (~1100 Ma). Geographically, the Proterozoic metaphytes fossils have a wide distribution in USA, Spitsbergen, Canada, Yakutia, Siberia, Australia, China, Kazakhstan, Spain, Iran, Africa, Namibia, Argentina, Antarctica, Sweden, Ukraine and Ural including India.

Multicellular carbonaceous fossils have been classified in to 13 generic level categories of different algal communities based on morphometric features (Hofmann, 1992). Earlier available carbonaceous fossil record in Palaeo-proterozoic sediments of 1.87 billion years old strata of USA shows low in diversity but includes key forms viz.

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Grypania spiralis, (Han and Runnegar, 1992; Schneider et al., 2002), multicellular metaphytes (Phaeophyta and Chlorophyta) from the 1700 Ma old strata of China (Yan, 1995; Zhu and Chen, 1995; Yan et al., 1997) and ~1630 Ma old deposits of India (Rai and Singh, 2006) in association with chuarid remains (Hofmann and Chen, 1981) which shows the advent of multicellularity during Palaeoproterozoic time. Quantitatively, Mesoproterozoic records of carbonaceous fossils show appreciable amount and diversity rather than Palaeoproterozoic records (Walter et al., 1976; Hofmann, 1992; Maithy and Babu, 1988; Kumar, 1995). Mesoproterozoic fossils records are characterized by dominance of benthic forms including the discovery of Rhodophycean fossils (Butterfield et al., 1990, 2000) recorded from ~ 1200 Ma old succession of the Arctic Canada. The rate of eukaryotic evolution was very slow during middle Mesoproterozoic as it followed Darwinism to fossils biology. At late Mesoproterozoic-early Neoproterozoic, the rate of evolution was faster because of the complex morphology and explosion due to geodynamics on the planet earth (Janhunen et al., 2007). The Neoproterozoic time period represents an acme for the carbonaceous megafossils diversity which includes number of taxa such as *Chuaria, Tawuia, Longfengshania, Sinosebeliditids, Pararenicola, Protoarenicola, Glossophyton* etc. whose phylogenetic interpretations remains controversial (Xiao et al., 2002). Branched multicellular algal thallus described from the Late Neoproterozoic and Early-Middle Cambrian sediments are more diversified (Walcott, 1919; Conway Morris and Robinson, 1988; Mao et al., 1994; Chen et al., 1995; Yuan et al., 1999; Zhu et al., 2000; Xiao et al., 2002; Zhao et al., 2004; Grazdhdankin et al., 2007; Tang et al., 2007; Dong et al., 2008). The micropalaeontological evidences along with carbonaceous fossils suggests a major algal clades during the Neoproterozoic time span (Hofmann and Aitkin, 1979; Hofmann, 1985; Vidal et al., 1993; Knoll, 1992, Knoll et al., 2006; Porter and Knoll, 2000; Butterfield, 2000; Xiao et al., 2002; Tang et al., 2007) due to the wide spread global cooling, low CO_2 concentration and ability of cold seawater to mix and transport nutrients efficiently (Hofmann et al., 1998; Grey, et al., 2003). The concept of Snowball Earth was supported by Janhunen et al. (2007) in Neoproterozoic. The noticeable increase in both multiplicity and profusion of carbonaceous macrofossils throughout the Proterozoic Eon include a good relationship of biotic and abiotic factors (Xiao et al., 2002).

Precambrian sequences in India are extensively developed and widely distributed in the Northern and Southern parts of Central Indian Tectonic Zone (CITZ). The tectonically least disturbed, unmetamorphosed, largest and most fascinating Meso-Neoproterozoic intracratonic Vindhyan basin has been drawing a global attention amongst the Precambrian palaeobiologists that has been symbolizing the plentiful evidences of ancient life. This ancient life undertook several evolutionary changes from unicellular to multicellularity, from prokaryotes to eukaryotes by their noteworthy fossil records. These palaeobiotic entities have played a significant role in deciphering the evolutionary history and environment during early life.

Varieties of carbonaceous fossil remains were reported earlier from the different stratigraphic succession of Proterozoic basins of India namely Vindhyan (Maithy and Babu, 1988; Kumar, 1995; Kumar and Srivastava, 2003; Rai and Singh, 2006); Bhima (Suresh and Sundara Raju, 1983; Maithy and Babu, 1996); Kurnool (Sharma and Shukla, 1999) basins and sediments of Lesser Himalaya (Tewari, 1996). Among these, the Vindhyan basin represents plantiful records of *Chuaria-Tawuia* compressions reported from Semri Group (Maithy and Babu, 1988; Kumar, 1995; Rai and Gautam, 1998; Rai and Singh, 2006; Srivastava and Bali, 2006), Rewa Group (Rai et al., 1997) and Bhander Group (Kumar and Srivastava, 1997, 2003; Srivastava, 2002). These palaeobiological records are the emerging tool rather other methods like isotopes, palaeomagnetism and in absence of the true sedimentary structures, to give more information such as age, environments, bio-zonation for the Precambrian sediments.

The present paper deals with newly discovered, well preserved and diversified metaphyte fossils with their systematic description to understand their implications for early evolution, evolutionary trend and environment in geological past in resolving the problems and to establish inter to intra continental correlations.

Geological setting

The thick piles (~4000 m) of arenaceous and argillaceous dominating Vindhyan sediments of shallow marine origin (Singh, 1976) resting unconformably over the Bundelkhand massif and the Bijawar Group (Crawford and Compston 1970; Ray et al., 2002) occupies 1,62,000 km^2 in Central India. It extends from Dehri on Son, Bihar in the east to Hoshangabad (Madhya Pradesh) and Chittorgarh (Rajasthan) in the west. The ~44000 km^2 area is concealed under the Gangetic alluvium in north and covered by Deccan Traps in South (Figure 1).

Lithostratigraphically, the Vindhyan Supergroup has been subdivided into four successive groups namely the Semri Group (Lower Vindhyan), Kaimur, Rewa and Bhander groups (Upper Vindhyan) (Figure 2) in ascending order (Auden 1933) and detailed work on geology and its allied disciplines given by pioneer earth scientists (Sastri and Moitra, 1984; Bhattacharya, 1993; Bose et al., 2001; Chakraborty, 2006). The Semri and Bhander groups include a heterogeneous assemblage (sandstone, shale and limestone) where as the Kaimur and Rewa groups are predominantly arenaceous in nature. The sediments of Vindhyan Supergroup are in general excellent storehouse of palaeobiological remains viz., micro-macro fossils and stromatolites (Auden, 1933; Valdiya, 1969; McMenamin et al., 1983; Kumar, 1995; Maithy and

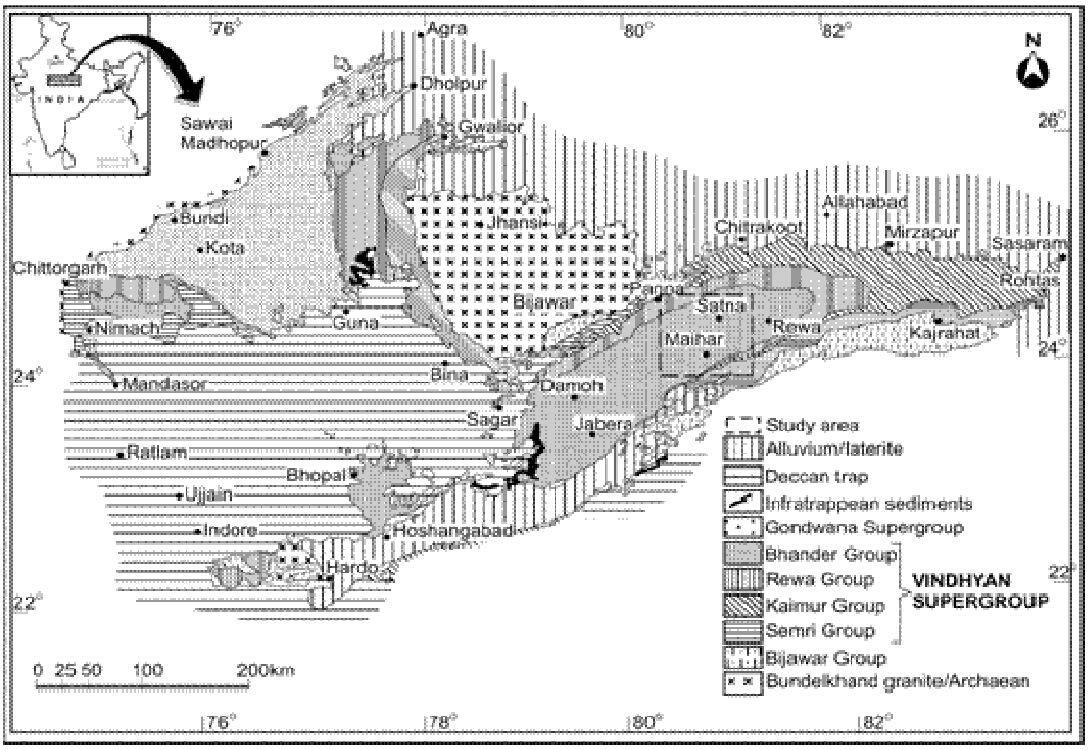

Figure 1. Generalized regional geological map of the Vindhyan Basin (after Soni et al., 1987) showing the position of study area.

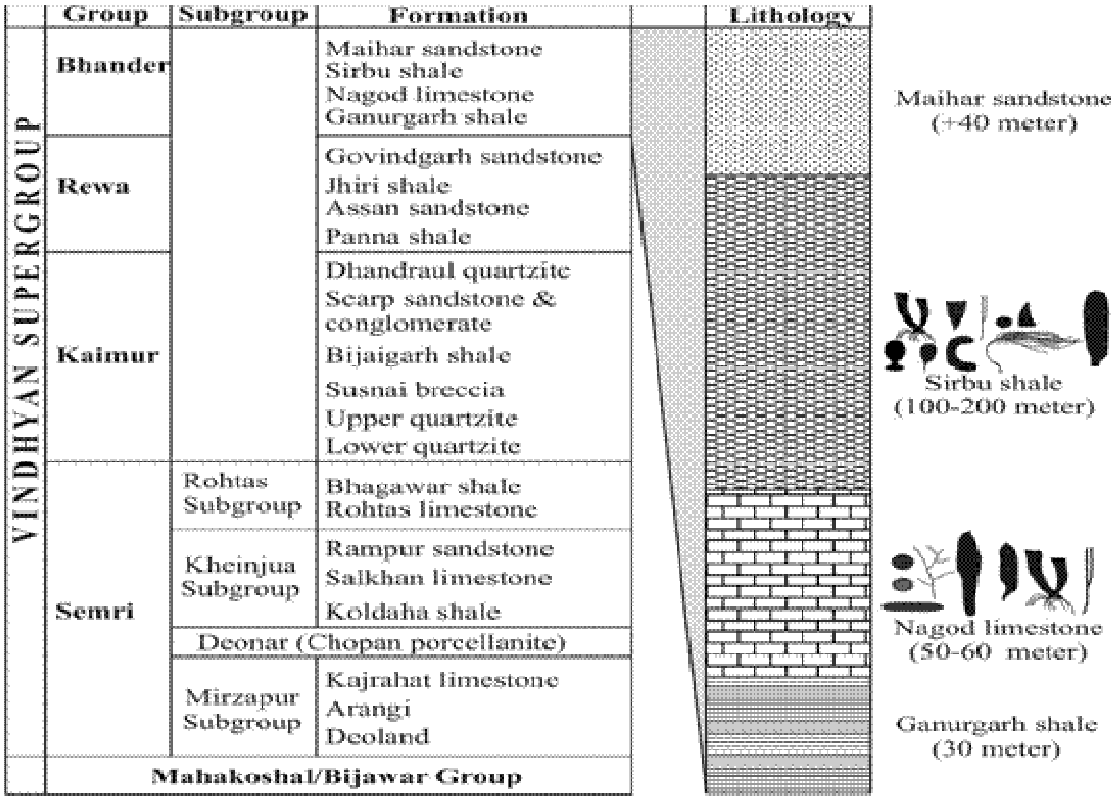

Figure 2. Generalized stratigraphic succession of the Vindhyan Supergroup (proposed by Auden 1933) including Bhander Group in and around Satna-Maihar area.

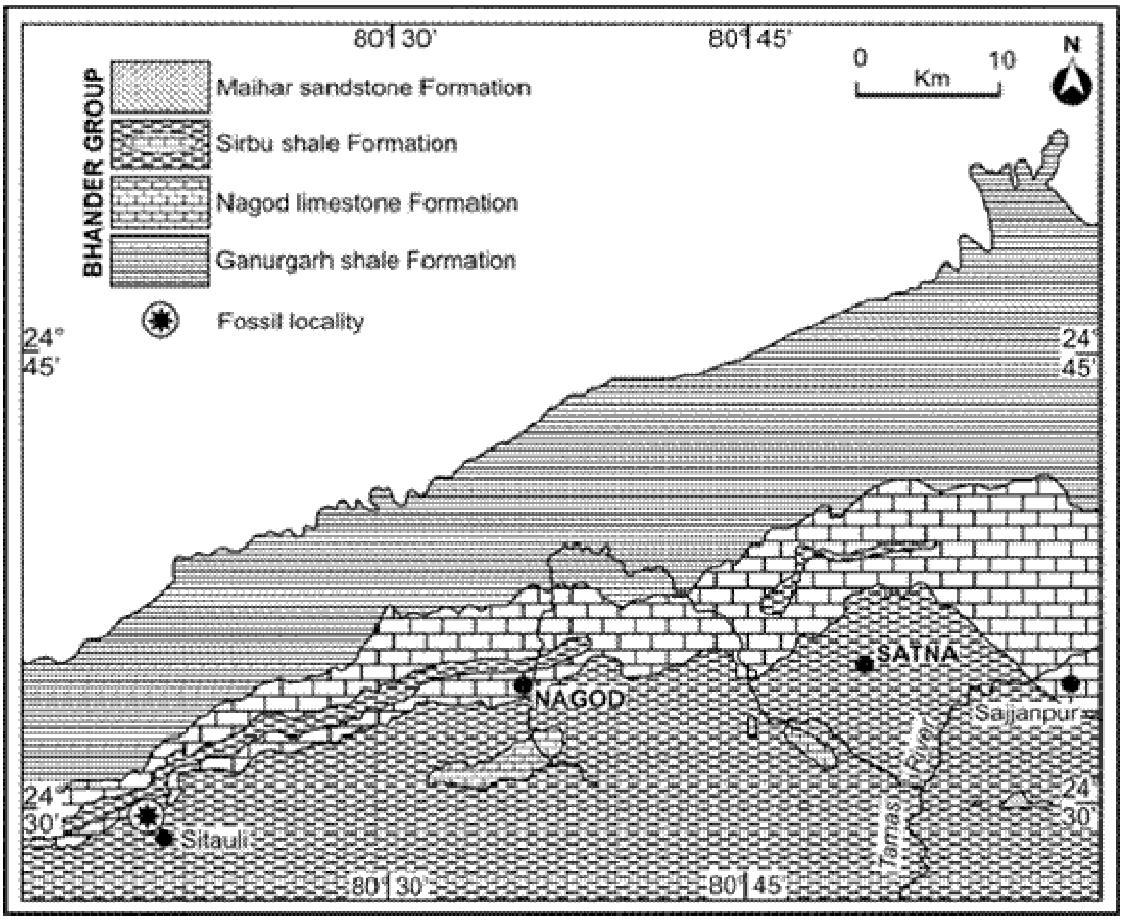

Figure 3. Geological map of the Satna-Nagod area (modified after Mathur 1984).

Babu, 1988; Kumar, 2001; Kumar and Srivastava, 2003; Rai and Singh, 2004, 2006; Prasad et al., 2005, 2007; Prasad, 2007). The sedimentary and tectonic history of the Vindhyan basin has been the subject matter of a lively debate ever since the pioneering work by eminent geoscientists (Singh, 1976; Chakraborty, 2006).

The samples for the present study were collected from the two lithounits (Nagod limestone and Sirbu shale formations) of the younger most Bhander Group exposed in Satna district. The Bhander Group is characterized in to four formations namely Ganurgarh shale, Nagod limestone, Sirbu shale and Maihar sandstone formations (Figure 3) in ascending order (Rao et al., 1976).

The lower most Ganurgarh shale Formation (30 m) comprising shale is poorly exposed and successively overlain by the Nagod limestone Formation.

The 50 - 60 m thick Nagod limestone Formation comprises shales and stromatolite (*Baicalia biacalica*, Krylov) bearing limestone and dolomite deposits with minor sandy units exposed in low lying areas of south and east of Maihar township, Tamas River valley section and limestone quarries. The limestone unit broadly subdivided into five units viz: a) dirty white, dirty yellow, ash grey and pinkish laminated argillaceous limestone; b) dark grey limestone; c) light grey dolomitic limestone with chert intercalations; d) greenish grey and purple stromatolitic limestone, shale and e) dirty yellow, ash grey and pinkish laminated argillaceous limestone in ascending order.

The overlying 200 m thick Sirbu shale formation widely exposed in low lying areas, isolated hillocks, in nala cutting and well cutting sections. Lithologically it is composed of shales, siltstone, stromatolite bearing limestone/dolomites and sandstones. Majority of the outcrops are distributed in and around Maihar township. (Figure 4) The overlying Maihar sandstone Formation deposited inform of scarps of sandy unit in the western part of the area which is dominated by medium to fine grained sandstone with evidences of algal mats (Rai, 1999; Kumar and Pandey, 2008).

Age of the sediments

The age of the Vindhyan sediments has become a matter of debate in Indian stratigraphy since last century due to inconsistant radiometric dates and number of other bio-

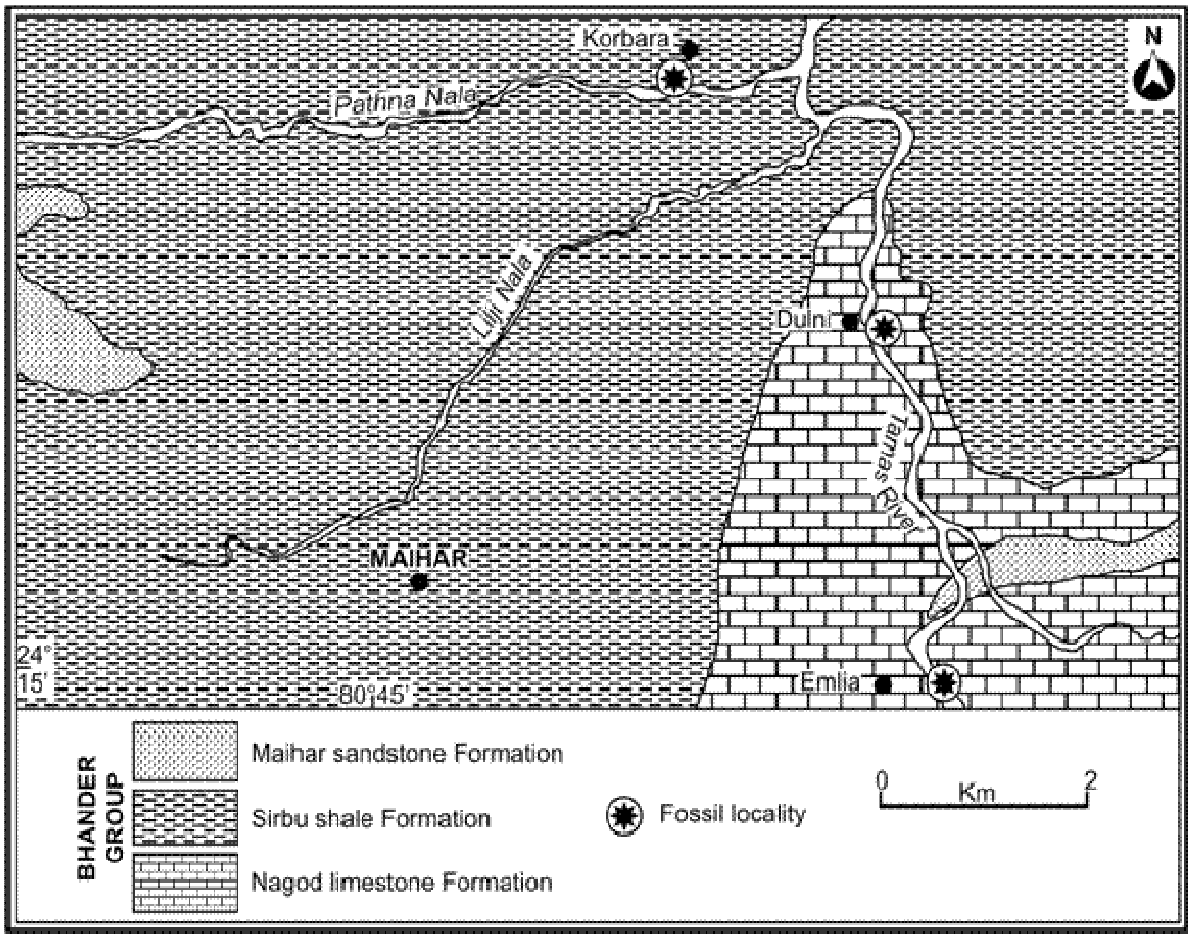

Figure 4. Geological map of the Maihar area (Bhattacharya 1993) showing the location of fossiliferous horizon.

biogenic evidences (Venkatachala et al., 1996; Seilacher et al., 1998; Azmi, 1998; Kathal, 2000; Kumar et al., 2002, Ray et al., 2002, 2003; Sarangi et al., 2004) and palaeomagnetic studies (Gregory et al., 2006; Athavale et al., 2007; Malone et al., 2008). Available published radiometric date along with palaeobiological data suggest that the sedimentation in the Vindhyan basin was started from 1800 Ma (Misra and Kumar, 2005 and cited reference there in). Microfossil (acritarchs and cyanobacteria) assemblage recovered by Prasad, Uniyal and Asher (2005) suggested Palaeoproterozoic to Late Ediacaran age for the Vindhyan sediments. On the other hand the geomagnetic polarity time scale indicates change of the polarity in the Vindhyan formations, which

is indicative of the Meso-Neoproterozoic-lower Cambrian age for the Vindhyan Supergroup.

Ray (2006) has solved the age of the Lower Vindhyan rocks in the Son Valley however, owing to absence of sufficient radiometric dates the age of the Bhander group is quite controversial. Available radiometric date and palaeontological data from the sediments of Bhander Group provide a trend from Late Neoproterozoic to Ediacaran time (Friedman et al., 1996; De, 2006; Kumar and Pandey, 2008). C, O, Sr based isotope geochemistry suggests that the deposition of the Bhander Group have taken place in Neoproterozoic time interval (Kumar et al., 2002). $^{87}Sr/^{86}Sr$ and Pb-Pb isotopes (Ray et al., 2003) data have indicated the Neoproterozoic (750-650 Ma) age for the Bhander Group. Precambrian - Cambrian transitions within the Bhander Group have been proposed based on carbon isotopes data (Friedman et al., 1996). Recent discovery of Ediacaran fossils from the Bhander Group support the Ediacaran age and Pc-C boundary in between Nagod limestone and overlying Sirbu shale Formation of the Vindhyan sequences (De, 2006). Recently the recorded microfossil assemblage from the Bhander Group has suggested Cryogenian to Late Vendian age range ca. 650 - 544 Ma (Prasad, 2007).

MATERIALS AND METHODS

The fossil bearing gray to dark gray shale samples incorporated in present study were collected in year 2006 during field excursion from the four different localities viz., Tamas river section at the Emilya (24° 15' 23.17"N : 80° 48' 15.70"E) (Figure 5a), Pathna nala

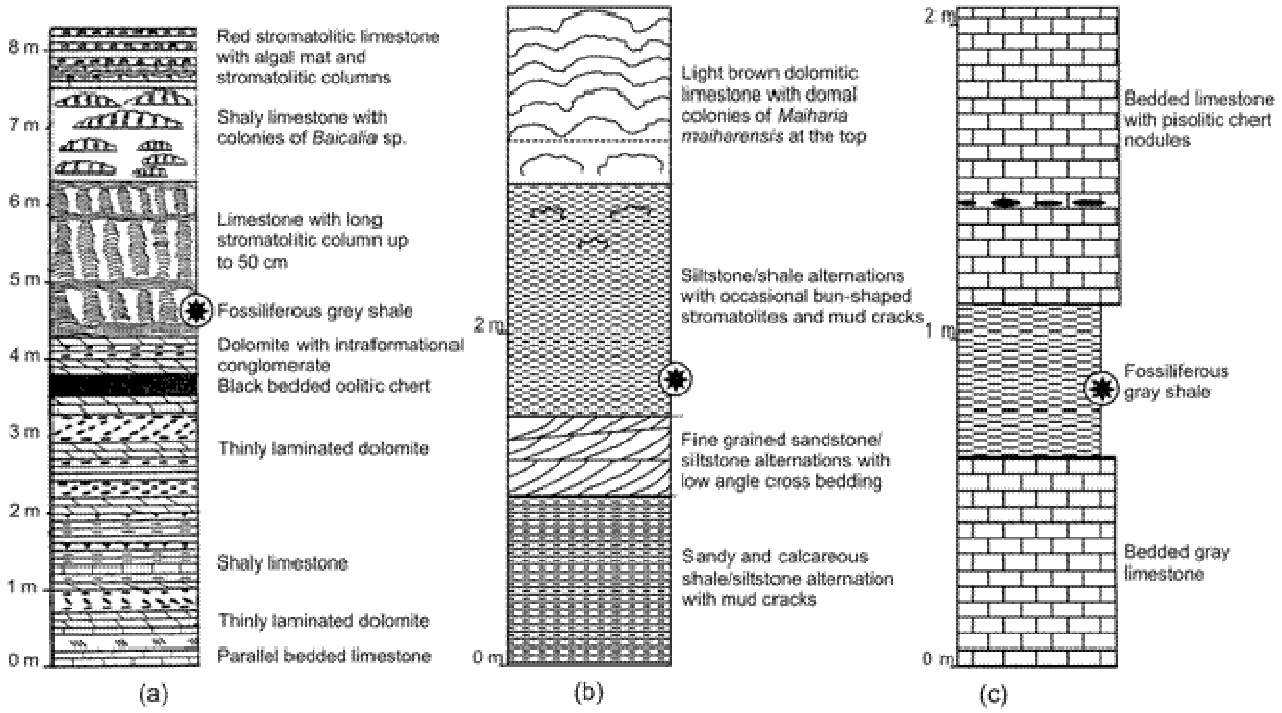

Figure 5. Generalized lithologs -
a) Nagod limestone, Tamas River section, Emlia village (After Singh, 1980);
b) Sirbu shale, Pathna Nala section, Korbara village (After Kumar, 1977);
c) Nagod limestone, Tamas River section, Dulni village, Stana-Maihar area, Madhya Pradesh.
✸ Showing the position of fossiliferous strata.

section at Korbara (24° 18' 35.94"N : 80° 46' 08.68"E) (Figure 5b) and Dulni (24° 17' 24.11"N : 80° 48' 11.18"E) (Figure 5c) and well cutting of the Sitauli (24° 29' 40.72"N : 80° 20' 25.36"E) villages situated in and around Satna district, Madhya Pradesh (Figures 3 and 4). The well preserved multicellular metaphyte fossils described here were obtained along the bedding planes of rock surface representing unit-D of the Nagod limestone and Sirbu shale formations belonging to Bhander Group.

The gross morphology of the fossils are studied and measured under Wild Heerbrugg low power microscope M8 and photographed on software supported Leica DFC290 digital camera. The studied materials and photographs are deposited in the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow, India (BSIP-1223).

Nature and gross morphology of fossils

Morphologically eighteen (including two new) distinct types of metaphytes have been identified referable to the *Chuaria, Tawuia, Longfengshania* and *Protoarenicola.* The Table 1 represents entombment of large amount of biomass in shale sample collected from the four localities of Nagod limestone and Sirbu shale formations. The carbonaceous fossils described in this paper are morphologically diversified. These are fan shaped, leaf like carbonaceous film with holdfast at base, dichotomously branched filaments, pitcher shaped, mesh of thin filaments, palmate, elongated, algal thallus along with multicellular reproductive structures. The carbonaceous algal fossils are megascopic, preserved along the bedding planes and few millimeters to centimeter thick.

Holdfast

Most of the specimens described in assemblage include discoidal, rhizoidal and slightly cylindrical holdfast like structure. Holdfast at the base of algal thallus represents benthic habitat in lower energy and clear environment flourished on the substrate (Wang and Wang, 2008). The holdfasts bearing algal thalli are *S. minor*, *Baculiphyca taeniata* and *Flabellophyton lantianensis.*

Branching

The filamentous algal thalli described here include distinct branching patterns and distinguished by their acute angles. Algal thalli comprised of filaments, dichotomy, taenoid dichotomy, monopodial and ribbon like branchings. Some specimens show whiskbroom type pattern. Dichotomously branched taxa are *Doushantuophyton lineare*, *Enteromorphytes sinianensis* and *Konglingiphyton erecta* while *Doushantuophyton cometa* are multibranched algal thalli.

Thallus

Algal fossils described in the present assemblage, comprises vegetative thallus of variable shapes. They are long blades, widest at apex and tapering at base, fixed on holdfast with thin stipe (*Eopalmaria*, *Jiangchuania* and *Longfengshania*). Few of the algal thalli are fan shaped comprised of closely arranged filaments (*Flabellophyton* and *Huangshanophyton*).

Table 1. Distribution of Carbonaceous fossils in Nagod limestone and Sirbu shale formations, Bhander Group.

Taxa	Formation			
	Nagod limestone formation		Sirbu shale formation	
	Fossil locality			
	Emlia village section	Dulni village section	Korbara village Section	Sitauli village section
Aggregatosphaera miaoheensis	-	-	+	-
Baculiphyca taeniata	+	-	-	+
Chuaria circularis	+	+	+	+
Doushantuophyton cometa	-	-	+	+
Doushantuophyton lineare	+	-	+	-
Enteromorphites siniansis	+	-	+	-
Palaeochorda gen et. sp. nov. *P. vindhyansis*	+	-	-	-
Eopalmaria pristina	+	-	-	+
Flabellophyton lantianensis	-	-	-	+
Glomulas filamentum	-	-	+	-
Huangshanophyton fluticulosum	-	-	-	+
Jiangchuania taeniophylla	-	-	-	+
Konglingiphyton erecta	+	-	-	-
Longfengshania ovalis	-	-	-	+
Protoconites minor	-	-	-	+
Protorenicola biguashanensis	-	-	-	+
Sitaulia gen. et. sp. nov. *S. minor.*	-	-	-	+
Tawuia dalensis	+	+	-	+

Affinity

Morphological characteristics that is, holdfast, branching and thalloidal nature reveals that the fossils are multicellular, benthic seaweeds and their affinities probably belong to modern algae Rhodophyta, Chlorophyta, Xanthophyta and Phaeophyta division of algae. The anatomical features are not easily accessible due to carbonization during fossilization and the multicellularity can be seen in macerated residues in fragmentary forms.

Systematic description

a) Genus: Aggregatosphaera (Xiao et al., 2002).
Type species: *Aggregatosphaera miaoheensis* (Xiao et al., 2002), (Plate 2: g, h and i).
Occurrence: Sirbu shale Formation, Pathna Nala section, Korbara village.
Description: Three-dimensional, spherical cell-like vesicles, colonial organisms comprised of loosely packed one to several spherical vesicles 25 to 50 µm in diameter; colony size 0.5 mm., colonies consisting of single to multiple spherical cells like vesicles preserved as external moulds.
Remarks: The cellular structures in the present form are very small in size; three dimensionally preserved bearing similar morphological characteristics to Miaohe *Aggregatosphaera* of Upper Sinian Doushantuo Formation exposed at the village of Miaohe in Yangtze gorges area from the South China (Xiao et al., 2002, p. 352, figures 2.9 - 2.14). *A. miaoheensis* recovered from the Sirbu shale Formation, are morphologically similar to the silicified prokaryotic coccoids *Paratetraphycus giganteus* (Zhang, 1985; Zhang et al., 1998; Xiao et al., 2002); *Tetraphycus*; *Sphaerophycus*; *Myxococcoides*, *Phanerosphaerops* and *Glenobotrydion* (Schopf, 1968; Schopf and Blacic, 1971; Oehler, 1978; Knoll and Golubic, 1979; Horodyski and Donaldson, 1980; Hofmann and Jackson, 1991). But this form totally differs from these coccoidal prokaryotes due to its surface preservation. Xiao et al. (2002) have placed this taxon in a eukaryotic alga due to its 3D preservation. It does not tally with diagnosis of genus *Chuaria* due to the absence of wrinkles, folding and unusual preservation as external mold, cyano-bacterial envelopes or acritarch walls. These forms may be part of reproductive stage of algal life cycle (Xiao et al., 2002).

b) Genus: Baculiphyca (Yuan et al., 1995; Xiaoet al. 2002).
Type species: *Baculiphyca taeniata* (Yuan et al., 1995; Xiao et al., 2002) (Plate 1: a and g).
Occurrence: Nagod limestone Formation, Tamas River section at Emliya village, Sirbu shale Formation, Sitauli village section.
Description: Elongated, unbranched clavate algal thallus, measuring 2.0 to 2.5 mm long and 0.3 to 0.5 mm wide, attached on substrate by a basal holdfast. Holdfast consists of fine rhizoids; the thallus expands apically at an angle of 5° to 7°. Clavate structure is terete in lower part and squared at the top may represent breakage. Bent and folded thalli indicate an originally flexible upper structure.
Remarks: The present fossil is comparable to known taxa *Baculiphyca* cf. *B. taeniata* - from the Upper Sinian Doushantuo Formation of Miaohe section exposed in Yangtze Gorges at China (Yuan et al., 1995, p. 97, pl. 2, figures 2, 3, 5 and 6). However, it is smaller one from the China (Yuan et al., 1995). The specimens of *B. taeniata* recovered from the Nagod limesotne are broken or juvenile individuals may be due to either biological degradation or physical factor (Plate 1: g). The taxon from the Sirbu shale is characterized by holdfast structures with long folded thallus (Plate 1: a). The presence of a rhizoidal holdfast in association with bent and folded blades suggests that *B. taeniata* is a fossil alga having affinity to modern green algae belonging to Siphonocladales (Xiao

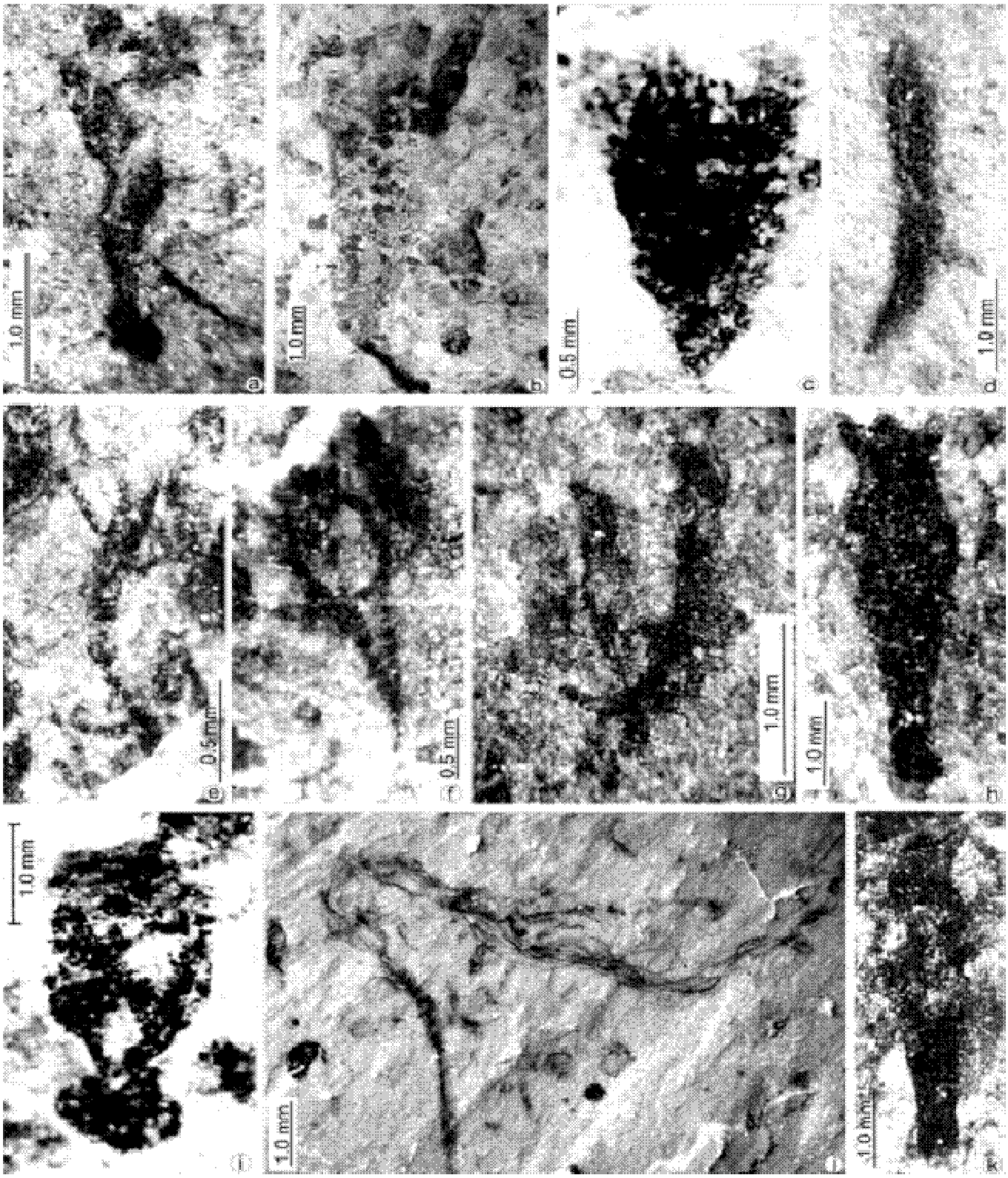

Plate 1. a- *Baculiphyca taeniata*, Sirbu shale Formation, Sitauli section; b- *Flabellophyton lantianensis*, Sirbu shale Formation, Sitauli section; c- *Huangshanophyton fluticulosum,* Sirbu shale Formation, Sitauli section; d. *Doushantuophyton cometa*, Sirbu shale Formation, Pathna Nala section; e- *Konglngiphyton erecta*, Nagod limestone Formation, Emlia section; f- *Doushantuophyton lineare*, Nagod limestone Formation, Emlia section; g- thallus of *Baculiphyca taeniata*, Nagod limestone Formation; Emlia section; h- *Eopalmaria pristina*, Nagod limestone Formation, Emlia section; i- *Sitaulia minor* gen. et. sp. nov., Sirbu shale Formation; j- *Doushantuophyton cometa*, Sirbu shale Formation, Sitauli section; j- *Eopalmaria pristina*, Nagod limestone Formation, Emlia section.

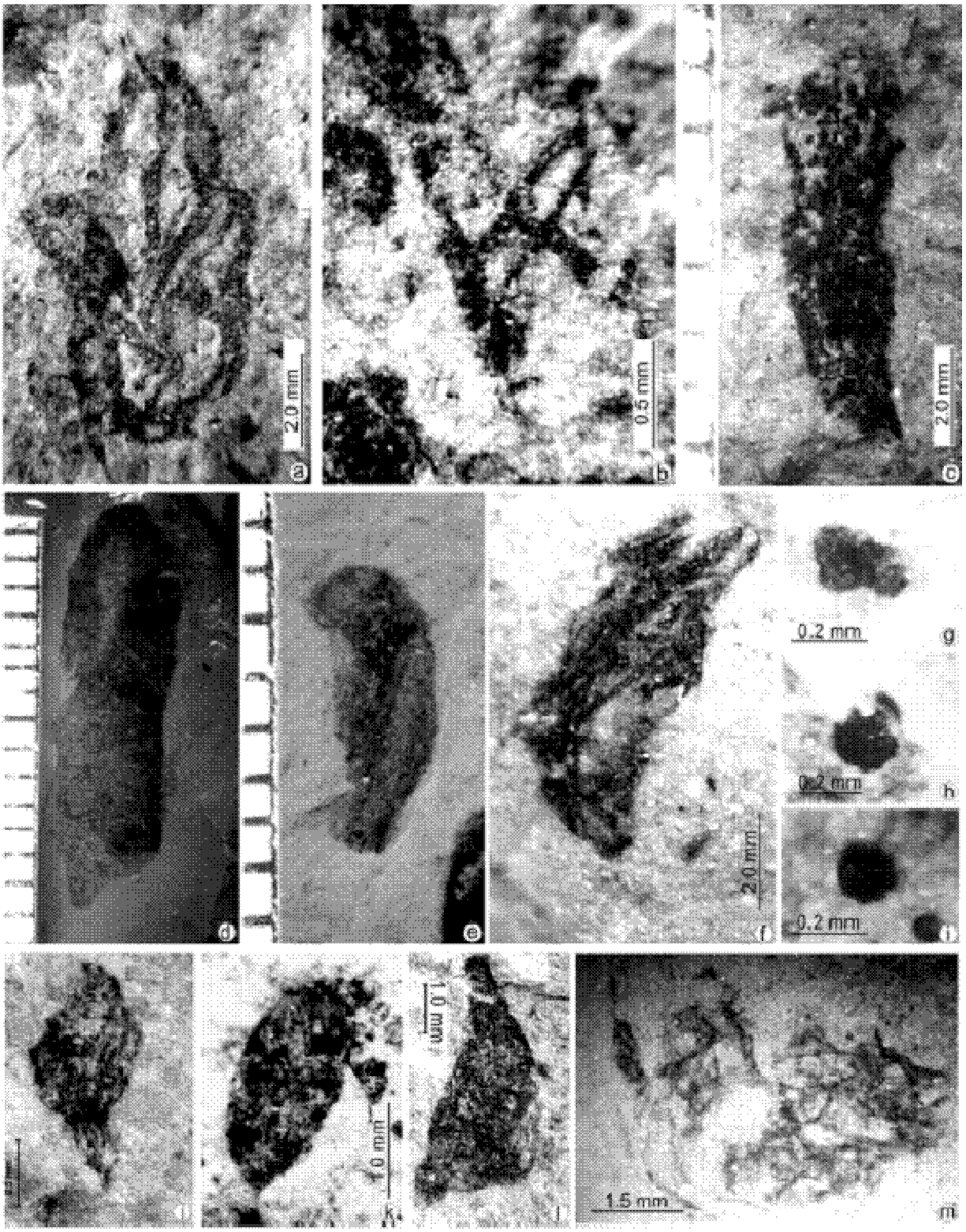

Plate 2. a- *Palaeochorda vindhyansis* gen. et. sp. nov., Nagod limestone Formation, Emlia section; b- *Konglngiphyton erecta*, Nagod limestone Formation, Emlia section; c- *Eopalmaria pristina*, Sirbu shale Formation, Sitauli section; d- *Jiangchuania taeniophylla*, Sirbu shale Formation, Sitauli section; e- *Eopalmaria pristina*, Sirbu shale Formation; f- *Enteromorphites sinianensis,* Sibu shale Formation, Pathna Nala section; g, h, i- *Aggregatosphaera miaohensis*, Sirbu shale Formation; j- *Longfengshania ovalis*, Sirbu shale Formation, Sitauli section; k- *Longfengshania ovalis*, Sirbu shale Formation, Sitauli section; l- *Protoconites minor*, Sirbu shale Formation, Sitauli section; m- *Glomulas filamentum*, Sirbu shale Formation, Pathna Nala section.

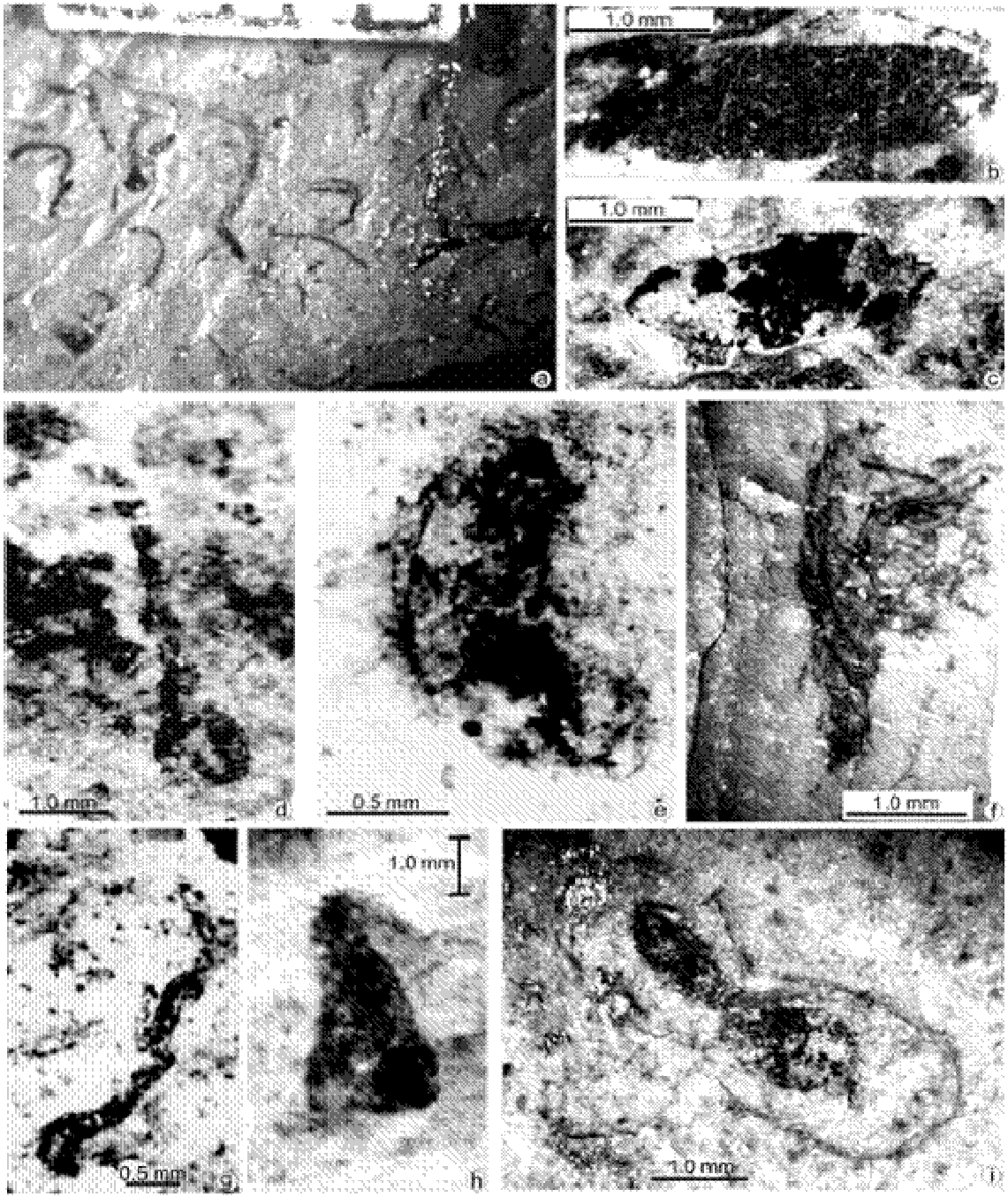

Plate 3. a- Overview of metaphyte bearing shale, Sirbu shale Formation, Pathna Nala section; b- *Tawuia dalensis*, Nagod limestone Formation, Emlia section; c *Tawuia dalensis*, Sirbu shale Formation, Sitauli section; d- *Protoarenicola biguashanensis*, Sirbu shale Formation, Sitauli section; e- *Tawuia dalensis* (c-shaped), Sirbu shale Formation, Sitauli section; f- *Enteromorphites sinianensis*, Sirbu shale Formation, Pathna Nala section; g- *Doushantuophyton cometa*, Sirbu shale formation, Sitauli section; h- *Protoconites minor*, Sirbu shale Formation, Sitauli section; i- *Chuaris cicularis*, showing the cell division, Sirbu shale Formation, Sitauli section.

et al., 2002).

c) Genus: Chuaria (Walcott, 1899; Vidal and Ford 1985).
Type species: *Chuaria circularis*; Walcott, 1899. (Plate 3i; Plate 4: a - e and g - i).
Occurrence: Nagod limestone Formation, Tamas River section at Dulni and Emlia villages and Sirbu shale Formation, Pathna Nala at Korbara and Sitauli villages.
Description: Specimens flattened, diameter ranges from 0.1 to 2.0 mm, two dimensional, opaque, circular to elliptical carbonaceous compressions and impressions with distinct concentric wrinkles/ folds, wrinkles/fold indistinct in small specimens, concentric folding

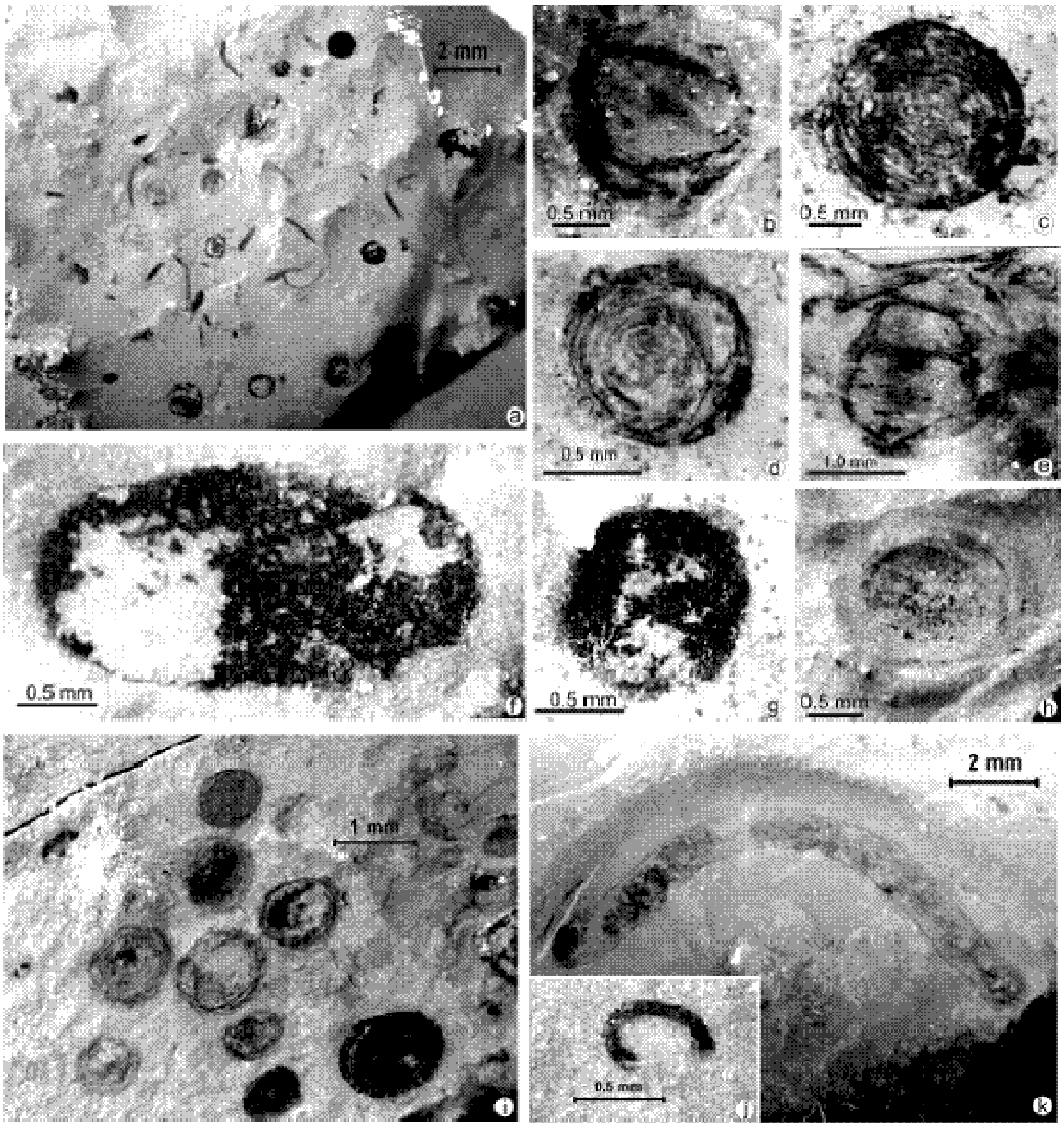

Plate 4: a- preservation of algal impression in association with taphonomic varients of *Chuaria circularis*, Sirbu shale Formation, Pathna Nala section; b and e- *Chuaria circularis cf. Leiosphaeridia jacutica,* Nagod limestone Formation, Dulni section; c- *Chuaria circularis,* comprised of typical concentric rings, Nagod limestone Formation, Dulni section; d- *Chuaria circularis*, comprised of concentric rings with folded sculpture, Nagod limestone Formation, Dulni section; f- *Tawuia dalensis,* Nagod limestone Formation, Dulni section; g- *Chuaria circularis*, simple circular black carbonaceous disc, Sirbu shale Formation, Sitauli village section; h- *Chuaria circularis having thick outer wall,* Nagod limestone Formation, Dulni section; i- *Chuaria circularis* cf. *Leiosphaeridia crassa,* Sirbu shale Formation, Pathna Nala section; j- *Protoarenicola biguashanensis,* Sirbu shale Formation, Pathna Nala section; k- *Tawuia dalensis* (c- shaped) Sirbu shale Formation, Pathna Nala section.

wrinkles around the fossil periphery with sufficient relief to leave substantial imprints on bedding planes. Generally occurs in isolated condition, rarely in clusters.

Remarks: *Chuaria*, an enigmatic carbonaceous organism extensively reported from Palaeoproterozoic to Neoproterozoic sediments since its first discovery by Sir. C. D. Wolcott (1899). Several attempts have been made to assign its diagnostic characters and understand the biological affinity (Hofmann and Chen, 1981, Vidal and Ford, 1985, Hofmann, 1992; Hofmann and Railbird, 1994; Steiner, 1997; Kumar and Srivastava, 2003; Dutta et al., 2006). Earlier studies regarding their biological affinities in palaeobiotic communities recognized as a impression of *Leiosphaeridia* (Ford and Breed, 1973) and *Orygmatosphaeridium* (Maithy and Shukla, 1977) type of acritarchs; Megasphaermorphs acritarch (Steiner, 1997); spherical planktonic organisms (Gussow, 1973); algal cyst (Vidal, 1974, 1976; Hofmann, 1977; Jux, 1977); Chlorophyta rather

than prokaryotes based on the division (Steiner, 1994); reproductive stage of cyst like body of a Chlorophycean or Xanthophycean (Kumar, 2001), eukaryotes substance (n-alkane/n-alkene doublets) through gas chromatography (Dutta et al., 2006), colonies of filamenttous cyanobacteria comparable to modern colonial cyanobacteria *Nostoc* (Sun, 1987). The recovered *Chuaria* specimens of Nagod limestone Formation are large, black, circular impression showing size ranges between 0.5 to 2.0 mm (Plate 4: b - e and h). The specimens from the Sirbu shale Formation are small (0.3 to 1.0 mm), black circular compressions in comparison to Nagod limestone Formation specimens (pl. 4, figures a, g and i). Wrinkles and prominent folding on vesicles are common same as *Leiosphaeridia crassa.* The diameters of the present forms are smaller than earlier reported forms (Hofmann, 1992; Maithy and Shukla, 1984; Rai et al., 1997; Srivastava, 2002) and are most dominant form in Bhander sediments.

d) Genus: Doushantuophyton; Steiner 1994.
Type species: *Doushantuophyton lineare* (Steiner, 1994; Xiao et al. 2002) (Plate 1f).
Occurrence: Nagod limestone Formation, Tamas River section, Emliya village.
Description: Regular branching algal thalli, dichotomies, more or less uniformly distributed along branches, length 1.0 to 3.0 mm with constant width, branches slightly expanded distally, more or less incomplete.
Remarks: The present form is morphologically similar to the known species *Doushantuophyton lineare* (Steiner, 1994, p. 112 - 113, Plate 18, figures 1, 3, 7, 9, 10 and 11, text-figure 65). Three species of the Daushantuophyton - *D. lineare; D. quyuani* and *D. rigidulam* are proposed based on regular thallus strength (soft and stiff), length and arrangement of branching pattern (dichotomous and pseudomonopodial) from the upper Sinian Doushantuo Formation exposed at Miaohe village in Yantzge gorges in South China. Later its diagnostic characters were emended on the basis of branching pattern (Xiao et al., 2002).

e) *Daushantuophyton cometa*; Yuan, Li and Cao Ruiji 1999. (Plate 1: d and j; Plate 3g)
Occurrence: Sirbu shale Formation, Pathna Nala section in Korbara village and Sitauli village section.
Description: Specimens multi-branched, comet/broom like algal thallus composed of 10 to 15 flexible separate dichotomously branched filaments, length of the filaments ranges 5.0 to 10.5 mm and width of the each filament measured up to 0.1 mm, prominent cylindrical holdfast like structure seen.
Remarks: The morphological features of the recorded form are similar to the known fossil *D. cometa* Yuan et al., (1999) described from the Lantian Formation of Anhui Province, China.

f) Genus: Enteromorphites (Zhu and Chen, 1984; Xiao et al., 2002.
Type species: *Enteromorphites siniansis* (Zhu and Chen, 1984; Xiao et al., 2002) (Plates 2 f and 3 f).
Occurrence: Sirbu shale Formation, Pathna Nala section in Korbara village.
Description: Algal thalli contain two or three successive dichotomous branches, some branches possibly aborted or bent, overtopped, resulting in short branches and irregular dichotomies, branch width ranges from 0.2 mm to 0.3 mm, maximum length of the thalli measured up to 2.0 mm, typically decreasing towards the apex, one to as many (six) times, surface smooth and no holdfast present.
Remarks: Zhu and Chen (1984, p. 559 - 560, plate 1, figures. 1 and 2) established the Genus *Enteromorphites* with reference to the modern green algal genus *Enteromorpha.* Due to typographical mistake and branching pattern Xiao et al. (2002) has emended its diagnostic features (Xiao et al., 2002, p. 360 - 361, figs. 5.7 - 5.12). The morphological features of the recorded form are similar to the known fossils *E. siniansis* (Zhu and Chen) Xiao et al., 2002), described from the uppermost Doushantuo Formation at Miaohe in the Eastern Yangtze Gorges, China (Chen and Xiao, 1992, 526, Plate II, figure 4).

g) Genus: Eopalmaria **(**Yan, 1995).
Type species: *Eopalmaria pristina*; Yan, 1995 (Plate 1: d, h and k; Plate 2e)
Occurrence: Nagod limestone Formation, Tamas River section at Emlia village and Sirbu shale Formation, Sitauli village section.
Description: Elongated, flat sheet like algal blades with tiny crust, foliate algal thalli, multiaxial apical rounded, base sometimes appear stalk like projection, length of the thalli ranges from 4 to 8 mm and width of the thalli ranges from 1.25 to 6 mm in middle, 0.5 to 1.0 mm wide at base.
Remarks: The identified fossils are morphologically similar to the known specimens of *E. pristina* Yan recorded from the ~1700 Million years old Changcheng System of Jixian, China (Yan and Liu, 1997). The morphological characters and shape of the fossil *E. pristina* can be compared with Rhodophyta, *Mosnostroma* of the Chlorophyta and *Spathoglossum* of the Phaeophyta as suggested by Yan and Liu (1997).

h) Genus: Flabellophyton (Chen et al., 1994).
Type species: *Flabellophyton lantianensis* (Chen et al., 1994) (Plate 1b).
Occurrence: Sirbu shale Formation, Sitauli village section.
Description: Fan shaped carbonaceous algal thalli, closely arranged filaments, smooth, unbranched, length of the thallus 6.71 mm and width 2.72 mm at apex of the thallus, stalked with narrow rounded holdfast at base, diameter 1.42 mm.
Remarks: The morphology and length/width ratio of the recorded form is equal but smaller in size than the known fossil form *F. Lantianensis* Chen et al., (1994) recorded from the Neoproterozoic Lantian Formation, South Anhui Province, China.

i) Genus: Glomulus (Steiner, 1994).
Type species: *Glomulus filamentum* (Steiner, 1994; Xiao et al., 2002) (Plate 2m).
Occurrence: Sirbu shale Formation, Pathna Nala section in Korbara village.
Description: Irregular colonies comprising of numerous unbranched filaments, aggregated into multiple sinuous - folded bundles; colony size usually less than 5 to 10 mm (typically 0.1 to 0.2 mm in maximum dimension); thin filaments typically 5 to 10 µm in diameter, twisted, forming bundles less than 0.5 mm wide. Possible sheaths have also been observed enclosing the filaments.
Remarks: For the first time, Steiner (1994) has introduced the genus *Glomulus* as irregular colonial forming bundles of twisted filaments from the upper Doushantuo black shales of Miaohe, China. The algal thallus of Longenema is recognized as junior synonymous of *G. filamentum*. Aggregated filaments of G. filamentum are very much similar to the cyanobacteria Poly-trichoides lineatus found widely in Neoproterozoic shales and cherts (Hermann, 1990). Appearance in clusters/bundles of the thin filaments, *G. filamentum* is likely to be a cyanobacterial colony of non septate filaments.

j) Genus: Huangshanophyton; **(**Chen et al., 1994).
Type species: *Huangshanophyton fluticulosum*; (Chen et al., 1994). (Plate 1c).
Occurrence: Sirbu shale Formation, Sitauli village section.
Description: Fan shaped algal thalli consists of mesh of thin filaments, filaments straight or curved, un-branched, aseptate; 2.08 mm in height and 1.30 mm in width; basal part ill preserved.
Remarks: The Genus *Huangshanophyton* cf. *H. fluticulosum* has been originally reported from the Lantian Formation of South China (Chen et al., 1994). Later on, from the same stratigraphic successsion exposed at Xuning county of South China, Yuan et al. (1999)

recorded the taxon. The present form is smaller in size reported by Chen et al. (1994). The species *H. fluticulosum* is reported for the first time from the Sirbu Shale of Bhander Group Upper Vindhyan, India.

k) Genus: Jiangchuania (Tang et al., 2007).
Type species: *Jiangchuania taeniophylla*; (Tang et al., 2007) (Plate 2: c and d)
Occurrence: Sirbu shale Formation, Sitauli village section.
Description: Rod and ribbon like carbonaceous algal thalli, having smooth and distinct margins, elongated, more or less parallel, apex semi circular, base appearing stipe like projection, holdfast absent, length of the thalli ranges 2.0 to 16 mm and width of the blade 1.2 to 4.0 mm in middle, stipe 1.0 mm wide at base and 0.5 mm long. Length and breadth ratio of the thalli is 4:1.
Remarks: The gross morphology of the present specimen is similar to the *J. taeniophylla* Tang described from the uppermost Sinian Yuhuucum Formation in eastern Yunnan province of south China (Tang et al., 2007). In the absence of basal stipe, thallus looks like *Tawuia dalensis* Hofmann. It has been placed in group *Longfengshaniacea* based on stipe and unbranched thallus (Tang et al., 2007).

l) Genus: Konglingiphyton (Chen and Xiao, 1992; Xiao et al., 2002).
Type species: *Konglingiphyton erecta* (Chen and Xiao, 1992; Xiao et al., 2002) (Plates 1e and 2 b).
Occurrence: Nagod limestone Formation, Tamas River section at Emlia village.
Description: Dichotomously branched algal thallus, preserved on the surface of shale, 2.0 mm long, composed two or more dichotomies, basal branches 0.1 to 0.5 mm wide, but terminal branches up to 1.0 mm in width, diverging angle varies from 10 to 40°; width of segments gradually increases distally.
Remarks: The present forms are morphologically similar to the *K. erecta* originally recorded from the black shales of Upper Sinian Doushantuo Formation, China (Chen and Xiao, 1994), Earlier it was reported from the different regions of China belonging to the upper Sinian Doushantuo Formation (Yuan et al., 1995; Yuan et al., 1999) and has been compared with the modern Rhodophyta algal thalli of *Palaeoscinaia* and *Ramalga* (Ding et al., 1996), diagnostic characters of the *K. erecta* later emended by Xiao et al., (2002) on the basis of basal constrictions at dichotomies. This recorded form from the Nagod Limestone shale is small in size.

m) Genus: Longfengshania; Du 1982.
Type species: *Longfengshania stipitata*; (Du, 1982). *Longfengshania ovalis* (Duan et Du, 1985; Tang et al. 2007) (Plate 2 j and k).
Occurrence: Sirbu shale Formation, Sitauli village section.
Description: Oval to oblong thallus, top widest and tapering towards the base, appear as balloon shape, foleaceous shield, inner side of shield face smooth and flat, shield generally jointed by a stipe like appendage at base, stipe joins smoothly to the thallus and expands at the contact position between foliate and sub leaf like stalk. The thallus ranges from 1.18 to 2.5 mm in length, 0.842 to 1.0 mm width and basal stipe 0.5 mm long.
Remarks: The present forms are morphologically akin to *L. ovalis* known from the Qingbaikou System, Yanshan Mountain area of North China (Du, 1985; Du and Tian, 1986); Middle Proterozoic Little Dal Group of NW Canada (Hofmann, 1985) and Mesoproterozoic sediments of Vindhyan Supergroup from India (Sahni and Srivastava, 1954; Maithy and Babu, 1988), upper most Sinian of the eastern Yunnan, south China (Tang et al., 2007). Its affinity has been assigned as benthic thallophytes/photosynthetic alga (Tang et al., 2007) in place of bryophyte (Zhang, 1988). The genus *Longfengshania* with their systematics (Liu and Du, 1991) for the first time described (Du, 1982) from the Changlongshan Formation of China.

n) Genus: Palaeochorda Gen. Nov.
Diagnosis: Smooth unbranched algal thalli comprised 5 to 10 long linear, twisted, bent tubes, gathering in tuff at base, apex slightly angular; length of the one tube measured up to 10.0 mm. and width less than 2.0 mm (ratio 1: 5).
Palaeochorda vindhyansis gen. et. sp. nov. (Plate 2a).
Type section: Nagod limestone Formation, Tamas River section at Emlia village.
Etymology: The generic name is after the extant genus *Chorda* of Phaeophyta and the specific name is after the Vindhyan Basin.
Diagnosis: Same as Genus.
Description: Thalli smooth, unbranched, folded and bent hollow tubular blades, attached to other at base, growths upward, each blades margin parallel and tapering toward apex, diameter ranges 0.4 to 0.5 mm at middle and length of the blades ranges 7.0 to10 mm; angle of divergence 10 to 20°.
Comparison and Remarks: The present form is not comparable to any taxa known from any Precambrian sediment throughout the world. Morphological characteristics of the present taxa closely resembled to the known modern brown algal species *Chorda filum* Stackhouse. *C. filum* is characterized by hollow, slippery, unbranched, whip like long chord like frond belonging to brown algae. The presently described specimen is smaller in size as compared to modern *Chorda* (40 cm). Blades of *P. vindhyansis* can be comparable to the modern phaeophyta taxon *Myelophycus caespitosus* (Harvey) Kjellman. The tubular arrangement of described form here morphologically similar to the *Capilliphyca flexa* Yuan recorded from Doushantuo Formation, China. This form is smaller than the modern form *Chorda* might be juvenile stage however all the algae from the Proterozoic sequences shows static changes in gene pool rather than other factors (Knoll et al., 2006).

o) Genus: Protoarenicola; Wang, 1982.
Type species: *Protoarenicola baiguashanensis* (Wang 1982; Dong et al., 2008) (Plates 3d and 4 j).
Occurrence: Sirbu shale Formation, Sitauli village and Pathna Nala in Korbara village sections.
Description: Thallus narrow and slender, occasionally curved consisting of numerous, fine straight annulations with uniform diameter throughout the length; sides distinct and smooth; anterior end conical with small, distinct, ovate bulb in front, 1.0 to 1.92 mm in length and about 0.22 mm thick, diameter of the disc 0.605 mm.
Remarks: The present described form is similar to the known *P. baiguashanensis.* Wang from the different parts of world (Wang, 1982; Sun et al., 1986; Hofmann, 1992; Dong et al., 2008) including India (Maithy and Babu, 1996). The length of the cylindrical tube is short due to the preservation factor. The Genus *Protoarenicola* has been originally described from the Huainan of Anhui Province in China (Wang, 1982), identified as sinosabelliditid remains (Hofmann, 1992). Earlier affinity of Protoarenicola has been assigned as worm like metazoan (annelid) traces due to the presence of annulations on body and attached proboscis (circular disc at one end) cf. *Chuaria*. For the recorded fossils of Jiuliqao Formation, Feishui Group in China (Sun et al., 1986). Later, this taxon is considered as a broad cyanobacterial filament rather than annelid owing to absence of essential characters- midline, setae and clitellum, which represent life cycle of any algae (Maithy and Babu, 2005). Dong et al., (2008) described *Protoarenicola* as an epibenthic organism, possibly coenocytic algae.

p) Genus: Protoconites (Chen et al., 1994; Xiao et al., 2002).
Type species: *Protoconites minor* (Chen et al., 1994; Xiao et al., 2002) (Plates 2l and 3h).
Occurrences: Sirbu shale Formation, Sitauli village section.
Description: Small conical tubes, pointed apex that expands to a squared-off termination (possibly with an aperture), 0.2 to 0.4 mm in

diameter at apex and up to 2.2 to 4.0 mm long, aperture are 1.0 to 1.5 mm wide, angle of divergence 10 to 20°, holdfast absent, smooth walls, annulations or transverse markings no observed.
Remarks: The recorded specimen are morphologically similar alike to *Protoconites minor* known from the Upper Sinian sediments belonging to Miaohe province of China (Chen et al., 1994, p. 402, plate IV, figures 10 and 11).

q) Genus: Sitaulia Gen. Nov.
Diagnosis: Thallus lobate, elongated, oval shaped disc attached with holdfast, thallus consists of cellular structures, short, distal neck like structure jointed the disc and holdfast.
Type species: *Sitaulia minor* gen. et. sp. nov. (Plate 1i)
Type section: Sirbu shale Formation, Sitouli village section.
Etymology: The generic name is after the Sitauli village of Madhya Pradesh, Central India.
Diagnosis: Same as genus.
Description: Oval shaped algal thallus, stalked on disc like holdfast, short distal necks like structure joint the thallus and holdfast together; no cellular structure observed on the body, upper body ranges 2.21 mm length, diameter of the holdfast 0.908 mm, length of the neck 0.485 mm long and 0.25 mm wide.
Remarks: The algal thallus of the *S. minor* shows close resemblance with the known modern Xanthophyta *Characiopsis*, which is characterized by small, elongate disc like thallus.

r) Genus: Tawuia; Hofmann and Aitkin, 1979.
Type species: *Tawuia dalensis*; Hofmann, 1979 (Plates 3b, c and e; 4f and k).
Occurrence: Nagod limestone Formation, Tamas River section, Dulni and Emlia villages and Sirbu shale Formation, Sitauli village section.
Description: Sausage shape, elongated rod/ribbon like carbonaceous discs, with more or less parallel sides and both ends subrounded, sometimes slightly curved (C- shaped), wall thin, marginal folding absent, 2 to 3 mm long and 0.5 mm wide.
Remarks: The present ribbon like compressions are akin to *T. dalensis* Hofmann known from different Proterozoic horizons of Canada, China, Svalbard, Russia including India (Hofmann and Aitkin, 1979; Maithy and Shukla, 1984, 1992; Maithy and Babu, 1988; 1996; 2005; Rai et al., 1997; Kumar and Srivastava, 1997, 2003; Kumar, 2001; Srivastava, 2002). The affinities of this form have been considered as metazoans and Phaeophyte algae (Hofmann, 1981, 1992), siphonaceous algal thallus or a filamentous cell of Chlorophycean/ Xanthophycean algae (Kumar, 2001) with a circular cross section. It has been considered as sinosabliditid form of worm like organism of uncertain affinity (Sun et al., 1986). The *Tawuia* associated with *Chuaria* has been globally recorded from the Meso-Neoproterozoic sediments. However, later, a revised opinion considered *Chuaria* and *Tawuia* as eukaryotes (Dutta et al., 2006). The present specimens are smaller in size in comparison to figured specimens recorded from the Mesoproterozoic sediments of Canada, China and India. It has been considered as a valid and convenient biostratigraphic index fossil for the global correlation of 1200-1000 Ma sediments.

DISCUSSION AND CONCLUSION

1. Eighteen (18) algal thalli taxa including two (02) new genera (*Sitaulia* and *Palaeochorda*) cf. extant Phaeophyta and Xanthophyta in association with Chuaria-Tawuia fossils are being recovered for the first time from the Bhander Group.
2. The identified five (05) taxa viz. *B. taeniata; Doushantuophyton lineare; Konglingiphyton erecta; Enteromorphites siniansis; Eopalmaria pristine* in Nagod limestone Formation.
3. Recorded eleven (11) taxa viz. *A. miaoheensis; Daushantuophyton cometa; Doushantuophyton lineare; Palaeochorda vindhyansis* gen nov. sp. nov.*; Flabellophyton lantiaenensis; Glomulus filamentum; Huangshanophyton futiculosum; Jiangchuania taeniophylla; Longfengshania ovalis; Protoconites minor; Protoarenicola biguashanensis and Sitaulia minor* gen nov. sp. nov. from the overlying Sirbu shale Formation.
4. The varied forms of different genus without more speciation (biodiversity) belonging to Chlorophyta, Phaeophyta, Rhodophyta and Xanthophyta reported from the Terminal Neoproterozoic sediments of China and Russia (see the references in text remarks) and indicates congenial stable environment which support given views (Xiao et al., 2002).
5. In present study two phenomenons have been observed 1). Decreasing size and density of *Chuaria-Tawuia* assemblage, 2). Increasing biodiversity, explosion and complexity of different division of algae lithostratigraphically in shales facies of two formations (Nagod limestone to Sirbu shale formations) rather than Mesoproterozoic (cited references in introduction text) and indicating heterogeneous environmental (low and high energy) deposition.
6. Variable biological affinities of *Chuaria* taxa considered by several workers based on the morphological features and integrated studies like XRD, n-alkane/n-alkene doublets through gas chromatography (see references in taxonomy part). The impression and compression including moulds of different algal taxa viz. *Chuaria-Tawuia* assemblage and allied remains recorded from the Bhima group and other parts of India considered them a different reproductive stage of life cycle of a single algal taxon (Maithy and Babu, 2005).
7. In present study, the authors supports the given earlier view for *Chuaria* as *Leiosphaerids* (Ford and Breed, 1973) and *Orygmatosphaeridium* (Maithy and Shukla, 1977) acritarchs due to complex morphology (angular folding, rinckles and varying preservation mode). Maithy and Babu (1993) reviewed explored data of acritarchs including *Leiosphaeridia* from the Ganurgarh Formation and published data from other formations of the Bhander Group and suggested evolutionary trends (decreasing of the size from older to younger sediments).
8. The stipe like appendage at the base of algal thalli similar to the leaf, carbonaceous films of *Longfengshania, Jiangchuania* and *Eopalmaria* are mostly recorded from the Meso-Neoproterozoic sediments of China, India and Canada (see the reference as given in remarks of the concerned taxa). The small sized holdfast associated forms in present assemblage indicates vegetative remains of an alga near shore (photic zone) habitat.
9. The simple parenchymatous thalli, bilateral symmetry and erect growth are characteristic features in some of the fossils recorded from the Terminal Neoproterozoic se-

diment China (Chen et al., 1994; Xiao et al., 2002).
10. The variable age for the sediments of Vindhyan Supergroup based on lithofacies, isotopes, radiometric, palaeomagnetic studies and palaeobiological have been assigned globally. There are less chances for the preservation of biomolecular signatures during Precambrian time due to natural calamities. Hence the palaeobilogical studies (micro and macorfossils) are more authentic for the age and environment after the biomolecular signatures (DNA, RNA).
11. Age for the Upper Vindhyan sequences is Neoproterozoic to Lower Cambrian (Athavale et al., 2007) and latest Mesoproterozoic (Malone et al., 2008) based on the Palaeomagnetic studies. Palaeobiological data (Prasad et al., 2005; Maithy and Babu, 1997) correlates with Bhander limestone age 650 Ma based on more authentic Pb-Pb isotopes methods (Ray et al., 2003) than other isotopes like U-Pb and C isotopes.
12. The quantitative and qualitative analysis of the newly discovered assemblage from the Bhander Group and previously recorded data on micro-macrofossils indicate an evolutionary trend and from Cryogenian to Ediacaran age; shallow marine water congenial environment during the deposition of the Nagod limestone and overlying Sirbu shale formations.

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