
Upper Vindhyan biota and Precambrian/Cambrian Boundary

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The upper age limit of the Vindhyan Supergroup is yet a point of debate. The evidences from structural biological remains, megafossils and organic-walled microfossils, from the Bhander Group support the view that the upper age limit of Vindhyan Supergroup does not extend beyond Vendian. This fact also gets support by the absence of Ediacaran fauna and vendotaenids in Bhander. All the evidences now point to the fact that the deposition of the Vindhyan sediments ceased before the Precambrian/Cambrian Transition interval.

Key-words — Organic-walled microfossils, *Obruchevella*, Bainsi, Bhander Group, Vendian (India).

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सारांश

उपरि विन्ध्य जीविता एवं कॅम्ब्रिय-पूर्व/कॅम्ब्रिय सीमा

प्रभात कुमार माइती एवं रूपेन्द्र बाबू

विन्ध्य महासमूह की ऊपरी आयु सीमा अभी भी विवादास्पद है। भन्डेर समूह से प्राप्त जीवन के प्रमाण, गुरुजीवाश्म तथा कार्बनिक-भित्तिदार सूक्ष्मजीवाश्म इस कथन को पुष्टी करते हैं कि विन्ध्य महासमूह की ऊपरी आयु सीमा वेन्डियन से अधिक नहीं हो सकती। भन्डेर में एडियाकरन जीवजात और वेन्डोटीनिडों की अनुपस्थिति भी इसकी द्योतक है। अभी तक उपलब्ध सभी प्रमाणों से यह व्यक्त होता है कि विन्ध्य अवसदों का निक्षेपण कॅम्ब्रिय-पूर्व - कॅम्ब्रिय परिवर्तन के पहले ही रुक गया था।

THE age for the upper limit of the Vindhyan sediments had been a controversial topic since long. Geologists, palaeobiologists and physicists have given different opinions. Oldham (1893) suggested a Cambrian age for the Vindhyan. Auden (1933) stated that the age of the Vindhyan may be anything from Algonkian to Devonian. Sitholey *et al.* (1953) assigned a Cambrian age to Upper Vindhyan. Boileau (quoted in Krishnan & Swaminathan, 1959) considered the topmost bed of Vindhyan to be Lower Carboniferous. Salujha (1982) on the basis of palynological studies, extended the upper limit of the Vindhyan up to Early Silurian.

Contrary to this, Sarkar *et al.* (1964) considered the upper age limit of the Vindhyan to be less than 600 Ma because they unconformably overlie the folded Malani Rhyolites. Maithy and Mandal (1983) assigned a Late Proterozoic age to Shikaoda Sandstone (= Upper Bhander Sandstone). Later, Maithy and Meena (1989), on the basis of their biotic studies,

considered the upper limit of the Vindhyan to be 600 Ma. Rao *et al.* (1977), on the basis of their study on stromatolites put the age of Upper Vindhyan from 900-600 Ma.

Geophysical dates are not available for the upper part of the Bhander Group. The only date available is by the fission track method for Bundi Hill Sandstone (= Lower Bhander Sandstone), i.e., \pm 650 Ma (Srivastava & Rajagopalan, 1988). Crawford and Compston (1970), on the basis of their Rb/Sr isochron, put a younger age limit (550) Ma for the uppermost Vindhyan bed.

The Bhander Group is the youngest group of the Vindhyan Supergroup. The generalised lithostratigraphic scheme for the different formations of Bhander Group are detailed below (after Sastry & Moitra, 1984). This scheme is useful for large part of the Vindhyan Basin. Slight modifications owing to the absence or addition of one or two formations may be required in other areas of the basin.

- BHAVPURA SHALE FORMATION
(= DHOLPURA SHALE)
- BALWAN LIMESTONE FORMATION
(= UPPER BHANDER LIMESTONE)
- SHIKAODA SANDSTONE FORMATION
(= UPPER BHANDER SANDSTONE)
- SIRBU SHALE FORMATION
- BUNDI HILL SANDSTONE FORMATION
(= LOWER BHANDER SANDSTONE)
- LAKHERI LIMESTONE FORMATION
(= LOWER BHANDER LIMESTONE)
- GANURGARH SHALE FORMATION

BIOTIC ANALYSIS

Ganurgarh Shale Formation

Maithy and Babu (1993, p. 49) recorded organic-walled microfossils from an outcrop exposed along the railway cutting about 2 km west of Mid-Ghat, Bhopal District, Madhya Pradesh. The recorded OWM are remarkable and comprise acritarch (simple with incipient processes), tubular filament and multicellular sheath. The acritarch are *Leiosphaeridia sensu* Jankauskas, *Granomarginata*, *Symplastosphaeridium*, *Vavosphaeridium*, *Nucellosphaeridium* and *Cymatospheroides*. The filamentous tubular forms are represented by aseptate simple tubes clumped together in filamentous sheath, comparable to *Polythricoides lineatus* Jankauskas.

This assemblage resembles the Neoproterozoic of Arcoona Quartzite Member of the Tent Hill Formation, South Australia (Damassa & Knoll, 1986); grey black shales of Kubis and Schwarrand subgroups of the Nama Group (Germs, Knoll & Vidal, 1986); Upper Vendian of Baltic region (Volkova, 1969; Korkutis, 1981); Assemblage III, Upper Redkino in the bore holes of Zimne Gorey in the Valdai Series, north western Arkhangelesk District (Ragozina & Sivertseva, 1990).

Lakheri Limestone Formation (= Lower Bhander Limestone)

Interesting macrofossils (structural biological remains and ?ichnofossils) and organic-walled microfossils are now better known. OWM were recorded previously by Maithy and Gupta (1983) and Maithy and Meena (1989). The reported forms are as follows.

Algae—*Sphaerophycus parvum*, *Myxococcoides psilata*

Septate tubular forms—*Biocatenoides sphaerula*, *Gunflintia minuta*

Aseptate tubular forms—*Eomycetopsis* sp., *Animikiea septata*

Acritarch—*Protosphaeridium*, *Orygmatosphaeridium*, *Kildinosphaera*

PLATE 1

Magnification : (figs 1-19, 22, 23 as per bar in fig. 6; figs 20, 21 as per bar in fig. 21; figs 24, 25 as per bar in fig. 24).

1. *Siphonophycus*, Slide no. BSIP 11908; Lakheri Limestone Formation, Khemri-Kotar, Satna District, M.P.
2. *Eomycetopsis*, Slide no. BSIP 11908; Lakheri Limestone Formation, Khemri-Kotar, Satna District, M.P.
- 3, 17. *Octaedryxium*, Slide no. BSIP 11910; Lakheri Limestone Formation, Bainsikuan, Rewa District, M.P.
- 4, 7, 12. *Sphaerocongregus variabilis*, Slide no. BSIP 11911; Sirbu Shale Formation, Khemri-Kotar, Satna District, M.P.
5. *Micrhystridium*, Slide no. BSIP 11906; Lakheri Limestone Formation, Bainsikuan, Rewa District, M.P.
6. *Margominuscula*, Slide no. BSIP 11912; Lakheri Limestone Formation, Bainsikuan, Rewa District, M.P.
8. *Sphaerophycus parvum*, Slide no. BSIP 11909; Lakheri Limestone Formation, Khemri-Kotar, Satna District, M.P.
9. *Biocatenoides*, Slide no. BSIP 11909; Lakheri Limestone Formation, Khemri-Kotar, Satna District, M.P.
10. *Granomarginata*, Slide no. BSIP 11909; Lakheri Limestone Formation, Khemri-Kotar, Satna District, M.P.
11. *Favosphaeridium*, Slide no. BSIP 11911; Sirbu Shale Formation, Khemri-Kotar, Satna District, M.P.
13. *Sphaerophycus mirabilis*, Slide no. BSIP 11908; Lakheri Limestone Formation, Khemri-Kotar, Satna District, M.P.
14. *Cymatosphaera*, Slide no. BSIP 11910; Lakheri Limestone Formation, Bainsikuan, Rewa District, M.P.
15. *Melanocyrrillum*, Slide no. BSIP 11910; Lakheri Limestone Formation, Bainsikuan, Rewa District, M.P.
- 16, 23. *Eosynechococcus* sp., Slide nos. BSIP 11906, 11914; Lakheri Limestone Formation, Khemri-Kotar, Satna District, M.P.
22. *Euontophysalis*, Slide no. BSIP 11913; Lakheri Limestone Formation, Khemri-Kotar, Satna District, M.P.
- 18, 19. *Obruchevella varra*, Slide no. BSIP 11907; Lakheri Limestone Formation, Khemri-Kotar, Satna District, M.P.
20. Single trails, Specimen no. BSIP 37772; Lakheri Limestone Formation, Bainsikuan, Rewa District, M.P.
21. Paired trails, Specimen no. BSIP 37773; Lakheri Limestone Formation, Bainsikuan, Rewa District, M.P.
- 24, 25. *Sekwia eccentrica*, Specimen nos. BSIP 37774, 37775; Lakheri Limestone Formation, Bainsikuan, Rewa District, M.P.

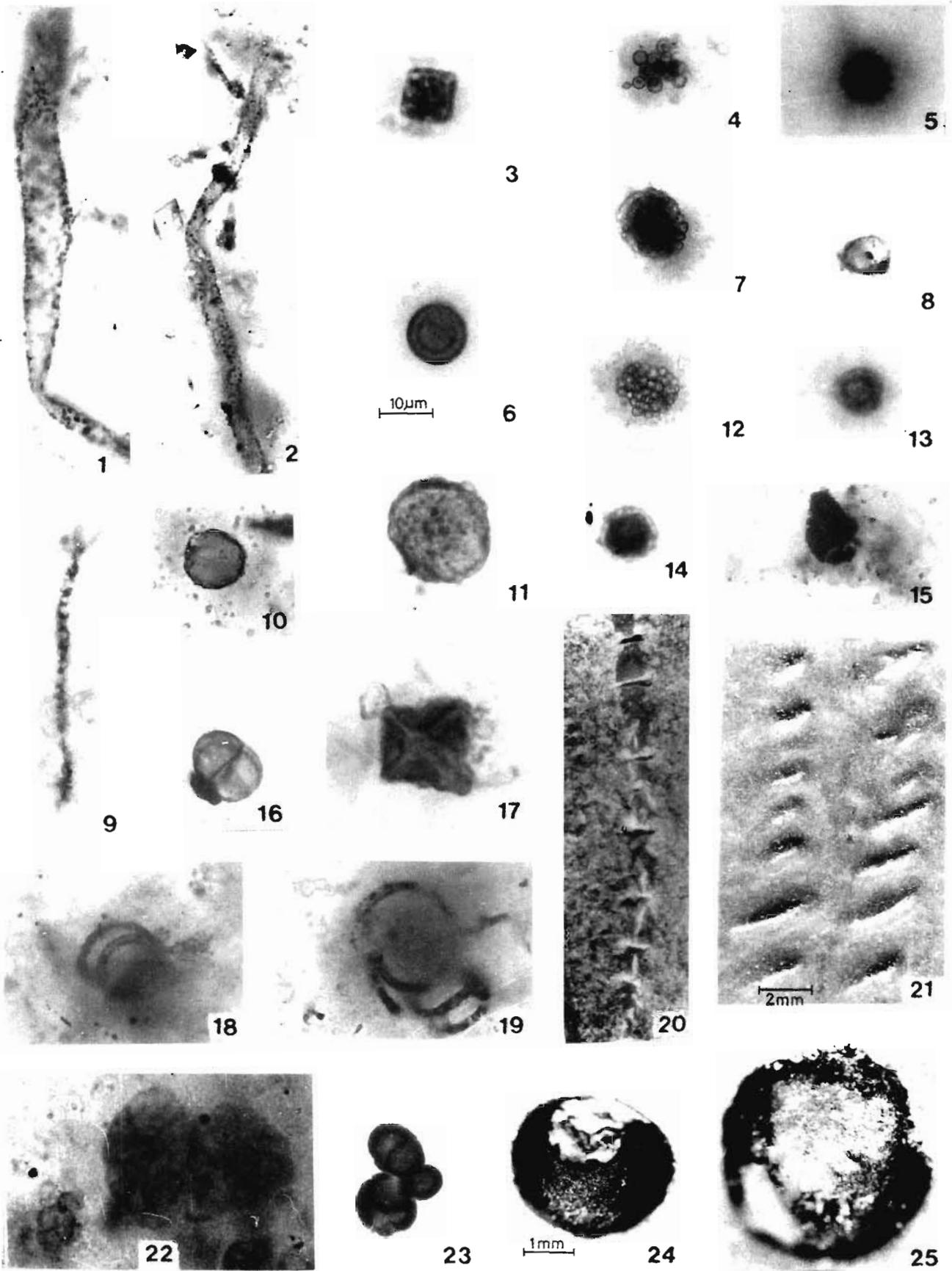


PLATE 1

Recently, Maithy and Babu (1994) have reported endosporulating cyanobacteria *Sphaerocongregus variabilis* Moormann from Damoh. This form is a global biostratigraphic marker for the Vendian (Zang & Walter, 1992).

Several marker OWM have been recorded by us in our recent studies in the black chert from Bainkuian, Rewa District. The acritarch forms are *Micrhystridium* (Pl. 1, fig. 5), *Cymatiosphaera* (Pl. 1, fig. 14), *Margominuscula* (Pl. 1, fig. 6) and *Octaedryxium* (Pl. 1, figs 3, 7). The last form is a Vendian marker. In addition, vase-shaped microfossil *Melanocyrrillium* Bloesser (Pl. 1, fig. 15), a Neoproterozoic form, is also recorded.

The study on the silicified oncolites from the Khemri-Kotar, Satna District has shown the presence of unbranched tubular aseptate forms referable to *Biocatenoides* (Pl. 1, fig. 9), *Eomycetopsis* (Pl. 1, fig. 2), *Siphonophycus* (Pl. 1, fig. 1), *Granomarginata* (Pl. 1, fig. 10), and the spirally coiled form *Obruchevella varra* (Pl. 1, figs 18, 19) along with the coccoid form *Sphaerophycus parvum* (Pl. 1, fig. 8), *Sphaerophycus mirabilis* (Pl. 1, fig. 13), *Eosynechococcus* sp. (Pl. 1, figs 16, 23) and *Eoentophysalis* (Pl. 1, fig. 22). Presence of *Obruchevella* is significant as it is commonly known from the Vendian though it ranges up to the Cambrian.

In Samaria Shale Formation, Maithy and Mandal (1983) reported *Gloeocapsamorpha karaultensis* and *Orygmato-sphaeridium plicatum*. So far *Gloeocapsamorpha* is known to occur from Neoproterozoic onwards, but is not known to occur in the Mesoproterozoic.

From Bainkuian (Rewa District), megafossil *Sekwia excentrica* Hofmann 1981 is reported for the first time in the Vindhyan. This form was previously recorded from the Neoproterozoic of Sekwi Brook area, Mackenzie Mountain, north-west Canada. The Bainkuian specimens are preserved as discoidal cast (Pl. 1, figs 24, 25) measuring 2-4 mm in diameter with a distinct globular area, which may be eccentric. Hofmann (1981) considered this form to be possibly medusoid. However, it shows morphological similarity to cocoons of Annelida.

Doubtful 'ichnofossils' (surface trails) are known from Bainkuian, Rewa District. The forms are preserved as paired trails (Pl. 1, fig. 21), single trails (Pl. 1, fig. 20) and reentering trails.

Bundi Hill Sandstone Formation (= Lower Bhander Sandstone)

Maithy and Mandal (1983) reported the presence of OWM *Protoletosphaeridium*, ? germinating cell and ? budding cell from the Karauli-Sapotra region of northeast Rajasthan. Signatures of biogenic activity were registered in the form of burrows and bioturbation of sediments from the siliclastic tidal flat deposits of Bundi Hill Sandstone exposed around Maihar, Satna District (Chakrabarti, 1990). The burrows vary from large-diameter, near-vertical stubby forms to microscopic thread-like feature cutting across the physical sedimentary structures. Thin section study of the large-diameter burrows (Chakrabarti, 1990) shows two different patterns in the nature of burrow fill — (i) staggered concave upward internal laminae showing broad based 'U' in 'V' structures resembling *Monocraterion*, and (ii) an ill-defined arrangement of the upward laminae of the burrow fill, the stubby thumb-like burrow being bordered by clay lining on the burrow wall. On the basis of this evidence Chakrabarti (1990) fixed the age of Lower Bhander Sandstone Formation at a much younger level than Late Riphean, possibly Late Precambrian.

Sirbu Shale Formation

The Sirbu Shale Formation preserves OWM comprising algal filaments and acritarch (Maithy & Mandal, 1983; Maithy & Meena, 1989), e.g., *Archaeorestis*, *Taeniatum*, *Eomycetopsis*, *Gunflintia minuta*, *Sphaerocongregus variabilis*, *Letosphaeridia*, *Granomarginata* and *Baltisphaeridium*. The assemblage is lacking in acanthomorphic acritarch, but is dominated by *Letosphaeridia* which were earlier assigned to *Kildtnosphaera*, *Orygmato-sphaeridium* and *Protosphaeridium*. A recent examination of the Sirbu Shale of Satna-Maihar and Bundi-Kota sections adds to our knowledge the presence of *Favosphaeridium* (Pl. 1, fig. 11) and *Sphaerocongregus variabilis* (Pl. 1, figs 4, 7, 12).

Shikaoda Sandstone Formation (= Upper Bhander Sandstone)

Algal forms and acritarch have been reported by Maithy and Mandal (1983, 1984) in the siltstone and shale beds exposed 2 km north of Karauli on Hindaun Road. The recorded remains are *Corymbococcus*, *Vindhyacapstopsis*, *Palaeoglaucocystis*, ? germinating cell and *Granomarginata*.

The form *Vindhyacapsiopsis* has previously been reported from the Proterozoic of Queensland (Licari *et al.*, 1969; *Eucapsiopsis*?)

Balwan Limestone Formation (= Upper Bhandar Limestone)

So far only one form of stromatolite *Collenta* is known from this bed (Prasad, 1980).

Bhavpura Formation (= Dholpura Shale Formation)

The Bhavpura Shale Formation constitutes the youngest stratigraphic unit of the Vindhyan Supergroup (Prasad, 1984). This bed is exposed only at Lakheri, Rajasthan. Maithy *et al.* (1992) claimed the presence of Ediacaran(?) biota in the ferruginous siltstone exposed approximately at the base of a small hillock near Bhavpura (25° 41' : 76° 13') and referred them to *Cyclomedusa davidi*, *Medusimites asteroids* and *Beltaneformis brunsaе*. The former two forms show more or less circular outline with central circular area as in the forms referred to *Cyclomedusa*. The outer area shows concentric and radial thickenings. Sharma *et al.* (1992, p. 30, text-figs 25, 26) have without examining the described specimens (according to them the specimens are not available in BSIP repository), considered them to be a product of weathering and to be non-fossils. To us the statement of Sharma *et al.* (1992) seems to be a biased one as all the specimens show well-organised distinct organisation and are still available for examination in the BSIP repository. A re-examination of the so-called Ediacaran forms reveals that they show similarity to the forms recently recorded as sponges by Gehling and Rigby (1996) from the Neoproterozoic of South Australia.

CONCLUDING REMARKS

Knoll and Walter (1992) favoured a Proterozoic-Cambrian boundary at ± 540 Ma. According to them the end of the Proterozoic Eon was a time of pronounced biological, biogeochemical, climatic and tectonic changes. Worldwide the latest Proterozoic shows the presence of Ediacaran animals and comprises a morphologically distinctive fauna of architecturally simple, unskelatalised invertebrates. The Ediacaran fossils are known now from at least 24 localities. There is a general agreement that Ediacaran assemblages occur only in a discrete interval of latest

Proterozoic time, but it is not clear whether all assemblages are strictly coeval.

According to Crimes (1987) ichnofossils provide additional and largely independent evidence of Proterozoic animal evolution. The assemblages of simple tracks, traces and burrows found in Proterozoic rocks are distinct from those in basal Cambrian and younger deposits, and they seem to be recognisable globally in siliciclastic sediments.

Likewise fossil protists and prokaryotes have important role in marking the Terminal Proterozoic. According to Knoll and Walter (1992) photosynthetic organisms are abundantly represented in the uppermost Proterozoic rocks, but their stratigraphic potential varies widely. Seaweeds are morphologically complex, but they get rarely preserved. However, exceptions are there. The problematic organic ribbons known as vendotaenids occur regularly in the uppermost Proterozoic sediments (Gnilovskaya, 1990). Cyanobacteria and cyanobacteria-like microfossils are widely distributed in the uppermost Proterozoic rocks, but all have close similarities both to the older fossils and living taxa. Amongst the known forms, *Sphaerocongregus* is recognised as Vendian marker and the helical *Obruchevella* is known to occur in uppermost Proterozoic and Lower Cambrian. The most important fossils for Neoproterozoic biostratigraphy are the acritarch, and organic-walled microfossils produced by the phytoplanktonic protists. Both sphaeromorphic and acanthomorphic forms have useful role in correlating the rocks of Neoproterozoic-Cambrian succession. Recent studies show that the size of sphaeromorphids increases towards the close of Proterozoic. Contrary to this the acanthomorphic forms are larger in size in Neoproterozoic and show gradual reduction towards Precambrian/Cambrian transition. But the processes are complex and more in length particularly Cambrian onwards.

In recent years isotopic chemostratigraphy has played a significant role in correlation of Precambrian/Cambrian transition. Detailed isotopic curves for the Neoproterozoic Eon show marked variation and changes in the world ocean and as such provide a useful stratigraphical signal.

Analysis of the recorded biological remains from the Bhandar Group indicates total absence of Ediacaran fauna and Vendotaenids. The organic-

walled microfossils are marked by the Vendian forms. The *Leiosphaeridia* shows increase in size, however, the known marker acanthomorphic acritarch of the uppermost Proterozoic sediments are totally absent. The ichnofossils so far recorded from the Bhandar Group also do not show any similarity to the ichnofossils of Neoproterozoic. Recently S.K. Bhattacharya of P.R.L. investigated the $\delta^{13}\text{C}$ from the Lakheri Limestone Formation provided by us. According to his analysis the $\delta^{13}\text{C}$ shows positive excursion of ± 2.9 to ± 4.0 . Therefore, all the evidences presently indicate that the upper limits of Vindhyan extend only up to Vendian and not beyond. Most probably due to regression of sea level the sedimentation in the Vindhyan ceased much before the Precambrian/Cambrian Transition interval.

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