BOUTAKOFFIASPORA, A NEW MEGASPORE GENUS FROM KIFWA—KASONGO, ZAÏRE

K. P. JAIN AND S.C.D. SAH

Birbal Sahni Institute of Palaeobotany, Lucknow

ABSTRACT

The material, comprising well preserved fossil megaspores, was collected from the Kifwa-Kasongo beds near Ankoro in Shaba province, Zaïre. The age of these beds is uncertain. From the stratigraphical position of the beds, it appears that the fossils come from a Cenozoic and probably Late Cenozoic horizon.

The Zaïre fossils are described under a new megaspore genus *Boutakoffiaspora* with two new species viz., *B. lepersonnea* and *B. cahenii*. *Boutakoffiaspora* is regarded here as a megaspore genus chiefly because of the presence of distinct proximal triradiate mark and in the absence of any trace of vascular supply.

B. lepersonnea differs from *B. cahenii* mainly in its larger size, elongated polar axis and in the presence of a canal in two episporic folds. Both the species are considered to be related to the extant genus *Salvinia* because of the presence of (i) three-layered megaspore coat, (ii) unequally thickened perispore wall, divided proximally into three folds, (iii) vacuolate and spongy nature of the perispore wall, and (iv) three lateral ridges. The comparatively large size and elongated polar axis of these megaspores (as seen in *B. lepersonnea*) shows considerable variation from those of modern *Salvinia*. This variation suggests that the megaspores may belong to an extinct genus of water ferns, closely related to *Salvinia*.

From the habitat and present day distribution of *Salvinia* it has been inferred that the Kifwa-Kasongo beds were deposited under fresh-water environment and the climate was moist, tropical to sub-tropical.

INTRODUCTION

The material on which the present study is based consists of several sandstone pieces containing well preserved megaspore remains. The collection was made by Mr. N. BOUTAKOFF and subsequently sent by Mr. L. CAHEN, Director, Musée Royal de l' Afrique Centrale, Tervuren, Belgium, to Dr. M. N. BOSE, who very kindly entrusted the material to us for investigation.

The rock is a fine-grained, impure, argillaceous sandstone, dirty white in colour. It is characterised by having a clayey, chloritic matrix. At several places the cementing material appears to be mixed with organic matter. Quartz grains are angular to subangular with a few sub-rounded, showing strain lamellar shadows suggestive of poor (+++) maturity. This indicates ill sorting and least transport distance from the parent rock to the place of deposition. Few fragments of quartzite are also present. Ferruginous staining (— —) is also occasionally seen. The rock is practically devoid of felspars, indicating a long depositional interface.

The age of this megaspore-bearing sandstone bed is a debatable problem. In a personal communication Mr. L. CAHEN mentions that the precise age of these beds is unknown and their description has also not been published so far. The original note of Mr. N. BOUATKOFF gives the following details, "Fossiles de Kifwa-Kasongo; Echantillons K_1 a K_{30} provenant des couches du système de Kifwa-Kasongo* (étage supérieur des grès crayeux et calcareux tendres (K_4) reposant sur les argilites rouges et bariolées du système du Karroo

* (ainsi nomme par N. Boutak offen 1934).

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(étage du Lualaba) et parfois sur des lambeux des grès qui surmountent ces argilites (Étage du Lubilache). Il y a discordance entre Karroo et les couches de Kifwa-Kasongo-village de Kifwa-Kasongo s/Luvua; 20 km environ en amont d' Ankoro (confluent Luvua-Lualaba) rive gauche; falaise dominant la Luvua á l' est du village á 1 km de celui-ci".

In view of the present state of knowledge N. BOUTAKOFF's original data need to be reinterpreted.

Mr. J. LEPERSONNE has kindly reexamined the area concerned on aerial photographs, it is identical to areas further in Maniema where the "Lualaba" and "Lubilache" of N. BOUTAKOFF in fact belong to the "Série de la Houte Lueki of Triassic to Lower Jurassic age (A. L. LOMBARD, 1961; L. CAHEN et J. LEPERSONNE, 1971)."

In this entire area, the "Série de la Haute Lueki" is almost never surmounted by younger Mesozoic beds and where this occurs, this state of affairs is readily distinguishable on aerial photographs. This is not the case at Kifwa-Kasongo.

The area is also normally devoid of early Cenozoic beds such as the "Série des Grés polymorphes," so that the unconformity which, according to N. BOUTAKOFF separates the Kifwa-Kasongo beds from the "Série de la Haute Lueki" probably separates late Cenozoic beds from early Mesozoic ones.

According to L. CAHEN and J. LEPERSONNE (verbal information) the Kifwa-Kasongo beds are thus almost certainly of Cenozoic and probably of Late Cenozoic age.

For the present, no age deduction can be made on the basis of plant fossils.

The fossil megaspores resemble in their anatomical details the megaspores met with in the living genus *Salvinia*. All the known species of *Salvinia* are acquatic and their present day geographic distribution restricts them, except for *S. natans*, to the tropics. Consequently, it is inferred that the Kifwa-Kasongo beds were deposited under fresh-water conditions, with moist, tropical to sub-tropical environment. The fresh-water aspect of deposition is also substantiated by the presence of fresh-water diatoms (Pl. 2, Fig. 22).

TAXONOMY

The fossil megaspores have been treated in accordance with the International Code of Botanical Nomenclature and conform with the proposals of POTONIÉ and KREMP (1954) and subsequently modified by POTONIÉ (1956, 1958, 1960). We agree with the opinion expressed by SAH (1967, pp. 6-7), that in the interest of stratigraphic palynology one system of binomial nomenclature should be adopted for fossils of all geologic horizons. We are, therefore, instituting a new form genus for the megaspores from Zaïre, instead of referring them to a natural taxon.

SYSTEMATIC DESCRIPTION

Turma— CYSTITES Potonié & Kremp, 1954.

Genus— Boutakoffiaspora gen. nov.

Type species— Boutakoffiaspora lepersonnea gen. et sp. nov.

Type Locality— Kifwa-Kasogno, Shaba Province, Zaïre*.

Generic Diagnosis— Megaspores large, globular to elliptical in shape; trilete, Y-

*Formerly, Katanga province, Congo.

mark distinct. Proximal-half episporic, protruding, narrow, three-folded, 3-angled; base triangular, sides straight, concave or sometimes convex, angles obtusely rounded or notched, interapical grooves or ridges prominent; surface variable, canals present or absent. Distal half comparatively large, sphaerical or oval in shape, surface smooth to ornamented, base rounded or conical. Megaspore wall thick, three-layered, spongy or vacuolate; three internal ridges prominent. Polar axis globular to elongate.

Dimensions—

Overall polar length—4—7 mm

Overall equatorial diameter—3—4.5 mm

Generic comparison and affinity—The external features of the present fossils along with their large size affords some comparison with the *incertae sedis* genus *Carpolithus* Linnaeus, a non-committal genus, which was instituted for incorporating fossil fruits and seeds. Certain common features, viz., the presence of collar-like swelling and anastomosing longitudinal ridges have been reported to occur in *Carpolithus (Ginkgoites?) selwyni* Bell (1949) and *C. fultoni* Bell (1949) respectively. CHANDLER (1957) interprets the apical portion as three small triangular patent perianth segments. The detailed anatomical study of the present well preserved petrified fossils do not indicate the presence of any kind of vascular supply system. This feature alone precludes the possibility of their being a seed or a fruit.

These specimens from Kifwa-Kasongo are regarded here as megaspores belonging to some heterosporous plant. The adaptation of heterospory is still today known to occur in Selaginellaceae, Isoetaceae, Marsiliaceae and Salviniaceae. Most of the known fossil megaspore genera reported from different geologic horizons have been compared with their nearest living representatives, such as *Selaginella*, *Isoetes*, *Pilularia*, *Regnellidium*, *Azolla* and *Salvinia*.

The present specimens are mainly characterised by a three-layered wall, unequally thickened epispore which divides into three raised folds at the proximal end. The occurrence of an epispore is known to occur in the megaspore walls of the genera like *Azolla*, *Regnellidium* and *Salvinia* (SAHNI & RAO, 1943; p. 62). The presence of this feature excludes its comparison with other fossil genera related to *Selaginella*, *Isoetes*, *Marsilea* and *Pilularia*. The fossil history of the megaspores of *Azolla* is well known. They are mainly characterised by the presence of three distinct floats and glochidia. Their absence in the present specimens excludes their relationship with the former. This fact also excludes comparison with *Regnellidium* and its allied fossils which in addition contain four layers in its megaspore wall (SAHNI & RAO, 1943). The occurrence of three episporic folds in living *Salvinia* has been reported and are perhaps homologous to the three floats of *Azolla* (EAMES, 1936; p. 256).

The fossil records of *Salvinia* are mainly vegetative organs (SHAPARENKO, 1956). DIJKSTRA (1961, p. 8) has listed almost all the known fossil records of megasporangia, megasporocarps and megaspores of *Salvinia*. KIRCHHEIMER (1930) has described in great detail the Miocene micro-and macro-spores related to the extant genus *Salvinia*. He records the presence of three layers viz., the endospore, the exospore and perispore (often called epispore), in the megaspore coat. The structural details of the outermost thickest layer has only been illustrated (figs. 16 & 19), which is closely comparable to the perispore of the present megaspores (Pl. 1, Fig. 6). The other fossil megaspores of *Salvinia* have been described by FLORIN (1919), NIKITIN (1938), DOROFIEYEV (1956, 1957), LANCUCKA-

Srodoniowa (1958) and Jain and Hall (1969) as new species of the natural genus. The species recorded by different authors mentioned above, except for *Salvinia aureovallis* Jain & Hall (1969), do not show anatomical details to indicate the presence of a three layered megaspore coat. They are comparable only in having trifold proximal projection.

The Zaïre megaspores show considerable resemblance with the megaspores of the extant genus *Salvinia* in having the following common morphological and anatomical features described by Kundt (1911), Yasin (1911) and Eames (1936)—

1. Presence of three layered megaspore coat, with an unequally thickened outermost epispore (often called perispore), dividing into three folds at the proximal end, the middle exospore and innermost endospore, both being thin and homogeneous.
2. Folds raised in the form of a canopy or tent lying over the three flat sides of the tetrahedral spore.
3. Vacuolate and spongy nature of the perispore.
4. Presence of three ridges at the sides.

The presence of the last three features indicate aquatic and floating habits of the fossil megaspores. The megaspores of *Salvinia* have been reported to float on the surface of the water in a horizontal manner (Eames, 1936, p. 257). The horizontal floating habit of the megaspores is also indicated by the fact that the Zaïre megaspores are characterized by three equilateral ridges, small proximal half, and canals in two of the folds.

In spite of its close similarity with *Salvinia* as evidenced from the characters mentioned above, it differs considerably in its comparatively large size and elongated polar axis. In all the living species of *Salvinia*, the megaspores neither attain such a large size (4-7 mm) nor have elongated polar axis. It is, therefore, suggested that the present megaspores belong to an extinct genus of water ferns, probably allied to *Salvinia*.

Derivation of name—The genus is named after Mr. N. Boutakoff who collected this material.

Boutakoffiaspora lepersonnea gen. et sp. nov.

Pl. 1, Figs. 1-3 & 5-8; Pl. 2, Figs. 15-16 & 19-21

Holotype—Pl. 1, Fig. 1. Specimen No. R. G. 1725.

Type Locality—Kifwa-Kasongo, Shaba Province, Zaïre.

Diagnosis—Megaspores tetrahedral, trilete, amb oval elliptical, outer surface glossy. Y-mark distinct at proximal tip, arms reaching basal periphery; proximal half narrow, raised, triangular at the base, trifolded, basal sides concave with interapical grooves, angles obtusely rounded to notched, internal cavity triangular; distal half large, oval-elliptical, surface smooth, base nippled, cavity circular. Megaspore wall three-layered, epispore (perispore) very thick, unequal in thickness, thickest and dividing into three folds towards the proximal end, folds resting over a thick basal collar surrounding an inner triangular narrow opening. Transverse canals distinct in two of the three folds. Exospore and endospore thin, homogeneous. Three lateral ridges prominent.

Dimensions—

Overall polar length—7 mm

Overall equatorial diameter—4.5 mm

Proximal/Distal length ration—1 : 2.5

Size of the distal half—5 × 4.5 mm

Size of the proximal half—2 × 3 mm

Spore wall thickness—Normal—437 μ
Thickest at 937.5 μ collar

Size of the inter cavities—Proximal (Triangular) 1187 × 938 μ
Distal (Circular) 1.5 mm

Diameter of canal — 313 μ

Internal anatomy—The longitudinal section of the complete specimen shows that the megaspore wall is quite thick and three layered. The innermost layer (endospore) is very thin and is made up of hexagonal, horizontally elongated, contiguous vesicles forming a well knitted network (Pl. 2, Fig. 19). It is the inner lining of both proximal and distal cavities. Just in between the endospore and the perispore layers lies the exospore, which is thick, homogeneous and is constituted of vertically elongated vesicles. The perispore is unequally thick, 437-937 μ, ± uniform in the distal part but thickest at the proximal zone where it invaginates inside, forming a collar-like thickening all around and leaving a narrow triangular opening inside; it further divides into 3 folds, which are raised on the three sides of the so formed triangular collar. Two of the collar-like thickenings at the base of the two-folds possess a well defined canal while the third fold appears to be solid in the studied eight specimens. The perispore is made up of several zones, some coarsely and others finely vesicular. In the outermost zone, the vesicles are smaller and thin walled, where as those lying towards the exospore are thick walled and the innermost vesicles attached to exospore are large having air spaces. The vesicles in contact with the exospore are again small, circular, and thin-walled. (Pl. 1, Fig. 6). Canals are club-shaped; vesicles lining the canal margin are thick-walled, circular to oval. The three folds seem to separate from each other along the trilete mark which extend from the apex to the arcuate ridge, about 1/6 the length of the spore.

Comparison—Boutakoffiaspora lepersonnea sp. nov. differs from *Salvinia hassiaca* Kirchheimer (1930) in its comparatively much larger size, presence of canals in two episporic folds, and in having a distinctly elongated polar axis. It also differs from the other known fossil species of *Salvinia* in its much larger size and some accompanying wall differences.

Derivation of specific name—It has been named after Mr. J. LEPERSONNE.

Boutakoffiaspora cahenii sp. nov.

Pl. 1, Fig. 4; Pl. 2, Figs. 10-14 & 17-18

Holotype—Pl. 2, Fig. 10. Specimen no. RG/1703.

Type locality—Kifwa-Kasongo, Shaba Province, Zaïre.

Diagnosis—Megaspores tetrahedral, trilete, amb globular, surface glossy. Proximal half narrow, triangular, protruding, trifold. Y-mark prominent at proximal tip, arms reaching up to the 1/3 the spore length, interapical sides considerably concave with distinct grooves, angles rounded, cavity triangular. Distal half globular, surface ornamented,

tubercles prominent, 100-120 μ high, placed distantly on the upper part; lower part smooth basal nipple present or indistinct, cavity circular. Megaspore wall three-layered, anatomically similar to the type species. All the three folds appear solid, canals absent. Three internal ridges prominent.

Dimensions—

Overall polar length —4-5 mm

Overall equatorial diameter—3-4 mm

Proximal/distal length ratio—1 : 2

Size of proximal half—1.25 mm

Size of distal half—2.5 mm

Spore wall thickness—Normal thickness—337.5 μ
Thickest zone at collar—662.5 μ

Comparison—Boutakoffiaspora cahenii sp. nov. resembles in most of its morphological and anatomical features with *Boutakoffiaspora lepersonnea* gen. et sp. nov. but differs mainly in having lesser proximal/distal length ratio, smaller size, globular shape, ornamented upper part of the distal half and in the absence of a canal system. The other fossil species of *Salvinia* essentially differ from the present species in their smaller size. Comparison with the other species of fossil *Salvinia* is not possible due to their incompletely known anatomical features.

Derivation of specific name—Mr. L. CAHEN, Director Musée Royal de l' Afrique Centrale, Tervuren, Belgium is well known for his extensive contribution towards the geology of Congo (now Zaïre) and hence it gives us great pleasure in naming the species after him.

ACKNOWLEDGEMENT

It gives us great pleasure to record here our sincere thanks to Mr. L. CAHEN, Director Musée Royal de l' Afrique Centrale, Tervuren, Belgium, for entrusting us this work and for the ready help given to us on various occasions. We are grateful to Dr. M. N. BOSE for passing on the material to us which was originally sent to him, and to the Director, Birbal Sahni Institute of Palaeobotany for laboratory and library facilities.

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EXPLANATION OF PLATES

Plate 1

Routakoffiaspora gen. nov.

1. *B. lepersonnea* sp. nov., ×8. Specimen No. R. G. 1725 (Holotype).

2. *B. lepersonnea* sp. nov., Longitudinal section of specimen No. R. G. 1697 showing unequally thickened perispore. ×8.

3. *B. lepersonnea* sp. nov., ×8. Specimen No. R. G. 1697.

4. *B. cahenii* sp. nov., cross section along the distal part showing thick perispore wall (p.s.) and circular cavity (c.c.). ×15. Specimen No. R. G. 1708.

5. *B. lepersonnea* sp. nov., a broken specimen at the distal end showing thick incomplete perispore wall, surrounding endo-exospore wall, along with the mark of the three inner ridges (r.). ×8. Specimen No. R. G. 1699.

6. *B. lepersonnea* sp. nov., a magnified portion of perispore wall in cross section showing marginal thin-walled vesicles (t.w.) on two sides and thick-walled vacuolate vesicles (th.w.) in between the two. ×500. Specimen No. R. G. 1697.

7. *B. lepersonnea* sp. nov., a magnified apical (proximal) portion of Fig. 3. showing canals (c.) in two episporic folds (e.f.). ×36.

8. *B. lepersonnea* sp. nov., a magnified portion of fig. 15 in pl. 2 near canal, showing the thick walled vesicles lining the canal. ×500. Specimen No. R. G. 1707.

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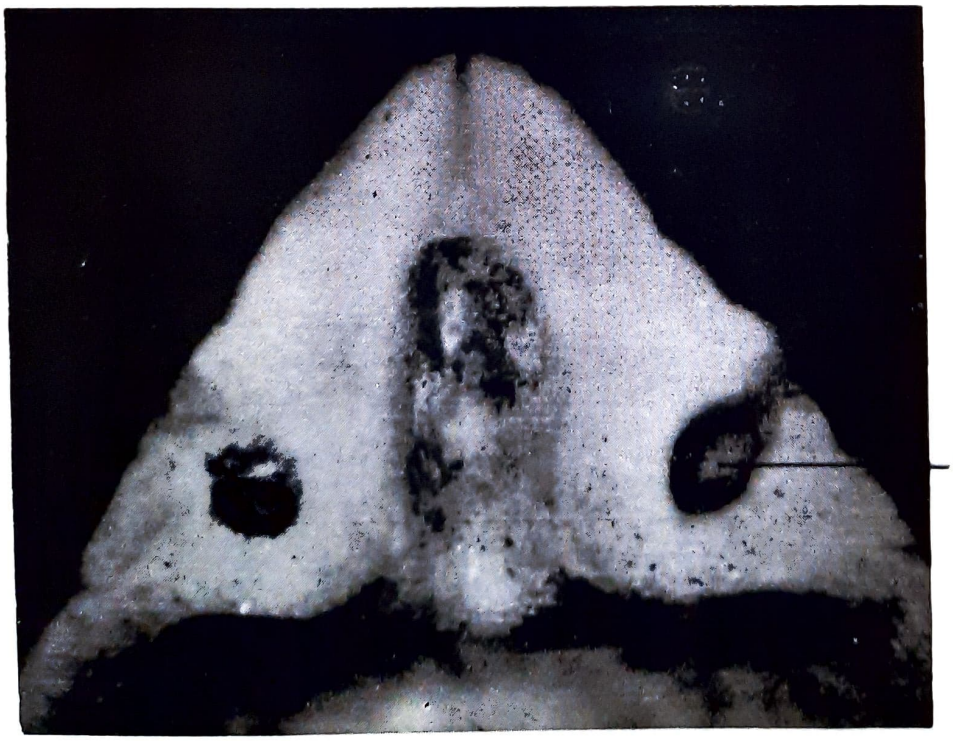

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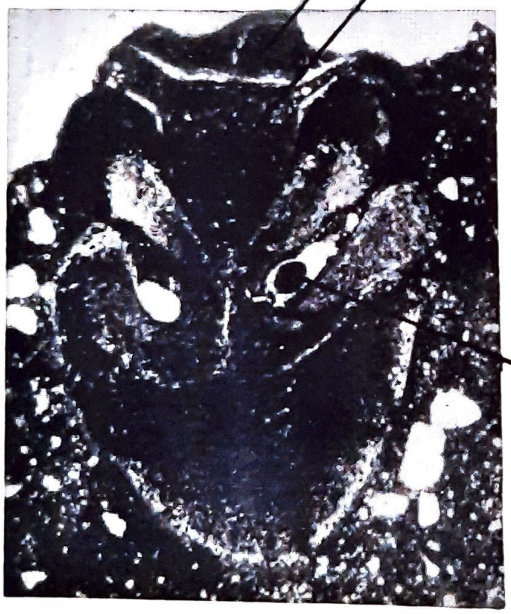

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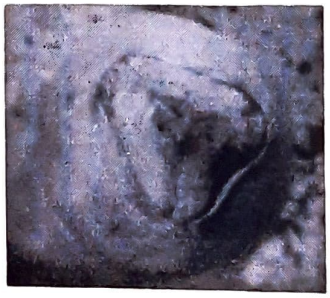

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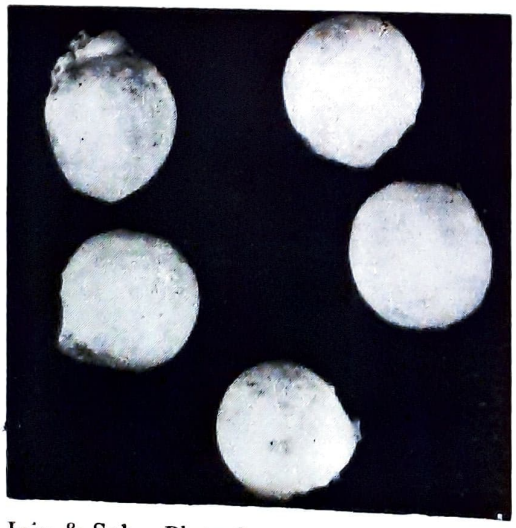

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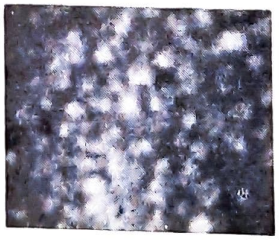

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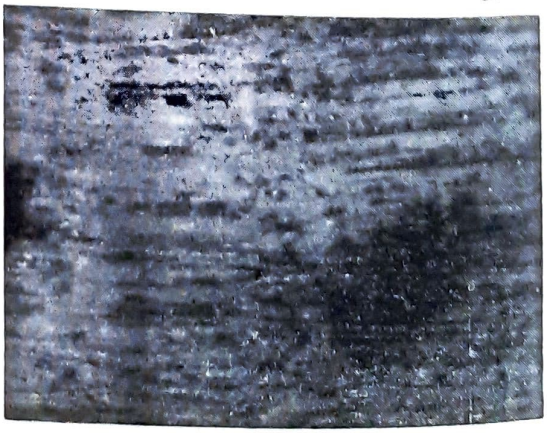

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Jain & Sah—Plate 2

PLATE 2

9. *B. lepersonnea* sp. nov., a broken specimen showing the inner view of the base of the proximal half. with triangular opening. ×6. Specimen No. R. G. 1701.

10. *B. cahenii* sp. nov., polar view showing triradiate mark and concave interapical sides. ×8. Specimen No. R. G. 1703.

11. *B. cahenii* sp. nov., lateral view. ×8. Specimen No. R. G. 1702.

12. *B. cahenii* sp. nov., showing ornamentation on the upper part of the distal half. ×8. Specimen No. R. G. 1704.

13. *B. cahenii* sp. nov., same. ×8. Specimen No. R. G. 1705.

14. *B. cahenii* sp. nov., longitudinal section showing unequally thickened perispore (p.s.) and folds without canals. ×10. Specimen No. R. G. 1702.

15. *B. lepersonnea* sp. nov., showing three folds (f.) in transverse (oblique) section, two with canals and one solid, encircling a triangular cavity. ×15. Specimen No. R. G. 1707.

16. *B. lepersonnea* sp. nov., polar view, showing triradiate mark and straight interapical sides with grooves ×8. Specimen No. R. G. 1725.

17. *B. cahenii* sp. nov., cross section of the proximal part showing three folds (f.) without canals with inner triangular cavity (t.c.). ×12. Specimen No. R. G. 1700.

18. *B. cahenii* sp. nov., Specimen No. R. G. 1700.

19. *B. lepersonnea* sp. nov., a magnified portion of the endospore layer. ×48. Specimen No. R. G. 1697.

20. *B. lepersonnea* sp. nov., a magnified portion of the perispore layer, ×60 Specimen No. R. G. 1708.

21. *B. lepersonnea* sp. nov., broken specimen showing collar thickening (c. th.) encircling the triangular. opecing. ×6. Specimen No. R. G. 1719.

22. *Pinnularia* sp. (fresh-water diatom). ×500. Specimen No. R. G. 1709.