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SOME DINOFLAGELLATES AND HYSTRICHOSPHAERIDS FROM THE LOWER TERTIARY OF SPITSBERGEN

BY
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Some Dinoflagellates and Hystrichosphaerids from the Lower Tertiary of Spitsbergen

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Three Figures in the Text and One Plate

Abstract. A few dinoflagellates and hystrichosphaerids from the Lower Tertiary of Spitsbergen are described. The dinoflagellates include *Svalbardella cooksoniae* n.gen., n.sp. and *Deflandrea phosphoritica* Eis..

Introduction

During a palynological investigation of the Spitsbergen Tertiary a few marine samples known to contain foraminifers have been studied.

The plant microfossil content in these samples is relatively poor, but in addition to pollen and spores it includes the few types of dinoflagellates and hystrichosphaerids forming the subject of the present paper. The pollen and spore content is reserved for a subsequent publication.

Only two forms of dinoflagellates were isolated in sufficient numbers of well-preserved examples to be specifically identified or described. One of these, *Deflandrea phosphoritica* Eis., is of special interest, since it is already known to have a wide geographical distribution in the Lower Tertiary. The other form is entirely new; it is described in this paper as *Svalbardella cooksoniae* n.gen., n.sp.

Of the remaining dinoflagellates and hystrichosphaerids some, although badly preserved, are described, in order to give an idea of the assemblage as a whole.

Material and methods

The samples were collected at Sarsbukta (78° 40' N — 11° 40' E), Forlandsundet, Vestspitsbergen by Geologist Rolf W. Feyling-Hanssen of the Geological Survey of Norway during the 1950 expedition of the Norwegian Polar Institute. They consist mainly of soft claystones.

One sample (R. F.-H.: 260 M) was richer in microfossils than the others and it is from this that all the specimens described in this paper were isolated.

The samples were treated in the following way: After the calcareous material had been removed the minerals were dissolved in hydrofluoric acid; the residue was treated as usual for palynological investigations, namely with oxidizing agents followed by acetolysis or alkali treatment. The specimens were picked out and mounted in glycerine-jelly.

Descriptions

Genus *DEFLANDREA* Eisenack.

Deflandrea phosphoritica Eisenack.

Figs. 4—8; text-fig. 1.

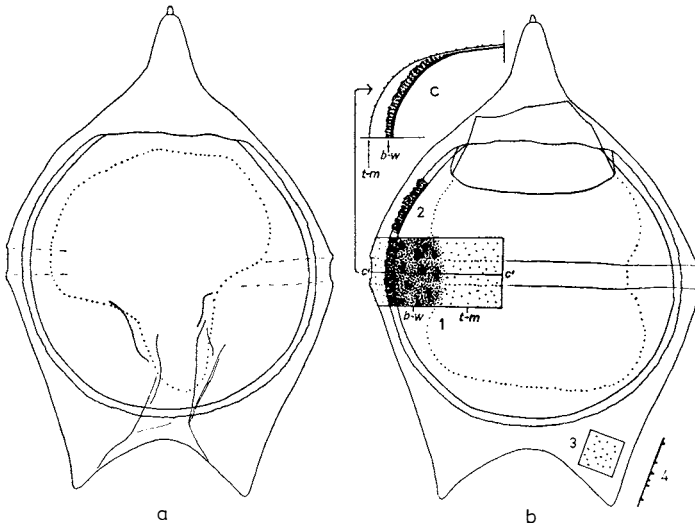
1938. Schr. Phys.-ökon. Ges. Königsberg (Pr.), 70, p. 187.

1954. Palaeontographica, 105 A, p. 52.

More than 20 specimens answering Eisenack's diagnosis (1954) have been found. They possess, however, certain features not mentioned by Eisenack and other authors; a detailed description of the Spitsbergen specimens is therefore given here.

Description. Theca as in Eisenack's diagnosis, but on the average somewhat larger; length 120—150 μ , breadth 90—105 μ . The specimens are invariably flattened dorsoventrally. The apical horn usually ends in a minute solid papilla. The theca-membrane has minute granules, sometimes rod-like, scattered over the surface; in some specimens they are quite prominent, in others hardly noticeable (examined with an oil immersion lens, numerical aperture 1.30).

The girdle is indistinct on the ventral face but dorsally it is often marked by two rows of granules (fig. 6). The hypotheca has more or less conspicuous folds running longitudinally on the ventral side from the angle between the antapical horns; these folds are suggestive of a longitudinal furrow.



Text-fig. 1. *Deflandrea phosphoritica* Eis. Diagrammatic drawing of a granular specimen. — a. Ventral face. — b. Dorsal face, with details of theca-membrane (t-m) and wall of internal body (b-w) in surface view (1), wall of internal body in optical section (2), theca-membrane in surface view (3) and in optical section (4). — c. Reconstruction of an equatorial section corresponding to c'—c' in fig. b. — Fig. 4 \times 1000, otherwise \times 500.

A rounded body occupies the greater part of the interior of the theca. Along its outline the wall of the body is 2—3 μ thick, two-layered; the inner layer is very thin, the outer layer is of a granular to rod-like composition and with a rough surface, sometimes with scattered wart-like processes. In surface view the body-wall is densely dotted, but the dots disappear at a variable distance from the outline of the body, leaving an unpatterned or vaguely patterned area on both its ventral and dorsal surfaces. The shape of these areas is approximately the same in all specimens: the dorsal area is somewhat hour-glass-shaped with the constriction adjoining the girdle; the ventral area narrows antapically into a "tongue" in the position of the longitudinal furrow (in text-fig. 1 these areas are indicated by dotted lines). The minute scattered dots seen in these areas are the granules of the theca-membrane.

Apically the internal body has an oblique opening as if a part had been cut off by a knife parallel to the girdle but with a slight dip towards the dorsal face. In the dorsal side of the theca itself there is an irregularly angular opening whose lower border-line exactly coincides with that of the opening in the body. In some specimens the top portion of the body still remains inside the theca, covering the opening more or less like a lid.

Specimens: PAP $2/5$ (fig. 4). PAP $2/6$ (fig. 5), PAP $2/7$ (fig. 6).

Affinities and remarks. I have had an opportunity to compare my specimens with a preparation of *D. phosphoritica* from the German Lower Oligocene kindly lent me by Prof. A. Eisenack, and no specific differences could be noticed. The German specimen has a very minutely granular theca comparable to the smoother ones from Spitsbergen; the internal body has scattered wart-like processes that in optical section are somewhat more prominent than those of the Spitsbergen specimens.

Concerning the natural relationship of the species I refer to Eisenack (1954).

The granulation of the theca-membrane varies to some extent, but it is too inconstant a character for a further differentiation. A roughening to a variable degree of the theca is also found in undescribed specimens from W. Australian Eocene deposits which Dr. I. C. Cookson has kindly shown me (cp. also Deflandre & Cookson 1955, p. 249). Klumpp (1953, pl. 19, fig. 6) has figured one specimen with an obviously roughened theca.

The peculiar areas of the internal body have not been mentioned in previous descriptions. In specimens which have suffered no or little flattening the borders of the areas will be difficult to detect because they are situated near the periphery of the image of the spherical body. However, if present the areas will still be evidenced by the difference in the composition of the wall. The areas are not sharply defined in the German specimen, but their existence is shown by the disappearance of the wart-like processes a short distance from the periphery. A figure in Reissinger (1950, pl. 19, fig. 10) evidently shows the outline of the dorsal area of the internal body. Corresponding areas have been found in the Australian specimens (cp. figs. 7 and 8) which compare very well with the Spitsbergen ones with a rough theca.

The internal body obviously has a fixed position inside the theca; this is shown by the constant coincidence of the opening of the body with that in the theca-membrane. It appears that the peculiar areas of the internal body

represent some kind of connection between the theca and the body, keeping the latter in its position (cp. text-fig. 1, b and c). Eisenack (1954, p. 83) has also stated that "auf den Vorder- und Rückseiten tangieren sich die beiden Hüllen weitgehend".

Opinions with regard to the nature of the internal body are divergent. An internal body occurs in all the known species of *Deflandrea* (Alberti 1959) although occasionally specimens are found without it (Deflandre & Cookson 1955, p. 253); it is a distinctive character in most species of *Wetzeliella* Eis. and also of the species of *Svalbardella* described in the present paper. The frequent presence of the internal body in contrast with the rare occurrence of cysts in recent marine dinoflagellates caused Eisenack (1954, pp. 82--84) to regard it as an integral part of the organism, whereas Deflandre & Cookson (l. c.) expressed the opinion that it is a cyst.

Distribution. At present the known distribution of *D. phosphoritica* outside Spitsbergen is as follows (for references see Alberti 1959):

- Oligocene, Upper: NW. Germany (E. Gerlach, pers. comm.).
 - Middle: Wittenberg and Freienwalde, E. Germany; Holstein, NW. Germany.
 - Lower: Samland, E. Prussia.
- Eocene, Upper: Conow and Schönewald, E. Germany; Aral Lake District, USSR; Holstein, NW. Germany.
 - Lower: Wyttschaete, Belgium.
 - Lower?: Birregurra, Victoria, Australia.
 - Kara-Tau and Turgai, USSR; Rottneest Island, W. Australia (I. C. Cookson, pers. comm.).

Paleocene, Upper, or lowermost Eocene: Stalingrad, USSR.

E. Gerlach (pers. comm.) and Maier (1959) found the upper limit of *D. phosphoritica* to be Upper Oligocene. •

Deflandrea sp.

Fig. 9.

Description. Theca rounded, apical horn short and blunt, antapical horns short and somewhat more pointed, slightly unequal in length. Theca 87 μ long, 61 μ broad. An approximately equatorial girdle and a longitudinal furrow are indicated. Membrane less than 1 μ thick, the outer surface smooth, the inner one roughened by low corrugations which in surface view appear as irregular ridges. No indications of plates. A thin-walled internal body entirely fills the theca except for the horns. Both the dorsal(?) surface of the epitheca and that of the body have an opening in exactly the same place; it is somewhat rounded, 27 μ in diameter with its lower end straightly cut.

Specimen: PAP ²/₉.

Affinities and remarks. A single specimen of this description was found. Its general characteristics are those of a *Deflandrea* but it appears to be distinct from all the known species.

Genus *SVALBARDELLA* n.gen.

Diagnosis. Shells of planktonic microorganisms. Shape fusiform with somewhat swollen middle part and blunt ends. No appendages. Girdle approximately equatorial. Middle part of shell entirely filled by a thin-walled ellipsoid body.

Type species: *S. cooksoniae* n.sp.

Description: In addition to the characters given above there are indications of plates and a longitudinal furrow in the type species. The internal body and the shell possess a more or less irregular opening dorsally towards the apical end.

The genus is so far monotypic. The fusiform shape of the shell distinguishes it from previously described microplanktonic fossils with a distinct girdle and an internal body.

Svalbardella cooksoniae n.sp.

Figs. 1—3; text-fig. 2.

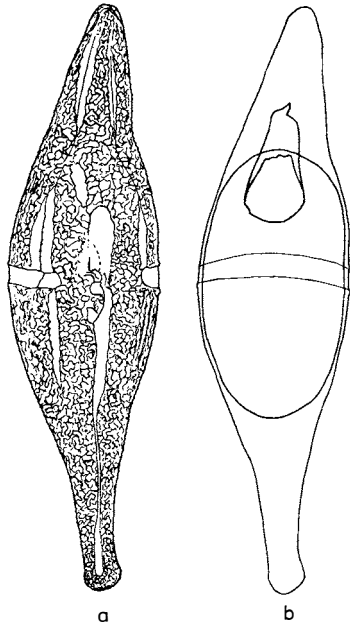
Diagnosis. Theca fusiform with its middle part somewhat convex; length 150—172 μ , breadth 35—42 μ . Girdle nearly equatorial, shallow, with a break on the ventral face. A "longitudinal furrow" starts between the ends of the girdle and runs to the end of the hypotheca. Theca-membrane minutely reticulate, in profile finely undulate. The convex part of the theca is entirely filled by an internal body of ellipsoid shape with smooth and thin wall.

Holotype: PAP ²/₁ (figs. 1—3; text-fig. 2).

Paratypes: PAP ²/_{2, 3, 4}.

Type locality: Sarsbukta (78° 40' N—11° 40' E), Vestspitsbergen (sample R. F.-H.: 260 M).

Description. All specimens obtained (10) have an internal body which dorsally, towards its apical end, has a somewhat angular opening; at the corresponding place in the theca there is a similar and usually longer opening whose lower border-line coincides with that of the opening of the body. The internal body entirely fills the theca in the equatorial region, but its wall is distinct from the theca-membrane along the lateral outline. The girdle is usually easily observable, but its edges are only slightly noticeable in the outline of the theca. The holotype clearly shows the ends of the girdle on the ventral side. What appears to be a longitudinal furrow is found in most specimens on close examina-



Text-fig. 2. *Svalbardella cooksoniae* n.sp. The holotype. — a. Ventral face. — b. Outline drawing showing the internal body, and the opening and the girdle on the dorsal face. \times 500.

tion, but it is less distinct than the girdle. The details at the starting point of the furrow are not clear.

The membrane has indistinct lines suggestive of plates. Some specimens are recognizable by their shape only, the fine ornamentation and other details not having been preserved.

Affinities and remarks. The presence of a girdle and most probably of a longitudinal furrow and of plates establish the inclusion of this fossil in the dinoflagellates. Its shape somewhat recalls the genus *Centrodinium* and also some species of *Murayella* (*M. biconica* and *M. intermedia*), but as there are only indications of the plates it cannot be more closely compared with any of these recent genera.

I know of no fossils with which to compare this species. There is a superficial resemblance to some specimens figured by Wetzel (1933, pl. 2, figs. 17—20) and Deflandre & Cookson (1955, pl. 8, fig. 1), but otherwise they are not comparable.

As in *Deflandrea phosphoritica* the internal body has a fixed position inside the theca, and the openings are very similar. Evidently the internal body is of the same nature in the two organisms.

The generic name is derived from Svalbard, which is a group name for all the islands in the Arctic Ocean placed under Norwegian sovereignty; the specific name is given in honour of Dr. Isabel C. Cookson, who discovered the first specimen of this species in a Spitsbergen preparation.

cf. *APTEODINIUM* Eisenack.

Fig. 10.

1958. Neues Jb. Geol. Paläont., Abh., 106, p. 385.

Description. Theca rounded with a short apical horn, antapical end incomplete in the single specimen obtained, but apparently without horns; length of theca about 78 μ , breadth 82 μ . Girdle indicated. Membrane about 2 μ thick and of granular composition; no indication of plates. There is a trapezium-shaped opening in the epitheca about 25 \times 30 μ . At the apex a thin inner wall is noticed, which follows the rounded outline of the theca without entering the horn; it may be the wall of an internal body which entirely fills the theca except for the apical horn.

Specimen: PAP ²/₁₀.

Affinities. The specimen has obvious resemblances to Eisenack's genus *Apteodinium*, and particularly to *A. granulatum* Eisenack (1958, p. 386), but its poor state of preservation precludes a close identification.

DINOFLAGELLATE incertae sedis

Fig. 11.

A single specimen with a rounded theca, antapical end incomplete, breadth 85 μ . Apical horn slender, 25 μ long. Girdle marked by ridges, apparently helicoid. Theca-membrane of granular composition with ridges suggestive of plates.

The specimen is poorly preserved; it somewhat resembles *Goniaulax orthoceras* Eisenack (1958, p. 388).

Specimen: PAP ²/₁₁.

HYSTRICHOSPHAERIDS

Hystrichosphaerids are poorly represented in the material, but a few characteristic specimens seem worth mentioning.

Type 1 (text-fig. 3 a).

Body diameter about 75μ , wall thin and smooth, folded. About 17 appendages *c.* 45μ long, with stalks $4-5 \mu$ broad, evidently hollow and composed of longitudinal fibrils spreading fan-like into the body-wall at their bases. Their apices are funnel-shaped; more or less distinct lines seem to represent the fibrils, which also appear as hair-like processes from the frilled edge of the funnel. A few of the appendages indicate that the edge was probably more clearly defined and less frilled originally.

This type seems to belong to the same morphological category as *Hystrichosphaeridium complex* Deflandre (1946).

Specimen: PAP ²/₁₂.

Type 2 (text-fig. 3 b and c).

Body diameter *c.* 60μ , wall *c.* 1μ thick, surface minutely dotted. More than 25 appendages, $15-20 \mu$ long, $1-4 \mu$ broad, hollow, with slight indications of longitudinal lines suggestive of fibrils; their apices are slightly funnel-shaped and irregularly serrated.

The specimen is incomplete and folded; the appendages are also more or less mis-shapen, but some of them are well characterized and bear strong resemblance to those of *H. inodes* Klumpp (1953, p. 391), which, however, have more funnel-shaped apices.

Specimen: PAP ²/₁₃.

Type 3 (text-fig. 3 d).

Body $41 \times 35 \mu$, wall thin, distinctly granular. More than 50 appendages, $7-10 \mu$ long, slender, tapering and somewhat flexuous, apices delicately bi- to tri-furcate.

This specimen may belong to the genus *Baltisphaeridium* Eisenack (1953, p. 398).

Specimen: PAP ²/₁₄.

Type 4.

Body diameter 25μ , wall *c.* 1μ thick, smooth. About 60 appendages, *c.* 4μ long, solid, conical, bases *c.* 1μ broad, apices sharply pointed.

The specimen resembles *Micrhystridium pachydermun* Deflandre & Cookson (1955, p. 282) but is somewhat larger.

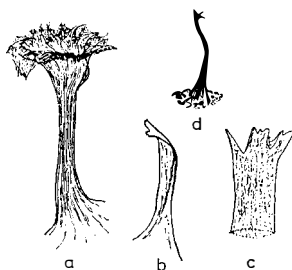
Specimen: PAP ²/₁₅.

Type 5.

Body diameter 35μ , wall *c.* 1.5μ thick, smooth. Appendages *c.* 40, about 10μ long, *c.* 1.5μ broad at their bases, tapering towards a pointed apex; some bifurcate in the lower half of the stalk.

The specimen may belong to *Micrhystridium* Deflandre.

Specimen: PAP ²/₁₆.



Text-fig. 3. Appendages of hystrichosphaerids. — a. Type 1. — b. c. Type 2. — d. Type 3. — a $\times 500$; b, c, d $\times 1000$.

INCERTAE SEDIS

Crassosphaera concinna Cookson & Manum

1960. Nytt Mag. Bot. 8, p. 6.

The single specimen found is described and figured in Cookson & Manum (1960).

Specimen: PAP 1/1.

Stratigraphical considerations

The samples investigated were collected from one of the small isolated Tertiary deposits NW. of the main Tertiary basin of Vestspitsbergen. These deposits are assumed to be contemporaneous with or younger than the youngest beds of the main basin (Orvin 1940, with a geological map).

The most authoritative dating of the Spitsbergen Tertiary is that by Ravn (1922), who, from the bivalves of some beds in the main basin, regarded the age as Middle to Upper Paleocene and perhaps Eocene.

In "Flora fossilis arctica" Heer dated the flora as Miocene. However, my palynological investigations of the coals of the lower beds of the main basin support Ravn's dating.

The occurrence in the present material of *Deflandrea phosphoritica*, a marine planktonic organism of well known stratigraphical range, confirms the age of the deposit as being Lower Tertiary, and indicates that it is not older than Upper Paleocene.

The pollen content of this deposit shows that it is not contemporaneous with the lower beds of the main basin and is probably younger. However, they have several floristic elements in common, so that the difference in age cannot be very great. It therefore seems reasonable to assume an Upper Paleocene to Eocene age for the deposit containing the microplankton.

A palynological correlation of the deposit with the youngest beds of the main basin cannot yet be made, because the microfossil content of the latter is not sufficiently known at present.

Acknowledgements

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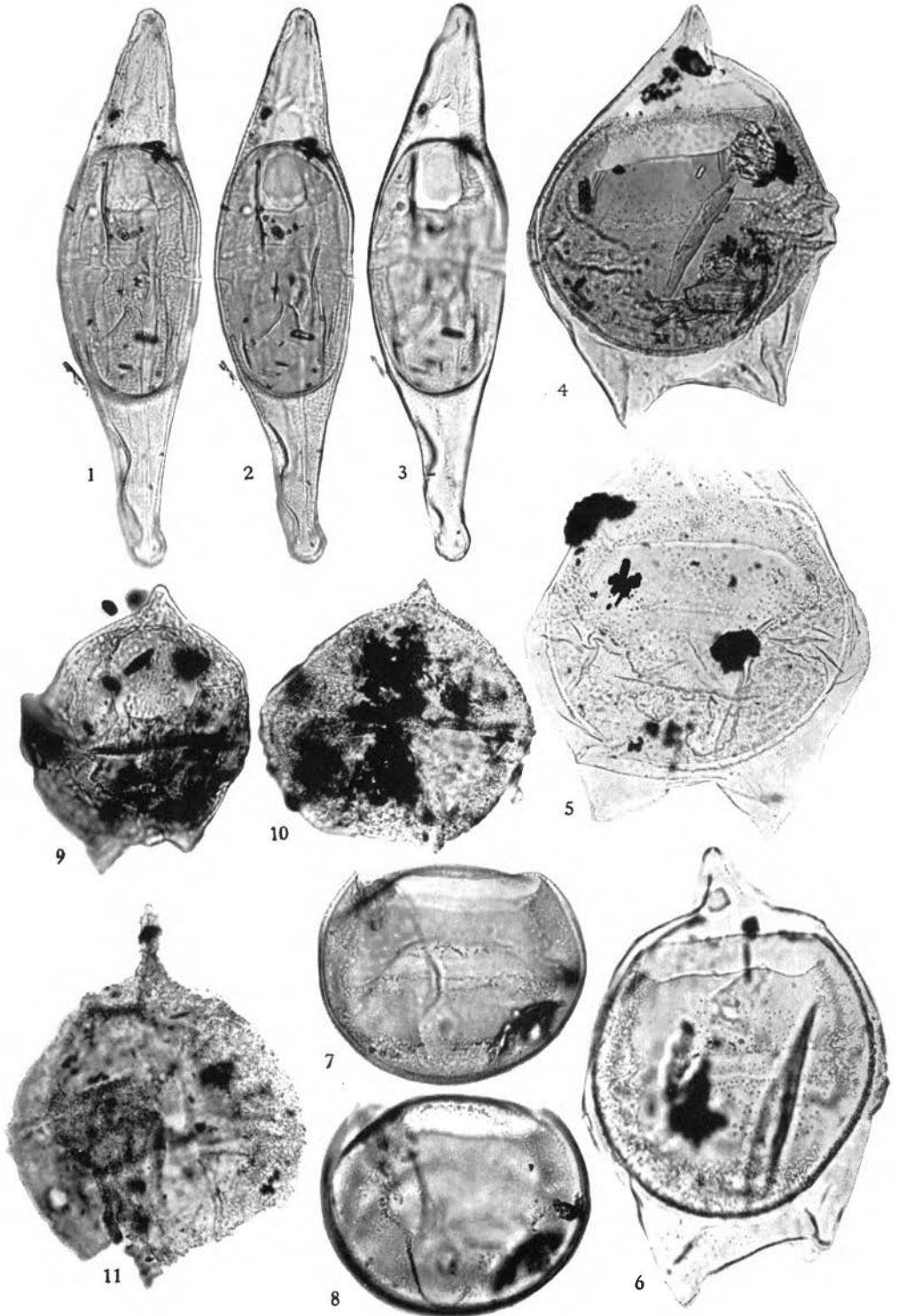
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Explanation of plate

All figures $\times 500$.

- Figs. 1—3. *Svarbardella cooksoniae* n.gen., n.sp. Holotype photographed at three different foci. PAP ²/₁.
- Figs. 4—6. *Deflandrea phosphoritica* Eis. Figs. 5 and 6 show specimens focused on the ventral and dorsal surface of the internal body respectively, with the unpatterned areas visible. Fig. 4: PAP ²/₅; fig. 5: PAP ²/₆; fig. 6: PAP ²/₇.
- Figs. 7—8. A cyst of *Deflandrea phosphoritica* Eis. focused on the dorsal and ventral surface respectively. Australian specimen. PAP ²/₈.
- Fig. 9. *Deflandrea* sp. PAP ²/₉.
- Fig. 10. cf. *Apteodinium* Eis. PAP ²/₁₀.
- Fig. 11. Dinoflagellate inc. sed. PAP ²/₁₁.



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