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Dedicated to

PROFESSOR ALFRED EISENACK

pioneer in fossil microplankton

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ABSTRACT

The present study deals with organic-walled microplankton having probable phytoplanktic affinities and belonging to the Group Acritarcha EVITT, 1963. A continuously cored well through the Lower Viruan (Middle Ordovician) at Ekön, in the county of Östergötland in Sweden, has revealed the presence of twenty-nine species of the acritarch genera *Aremoricanium, Baltisphaeridium, Goniosphaeridium, Multiplicisphaeridium, Peteinosphaeridium* and *Tylotopalla*. Five new species are proposed, i.e.: *Aremoricanium carolineae, Baltisphaeridium annelieae, Baltisphaeridium christoferii, Baltisphaeridium ingerae* and *Goniosphaeridium christianii*. A biostratigraphic account is given and a quantitative analysis is carried out with regards to the phytoplanktic density. The acritarch assemblage of the Lower Viruan of Ekön is compared with assemblage material from equivalent strata of the Gammalsby boring from Öland and the Grötlingbo boring from Gotland.

INTRODUCTION

During the course of a survey of the Cambro-Ordovician strata for the map description of solid rocks Linköping NO (Gorbatschev, Fromm & Kjellström 1976) a rich and well-preserved microplankton flora belonging to the Group Acritarcha was documented. As the material displayed a microplankton flora partly never recorded previously from Balto-Scandia (cf. references in Kjellström 1971 a, 1971 b, 1972) it was decided to treat these phytoplankton in more detail in a separate publication.

The present contribution thus aims at a documentation of acritarchs from the Lower Viruan (Middle Ordovician) of the Ekön Borehole No. 1. The Ekön boring, carried out under the auspices of the Geological Survey of Sweden, is situated in the northern part of the town of Motala in the county of Östergötland (Fig. 1). The stratigraphy and lithology of this core have previously been studied by Jaanusson (1962). The present material is derived from twenty-eight levels of the Lower Viruan, viz. from the following topostratigraphic divisions of the serie: Segerstad Limestone, Skärlöv Limestone, Seby Limestone, Folkeslunda Limestone and Furudal Limestone (Fig. 31). The sediments consist of (1) reddish brown, mostly thick-bedded limestone (calcarenites of the Segerstad, Skärlöv and Seby Limestones); (2) grey, fine-grained limestones with intercalations of mudstone (calcilutites of the Folkeslunda Limestone); and (3) grey, finely nodular, dense limestones (calcilutites of the Furudal Limestone). Almost all samples, each weighing approximately 25 g, with the exception of the red sediments yielded a rich and well-preserved microplankton flora (each slide contains some 3000 specimens).

The density of different acritarch species of the Lower Viruan is given here for the first time. By definition density in this respect refers to the number of

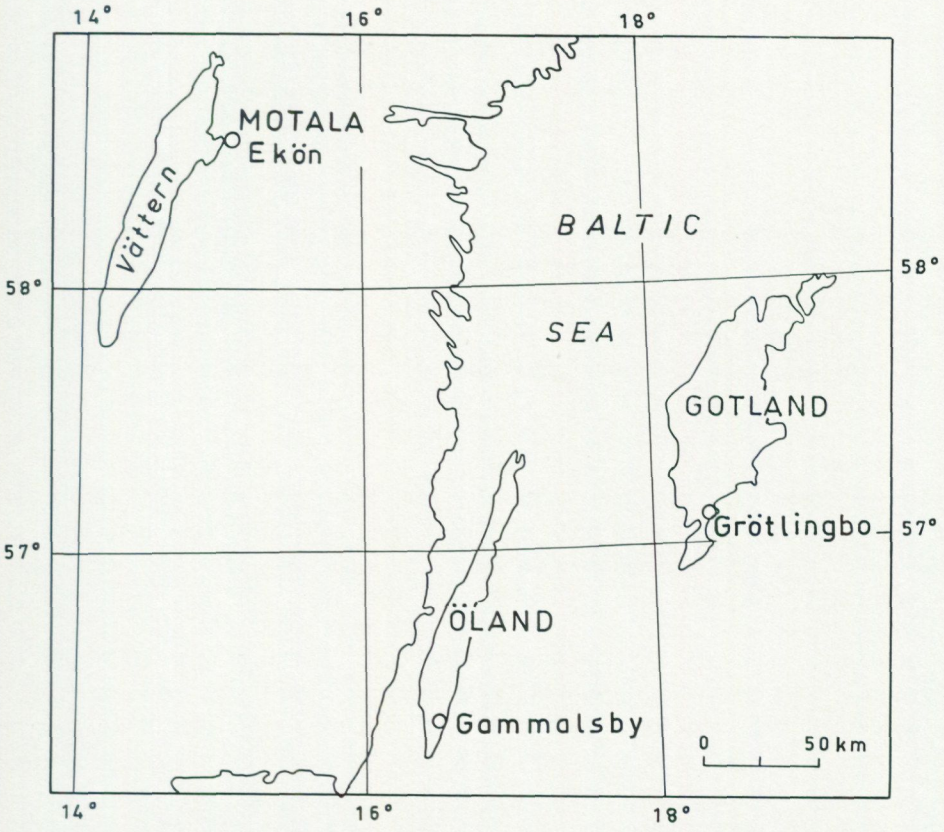

Fig 1. Location map of the Ekön Borehole No. 1, Östergötland, Gammalsby Borehole No. 1. Öland and Grötlingbo Borehole No. 1, Gotland.

individuals per unit sample size (Jaanusson 1976). The number of specimens counted in the present study has been set to 150 per sample (proposal given by Jaanusson, pers.com.), each sample (= 25 g of sediments) represented by one slide. The phytoplanktic density, expressed in percentages, is given for each species in the following section. Species characterized by a density of 10 % or >10 % are furthermore diagrammatically presented in Fig. 32. Those species possessing a density <10 % are grouped together in Fig. 32 under the heading "Others".

The slides are stored at the Section for Stratigraphy and Palaeontology of the Geological Survey of Sweden, Stockholm. The microphotographic work has been carried out by the present writer using a Leitz Ortholux microscope fitted with a Hasselblad 500 CM camera. The slides were photographed with an orthochromatic negative material (Agfa Ortho 25 Professional).

PALAEONTOLOGY AND STRATIGRAPHY

GENUS *AREMORICANIUM* DEUNFF, 1955

Aremoricanium carolineae, n.sp.

Fig. 2

DIAGNOSIS. — *Aremoricanium* sp. with a thin, reticulate, ovate vesicle, possessing a characteristic neck-like extension. Processes, bi- or trifurcate, smaller at the vicinity of the tubular extension, larger at the equatorial area, in particular at the opposite side of the tubular extension where they have well-developed peteinos. The process interior does not communicate with the vesicle cavity.

DIMENSIONS. — Vesicle diameter: 50—60 μ; process length (smaller non-peteinos): 10—12 μ; process breadth (smaller non-peteinos): <2 μ; process length (larger peteinos-developed): 10—12 μ; process breadth (larger peteinos-developed): 12—15 μ; tubular extension, length: 10—12 μ; tubular extension, breadth: 16—18 μ.

REMARKS. — *A. carolineae* n.sp. fundamentally differs from prevously described species of the genus *Aremoricanium* (*A. cylindrosum* EISENACK, 1963; *A. decoratum* LOEBLICH & MACADAM, 1971; *A. deflandrei Henry*, 1969; *A. rigaudae* DEUNFF, 1955; *A. simplex* LOEBLICH & MACADAM, 1971; *A. syringosagis* LOEBLICH & MACADAM, 1971; *A. tosotrichion* LOEBLICH & MACADAM, 1971) in having peteinos-developed processes.

HOLOTYPE. — SGU, slide no.: 102.06; coord. (Leitz Ortholux): 22/115; Fig. 2.

TYPE LOCALITY AND TYPE STRATUM. — Ekön Borehole No. 1, Östergötland, Sweden; Lower Viruan (Middle Ordovician), Furudal Limestone, 102.06 m.

OCCURRENCE. — Ekön Borehole No. 1, 102.06 m, Furudal Limestone (Lower Viruan).

DENSITY. — <10 % at 102.06 m.

Aremoricanium deflandrei HENRY, 1969

Fig. 3

1969 *Aremoricanium deflandrei* HENRY. — Henry: p. 78, Pl. 4, Figs. 26, 29.
1971b *Aremoricanium deflandrei* HENRY. — Kjellström: pp. 7—8, Fig. 1.
1972 *Aremoricanium deflandrei* HENRY. — Kjellström: p. 715.

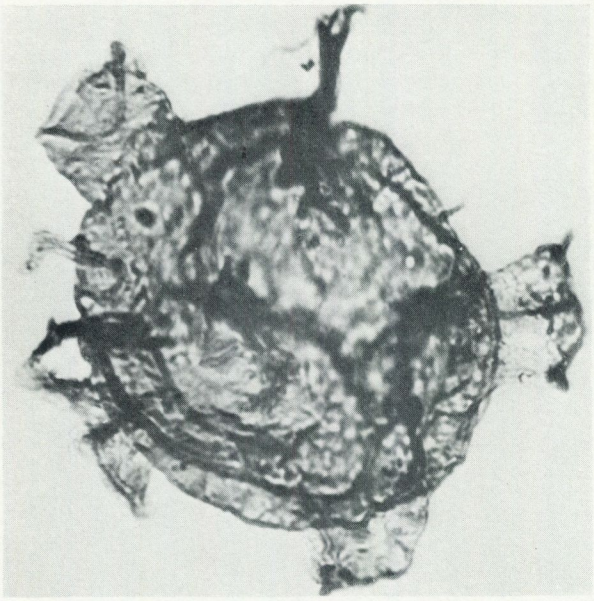

Fig. 2. *Aremoricanium carolineae* n.sp. Slide: 102.06, coord.: 22/115. Holotype. 1cm on photo = 10 μ.

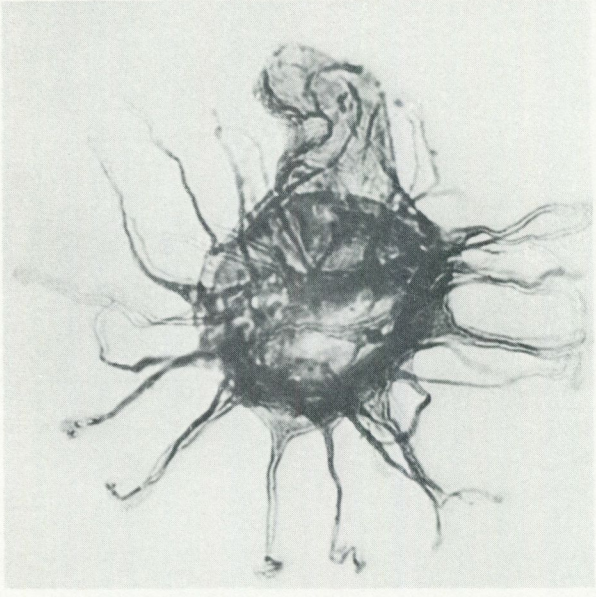

Fig. 3. *Aremoricanium deflandrei* HENRY, 1969. Slide: 105.10, coord.: 42/122. 1 cm on photo = 10 μ.

DIMENSIONS. — Vesicle diameter: 35—37 μ, internal body: $\sim$ 35 μ; process length: 20—25 μ, process breadth (at the base): $\sim$ 4 μ; cylindrical expansion length: 20—22 μ; breadth: $\sim$ 20 μ.

OCCURRENCE. — Ekön Borehole No. 1, 105.10 m — 101.10 m, Folkeslunda and Furudal Limestones (Lower Viruan).

DENSITY. — <10 % at level 105.10 m, 102.06 m, 101.55 m and 101.10 m.

PREVIOUS RECORDS. — Lower Viruan of Grötlingbo Borehole No. 1, Gotland and Gammalsby Borehole No. 1, Öland. Llanvirnian of Juvigné (Mayenne), France.

Aremoricanium simplex LOEBLICH & MACADAM, 1971
Fig. 4

1971 *Aremoricanium simplex* LOEBLICH & MACADAM. — Loeblich & MacAdam: pp. 43—44, Pl. 17, Figs. 1—7.

DIMENSIONS. — Vesicle dimensions: 75—80 μ in length (including tubular extension); in breadth: 35—40 μ.

OCCURRENCE. — Ekön Borehole No. 1, 105.10 m — 101.55 m, Folkeslunda and Furudal Limestones (Lower Viruan).

DENSITY. — <10 % at level 105.10 m, 103.55 m, 102.06 m and 101.55 m.

PREVIOUS RECORDS. — Mountain Lake Member of the Middle Ordovician Bromide Formation (Llanvirnian — Llandeilian) of Oklahoma. *A. simplex* has not been encountered formerly in Balto-Scandia.

GENUS *BALTISPHAERIDIUM* EISENACK, 1958 EMEND. EISENACK, 1969
Baltisphaeridium annelieae, n.sp.
Fig. 5

DIAGNOSIS. — *Baltisphaeridium* sp. with moderately thin, single walled, spherical, psilate vesicle. Excystment structure formed as a partial rupture. Angular proximal process contact with the vesicle. Separation of the interior of the process from the vesicle cavity. Numerous (>60) processes, closely distributed over the entire vesicle surface, in length not exceeding the length of the vesicle

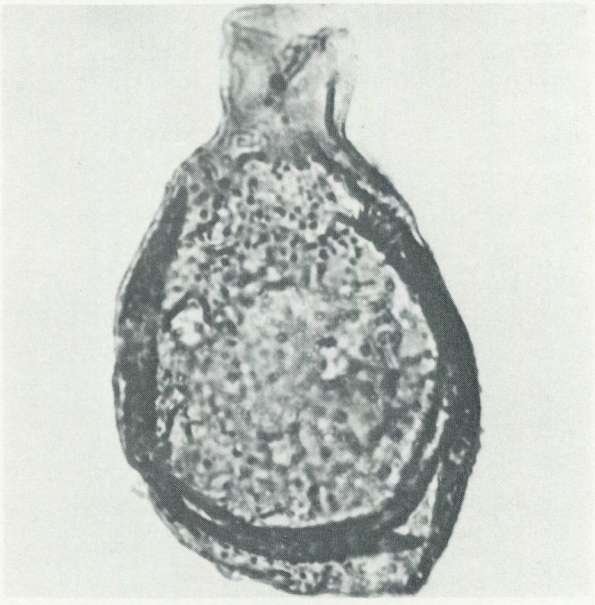

Fig. 4. *Aremoricanium simplex* LOEBLICH & MACADAM, 1971.
Slide: 105.10, coord.: 27/122. 1 cm on photo = 10 μ.

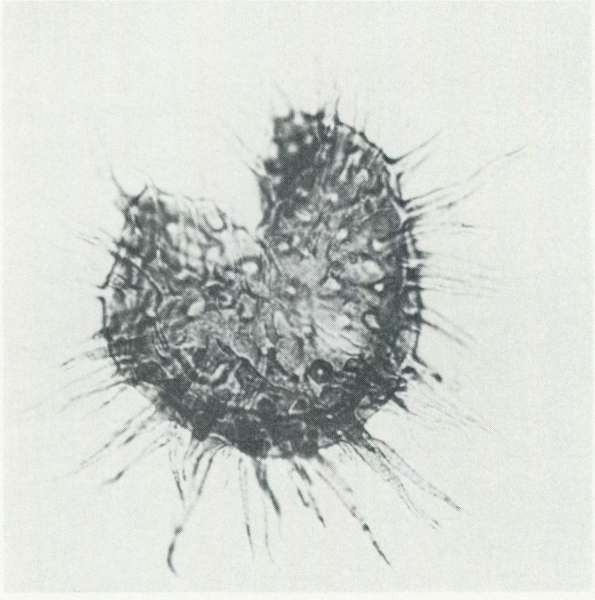

Fig. 5. *Baltisphaeridium annelieae* n.sp.
Slide: 104.10, coord.: 44/122. Holotype.
1 cm on photo = 15 μ.

diameter, echinate, slender, homomorphic, simple with acuminate distal terminations.

DIMENSIONS. — Vesicle diameter: 65—70 μ; process length: 25—30 μ.

REMARKS. — The echinate processes, closely distributed over the vesicle, is the fundamental distinguishing criterion for this species.

HOLOTYPE. — SGU, slide no.: 104.10; coord.: 44/122; Fig. 5.

TYPE LOCALITY AND TYPE STRATUM. — Ekön Borehole No. 1, Östergötland, Sweden; Lower Viruan (Middle Ordovician), Folkeslunda Limestone, 104.10 m.

OCCURRENCE. — Ekön Borehole No. 1, 105.10 m — 102.06 m, Folkeslunda and Furudal Limestones (Lower Viruan).

DENSITY. — <10 % at level 105.10 m, 104.10 m, and 102.06 m.

Baltisphaeridium brevispinosum (EISENACK, 1931)
Fig. 6

SYNONYMA. — See synonymous list in Kjellström 1971a.

1971a *Baltisphaeridium brevispinosum* EISENACK. — Kjellström: p. 18, Pl. 1, Fig. 2.

1972 *Baltisphaeridium brevispinosum* EISENACK. — Kjellström: p. 715.

1972 *Baltisphaeridium brevispinosum* EISENACK. — Johansson, Karis & Kjellström: p. 580.

DIMENSIONS. — Vesicle diameter: 48—50 μ; process length: 14—18 μ; process breadth: 2—4 μ.

OCCURRENCE. — Ekön Borehole No. 1, 105.10 m — 102.06 m, Folkeslunda and Furudal Limestones (Lower Viruan).

DENSITY. — <10 % at level 105.10 m, 103.55 m and 102.06 m.

PREVIOUS RECORDS. — Lower Viruan of Grötlingbo Borehole No. 1, Gotland and Gammalsby Borehole No. 1, Öland. Upper Arenigian of Ljungsbro, Östergötland. Ordovician erratics of the Baltic. Upper Arenigian of Podborowisko Borehole No. 1, Poland. Upper Arenigian (Klabava Shales) of Czechoslovakia. Arenigian of Veryhac'h, France (full documentation in Kjellström 1971a).

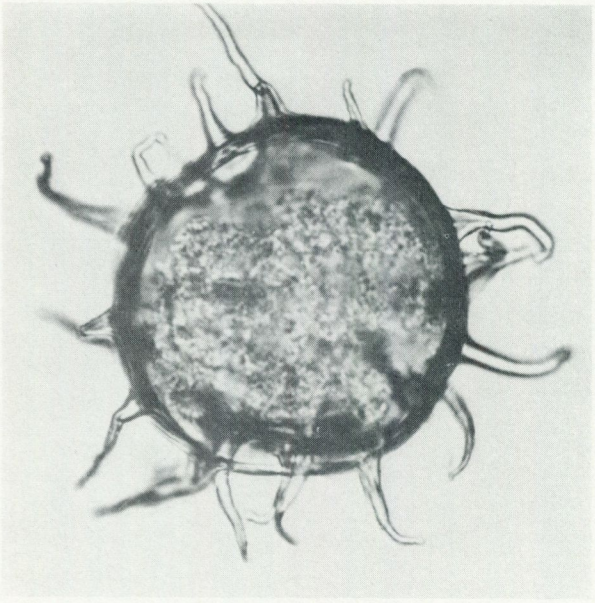

Fig. 6. *Baltisphaeridium brevispinosum* (EISENACK, 1931).
Slide: 105.10, coord.: 27/125. 1 cm on photo = 10 μ.

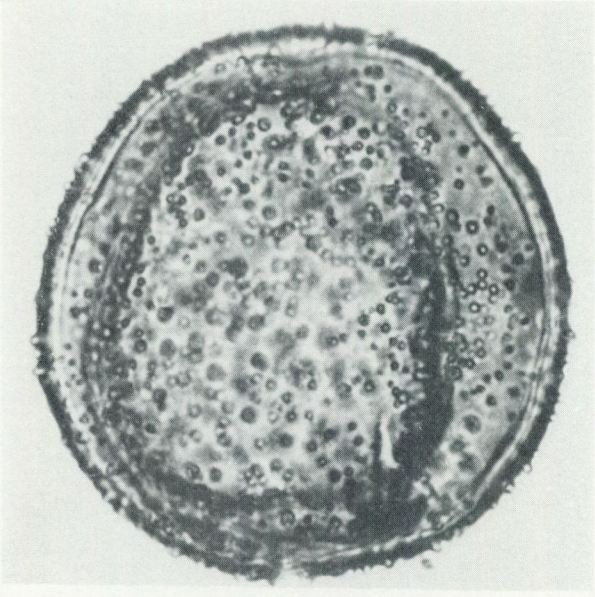

Fig. 7. *Baltisphaeridium brevituberculatum* KJELLSTRÖM, 1971.
Slide: 106.05, coord.: 35/127. 1 cm on photo = 10 μ.

Baltisphaeridium brevituberculatum KJELLSTRÖM, 1971
Fig. 7

1971b *Baltisphaeridium brevituberculatum* KJELLSTRÖM. — Kjellström: p. 10, Fig. 3.
1972 *Baltisphaeridium brevituberculatum* KJELLSTRÖM. — Kjellström: p. 715.

DIMENSIONS. — Vesicle diameter: 68—73 μ.

OCCURRENCE. — Ekön Borehole No. 1, 106.05 m—101.55 m, Folkeslunda and Furudal Limestones (Lower Viruan).

DENSITY. — <10 % at level 106.05 m, 105.10 m, 103.55 m, 102.06 m and 101.55 m.

PREVIOUS RECORDS. — Lower Viruan of Grötlingbo Borehole No. 1, Gotland and Gammalsby Borehole No. 1, Öland.

Baltisphaeridium calicispinae GÓRKA, 1969
Fig. 8

1969 *Baltisphaeridium calicispinae* GÓRKA. — Górka: p. 36, Pl. 6, Figs. 3, 4; Pl. 8, Figs. 1—3, 5; Pl. 10, Fig. 3; Text-fig. 10.
1971a *Baltisphaeridium calicispinae* GÓRKA. — Kjellström: p. 21, Pl. 1, Fig. 4.
1972 *Baltisphaeridium calicispinae* GÓRKA. — Kjellström: p. 715.
1972 *Baltisphaeridium calicispinae* GÓRKA. — Johansson, Karis & Kjellström: p. 580.
1976 *Baltisphaeridium calicispinae* GÓRKA. — Gorbatschev, Fromm & Kjellström: p. 105, Fig. B.

DIMENSIONS. — Vesicle diameter: 75—80 μ; process length: 60—70 μ; process breadth: 5—7 μ.

OCCURRENCE. — Ekön Borehole No. 1, 105.10 m, Folkeslunda Limestone (Lower Viruan).

DENSITY. — <10 % at level 105.10 m.

PREVIOUS RECORDS. — Lower Viruan of Grötlingbo Borehole No. 1, Gotland and Gammalsby Borehole No. 1, Öland. Upper Arenigian of Ljungsbro, Östergötland. Podborowisko Borehole No. 1, Poland. Lower Caradocian of Ketrzyn Borehole No. 1 and Mielnik Borehole, Poland.

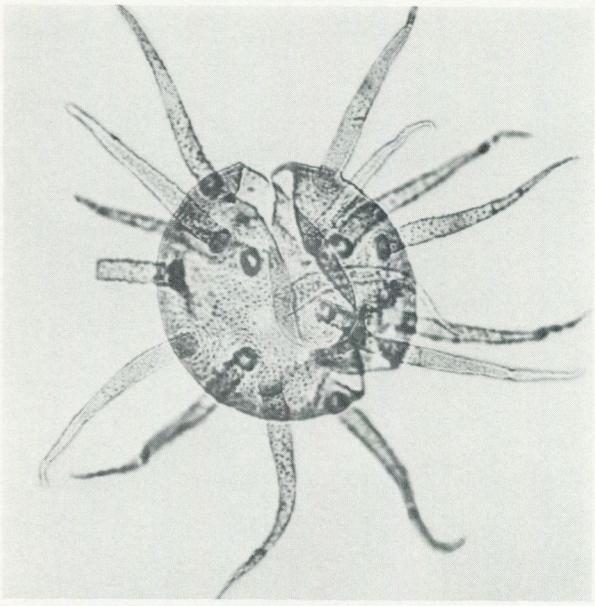

Fig. 8. *Baltisphaeridium calicispinae* GÓRKA, 1969.
Slide: 105.10, coord.: 28/108. 1 cm on photo = 23 μ.

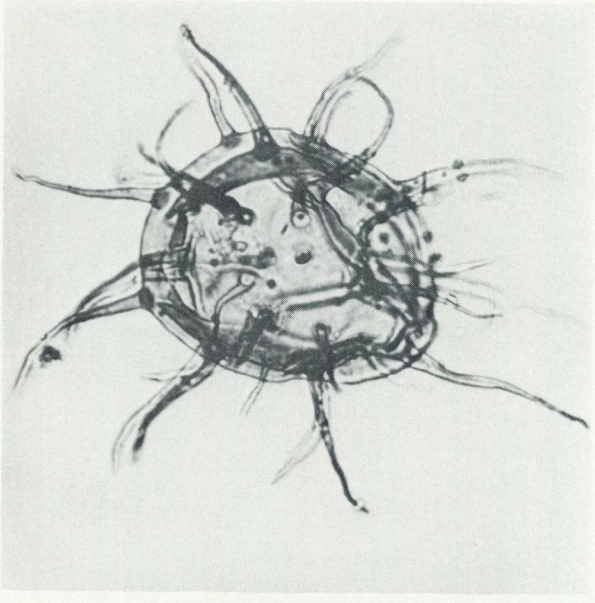

Fig. 9. *Baltisphaeridium christoferii* n.sp. Slide: 106.05, coord.: 43/123. Holotype. 1 cm on photo = 13 μ.

Baltisphaeridium christoferii n.sp.
Fig. 9

DIAGNOSIS. — *Baltisphaeridium* sp. with moderately thin, single walled, subspherical to spherical, psilate vesicle. Separation of the interior of the process from the vesicle cavity. Well-defined proximal process plug formed by the separation of ectoderm at the inside of the basal process cavity. Numerous processes, about 30, in length not exceeding the length of the vesicle diameter, psilate, conical, slender, homomorphic, simple with acuminate distal terminations.

DIMENSIONS. — Vesicle diameter: 45—55 μ; process length: 22—34 μ; process breadth (at proximal part): 2 μ.

REMARKS. — *Baltisphaeridium christoferii* n.sp. is easily separated from other species of the genus *Baltisphaeridium* in having slender processes with clearly defined proximal process plugs.

HOLOTYPE. SGU, slide no.: 106.06; coord.: 43/123; Fig. 9.

TYPE LOCALITY AND TYPE STRATUM. — Ekön Borehole No. 1, Östergötland, Sweden; Lower Viruan (Middle Ordovician), Folkeslunda Limestone, 106.05 m.

OCCURRENCE. — Ekön Borehole No. 1, 106.05 m—103.55 m, Folkeslunda Limestone (Lower Viruan).

DENSITY. — <10 % at level 106.05 m, 155.10 m and 103.55 m.

Baltisphaeridium constrictum KJELLSTRÖM, 1971
Fig. 10

1971a *Baltisphaeridium constrictum* KJELLSTRÖM. — Kjellström: p. 22, Pl. 1, Figs. 5, 6.
1972 *Baltisphaeridium constrictum* KJELLSTRÖM. — Kjellström: p. 715.

DIMENSIONS. — Vesicle diameter: 72—78 μ; process length: 48—80 μ; process breadth (at the base): $\sim$ 18 μ.

DENSITY. — <10 % at level 105.10 m, 103.55 m, 102.06 m, 101.55 m and 101.10 m.

PREVIOUS RECORDS. — Lower Viruan of Grötlingbo Borehole No. 1, Gotland and Gammalsby Borehole No. 1, Öland.

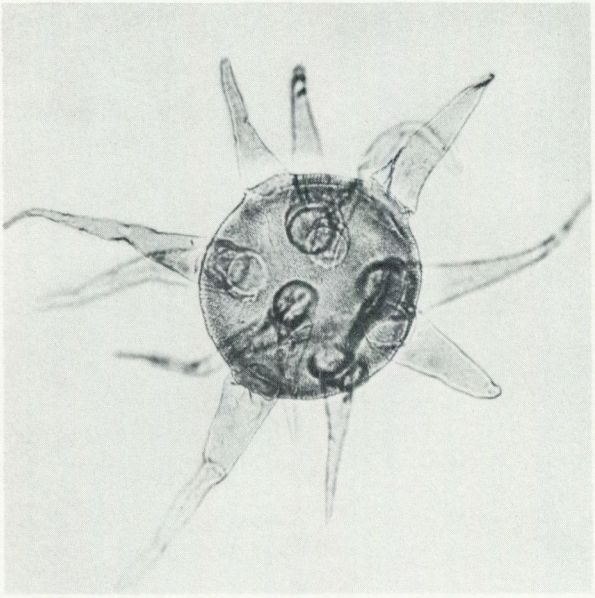

Fig. 10. *Baltisphaeridium constrictum* KJELLSTRÖM, 1971. Slide: 105.10, coord.: 35/121. 1 cm on photo = 25 μ.

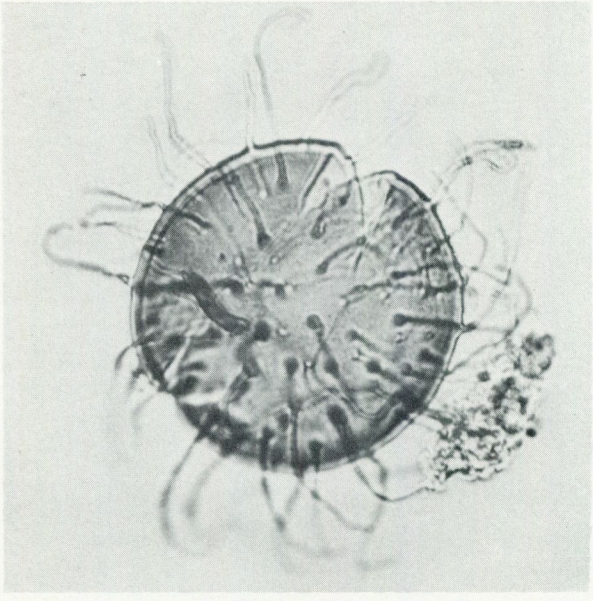

Fig. 11. *Baltisphaeridium flagellicum* KJELLSTRÖM, 1971. Slide: 105.10, coord.: 30/115. 1 cm on photo = 13 μ.

Baltisphaeridium flagellicum KJELLSTRÖM, 1971
Fig. 11

1971a *Baltisphaeridium flagellicum* KJELLSTRÖM. — Kjellström: p. 25, Pl. 1, Fig. 10.
1972 *Baltisphaeridium flagellicum* KJELLSTRÖM. — Johansson, Karis & Kjellström: p. 580.

DIMENSIONS. — Vesicle diameter: 52—56 μ; process length: $\sim$ 20 μ; process breadth: $\sim$ 2 μ.

OCCURRENCE. — Ekön Borehole No. 1, 106.05 m — 103.55 m, Folkeslunda Limestone (Lower Viruan).

DENSITY. — 20 % at level 106.05 m; 25 % at level 105.10 m; 10 % at level 103.55 m.

PREVIOUS RECORDS. — Lower Viruan of Grötlingbo Borehole No. 1, Gotland.

Baltisphaeridium hamatum (DOWNIE, 1958)
Fig. 12

1958 *Hystrichosphaeridium hirsutoides* var. *hamatum* DOWNIE. — Downie: p. 335, Pl. 16, Fig. 1; Text-fig. 2 j, k.
1964 *Baltisphaeridium hirsutoides* var. *hamatum* DOWNIE. — Downie & Sarjeant: p. 91.
1965 *Micrhystridium hamatum* DOWNIE. — Deflandre & Deflandre: Fiche 2248.
1966 *Baltisphaeridium hirsutoides* var. *hamatum* DOWNIE. — Downie & Ford: p. 313.

DIMENSIONS. — Vesicle diameter: 34—40 μ; process length: $\sim$ 2 μ.

REMARKS. — It has been stated earlier (Kjellström 1971a) that although *Baltisphaeridium hirsutoides* constitutes a great variety of transitional forms, the nature of the processes of *B. hirsutoides* var. *hamatum* DOWNIE, 1958 merits this variety to be ranked at the specific level.

OCCURRENCE. — Ekön Borehole No. 1, 104.10 m—101.10 m, Folkeslunda and Furudal Limestones (Lower Viruan).

DENSITY. — $<$10 % at level 104.10 m and 101.10 m.

PREVIOUS RECORDS. — Shineton Shale, Tremadocian, England. *B. hamatum* has not been recorded previously from the Balto-Scandia.

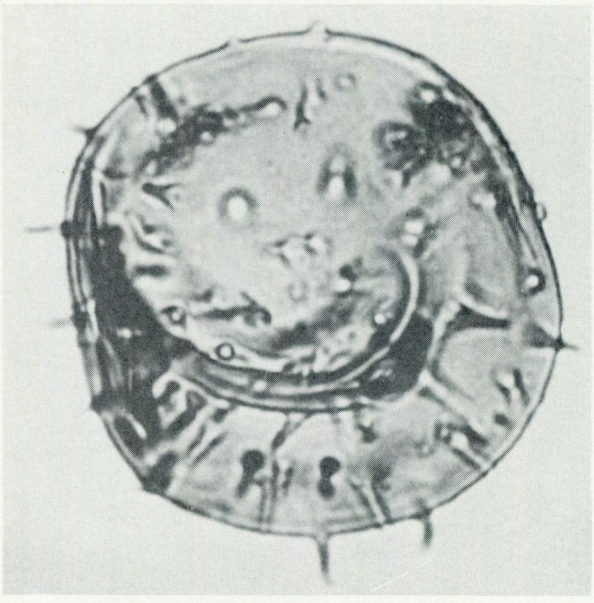

Fig. 12. *Baltisphaeridium hamatum* (DOWNIE, 1958).
Slide: 104.10, coord.: 33/126. 1 cm on photo = 0.6 μ.

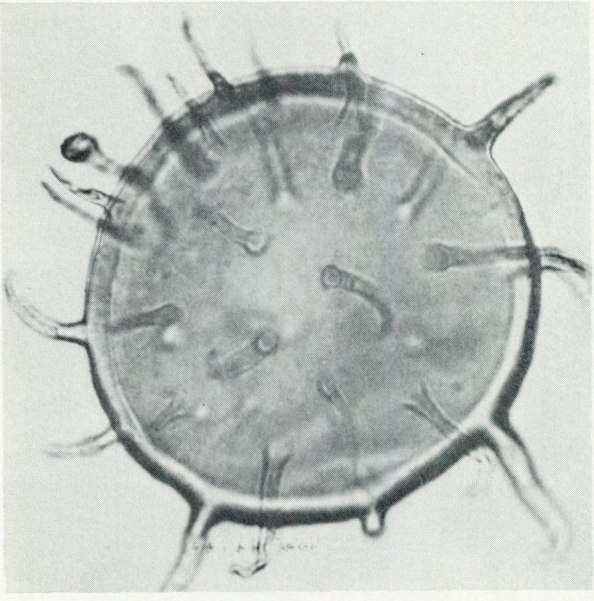

Fig. 13. *Baltisphaeridium hirsutoides* (EISENACK, 1951).
Slide: 105.10, coord.: 47/130. 1 cm on photo = 10 μ.

Baltisphaeridium hirsutoides (EISENACK, 1951)
Fig. 13

SYNONYMA: See synonymous list in Kjellström (1971a).
1971a *Baltisphaeridium hirsutoides* EISENACK. — Kjellström p. 26, Pl. 1, Fig. 12.

DIMENSIONS. — Vesicle diameter: 60—63 μ; process length: 10—12 μ; process breadth: $\sim$ 4 μ.

OCCURRENCE. — Ekön Borehole No. 1, 105.10 m—101.10 m, Folkeslunda and Furudal Limestones (Lower Viruan).

DENSITY. — 10 % at level 104.10 m and 103.55 m; 25 % at level 102.06 m and 101.55 m; <10 % at level 105.10 m and 101.10 m.

PREVIOUS RECORDS. — Lower Viruan of Grötlingbo Borehole No. 1, Gotland. Ordovician erratics of the Baltic. Lower Ordovician of Estonia. Upper Arenigian of Poland. Arenigian and Llanvirnian of England (full documentation in Kjellström 1971a).

Baltisphaeridium ingerae n.sp.
Fig. 14

DIAGNOSIS. — *Baltisphaeridium* sp. with moderately thick, single walled, spherical, granulate vesicle. No excystment structure recorded. Angular proximal process contact with the vesicle. Separation of the interior of the process from the vesicle cavity. Numerous processes, about 30, in length not exceeding the length of the vesicle diameter, echinate, slender, filiforme, homomorphic, simple with acuminate distal terminations.

DIMENSIONS. — Vesicle diameter: 55—62 μ; process length: 34—38 μ; process breadth (at the base); $\sim$ 2.5 μ.

REMARKS. — *Baltisphaeridium ingerae* n.sp. readily distinguishes from *B. annelieae* n.sp. in possessing a smaller number of processes, widely distributed over the granulated vesicle surface.

HOLOTYPE. — SGU, slide no.: 105.10 coord.: 30/111; Fig. 14.

TYPE LOCALITY AND TYPE STRATUM. — Ekön Borehole No. 1, Östergötland, Sweden; Lower Viruan (Middle Ordovician), Folkeslunda Limestone, 105.10 m.

OCCURRENCE. — Ekön Borehole No. 1, 106.05 m—105.10 m, Folkeslunda Limestone (Lower Viruan).

DENSITY. — <10 % at level 106.05 m and 105.10 m.

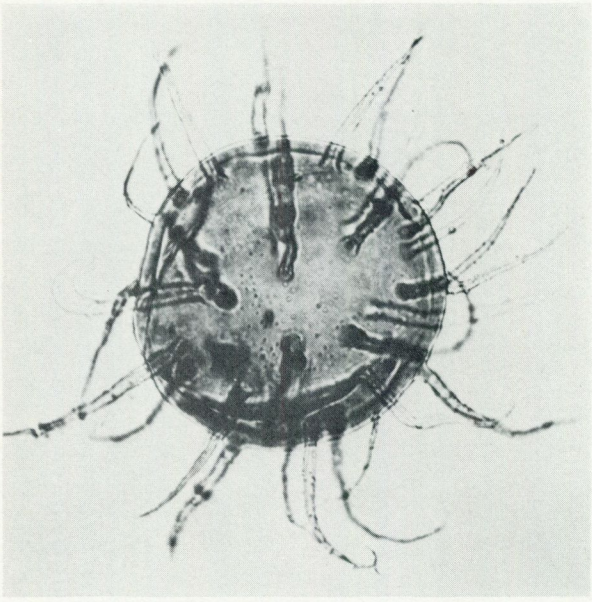

Fig. 14. *Baltisphaeridium ingerae* n.sp. Slide: 105.10, coord.: 30/111. Holotype. 1 cm on photo = 15 μ.

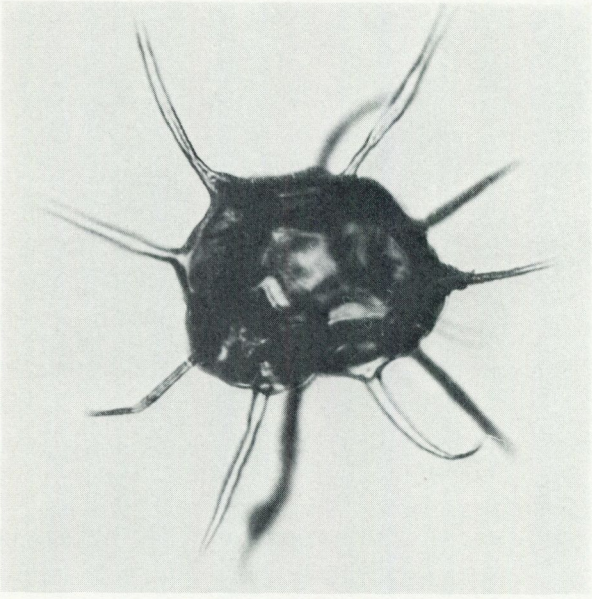

Fig. 15. *Baltisphaeridium longispinosum* (EISENACK, 1931). Slide: 104.10, coord.: 25/122. 1 cm on photo = 14 μ.

Baltisphaeridium longispinosum (EISENACK, 1931)
Fig. 15

SYNONYMA: See synonymous list in Kjellström (1971a).

1971a *Baltisphaeridium longispinosum* EISENACK. — Kjellström: p. 29, Pl. 2, Fig. 2.

1972 *Baltisphaeridium longispinosum* EISENACK. — Kjellström: p. 715.

1972 *Baltisphaeridium longispinosum* EISENACK. — Johansson, Karis & Kjellström: p. 580.

DIMENSIONS. — Vesicle diameter: 40—50 μ; process length: 25—38 μ; process breadth: $\sim$ 2 μ.

OCCURRENCE. — Ekön Borehole No. 1, 104.10 m—101.10 m, Folkeslunda and Furudal Limestones (Lower Viruan).

DENSITY. — 10 % at level 104.10 m, 15 % at level 103.55 m; <10 % at level 102.06 m, 101.55 m and 101.10 m.

PREVIOUS RECORDS. — Lower Viruan of Grötlingbo Borehole No. 1, Gotland and Gammalsby Borehole No. 1, Öland. Upper Arenigian of Ljungsbro, Östergötland. Ordovician to Upper Llandoverian of the Baltic. Upper Arenigian of Podborowisko Borehole No. 1, Poland. Caradocian of Zbrza Borehole No. 1 and Goldap Borehole No. 1, Poland. Arenigian (Klabava Shales) of Czechoslovakia. Ashgillian of Bohemia. Llandoverian of San Pedro, Spain. Ordovician of Veryhac'h and Presqu'ile de Crozon, France. Lower Ordovician of Kent, England. Ordovician of Oklahoma, U.S.A. Devonian of Belgium (full documentation in Kjellström 1971a).

Baltisphaeridium nanninum EISENACK, 1965
Fig. 16

1965 *Baltisphaeridium nanninum* EISENACK. — Eisenack: p. 260, Pl. 22, Fig. 6—8.

1968 *Baltisphaeridium nanninum* EISENACK. — Eisenack: p. 7.

1969 *Baltisphaeridium nanninum* EISENACK. — Eisenack: p. 250..

1971a *Baltisphaeridium nanninum* EISENACK. — Kjellström: p. 35, Pl. 2, Fig. 6.

DIMENSIONS. — Vesicle diameter: 60—65 μ; process length: $\sim$ 4 μ.

OCCURRENCE. — Ekön Borehole No. 1, 106.05 m—103.55 m, Folkeslunda Limestone (Lower Viruan).

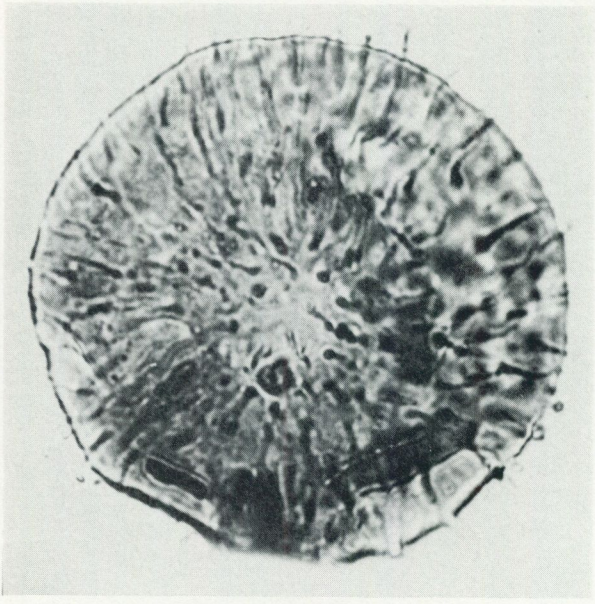

Fig. 16. *Baltisphaeridium nanninum* EISENACK, 1965.
Slide: 105.10, coord.: 24/114. 1 cm on photo = 9 μ.

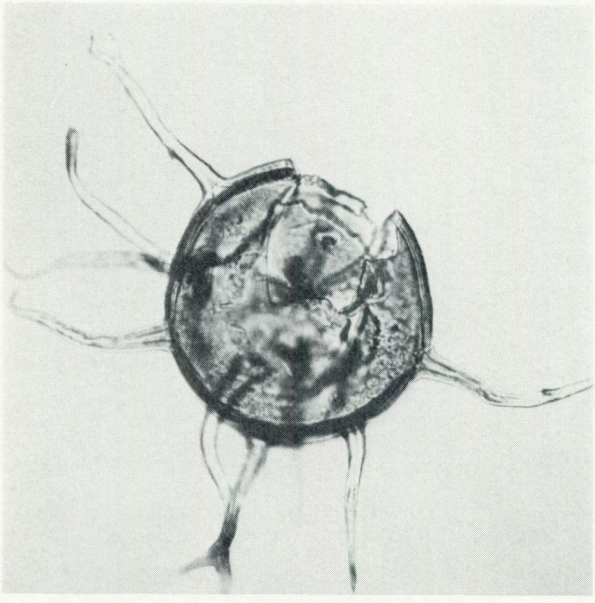

Fig. 17. *Baltisphaeridium pachyacanthum* (EISENACK, 1963) n.nom. 1965.
Slide: 105.10, coord.: 48/114. 1 cm on photo = 17 μ.

DENSITY. — 10 % at level 105.10 m and 104.10 m; <10 % at level 106.05 m and 103.55 m.

PREVIOUS RECORDS. — Lower Viruan of Grötlingbo Borehole No. 1, Gotland. Lower and Upper Visby Marl (Llandovery), Slite Group (Wenlock) and Hemse Group (Ludlow), Gotland.

Baltisphaeridium pachyacanthum (EISENACK, 1963) n.nom., 1965
Fig. 17

SYNONYMA: See synonymous list in Kjellström 1971a.

1971a *Baltisphaeridium pachyacanthum* EISENACK. — Kjellström: p. 37, Pl. 2, Fig. 8.

1972 *Baltisphaeridium pachyacanthum* EISENACK. — Kjellström: p. 715.

1972 *Baltisphaeridium pachyacanthum* EISENACK. — Johansson, Karis & Kjellström: p. 580.

DIMENSIONS. — Vesicle diameter: 60—66 μ; process length: 37—40 μ.

OCCURRENCE. — Ekön Borehole No. 1, 106.05 m—101.10 m, Folkeslunda and Furudal Limestones (Lower Viruan).

DENSITY. — 25 % at level 106.05 m and 105.10 m; <10 % at level 104.10 m, 103.55 m, 102.06 m, 101.55 m and 101.10 m.

PREVIOUS RECORDS. — Lower Viruan of Grötlingbo Borehole No. 1, Gotland and Gammalsby Borehole No. 1, Öland. Upper Arenigian of Ljungsbro, Östergötland. Upper Arenigian of Podborowisko Borehole No. 1, Poland. Llandeilian of Ketrzyn Borehole No. 1, Poland. Caradocian of Goldap Borehole No. 1, Poland (full documentation in Kjellström 1971a).

Baltisphaeridium plicatispinae GÓRKA 1969
Fig. 18

1931 *Ovum hispidum longispinosum* EISENACK pars. — Eisenack: p. 110, Pl. 5, Figs. 14, 17.

1938 *Hystrichosphaeridium longispinosum* EISENACK pars. — Eisenack; p. 12, Pl. 1, Fig. 1.

1969 *Baltisphaeridium plicatispinae* GÓRKA: p. 37, Pl. 10, Fig. 1; Text-fig. 1.

1971b *Baltisphaeridium plicatispinae* GÓRKA. — Kjellström: p. 17, Fig. 10.

DIMENSIONS. — Vesicle diameter: 58—65 μ; process length: 50—60 μ; process breadth: $\sim$ 3 μ.

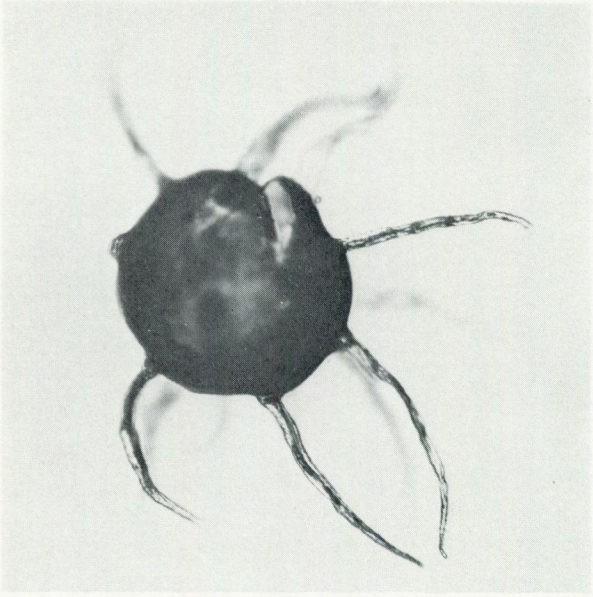

Fig. 18. *Baltisphaeridium plicatispinae* GÓRKA, 1969.
Slide: 104.10, coord.: 42/114. 1 cm on photo = 20 μ.

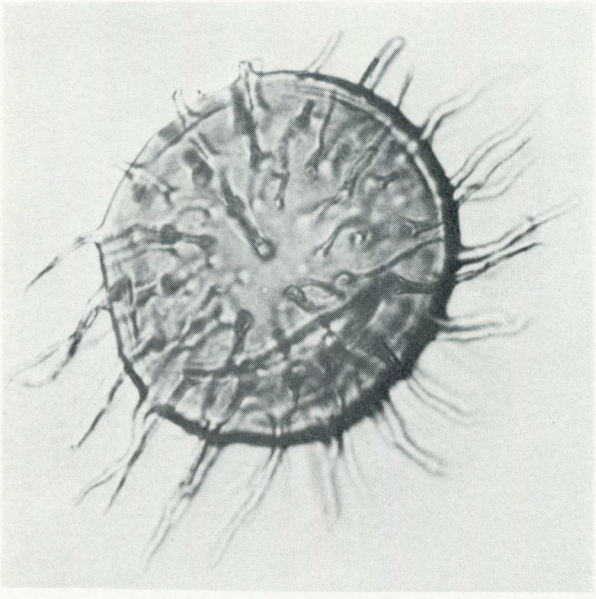

Fig. 19. *Baltisphaeridium ritvae* KJELLSTRÖM, 1971.
Slide: 105.10, coord.: 49/120. 1 cm on photo = 11 μ.

OCCURRENCE. — Ekön Borehole No. 1, 104.10 m—103.55 m, Folkeslunda Limestone (Lower Viruan).

DENSITY. — <10 % at level 104.10 m and 103.55 m.

PREVIOUS RECORDS. Lower Viruan of Grötlingbo Borehole No. 1, Gotland. Ordovician erratics of the Baltic. Llandeilian of Zebrak Borehole No. 1, Poland. Upper Ashgillian of Paslek Borehole No. 1, Poland.

Baltisphaeridium ritvae KJELLSTRÖM, 1971
Fig. 19

1971a *Baltisphaeridium ritvae* KJELLSTRÖM: — Kjellström p. 39, Pl. 2, Fig. 11.
1972 *Baltisphaeridium ritvae* KJELLSTRÖM: — Kjellström: p. 715.
1972 *Baltisphaeridium ritvae* KJELLSTRÖM. — Johansson, Karis & Kjellström: p. 580.
1976 *Baltisphaeridium ritvae* KJELLSTRÖM. — Gorbatschev, Fromm & Kjellström: p. 105, Fig. C.

DIMENSIONS. — Vesicle diameter: 50—55 μ; process length: 22—28 μ; process breadth: <2 u.

OCCURRENCE. — Ekön Borehole No. 1, 105.10 m—101.55 m, Folkeslunda and Furudal Limestones (Lower Viruan).

DENSITY. — <10 % at level 105.10 m, 103.55 m, 102.06 m and 101.55 m.

PREVIOUS RECORDS. — Lower Viruan of Grötlingbo Borehole No. 1, Gotland and Gammalsby Borehole No. 1, Öland. Upper Arenigian of Ljungsbro, Östergötland.

Baltisphaeridium varsoviensis GÓRKA, 1969
Fig. 20

1969 *Baltisphaeridium varsoviensis* GÓRKA. — Górka: p. 41, Pl. 8, Fig. 4, textfig. 13.
1971b *Baltisphaeridium varsoviensis* GÓRKA. — Kjellström: p. 22, Fig. 14.
1972 *Baltisphaeridium varsoviensis* GÓRKA. — Kjellström; p. 715.

DIMENSIONS. — Vesicle diameter: 72—77 μ; process length: 43—48 μ; process breadth: 5—6 μ.

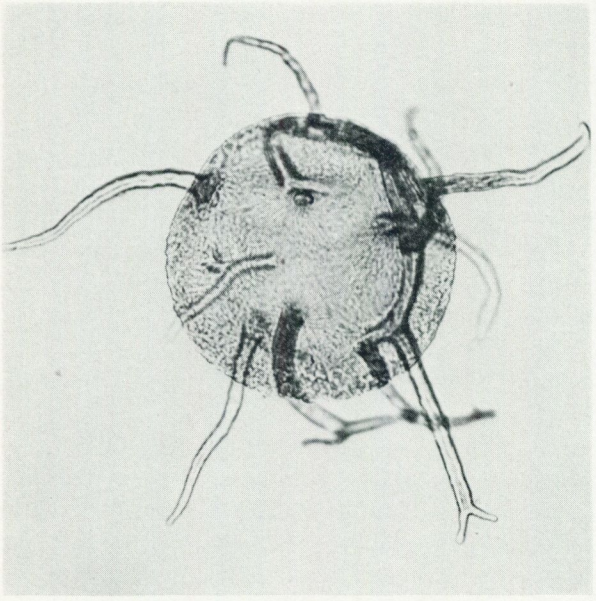

Fig. 20. *Baltisphaeridium varsoviensis* GÓRKA, 1969. Slide: 105.10, coord.: 40/129. 1 cm on photo = 20 μ.

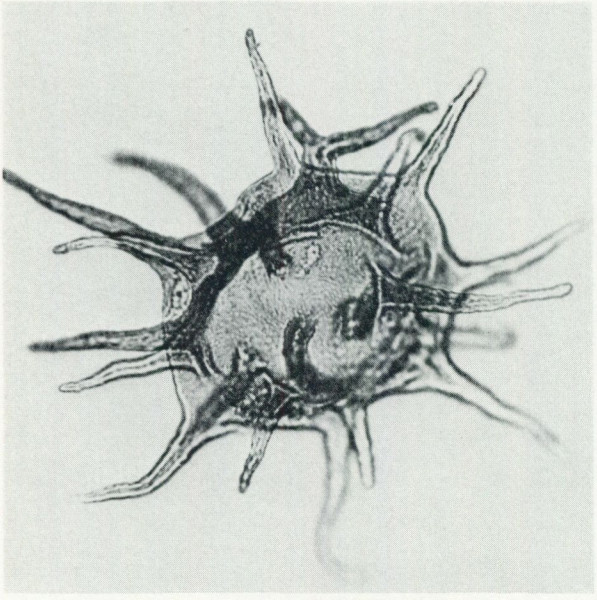

Fig. 21. *Goniosphaeridium christianii* n.sp. Slide: 102.06, coord.: 23/112. Holotype. 1 cm on photo = 18 μ.

GENUS *GONIOSPHAERIDIUM* EISENACK, 1969 EMEND. KJELLSTRÖM, 1971

Goniosphaeridium christianii n.sp.

Fig. 21

DIAGNOSIS. — *Goniosphaeridium* sp. with thin, single walled, subspherical, shagrinate, vesicle. No excystment structure recorded. Curved proximal process junction with the vesicle. Free communication between the process interior and the vesicle cavity. Processes about 20 in number, in length almost equal to the vesicle radius, shagrinate, broad base area, conical, homomorphic, simple with bulbous distal terminations.

DIMENSIONS. — Vesicle diameter: 68 μ—75 μ; process length: 40—45μ; process breadth (at proximal part): $\sim$ 6 μ.

REMARKS. — *Goniosphaeridium christianii* n.sp. is separated from previously described species of the genus in having a shagrinate vesicle in combination with processes, all of which possessing bulbous distal ends.

HOLOTYPE. — SGU, slide no.: 102.06; coord.: 23/112; Fig. 21.

TYPE LOCALITY AND TYPE STRATUM. — Ekön Borehole No. 1, Östergötland, Sweden; Lower Viruan (Middle Ordovician), Furudal Limestone, 102.06 m.

OCCURRENCE. — Ekön Borehole No. 1, 102.06 m—101.55 m, Furudal Limestone (Lower Viruan).

DENSITY. — 10 % at level 102.06 m; <10 % at level 101.55 m.

Goniosphaeridium conjunctum KJELLSTRÖM 1971

Fig. 22

1971a *Goniosphaeridium conjunctum* KJELLSTRÖM. — Kjellström: p. 43, Pl. 3, Fig. 4.

DIMENSIONS. — Vesicle diameter: 30—35 μ; process length: 30—33 μ; process breadth (at the base): 4—6 μ.

OCCURRENCE. — Ekön Borehole No. 1, 106.05 m — 105.10 m, Folkeslunda Limestone (Lower Viruan).

DENSITY. — <10 % at level 106.05 m and 105.10 m.

PREVIOUS RECORDS. — Lower Viruan of Grötlingbo Borehole No. 1, Gotland.

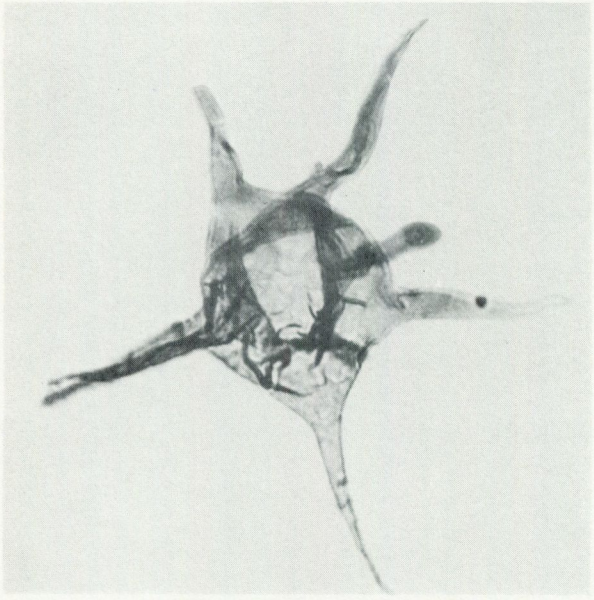

Fig. 22. *Goniosphaeridium conjunctum* KJELLSTRÖM, 1971.
Slide: 106.05, coord.: 50/110. 1 cm on photo = 12 μ.

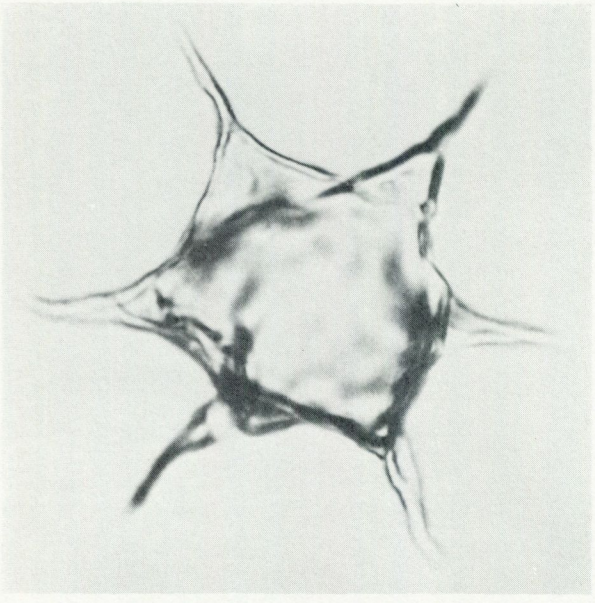

Fig. 23. *Goniosphaeridium connectum* KJELLSTRÖM, 1971.
Slide: 104.10, coord.: 39/122. 1 cm on photo = 0.7 μ.

Goniosphaeridium connectum KJELLSTRÖM, 1971
Fig. 23

1971a *Goniosphaeridium connectum* KJELLSTRÖM. — Kjellström: p. 44, Pl. 3, Fig. 5.

DIMENSIONS. — Vesicle diameter: 25—28 μ; process length: 12—14 μ.

OCCURRENCE. — Ekön Borehole No. 1, 104.10 m—103.55 m, Folkeslunda Limestone (Lower Viruan).

DENSITY. — <10 % at level 104.10 m and 103.55 m.

PREVIOUS RECORDS. — Skagen Limestone (post-Lower Viruan) of Grötlingbo Borehole No. 1, Gotland. This species has thus not been recorded from the Lower Viruan of the Grötlingbo boring.

Goniosphaeridium cf. *makrosphaericum* EISENACK, 1970
Fig. 24

DIMENSIONS. — Vesicle diameter: 47—54 μ; process length: 18—23 μ; process breadth: ~ 6 μ.

OCCURRENCE. — Ekön Borehole No. 1, 106.05 m—101.10 m, Folkeslunda and Furudal Limestones (Lower Viruan).

DENSITY. — 25 % at level 103.55 m; <10 % at level 106.05 m, 105.10 m, 102.06 m, 101.55 m and 101.10 m.

PREVIOUS RECORDS. — Jörden Beds of Lower Silurian, Estonia (as *G. makrosphaericum* in Eisenack 1970).

Goniosphaeridium mochtiensis (GÓRKA, 1969) n.comb.
Fig. 25

1969 *Baltisphaeridium mochtiensis* GÓRKA. — Górka: p. 43, Pl. 11, Fig. 12: Text-fig. 15.
1971b *Goniosphaeridium mochtiensis* GÓRKA. — Kjellström: p. 26, Fig. 16.
1972 *Goniosphaeridium mochtiensis* GÓRKA. — Kjellström: p. 715.

DIMENSIONS. — Vesicle diameter: 60—65 μ; process length: 42—45 μ; process breadth (at the base): ~ 6 μ.

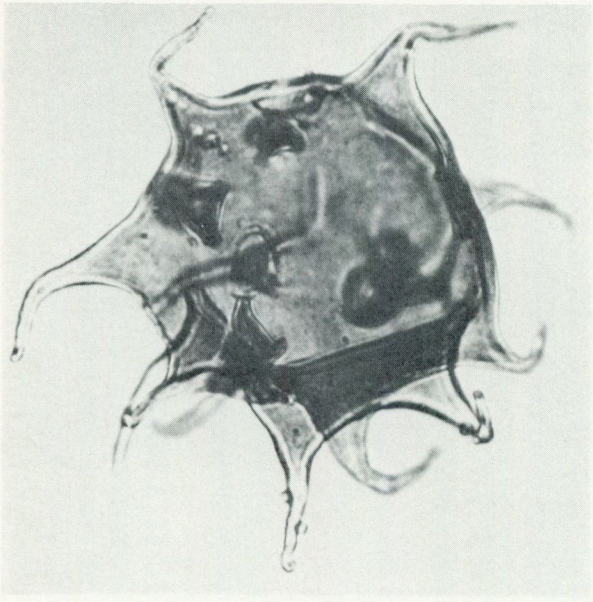

Fig. 24. *Goniosphaeridium* cf. *makrosphaericum* EISENACK, 1970.
Slide: 106.05, coord.: 44/126. 1 cm on photo = 11 μ.

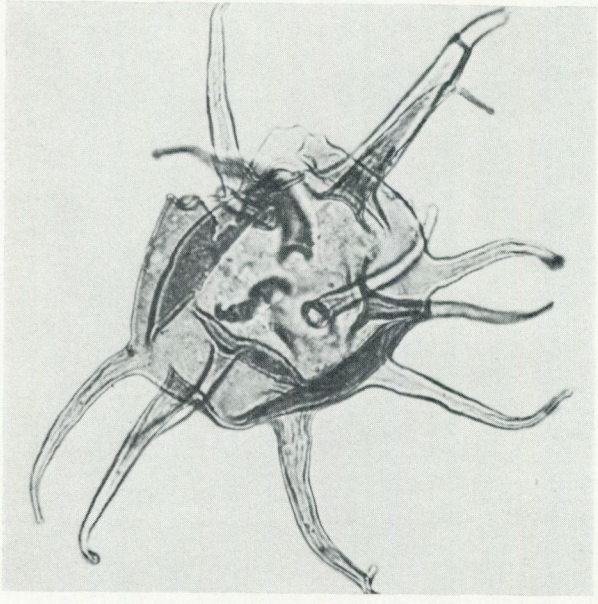

Fig. 25. *Goniosphaeridium mochtiensis* (GÓRKA), 1969) n.comb.
Slide: 105.10, coord.: 44/115. 1 cm on photo = 16 μ.

OCCURRENCE. — Ekön Borehole No. 1, 105.10 m—101.10 m, Folkeslunda and Furudal Limestones (Lower Viruan).

DENSITY. — 20 % at level 104.10 m; 15 % at level 103.55 m; <10 % at level 105.10 m, 102.06 m, 101.55 m and 101.10 m.

PREVIOUS RECORDS. — Lower Viruan of Grötlingbo Borehole No. 1, Gotland and Gammalsby Borehole No. 1, Öland. Lower Caradocian of Mielnik Borehole No. 1, Poland. Ordovician erratic boulders of Sarbia and Mochty, Poland.

GENUS *MULTIPLICISPHAERIDIUM* STAPLIN, 1961 RESTR. STAPLIN, JANSONIUS & POCOCK, 1965

Multiplicisphaeridium alloiteaui DEUNFF, 1955

Fig. 26

1955 *Micrhystridium alloiteaui* DEUNFF. — Deunff: p. 148, Pl. 4:3.
1963 *Baltisphaeridium alloiteaui* DEUNFF. — Downie & Sarjeant: p. 89.
1964 *Baltisphaeridium alloiteaui* DEUNFF. — Downie & Sarjeant: p. 87.
1967 *Micrhystridium alloiteaui* DEUNFF. — Moreau-Benoit: p. 202.
1970 *Baltisphaeridium alloiteaui* DEUNFF. — Lister: p. 49.

DIMENSIONS. — Vesicle diameter: 43—51 μ; process length: 6—8 μ; process breadth: $\sim 2\,\mu$.

OCCURRENCE. — Ekön Borehole No. 1, 106.05 m—103.55 m, Folkeslunda Limestone (Lower Viruan).

DENSITY. — 15 % at level 106.05 m; <10 % at level 105.10 m, 104.10 m and 103.55 m.

PREVIOUS RECORDS. — Lower Viruan of Grötlingbo Borehole No. 1, Gotland and Gammalsby Borehole No. 1, Öland. Ordovician erratics of Mochty, Poland.
OCCURRENCE. — Ekön Borehole No. 1, 106.05 m, Folkeslunda Limestone (Lower Viruan).

DENSITY. — <10 % at level 106.05 m.

PREVIOUS RECORDS. — Caradocian of England. Ordovician of Belgium. Middle Devonian of Canada. *M. alloiteaui* has not been recorded previously from the Balto-Scandia.

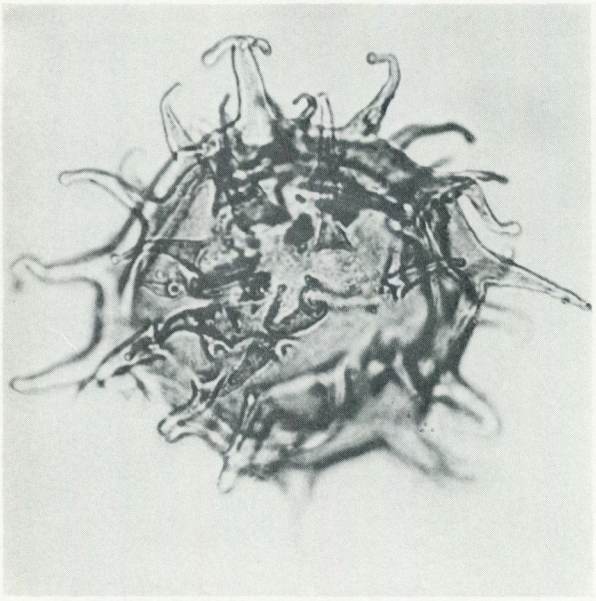

Fig. 26. *Multiplicisphaeridium alloiteaui* DEUNFF, 1955.
Slide: 106.05, coord.: 32/108. 1 cm on photo = 10 μ.

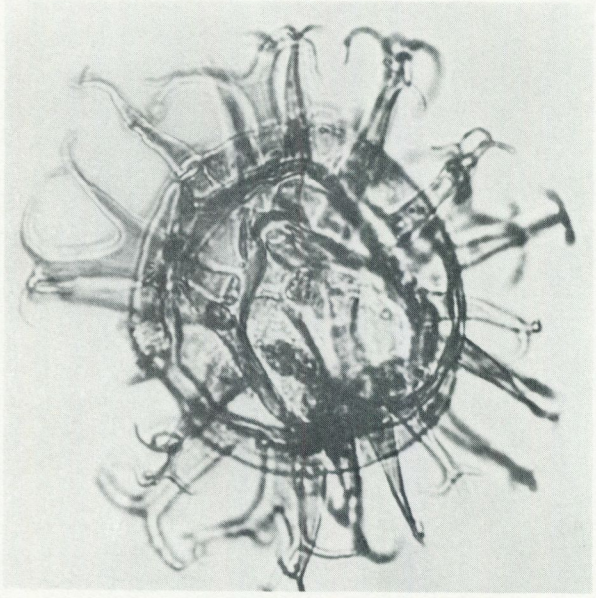

Fig. 27. *Peteinosphaeridium groetlingboensis* KJELLSTRÖM, 1971.
Slide: 101.10, coord.: 35/112. 1 cm on photo = 10 μ.

GENUS *PETEINOSPHAERIDIUM* STAPLIN, JANSONIUS & POCOCK, 1965 EMEND. EISENACK, 1969

Peteinosphaeridium groetlingboensis KJELLSTRÖM, 1971

Fig. 27

1971a *Peteinosphaeridium groetlingboensis* KJELLSTRÖM. — Kjellström: p. 52, Pl. 4, Fig. 1.
1972 *Peteinosphaeridium groetlingboensis* KJELLSTRÖM. — Kjellström: p. 715.

DIMENSIONS. — Vesicle diameter: 40—45 μ; process length: 12—18 μ; process breadth: $\sim$ 2.5 μ.

OCCURRENCE. — Ekön Borehole No. 1, 102.06 m—101.10 m, Furudal Limestone (Lower Viruan).

DENSITY. — < 10 % at level 102.06 m, 101.55 m and 101.10 m.

PREVIOUS RECORDS. — Viruan (?Dalby Topoformation, cf. Kjellström 1971a, pp. 59, 61) of Grötlingbo Borehole No. 1, Gotland. Lower Viruan of Gammalsby Borehole No. 1, Öland.

Peteinosphaeridium nudum (EISENACK, 1959)

Fig. 28

SYNONYMA. — See synonymous list in Kjellström 1971a.
1972 *Peteinosphaeridium nudum* EISENACK. — Kjellström: p. 715.

DIMENSIONS. — Vesicle diameter: 60—70 μ; process length: 15—18 μ; process breadth: 1—3 μ.

OCCURRENCE. — Ekön Borehole No. 1, 104.10 m—101.10 m, Folkeslunda and Furudal Limestones (Lower Viruan).

DENSITY. — 20 % at level 104.10 m; 15 % at 103.55 m; 25 % at level 102.06 m; 45 % at level 101.55 m; 60 % at level 101.10 m.

PREVIOUS RECORDS. — Lower Viruan of Grötlingbo Borehole No. 1, Gotland and Gammalsby Borehole No. 1, Öland. Middle Ordovician erratics of the Baltic. Middle Ordovician of Zebrak Borehole No. 1 and Mielnik Borehole No. 1, Poland. Silurian of Belgium (full documentation in Kjellström 1971a).

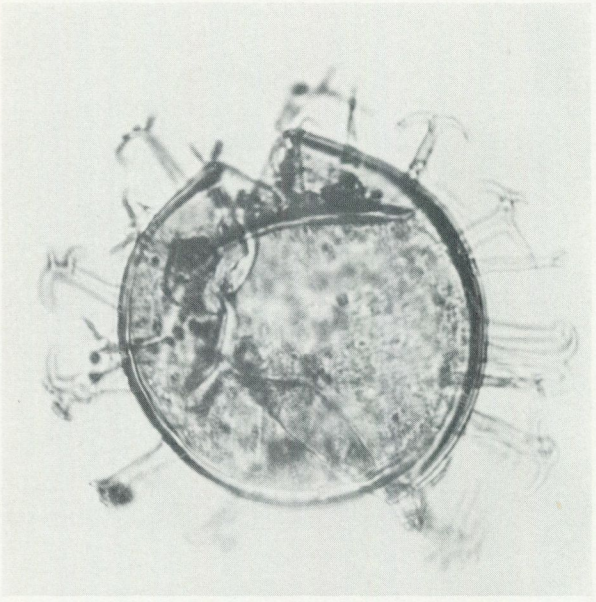

Fig. 28. *Peteinosphaeridium nudum* (EISENACK, 1959).
Slide: 101.10, coord.: 23/111. 1 cm on photo = 13 μ.

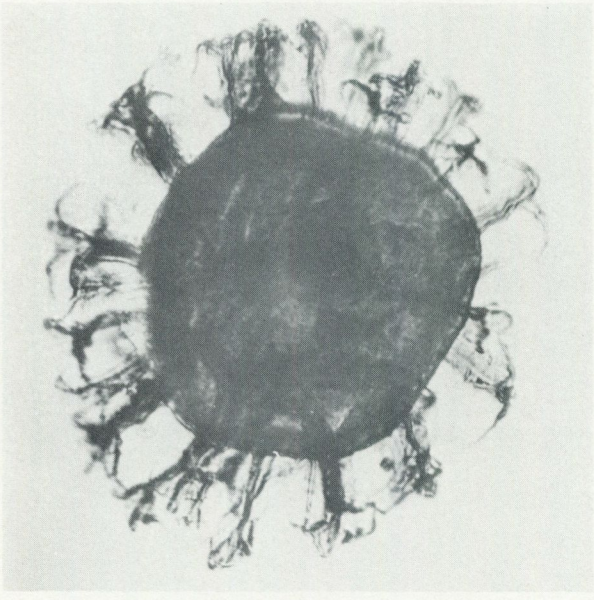

Fig. 29. *Peteinosphaeridium trifurcatum* (EISENACK, 1959).
Slide: 106.05, coord.: 30/128. 1 cm on photo = 18 μ.

Peteinosphaeridium trifurcatum (EISENACK, 1931)
Fig. 29

SYNONYMA. — See synonymous list in Kjellström 1971a.
1972 *Peteinosphaeridium trifurcatum* EISENACK. — Kjellström: p. 715.
1972 *Peteinosphaeridium trifurcatum* EISENACK. — Johansson, Karis & Kjellström: p. 580.

DIMENSIONS. — Vesicle diameter: 70—80 μ; process length: 25—30 μ; process breadth: 4—6 μ.

OCCURRENCE. — Ekön Borehole No. 1, 106.05 m—101.10 m, Folkeslunda and Furudal Limestones (Lower Viruan).

DENSITY. — <10 % at level 106.05 m, 104.10 m, 103.55 m, 102.06 m, 101.55 m and 101.10 m.

PREVIOUS RECORDS. — Viruan (?Dalby Topoformation) of Grötlingbo Borehole No. 1, Gotland. Lower Viruan of Gammalsby Borehole No. 1, Öland. Middle Ordovician erratics of the Baltic. Upper Arenigian of Podborowisko Borehole No. 1, Poland. Upper Arenigian of Ljungsbro, Östergötland. Arenigian-Llanvirnian of Kent, England.

GENUS *TYLOTOPALLA* LOEBLICH, 1970
Tylotopalla caelamenicutis LOEBLICH, 1970
Fig. 30

1966 *Baltisphaeridium sanpetrensis* CRAMER. — Cramer: p. 65.
1970 *Tylotopalla caelamenicutis* LOEBLICH. — Loeblich: p. 738, Fig. 33 A—C.
1972 *Lophosphaeridium agudisimum* CRAMER. — Cramer & Díez: p. 166, Pl. 36: 56, 57.

DIMENSIONS. — Vesicle diameter: 44—47 μ; process length: 10—12 μ; process breadth: $\sim$ 4 μ.

OCCURRENCE. — Ekön Borehole No. 1, 106.05 m, Folkeslunda Limestone (Lower Viruan).

DENSITY. — <10 % at level 106.05 m.

PREVIOUS RECORDS. — Maplewood Shale (Upper Llandovery) of Rochester, U.S.A. *T. caelamenicutis* has not been recorded previously from the Balto-Scandia.

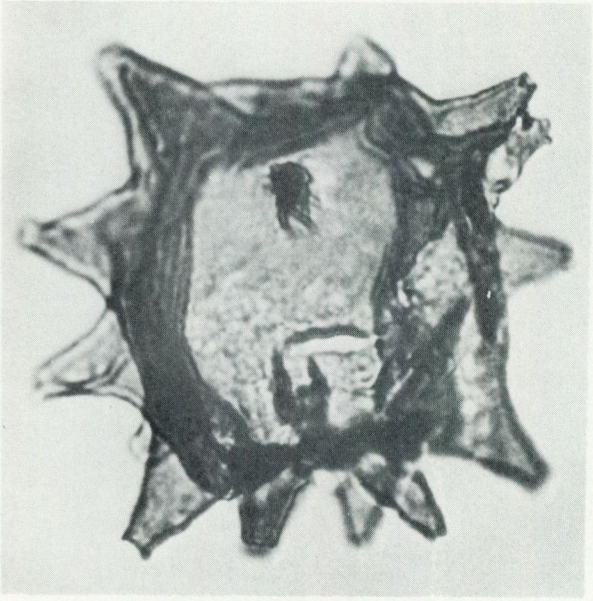

Fig. 30. *Tylotopalla caelamenicutis* LOEBLICH, 1970.
Slide: 106.05, coord.: 49/121. 1 cm on photo = 10 μ.

SUMMARY

In total twenty-nine acritarch species belonging to six genera are encountered in the Lower Viruan of the Ekön boring (Fig. 31). Ten of these are here reported for the first time from Balto-Scandia (Fig. 34), viz.: *Aremoricanium carolineae* n.sp., *A. simplex, Baltisphaeridium annelieae* n.sp., *B. christoferii* n.sp., *B. hamatum, B. ingerae* n.sp., *Goniosphaeridium chrisiianii* n.sp., *G.* cf. *makrosphaericum, Multiplicisphaeridium alloiteaui,* and *Tylotopalla caelamenicutis.* Stratigraphically firm records of eight species of the total assemblage of Ekön have also been recovered from equivalent strata of the Gammalsby as well as of the Grötlingbo borings, i.e. *Aremoricanium deflandrei, Baltisphaeridium brevispinosum, B. brevituberculatum, B. constrictum, B. longispinosum. B. varsoviensis, Goniosphaeridium mochtiensis,* and *Peteinosphaeridium nudum* (the solid lines on Fig. 34 denote stratigraphically firm records whereas a broken line denotes inexactly dated samples within the interval Folkeslunda—Furudal—Dalby). Thirty-one species (stratigraphically firm records) from the Lower Viruan of Gammalsby and Grötlingbo have not been found present at all in the Lower Viruan of Ekön.

As has been previously documented (Kjellström 1971a, 1971b, 1972) the reddish brown calcarenites of the Segerstad and Skärlöv Limestones of the Grötlingbo and Gammalsby borings were entirely devoid of any acritarch constituent. The same conditions, probably due to the oxidizing environment, prevail in the Ekön material

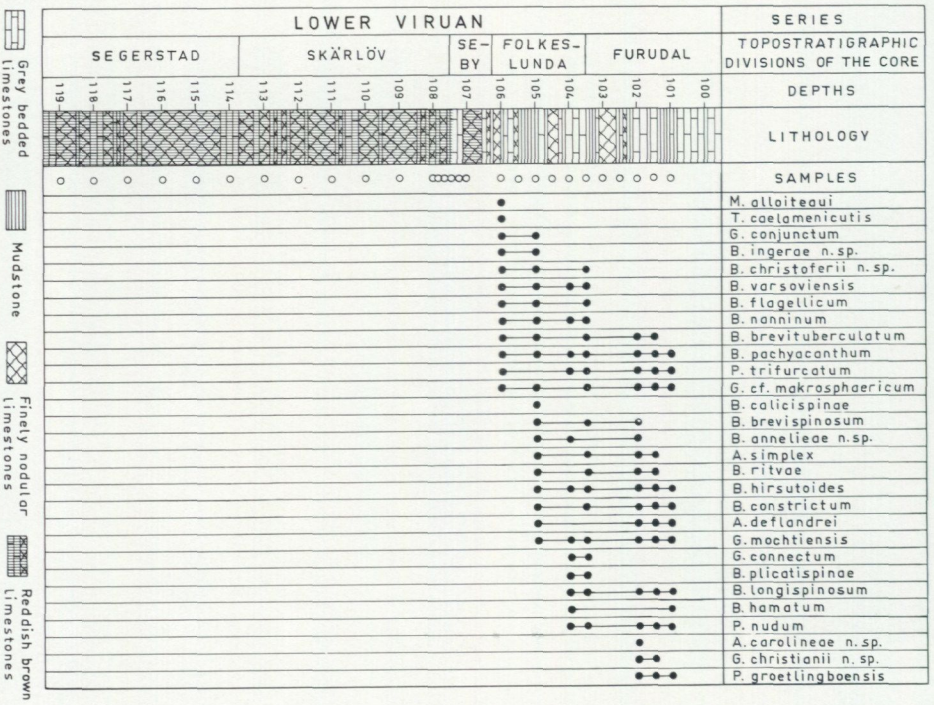

Fig. 31. The occurrence of acritarchs from the Lower Viruan of the Ekön Borehole No. 1.

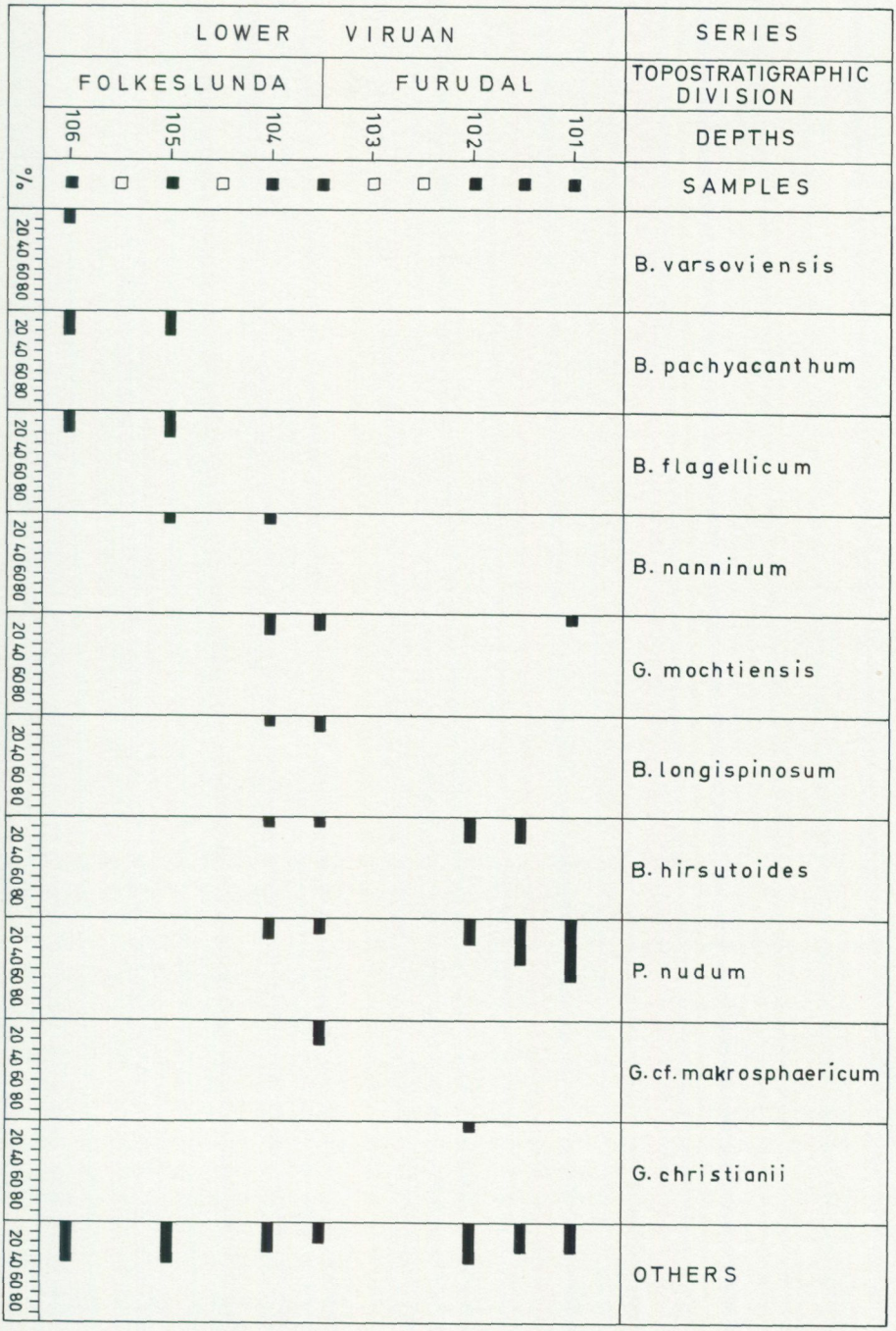

Fig. 32. Diagrammatic representation of the density of some common acritarch taxa in the Lower Viruan of the Ekön Borehole No. 1.

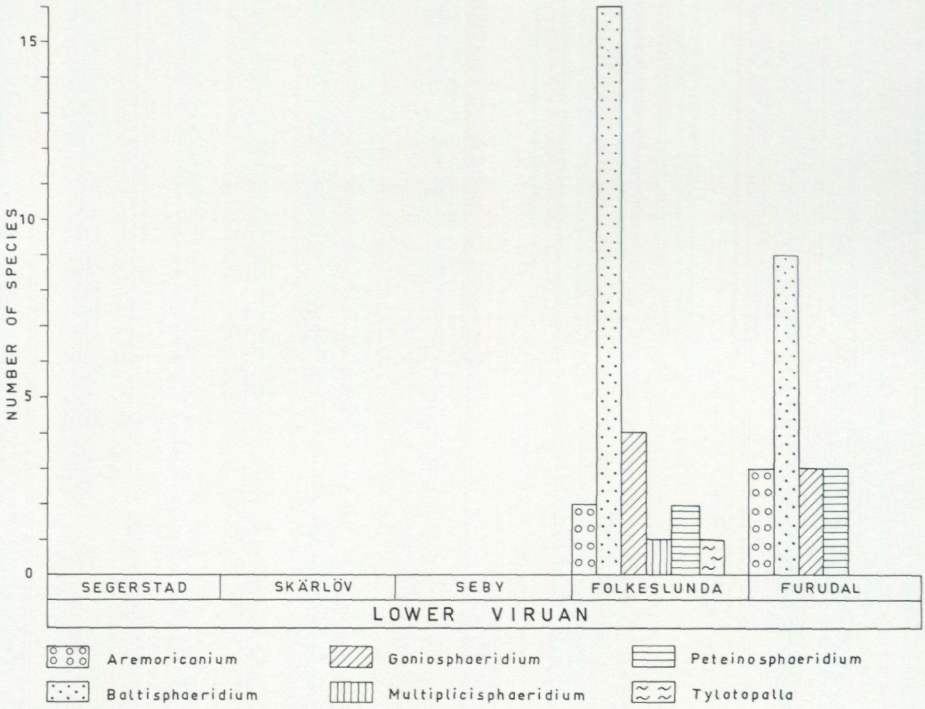

Fig. 33. Variation in the occurrence of acritarchs from the Lower Viruan of the Ekön Borehole No. 1.

(Fig. 31). In the Gammalsby core the red calcarenites of the Seby Limestone also lacked any acritarchs, but in some intercalations of grey limestone of this formation a rich and well-preserved acritarch flora was met with. In the Seby Limestone of Ekön, however, no sample derived from the grey intercalations yields acritarchs. This may be an indication that the grey limestone intercalations of the Seby Limestone of Ekön primarily were deposited in an oxidizing environment. The absence of acritarchs at the levels 105.55 m, 104.55 m (Folkeslunda Limestone) and 102.55 m (Furudal Limestone) might in a similar way indicate a primary oxidizing environment (cf. the variegated grey and red limestones of the Ryd and Gullhögen Topoformations of Billingen, Jaanusson 1967).

In the productive levels of the Folkeslunda Limestone the dominating genus regarding the number of species is *Baltisphaeridium* (Fig. 33). Sixteen species have thus been recorded from here, whereas in the Furudal Limestone only nine species of genus *Baltisphaeridium* have been encountered (cf. Fig. 31). In contrast to the Folkeslunda Limestone, the Furudal Limestone does not yield the genera *Multiplicisphaeridium* and *Tylotopalla*.

In the present core, the following species are locally confined to the Folkeslunda Limestone: *Baltisphaeridium christoferii, B. flagellicum, B. ingerae, B. nanninum, B. varsoviensis, Goniosphaeridium conjunctum, Multiplicisphaeridium alloiteaui,* and *Tylotopalla caelamenicutis*. Locally restricted to the Furudal Limestone of the

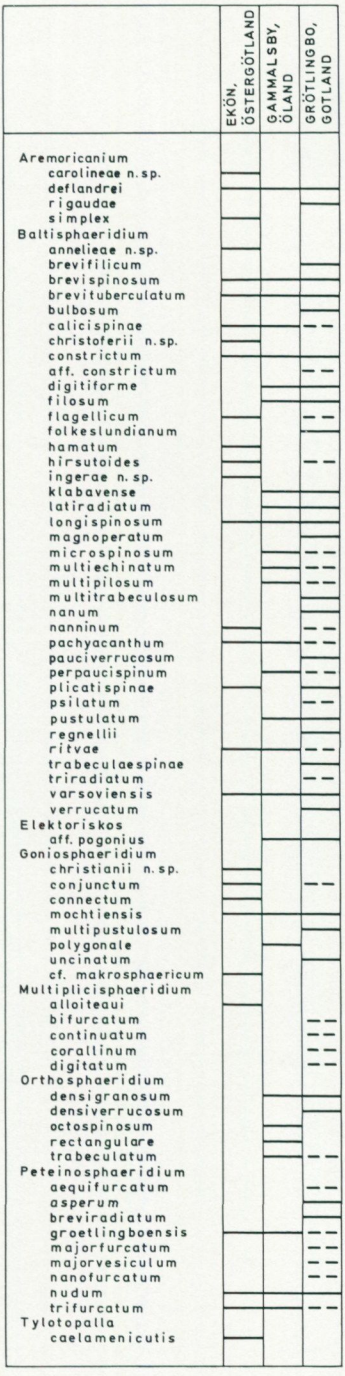

Fig. 34. The occurrence of acritarchs from the Lower Viruan of the Ekön, Gammalsby and Grötlingbo borings. Broken lines denote inexactly dated records within the interval Folkeslunda – Furudal – Dalby (cf. Kjellström 1971 a, p. 59).

Ekön core are: *Aremoricanium carolineae, Goniosphaeridium christianii* and *Peteinosphaeridium groetlingboensis.*

In the preceding section of the present paper the phytoplanktic density has been given for each species. Most of the species occurring in the Ekön boring show low density percentages, that is <10 %. Ten species out of twenty-nine in total possess a density of 10 % or more, i.e.: *Baltisphaeridium flagellicum, B. hirsutoides, B. longispinosum, B. nanninum, B. pachyacanthum, B. varsoviensis, Goniosphaeridium christianii, G. mochtiensis, G.* cf. *makrosphaericum,* and *Peteinosphaeridium nudum* (Fig. 32). Among these *P. nudum* reveals specific characteristics. Starting at the level 104.10 m (density: 20 %) it gradually expands extensively in the three uppermost levels (density: 25 %, 45 %, 60 %, respectively). Similar trends as regards the density expansion towards younger strata is given by *B. hirsutoides* although not so pronounced as is the case with *P. nudum.*

Finally, two main density groupings can be identified, viz.: one group (composed of *B. flagellicum, B. pachyacanthum* and *B. varsoviensis)* confined to the levels at 106.05 m and 105.10 m, and another group (composed of *B. hirsutoides, B. longispinosum, G. christianii, G. mochtiensis, G.* cf. *makrosphaericum* and *P. nudum)* being characteristic of the interval 104.10 m—101.10 m (cf. Fig. 31).

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