ORGANIC REMAINS FROM THE BHIMA BASIN AND REMARKS ON THE AGE OF VINDHYANS AND SUBSURFACE SEDIMENTS IN THE GANGA VALLEY

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ABSTRACT

Palynological fossils from the Lower and Upper Bhima sediments are studied. An assemblage consisting of *Leiosphaeridia*, *Protoleiosphaeridium*, *Lophosphaeridium*, *Schismatosphaeridium*, *Lophotriletes*, algal filaments and organic plates perhaps of animal origin is recorded. A Late Cambrian age is assigned to the Bhimas. The Bhima sediments are deposited under neritic depositional environment.

A reassessment of available data from Vindhyans and Ujhani St. Well-1 (1010—1247 m.) and Tilhar deep well (1660—2051 m.) sediments occurring below the unconformity in the Ganga valley is made. It is suggested that the Vindhyan sediments are Late Precambrian-Cambrian in age. The Ganga valley sediments (Ujhani and Tilhar) below the unconformity are considered Pre-Ordovician in age.

INTRODUCTION

The Bhima basin covering an area of 9,000 sq km is situated in the Gulbarga and Bijapur districts of Mysore state. The lithological suits of the Bhima series compare with those of the Kurnool Series in Cuddapah basin. The basin has an irregular outline fringing the Decean traps. The Kaladgi sediments lie to the west of the Bhima but they are not in contact with them.

The Bhima Series is divided into 3 stages by MAHADEVAN (1947). These are as follows:—

Upper (100 m)—Red, blue, buff and purple shales with locally developed sandstones at the bottom and grey flaggy limestone at the top.

Middle (165 m)—Yellowish, grey, bluish and buff limestone and flaggy limestone.

Lower (110 m)—Sandstones and green and purple shales with conglomerates at the base.

The Lower and Middle Bhimas outcrop south and east of the basin while the Upper Bhimas outcrop towards the north and west.

The geological information is summarised by MAHADEVAN and KAZIM (1947), KRISHNAN (1968) and SASTRI *et al.* (1969). The above summary is drawn from SASTRI *et al.* (1969).

SALUJHA *et al.* (1969) studied the Bhima sediments for microfossils and obtained an assemblage of sphaeromorphs and other acritarchs. SREENIVASA and GOWDA (1970) also studied the palynology of Bhima Shales and obtained an assemblage which they date as Cambrian-Silurian in age. The present investigation is confined to exposed sediments of Lower and Upper Bhima Series (Table-1).

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Table—1. Details of samples studied from the Bhima Basin

Sample No. no.		Traverse	Locality	Lithology	Palyno fossils
UPPER BHIMA	B15	Talikot to Gulberga.	About 2 miles SW of Jainspur, 25 km. from Shahpur; 16° 54′ 21″: 76° 46′ 42″.	Greyish-red calcareous shale	×
	B13	Ditto	About 2 miles north of Halkal enroute to Gulberga; 16° 47″ 00″: 76° 47′ 20″.	Pale olive calcareous shale	+
	B14	Ditto	About a furlong north of B/13; 16° 47′ 41″; 76° 46′ 50″.	Purple shales ..	+
	B5	Ditto	In front of Talikot inspection bungalow; 16° 28′ 30″; 16° 28′ 30″. 76° 19′ 00″.	Hard, compact, medium dark-grey limestone.	+
	B7	Ditto	Ditto	Hard, compact, medium grey limestone.	×
	B12	Ditto	At Hulkal villaeg en route, Gulberga; 16° 45′ 20″: 76° 47′ 33″.	Medium grey limestone ..	×
	B18	Ditto	8 miles north of Bhima river crossing; 17° 08′ 13″ : 76° 47′ 33″.	Dark-grey limestone ..	×
LOWER BHIMA	B10	Ditto	Salvergi village; 16° 26′ 53″: 76° 24′ 21″.	Aranaceous shale with thin bedded limestone and sandstone.	+
	B4	Bagalkot to Muddebihal to Talikot.	3/4 mile short of Mukinal; 16° 25′ 50″: 76° 16′ 20″.	Fine to medium grained moderately hard and compact calcareous sandstone. calcareous sandstone.	×
	B3	Ditto	1½ miles short of Mukihal on Talikot road; 16° 25′ 30″: 76° 15′ 51″.	Hard compact, pale red limestone.	×
	B20	Gulberga-Shahabad road section (Gulberga to Gurumatkel).	About 8 miles SE, of Gulberga near Anti Village; 17° 06′ 40″: 77° 24′ 12″.	Compact, moderately hard, light brown to dark brown calcareous shale.	+
	B24	Ditto	At Rabanpalli Checkpost; 17° 03′ 22″: 77° 29′ 26″.	Fine-grained laminated greenish grey sandstone.	×
	B21	Ditto	Near Kudlupur; 17° 04′ 00″: 77° 26′ 00″.	Hard, compact, medium grained, greyish orange pink quartzite.	×

+ = Presence
× = Absence

A total of 13 samples from Lower and Upper Bhimas were investigated for microfossils, 5 samples (Table 2) yielded well preserved algal sphaeromorphs, acritarchs, filamentous algae, cellular tissue and a doubtful trilete spore associated with amorphous organic debris.

Methods for this study are the same as that employed for the Kaladgi samples (VENKATACHALA & RAWAT, 1972). The slides are preserved in the repository of the Palynology Laboratory of the Institute of Petroleum Exploration, ONGC. The slide numbers of the illustrated specimen are given. The material for this study was collected by Shri L. L. Bhandari, A. N. Chaube and one of the authors (B. S. V.).

SYSTEMATIC PALYNOLOGY

Five genera and seven species of microfossils are recognised along with three unidentifiable organic fossils described under *Incertae Sedis*. Three species are newly proposed.

ACRITARCHA Evitt, 1963
SPHAEROMORPHITAE Downie, Evitt & Sarjeant, 1963

Leiosphaeridia (Eisenack, 1958) Downie & Sarjeant, 1963

Type Species—Leiosphaerida baltica Eisenack, 1958

Leiosphaeridia aglutinata Venkatachala & Rawat, 1972

Pl. 1, figs. 1, 3

Holotype—VENKATACHALA & RAWAT, 1972; Pl. 1, fig. 3.
Description—Vesicle spheroidal, 55-60 × 45-55 μ. Wall ill defined up to 1.0 μ thick, often folded, smooth, generally aglutinated with fine organic debris and mineral particles.
Comparision—Leiosphaeridia baltica Eisenack, 1958 is larger in size (150 μ) and is reported from the baltic Ordovician. *L. pellucida* and *L. tenella* described from Vindhyans of Son Valley by SALUJHA *et al.* (1971) are distinguished by their wall ornamentation.
Illustrated specimen—B 14/1.

Leiosphaeridia dakshinii sp. nov.

Pl. 1, figs. 4, 5, 6, 10

Holotype—Pl. 1, fig.4.
Type locality—About 2 miles north of Halkal enroute to Gulberga.
Description—Vesicle spheroidal, 20-45 μ. Wall ill-defined, less than 1.0 μ, smooth.
Remarks—Aglutinated organic debris in the vesicle and surrounding them is a common feature.
Comparison—Leiosphaeridia pellucida described by Salujha *et al.* (1971) is comparable in size with the present species, but the former is distinguished by its punctate wall.
Illustrated specimens—B 13/1, B 13/2.

Leiosphaeridia sp.

Pl. 1, figs. 2, 7

Description—Vesicle spheroidal, 18 × 33 μ, thin walled; wall less than 0.5 μ thick, smooth, granulose debris adhering to the vesicle giving a granulose-verrucose appearance; as seen in other species of thin walled, *Leiosphaeridia*.

Illustrated specimen—B 10/3.

Protoleiosphaeridium Timofeev, 1956

Type species—Protoleiosphaeridium conglutinatum Timofeev, 1958

Protoleiosphaeridium sp.

Pl. 1, fig. 8

Description—Vesicle spheroidal, 11 μ Wall ill-defined, thin up to 0.5 μ, smooth.
Illustrated specimen—B 10/3.

Lophosphaeridium Timofeev, 1959

Type species—Lophosphaeridium rarum Timofeev, 1959

Lophosphaeridium sp.

Pl. 1, fig. 13

Description—Vesicle spheroidal, variously folded, 20 μ. Wall thin, less than 1.0 μ, covered with small, about 1.0 μ long and 0.5 μ broad coni.

Comparison—Lophosphaeridium rarum Timofeev (1959) is distinguished by its larger size (69 μ). *L. conatum* Venkatachala & Rawat (1972) recorded from Kaladgi Formation is comparatively larger in size and possesses closely placed coni. *L. sp.* described by SALUJHA *et al.* (1971) possesses longer coni (2-3 μ) as compared to the present species. Other species recorded by SALUJHA *et al.* (1971) from Vindhyans of Son Valley differ in nature of coni and vesicle ornamentation. *L. jainii* recorded from Vindhyans of Rajasthan by SALUJHA *et al.* (1971) resembles in size, but can be differentiated from the present species by its well developed coni.

Illustrated specimen—B 10/2.

Schismatosphaeridium Staplin, Jansonius & Pocock, 1965

Type species—Schismatosphaeridium perforatum Staplin, Jansonius & Pocock, 1965

Schismatosphaeridium bhimai sp. nov.

Pl. 1, figs. 11, 12

Holotype—Pl. 1, Fig. 12.

Type locality—About a *furlong* north of Halkal.

Description—Vesicle spheroidal, 18 × 16 μ. Wall thin, smooth; organic debris and mineral particles collect on the vesicles giving an ornamented appearance. Pylome present, 6-10 μ wide.

Comparison—Schismatosphaeridium bhimai is distinguished from the type species by its smooth wall and smaller size. *S. verrucosus* Venkatachala & Rawat (1972) described from Kaladgi sediments differs in wall ornamentation.

Illustrated specimen—B 14/2.

Lophotriletes (Naumova) Potonié & Kremp, 1954

Type species—Lophotriletes gibbosus (Ibrahim) Potonié & Kremp, 1954

?Lophotriletes antiquitus sp. nov.

Pl 1, fig. 9

Holotype—Pl. 1, fig. 9

Type locality—About 2 miles north of Halkal enroute to Gulberga.

Description—Microspore roundly triangular, with rounded corners and straight to slightly concave interapical area, 28 μ, Trilete; Y-mark distinct, rays thin, extending more than ⅔ of radius. Exine thin, 0.5 μ, conate; coni small, sharp tipped, irregularly distributed.

Remarks—Contamination from other sources is ruled out because, *Lophotriletes* of the type recorded here are common only in the Paleozoic sediments. At the time of processing these samples, no Paleozoic material was under processing. Lophate pteridophytic spore types of Mesozoic and Tertiary ages are distinctly different from the type recorded here.

Illustrated specimen—B 13/2.

Incertae sedis

Type-1

Pl 1, figs. 16, 17

Description—Elongated oblong filament, 43 μ long and 12 μ broad. Wall thin, 0.5 μ, smooth. Two longitudinal thin folds run along the body; cellular constrictions, numbering 5-6 are seen in the specimens.

Illustrated specimen—B 10/1.

Type-2

Pl. 1, fig. 14

Description—Elongated filament?, about 50 μ long and 17 μ broad, probably non-septate. Wall thin, less than 1.0 μ, smooth. The wall appears granulate due to aglutination with fine organic debris and mineral particles.

Illustrated specimen—B 14/1.

Organic Plates

Pl. 1, figs. 15, 18

Description—Elongated plates with few to many distinct, simple, oval, 3-6×3-4 μ wide perforations all over.

Affinity—Perhaps of animal origin.

Illustrated specimens—B 13/1, B 14/2.

DISCUSSION

Age of the Bhima Series

The assemblages recovered from the Bhima sediments are poor in quality as well as in quantity. The acritarch genera present are: *Leiosphaeridia*, *Protoleiosphaeridium*, *Lophosphaeridium* and *Schismatosphaeridium*.

A trilete spore here assigned to *? Lophotriletes* is recorded from the Upper Bhima shales in sample No. B 13.

The Dharwar assemblage (VENKATACHALA *et al.*, 1972) is distinctly different in possessing smooth-walled sphaeromorphs and as such can not be compared. The fossil evidence from the Bhimas is too meagre to attempt wider comparisons. The distribution of fossils in the Lower and Upper Bhima sediments are uniform (Table 2).

Table—2. Distribution of fossils in different fossiliferous samples of Bhima sediments.

Fossils Sample No.	Upper Bhima			Lower Bhima	
	B14	B5	B13	B20	B10
Leiosphaeridia	+	+	+	+	+
Protoleiosphaeridium		+			+
Lophosphaeridium		+			+
Schismatosphaeridium		+			+
Lophotriletes			+		
Filaments	+			+	+
Organic plates	+		+		

SALUJHA *et al.* (1969) studied fossils from sediments of Bhima Series exposed in Gulbarga district of Mysore state and concluded that they are Early to Late Cambrian in age. This age assignment is based on acritarch fossils. The assemblage recorded by them is as follows:

Archaeofavosina, *Trematosphaeridium*, *Granomarginata*, *Vavosphaeridium*, *Lophosphaeridium*, *Trachysphaeridium*, *Ooidium* and *Tasmanites*.

SREENIVASA and GOWDA (1970) in a note submitted to the Purana Symposium assigned a Cambrian-Silurian age.

The fossils recovered in this study as well as those illustrated by SALUJHA *et al.* (1969) are no doubt meagre but conclusive. Distinct acritarch forms that are present in the Bhimas lead us to conclude that they are of Cambrian age.

The Precambrian acritarchs are not evolved and represent simple sphaeromorphs and thus are not comparable to the Bhima fossils. (PICHOVA, 1967; TIMOFEEV, 1959, 1960 and 1963). The assignment of Cambrian-Silurian age by SREENIVASA and GOWDA (1970) seems to be not well founded. Ordovician fossils the world over are well documented and distinguish in possessing advanced acritarch genera such as *Micrhystridium*, *Baltisphaeridium*, *Hystrichosphaeridium*, *Veryhachium* and other long spined acritarchs (DOWNIE, 1958, 1967; COMBAZ, 1967, KOROLEV, 1971; VAVRADOVA, 1965). Silurian fossils are invariably associated with Chitinozoan remains and a variety of acritarch remains, viz., *Veryhachium*, *Baltisphaeridium*, *Leiofusa*, *Cymatiosphaera*, *Micrhystridium*, *Polyedryxium*, *Pulvinosphaeridium*, *Tunisphaeridium*, *Pterospermopsis* as detailed in Table 3 (See COMBAZ *et al.*, 1967; CRAMER, 1964, 1966, 1967, 1968, 1969, 1970; DOWNIE, 1959, 1960, 1963; DOWNIE *et al.*, 1967; DEFLANDRE, 1942, 1945; EISENACK, 1931, 1951, 1954, 1955, 1959, 1963, 1965; GRIGNANI, 1967; JANSONIUS, 1967).

Table 3—Characteristic fossil assemblages in Precambrian-Silurian (compiled from available literature)

Silurian— Complexity of spines and other ornamentation in the acritarchs and continuance of trilete spores and chitinozoans, which become more complex in morphology. The fossils are:—
Hstrichosphaeridium, *Baltisphaeridium*, *Veryhachium*, *Cymatiosphaera*, *Micrhystridium*, *polyedryxium*, *Pulvinosphaeridium*, *Tunisphaeridium*, *Deflandrastrum*, *Carminella*, *Leiofusa*, *Domasia*, *Deunffia*, *Pterospermopsis*, *Tasmanites*, *Estiastra*, *Quadraditum*, *Helios*, *Hoegisphæra*, *Geron*, *Ambitisporites*, *Amocosporites*, *Tetraletes*, *Retialetes*, *Retusotriletes*, *Apiculoretusispora*, *Anapiculatisporites*, *Punctatisporites*, *Lophotriletes*, *Stenozonotriletes*, *Angochitina*, *Conochitina*, *Desmochitina*, *Margachitina*, *Cyathochitina*, *Lagenochitina*, *Pterochitina*, *Ancyrochitina*, *Plectochitina*, *Scolecodonts*.

Ordovician— Apperance of advanced acritarchs such as, *Veryhachium*, *Hystrichosphaeridium*, *Baltisphaeridium*, *Polyedryxium*, *Cymatiosphaera*, *Dasydiacrodium*, *Acanthodiacrodium*, *Dactylofusa*, *Cymatiogalea*, *Priscotheca; appearance* of true trilete spores, viz., *Attritasporites*, *Virgatasporites*, *Leiotriletes* etc., which are distinct land plant spores and occurrence of chitinozoans, such as: *Eremochitina*, *Ancyrochitina*, *Cyathochitina*, *Rhabdochitina*, *Hercochitina*, *Desmochitina*.

Cambrian— Appearance of ornate acritarchs in association with simple ones, such as *Trachysphaeridium Lophosphaeridium*, *Retisphaeridium*, *Schismatosphaeridium*, *Archaeohystrichosphaeridium* etc. and presence of simple trilete spores, viz., *Leioligotriletes* of doubtful land plant affinity.

Pre-Cambrian— Sphaeromorphs without any morphological complexities such as, *Leiosphaeridia*, *Protoleiosphaeridium*, *Granomarginata*, *Sphaerophycus*, *Palaeoanacystis*, *Myxococcoides*, *Palaeolyngbya*, *Oscillatoriopsis*, *Calyptothrix*, *Cephalophytarion*, *Siphonophycus*, *Anabaenidium*, *Caryosphaeroides*, *Glenobotrydion*, *Archaeonema*, *Archaeosphaeroides*, *Gunflintia*, *Gloeodiniopsis* and bacteria, such as, *Eobacterium*, *Entosphaeroides*, *Kakabekia*, *Huroniospora* and filamentous fungi. viz., *Eomycetopsis*.

The absence of advanced Ordovician and Silurian fossils in the assemblages recorded here as well as by SALUJHA *et al.* (1969) negates the assignment of a Ordovician-Silurian age to the Bhima sediments.

The Kaladgi assemblage is closely comparable to the Bhima assemblage. The acritarch genera recorded in the Bhimas (See table 2) are also recorded in the Kaladgis (VENKATACHALA & RAWAT, 1971). *Retisphaeridium* and *Archaeohystrichosphaeridium* are presently recorded only in the Kaladgi sediments. The occurrence of trilete spores in the Bhimas is significant and may point towards a younger age to the Bhima sediments as compared to the Kaladgis. A Late Cambrian age is assigned to the Bhimas on the basis of the above comparative study. The fossil evidence supports a neritic depositional environment to the sediments.

REMARKS ON THE AGE OF VINDHYANS

Vindhyan assemblages have been studied by SALUJHA *et al.* (1969). The Lower Vindhyans from Son Valley as well as the Kurnools are assigned an Early Cambrian-Late

Cambrian age. The Upper Vindhyans in Rajasthan are assigned a Late Cambrian-Ordovocian age and in the Son Valley a Late Cambrian-Silurian age by the authors by comparison with the then available literature. The assemblages described by them is closely comparable to the one in this study. A more detailed comparison is now possible by comparative studies of the vast literature available today. Cambrian-Silurian age assignment for the Upper Vindhyans on the basis of the palynological assemblages recovered by SALUJHA *et al.* (1969) is here not considered tenable due to the following reasons:

(i) Absence of any complex spinose acritarchs such as *Baltisphaeridium, Hystrichosphaeridium, Veryhachium, Dasydiacrodium, Acanthodiacrodium, Tunisphaeridium, Leiofusa, Carminella* and other forms which are Ordovician & Silurian markers (COMBAZ, 1967; DOWNIE, 1958, 1959, 1963 1967; DEUNFF 1956, 1958, 1961, 1968; CRAMER, 1964, 1966, 1967, 1968, 1969, 1970).

(ii) Absence of any true Chitinozoa which are present in both Ordovician and Silurian sediments (literature references as above). Only doubtful chitinozoan remains are recorded by the above authors (SALUJHA *et al.*, 1969).

(iii) Simplicity of morphology of the acritarchs recovered from the Vindhyans (as discussed above).

(iv) Absence of true trilete spores with morphological complexities such as crassitude which appear in the Ordovician and continue in the Silurian. The simpler types as recorded here from the Upper Bhima sediments as well as the doubtful ones recorded by SALUJHA *et al.* (1969) are excluded from this group. Ordovician trilete spores are viz., *Attritasporites, Leiotriletes, Virgatasporites* and others with distinct equatorial extensions. *Ambitisporites* and *Punctatisporites* recorded from the Lower Silurian of Libya studied by HOFFMEISTER (1959) are well developed distinct land plant spores. These are also recorded by CRAMER (1966) from the Lundlovian- Lower Gedinnian of Spain in assosication with *Apiculoretusispora, Anapiculatisporites, Tetraletes, Retialetes* and *Amocosporites.*

Thus the authors are inclined to suggest a Pre-Cambrian-Cambrian age to the Vindhyan sediments. PICHAMUTHU (1971) in a recent review has discussed the geochronological data from the Precambrian-sediments of peninsular India (See also KRISHNAN, 1969). The lavas occurring in the Chitaldurg Schists are assigned 2345 $\pm$ 60 m.y. by CRAWFORD (1969). HOLMES (1955) had assigned 2450$\pm$120 m.y. to these sediments on a dating for a galena from Ingladhal. On the basis of a study by VINOGRADOV (1964) assigned 1400$\pm$ 70 m.y. to the Lower Semries and 910—940 m.y. to the Kaimurs. The phalgopites from the diamond bearing Majhgawan pipe at Panna which intrudes the Kaimur sandstone gave a Rb-Sr age of 1140 m.y., thus PICHAMUTHU (1971) considers that the base of the Upper Vindhyans must be at least 1150 m.y. old if not more. The geochronological data given by PICHAMUTHU (1971) is in agreement with the conclusions of this study also.

REMARKS ON THE AGE OF UJHANI AND TILHAR SEDIMENTS

SASTRI and VENKATACHALA (1968) studied the Tilhar sediments and assigned a Lower Palaeozoic age to the sediments below the unconformity at 1660—2051 m. depth. SALUJHA *et al.* (1967) also suggested a Lower Palaeozoic age to the Ujhani sediments met with in the Ujhani structural well below the unconformity at 1010—1247 m.

The assemblage as a whole in the Ganga valley subsurface sediments below the unconformity (Tilhar deep well, SASTRI & VENKATACHALA, 1968; Ujhani Structural well,

SALUJHA *et al.*, 1967) is homotaxial. This assemblage as already suggested by SALUJHA *et al.* (1967), SASTRI and VENKATACHALA (1968), VENKATACHALA (1970) and METRE (1968) is closely comparable to the Vindhyan assemblage. It is also comparable to the Kaladgi and Bhima assemblages. *Diplocraterion*, a trace fossil found in the Tilhar well at 1750—1752 m. is known from the Precambrian-Cambrian sediments of Sweden by TORELL (1870, in HANTZOCHAL, 1962). This fossil is considered to be of Paleozoic age and indicative of a marine habitat.

Filaments of Nostocalean alga recorded from the Tilhar is closely comparable to *Nodularites maslovi* described from the Cambrian of U.S.S.R. by HIZHNYAKOV and SCHEPELEVA (1964). This form is commonly recorded in other Cambrian sediments also by HIZHNYAKOV and SCHEPELEVA (1964). The acritarch assemblage also exhibits a very simple organization lacking the development of spines, hairs or horns that are common in the Tremadocian assemblages. Thus, it is suggested that the Tilhar as well as the Ujhani sediments under discussion are Pre-Ordovician in age (see also VENKATACHALA, 1970).

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REFERENCES

COMBAZ, A. (1966). Remarques sur less Niveaux a Tasmanacees du Paleogoique Saharien. *Palaeobotanist.* **15**(1-2): 29-34.

COMBAZ, A. (1967). Un Microbios due Tremadocian dans Un songage d' hassi-messaoud. *Act. Soc. linn. Bordeaux.* **104**(29): 1-26.

COMBAZ A. (1967). Leiosphaeridaceae Eisenack, 1954 and Protoleiosphaeridae Timofeev, 1959-Leurs affinites, leur role sedimentologique et geologique. *Rev. Palaeobot. Palynol.* **1**:309-321.

COMBAZ, A., LANGE, F. W. & PANSART, J. (1967). Les "Leiosfusidae" Eisenack, 1938. *Rev. Palaeobot. Palynol.* **1**: 291-307.

CRAFORD, A. R. (1969). Reconnaissance Rb.-Sr. dating of the Precambrian rocks of southern penninsular India. *J. geol. Soc. India.* **10**(2): 117-166.

CRAMER, F. H. (1964) Microplankton from three Paleozoic formations in the province of Leon (NW-Spain). *Leids geol. Meded.* **30**: 253-261.

CRAMER, F. H. (1966). Additional morphographic information on some characteristic acritarchs of the San Pedro and Furada formations (Silurian-Devonian boundary) in Leon and Asturias, Spain. *Notas Comun. Inst. geol. min. Esp.* **83**: 27-48.

CRAMER, F. H. (1967). Chitinozoans of a composite section of Upper Llandoverian to basal Lower Gedinnian sediments in northern Leon, Spain. A preliminary report. *Bull. Soc. belge Geol. Palepont, Hydrol.* **75**(1): 69-129.

CRAMER, F. H. (1968). Palynologic microfossils of the Middle Silurian Maplewood shale in New York. *Rev. Micropalaeont.* **11**(2): 61-70.

CRAMER, F. H. (1969). Possible implications for Silurian Paleogeography from phytoplankton assemblages of the Rose Hill and Tuscarora formations of Pennsylvania. *J. Paleontol.* **43**(2): 485-91.

CRAMER, F. H. (1970). Acritarchs and chitinozonas from the Silurian Ross Brook Formation, Nova Scotia. *J. Geol.* **78**(6)/745-749.

CRAMER, F. H. (1970). *Angochitina sinica*, a new Siluro-Devonian chitinozoan from Yunnan Province, China *J. Paleontol.* **44**(6): 1122-1124.

DEFLANDRE, G. (1942). Sur les hystrichospheres des calcaires Siluriens de la Montagne Noire. *Acad. Sci. Paris, C. R.* **215** (20): 1-6.

DEFLANDRE, G. (1945). Microfossiles des Calcaires Siluriens de la Montagne Noire. *Ann. Paleont.* **31**: 39-75.

DEUNFF, J. (1956). Progress recents de nos connaissances sur les microplanctons fossilsa hystrichosphaeres des mers primaires. *Grana Palynol.* **1**(2): 79-84.

DEUNFF, J. (1958). Microganismes planctoniques due Primaire Armoricain, I-Ordocicien due Veryhach (presequc' ile de Crozon) *Bull. Soc. geol. miner. Bretagne.* **2**:1-42.

DEUNFF, J. (1961). Un Microplancton a hystrichospheres dans le Tremadoc du Sahara. *Rev. Micropaleont.* **4**(1): 37-52.

DOWNIE, C. (1958). An assemblage of microplankton from the Shineton shales (Tremadocian) *Proc. Yorkshire geol. Soc.* **31**(12): 331-350.

DOWNIE, C. (1959). Hystrichospheres from the Silurian Wenlock shale of England. *Palaeontology.* **2**: 56-71.

DOWNIE, C. (1960). *Deunffia* and *Domasia*, new genera of hystrichospheres. *Micropaleontology* **6** (2): 197-202.

DOWNIE, C. (1963). Hystrichospheres (acritarchs) and spores of the Wenlock shale (Silurian) of Wenlock, England. *Palaeontology.* **6**: 625-652.

DOWNIE, C. (1967). The geological history of the microplankton. *Rev. Palaeobot. Palynol.* **1**: 259-281.

DOWNIE, C. & SARJEANT, W. A. S. (1963). On the interpretation and status of some hystrichosphere genera. *Palaeontology.* **6**: 83-96.

DOWNIE, C., BLACK, M., ROSS, R. & SARJEANT, W. A. S. (1967). The fossil record. *Geol. Soc. London:* 181-209.

EISENACK, A. (1931). Neue mikrofossilien des baltischen Silurs. *J. Paleont.* A. **13**: 74-118.

EISENACK, A. (1951). Über Hystrichosphaeridean und andere Kleinformen aus baltischen Silur und Kambrium. *Senck.* **32** (1/4): 187-204.

EISENACK, A. (1954). Hystrichossphären aus dem baltischen Gotlandium,. *Senckenbergiana* **B 34**: 205-211.

EISENACK, A. (1955). Neue Chitinozoen aus dem Silur des Balticums und dem Devon der Eifel. *Senckenberg.* **36**: 311-319.

EISENACK, A. (1958). Mikrofossilien aus den Ordovizium des Baltikums. 1. Marksitschicht, Dictyonema Schiefer, Glaukonitsand, Glaukonitkalk. *Senck. Leth.* **39** (4-6): 389-405.

EISENACK, A. (1959). Neotypen baltiseher Silur-hystrichosphaeren und neue arten. *Palaeontographica.* **112**(A) 192-211.

EISENACK, A. (1963). Hystrichosphaeren. *Biol. Rev.* **38**: 107-139.

EISENACK, A. (1965). Foraminiferen aus dem baltischen Silur. *Senck.* **35** (1-2): 51-72.

FOOTE, R. B. (1876). The geological features of the south Marhatta country and some adjoining districts. *Mem. geol. Surv. India* **12**(1).

GRIGNANI, D. (1967). Correlation with chitinozoa in the Devonian and Silurian in some Tunisian well samples. *Rev. Palaeobot. Palynol.* **5**: 315-325.

HANTZOCHEL, W. (1962). Trace fossils and Problematica, in Treatise on Invertibrate paleontology. Part V. *Geol. Soc. America. Kans. Univ. Press*: 187-245.

HIZYAKOV, A. B. & SPHEPELEVA, E. D. (1964). Geology and Oil & Gas potentiality Volino-Podolsky marginal part of Russian platform. *Trans. Ukran. Nigr. Bull.* **9**: 151-158.

HOFFMEISTER, W. S. (1959). Lower Silurian plant spores from Libya. *Micropaleontology* **5**(3): 331-334.

HOLMES, A. (1955). Dating the Precambrian of Peninsular India and Ceylon. *Proc. geol. Assoc. Canada.* **7**: 81-106.

JANSONIUS, J. (1967). Systematics of the Chitinozoa. *Rev. Palaeobot. Palynol.* **1**: 345-360.

KOROLEV, V. G. (1971). Dispersional remnants of fossil plants of Kirghizia. *Acad. Sci. Kirg. Sov. Social. Rep. Inst. Geol.* Spl. Pub. **3.** *Int. Conf. Paty.:* 1-45.

KRISHNAN, M. S. (1968). *Geology of India and Burma.* Higginbothams, Madras.

KRISHNAN, M. S. (1969). Pre-Cambrian geochronology of India. *Indian. Geosci. Ass. Pres. Add. Ann. Meet.:* 1-13.

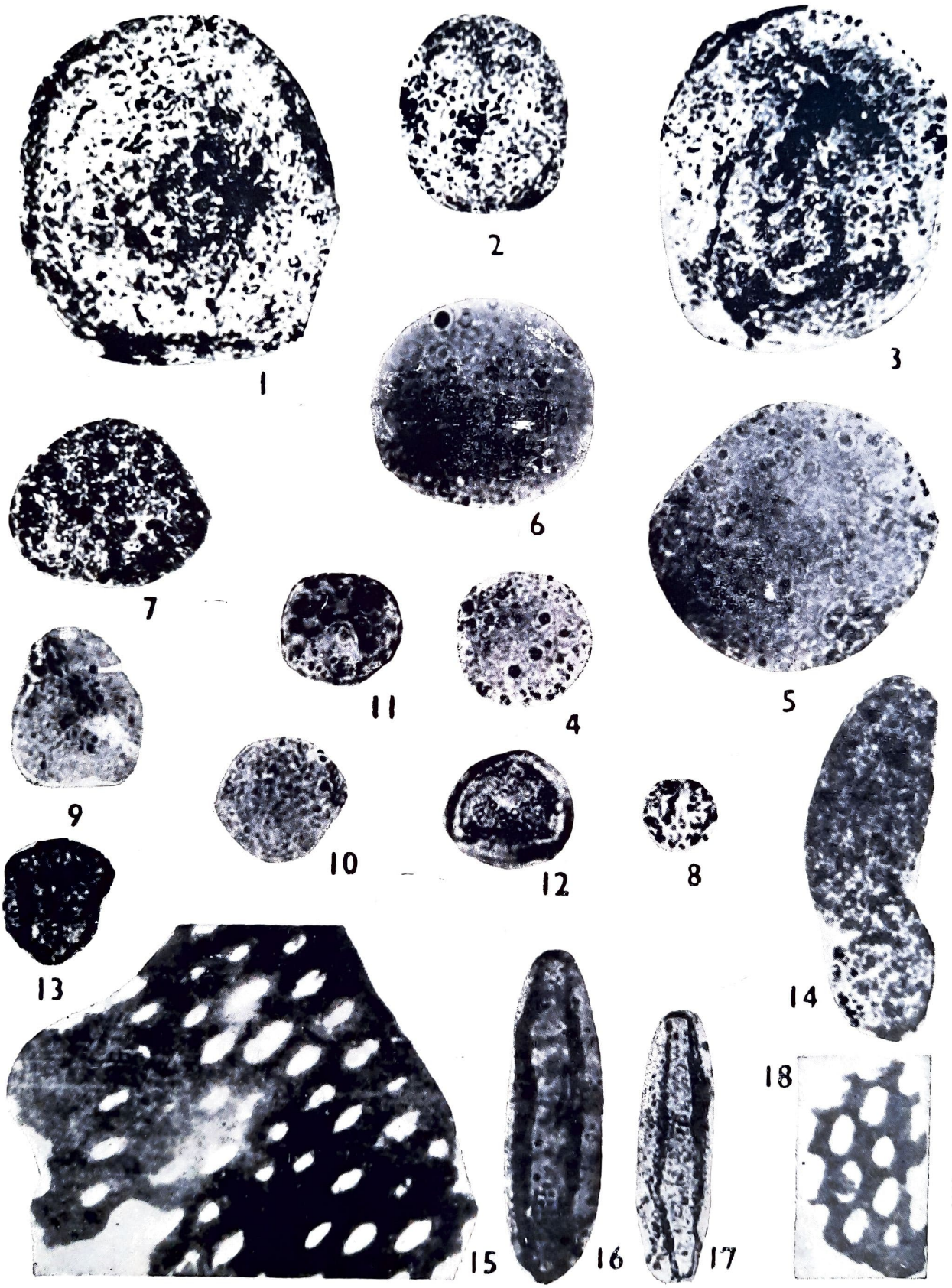
MAHADEVAN, C. (1947). The Bhima Series and other rocks in Gulbarga district. *J. Hydrabad geol. Surv.* **5**(1): 1-60.

MEHADEVAN, C. & KAZIM, S. (1947). The Bhima Series and other rocks in Gulbarga dist. *J. Hyderabad Geol. Surv.* **5.**

METRE, W. B. (1958). Petroleum industry and sub-surface geology, 13th lecture, T. H. Holland *Meml. Lect. Min. geol. Metall. Inst. India*: 1-55.

PICHAMUTHU, C. S. (1971). Precambrian geochronology of Peninsular India. *J. geol. Soc. India.* **12**(3): 262- 273.

PICHOA, N. G. (1967). Microfossils of Lower Cambrian and Precambrian deposits in eastern Sibaria. *Rev. Palaeobot. Palynol.* **5**: 31-38.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SALUJHA, S. K., RAWAT, M. S. & REHMAN, K. (1967). Palynological study of Pre-Tertiary (Ujhani) sediments in Uttar Pradesh, India. *Bull. ONGC.* **4**(1): 56-61.

SALUJHA, S. K., REHMAN, K., ARORA, C. M. & RAWAT, M. S. (1969). Final report on palynological studies of Vindhyan sediments and their probable equivalents in Peninsular India. *Report of ONG Commission:* (Unpublished).

SALUJHA, S. K., REHMAN, K. & ARORA, C. M. (1971). Plant microfossils from the Vindhyans of Son Valley, India. *J. geol. Soc. India.* **12**(1): 24-33.

SALUJHA, S. K. REHMAN, K. & RAWAT, M. S. (1971). Fossil palynomorphs from the Vindhyans of Rajasthan (India). *Rev. Paleobot. Palynol.* **11**: 65-83.

SASTRI, V. V., BHANDARI, L. L., CHAUBE, A. N., FULORIA, R. C., SINHA, R. N. & CHOWDHARY, L. R. (1969). Poorly explored sedimentary basins of India. *Econ. Comm. Asia, Far East Symp. Dev. Pet. Resources:* 1-40.

SASTRI, V. V. & VENKATACHALA, B. S. (1968). Organic remains, age and environment of the Pre-Siwalik sediments encountered in some deep wells drilled in southern part of Ganga Valley. *Bull. ONGC.* **5**(2): 75-82.

SREENIAVSA, T. N. & GOWDA, S. S. (1970). Fossil acritarcha from Bhima "Series" of Gulbarga district, Mysore state, India and their geological significance. *Proc. Symp. Purana Form. Peninsul. India,* (Abst.).

STAPLIN, F. L., JANSONIUM, J. & POCOCK, S. A. J., (1965). Evaluation of some acritarchous Hystrichosphere genera. *N. Jb. geol. palaeontol. Abhandl.* **123**(2): 167-201.

TIMOFEEV, B. V. (1959): The ancient flora of the Pre-Baltic and its stratigraphic significance. *Vses. Naucbn. Issled. geol. Inst.* **129**: 1-350.

TIMOEFEV, B. V. (1960). Sur la caracteristique micropaleontologique de la formation due visingso. *Geol. Foren Stockholm, Forh.* **82**(1): 29-42.

TIMOFEEV, B. V. (1963). On organic remains in the Eocambrian of Norway. *Norsk. Geol. Tidsscr.* **43**(4): 473-470.

VAVRADOVA, M. (1965). Ordovician acritarchs from central Bohemia. *Vestnik. UUG.* **40**: 251-357.

VENKATACHALA, B. S. (1972). Observation on some palynological contributions to Indian Stratigraphy *Palaeobotanist.* **19**(3): 284-296.

VENKATACHALA, B. S., BHANDARI, L. L., CHAUBE, A. N. & RAWAT, M. S. (1972). Organic remains from Dharwar sediments. (MS.).

VENKATACHALA, B. S. & RAWAT, M. S. (1972). Organic remains from Kaladgi Basin. *Geophytology (in press)*

VINOGRADOV, A., TUGARINOV, A., ZHYKOV, C., STAPNIKOAA, N. BIBIKOVA, E. & KHORRE, K. (1964). Geochronologv of Indian Pre-Cambrian. *Rep. Twenty-Second Session Int. Geol. Congr.*, Pt.-10. Archaean and Pre-Cambrian Geology.

EXPLANATION OF PLATE 1

(All magnified × 1000)

1,3. *Leiosphaeridia aglutinata* Venkatachala & Rawat.
2, 7. *Leiosphaeridia* sp.
4-6, 10. *Leiosphaeridia dakshinii* sp. nov.
8. *Protoleiosphaeridium* sp.
9. *?Lophotriletes antiquitus* sp. nov.
11, 12. *Schismatospharedium bhimai* sp. nov.
13. *Lophosphaeridium* sp.
14. *Incertae sedis* type-2.
15, 18. Organic plates.
16, 17. Incertae sedis type-1