International Scholars Journals

International Journal of Histology and Cytology ISSN 2756-3707 Vol. 13 (1), pp. 001-007, January, 2025. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Unveiling Ancient Ecosystems: The Role of Soft-Bodied Metazoans and Microphytofossils in Mesoproterozoic Vindhyan Supergroup

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Accepted 24 November, 2024

An assemblage of microbial remains consisting two types of preservations are being recorded for the first time from the phosphoritic chert intercalated in Tirohan Limestone (Rohtas Limestone Formation) of Semri Group, Vindhyan Supergroup, exposed in Chitrakoot, Madhya Pradesh. The uniquely preserved, cryptic forms are multicellular, bilaterally symmetrical, monoecious, cylindrical elongated coiled body with clitellum and ornamented structures (setae). This assemblage shows possible biomineralized novel post embryonic developmental stages of the juvenile and young forms of the annelids. The dark brown organic-walled microfossils (prokaryote and protists) are sparse, cellularly preserved, distorted, small sized, simple sphaeromorphs. The present explored preliminary results are based on the Mesoproterozoic stray fossils of two bioentities in limited material, and are the authentic key events to consider remarkable potential value in understanding the evolution and divergence of the metazoan in India along with status of Indian subcontinents (geographic position) in geological past of world history. It is a team effort of the earth scientists (geologists, botanist, and zoologist) based on the extinct and extant annelids in present brief communication.

Key words: Soft bodied metazoan, annelid, clitellum, Mesoproterozoic, Tirohan limestone, Vindhyan.

INTRODUCTION

The great Vindhyan is one of the largest and thickest Precambrian basin of peninsular India and is tectonically least disturbed and unmetamorphosed. Its sediments are about 5000 m thick and belong to a supergroup of heterogeneous lithofacies that are areno-argillaceous, siliciclastic, and carbonate, typified in the Son Valley in Uttar Pradesh (Sastri and Moitra, 1984) (Figure 1). Since 1997, the most authentic data on some animal faunas have come from the Vindhyan. Any discovery from Precambrian sediments is always a matter of interest to earth scientists of the world. The present discovery of Mesoproterozoic metazoan fossils is one of the most important, for the phosphoritic chert in which they occur belongs to the Semri group, the oldest of the Vindhyan. There is no earlier report of fossils possessing essential annelid characters; hence, this finding is of great importance in considering the origin of annelids as a taxon.

The best molecular clock estimation for the last common bilaterian ancestor varies from 1200 to 600 Ma, focusing on the Ediacaran sediments and divergence of the metazoan m cells with molecules (Wray et al., 1996; Ayala et al., 1998; Rasmussen et al., 2002; Tang et al., 2006). However, the origin and evolution of animals are based on morphology as well as chemo- and molecular-fossil data (Jermilin et al., 2005). This find of morphological data thus helps us understand how the annelid fauna related to the coeval Ediacaran fauna. The Chitrakoot region from where materials of the present study has been taken, is an area confined to an unevenly condensed succession of Semri group strata resting unconformably upon Bundelkhand granites (Narain, 1960). The Tirohan limestone is the youngest lithostratigraphic unit of this group (Table 1), containing phosphoritic chert stromatolites, *Jurussania* (Krylov), which are widely exposed in isolated hillocks, including Kamtanath Hill in the Paisuni River Valley of the Chitrakoot area in Uttar

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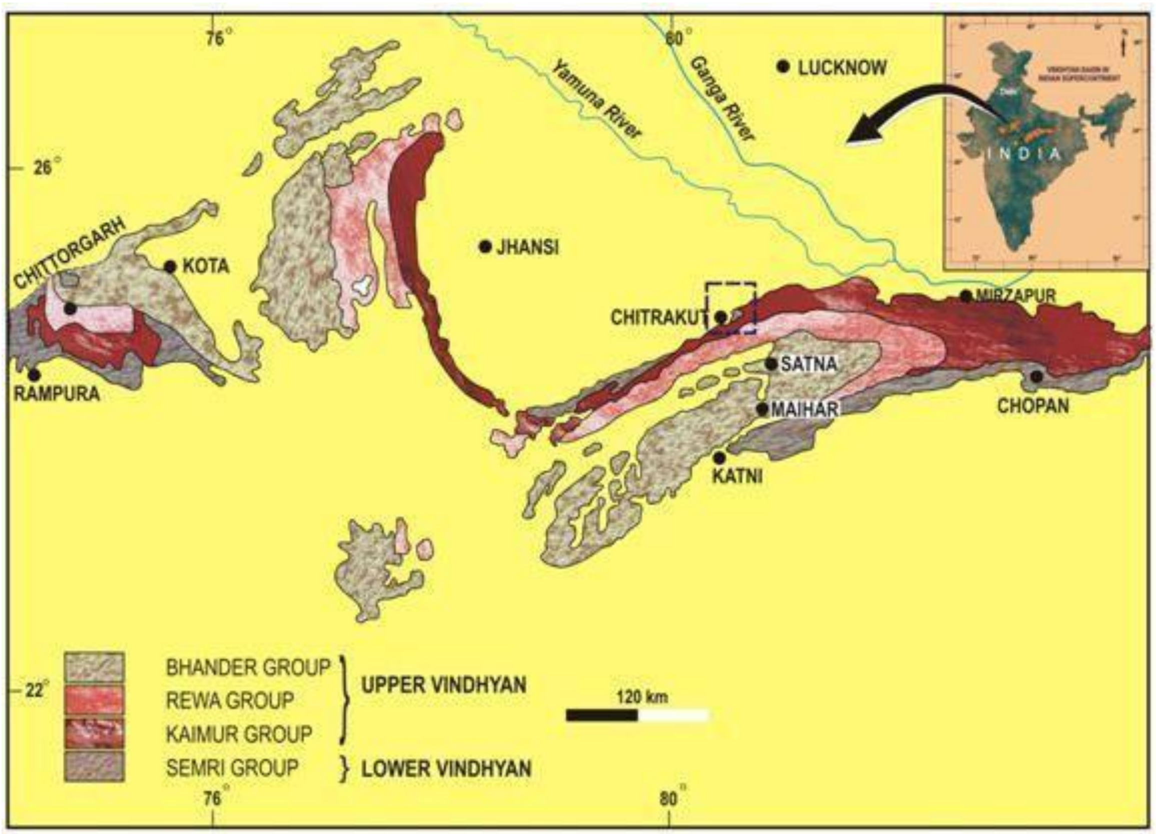

Figure 1. Generalized geological map of the Vindhyan Basin showing the position of study area (Krishnan and Swaminathan, 1959).

Table 1. Lithostratigraphic succession of Vindhyan Supergroup in Chitrakut area (Safaya, 1975).

Supergroup	Group	Formation	Lithologies/Members	Age (Ma)
	Rewa	Panna Formation	Calcareous shale, glauconitic shale, sandstone, siliceous and cherty shale	
	Kaimur	Baghain Sandstone	Light pinkish brown to buff colored medium to coarse grained, cross bedded, indurated sandstone, conglomerate bed at base	
Vindhyan		Bhounri Formation	Pitted flaggy fine to medium grained sandstone	
		Khoh Formation	Silicified chert, agate and breccia	
	Semri	Chitrakut Formation	Tirohan Limestone Member Upper Green Sandstone Member Pellet Limestone Member Lower Green Sandstone Glauconitic Limestone Member	1504-1409 Ma (based on Rb-Sr dating)[1]Kumar et al., 2001
Bundelkhand Gneissic Complex				2500 Ma (Pb-Pb dating)[2] Singh and Kumar, 1978

Pradesh and Madhya Pradesh, India. The fossiliferous localities lie at Latitude 25° 09’44.9 N and Longitude 80° 52 05.33 E (Figure 3) and Latitude 25° 10 18.8 N and Longitude 80° 50 37. 5 E (Figure 2). Because of the relative scarcity of fossils prior to ~543 Ma and with the explosion and radiation of the better-known, morphologically complex populations, the earliest appearance of animal remains is yet to be understood.

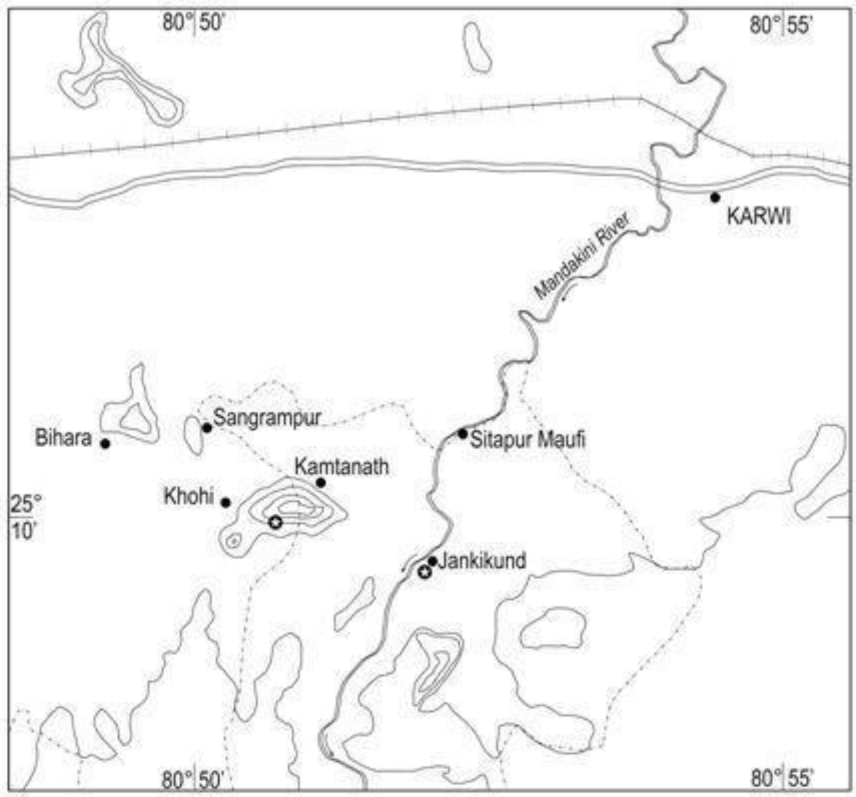

Figure 2. Map showing the position of sample collection sites in study area.

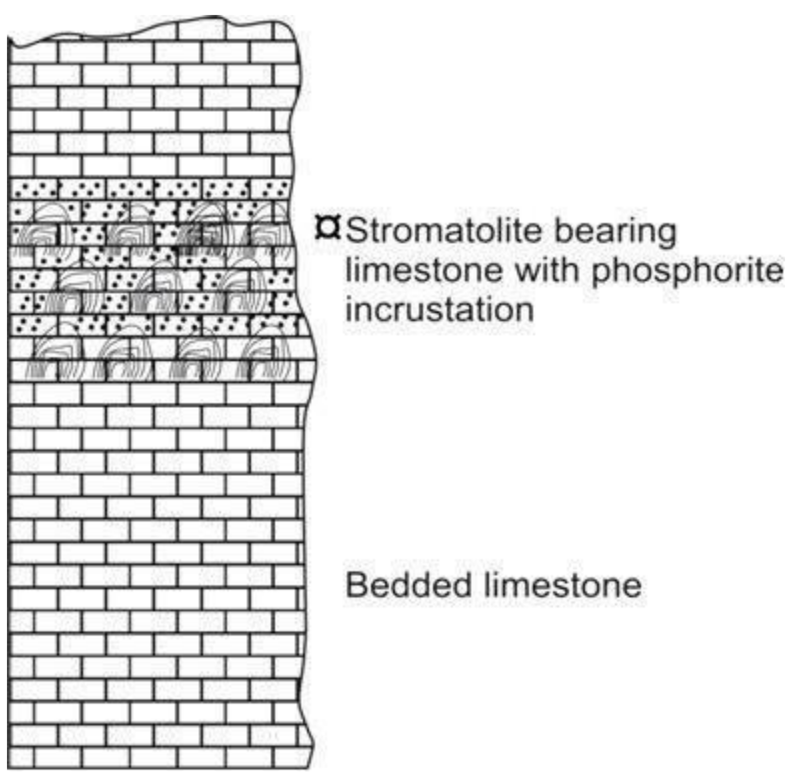

Figure 3. Lithocolumn of Jankikund section (Anabrasu, 2001). Star (¤) showing the position of fossilliferous unit.

There is, as found so far, no other coeval occurrence of metazoan and algal information from the Proterozoic deposits in the world. The OWMs recorded data have been summarized from the Vindhyan Supergroup (Prasad et al., 2005). The aim of the present study is to disseminate and add new information for the findings of triploblastic animals belonging to the lower metazoans group and their origin including habit and habitat on the land nearly Ediacaran period earlier than the evisences previously suggested by pioneer earth scientists.

MATERIALS AND METHODS

Petrographic thin sections were prepared both in perpendicular aspect as well as on the bedding planes of the surface phosphoritic chert samples associated with columnar stromatolites, Jurussania (Krylov), in bedded limestone. The preservation of the microfossils varies from section to section due to cutting of samples from different angles (Figure 4b). Variation is even more obvious in sections from the same sample and depends upon the thinness of the sections. The slides have been examined and microphotographed under immersion oil from transmitted optical light in an Olympus BH2 microscope under 40X and 100X. The studied materials, slides, and photographic negatives have been deposited in the museum of Birbal Sahni Institute of Palaeobotany, Lucknow, India (Statement No. BSIP 1168).

OBSERVATIONS AND RESULTS

The present findings—that is, with two kinds of preserved microfossil remains —have been recorded for the first time from the phosphoritic chert intercalated in Tirohan limestone (equivalent to the Rohtas Limestone Formation) of the Semri Group of the Vindhyan Supergroup exposed in Chitrakoot, Madhya Pradesh. The uniquely preserved cryptic forms are multicelluar, bilaterally symmetrical, monocious, cylindrical and elongated coiled bodies with clitella, ornamented struc-tures, and setae. The dark brown organic-walled microfossils—prokaryotes, and simple sphaeromorphs (protists) are sparse, cellularly preserved, distorted, small in size. These specimens, recovered as scattered Mesoproterozoic fossils, are of remarkable potential value for understanding the evolution and divergence of metazoans of India.

Figure 4a represents a fossil earthworm specimen in cross section, measuring 165.0 m long and 10.0 m broad, showing a simple cylindrical and elongated body, somewhat flattened, annulated, with pointed anterior and blunt posterior. The anterior end possesses a small, fleshy, preoral lobe, a prostomium under which lies the mouth. There is no well-demarcated head, but there appears to be a single oral segment, a peristomium behind the prostomium. The body is divided into a series of 30 to 70 circular metameres, or ring-like segments, with prominent grooves. A groove between segments is about 1.0 m thick and bears two or three dark spots, possibly nodules, on the body. Each segment, which is separated by a groove, bears four pairs of “S” shaped chitinoids, locomotor appendages, and setae measuring ±3.0 to 5.0 m, situated on the ventral side of the body; the first and last segments, however, lack them. A prominent saddle shaped ± 8.0 m long clitellum or cingulum is situated between metameres or segments 33 and 36.

There are no parapodia, and the last segment of the posterior end, the pygidium, bears an oval ventral anus, which is invisible here due to the angle of cutting of the material. The size of these fossil forms compares to extant forms in a ratio of 1: 15 to 30. The reported fossil form most resembles the extant *Lumbricus terrestris*, which lives in moist soil and makes deep burrows. It is found in Europe and North America, as well as in the eastern ghat of India (Bhal, 1950). Figure 4c is of a fragment of fossil earthworm showing some metameres measuring 30.0 m long and 10.0 m broad. Figure 4h represents fragmentary small prokaryotes, aseptate trichomes, Siphonophycus (upper arrow), and simple protists, Leiosphaeridia (lower arrow), resembling known forms from Palaeoproterozoic and Mesoproterozoic transitory sediments (Prasad et al., 2005; Knoll et al., 2006). The food matter consumed by an earthworm is discharged as excrement or fecal matter in casts on the ground surface during the action of digging and boring in the earth, as shown in Figure 4e (enlarged round pellets) and 4i. This material interpreted as fecal matter, resembles the fecal matter of extant forms. Figure elements 4d, f, and g show layers of the body with engulfed materials.

DISCUSSION

We discuss the present findings from chert, intercalated on the top of the limestone during the formation of the Semri group, in light of the available data on other fossils of the lower Vindhyan. The calcified metazoan tubes associated with stromatolites are also known from the Nama group of Namibia (Grotzinger et al., 2000). It is assumed that the origin and development of metazoans depended on the availability of essential requirements such as oxygen, salicic acid and phosphate minerals in carbonate host rocks in suitable oceanic water conditions from the Proterozoic to the present. The oxygen-producing carbonaceous mega-remains of Eukaryotes were reported from Palaeoproterozoic and Mesopro-terozoic transitory sediments (Han and Runnegar, 1992; Rai and Singh, 2006). Atmospheric oxygen rose to a level that allowed aerobic metabolism (Knoll, 1996). The development of biocommunties is dependent on the phosphatic minerals which are essential for survival (Sly et al., 2003). The oxygen isotope has reversible properties as toxin and atoxin based on the composition of surface and oceanic water, which may differ in the same lithofacies, particularly carbonate host rocks usually having salicic properties in ion exchange that affect water

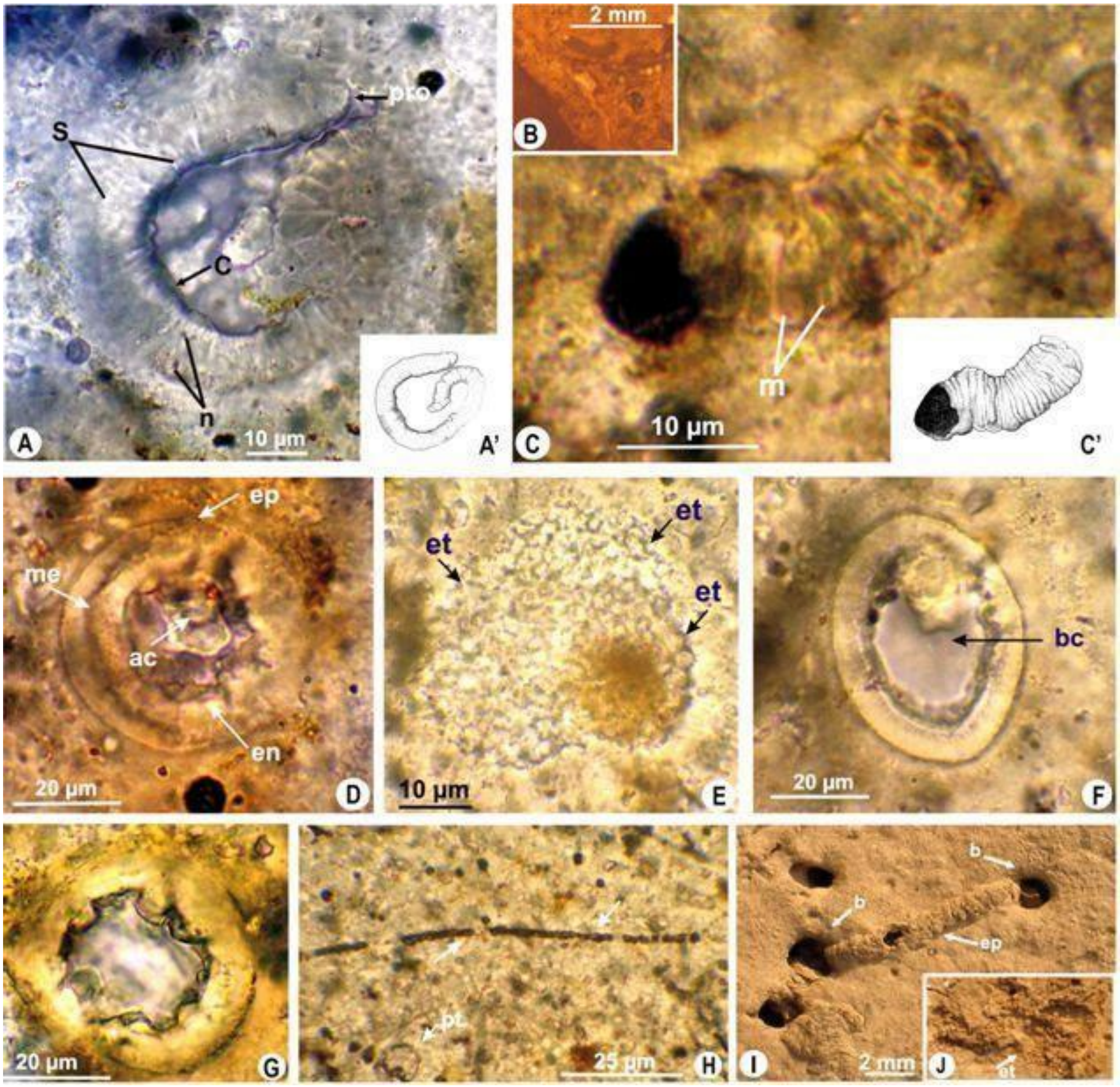

Figure 4. (a) A complete crescent or sickle shaped fossil annelid earthworm. (a') line diagram of 'a' (BSIP Slide no. 13317); (b) A view of fossil -bearing chert section; (c) A cylindrical fragment of fossil annelid earthworm; (c') line diagram of 'c' (BISP Slide no. 13319); (d, f, g) Transverse sections of annelid earthworm fossils body in different angled position showing body layers (BSIP Slide no.13317-13319); (e) excrement or fecal material (BSIP Slide no. 13319); (h) *Siphonophycus* sp. , upper arrow *; Leiosphaeridia* sp. lower arrow (BSIP Slide no. 13319); (i) A specimen of fossil annelid earth worm and burrows in which earthworms take shelter; (j) excrement or fecal matter of fossil annelid earthworm (BSIP Slide no. 13319). Abbreviations b- *burrow*; bc - *body cavity* c- *clitellum* ac –*alimentary canal*; ep-*epidermis;* en- *endodermis*; et-*excreta* ; m-*metameres or body* segments; me-*mesodermis*; n-*nephridiopore*; pro-*prosternium*; pt- *protist*s; s-*setae*. (Bar in each figure showing the measurements of the forms).

quality for worms.

Preserved forms such as compressions, impressions, molds and biorelics stromatolites is always a matter of debate (Walter, 1972; Fendonkin, 2003; Narbonne, 2005; Prasad et al., 2005; Knoll et al., 2006). The importance of essential minerals in lithofacies belonging from the Proterozoic–Lower Cambrian age has been debated since their discovery (Cook and Shergold, 1984; Gehling, 1999). The body plan of invertebrate fossil fauna from Neoproterozoic sediments is radial in parazoa and sponges and bilateral in metazoans such as mollusks, annelids, and arthropods (Fedonkin, 2003; Narbonne, 2005; Maithy and Babu, 1997; Chen et al., 2000). The earliest macroscopic fossils representing worms are traces formed on the bedding planes of Mesoproterozoic sandy facies from Australia and India (Seilacher et al., 1998; Maithy and Babu, 1988).

The oldest invertebrate fossil is a parazoan in the Porifera. A new body fossil and oldest tissue-grade colonial eukaryotes have been reported from India and Canada (Maithy and Babu, 1986; Fedonkin and Yochelson, 2002). Probable Proterozoic fungi and the origin of the bilaterian body plan with the evolution of a developmental regulatory mechanism have been discussed by Davidson et al. (1995) and Butterfield (2005).

The present findings are added to earlier records from Pre-Ediacaran up to Mesoproterozoic sediments in the world. The discovery of triploblastic fossils (Seilacher et al., 1998) and small shelly faunas (Azmi, 1998) a decade ago generated controversy regarding the age and nature of metazoans from lower Vindhyan sediments. In an attempt to resolve this issue, micropaleontological infor-mation on prokaryotes and protists from overlain and underlain glauconitic limestone of the Vindhyan Supergroup in the Paisuni and Son River valleys has been studied (Prasad et al., 2005). Gregory et al. (2006) recently summarized their age as indicated by various methods. Recently published report (Bengston et al., 2009) proofs more than a billion years older origin for the “Cambrian fossils” reported by Azmi (1998). In some parts of the world, earlier recorded annelid fossils are preserved in bedding planes of Mesoproterozoic rocks; these are actual annelid fossils rather than uninformative artifacts of inorganic origin or pseudo-fossils.

The body wall of invertebrates including annelids may fail to fossilize due to microbial action and post-mortem disintegration. Earlier reported worms from Neoprote-rozoic sequences are cellularly preserved organisms without the well-marked essential affinities of worms and possibly have most decay-resistant reproductive parts of some prokaryotes in persisting biocommunties. The paucity of multicellular epibiont and endolithic microbiota from this transitional zone suggests that they were either destroyed or survived due to changes of habit and habitat, such as adoption of hibernation, decrease of size, or distorted OWM with certain ornamentation. The extant microbiocommunties appear to be the most sensitive and tolerant. According to Darwinian law, repro-ductive success would be enhanced by changing their lifestyle and physiology to better fit a prevailing ecosys-tem that was created by abrupt changes due to natural disaster during deposition, probably by mucoci-liary creeping or peristaltic crawling on sandy facies, and hibernating in soil for their existence.

The reported annelid fossils appear to be true tube dwellers, the tubes of which may be composed of mucus and hardened to a parchment- like consistency and upon which particles of sand or shell stick together. A secretion of lime is then laid down on this mucous framework. The worms reported were up to 4470 m deep sediments and the extant form found in sand and mud was up to 5550 m deep. The nature has provided appropriate strength to persist during the Columbia and Rodinia supercontinent assembly, and its convergent range is ca. 19000 to 1100 Ma (Karlstorm et al., 2001; Rogers et al., 2003) . It is our assumption that the third law of Newton could be most appropriate to this view.

Metazoan findings in the present study are the most significant for Precambrian sediments. They also speak to a hypothesis based upon a Paleogene floral assem-blage, eucalyptus and their geographical distribution in three continents (Mehrorta, 2003); extant annelid earthworms are mostly found in the duff beneath these trees (Bhal, 1950). The comprehensive analyses of geographical distributions of dinosaurs with natural calamities (such as craters) in time strongly support the same view based on other data.

Conclusion

The composition and distribution of the present findings, published data on palaeobiology as well as on extant forms from the Vindhyan and elsewhere in the world, indicate the Calymian age and complex geodynamics, stable and unstable environments of the upper part of the Semri group, and it also reflects the divergence of this animal phylum in the terminal Proterozoic followed by a monophyletic process. One can confidently say that most probably India, Australia and South America were together as one supercontinent, Gondwana, at that time based on comprehensive analysis of synergetic data.

ACKNOWLEDGEMENTS

The authors are thankful to Dr. N. C. Mehrotra, Director, Birbal Sahni Institute of Palaeobotany, Lucknow, India for providing necessary facilities and permission to publish research work in prestigious journal. The authors are highly indebted to Prof. Steve Westrop, and Dr. Sandy Dengler, University of Oklahoma for critical review and admirable suggestions of the manuscript.

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