ORGANIC REMAINS FROM KALADGI BASIN

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ABSTRACT

Palynological remains from Lower Kaladgi are studied. An assemblage consisting of *Leiosphaeridia, Protoleiosphaeridium, Granomarginata, Schismatosphaeridium, Lophosphaeridium, Retisphaeridium, Trachysphaeridium, Archaeohystrichosphaeridium*, and organic plates, perhaps of animal origin is found in the Lower Kaladgi sediments, which is characteristic of Upper Precambrian-Lower Cambrian age.

A neritic depositional environment is envisaged on the occurrence of large algal stromatolites and sphaeromorphs.

INTRODUCTION

The Kaladgi basin extending between Belgaum and Kaladgi is located nearly 200 km north west of the Cuddapah basin and is an elongated basin extending nearly EW for 250 km and occupies an area of 15,000 sq km. The Kaladgi Formation rests unconformably upon the gneisses and schists of the Dharwar System. Deccan Trap volcanic rocks cover the Kaladgi sediments in the northern part of the basin.

The generalized stratigraphy is as follows:

Upper Kaladgi (350—550 m)	..	Shales, limestones, and haematite schists, quartzites and conglomerates.
Lower Kaladgi (2,400—3,300 m)	..	Siliceous and oolitic limestones, ferruginous shales, clay sandstones and shales, chert breccias, orthoquartzites and conglomerate.

The Lower Kaladgi sediments mainly occur in the northern, western and southern parts of the basin. The Upper Kaladgi sediments conformably overlie the Lower Kaladgi and are present in the north western part of the basin (SASTRI *et al.*, 1969).

FOOTE (1876), SAHASRABUDHE (1964) and SASTRI *et al.*, (1969) have given excellent accounts of the geology of the area.

Stromatolites occur extensively in the dolomites and the dolomitic limestones of the Lower and Upper Kaladgis. The exposures containing stromatolites occur extensively on the northern bank of the Ghataprabha river and around Alagundi (VISWANATHIAH & GOWDA, 1970). Six distinct stromatolitic bands are also recorded by RAJULU and GOWDA (1966) near Lokapur, Midchi Halli, and north of Varchagal. These records indicate abundantly preserved evidence of organic activity in the Kaladgis.

The present study concerns with acid resistant organic remains from the Lower & Upper Kaladgi Formations. A total of 16 samples were investigated for microfossils; 6 samples (Table 1) yielded well preserved algal sphaeromorphs, acritarchs and cellular

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Table 1—Details of samples studied from the Kaladgi Basin

	Sample no.	Traverse	Locality	Lithology	Palynofossils
1	2	3	4	5	6
Badami Sandstone	K8	Gokak-Yargatti Bagalkot Road.	About 6 miles, 2 furlong on Gokak-Yargatti road; 16° 1' 59": 74° 58' 37".	Greenish, Chloritic sandstone fine to medium grained interbedded with fine textured quartzite and coarse grained sandstone.	×
Upper Kaladgi	K12	Gokak-Yargatti-Bagalkot road traverse.	About a mile short of Lokapur; 16° 09' 24" : 75° 21' 30".	Limestone, compact, hard with chert bands.	×
Lower Kaladgi.	K27	Bagalkot-Badami-Ramdurg Road section.	On Cliff in Pattadakal-keudur road near Bhadranaikanjalihalla; 15° 58' 00": 75° 46' 48".	Gray to purplish, compact arenaceous shale.	+
	K32	Bagalkot-Biligi-Kanur-Jamkhandi-Bagalkot traverse.	1½ miles south of Kanur; 16°25' 34":75° 21' 38".	Light buff coloured mudstone.	×
	K4	Dharwar-Saundatti-Gokak road traverse.	At the Malaprabha bridge ; 15° 51' 19":75° 06' 55".	Reddish calcareous shale, nodular with silicous veins.	×
	K11b	Gokak-Yargatti-Bagalkot road trav.	6 miles from Chandays ; 16° 02' 35":75° 09' 16".	Choclate brown friable between purple calcareous shale.	+
	K11c	Ditto	6 miles from Chandays ; 16° 02' 35":75° 09' 16".	Argillaceous limestone	+
	K10	Gokak-Yargatti-Bagalkot road traverse.	5 miles, 2 furlongs short of Chandargi; 16° 01' 43":75° 05' 36".	Fine grained purple agrillaceons sandstone.	×
	K22	Gokak-Yargatti-Bagalkot road Traverse.	Near Khajjdoni; 16° 10' 16":75° 27' 14".	Grey purple shale	×
	K21	Ditto	Near Khajjdoni; 16° 09' 25":75° 22' 36".	Grey slates	×
	K18	Ditto	Along the road to Lokapur Nala; 16° 07' 59":75° 21' 30".	Dark compact shale	+
	K14	Ditto	About a furlong SE of Varchgal village; 16° 07' 26":75° 21' 26".	Grey flaggy limestone	×
	K13	Ditto	Ditto	Flaggy limestone intercalated by thin soft greyish shale.	+
	K3	Dharwar-Saundatti-Gokak road traverse.	1 km short of Manoli village; 15° 48' 27":75° 06' 35".	Pink-reddish brown arenaceous shale.	×
	K25	Bagalkot-Badami-Ramdurg road section.	9 miles short of Badami on Togunali-Badami road; 16° 01' 18":75° 42' 55".	Grey thinly liminated araneous shale.	+
	K29	Ditto	Near Ramdurg; 15° 57' 17":75° 17' 09".	Grey shale overlain by Badami quartzite.	×

+ =Presence
× =Absence

tissue associated with amorphous organic debris (see Table 2). The material for this study was collected by S/Shri L. L. Bhandari, A. N. Chaube and one of the authors (B. S. V.).

Table 2—Distribution of fossils in different fossiliferous samples of Kaladgi sediments

Sample No./Fossils	K25	K27	K11	K13	K18
Leiosphaeridia	+	+	..	+	+
Protoleiosphaeridium	+	+	+	..	+
Granomarginata	+	..	+	..	..
Schismatosphaeridium	..	+	..	..	..
Lophosphaeridium	..	+	+	..	..
Retisphaeridium	+	..	..	..	..
Trachysphaeridium	+	..	+	..	+
Archaeohystrichosphaeridium	+	..	..	..	..
Organic plate	+	+	+	..	..

METHOD

The rock samples were thoroughly washed with distilled water and burnt over a flame to destroy any sticking organic matter. 50 grams of the sample, taken after discarding trimmings from sides, was digested with commercial Hydrofluoric acid (two days). The washed macerate was treated with Nitric acid (40%) and Potassium hydroxide solution (10%) before separating the organic residue from the inorganic debris by heavy liquid floatation technique (VENKATACHALA & SHARMA, 1972). The organic residue thus obtained was mounted with Polyvenyl alcohol and Canada balsam and dried in an oven at 60°C.

4 slides were studied for each sample. Fossils are rare and not well preserved. The slides were scanned and the fossils studied with the help of a zeiss photomicroscope. The photographs are taken with a 100 × oil immersion lense on Kodak microfile (10° Din). The photographs appended to this report are enlarged 1000 times. The type collection o fossils marked on the slides are lodged in the repository of the Palynology Laboratory of the Institute of Petroleum Exploration, ONGC, Dehra Dun. The slide numbers of the illustrated specimen are given.

SYSTEMATIC PALYNOLOGY

8 genera and 14 species of microfossils are recognized in this study, of which 8 species are newly proposed.

Group—ACRITARCHA Evitt, 1963

Subgroup—SPHAEROMORPHITAE Downie, Evitt & Sarjeant, 1963

Genus—**Leiosphaeridia** (Eisenack, 1958) Downie & Sarjeant, 1963

Type species—*Leiosphaeridia baltica* Eisenack, 1958

Leiosphaeridia insigna sp. nov.

Pl. 1, Figs. 12 & 13

Holotype—Pl. 1, Fig. 12.
Type locality—Lokapur.

Description—Vesicle spheroidal, 23-28 μ. Wall thin, ±0.5 μ, smooth; sometimes folded due to thin wall.

Comparison—*Leiosphaeridia laevigata* Stockman & Williere, 1963 is much larger in size. *L. vindhyana* recorded from Upper Bhander Sandstones, Karauli area, Rajasthan by SALUJHA *et al.* (1971) is comparable in size with the Kaladgi species, but the latter is distinguished by its extremely thinner and transparent wall. *L. pallucida* aad *L. tenella* described by SALUJHA *et al.* (1971) from Vindhyans of Son valley differ in wall ornamentation. The type species is differentiated by its larger sizee. *L. ornata* Venkatachala *et al.* (1973) recorded from Dharwar exposures is an ornate form.

Leiosphaeridia sp. A

Pl. 1, Figs. 4, 7

Description—Vesicle spheroidal, 22-28 μ; wall smooth, granulose, grana sparsely distributed, plyome distinct, circular, 15 μ.

Leiosphaeridia sp. B

Pl. 1, Fig. 11

Description—Vesicle broken, triangular in folded condition, 25-37 μ. Wall thin, less than 1 μ, smooth; folds simulating a Y-mark.

Genus—**Protoleiosphaeridium** Timofeev, 1956

Type species—*Protoleiosphaeridium conglutinatum* Timofeev, 1959

Protoleiosphaeridium kaladgiensis sp. nov.

Pl. 1, Fig. 5

Holotype—Pl. 1, Fig.5
Type locality—About a furlong south-east of Varchagal village.
Description—Vesicle spheroidal, folded, 16×14 μ. Wall very thin, less tian 0.5 μ, smooth.

Comparison—*Protoleiosphaeridium diatretus*, illustrated by SALUJHA *et al.* (1971) from Upper Vindhyans of Rajasthan is distinguished by its perforations on the vesicle. *P. conglutinatum* Timofeev, 1959 is comparatively larger in size and has minute sculpturing on the vesicle.

Protoleiosphaeridium sp. A.

Pl. 1, Fig. 9

Description—Vesicle spheroidal, 12-13 μ; wall thin, less than 0.5μ, smooth to finely ornamented.

Protoleiosphaeridium sp. B

Pl. 1, Fig. 10

Description—Vesicle espheroidal, specimen illustrated here is triangular in equatorial compression due to folding, 20 μ. Wall thin, less than 1.0 μ, granulose; grana fine and irregularly spaced, can be deciphered in equatorial margins. The folds almost running parallel to the *extrema lineamenta* simulate a trilete mark, however, two sets of folds are seen in this specimen.

Comparison—*Protoleiosphaeridium* sp. B is distinguished from the type species by its granulose wall. *P. pristinum* described by SALUJHA *et al.* (1971) agrees in size but the Vindhyan species has perforated vesicle. *P. diatretus* Salujha *et al.*, 1971 has also a perforated wall.

Protoleiosphaeridium sp. C

Pl. 1, Fig. 14

Description—Vesicle spheroidal, 22 μ, specimen dark and badly preserved.

Protoleiosphaeridium sp. D

Pl. 1, Figs. 6, 8

Description—Vesicle spheroidal, folded, 20-24 μ, Wall thin less than 1.0 μ, smooth, specimen broken.

Genus—**Granomarginata** Naumova, 1961

Type species—*Granomarginata prima* Naumova, 1961

Granomarginata kaladgii sp. nov.

Pl. 1, Fig. 3

Holotype—Pl. 1, Fig. 3
Type locality—9 miles short of Badami.
Description—Vesicle spheroidal, 20-22 μ. Wall thin, up to 0.5 μ, granulose; grana up to 0.5 μ wide, closely set, descernible in the equatorial outline.

Comparison—*Granomarginata clara* Venkatachala *et al.*, 1973 described from Dharwar exposures is distinguished by its thick wall and comparatively bigger size. *G. primitiva* described by SALUJHA *et al.* (1971) from Vindhyans of Son valley is a smaller form and has a thick peripheral thickening.

Granomarginata sp. A

Pl. 1, Fig. 24

Description—Vesicle spheroidal, folded in equatorial compression, 23 × 25μ; the tetragonal folds give a squarish appearance to the specimen. Wall less than 1 μ thick, granulose; grana closely set and regularly distributed. Wall margin uneven due to granulose ornamentation.

Remarks—Due to the thin walled nature of the vesicle, various types of folds occur on

account of compression, the vesicles are spheroidal in inflated condition, and the secondary folds may give various derived shapes.

Granomarginata sp. B

Pl. 1, Figs. 1, 2

Description—Vesicles spheroidal to oval, 45 × 35 μ, folded; wall ill-defined, less than 1.0 μ. Wall marginated with grana.

Genus—**Schismatosphaeridium** Staplin, Jansonius & Pocock, 1965

Type species—*Schismatosphaeridium perforatum* Staplin *et al.*, 1965

Schismatosphaeridium verrucosus sp. nov.

Pl. 1, Fig. 25

Holotype:—Pl. 1, Fig. 25.
Type locality—Near Bhadranaikanjalihalla
Description—Vesicle spheroidal, 27 μ; wall less than 1.0μ thick, verrucose; verruae up to 2.0 μ broad, irregular in shape and size; wall folded. Pylome present ? upto 7 μ in diameter.

Comparison—*Schismatosphaeridium perforatum* originally described from Upper Llandoverian by STAPLIN *et al.* (1965) are similar in size but have a granulose or chagrinate sculpture. Other species described by the same authors have a comparable ornamentation and a very well defined pylome. The genus is also recorded from Algonkian by PFLUG (cited by STAPLIN *et al.*, 1965). *S. bhimai* Venkatachala & Rawat, 1973 differs in having smooth wall.

Genus **Lophosphaeridium** Timofeev, 1959

Type species—*Lophosphaeridium rarum* Timofeev, 1959

Lophosphaeridium conatum sp. nov.

Pl. 1, Fig. 22

Holotype—Pl. 1, Fig. 22.
Type locality—Near Bhadranaikanjalihalla.
Description—Vesicle spherical, folded, 35-40 μ, the specimen illustrated here is *ca.* 37 μ. Wall thin, up to 1 μ, bearing sharp coni, which are less than 1 μ long and equally broad, coni closely spaced, giving a punctate appearance in the surface view.

Comparison—*Lophosphaeridium jansoniusii*, *L. vetulum* described by SALUJHA *et al.* (1971) are smaller in size and presumably possess larger coni for their ornamentation. *L. rarum* Timofeev (1959) recorded from Ordovician of U.S.S.R. is a larger form and is ornamented with sparsely arranged processes.

Genus—**Retisphaeridium** Staplin, Jansonius & Pocock, 1965

Type species—*Retisphaeridium dichamerum* Staplin *et al.*, 1965

Retisphaeridium indicum sp. nov.

Pl. 1, Figs. 17, 18, 23

Holotype—Pl. 1, Fig. 23

Type locality—9 miles short of Badami on Togunali-Badami road.

Description—Vesicle subcircular to polygonal, 25-35 μ. Wall smooth, less than 1 μ thick, low costae present, irregularly distributed, rarley forming meshes; folds irregular

Comparison—*Retisphaeridium dichamerum* recorded from Middle Cambrian, of Southern Alberta, Canada by STAPLIN *et al.* (1965) is comparable in size. However, *R. indicum* possesses less number of costae.

Genus—**Trachysphaeridium** Timofeev, 1959

Type species—*Trachysphaeridium patellare* Timofeev, 1959

Trachysphaeridium sp. A

Pl. 1, Fig. 21

Description—Vesicle spheroidal, 15 μ. Wall thin, about 0.5 μ, ornamented with fine baculae, less than 1 μ high and about 0.5 μ broad. Peripheral fold observed on the vesicle.

Trachysphaeridium sp. B

Pl. 1, Figs. 15, 19, 20

Description—Vesicle spheroidal, 10-16 μ. Wall up to 1 μ thick, ornamented with small somewhat closely spaced baculae; bacula as high as broad at the basal region, up to 1 μ; tips blunt.

Subgroup—ACANTHOMORPHITAE Downie, Evitt & Sarjeant, 1963

Genus—**Archaeohystrichosphaeridium** Timofeev, 1959

Type species—*Archaeohystrichosphaeridium volgdense* Timofeev, 1959

Archaeohystrichosphaeridium kaladgiensis sp. nov.

Pl. 1, Fig. 16

Holotype—Pl. 1, Fig. 16.

Type locality—Near Bhadranaikanjalihalla.

Description—Vesicle spherical, 25-30 μ, illustrated specimen measures 30 μ. Wall about 1 μ thick, spinulose; spines conical, up to 4 μ long with a base of 1.5-2.0 μ, solid, sharp tipped, sparsely spaced, about 25 spines can be counted on the equatorial margin.

Comparison—*Archaeohystrichosphaeridium luberi* Timofeev (1959), *A. pentagonum* Timofeev (1959) can be distinguished from the Kaladgi species in the nature of spines arising from the vesicle. *Archaeohystrichosphaeridium* sp. 1 described by SALUJHA *et al.* (1971) from Vindhyans of Rajasthan has smaller spines and thicker exine.

Incertae Sedis

Longitudinal organic plate

Pl. 1, ig. 26

Description—Elongated plate with three distinct simple-oval, 7 ×5 μ wide perforations, with thickened margins.

Affinity—Perhaps of animal origin.

DISCUSSION

Fossils are recovered only in the Lower Kaladgi samples (See Table 1). The fossil assemblage is associated with amorphous organic debris which often crowds the slide making the study difficult. The following acritarchs are recorded: *Leiosphaeridia, Protoleiosphaeridium, Granomarginata, Schismatosphaeridium, Lophosphaeridium, Retisphaeridium, Trachysphaeridium, Archaeohystrichosphaeridium.*

Quantitative estimates have not been made as the number of specimens recorded in each sample is not more than 10, however, *Leiosphaeridia* and *Protoleiosphaeridium* are the most common fossils.

The Precambrian acritarchs are mostly simple sphaeromorphs without any spinous ornamentation. (see DOWNIE, 1967 for detailed discussion). This fact is also substantiated by our studies on the assemblages from Dharwar sediments (VENKATACHALA *et al.*, 1973). The Dharwar assemblage is also associated with algal remains such as *Myxococcoides, Palaeoanacystis, Globophycus, Glenobotrydion* and others which are significantly absent in the Kaladgi assemblage. TIMOFEEV (1959) and PICHOVA (1967) have also recorded a large number of fossils from the Precambrian sediments of U.S.S.R. These assemblages are also distinguished by a group of simple sphaeromorphs.

Advanced structurally differentiated acritarchs appear in the Cambrian (DOWNIE, 1967). The Kaladgi assemblage is characterised by the presence of *Granomarginata, Schismatosphaeridium, Lophosphaeridium, Trachysphaeridium, Retisphaeridium* and *Archaeohystrichosphaeridium*, all of which are ornate acritarchs. Thus, the assemblage is significantly advanced over the Precambrian acritarchs.

Leiosphaeridia and *Protoleiosphaesidium* are common to both Precambrian and Cambrian sediments and continue into the Silurian and Devonian sediments. *Schismatosphaeridium* is known only in the Upper Llandoverian and may occur also in Cambrian sediments (STAPLIN *et al.*, 1965). *Granomarginata* is known only from the Precambrian-Cambrian (DOWNIE, 1967; TIMOFEEV, 1959). *Lophosphaeridium, Trachysphaeridium* and *Archaeophystrichosphaeridium* have a range from Cambrian-Lower Ordovician (TIMOFEEV 1959, 1960, COMBAZ, 1967). *Retisphaeridium* is known from the Middle Cambrian (STAPLIN *et al.*, 1965).

The Ordovician assemblages studied by COMBAZ (1967), DEUNFF (1961) and DOWNIE; (1958) distinguish by the occurrence of advanced forms as compared to the Kaladgi assemblage. *Baltisphaeridium, Micrhystridium, Veryhachium, Hystrichosphaeridium, Diornotosphaera, Cymatiosphaera* and other variously ornamented acritarchs appear in the Tremadocian and continue into the younger Ordovician. COMBAZ (1967) also records a number of ornate, well defined trilete spores. Thus Tremadocian represents a time when evidence for the appearance of land plants can be authentically documented.

It is deduced from the above discussion that the Kaladgi assemblage shows a distinct advancement over the Dharwar assemblage (VENKATACHALA *et al.*, 1973), and not as advanced as the Tremadocian (Lower Ordovician) assemblages.

The occurrence of simple Leiosphaerids which dominate the assemblage in association with *Granomarginata* both of which are Precambrian-Cambrian fossils and other ornate forms as discussed above suggest an Upper Precambrian-Lower Cambrian age to the Lower Kaladgi Sediments studied here.

Viswanathiah, Rajulu and Sathyanarayan (1964); Rajulu and Gowda (1966, 1968) and Viswanathiah and Gowda (1970) have studied algal stromatolites from the Lower Kaladgi sediments and are inclined to accord a Precambrian age to the sediments. The present study of the acid resistant algal sphaeromorpha suggests a younger age.

The fossil evidence supports a neritic depositional environment to the sediments. The occurrence of large algal stromatolites in the Lower Kaladgis also is significant. Stromatolites are known mainly from shallow water protected marine environment in open intertidal zones between the low water and high water marks (Ginsburg, 1955). The algal colonies need sunlight to develop and form stromatolitic limestones, thus the sediments were not laid in deeper waters. The delicate algal sphaeromorphs and acritarchs preserved in the Lower Kaladgi shales also cannot be preserved under turbulant conditions. These evidences confirm that the sediments were deposited in intertidal or a mudflat environment.

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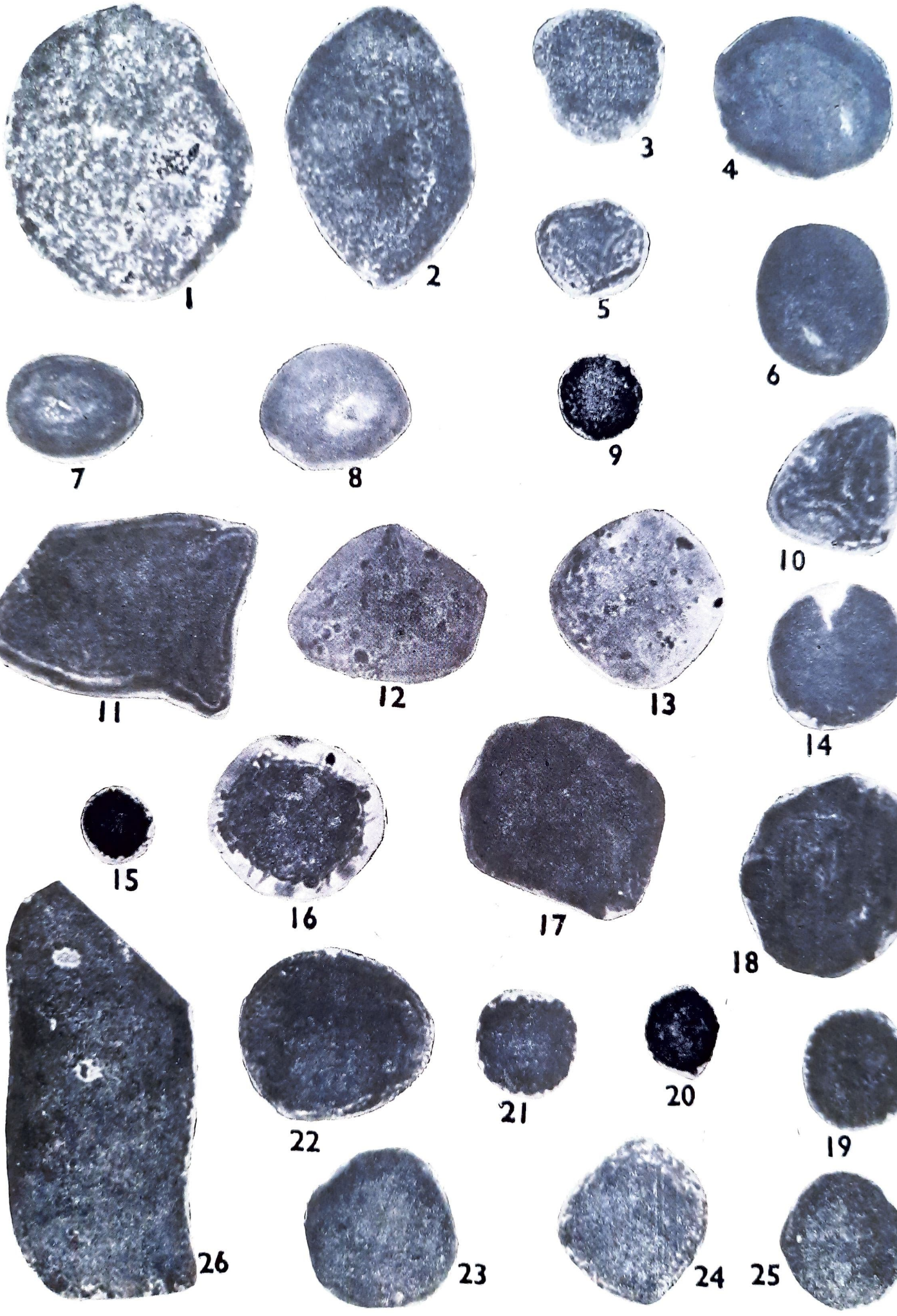
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EXPLANATION OF PLATE 1

(All figures unless otherwise stated are ×1000)

1, 2. *Granomarginata* sp. B, Specimen no. K 11C/1.
3. *Granomarginata kaladgii* sp. nov., Specimen no. K 25/2.
4, 7. *Leiosphaeridia* sp. A, Specimen no. K 27/2.
5. *Protoleiosphaeridium kaladgiensis* sp. nov., Specimen no. K 13/2.
6, 8. *Protoleisphaeridium* sp. D, Specimen no. K 25/1.
9. *Protoleiosphaeridium* sp. A, Specimen no. K 11b/1.
10. *Protoleiosphaeridium* sp. B, Specimen no. K 27/1.
11. *Leiosphaeridia* sp. B, Specimen no. K 27/1.
12, 13. *Leiosphaeridia insigna* sp. nov., Specimen no. K 18/2.
14. *Protoleiosphaeridium* sp. C, Specimen no. K 25/2.
15, 19, 20. *Trachysphaeridium* sp. B, Specimen no. K 11C/1.
16. *Archaeohystrichosphaeridium kaladginensis* sp. nov., Specimen no. K 27/2.
17, 18, 23. *Retisphaeridium indicum* sp. nov., Specimen no. K 25/1.
21. *Trachysphaeridium* sp. A, Specimen no. K 18/3.
22. *Lophosphaeridium conatum* sp. nov., Specimen no. K 27/2.
24. *Granomarginatata* sp. A, Specimen no. K 11/2.
25. *Schismatosphaeridium verrucosus* sp. nov., Specimen no. K 27/2.
26. Longitudinal organic plate (× approx. ×700). Specimen no. K 11C/1.