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Reduviasporonites indicus sp. nov. from the Late Permian strata of Mand Coalfield, Chhattisgarh, India

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ABSTRACT

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Reduviasporonites considered as a fossil algal/fungal remain, is usually recorded at the proximity of Permian-Triassic boundary. Till date it has been reported from China, Australia, Russia, Greenland, Austria and Saudi Arabia. Here we report a new species of *Reduviasporonites* (*R. indicus*)-a very significant evidence for mass extinction event at PTB for the first time from Indian Lower Gondwana sediments of Mand Coalfield, Chhattisgarh. Recent geochemical study of *Reduviasporonites* suggests that it is of an algal origin rather than fungal. The size of the grain depends on the palaeolatitudational difference.

Key–words—Algal/Fungal remain, Late Permian, Mand Coalfield, Son-Mahanadi Basin, India.

भारत में छत्तीसगढ़ के मंड कोयलाक्षेत्र के विलंबित पर्मियन स्तरी से प्राप्त *रेडुवियास्पोरोनाइटिस इंडिकस* नवप्रजाति

राम अवतार, ए. रजनीकांथ एवं सौरभ गौतम

सारांश

जीवाश्म शैवाल/कवक अवशेष के रूप में विचारणीय *रेडुवियास्पोरोनाइटिस* सामान्यतः पर्मियन-ट्राइएसिक सीमा के सामीप्य में मिलती है। अब तक यह चीन, आस्ट्रेलिया, रूस, ग्रीनलैंड, आस्ट्रिया एवं सऊदी अरब में मिली है। हम पहली बार मंड कोयलाक्षेत्र, छत्तीसगढ़ के भारतीय अधो गोंडवाना अवसादों से *रेडुवियास्पोरोनाइटिस (आर. इंडिकस)* की एक नवीन जाति का विवरण दे रहे हैं, जो कि पी टी बी में स्थूल विलोपन घटना हेतु अति महत्वपूर्ण प्रमाण है। *रेडुवियास्पोरोनाइटिस* का अभिनव भू-रासायनिक अध्ययन सुझाता है कि यह शैवाल उद्गम है, न कि कवक तथा कण का आकार पुराअक्षांश विभेद पर निर्भर करता है।

संकेत-शब्द—जीवाश्म शैवाल/कवक अवशेष, विलंबित पर्मियन, मंड कोयलाक्षेत्र, सोन-महानदी द्रोणी, भारत।

INTRODUCTION

THE Gondwana sequence all over the southern hemisphere is known for rich plant microfossils (Goubin, 1965; Balme, 1970; Anderson, 1981; Tiwari, 1999; Venkatachala *et al.*, 1993; Helby *et al*., 1987). A fungal event was recorded globally near P/T boundary correlatable with land and marine crises (Erwin, 1993; Eshet *et al.*, 1995; Visscher *et al.*, 1996; Elsik, 1999). Many microfossils recovered near the P/T sequences have been attributed to organic walled morphologies (OWM) / chitinozoans / rotifers / acritarchs / tintinids/ coelenterates / protozoans/ algae (Pierce & Turner, 1993; Porter & Knoll, 2000; Tripathi, 2004; Afonin *et al*., 2001). Wilson (1962) has described *Reduviasporonites* as a unique spore signifying fungal event. It is characterized by flask— shaped morphology with terminal circular rim along with spore/pollen, woody material, algal, fungal spores and other organic matter.

Lithologically the sample is categorized in the Mand Coalfield, Son-Mahanadi Graben equivalent to the Raniganj Formation assignable to Late Permian age. Rich palynoassemblage comprising Late Permian palynofossils—*Faunipollenites, Striatopodocarpites, Crescentipollenites, Striatites, Rhizomaspora, Scheuringipollenites, Densipollenites, Arcu-*

atipollenites, *Trabeculosporites, Alisporites, Gondisporites, Lundbladispora, Playfordiaspora,* and *Rhizomaspora* (Charkraborti & Ram-Awatar, 2006) and others fungal spores attributed to *Tetraploa, Alternaria* and *Trichothyrites* sp. belonging to microthyriaceous fungal fruiting bodies*, Glomus,* along with *Reduviasporonites* indicates an enhanced saprophytic activity.

Age	Formation	Thickness	Lithology
Recent to Sub-Recent			Alluvial soil, pebbly to bouldery bed with silty clay band, laterite, etc.
Cretaceous	Deccan Trap	200 m+	Basaltic and doleritic flows, dykes and sills.
Lower to Middle Triassic	Supra-Panchet/ Kamthi Formation	200 m	Unclassified younger sediments, mostly mega cross-bedded, pebbly sandstone.
		280 m+	Buff coloured, course to pebbly, crossed bedded, reworked shaly clasts- bearing sandstone with abundant ferruginous sandstone band with/ without red claystone to siltstone or white marl bed at the base.
	Raniganj	180 to 200 m	Cyclic sequence of fine- to medium-grained sandstone, grey shale, claystone, carb-shale and two coal seams.
	Barren Measures	280 to 350 m	Interbanded sequence of sideritic claystone, grey shale, siltstone, and fine-grained sandstone band in the east to dominantly medium to coarse-grained sand stone with interbanded sequence of sideritic claystone, grey-shale, and light green siltstone to sandstone bands.
Upper Permian	Upper Barakar	100 to 220 m	Mostly medium- to coarse-grained sandstone, with subordinate very coarse to pebbly, massive sandstone. This fining upward sequence includes five regional coalseams (nos. V to IX) and one local coal seam (No. VIIL). Grey claystone to siltstone bands are to common at the top and bottom.
Lower Permian	Middle Barakar	140 to 200 m	Mostly coarse- to very coarse-grained sandstone with granule to pebbly sandstone at base of each depositional sequence. Fine-grained sandstone siltstone are rarely present. It contains five to six local seams (Nos. band IVL 1 to IVL 6).
	Lower Barakar	280 to 400 m	Mostly very coarse-grained to granule size arkosic sandstone with pink quartz and garnet grains and also with subordinate medium- to coarse-grained sandstones. It includes four regional coal seams (Nos.1-IV). Pebbly to matrixes-base conglomerate bands are common. Basal 40-50 m zone is fine- to medium-grained with minor siltstone.
Lowermost Permian to Upper Carboniferous	Talchir Formation	150 m+	Khaki to brownish green, siltstone, shale, fine-grained with basal boulder bed.
		----------Unconformity----------	
Late Proterozoic	Chanderpur Group		Variegated quartzes sandstone; calcareous variegated shale
		----------Unconformity----------	
Early Proterozoic	Bilaspur, Raigarh, Sundergarh Complex		Vein quartz, pegmatite, granite gneiss, massive granite

Table 1—General stratigraphic succession in the Mand Raigarh Coalfield.

GEOLOGY OF THE AREA

Chakraborti *et al*. (2002) modified the total sedimentary rocks of this basin on the lithological consanguinity into Talchir, Barakar, Barren Measures, Raniganj and Kamthi formations. The revised stratigraphic sequence is given in Table 1 (after Chakraborti *et al*. 2002).

MATERIAL AND METHODS

The material for the present investigation was collected from a borehole MJB-1, drilled by the Geological Survey of India, ~ 2.5 km north-west of Village Sithra, District Raigarh, Chhattisgarh (Figs 1 A , B). The lithological details of the samples are given in Table 2. For the recovery of spores and pollen grains, samples were ground into smaller pieces (2-3 mm in size) and treated with hydrofluoric acid (40% concentration) to dissolve the siliceous component, followed by nitric acid to digest the organic matter and finally 5-10% alkali to remove the humus. The samples were thoroughly washed with distilled water and the residue was mixed with polyvinyl alcohol and smeared over cover glass and kept for drying at room temperature. After complete drying, the cover glasses were mounted with canada balsam. The microphotographs were taken on Olympus Microscope (B.H.2 Model, No. 216294).

SYSTEMATICS

***Reduviasporonites* Wilson 1962 emend. Foster *et al.* 2002**

***Reduviasporonites indicus* n. sp.**

(Pl. 1.1-11)

Sr. No.	Sample no.	Lithology	Depth (m)
1.	MJB-1/1*	Clay stone	12.05
2.	MJB-1/2	Carbonaceous shale	39.80
3.	MJB-1/3	Carbonaceous shale	41.00
4.	MJB-1/4	Carbonaceous silty sandstone	45.80
5.	MJB-1/5	Carbonaceous shale	64.60
6.	MJB-1/6	Carbonaceous shale	78.20
7.	MJB-1/7	Carbonaceous shale	78.40
8.	MJB-1/8	Silty sandstone	112.90
9.	MJB-1/9	Coaly shale	132.80
10.	MJB-1/10	Carbonaceous shale with vitrinite lamellae	170.40
11.	MJB-1/11	Carbonaceous shale with vitrinite lamellae	188.00
12.	MJB-1/12	Coaly shale with vitrinite lamellae	193.40
13.	MJB-1/13	Coaly shale	220.00
14.	MJB-1/14	Coaly shale	316.80
15.	MJB-1/15	Coaly shale	385.00

*Productive sample

Table 2—List of samples collected from B.H. MJB-1.

Diagnosis and Description—Spore flask-shaped and brown in colour. The inner body commonly has the same shape as the outer cell and may be adpressed to the inner surface of the main cell. A wide circular orifice present at the oral pole; the arboral pole appears to be closed and solid. Mean length 110.01 µm; mean width 68.63 µm; mean oral opening

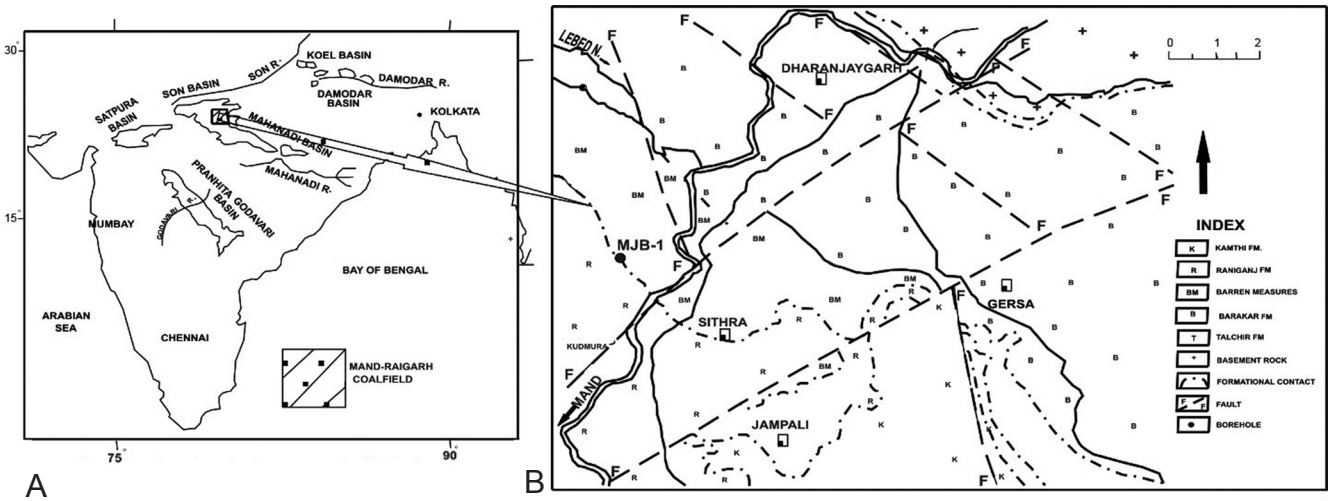

Fig. 1—A. Map showing the study area and principal Gondwana Basins of India (after Chakraborty, 2003), B. Simplified geological map showing borehole location in parts of Mand-Raigarh Coalfield (after Chakraborti *et al.*, 2002).

diameter 20.18 µm. Outer cell wall varies from 0.5-1.25 µm thick; surface of the cell wall is mostly infra–granulose rarely infrapunctate; each cell is isolated with many folds on the body surface; no internal structures have been seen.

Holotype—Plate 1, Fig. 3, BSIP Slide No. 13505 (length 107 µm, maximum width 68 µm, oral opening 20 µm in diameter).

Isotype—Plate 1, Fig. 1, BSIP Slide No. 13508 (length 114 µm, maximum width 65 µm, oral opening 27 µm in diameter).

Comparison—The present specimen is broadly comparable with *Reduviasporonites chalastus* Foster *et al.,* 2002 (pl. 4, fig. 3), but the size of the specimens is slightly bigger compared to *R. chalastus* and inner cell material is absent. Besides, cells described by Foster *et al.* (2002) are generally elongate, cylindrical, spherical, ovoid and Y-shaped, rarely flask-shaped and found generally in chains. The size of the constituent cell in *Reduviasporonites chalastus* also depends on the palaeolatitude (Foster *et al.*, 2002). All the specimens recovered in the present study are in isolated forms. Besides, the present species also differs from *R. catenulatus* (Wilson, 1962) in shape and also in the absence of concentric or subpolygonal fold patterns and terminal rims. Hence, a new species is being proposed here. Recently, Foster *et al.*, (2002) studied the geochemistry of the specimens of the topotype of *Reduviasporonites* and confirmed that it could also be attributed to algal origin. Similar algal affinity (Zygnemataceae algae) was also suggested by Krassilov *et al.,* (1999), which were later supported by Afonin *et al.*, (2001).

Locality—Borehole MJB-1, depth 12.05 m, 6 km NNW of Sithra Village, Mand Coalfield, Chhattisgarh, India.

Repository—Birbal Sahni Institute of Palaeobotany, Lucknow, India.

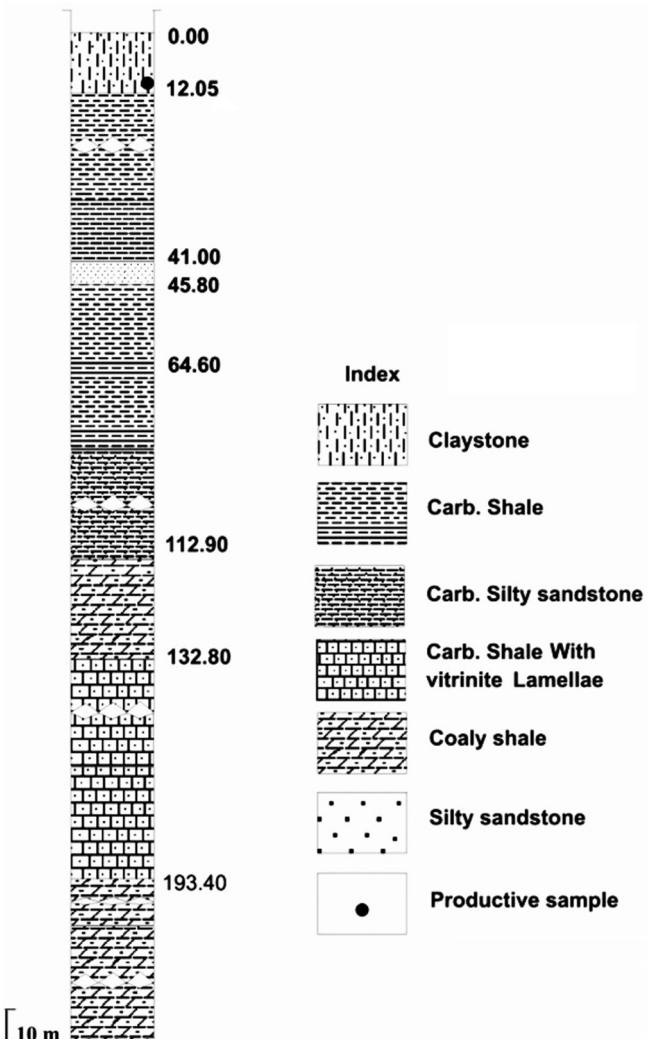

Fig. 2—Showing lithocolumn and position of productive sample.

DISCUSSION AND CONCLUSIONS

Flask-like microfossils showing superficial resemblance to different biological groups are generally treated under various categories, i.e. organic walled morphologies (OWM), rotifers, acritarchs, tintinnids, coelenterates, cysts of protozoans (VSMS), algae, fungi and others. The present specimen shows apparent resemblance with chitinozoans but differs in not having prosome (operculum) that usually seals the aperture/neck (Paris p.c.). Moreover, chitinozoans are mostly found in of Ordovician–Devonian sequences of the world. Rotifers

PLATE 1

Images of fungal spore *Reduviasporonites indicus* sp. nov.

1. *Reduviasporonites indicus* sp. nov., Slide No. BSIP 13508, Coordinates 16 x 136.
2. *Reduviasporonites indicus* sp. nov., Slide No. BSIP 13505, Coordinates 07 x 127.
3. *Reduviasporonites indicus* sp. nov., Slide No. BSIP 13505, Coordinates 10 x 136.
4. *Reduviasporonites indicus* sp. nov., Slide No. BSIP 13509, Coordinates 07 x 112.
5. *Reduviasporonites indicus* sp. nov., Slide No. BSIP 13508, Coordinates 08 x 130.
6. *Reduviasporonites indicus* sp. nov., Slide No. BSIP 13505, Coordinates 19 x 122.
7. *Reduviasporonites indicus* sp. nov., Slide No. BSIP 13508, Coordinates 06 x 123.
8. *Reduviasporonites indicus* sp. nov., Slide No. BSIP 13508, Coordinates 12 x 115.
9. *Reduviasporonites indicus* sp. nov., Slide No. BSIP 13508, Coordinates 12 x 116.
10. *Reduviasporonites indicus* sp. nov., Slide No. BSIP 13509, Coordinates 11 x 116.
11. *Reduviasporonites indicus* sp. nov., Slide No. BSIP 13508, Coordinates 05 x 122.

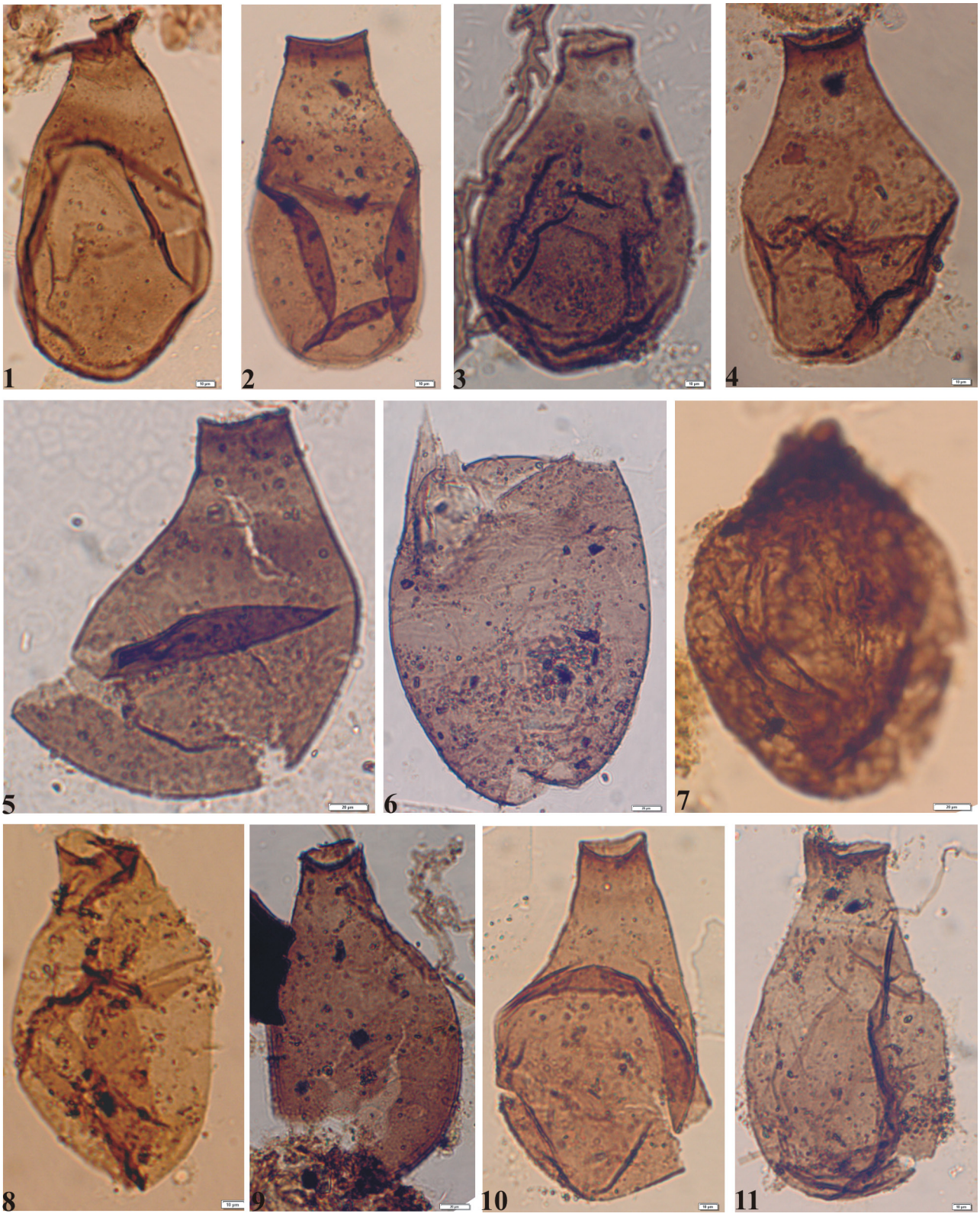

PLATE 1

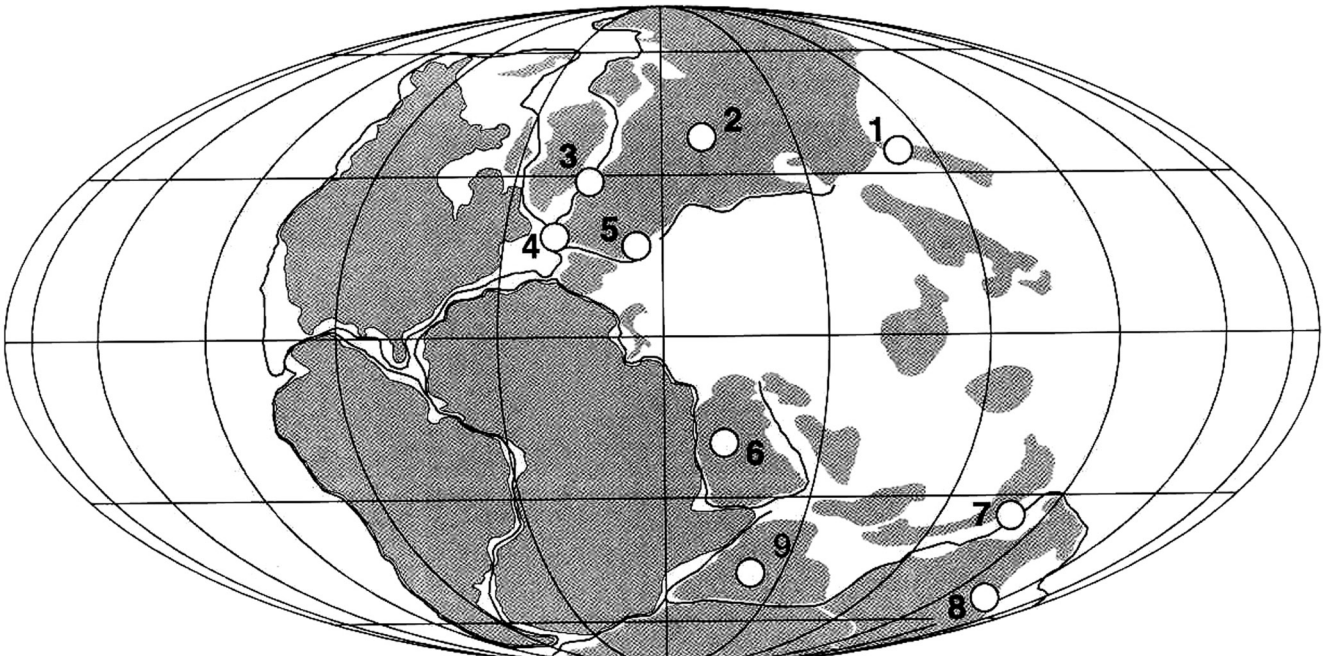

Fig. 3—Palaeogeographic map showing the position of the samples studied including present study (modified after Ziegler *et al*., 1997).

Sr. No.	Country	Formation(s)/ bed	Author(s)	Assemblage Zone	Age
1.	China	Guodikeng Fm.	Li *et al*., 1986 Ouyang & Norris, 1999	*Lueckisporites virkkiae, Alisporites* sp.	Late Permian/ Early Triassic
2.	Russia	Vetlugian Series	Lozovskiy, 1992	Oto./ Opho. zones	Early Triassic
3.	Kap Stoch, Greenland	Karstryggen Fm.	Balme, 1980	*Taeniaesporites, Protohaploxypinus*	Late Permian to Early Triassic
4.	Conisborough and Hilton plant Beds, U.K.	Hilton plant Bed	Clarke, 1965 ; Henderson & Mei, 2000	Conodonts and palynofloras	Late Permian
5.	Austria	Tesero Section	Noé, 1987 & Looy *et al*., 2001	*H. parvus* and fungi	P/T boundary
6.	Saudi Arabia	Basal Khuff clastics (Borehole DILM-1)	Stephenson & Filatoff, 2000		Late Permian
7.	Australia (N)	Rewan Formation	Foster, 1979	*Protohaploxypinus microcorpus* zone	Late Permian
8.	Australia (E)	New Castle Coal Measures	Helby, 1992	*Aratrisporites*	Early Triassic
9.	Son-Mahanadi Graben, India	Borehole MJB-1	Chakraborti & Ram-Awatar, 2006	*Gondisporites raniganjensis*	Late Permian

Table 3—Distribution Chart of *Reduviasporonites.*

are many-celled, thick-walled, flask-shaped, tubular bodies of freshwater origin and have been recorded in Quaternary sediments of West Coast of India (Limaye *et al.*, 2007). Some flask-shaped structures are also treated under coelenterates. The extant members of coelenterates such as *Cordyloflora* and a few fresh water *hydroids*, except *Hydra* (Tripathi, 2004) are marine (Buchsbaum, 1948). Similar vase- shaped microfossils (VSMS) mostly observed in thin sections (Porter & Knoll, 2000) were also recorded from the Precambrian. Identical forms were grouped under Tintinnids, which are mostly neritic, warm-water, bored and austral (Pierce & Turner, 1993).

The genus *Reduviasporonites* was initially recorded in abundance at the end of the Late Permian by Wilson (1962). Many workers speculated its maiden presence at the P/T boundary (Eshet *et al.,* 1995; Visscher *et al*., 1996; Elsik, 1999; Peng *et al*., 2006; Wood & Mangerud, 1994; Wood & Elsik, 1999; Steiner *et al*., 2003). Its occurrence is also known near P/T boundary from China, Russia, Australia, Saudi Arabia, Austria, Greenland and U.K. (Fig. 3; Table 3). The present evidence when viewed along with other plant fossil evidences such as *Glossopteris* and *Samaropsis* (Ziegler *et al*., 1997), ovoid and non-calcareous fresh to brackish-water estherids (*Palaeolimandia* sp.) indicates a brackish water environment during the end Permian times for the sequence of the borehole in the Mand Coalfield (Bandhopadhyay 1990). The present record of *Reduviasporonites* constitutes a part of palyno-assemblage studied by Chakraborti & Ram-Awatar, (2006) from borehole MJB-1 (12.05 m depth), which was assigned an age of Late Permian. The possibility of enhanced algal/ fungal activity also corroborates rich biological dynamism near the P/T boundary. The following conclusions may be drawn from the above study:

- *Reduviasporonites indicus* is a fungal rather than algal spore, because a number of other fungal/ algal remains (*Tetraploa, Alternaria* and *Trichothyrites*) have been recorded from the same horizon (Ram-Awatar, 2011).
- Size of the present specimen recorded for the first time from Late Permian sediments of Indian Gondwana is slightly bigger. This increase in size may be attributed to the latitudinal difference as discussed by Foster *et al.*, 2002.

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