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DISCOVERY OF *OBRUCHEVELLA* REITLINGER, 1948 FROM THE LATE PALAEOPROTEROZOIC LOWER VINDHYAN SUCCESSION AND ITS SIGNIFICANCE

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ABSTRACT

Appearance of *Obruchevella* Reitlinger, 1948, is considered to represent a major event in the evolution of the Proterozoic microbial community from its simple straight tubular morphology to that of a helix. Its occurrence marks a step forward in the evolutionary ladder of the biotic development during the Precambrian time interval.

The present paper records the occurrence of *Obruchevella* Reitlinger from the Salkhan Limestone Formation of the Son Valley area of Sonbhadra district of Uttar Pradesh, a geochronometrically well-constrained horizon of the Vindhyan Basin. The present report indicates that it is the earliest occurrence of *Obruchevella* Reitlinger, 1948 that belongs to the latest Palaeoproterozoic time interval. Two species, viz. *Obruchevella parva* and *Obruchevella pussilla,* comprising 11 specimens have been recovered from 4 thin sections. An attempt has been made to evaluate the present occurrence in the light of previous records from other Indian basins and its global significance in early biotic evolution.

Key words: Vindhyan, Proterozoic, fossils, evolution, *Obruchevella* Reitlinger.

INTRODUCTION

In recent years, the occurrence of Proterozoic fossils has brought the Vindhyan Basin into global focus. A variety of fossil assemblages has recently been discovered in Meso-Neoproterozoic succession of the Vindhyan Basin. Its micro-fossil entities mainly comprise filamentous and coccoid forms of various morphotaxa besides some unusual fossils, sphaeromorphs and acritarchs.

In the evolution of Precambrian life, the fossil finds reported from the Vindhyan Basin in recent years have been found to be quite significant and have raised considerable interest among Precambrian palaeobiologists. These reports pertain to the findings of *Grypania* (Kumar, 1995), *Chuaria* and *Tawuia* (Mathur, 1982) and putative traces believed to be made by triploblastic animals over 1.0 Ga ago (Seilacher, Bose and Pflüger, 1998). One taxon which has drawn maximum attention of palaeobiologists, is the helically coiled form *Obruchevella* Reitlinger, 1948 on account of its typical morphology (Mankiewicz, 1992). Although its unconfirmed record dates back to the ? Archean times (Gunia, 1984), its rather meagre development in Mesoproterozoic (Riphean) (Schenfil, 1980) followed by its widespread occurrence in the Late Neoproterozoic (Song, 1984) and bloom in the Early Cambrian (Mankiewicz, 1992) designates it a very special status amongst several palaeobiological communities of the Precambrian time. It has been convincingly considered as an important fossil of the Proterozoic Era with its extension into the early Cambrian. As an oddity, one report from Siberia suggests its latest occurrence in the Devonian (Chuvashov, Yuferev and Luchinina, 1985); however, in the absence of its reproducibility from the horizon, questions have been raised about its extension into the younger Palaeozoic strata (*Personal communication*).

The genus *Obruchevella* Reitlinger was first reported by Reitlinger (1948) from the Siberian Platform. So far, about 24 species of *Obruchevella* are known perhaps with overlaps of taxonomic identifications. *Obruchevella* is known to occur in a number of lithologies such as compressed phytoleims, as silicified form, calcareous, phosphatic fossils, etc. It has been compared to the Recent cyanobacteria *Spirulina* and *Arthrospira* in view of its morphologic closeness with them.

In India, *Obruchevella* has been previously reported from the Deoban Group (Cryogenian) (Rai, Kumar, Singh and Gautam, 1996; Srivastava and Kumar, 2003), Krol Formation (Ediacaran) (Kumar

and Rai, 1992) and the Tal Formation (Tommotian) (Ahluwalia and Bhargava, 1989) of Lesser Himalaya. So far its occurrence from the peninsular Indian basins have not been well reported, although cursory mentions have been made (Maithy and Babu, 1997; Rai, 2003).

Earlier reports indicate *Obruchevella*'s occurrenc in the inner sedimentary belt of the Deoban Group, which was recorded from the petrographic thin sections of the samples from bedded black chert horizons (Rai *et al.*, 1996). Similarly, in the outer sedimentary belt of the Krol Belt, *Obruchevella* was recorded from two distinct horizons of the Krol A Member of the Krol Formation (Kumar and Rai, 1992) and the Chert Member of the Tal Formation (Ahluwalia and Bhargava, 1989). Tiwari (1996) reported *Obruchevella* from the Infrakrol Formation. The Krol Formation is Ediacaran in age, whereas the Tal Formation is Tommotian (Early Cambrian) in age. In both these horizons, the *Obruchevella* specimens occur within the bedded black chert layers. A helically coiled, phosphatized specimen *Spirellus shankeri* was recovered from the acid macerates of the Tal chert-phosphorite unit (Peel, 1988).

The present note reports *Obruchevella* from the Lower Vindhyan succession of the Son Valley area (the Salkhan Limestone Formation of the Semri Group) and points out the evolutionary significance of this record in the Precambrian stratigraphy.

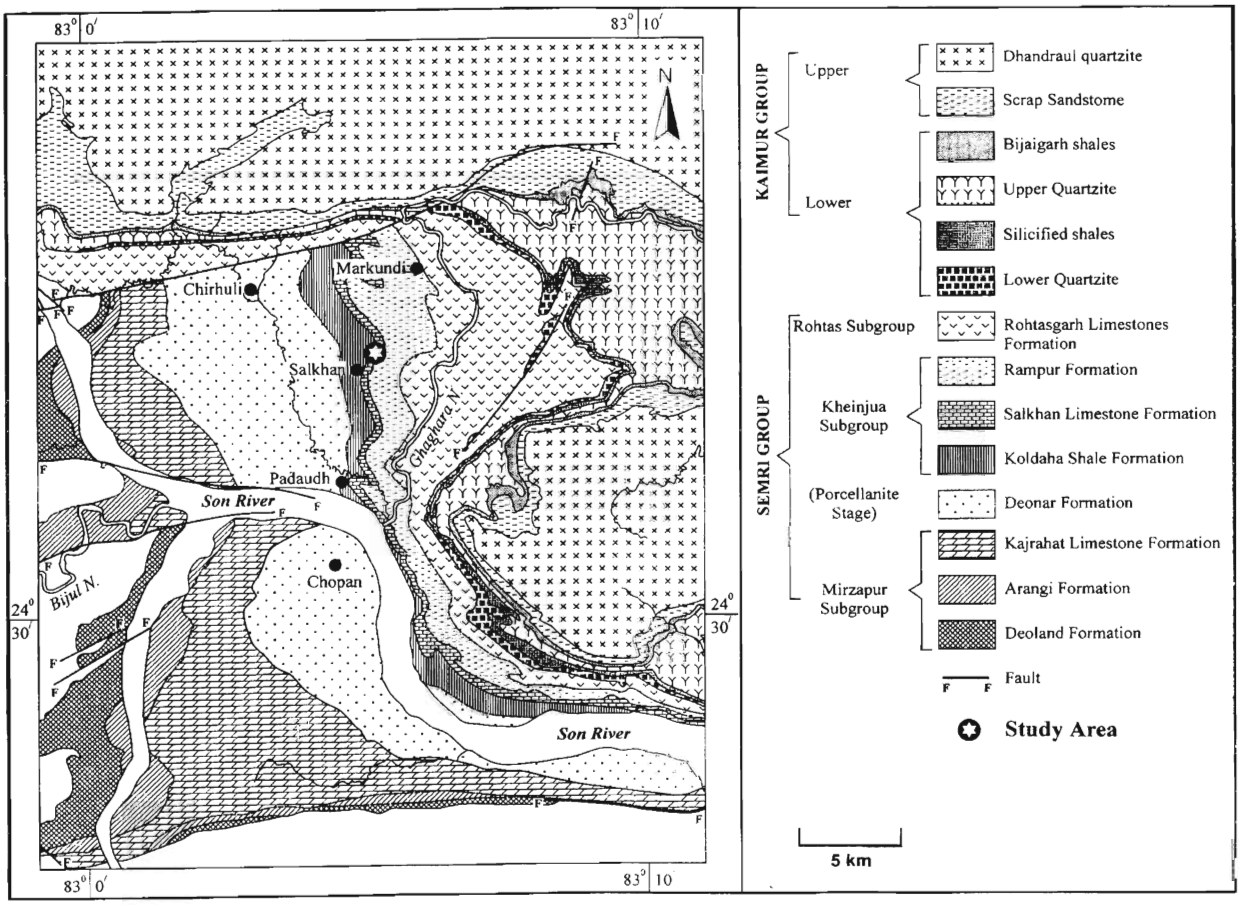


Fig. 1. Geological map of the part of the Vindhyan Basin in the Chopan area (modified after Auden, 1933 and Sastri and Moitra, 1984).

GEOLOGICAL SETTING

The *Obruchevella* yielding stromatolitic/ cryptalgalaminated succession of the Salkhan Limestone Formation is exposed in the Salkhan hill close to the Robertsganj-Chopan road (lat.24° 35' N, long.83° 04' E). In the Salkhan hill area, the rocks of the lower Vindhyan succession are exposed. The generalized lithostratigraphy of the Vindhyan Supergroup in the Son Valley area with details of the lower Vindhyan succession is given in fig. 1.

FOSSIL ASSEMBLAGE

The Salkhan Limestone Formation, which is about 90 m thick, shows that its middle part is rich in large columnar stromatolites with *Conophyton garganicus* as its dominant element. A few other form-taxa are *Cyathotes, Ephyaltes, Mistassinia and Siren* (identified after Vlasov, 1977). Well-laminated silicified bands with laminae thickness varying from one to several millimeters show the exceptional microfabric along with microbial fossils (Singh and Rai, 2001). About 25 different microbial species have been recorded earlier with most of these belonging to cyanobacterial affinity (McMenamin, Kumar and Awramik, 1983; Kumar and Srivastava, 1995; Singh and Rai, 2003). The present record has been made from the bedded silicified horizons occurring below the stromatolite-bearing horizons.

The present Vindhyan assemblage is characterised by two species, viz. *Obruchevella parva* Reitlinger, 1948 and *Obruchevella pussilla* Golovenok and Belova, 1983. The collection shows a well-preserved single specimen of *Obruchevella parva* and ten specimens of *Obruchevella pussilla.* The latter usually occur in clusters in different orientations.

SYSTEMATIC DESCRIPTION

Phylum **Cyanophyta** Sachs, 1874

Class **Hormogonophyceae** (Geitler) Elenkin, 1934

Order **Oscillatoriates** Elenkin, 1934

Family **Oscillatoriaceae** Elenkin, 1934

Genus ***Obruchevella*** Reitlinger, 1948, emend. Yakshchin and Luchinina, 1981

Obruchevella parva Reitlinger, 1948
(Pl. I, figs. 1 – 4)

Material : Slide no. V/TNG-1A England Finder no. is Q 38/1.

Description: Spirally coiled filament with closely adjoining whorls. The filament diameter is 5.0μm. with the coil diameter about 20 μm; length of the spire is 45μm; 18-20 whorls present. No internal structure such as cross-partition, etc. are seen within the filament. Plate I, figs. 1-4 shows *Obruchevella parva* specimen under different focuses as the specimen is occurring obliquely in the slide.

Remarks: Present specimen of *obruchevella parva* shows curvilinear form placed diagonally in the chert thin section. The form can be compared with the species *Obruchevella minor* reported by Zhang (1984) from the Doushantuo Formation (Late Sinian) of western Hubei, China. However, the tightness of the coil, length and structure of the helix and internal structures within the filament distinguish it from the present species.

Horizon: Salkhan Limestone Formation (Lower Vindhyan).

Locality: Salkhan Hill, situated on the main Road on Robertsganj to Chopan highways; at about 12 km from Robertsganj in South eastern Uttar Pradesh.

Obruchevella pussila Golovenok and Belova, 1983

(Pl. I, figs. 5-11)

Material: Ten Specimens. Slide no. WS4-9: England Finder no. is T 29/1 (Fig. 5); Slide no. WS4 -9: England Finder no. is E 32/3 (Fig. 6); Slide no. WS4-22: England Finder no. is P 40/4 (Fig. 7); Slide no. V/VIN-12: England Finder no. is J 50/3 (Fig. 8,9); Slide no. V/VIN-12: England Finder no. is N 37/1 (Fig. 10); Slide no. V/VIN-12: England Finder no. is M 37/3 (Fig. 11).

Description: Tightly coiled filament with walls of adjacent whorls touching each other. The filament

diameter is 1.0 μm with the coil diameter about 4 to 7 μm; length of the spire is 5 to 12 μm; 4 to 8 whorls present. No internal structure such as cross-partition etc. seen within the filament.

Remarks: Present form of *Obruchevella pussila* shows erect form with some specimens placed vertically or diagonally in the chert thin section. The form can be compared with the species *Obruchevella minuta* reported by Allison and Awramik (1989) from the Yukon territory, Canada belonging to the Late Proterozoic to ? Early Cambrian age. Though characterised by similar dimensions, the tightness of the coils and internal structure of the helix differentiates it from the present species.

Horizon: Salkhan Limestone Formation (Lower Vindhyan).

Locality: Salkhan Hill, situated on main Road on Robertsganj to Chopan highway. The fossil yielding locality is situated at about 12 km from Robertsganj in south eastern Uttar Pradesh.

RADIOMETRIC AGE CONSTRAINTS ON VINDHYAN *OBRUCHEVELLA*

The age constraint on the Vindhyan sediments has improved considerably in recent years. Several groups of earth scientists have dated various horizons belonging to the lower Vindhyans (table 1). These dates are at variance from those dated earlier by Russians and several other Indian and foreign workers (Shukla and Sharma, 1990; Rai *et al.*, 1996).

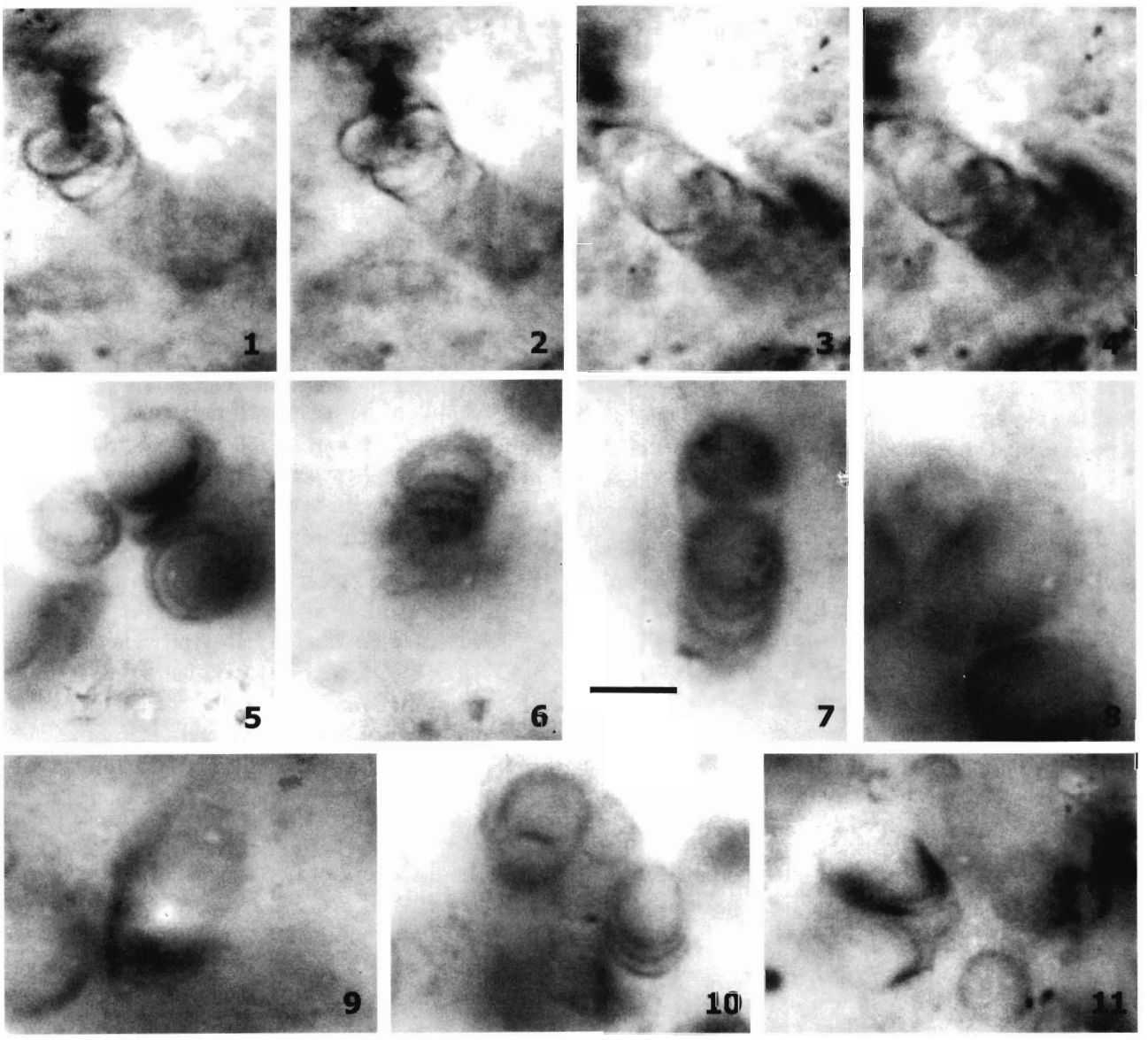
From the above geo-chronometric data, it appears that the Lower Vindhyan succession is well constrained. The uppermost part of the Semri Group, i.e. the Rohtasgarh Limestone Formation, dated at about 1600 Ma, indicates that the Lower Vindhyan sedimentation ended about 1600 Ma ago. Since the Palaeoproterozoic-Mesoproterozoic boundary has been demarcated at 1600 Ma (Gradstein *et al.*, 2004), the underlying Salkhan Limestone Formation would belong to the later part of the Palaeoproterozoic as there is a gap of about 300m between the dated horizon of the Rohtasgarh Limestone Formation and the Salkhan Limestone Formation. It can be convincingly said that the *Obruchevella*-yielding Salkhan Limestone Formation belongs to the latest Palaeoproterozoic time (Statherian)*.

DISCUSSION

1. In India, the Himalayan region has shown the presence of *Obruchevella* (Rai *et al.*, 1996; Kumar and Rai, 1992). The *Obruchevella* of the Krol Formation occurs in petrological thin sections of the cherts belonging to the Krol 'A' Member of the sequence in the Krol Hill syncline of the Solan area. It shows

Table 1. Radiometric dates of some horizons of the lower Vindhyan Succession along with the position of *Obruchevella*-bearing horizon.

S.No.	Formation	Geographical Locastion	Method	Age	Reference
1.	Rohtasgarh Limestone	Various localities in Son Valley, M. P. & Rajasthan	Pb-Pb	1601± 130 Ma	Ray *et al.* (2003)
2.	Rohtasgarh Limestone	Katni area, M.P.	Pb-Pb	1599±48	Sarangi *et al.* (2004)
3.	Rampur	Sidhi district, M.P.	SHRIMP U-Pb Zircon	1620±10 Ma 1628±12 Ma	Rasmussen *et al.* (2002)
4.	Salkhan Limestone	Sonbhadra district, U.P.		*	Present record of *Obruchevella*
5.	Deonar	Sidhi District, M.P.	SHRIMP U-Pb Zircon	1628± 8 Ma	Rasmussen *et al.* (2002)
6.	Deonar	Sidhi District, M.P.	U-Pb Zircon	1632± 5 Ma 1631± 1 Ma	Ray *et al.* (2002)
7.	Kajrahat Limestone	Sonbhadra district, U.P.	Pb-Pb	1729±110Ma	Sarangi *et al.* (2004)



EXPLANATION OF PLATE I

(Scale given is 20 microns for figures 1 to 4, and 5 microns for figures 5 to 11.)

1-4. Slide no. V/ TNG-1A showing helically coiled ***Obruchevella parva*** Reitlinger in different focuses: England Finder no. is Q 38/1.

5-11. ***Obruchevella pussilla*** Golovenok and Belova

5. Slide no. WS4-9: England Finder no. is T 29/1.

6. Slide no. WS4-9: England Finder no. is E 32/3.

7. Slide no. WS4-22: England Finder no. is P 40/4.

8, 9. Slide no. V/VIN-12: England Finder no. is J 50/3.

10. Slide no. V/VIN-12: England Finder no. is N 37/1.

11. Slide no. V/VIN-12: England Finder no. is M 37/3.

development of quite a few species of *Obruchevella* (unpublished record of VR). The Krol occurrence is Ediacaran (Vendian) in age. The occurrence in the overlying Tal Formation is observed in the lowest Chert Member where *Obruchevella* occurs both as silicified as well as phosphatized fossil. This occurrence is Early Cambrian in age. The Tal fossils are much larger than the Krol fossils. The Deoban Group of the Lesser Himalaya has also shown the development of *Obruchevella* in the chertified layers of its calcareous horizons. This occurrence is Cryogenian (Riphean) in age.

2. The Vindhyan Supergroup has been under global scrutiny because of several crucial palaeontological findings ranging from the oldest trace fossils to the occurrence of body fossils marking the Precambrian-Cambrian boundary in the succession. A large number of geo-chronometric dates generated over the last four decades for different horizons of the Vindhyan succession have been offset by the recently generated dates using highly reliable methodologies and instrumentation. The new dates from the lower Vindhyan succession suggest that the basin evolved at least half a billion years earlier than previously considered.

3. Although a host of stromatolites, carbonaceous, microbial and other fossils have been used to establish the biostatigraphy of the Vindhyan succession, very few age-diagnostic (index) fossils have been recorded.

4. *Obruchevella*, generally has been considered as a potential marker fossil in the Precambrian, its presence in the Lower Vindhyan succession indicates that the evolution of *Obruchevella* was initiated early in the Proterozoic.

5. *Obruchevella* is closely comparable to the extant form *Spirulina* (a modern cyanobacteria) which is known to contain high level nutrient substances indicating a major change in the biogeochemistry and metabolic activity of the microbial community. Therefore, the present record of *Obruchevella (O. parva* and *O. pussilla),* being the oldest occurrence, perhaps represents a major change (a biotic event) in the micro-organismic community during the Palaeoproterozoic.

CONCLUSIONS

1. The present report extends the geologic range of *Obruchevella* to the rocks older than 1600 Ma, and is perhaps the oldest record of this genus in the world. The other earlier record of *Obruchevella* from the Archean? strata seems to be deceptive as it is recorded from schist lithology from Snieznik Klodzki Massif of Poland, a likelihood of being a pseudo-fossil.

2. Although the Lesser Himalayan sedimentary basins of the Deoban Belt and the Krol Belt have yielded well-preserved fossil of *Obruchevella*, the present discovery indicates its appearance in the peninsular India as well.

3. Though the present record of *Obruchevella* is the oldest one, its finding from the well-dated Palaeoproterozoic sequence provides a precise chronologic framework for studying the biospheric evolution in this geologic time interval. The newly found occurrence clearly indicates that cyanobacterial diversification mostly happend very early and has not changed much during the past 1600 Ma or so.

4. The discovery of two species of *Obruchevella* (*Obruchervella parva* and *Obruchevella pussilla*) from the study area indicates that the palaeoenvironmental setting in the Vindhyan Basin provided a suitable ecologic niche for the growth, evolution and diversity of biotic communities more than 1,600 Ma ago, which is a testimony to the evolution being in action in the Vindhyan Basin.

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REFERENCES

Ahluwalia, A. D. and Bhargava, O. N. 1989. Petrographic classification of Phosphorites: two Alternatives. *Mem. Geol. Soc. India*, **13** : 61-73.

Allison C. W. and Awramik S. M. 1989. Organic-walled microfossils from earliest Cambrian or latest Proterozoic Tindir Group rocks, North west Canada. *Precamb. Res.* **43:** 253-294.

Auden, J.B. 1933. Vindhyan sedimentation in Son Valley, Mirzapur district. *Mem. Geol. Surv. India*, **62:** 141-250.

Chuvashov, B. I., Yuferev, O. V. and Luchinina, V. A. 1985. Algae of the Middle and Upper Devonian of western Siberia and the Urals. Palaeozoic biostratigraphy of the Western Siberia. *Trudy Instituta Geologii Ii Geo- fiziki, Sibrskoe Otdeleni, Akademiya Nauk SSSR*, 619 (In Russian).

Gunia T. 1984. Microfossis from the Quartzite Schists in vicinity of Goszow, Snieznik Klodzki Massif, Central Sudetes. *Geologia Sudetical*, **18:** 47-57 (In Russian).

Golovenok V.K. and Belova, M.Yu. 1983. Nakhodki obruchevell a rifee Patomskogo nagor'a I v vende Yuzhnogo Kazakhstana (Obrucehevellid from the Riphean of the Patom Highland and the Vendian of Southern Kazakghstan). Doklady Akademii Nauk SSSR, **272**: 1462-1465 (1985. Doklady Earth Science sections).

Gradstein, F.M., *et al.* 2004. A Geological Time Scale 2004. *Geological Survey of Canada, Miscellaneous Report*, **86**, (Poster).

Kumar, S. 1995. Megafossils from the Mesoproterozoic Rohtas Formation (the Vindhyan Supergroup), Katni area, Central India. *Precamb. Res.* **72** : 171-184.

Kumar, S. and Rai, Vibhuti, 1992. Organic Walled microfossils from the bedded black chert of the Krol Formation (Vendian), Solan area, Himachal Pradesh, India. *Jour. Geol. Soc. India*, **39** : 229-234.

Kumar, S and Srivastava, P. 1995. Microfossils from the Kheinjua Formation, Mesoproterozoic Semri Group, Newari area, Central India. *Precamb. Res.* 74 : 91-117.

Maithy, P. K. and Babu, R. 1997. Upper Vindhyan biota and Precambrian / Cambrian Boundary. *Palaeobot.* **46** (1, 2); pp 1-6.

Mankiewicz, C. 1992. Obruchevella and other microfossils in the Burgess Shale; Preservation and affinity, *Jour. Pal.* **66**(5) : 717-729.

Mathur, S.M. 1983. A new collection of fossils from the Precambrian Vindhyan Supergroup of Central India. *Curr. Sci.* **52** : 363-365.

McMenamin, D., Kumar, S., and Awramik, S. M. 1983. Microbial fossils from the Kheinjua Formation, middle Proterozoic Semri Group (Lower Vindhyan) Son valeey area, Central India. *Precamb. Res.* **21**: pp 247-271.

Peel, J.S. 1988. *Spirellus* and related helically coiled microfossils (Cyanobacteria) from the Lower Cambrian of North Greenland. *Report Gronlands Geologiske Undersogelse*, **137** : 5-32.

Rai, Vibhuti, Kumar, A., Singh, A.K. and Gautam, R. 1996. Role of alage in the formation of oncoids : an exceptional example from the bedded black chert of Deoban Formation (Meso-Neoproterozoic), Lesser Himalaya, India. *XVIndian Colloq. Micropal. Stratigr. Dehradun*, (July 1-3), 52-53.

Rai, Vibhuti, 2003. Dawn of *Obruchevella* in the Depths of the Vindhyan basin: Discovery and significance of the oldest occurrence. *XIX Indian Colloq. Micropal. Stratigr. on Rec. Dev. in Indian Ocean Paleoceanogr Paleocli., Banaras Hindu University,* 9-11 Oct. 2003 : 145.

Rasmussen, B, Bose, P.K., Sarkar, S., Banerjee, S, Fletcher, I. R. and McUcaughton, 2002. 1.6 Ga U-Pb Zircon age for the Chorhat Sandstone, Lower Vindhyan, India: Possible implication of early evolution of animals. *Geol.* **30**: 103-106.

Ray, J.S., Marin, M.W., Veizer, J. and Bowning, S.A. 2002. U-Pb zircon dating Sr isotope systemetics of the Vindhyan Supergroup; India. *Geol.* **30**: 131-134.

Ray, J.S., Veizer, J. and Davis, W.J. 2003. C, O, Sr and Pb isotope systematics of carbonate sequence of the Vindhyan Supergroup India : age, diagenesis, correlations and implications for global events. *Precamb. Res.* **121** : 103-140.

Reitlinger, E. A. 1948. Kimbrijskie foraminifery yakutii (Cambrian foraminifers of Yakutsk). *Byulletin' Moskovskogo obshchestva Ispytateki Prirody, Geologii*, **23**: 77-81.

Sarangi, S., Gopalan, K. and Kumar, S. 2004. Pb- Pb age of earliest megascopic, eucaryotic alga bearing Rohtas Formation, Vindhyan Supergroup, India: implication for Precambrian atmospheric oxygen evolution. *Precamb. Res.* **132** : 107-121.

Sastri, M. V. A. and Moitra, A. K. 1984. Vindhyan Stratigraphy- A Review. *Mem. Geol. Soc. India.* **16** : 109-148.

Schenfil, V. Yu. 1980. *Obruchevella* representatives in the Riphean of the *Yenisey ridge* region. *Doklady Earth Science Nauk* SSSR. **254**: 993-994 (In Russian)

Seilacher, J.W., Bose, P.K. and Pfluger, F. 1998. Triploblastic animals more than 1 billion years ago: trace fossil evidences from India. *Sci.* **282**: 80-82.

Shukla, M. and Sharma, M. 1990. Palaeobiology of Suket Shale, Vindhyan Supergroup-Age implications. *Spl. Pub. Geol. Surv. India*. **28**: 411-434.

Singh, A. and Rai, V. 2001. Bedding microfabric and microbial community and silicification : Discovery of exceptional preservation in ~ 1400 million year old Salkhan

Limestone Formation, Vindhyan Supergroup, India. *Biol. Mem.* **27** (2): 96-106.

Singh, V.K. and Rai, Vibhuti, 2003. Exceptionally preserved microbial mat textures from ~ 1600 Ma old Salkhan Limestone Formation, Vindhyan Supergroup, India. *XIX Indian Colloq. Micropal. Stratigr. on Rec. Dev. Indian Ocean Paleoceanog. Paleocl., Banaras Hindu University*, (9-11 Oct. 2003): 135-136.

Song, X., 1984. *Obruchevella* from the Early Cambrian Meishucun stage of the Meishucun section, Jinning , Yunan, China. *Geol, Mag.* **121**: 179-183.

Srivastava, P., and Kumar, S. 2003. New Microfossils from the Meso-Neoproterozoic Deoban Limestone, Garhwal Lesser Himalaya, India. *Palaeobot.* **52**: 13-47.

Tiwari, M. 1996. Palaeobiolgy of Late Proterozoic (Vendian) microbiota: evidences from the Infrakrol Formation of Lesser Himalaya. *Contrib. XV Indian Colloq. Micropal. Startigr.*, Wadia Institute of Himalayan Geology, Dehradun : 559-565.

Vlasov, F. Vu. 1977. Precambrian stromatolites from the Satkian Formation in the southern Urals. In: *Material on Palaeontology of Middle Palaeozoic of Urals and Siberia.* Uralian branch of Academy of Sciences, Ekatarinburg, Sverdlovskha.

Yakshin, M. S. and Luchinina, V. A. 1981. Novye dannye po iskopaemym vodoroslyam semejstva Oscillatoriaceae (Kirchn.) Elenkin (New data on fossil algae of the family oscillatoriaceae (Krichn.) Elenkin). *Trudy Instituta Geologii I GeoFiziki, Sibirskoe Otdelenie, Akademiya Nauk SSSR*, **475** : 28-34.

Zhang, Z., 1984. The occurrence of *Obruchevella* from the Toushantou Formation (late Sinian) of western Hubei and its significance. Ku Sheng Wu Hsueh Pao = *Acta Palaeontol. Sin.* **23** : 447-451.

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