Journal of The Palaeontological Society of India
Vol. 44, 1999, pp. 141-148

SILICEOUS SPONGE SPICULE-LIKE FORMS FROM THE NEOPROTEROZOIC BHANDER LIMESTONE, MAIHAR AREA, MADHYA PRADESH

S. KUMAR

DEPARTMENT OF GEOLOGY, UNIVERSITY OF LUCKNOW, LUCKNOW ,U.P., INDIA

ABSTRACT

The siliceous spicule-like forms are reported from the petrographic thin sections of a chert lens belonging to the Neoproterozoic Bhander Limestone which are comparable to the siliceous sponge spicules and can be considered to possibly represent the oldest known sponges. The presence of these forms indicates the possible existence of animal life in the Vindhyan Basin during the deposition of the Bhander Limestone.

Key words: Siliceous spicules, Sponge, Neoproterozoic, Riphean, Bhander Limestone, Vindhyan Supergroup

INTRODUCTION

The Vindhyan sediments have consistently been searched for the evidences of animal life since the discovery of carbonaceous discs by Jones in 1909. Since then, a number of reports describing animal body as well as trace fossils from the different stratigraphic horizons of the Vindhyan Supergroup appeared, but most of them are of doubtful biogenicity (for review see Venkatachala, Sharma and Shukla, 1996). More recently, the claims of discovery of small shelly fauna and brachiopods by Azmi (1998) and some bedding plane features interpreted as the burrows of worm-like undermat miners by Seilacher, Bose and Pfluger (1998) from the Semri Group (Lower Vindhyans) have been made but these discoveries were also dismissed by many workers as they doubted the organic nature of the reported fossils (see Jour. Geol. Soc. India, v. 52: pp. 120 – 130 and 481 – 500; Kerr, 1998; Brasier, 1998, 1999). As a consequence, the presence of animal life in the Vindhyan Supergroup is still looked upon with suspicion.

The present preliminary report records for the first time siliceous spicule-like structures which are comparable to with the siliceous sponge spicules. The presence of such spicule-like structures supports the existence of animal life in the Upper Vindhyan rocks as sponges constitute the Subkingdom Metazoa under phylum Porifera (de Laubenfels, 1955). These forms are being reported herein from the petrographic thin sections of the siliceous stromatolitic dolostone belonging to the Bhander Limestone of the Bhander Group. The fossil locality lies about 5 kms east of Maihar township in the Girgita mine from where the siliceous spicule-bearing sample has been collected from the eastern face of the quarry (fig. 1).

GEOLOGICAL SETTING

The Vindhyan rocks occupy an area of 104,000 sq. kms in Central India stretching from Dehri-on-Son in Bihar to Chittorgarh in Rajasthan. These

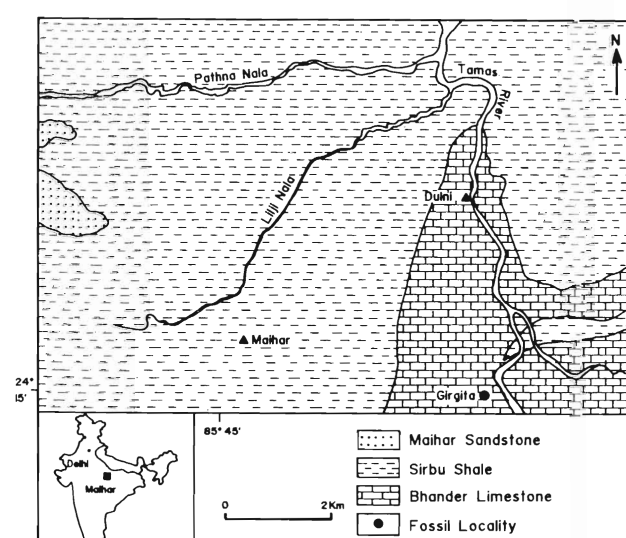


Fig. 1. Geological map of the Maihar area, Madhya Pradesh, showing the location of the sponge spicule-bearing horizon. (Modified after Bhattachrya, 1993).

Table 1: General lithostratigraphic succession in the Maihar-Son Valley area, Madhya Pradesh-Uttar Pradesh (After Auden, 1933; Singh, 1976).

	Group	Formation	Age
		Maihar Sandstone	ca. 600 Ma
	Bhander Group	Sirbu Shale	
		Bhander Limestone	ca. 650 Ma
Upper Vindhyan	Rewa Group	Rewa Sandstone Rewa Shale	
	Kaimur Group	Kaimur Sandstone	K/Ar dates 890±40 (After Vinogradov *et al.*, 1964; Kreuzer *et al.*, 1977)
		Unconformity	
		Rohtas Formation	
		Kheinjua Formation	K/Ar dates 1080±40
Lower Vindhyan	Semri Group		(After Vinogradov *et al.*, 1964;
			Kreuzer *et al.*, 1977)
		Porcellanite Formation	
		Basal Formation	
		Unconformity	
		Metamorphics and Granites	

rocks attain a thickness of ca. 4000 m with dominant lithology represented by shales, sandstones, limestones, dolostones with subordinate conglomerates and porcellanites. No metamorphic effects have been recorded in them and they are either undeformed or poorly deformed with very low dips.

The Vindhyan rocks constitute the Vindhyan Supergroup which has been subdivided into four groups; in stratigraphic order these are the Semri Group, the Kaimur Group, the Rewa Group and the Bhander Group. Each group has been further subdivided into different formations and members (Table 1). Conventionally, the Semri Group has been referred to as the Lower Vindhyans and the Kaimur, Rewa and Bhander Groups are included in the Upper Vindhyans.

In the Maihar area of Madhya Pradesh, the Bhander Group is well developed which has been subdivided into four formations viz., the Gunargarh Shale , the Bhander Limestone , the Sirbu Shale and the Maihar Sandstone (Table 1). The lowermost unit, the Gunargarh Shale is in general poorly developed. The Bhander Limestone is well exposed in the low-lying areas in the south and east of Maihar township, especially in the Tamas River valley section (fig.1). Good exposures can also be seen in a number of limestone quarries. It is conformably overlain by the areno-argillaceous Sirbu Shale which occupies much of the area around Maihar. The Sirbu shales grade into the Maihar Sandstone which constitutes the youngest unit of the Vindhyan Supergroup in Maihar area and forms the prominent scarps in the western part. The rocks are undeformed and show very low dips. A good geological information about different stratigraphic horizons of the area is given by Bhattacharya (1993).

The estimated thickness of the Bhander Limestone is ca. 50 m. It is represented by limestone and subordinate dolostone and shale. The limestone shows excellent development of columnar stromatolite *Baicalia baicalica* (Kumar, 1976) whose bioherms attain a height of few meters. Kumar and Srivastava (1997) have recorded *Chuaria–Tawuia* assemblage from the Bhander Limestone and the Sirbu Shale.

The Bhander Limestone is considered to have been deposited on a carbonate tidal flat (Singh, 1976).

MATERIAL

The siliceous spicules-bearing stromatolitc dolostone is collected from the Girgita mine where ca.10 m thick horizon of the Bhander Limestone is exposed. The dolostone forms the uppermost unit in the mine section. The dominant lithology of the Bhander Limestone is, however, represented by micritic limestone, stromatolitic limestone, oolitic limestone, intraclastic limestone and shales. In the stromatolitic dolostone, a few centimetre thick chert lens and thin chert stringers are present which have yielded the spicules. The chert is greyish black to black showing flat fracture. The siliceous spicule- like forms are recorded in the petrographic thin sections. They are restricted to micritic dolostone clasts seen embedded in a matrix filled with these siliceous peloids/oolites (Plate I, B). Microstromatolites are also associated with the sponge spicule-like forms (Plate I, D). The siliceous spicules are completely or partially replaced by dolomite(Plate I, G) but siliceous character is descernible at many places and it is made up of microcrystalline quartz or chert (Plate I, B).

All the thin sections showing siliceous spicules-like forms have been deposited in the Museum of the Geology Department, Lucknow University, Lucknow, U.P.

SILICEOUS SPICULES

The spicules are recorded only in a few petrographic thin sections of siliceous intraclastic dolostone. The spicules are in general very rare and are seen only in few micritic clasts. Only at few places they form a mesh. They also occur in isolation. In the present work, no attempt has been made to reconstruct the network and identify an individual taxon and thus no systematic classification has been attempted. The spicules show size variation in both length and width. Maximum recorded length is 2.2 mm and width varies from 0.01 to 0.06 mm. The following types of spicules are recognised :

Single-Rayed Spicules (Plate I, B,C,E ,F & G)

Single-rayed spicules are quite common. They are generally made up of one needle-like ray which is straight but in a few cases slightly curved also. In many cases, the ends are broken. Tapering ends are identical and pointed when preserved. Axial canal is seen only in a few cases (Plate I, F) and is filled with ferrugenous micritic material.

Polyactine Spicules (PlateI, A,B & C)

The most distinctive are polyactine spicules in which peculiar triactine, tetractine and pentactine rays are joined together and appear to form a mesh. Larger spicules are broken and incomplete. They meet at different angles but generally form acute angle. In some cases, the spicule bifurcates like a twinning fork and in others they occur parallel to each other.

AGE OF THE SILICEOUS SPICULE-BEARING BHANDER LIMESTONE

No radiometric date is available for the Bhander Limestone or even for the Bhander Group. Thus, its age can be deduced only after considering the available data for the Vindhyan Supergroup. The age of the Vindhyan Supergroup has not yet been resolved with any degree of confidence because of the poor availability of the radiometric dates which are also more than three decades old. Vinogradov, Tugarinov, Zhykov, Stapnikova, Bibikova and Khoree (1964) were the first to date the glauconite of the Semri and Kaimur Groups by K/Ar method. These dates were recalculated by Kreuzer, Harre, Kürsten, Schnitzer, Murti and Srivastava (1977) by using the latter recommended constant. They suggested 1080 ±40 Ma and 890 ±40 Ma for the glauconites of the Kheinjua and Kaimur sandstones respectively. A kimberlite pipe which has intruded the Kaimur rocks at Majhgawan has been dated as 1140 ±12 Ma by Rb-Sr method (Crawford and Compston, 1970). They have suggested that the age of the Vindhyan Supergroup extends over a very long period from at least 1200 Ma and possibly 1400 Ma to perhaps 550 Ma or even later. According to them, the base of the Upper Vindhyan is about 1150 Ma or more. This age assignment is broadly in agreement

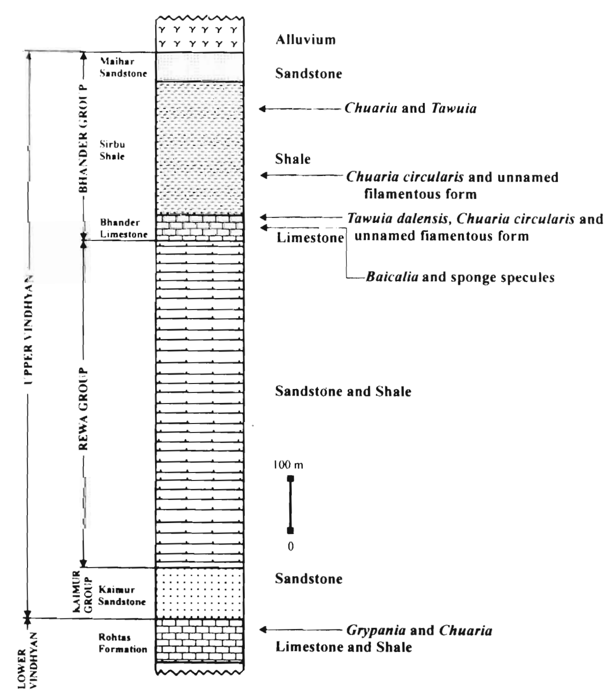


Fig. 2. Litholog of the Vindhyan Supergroup exposed around Maihar showing the position of the sponge spicule-bearing horizon (After Kumar, 1997).

with the age given by stromatolite assemblages of the Semri and the Bhander Groups. The Semri Group is characterised by the abundance of Conophytons represented by *Thassagates, Ephyaltes, Calypso, Cyathotes* and *Siren* (Kumar, 1999). The other columnar forms are *Kussiella, Jacutophyton, Colonnella* and the forms with very passive branching. This assemblage is suggestive of Lower to Middle Riphean age. No stromatolite has been recorded from the Kaimur and the Rewa Groups as no carbonate horizon is present in them. The uppermost Bhander Group displays extensive development of stromatolites both in Maihar (M.P) as well as in the Kota - Bundi areas (Rajasthan). The stromatolites of the Bhander Group are represented by *Baicalia – Tungussia – Inzeria* assemblage (Kumar,1999). All the forms show very active branching. However, no Conophyton has been recorded from the Bhander Group. The stromatolite assemblage has been assigned the Upper Riphean age. Since Conophytons are poorly developed in the Vendian and the thrombolites dominate in Phanerozoic, the Riphean age to the stromatolite-bearing Bhander Limestone appears justified.

The microfossils are abundantly reported from different horizons of the Vindhyan Supergroup (see Venkatachala *et al.*, 1996). However, there are only few reports which have described microbiota from the petrographic thin sections of the bedded cherts and only these reports have been considered for any meaningful discussion (McMenamin, Kumar and Awramik, 1983; Kumar and Srivastava, 1989). None of the microfossils are age indicators except *Obruchevella* and acritarchs which lack ornamentation, and reported from the Sirbu shales of the Bundi area, Rajasthan by Kumar and Srivastava (1997a). On this basis Upper Riphean age has been suggested for the fossil bearing horizon by them.

The carbonaceous megafossils are known from the Vindhyan Supergroup since 1909 when Jones recorded them from the Suket Shale (= the Rohtas Formation). *Chuaria – Tawuia* assemblage has now been recorded from the Suket Shale (the Semri Group) (Mathur, 1983), the Jhiri Shale (the Rewa Group) (Rai, Shukla and Gautam, 1997), and the Bhander Limestone and the Sirbu Shale (the Bhander Group) (Kumar and Srivastava, 1997b). Since this assemblage has not yet been reported from the Cambrian, the Vendian age can be suggested for the uppermost part of the Vindhyan Supergroup.

Friedman and Chakarborty (1997) have suggested Precambrian-Cambrian boundary within the Bhander Group on the basis of $\delta^{13}C$ excursion. But the variation in $\delta^{13}C$ values recorded by them cannot be taken as an excursion as the difference in the value is of the order of only 2.1‰ (PDB) and moreover the conclusion is based only on four analyses for a section which is more than 100 m thick. Furthermore, no Cambrian fossil has yet been reported from the Bhander Group.

The discovery of small shelly fauna and brachiopods from the Rohtas Formation by Azmi (1998) and some bedding plane features interpreted as the burrows of worm-like undermat miners from the Chorhat Sandstone by Seilacher *et al.* (1998) attracted global attention. Azmi's discovery invited many comments as he suggested Precambrian–Cambrian boundary within the Rohtas Formation which was earlier assigned Mesoproterozoic age (see Jour. Geol. Soc. India, v. 52: pp. 120 – 130 and 481 – 500; Kerr, 1998; Brasier, 1998, 1999). In subsequent publications, Azmi (1999a,b) withdrew the identification of brachiopod but defended the presence of shelly fauna to which he assigned Cambrian age. From the Badanpur locality of the Maihar area, Madhya Pradesh, Azmi (1999a,c) reported the presence of cherty limestone from which he claimed to have recovered shelly fauna by using conventional acetic acid treatment. Now, it is construed that he misidentified the cherty shale as cherty limestone. Bhatt, Singh, Gupta, Soni, Moitra, Das and De (1999) also noticed this anomaly in the Azmi's field observation and doubted the recovery of shelly fauna from the silicified shale. Thus, the discovery of shelly fauna and brachipods from the Lower Vindhyans has been firmly rejected.

Seilacher *et al.* (1998) have claimed the discovery of triploblastic animals from the Chorhat Sandstone (the Semri Group, Lower Vindhyans) on the basis of some intriguing bedding plane features which have been interpreted as the burrows of worm-like undermat miners. The horizon from which this discovery has been made is a shallow, tidal flat deposit with excellent preservation of sedimentary structures including mud cracks. Various forms of mud cracks with all possible preservational modes can be seen in the Chorhat Sandstone. It appears that the burrow system recorded by Seilacher *et al.* (1998) most probably represents syneresis cracks. This interpretation gets support from the fact that none of the horizons younger than the Chorhat Sandstone has yielded any body fossil which can even remotely be assigned an animal affinity, though the cumulative thickness of the younger horizons is ca. 3000 m. The inference of Seilacher *et al.* (1998) about the presence of triploblastic animal in the Lower Vindhyans is discarded in the absence of any firm evidence of biogenicity of the reported structures.

Very recently, Banerjee and Frank (1999) have dated porcellanite of the Semri Group by $^{40}Ar/^{39}Ar$ method. They suggested plateau age for the porcellanite at lower temperature as 617 ±3.5 Ma. However, at higher temperature steps, they measured higher ages from 920 to 1073 Ma. They tentatively interpreted that 617 Ma corresponds to depositional age. Their interpretation is perhaps based on the assumption that Azmi's discovery of brachiopod and small shelly fauna is genuine. Since Azmi's discovery has been discarded as stated earlier, interpretation made by Banerjee and Frank (1999) needs rethinking. Their data is based on an analysis of only one sample. Moreover, a detailed petrographic analysis of the porcellanite is a pre-requisite for the interpretation of the generated numbers. It may be mentioned that there are a number of porcellanite horizons in the Semri Group and unless the methodology used by Banerjee and Frank (1999) is tested for the stratigraphically controlled samples, their age assignment for the porcellanite of the Semri Group appears to be unreliable.

Thus, the upper age limit for the Vindhyan sediments in the light of the available data can be suggested as Vendian and the Bhander Limestone can be assigned the uppermost Riphean age (~ 650 Ma).

DISCUSSION AND CONCLUSIONS

1. The siliceous spicule-like forms recorded from the Bhander Limestone within the micritic clast could not be compared with any inorganic structure on the basis of mineralogy, texture and environmental setting. The spicules compare well with the sponge spicules reported by Mazumdar and Banerjee (1998) from the Early Cambrian Chert-Phosphorite Member of the Lower Tal Formation, Lesser Himalaya and by Brasier, Green and Shields (1997) from southwest Mongolia. On this basis, the Vindhyan spicules have been identified as sponge spicules.

2. The network of spicules in the Bhander Limestone is distinctly different in comparison to the network recorded in the Cambrian and younger horizons where cross-shaped and hexactine spicules are quite common and network is better organised. The Vindhyan spicules are single, branched or polyactine and perhapse represent the earliest arrangement of siliceous spicules in the sponges.

3. It appears that the silica biomineralisation preceeded the phosphate mineralisation.

4. The siliceous spicules in the Bhander Limestone support the presence of animal life in the Upper Vindhyans as the sponges are considered to be the most primitive metazoans belonging to animal kingdom. Their inclusion under Animal Kingdom has been confirmed by recent molecular phylogeny studies using 28S RNA and 16SrRNA (Christen, Ratto, Baroin, Perasso, Grell and Addoutte, 1991; Wainright, Hinkle, Sogin and Stickel, 1993).

5. Rigby (1976) has suggested a Precambrian origin to the sponges on the basis of very diverse record in the Cambrian. Glaessner (1984) has also singled out sponges for a Precambrian ancestry. Only recently Neoproterozoic sponge spicules have been recorded (Gehling and Rigby, 1996; Brasier *et al.*,1997; Li, Chen and Hua, 1998). The oldest record of such spicules is from the Doushantuo phosphate deposit of China which has been assigned the Early

Vendian age ~ 580 Ma (Li *et al.*, 1998). The Vindhyan spicules have been recorded in a horizon which has been assigned the Upper Riphean age. This places the emergence of siliceous sponges at ~ 650 Ma, i.e. about 70 million years earlier than previously reported.

6. From India, the siliceous sponge spicules have been reported from the Early Cambrian Chert-Phosphorite Member of the Lower Tal Formation (Mazumdar and Banerjee, 1998). Tiwari (1997) has recorded sponge spicules along with small shelly fossils from the Precambrian-Cambrian boundary interval in the Tethys succession of Northwestern Kashmir. Thus, the Vindhyan spicules possibly represent the oldest record of sponge spicules from India.

7. The spicules are reported from the intraclastic dolostone which also shows presence of domal, stratified and micro-stromatolites and peloids/oolites. It is suggested that the sponges were growing in subtidal environment, while the stromatolites and peloids/oolites were forming in intertidal zone. The common association of spicules, peloids/oolites and stromatolites in a intraclastic dolostone possibly represents a storm deposit.

8. The preservation of spicules was possible only where the spicule-bearing clasts were trapped within a chert lens. Permineralisation arrested the complete replacement of silica by carbonate. The general lack of spicules in limestone and dolostones is due to complete replacement of siliceous spicules by micrite because of early dissolution of silica aided by water turbulance and warm temperature.

ACKNOWLEDGEMENTS

The author is grateful to Prof. D.M.Banerjee for the help during the course of investigation and also for reviewing the manuscript. He is also thankful to Dr. Meera Tiwari and Dr. V.Rai for making the relevant literature available. Financial assistance in the form of a project entitled "Biosedimentology of the Precambrian buildups with emphasis on evolution of microbial community" sponsered by the Department of Science and Technology, New Delhi is thankfully acknowledged.

REFERENCES

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

Azmi, R. J. 1998. Discovery of Lower Cambrian small shelly fossils and brachiopods from the Lower Vindhyan of Son Valley, Central India. *Jour. Geol. Soc. India*, **52**: 381- 389.

Azmi, R. J. 1999a. Discovery of Lower Cambrian small shelly fossils and brachiopods from the Lower Vindhyan of Son Valley, Central India. Discussion. *Geol. Soc. India*, **53**: 125 – 130.

Azmi, R. J. 1999b. Discovery of Lower Cambrian small shelly fossils and brachiopods from the Lower Vindhyan of Son Valley, Central India. Discussion. *Geol. Soc. India*, **53**: 488 – 500.

Azmi, R. J. 1999c. Discovery of Lower Cambrian small shelly fossils and brachiopods from the Lower Vindhyan of Son Valley, Central India. Discussion. *Jour. Geol. Soc. India*, 53: 730.

Banerjee, D.M. and Frank, W. 1999. Preliminary $^{40}Ar/^{39}Ar$ dates of porcellanite and detrital mica from the Vindhyan of Central India. Workshop on Vindhyan Stratigraphy and Palaeobiology.Lucknow: 5. (Abstract).

Bhatt, D. .K., Singh, G., Gupta, S. Soni, M. K., Moitra, A. K., Das, D. P. and De, C. 1999. Fossil report from Semri Group, Lower Vindhyan. *Jour. Geol. Soc. India*, **53**: 717 –723.

Bhattacharya, A. 1993. The Upper Vindhyan of Maihar, Satna district, Madhya Pradesh, A field guide. *Geol. Soc. India., Bangalore*, 98p.

Brasier, M. 1998. From deep time to late arrival. *Nature*, **395**: 647 – 648.

Brasier, M. 1999. Discovery of Lower Cambrian small shelly fossils and brachiopods from the Lower Vindhyan of Son Valley, Central India. Discussion. *Jour. Geol. Soc. India*, **53**: 727 – 730.

Brasier, M., Green, O. and Shields, G. 1997. Ediacaran sponge spicule clusters from southwestern Mongolia and the origins of the Cambrian fauna. *Geology*, **25(4)**: 303 – 306.

Christen, R., Ratto, A., Baroin, A., Perasso, R., Grell, K. G. and Adoutte, A. 1991 An analysis of the origin of metazoans, using comparison of partial sequences of the 28S RNA, reveals an early emergence of triploblasts. *The EMBO Jour.*, **10**: 499 – 503.

Crawford, A.R. and Compston,W. 1970. The age of the Vindhyan System peninsular India. *Quart. Jour. Geol. Soc. London*, **125**: 351 – 371.

De Laubenfels, M.W. 1955. Porifera, p. 21-113. In : *Treatise on Invertebrate Paleontology* (Eds. Moore, R.C. and others), Archaeocyatha and Porifera, Pt. E, *Geol. Soc. of Amer. and University of Kansas Press.*

Friedman, G.M. and Chakraborty, C. 1997. Stable isotopes in Marine Carbonates: Their implications for the palaeoenvironment with special reference to the Proterozoic Vindhyan carbonates (Central India). *Jour. Geol. Soc. India*, **50**: 131 – 159.

Gehling, J.G. and Rigby, J.K. 1996. Long expected sponges from the Neoproterozoic Ediacara Fauna of South Australia. *Jour. Pal.* **70(2)**: 185 – 195.

Glaessner, M.F. 1984. *The dawn of animal life : A biohistorical study*. Cambridge University Press, Cambridge.

Kerr, R.A. 1998. Fossils challenge age of billion-year-old animals. *Sci.* 282: 601 – 602.

Kreuzer, H., Harre,W., Kürsten,M., Schnitzer, W.A., Murti, K.S. and Srivastava, N.K. 1977. K/Ar dating of two glauconites from the Chandarpur-Series (Chhattisgarh/India). *Geol Jb.* **B 28**: 23 – 36.

Kumar, S. 1976. Stromatlites from the Vindhyan rocks of Son Valley

Maihar area, district Mirzapur (U.P.) and Satna (M.P.) India. *Jour. Pal. Soc. India*, **18** :13 – 21.

Kumar, S. 1999. Stromatolite biostratigraphy of the Vindhyan Basin: Utility and SignificanceWorkshop on Vindhyan Stratigraphy and Palaeobiology, Lucknow: 18. (Abstract).

Kumar, S. and Srivastava, P. 1989. Indian Precambrian microbiota from bedded cherts: A review. *Jour. Pal. Soc. India*, **34**: 69 – 77.

Kumar, S. and Srivastava, P. 1997a. Micro-organisms from the bedded chert, the Sirbu Shale (Formation), Bhander Group, Bundi area, Rajasthan. Conf. on Biosedimentology of Precambrian Basins, Lucknow: 36. (Abstract).

Kumar,S. and Srivastava, P. 1997b. A note on the carbonaceous megafossils fromthe Neoproterozoic Bhander Group, Maihar area, Madhya Pradesh. *Jour. Pal. Soc. India*, **34**: 69 – 77.

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

Mazumdar, A. and Banerjee, D.M. 1998. Siliceous sponge spicules in the early Cambrian chert-phosphorite member of the Lower Tal Formation, Krol, Lesser Himalaya. *Geology*, **26 (10)**: 899 – 902.

McMenamin, D.S., Kumar, S. and Awramik, S.M. 1983. Microbial fossils from the Precambrian Vindhyan Supergroup of Central India. *Precamb. Res.* **21**. 247 – 271.

Li , C., Chen, J. and Hua, T. 1998. Precambrian sponges with cellular Structures. *Sci.* **279**: 879 – 882.

Rai, V., Shukla, M. and Gautam, R. 1997. Discovery of carbonaceous megafossils (*Chuaria – Tawuia* assemblage) from the Neoproterozoic Vindhyan succession (Rewa Group) Allahabad - Rewa area. *Curr. Sci.* **73**: 783 – 788.

Rigby, J.K. 1976. Some observations on occurrences of Cambrian Porifera in Western North America and their Evolution. *Brigham Young University Geology Studies*, **23**(2) : 51-60.

Seilacher, A., Bose, P.K. and Pfluger, F. 1998. Triploblastic animals more than 1 billion years ago: trace fossil evidence from India. *Sci.* **282**: 80 – 83.

Singh, I.B. 1976. Depositional environment of the Upper Vindhyan sediments in the Satna-Maihar area, Madhya Pradesh and its bearing on the evolution of Vindhyan sedimentation basin. *Jour. Pal. Soc. India*, **19**: 48 – 70.

Tiwari, M. 1997. *Nabaviella acanthomorpha* n.sp. a sponge spicule from the Precambrian-Cambrian Boundary interval in the Tethys sequence of Northwestern Kashmir. *Jour. Geol. Soc. India*, **50**: 655-658.

Venkatachala, B.S., Sharma, M. and Shukla, M. 1996. Age and life of the Vindhyans – facts and conjectures, p. 137-165. In : *Recent advances in Vindhyan Geology* (Ed. Bhattacharya, A.), *Geol. Soc. India, Bangalore, Mem*, **36**.

Vinogradov, A., Tugarinov, A., Zhykov, C, Stapnikova, N., Bibikova, E. and Khoree, K. 1964. Geochronology of the Indian pre-Cambrian. *XXII Int. Geol. Congr. Rep. New Delhi*, p. **10**: 553 – 567.

Wainright, P.O., Hinkle, G., Sogin, M.L. and Stickel, S.K. 1993. Monophyletic origins of Metazoa: an evolutionary link with fungi. *Sci.* **260**:340-342

Manuscript accepted October 1999

EXPLANATION OF PLATE

Plate I

A. A cluster of siliceous spicules seen in micritic matrix. Some of the circular and elliptical structures are considered as transverse sections of spicules. Light-coloured rhombs are dolomite crystals. Plane polarised light. Slide no. E1/99. Scale bar = 0.2 mm.

B. Siliceous spicule-bearing clasts seen in a siliceous oolite/peloid-bearing matrix. Crossed nicols. Slide no.E5/99. Scale bar = 0.2 mm.

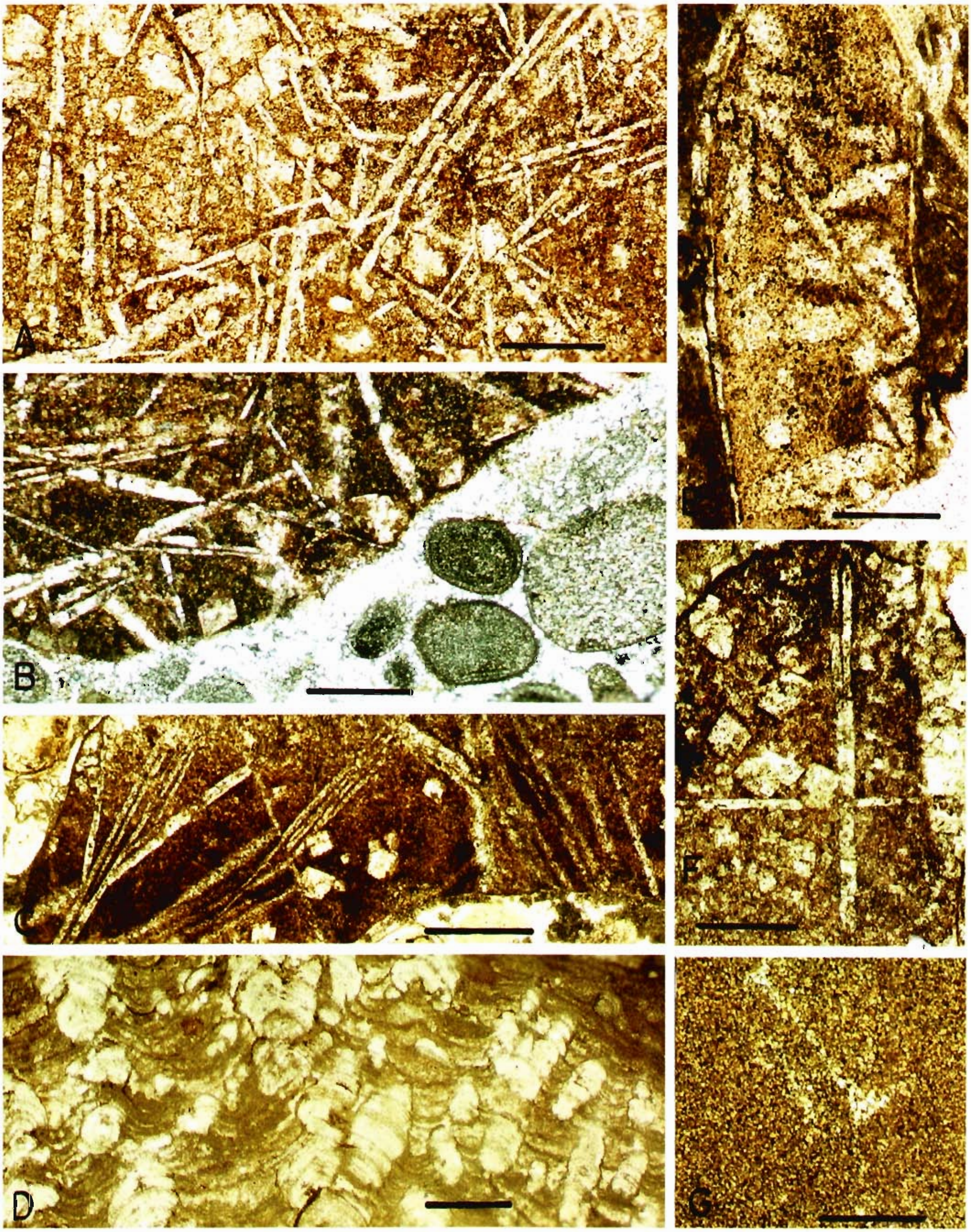
C. Monactine and triactine spicules are seen in a micritic clast. Plane polarised light. Slide no. E27/99. Scale bar = 0.2 mm.

D. Microstromatolites associated with spicule-bearing horizon. Plane polarised light. Slide no E40/99. Scale bar = 1 mm.

E. Monoactine spicules seen within a micritic clast. Most of the spicules are spindle shaped which may be due to oblique section of the clast. Plane polarised light. Slide no. E29/99. Scale bar = 0.2 mm.

F. Two monactine spicules are superimposed over each other. In the north-south oriented spicule axial canal is also seen. Plane polarised light. Slide no. E2/99. Scale bar = 0.2 mm.

G. Micritic clast showing filling by dolomite crystals which may be due to replacement of siliceous spicules by dolomite. Plane polarised light. Slide no. E1/99. Scale bar = 0.2 mm.



KUMAR