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Ordovician acritarchs from the Rapla borehole, Estonia

by Anneli Uutela and Risto Tynni

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ORDOVICIAN ACRITARCHS FROM THE RAPLA BOREHOLE, ESTONIA

by

ANNELI UUTELA and RISTO TYNNI

with 5 figures in the text and 30 plates

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Ninety-nine samples obtained from the Rapla borehole in Estonia were analysed for Palaeozoic acritarchs. The Rapla carbonate sequence ranges in age from Early Ordovician (Arenigian) to Early Silurian (Llandoverian) and has a rich, well preserved acritarch flora. The species identified were typical of the Palaeozoic in the Baltic area but smaller in size than those observed elsewhere in the Baltic. A total of 322 species are described and analysed stratigraphically, including 134 established as new species and 6 as new formas. Ten new genera are proposed.

Lower Palaeozoic floristic zones are possible to propose by reference to the present material only preliminaryly. In the Rapla core Lower Ordovician (Volhov and Kunda regional stages) is dominated by the small acanthomorphs and the number of species is low.

The number of species increases in the Middle Ordovician. The prominent genera are *Baltisphaeridium, Cheleutochroa, Labyrinthosphaeridium* n. gen., *Ordovicidium, Orthosphaeridium, Tasmanites* and *Veryhachium.* In the upper part of the Middle Ordovician the small acanthomorphs are dominant again, genera *Micrhystridium* and *Multiplicisphaeridium* are common.

In the lower Upper Ordovician the herkomorphs *Goniosphaeridium* and *Multiplicisphaeridium* are common while the variety of species becomes more restricted in the transition from the Upper Ordovician to the Lower Silurian.

Key words: microfossils, acritarchs, new taxa, Paleozoic, Ordovician, Rapla, Estonia

Anneli Uutela:
Geological Survey of Finland, SF-02150 Espoo, Finland

Risto Tynni:
SF-07510 Vakkola, Finland

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INTRODUCTION

Joint Estonian-Finnish research into the Palaeozoic deposits at Rapla was commenced in 1985 at the instigation of Prof. Dimitri Kaljo from the Estonian Academy of Sciences. This Rapla borehole represents one of the most complete Ordovician deposits in the whole Baltic area, and detailed descriptions of its lithological composition and dating in terms of Estonian regional stages are available from the work of Põlma (1972).

The aim of the present investigation was to ascertain the microfossil composition of the Ordovician rocks represented in the core and to show this stratigraphical value. The author Anneli Uutela is responsible for all the analyses and the description of species and the author Risto Tynni is responsible for the description of the new species. Jaak Nõlvak of the Estonian Academy of Sciences is responsible for the chitinozoans and this part will be published later.

AREAL DESCRIPTION AND RESEARCH METHODS

The Rapla borehole in northern Estonia (Fig. 1) belongin to the north-west part of the East European Platform was drilled into, the Ordovician rocks known as the North Estonian Confacies, by Männil (1966). Except in its lowest part, it provides one of the most complete Ordovician successions in the Baltic area. In the Rapla borehole the Ordovician — Lower Silurian sequence is 163.50 m thick and covers the regional stages from the Latorp (B_I, Lower Arenigian) to the Juuru (G_{1-2}, Lower Llandoverian), i.e. from the Lower Ordovician to the Lower Silurian. Lowermost in the sequence is a 0.95 m thick Latorp Regional Stage, B_I, of glauconite-dolomite, siltstone and siltstone with glauconite, and this is overlain at depths 192.00 — 31.10 m by carbonate deposits of varying clay content representing the regional stages from the Latorp to the Porkuni, B_I — F_{II}. Uppermost are limestones and marls representing the Juuru Regional Stage, G_{1-2} (Fig. 2). The Ordovician deposits in Estonia also include a thin, more terrigenous

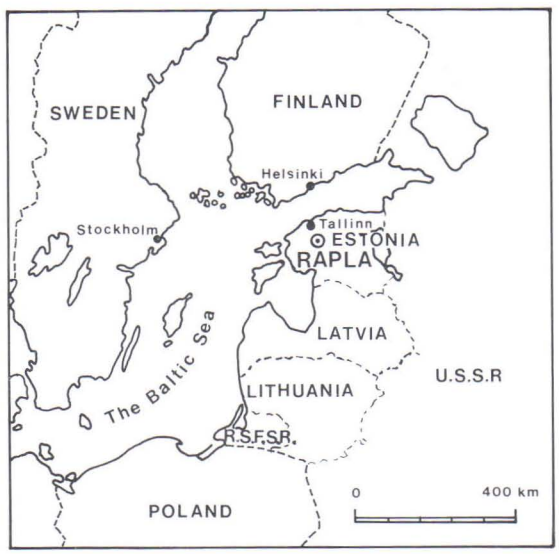

Fig. 1. Location of the Rapla borehole.

Kamariku bed ($F_{II}K$) 0.6 m in thickness, representing a horizon in the Porkuni Regional Stage, F_{II}, for which no core has been

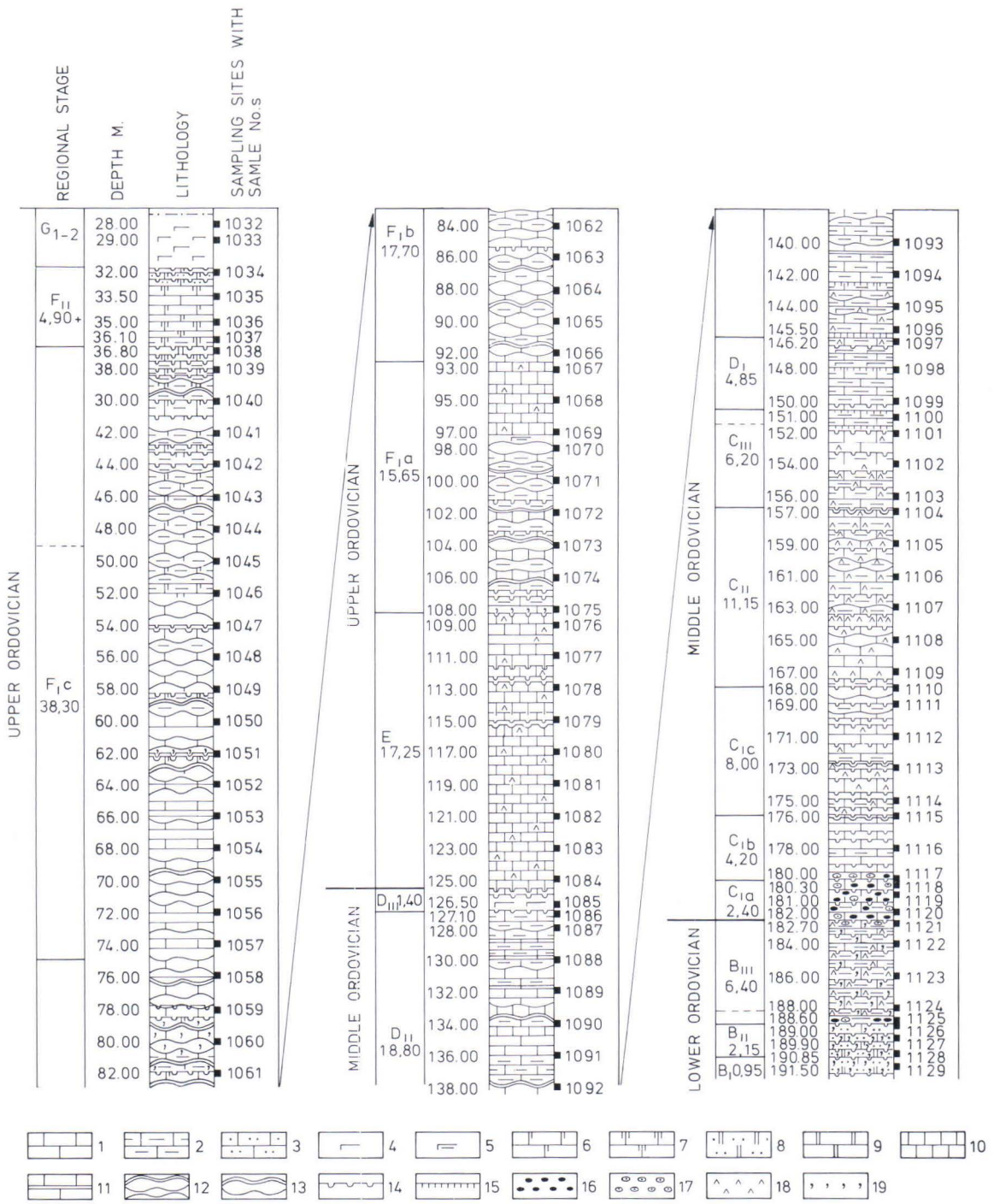

Fig. 2. Lithology of the Rapla borehole (Põlma 1972) and the samples studied. Legend: 1 = pure limestone, 2 = argillaceous limestone, 3 = silty limestone, 4 = calcareous marl, 5 = argillaceous marl, 6 = limestone with dolomite, 7 = dolomitic limestone, 8 = dolomitic siltstone, 9 = pure dolomite, 10 = cryptocrystalline and microcrystalline limestone, 11 = limestone interbedding with marls, 12 = seminodular limestone interbedding with marls, 13 = nodular limestone interbedding with marls, 14 = discontinuity surfaces, 15 = metabentonite, 16 = goethite ooids, 17 = calcareous and phosphate ooids, 18 = kukersite (kerogen), 19 = glauconite.

preserved. There are 100 discontinuity surfaces, the majority being concentrated in the intervals B_I — C_{III} and F_Ic — F_{II} (Põlma 1972).

The Ordovician carbonate sequence of the Rapla core may be divided into two lithologically distinct intervals, B_I — D_{III} and E — F_{II}, probably induced by different tectonic patterns (Põlma 1972).

The 99 samples available were processed using HCl and HF. Sodium polytungstate (Sometu, West Germany) with specific gravity 2.2 was used for gravity separation. The samples were mounted with glycerine jelly for light microscopy specimens. A further 32 samples were prepared for scanning electron microscopy.

EARLIER INVESTIGATIONS

The well preserved Palaeozoic deposits of the Baltic region became an object of interest for palaeontologists at a very early stage (Eichwald 1825, Pander 1830, Schmidt 1882). On fossil evidence, Schmidt (1882) divided the Ordovician of Estonia (originally Lower Silurian) into five stages, B — F, which he was able to correlate with deposits in Europe and to some extent in America as well. This classification was later developed into a more detailed regional division of the Ordovician and Silurian in Estonia comprising 18 stages of the former and 10 of the latter. The Estonian Regional Stages of the Ordovician and Lower Silurian are correlated with the British series in Fig. 3 (Kaljo 1984).

Ordovician and Silurian acritarchs from Estonia have been studied previously by Eisenack (1951, 1958, 1962, 1965a, 1967, 1970), W. Wetzel (1967) and Bockelie and Kjellström (1979), while the work of Timofeev (1963a) covers Siberia and Poland as well as the Baltic region and that of Umnova (1975) both the Baltic and the Moscow basin. Ordovician acritarchs from the Soviet Union have been studied by Timofeev (1963b, 1966), Umnova and Fanderflit (1971), German (1974) and Piskun (1974). Eisenack (1954, 1959, 1965a,b, 1968, 1976) also studied Palaeozoic acritarchs in Sweden, as did Kjellström (1971a,b, 1972, 1976), Le Herissé (1984) and Górka (1987). Some of the material discussed by Eisenack (1962, 1965a) was derived from erratics found on the coast of southern Finland, and acritarchs from similar sources have also been studied by Tynni (1975) and Uutela (1989). An *in situ* Palaeozoic deposit and Cambrian veins on Åland were described by Tynni (1982).

Many of the same Ordovician species as found here at Rapla have been described earlier in East Germany (Burmann 1968, 1973), Poland (Górka 1969, 1979, 1980) and Czechoslovakia (Vavrdová 1965, 1972, 1973, 1977, Konzalová—Mazancová 1969). Elsewhere in Europe, acritarchs have been studied in Belgium by Stockmans and Willière (1960, 1962, 1963, 1967, 1969) and Martin (1966a,b, 1967, 1968, 1973), in Britain by Lister (1970), Rasul (1979) and Turner (1982, 1984, 1985), in France by Henry (1969) and Martin (1972) and in Spain by Cramer (1963, 1964, 1967) and Cramer and Díez (1972a).

Acritarchs have been investigated in the U.S.A. by Loeblich (1970a,b), Loeblich and Tappan (1969, 1971, 1978), Tappan and Loeblich (1971), Jacobson (1978) and Colbath (1979, 1980), in Canada by Martin (1980, 1983), Legault (1982) and Jacobson and Achab (1985) and in Australia by Combaz and Peniguel (1972), Playford and Dring (1981) and Playford and Martin (1984).

Only a few isolated pieces of work have been carried out to date on acritarch finds in North Africa, Asia and South America.

ADAVERE		H_4	LLANDOVERY	LOWER SILURIAN
RAIKKÜLA		G_3		
JUURU		G_{1-2}		
PORKUNI		F II	ASHGILL	UPPER ORDOVICIAN
PIRGU	Adila F. Moe F.	F Ic		
VORMSI		F Ib		
NABALA	Saunja F. Paekna F.	F Ia		
RAKVERE		E	CARADOC	MIDDLE ORDOVICIAN
OANDU		D III		
KEILA		D II		
JÕHVI		D I		
IDAVERE	Vasavere F. Tatruse F.	C III		
KUKRUSE		C II	LLANDEILO	
UHAKU		C Ic		
LASNAMÄGI		C Ib	LLANVIRN	
ASERI		C Ia		
KUNDA		B III	ARENIG	LOWER ORDOVICIAN
VOLHOV	Loobu F. Sillaoru F.	B II		
LATORP		B I		
CERATOPYGE		A III	TREMADOC	
PAKERORT		A II		

Fig. 3. Correlation of the Ordovician and Lower Silurian Estonian regional stages with the British Series (Kaljo 1984).

LIST OF ACRITARCHS

Genus *Acanthodiacrodium* **Timofeev 1958**

Acanthodiacrodium ovale n. sp., Pl. I:1, Fig. 4. No. 189, p. 28.

A. sp., Pl. I:2, Fig. 4. No. 20, p. 28.

Genus *Acrosphaeridium* **n. gen.**, p. 29.

Acrosphaeridium densum n. sp., Pl. I:3, Fig. 4. No. 144, p. 29.

A. esthonicum n. sp., Pl. I:4a, b, Fig. 4. No. 269, p. 29.

A. reticulatum n. sp., Pl. I:5, Fig. 4. No. 249, pp. 29—30.

Genus *Actipilion* **Loeblich 1970**

Actipilion druggii Loeblich 1970, Pl. II:8, Fig. 4. No. 283, p. 30.

Genus *Akomachra* **Colbath 1979**

Akomachra ovula Colbath 1979, Pl. II:9, Fig. 4. No. 64, p. 30.

Genus *Arcosphaeridium* **n. gen.**, pp. 30—31.

Arcosphaeridium diversispinosum n. sp., Pl. I:6, Fig. 4. No. 280, p. 31.

A. poriferum n. sp., Pl. I:7a, b, Fig. 4. No. 302, p. 31.

Genus *Aremoricanium* Deunff 1955

Aremoricanium deflandrei Henry 1969, Pl. II:10, Fig. 4. No. 107, p. 31.

A. rigaudae Deunff 1955, Pl. II:11, Fig. 4. No. 100, pp. 31—32.

A. squarrosum Loeblich & MacAdam 1971, Pl. II:12, Fig. 4. No. 219, p. 32.

A. sp., Pl. III:24, Fig. 4. No. 17, p. 32.

Genus *Arkonia* Burmann 1970

Arkonia concava n. sp., Pl. III:25, Fig. 4. No. 132, p. 32.

A. semigranulata n. sp., Pl. III:26, Fig. 4. No. 235, p. 33.

Genus *Axisphaeridium* Eisenack 1967

Axisphaeridium timofeevi Eisenack 1967, Pl. II:13, Fig. 4. No. 165, p. 33.

A. tricolumnelare Uutela 1989, Pl. II:14, Fig. 4. No. 221, p. 33.

Genus *Bacisphaeridium* Eisenack 1962

Bacisphaeridium bacifer Eisenack (1934) 1962, Pl. II:15, Fig. 4. No. 299, p. 34.

B. granulatum n. sp., Pl. III:27, Fig. 4. No. 305, p. 34.

B. saetosum n. sp., Pl. III:28, Fig. 4. No. 310, pp. 34—35.

Genus *Baltisphaeridium* Eisenack 1958, emend. Eisenack 1969

Baltisphaeridium accinctum Loeblich & Tappan 1978, Pl. II:16, Fig. 4. No. 6, p. 35.

B. aliquigranulum Loeblich & Tappan 1978, Pl. II:17, Fig. 4. No. 265, p. 35.

B. annelieae (Kjellström) Bockelie & Kjellström 1979, Pl. II:18, Fig. 4. No. 65, p. 35.

B. bramkaense Górka 1979, Pl. II:19, Fig. 4. No. 114, p. 36.

B. breviciliatum (Staplin) Downie & Sarjeant 1963, Pl. II:20, Fig. 4. No. 319, p. 36.

B. brevispinosum Eisenack (1931) 1958, Pl. II:21, Fig. 4. No. 27, p. 36.

B. brevituberculatum Kjellström 1971, Pl. II:22, Fig. 4. No. 29, p. 36.

B. bystrentos Loeblich & Tappan 1978, Pl. II:23, Fig. 4. No. 162, p. 37.

B. aff. *B. capillatum* Jardiné *et al.* 1974, Pl. IV:32, Fig. 4. No. 320, p. 37.

B. castaneiforme n. sp., Pl. III:29, Fig. 4. No. 18, p. 37.

B. cirsinum n. sp., Pl. III:30a, b, Fig. 4. No. 2, pp. 37—38.

B. dasos Colbath 1979, Pl. IV:33, Fig. 4. No. 127, p. 38.

B. digitiforme Górka 1969, Pl. IV:34, Fig. 4. No. 146, p. 38.

B. dispar Turner 1984, Pl. IV:35, Fig. 4. No. 179, p. 38.

B. eisenackianum (Deunff) Downie & Sarjeant 1963, Pl. IV:36, Fig. 4. No. 92, pp. 38—39.

B. esthonicum n. sp., Pl. III:31, Fig. 4. No. 28, p. 39.

B. filosum Kjellström 1971, Pl. IV:37, Fig. 4. No. 37, p. 39.

B. flexuosum n. sp., Pl. V:48, Fig. 4. No. 66, pp. 39—40.

B. globosum Tynni 1975, Pl. IV:38, Fig. 4. No. 281, p. 40.

B. hamatum (Downie) Kjellström 1976, Pl. IV:39, Fig. 4. No. 81, p. 40.

B. heinzelinii Stockmans & Willière 1969, Pl. IV:40, Fig. 4. No. 272, p. 40.

B. hirsutoides Eisenack (1931) 1958, Pl. IV:41, Fig. 4. No. 50, p. 41.

B. ingerae Kjellström 1976, Pl. IV:42, Fig. 4. No. 4, p. 41.

B. kaurannei n. sp., Pl. V:49a, b, Fig. 4. No. 23, p. 41.

B. klabavense (Vavrdová) Kjellström 1971, Pl. IV:43, Fig. 4. No. 214, pp. 41—42.

B. latiradiatum (Eisenack) Staplin *et al.* 1965, Pl. IV:44, Fig. 4. No. 69, p. 42.

B. longispinosum longispinosum (Eisenack) Górka 1969, Pl. IV:45, Fig. 4. No. 47, p. 42.

B. maius n. sp., Pl. V:50, Fig. 4. No. 295, p. 42.

B. microspinosum (Eisenack) Downie 1959, Pl. IV:46, Fig. 4. No. 45, p. 43.

B. aff. *B. multiechinatum* Kjellström (1971) 1974, Pl. IV:47, Fig. 4. No. 7, p. 43.

B. multipilosum Eisenack (1931) 1958, Pl. VI:56, Fig. 4. No. 33, p. 43.

B. nanninum Eisenack 1965, Pl. VI:57, Fig. 4. No. 71, p. 43.

B. oligopsakium Loeblich & Tappan 1978, Pl. VI:58, Fig. 4. No. 72, p. 44.

B. onniense Turner 1984, Pl. VI:59, Fig. 4. No. 220, p. 44.

B. parvigranosum Loeblich & Tappan 1978, Pl. VI:60, Fig. 4. No. 129, p. 44.

B. parvulisidereum Colbath 1979, Pl. VI:61, Fig. 4. No. 3, p. 44.

B. pauciverrucosum Kjellström 1971, Pl. VI: 62, Fig. 4. No. 38, p. 45.

B. perclarum Loeblich & Tappan 1978, Pl. VI:63, Fig. 4. No. 210, p. 45.

B. pseudocalicispinum Górka 1980, Pl. VI:64, Fig. 4. No. 12, p. 45.

B. pustulatum Kjellström 1971, Pl. VI:65, Fig. 4. No. 109, p. 45.

B. ramiferum n. sp., Pl. V:51, Fig. 4. No. 273, pp. 45—46.

B. trabeculaespinae Górka 1969, Pl. VI:66, Fig. 4. No. 204, p. 46.

B. tranvikensis Tynni 1982, Pl. VI:67, Fig. 4. No. 31, p. 46.

B. trichophorum (Eisenack) Kjellström 1971, Pl. VI:68, Fig. 4. No. 35, pp. 46—47.

B. aff. *B. trophirhapium* Loeblich & Tappan 1978, Pl. VI:69, Fig. 4. No. 190, p. 47.

B. verrucatum Kjellström 1971, Pl. VI:70, Fig. 4. No. 67, p. 47.

B. sp., Pl. V:52, Fig. 4. No. 1, p. 47.

Genus *Buedingiisphaeridium* Schaarschmidt 1963, emend. Staplin 1965, Lister 1970

Buedingiisphaeridium balticum n. sp., Pl. V:53, Fig. 4. No. 75, pp. 47—48.

B. guttiferum n. sp., Pl. V:54, Fig. 4. No. 263, p. 48.

Genus *Cheleutochroa* Loeblich & Tappan 1978

Cheleutochroa aff. *C. diaphorosa* Turner 1984, Pl. VI:71, Fig. 4. No. 250, p. 48.

C. differta n. sp., Pl. V:55, Fig. 4. No. 236, pp. 48—49.

C. elegans n. sp., Pl. VII:72, Fig. 4. No. 309, p. 49.

C. gymnobrachiata Loeblich & Tappan 1978, Pl. XII:114, Fig. 4. No. 111, p. 49.

C. oculata n. sp., Pl. VII:73a, b, Fig. 4. No. 203, pp. 49—50.

C. ramosa n. sp., Pl. VII:74, Fig. 4. No. 297, p. 50.

C. rugosa n. sp., Pl. VII:75, Fig. 4. No. 225, p. 50.

C. tuberculosa n . sp., Pl. VII:76, Fig. 4. No. 234, p. 50.

C. venosa n. sp., Pl. VII:77, Fig. 4. No. 211, p. 51.

C. venosior n. sp., Pl. VII:78, Fig. 4. No. 215, p. 51.

Genus *Chlamydosphaeridia* Eisenack 1971

Chlamydosphaeridia sp., Pl. VII:79, Fig. 4. No. 143, p. 51.

Genus *Comasphaeridium* Staplin *et al.* 1965

Comasphaeridium bacillum n. sp., Pl. VIII:80, Fig. 4. No. 91, pp. 51—52.

C. sp. 1., Pl. VIII:81, Fig. 4. No. 187, p. 52.

C. sp. 2., Pl. VIII:82, Fig. 4. No. 258, p. 52.

Genus *Coronitesta* n. gen., pp. 52—53.

Coronitesta bicornis n. sp., Pl. VIII:83a, b, Fig. 4. No. 276, p. 53.

C. raplaensis n. sp., Pl. VIII:84, Fig. 4. No. 152, p. 53.

C. triangularis n. sp., Pl. VIII:85, Fig. 4. No. 228, pp. 53—54.

Genus *Costatilobus* Playford 1977

Costatilobus bulbosus n. sp., Pl. VIII:86, Fig. 4. No. 32, p. 54.

?C. grandispinosus n. sp., Pl. VIII:87, Fig. 4. No. 241, p. 54.

?C. trifidus n. sp., Pl. IX:88, Fig. 4. No. 259, pp. 54—55.

Genus *Cyclopospharidium* n. gen., p. 55.

Cyclopospharidium auriculatum n. sp., Pl. IX:89a, b, Fig. 4. No. 61, p. 55.

Genus *Cymatiosphaera* O. Wetzel 1933, emend. Deflandre 1954

?Cymatiosphaera aseriensis n. sp., Pl. IX:90, Fig. 4. No. 115, pp. 55—56.

C. crispa n. sp., Pl. IX:91, Fig. 4. No. 237, p. 56.

C. keilaensis n. sp., Pl. IX:92, Fig. 4. No. 238, p. 56.

C. latimurata n. sp., Pl. IX:93, Fig. 4. No. 233, p. 56.

C. minima n. sp., Pl. IX:94, Fig. 4. No. 212, pp. 56—57.

C. nabalaensis n. sp., Pl. IX:95, Fig. 4. No. 257, p. 57.

C. pavimenta Deflandre (1945) 1954, Pl. XII: 115, Fig. 4. No. 78, p. 57.

C. rakverensis n. sp., Pl. X:96, Fig. 4. No. 268, p. 57.

C. serrata n. sp., Pl. X:97, Fig. 4. No. 315, pp. 57—58.

C. sp., Pl. X:98, Fig. 4. No. 158, p. 58.

Genus *Dactylofusa* Brito & Santos 1965, emend. Combaz *et al.* 1967, restr. Cramer 1970

Dactylofusa lasnamaegiensis n. sp., Pl. X:99, Fig. 4. No. 133, p. 58.

Genus *Dasydorus* Playford & Martin 1984

Dasydorus cirritus Playford & Martin 1984, Pl. XII:116, Fig. 4. No. 34, p. 59.

Genus *Dicommopalla* Loeblich 1970

Dicommopalla macadamii Loeblich 1970, Pl. XII:117, Fig. 4. No. 169, p. 59.

Genus *Dictyosphaeridium* W. Wetzel 1952

D. reticulatum n. sp., Pl. X:100, Fig. 4. No. 105, p. 59.

Genus *Dictyotidium* Eisenack 1955, emended Staplin 1961

Dictyotidium multipolygonatum n. sp., Pl. X:101, Fig. 4. No. 200, p. 60.

D. oculatum n. sp., Pl. X:102, Fig. 4. No. 307, p. 60.

D. torosum? Playford 1981, Pl. XII:118, Fig. 4. No. 311, p. 60.

D. venosum n. sp., Pl. X:103, Fig. 4. No. 277, pp. 60—61.

D. sp. 1., Pl. X:104, Fig. 4. No. 292, p. 61.

D. sp. 2., Pl. XI:105, Fig. 4. No. 224, p. 61.

Genus *Dilatisphaera* Lister 1970

Dilatisphaera complicata n. sp., Pl. XI:106, Fig. 4. No. 141, p. 61.

D. nanofurcata n. sp., Pl. XI:107, Fig. 4. No. 36, pp. 61—62.

D. tubulifera n. sp., Pl. XI:108, Fig. 4. No. 46, p. 62.

Genus *Domasia* Downie 1960

Domasia spinosa n. sp., Pl. XI:109, Fig. 4. No. 293, p. 62.

Genus *Estiastra* Eisenack 1959

Estiastra sp., Pl. XI:110, Fig. 4. No. 300, p. 63.

Genus *Excultibrachium* Loeblich & Tappan 1978

Excultibrachium cf. *E. concinnum* Loeblich & Tappan 1978, Pl. XII:119a, b, Fig. 4. No. 148, p. 63.

Genus *Florisphaeridium* Lister 1970

Florisphaeridium abruptum n. sp., Pl. XI:111, Fig. 4. No. 159, pp. 63—64.

F. circulatum n. sp., Pl. XII:112, Fig. 4. No. 296, p. 64.

F. densum n. sp., Pl. XII:113, Fig. 4. No. 223, p. 64.

Genus *Goniosphaeridium* Eisenack 1969

Goniosphaeridium breviradiatum n. sp., Pl. XIII:129, Fig. 4. No. 202, pp. 64—65.

G. cantabricum (Cramer 1964) n. comb., Pl. XII:120, Fig. 4. No. 314, p. 65.

G. mochtiensis (Górka) Kjellström 1971, Pl. XII:121, Fig. 4. No. 90, p. 65.

G. oligospinosum Eisenack (1934) 1969, Pl. XII:122, Fig. 4. No. 313, p. 65.

G. parvispinosum n. sp., Pl. XIII:130, Fig. 4. No. 57, p. 66.

G. pellicidum (Timofeev) Tynni 1975, Pl. XII:123, Fig. 4. No. 87, p. 66.

G. polygonale Eisenack (1931) 1969, Pl. XII: 124, Fig. 4. No. 77, p. 66.

G. polygonale polyacanthum (Eisenack 1965), Pl. XII:125, Fig. 4. No. 8, pp. 66—67.

G. polygonale f. *rugosum* n. f., Pl. XIII: 131, Fig. 4. No. 289, p. 67.

G. splendens (Paris & Deunff) Turner 1984, Pl. XII:126, Fig. 4. No. 13, p. 67.

G. tenuispinosum n. sp., Pl. XIII:132, Fig. 4. No. 30, pp. 67—68.

Genus *Gorgonisphaeridium* Loeblich & Tappan 1978

Gorgonisphaeridium antiquum Loeblich & Tappan 1978, Pl. XII:127, Fig. 4. No. 52, p. 68.

G. spiralispinosum n. sp., Pl. XIII:133, Fig. 4. No. 95, p. 68.

G. sp., Pl. XIII:134, Fig. 4. No. 275, pp. 68—69.

Genus *Gyalorhethium* Loeblich & Tappan 1978

Gyalorhethium angustispinosum n. sp., Pl. XIII:135, Fig. 4. No. 184, p. 69.

G. sp., Pl. XIII:136, Fig. 4. No. 180, p. 69.

Genus *Hapsidopalla* Playford 1977

Hapsidopalla multifida n. sp., Pl. XIII:137, Fig. 4. No. 270, pp. 69—70.

Genus *Helosphaeridium* Lister 1970

Helosphaeridium varispinosum n. sp., Pl. XIV:138, Fig. 4. No. 171, p. 70.

Genus *Jœhvisphaera* n. gen., p. 70.

Jœhvisphaera capillata n. sp., Pl. XIV:139, Fig. 4. No. 207, p. 70.

Genus *Kundasphaera* Uutela 1989, emended, p. 71.

Kundasphaera lacunosa n. sp., Pl. XIV:140a, b, Fig. 4. No. 48, p. 71.

K. sp., Pl. XIV:141, Fig. 4. No. 139, p. 71.

Genus *Labyrinthosphaeridium* n. gen., pp. 71—72.

Labyrinthosphaeridium asperum n. sp., Pl. XIV:142, Fig. 4. No. 229, p. 72.

L. curvatum n. sp., Pl. XIV:143, Fig. 4. No. 217, p. 72.

L. cymoides n. sp., Pl. XIV:144, Fig. 4. No. 262, p. 72.

L. restrictum n. sp., Pl. XIV:145, Fig. 4. No. 230, pp. 72—73.

Genus *Lacunosphaeridium* n. gen., p. 73.

Lacunosphaeridium granosum n. sp., Pl. XV: 146a, b, Fig. 4. No. 284, p. 73.

L. spinosum n. sp., Pl. XV:147, Fig. 4. No. 197, p. 73.

Genus *Leiofusa* Eisenack 1938, restr. Eisenack 1965, emend. & restr. Combaz *et al.* 1967, Cramer 1970

Leiofusa brevispinosa n. sp., Pl. XV:148, Fig. 4. No. 274, p. 74.

L. granulacutis Loeblich 1970, Pl. XII:128, Fig. 4. No. 170, p. 74.

L. granulacutis f. *quincunx* Uutela 1989, Pl. XVII:161, Fig. 4. No. 298, p. 74.

L. iugosa n. sp., Pl. XV:149a, b, Fig. 4. No. 213, pp. 74—75.

L. obliquipunctata n. sp., Pl. XV:150, Fig. 4. No. 290, p. 75.

L. subcircularis n. sp., Pl. XV:151, Fig. 4. No. 116, p. 75.

Genus *Leiosphaeridia* Eisenack 1958, emend. Downie & Sarjeant 1963

Leiosphaeridia keilaensis n. sp., Pl. XV:152, Fig. 4. No. 193, pp. 75—76.

?L. sp., Pl. XVI:153, Fig. 4. No. 122, p. 76.

L. spp. Fig. 4. No. 14, p. 76.

Genus *Leiovalia* Eisenack 1965

Leiovalia similis Eisenack 1965, Pl. XVII:162, Fig. 4. No. 53, p. 76.

Genus *Liliosphaeridium* n. gen., pp. 76—77.

Liliosphaeridium kaljoi n. sp., Pl. XVI:154a, b, Fig. 4. No. 21, p. 77.

Genus *Lophosphaeridium* Timofeev 1959, emend. Lister 1970

Lophosphaeridium aculeatum n. sp., Pl. XVI: 155, Fig. 4. No. 164, p. 77.

L. aequicuspidatum Playford & Martin 1984, Pl. XVII:163, Fig. 4. No. 98, pp. 77—78.

L. citrinipeltatum Cramer & Díez 1972, Pl. XVII:164, Fig. 4. No. 15, p. 78.

L. deminutum Playford 1981, Pl. XVII:165, Fig. 4. No. 79, p. 78.

L. disparipelliculum Playford & Martin 1984, Pl. XVII:166, Fig. 4. No. 150, p. 78.

L. aff. *L. granulosum* (Staplin) Downie 1963, Pl. XVII:167, Fig. 4. No. 321, p. 78.

L. papillatum (Staplin) Downie 1963, Pl. XVII:168, Fig. 4. No. 43, p. 79.

L. pilosum Downie 1963, Pl. XVII:169, Fig. 4. No. 39, p. 79.

L. regulare n. sp., Pl. XVI:156, Fig. 4. No. 316, p. 79.

L. sp., Pl. XVI:157, Fig. 4. No. 251, p. 79.

Genus *Micrhystridium* Deflandre 1937, emend. Sarjeant 1967

Micrhystridium acerbum Martin 1968, Pl. XVII:170, Fig. 4. No. 117, p. 80.

M. acuminosum Cramer & Díez 1977, Pl. XVII:171, Fig. 4. No. 239, p. 80.

M. brevispinosum n. sp., Pl. XVI:158, Fig. 4. No. 9, p. 80.

M. curvatum n. sp., Pl. XVI:159, Fig. 4. No. 317, pp. 80—81.

M. digitatum n. sp., Pl. XVI:160, Fig. 4. No. 199, p. 81.

M. eatonensis Downie 1959, Pl. XVII:172, Fig. 4. No. 172, p. 81.

M. equispinosum Turner 1984, Pl. XVII:173, Fig. 4. No. 246, p. 81.

M. exiguum Rasul 1979, Pl. XVII:174, Fig. 4. No. 156, pp. 81—82.

M. fragile Deflandre 1947, Pl. XVII:175, Fig. 4. No. 113, p. 82.

M. granulatum n. sp., Pl. XVIII:177, Fig. 4. No. 118, p. 82.

M. henryi Paris & Deunff 1970, Pl. XVII:176, Fig. 4. No. 54, p. 82.

M. inconspicuum aremoricanum Paris & Deunff 1970, Pl. XIX:186, Fig. 4. No. 175, pp. 82—83.

M. lasnamaegiense n. sp., Pl. XVIII:178, Fig. 4. No. 124, p. 83.

M. minimum n. sp., Pl. XVIII:179, Fig. 4. No. 222, p. 83.

M. nannacanthum Deflandre 1945, Pl. XIX:187, Fig. 4. No. 16, p. 83.

M. nanodigitatum n. sp., Pl. XVIII:180, Fig. 4. No. 134, pp. 83—84.

M. aff. *M. parinconspicuum* Deflandre 1945, Pl. XIX:188, Fig. 4. No. 49, p. 84.

M. parvulum n. sp., Pl. XVIII:181, Fig. 4. No. 248, p. 84.

M. polygonale n. sp., Pl. XVIII:182, Fig. 4. No. 58, p. 84.

M. punctatum n. sp., Pl. XVIII:183, Fig. 4. No. 181, pp. 84—85.

M. shinetonensis Downie 1958, Pl. XIX:189, Fig. 4. No. 128, p. 85.

M. stellatum Deflandre 1945, Pl. XIX:190, Fig. 4. No. 80, p. 85.

M. stellatum f. *latispinosum* n. f., Pl. XVIII:184, Fig. 4. No. 155, p. 85.

M. stellatum salopiense Lister 1970, Pl. XIX:191, Fig. 4. No. 247, pp. 85—86.

M. taeniosum n. sp., Pl. XVIII:185, Fig. 4. No. 157, p. 86.

M. varipinnosum n. sp., Pl. XX:202, Fig. 4. No. 11, p. 86.

M. varispinosum n. sp., Pl. XX:203, Fig. 4. No. 194, pp. 86—87.

M. sp. 1., Pl. XX:204, Fig. 4. No. 240, p. 87.

M. sp. 2., Pl. XX:205, Fig. 4. No. 5, p. 87.

Genus *Multiplicisphaeridium* Staplin 1961, restr. Staplin *et al.* 1965, emend. Eisenack 1969

Multiplicisphaeridium actinospinosum n. sp., Pl. XX:206, Fig. 4. No. 119, pp. 87—88.

M. alloiteaui (Deunff 1955), Pl. XIX:192, Fig. 4. No. 44, p. 88.

M. bifurcatum Staplin *et al.* 1965, Pl. XIX:193, Fig. 4. No. 55, p. 88.

M. bipalmatum n. sp., Pl. XX:207, Fig. 4. No. 106, p. 88.

M. borracherosum (Cramer) Lister 1970, Pl. XIX:194, Fig. 4. No. 308, pp. 88—89.

M. borracherosum f. *regulare* n. f., Pl. XX:208, Fig. 4. No. 318, p. 89.

M. brevidigitatum n. sp., Pl. XX:209, Fig. 4. No. 253, p. 89.

M. cacteum n. sp., Pl. XX:210a, XXI:210b, Fig. 4. No. 25, pp. 89—90.

M. caperoradiolum (Loeblich 1970), Pl. XIX:195, Fig. 4. No. 206, p. 90.

M. cornigerum n. sp., Pl. XXI:211, Fig. 4. No. 294, p. 90.

M. cymoides n. sp., Pl. XXI:212, Fig. 4. No. 232, pp. 90—91.

M. digitatum Eisenack (1938) 1969, Pl. XIX:196, Fig. 4. No. 291, p. 91.

M. diversispinosum n. sp., Pl. XXI:213, Fig. 4. No. 163, p. 91.

M. ferum (Martin 1968), Pl. XIX:197, Fig. 4. No. 76, p. 91.

M. fisherii (Cramer 1968), Pl. XIX:198, Fig. 4. No. 205, p. 92.

M. fissile (Stockmans & Willière 1963) Pl. XIX:199, Fig. 4. No. 42, p. 92.

M. forquiferum (Cramer & Díez 1972), Pl. XIX:200, Fig. 4. No. 267, p. 92.

M. gotlandicum (Eisenack 1954), Pl. XIX:201, Fig. 4. No. 101, pp. 92—93.

M. irregulare Staplin, Jansonius & Pocock 1965, Pl. XXII:219, Fig. 4. No. 88, p. 93.

M. lichenoides n. sp., Pl. XXI:214, Fig. 4. No. 195, p. 93.

M. martae Cramer & Díez 1972, Pl. XXII:220, Fig. 4. No. 56, p. 93.

M. micropunctatum n. sp., Pl. XXI:215, Fig. 4. No. 255, pp. 93—94.

M. aff. *M. multipugiunculatum* Cramer & Díez 1977, Pl. XXII:221, Fig. 4. No. 135, p. 94.

M. opimum n. sp., Pl. XXI:216, Fig. 4. No. 209, p. 94.

M. aff. *M. palmitella* (Cramer & Díez 1972), Pl. XXII:222, Fig. 4. No. 161, p. 94.

M. parvipinnatum n. sp., Pl. XXI:217, Fig. 4. No. 96, p. 95.

M. parvirochesterensis (Cramer & Díez 1972), Pl. XXII:223, Fig. 4. No. 131, p. 95.

M. parvispinosum n. sp., Pl. XXI:218, Fig. 4. No. 104, p. 95.

M. radicosum Loeblich 1970, Pl. XXII:224, Fig. 4. No. 256, pp. 95—96.

M. aff. *M. ramusculosum macrocladum* (Deunff 1955), Pl. XXII:225, Fig. 4. No. 147, p. 96.

M. raplaense n. sp., Pl. XXIII:235, Fig. 4. No. 84, p. 96.

M. raspa (Cramer 1964), Pl. XXII:226, Fig. 4. No. 86, p. 97.

M. remotum f. *raplaense* n. f., Pl. XXIII:236, Fig. 4. No. 201, p. 97.

M. spinosum n. sp., Pl. XXIII:237, Fig. 4. No. 62, p. 97.

M. striatum n. sp., Pl. XXIII:238, Fig. 4. No. 260, pp. 97—98.

M. aff. *M. subbifurcatum* (Stockmans & Willière 1963), Pl. XXII:227, Fig. 4. No. 145, p. 98.

M. toyetaforme n. sp., Pl. XXIII:239, Fig. 4. No. 254, p. 98.

M. turgidum n. sp., Pl. XXIII:240, Fig. 4. No. 168, p. 98.

M. verrucosum n. sp., Pl. XXIII:241, Fig. 4. No. 264, pp. 98—99.

M. sp., Pl. XXIII:242, Fig. 4. No. 136, p. 99.

Genus *Nanocyclopia* Loeblich & Wicander 1976

?Nanocyclopia sp., Pl. XXIII:243, Fig. 4. No. 40, p. 99.

Genus *Ordovicidium* Tappan & Loeblich 1971

Ordovicidium aequifurcatum (Kjellström) Loeblich & Tappan 1978, Pl. XXII:228, Fig. 4. No. 243, p. 100.

O. elegantulum Tappan & Loeblich 1971, Pl. XXII:229, Fig. 4. No. 178, p. 100.

O. groetlingboensis (Kjellström) Loeblich & Tappan 1978, Pl. XXII:230, Fig. 4. No. 149, p. 100.

O. groetlingboensis f. *clavatum* n. f., Pl. XXVI:275, Fig. 4. No. 176, pp. 100—101.

O. heteromorphicum (Kjellström) Loeblich & Tappan 1978, Pl. XXII:231, Fig. 4. No. 126, p. 101.

O. nanofurcatum (Kjellström 1971) n. comb., Pl. XXII:232, Fig. 4. No. 182, p. 101.

O. nudum (Eisenack) Loeblich & Tappan 1978, Pl. XXIV:233, Fig. 4. No. 130, p. 101.

O. paucifurcatum (Eisenack 1959) n. comb., Pl. XXIV:234, Fig. 4. No. 196, pp. 101—102.

Genus *Orthosphaeridium* Eisenack 1968, emend. Kjellström 1971

Orthosphaeridium bispinosum Turner 1984, Pl. XXIV:244, Fig. 4. No. 261, p. 102.

O. chondrododora Loeblich & Tappan 1971, Pl. XXIV:245, Fig. 4. No. 303, p. 102.

O. densiverrucosum Kjellström 1971, Pl. XXIV:246, Fig. 4. No. 102, p. 102.

O. insculptum Loeblich 1970, Pl. XXIV:247, Fig. 4. No. 112, pp. 102—103.

O. insculptum f. *erectum* n. f., Pl. XXVI:276, Fig. 4. No. 140, p. 103.

O. latispinosum n. sp., Pl. XXVI:277, Fig. 4. No. 183, p. 103.

O. rectangulare Eisenack (1963) 1968, Pl. XXIV:248, Fig. 4. No. 312, p. 103.

O. vibrissiferum Loeblich & Tappan 1971, Pl. XXIV:249, Fig. 4. No. 110, p. 104.

O. sp., Pl. XXVI:278, Fig. 4. No. 208, p. 104.

Genus *Peteinosphaeridium* Staplin, Jansonius & Pocock 1965, emend. Eisenack 1969

Peteinosphaeridium granulatum n. sp., Pl. XXVI:279, Fig. 4. No. 174, p. 104.

P. hymenoferum Eisenack (1938) 1969, Pl. XXIV:250, Fig. 4. No. 22, pp. 104—105.

P. macropylum Eisenack (1959) 1969, Pl. XXIV:251, Fig. 4. No. 24, p. 105.

P. micranthum (Eisenack 1959), Pl. XXIV: 252, Fig. 4. No. 26, p. 105.

P. trifurcatum Eisenack (1931) 1969, Pl. XXIV:253, Fig. 4. No. 173, p. 105.

P. trifurcatum longiradiatum (Eisenack 1959), Pl. XXIV:254, Fig. 4. No. 192, pp. 105—106.

P. velatum Kjellström 1971, Pl. XXIV:255, Fig. 4. No. 19, p. 106.

Genus *Pheoclosterium* Tappan & Loeblich 1971

Pheoclosterium clavatum n. sp., Pl. XXVI: 280, Fig. 4. No. 89, p. 106.

Genus *Polyancistrodorus* Loeblich & Tappan 1969

Polyancistrodorus bryoides n. sp., Pl. XXVI: 281a, b, Fig. 4. No. 121, pp. 106—107.

P. columbariferus Loeblich & Tappan 1969, Pl. XXIV:256, Fig. 4. No. 186, p. 107.

P. aff. *P. intricatus* Colbath 1979, Pl. XXIV: 257, Fig. 4. No. 94, p. 107.

P. magnispinosus n. sp., Pl. XXVI:282a, XXVII:282b, Fig. 4. No. 97, p. 107.

P. palmatus n. sp., Pl. XXVII:283, Fig. 4. No. 282, pp. 107—108.

P. phylloides n. sp., Pl. XXVII:284, Fig. 4. No. 99, p. 108.

Genus *Polyedryxium* Deunff 1954, emend. Deunff 1971

Polyedryxium sp., Pl. XXVII:285, Fig. 4. No. 304, p. 108.

Genus *Polygonium* Vavrdová 1966

Polygonium delicatum Rasul 1979, Pl. XXIV: 258, Fig. 4. No. 70, p. 108.

Genus *Priscogalea* Deunff 1961

Priscogalea parva n. sp., Pl. XXVII:286, Fig. 4. No. 245, p. 109.

P. perforata Uutela 1989, emended, Pl. XXVII: 287, Fig. 4. No. 68, p. 109.

Genus *Pterospermopsis* W. Wetzel 1952

Pterospermopsis tranvikensis (Tynni 1982) n. comb., Pl. XXIV:259a, XXV:259b, Fig. 4. No. 120, pp. 109—110.

P. sp., Pl. XXVII:288, Fig. 4. No. 185, p. 110.

Genus *Pulvinosphaeridium* Eisenack 1954, restr. Deunff 1954

Pulvinosphaeridium granulatum n. sp., Pl. XXVII:289, Fig. 4. No. 301, p. 110.

Genus *Raplasphaera* n. gen., pp. 110—111.

Raplasphaera consuta n. sp., Pl. XXVII:290, Fig. 4. No. 244, p. 111.

R. undosa n. sp., Pl. XXVIII:291a, b, Fig. 4. No. 153, p. 111.

Genus *Revinotesta* Vanguestaine 1974

Revinotesta granulosa n. sp., Pl. XXVIII:292, Fig. 4. No. 278, pp. 111—112.

R. parva n. sp., Pl. XXVIII:293, Fig. 4. No. 41, p. 112.

Genus *Rhopaliophora* Tappan & Loeblich 1971

Rhopaliophora foliatilis Tappan & Loeblich 1971, Pl. XXV:260, Fig. 4. No. 285, p. 112.

R. palmata (Combaz & Peniguel) Playford & Martin 1984, Pl. XXV:261, Fig. 4. No. 108, pp. 112—113.

R. pilata (Combaz & Peniguel) Playford & Martin 1984, Pl. XXV:262, Fig. 4. No. 93, p. 113.

R. reticulata n. sp., Pl. XXVIII:294, Fig. 4. No. 286, p. 113.

Genus *Saharidia* Combaz 1967

Saharidia fragile (Downie) Combaz 1967, Pl. XXV:263, Fig. 4. No. 226, p. 113.

Genus *Schismatosphaeridium* Staplin, Jansonius & Pocock 1965

Schismatosphaeridium granosum n. sp., Pl. XXVIII:295, Fig. 4. No. 306, p. 114.

Genus *Solisphaeridium* Staplin, Jansonius & Pocock 1965

Solisphaeridium inaffectum Playford 1981, Pl. XXV:264, Fig. 4. No. 85, p. 114.

S. nanum (Deflandre) Turner 1984, Pl. XXV: 265, Fig. 4. No. 60, p. 114.

Genus *Stellechinatum* Turner 1984

Stellechinatum helosum Turner 1984, Pl. XXV:266, Fig. 4. No. 51, p. 115.

Genus *Stelliferidium* Deunff, Górka & Rauscher 1974

Stelliferidium aff. *S. modestum* (Górka) Deunff, Górka & Rauscher 1974, Pl. XXV:267, Fig. 4. No. 59, p. 115.

Genus *Taeniosphaeridium* n. gen., p. 115.

Taeniosphaeridium parvum n. sp., Pl. XXVIII: 296, Fig. 4. No. 137, pp. 115—116.

Genus *Tasmanites* Newton 1875

Tasmanites martinssoni Eisenack 1958, Pl. XXV:268, Fig. 4. No. 154, p. 116.

T. cf. *T. minutus* Eisenack 1965, Pl. XXV: 269, Fig. 4. No. 177, p. 116.

T. cf. *T. verrucosus* Eisenack 1962, Pl. XXV: 270, Fig. 4. No. 188, p. 116.

Genus *Timofeevia* Vanguestaine 1978

Timofeevia enodis n. sp., Pl. XXVIII:297, Fig. 4. No. 160, pp. 116—117.

T. nodosa n. sp., Pl. XXVIII:298, Fig. 4. No. 123, p. 117.

Genus *Tranvikium* Tynni 1982

Tranvikium polygonale Tynni 1982, Pl. XXV: 271, Fig. 4. No. 63, p. 117.

Genus *Tunisphaeridium* Deunff & Evitt 1968

Tunisphaeridium brevispinosum n. sp., Pl. XXIX:299, Fig. 4. No. 242, pp. 117—118.

T. spinosissimum n. sp., Pl. XXIX:300, Fig. 4. No. 266, p. 118.

T. sp., Pl. XXIX:301, Fig. 4. No. 271, p. 118.

Genus *Tylotopalla* Loeblich 1970

Tylotopalla sp., Pl. XXIX:302, Fig. 4. No. 252, p. 118.

Genus *Veryhachium* Deunff 1954

Veryhachium asymmetrospinosum n. sp., Pl. XXIX:303, Fig. 4. No. 231, p. 119.

V. brevitrispinum Staplin 1961, Pl. XXV:272 Fig. 4. No. 125, p. 119.

V. cymosum Wicander & Loeblich 1977, Pl. XXV:273, Fig. 4. No. 151, p. 119.

V. aff. *V. cymosum* Wicander & Loeblich 1977, Pl. XXV:274, Pl. XXX:308, Fig. 4. No. 138, pp. 119—120.

V. europaeum Stockmans & Willière 1960, Pl. XXX:309, Fig. 4. No. 287, p. 120.

V. geometricum (Deflandre) Deunff 1954, Pl. XXX:310, Fig. 4. No. 142, p. 120.

V. irroratum Loeblich & Tappan 1969, Pl. XXX:311 Fig. 4. No. 198, p. 120.

V. lairdi Deunff 1958, Pl. XXX:312, Fig. 4. No. 73, p. 121.

V. longispinosum Jardiné *et al.* 1974, Pl. XXX:313, Fig. 4. No. 218, p. 121.

V. oklahomense Loeblich 1970, Pl. XXX:314, Fig. 4. No. 74, p. 121.

V. oligospinoides n. sp., Pl. XXIX:304, Fig. 4. No. 227, pp. 121—122.

V. punctatum n. sp., Pl. XXIX:305, Fig. 4. No. 216, p. 122.

V. reductum Deunff 1958, Pl. XXX:315, Fig. 4. No. 166, p. 122.

V. rhombispinosum Tynni 1982, Pl. XXX:316, Fig. 4. No. 10, p. 122.

V. rhomboidium Downie 1959, Pl. XXX:317, Fig. 4. No. 322, pp. 122—123.

V. trapezionarion Loeblich 1970, Pl. XXX: 318, Fig. 4. No. 191, p. 123.

V. trispinosum (Eisenack) Deunff 1954, Pl. XXX:319, Fig. 4. No. 83, p. 123.

V. trispinosum granulatum Tynni 1982, emend., Pl. XXX:320a, b, Fig. 4. No. 103, p. 123.

V. trisulcum (Deunff 1958), Pl. XXX:321, Fig. 4. No. 167, pp. 123—124.

Genus *Villosacapsula* Loeblich & Tappan 1972

Villosacapsula decorata n. sp., Pl. XXIX:306, Fig. 4. No. 288, p. 124.

Genus *Vulcanisphaera* Deunff 1961

Vulcanisphaera minor n. sp., Pl. XXIX:307, Fig. 4. No. 82, p. 124.

Genus *Winwaloeusia* Deunff 1977

Winwaloeusia distrata (Deunff 1966), Pl. XXX:322, Fig. 4. No. 279, pp. 124—125.

REMARKS ON ACRITARCH FREQUENCIES

The Rapla material contains a total of 71 acritarch genera, of which 10 are proposed new genera: *Acrosphaeridium, Arcosphaeridium, Coronitesta, Cycloposphaeridium, Jœhvisphaera, Labyrinthosphaeridium, Lacunosphaeridium, Liliosphaeridium, Raplasphaera* and *Taeniosphaeridium*. The generally well preserved, abundant flora comprises 322 species, of which 134 are proposed as new species and six as new formas. The chief problem entailed in the description of new species was that the individual was often so small that its morphological features could not be distinguished other than by electron microscopy, which meant that its frequency was probably underestimated due to misinterpretation, overlapping etc. Some of the new species were represented by only a single individual discovered by either light or electron microscopy but not both, so that the diagnosis cannot be complete. They nevertheless differ sufficiently markedly in their morphology from any species established earlier that they cannot be combined with them in any way, not even bearing in mind the environmentally different rocks in which they were found. These problems were particularly pronounced when considering the proposed new genera. The representatives of the one or more smooth, spherical species of varying size making up the genus *Leiosphaeridium* were treated collectively on account of the insignificance of their stratigraphical position.

Further research in Estonia and elsewhere in the Baltic region is called for in order to determine the real range of the occurrence of each species before it will be possible to present a zonation of the Baltic in terms of acritarchs or compare the species occurring in different confacies. The present ranges of the species and their incidences at various depths in the Rapla core are presented in Fig. 4. Since the core contains 100 discontinuities, it is impossible to estimate the proportion of redeposited species on the basis of this borehole alone.

It is impossible to establish floristic zones with any degree of certainty by reference to the Rapla core alone without carrying out any comparative studies. The number of species attributable to the Volhov Regional Stage of the Lower Ordovician is low (partly because of dolomitization). Common species during this stage are the sphaeromorphs and members of the genus *Baltisphaeridium* among the acanthomorphs. *Liliosphaeridium kaljoi* n. gen., n. sp. and *Peteinosphaeridium hymenoferum* are found only at the Volhov — Kunda transition, the Lower Ordovician.

The Kunda Regional Stage is dominated by the small acanthomorphs, while the larger species are less numerous, with the exception of *Baltisphaeridium hirsutoides*. The sphaeromorphs are also common. *Tranvikium polygonale* occurs only at the Kunda — Aseri transition. The flora of the Aseri Regional Stage greatly resembled that of the Kunda.

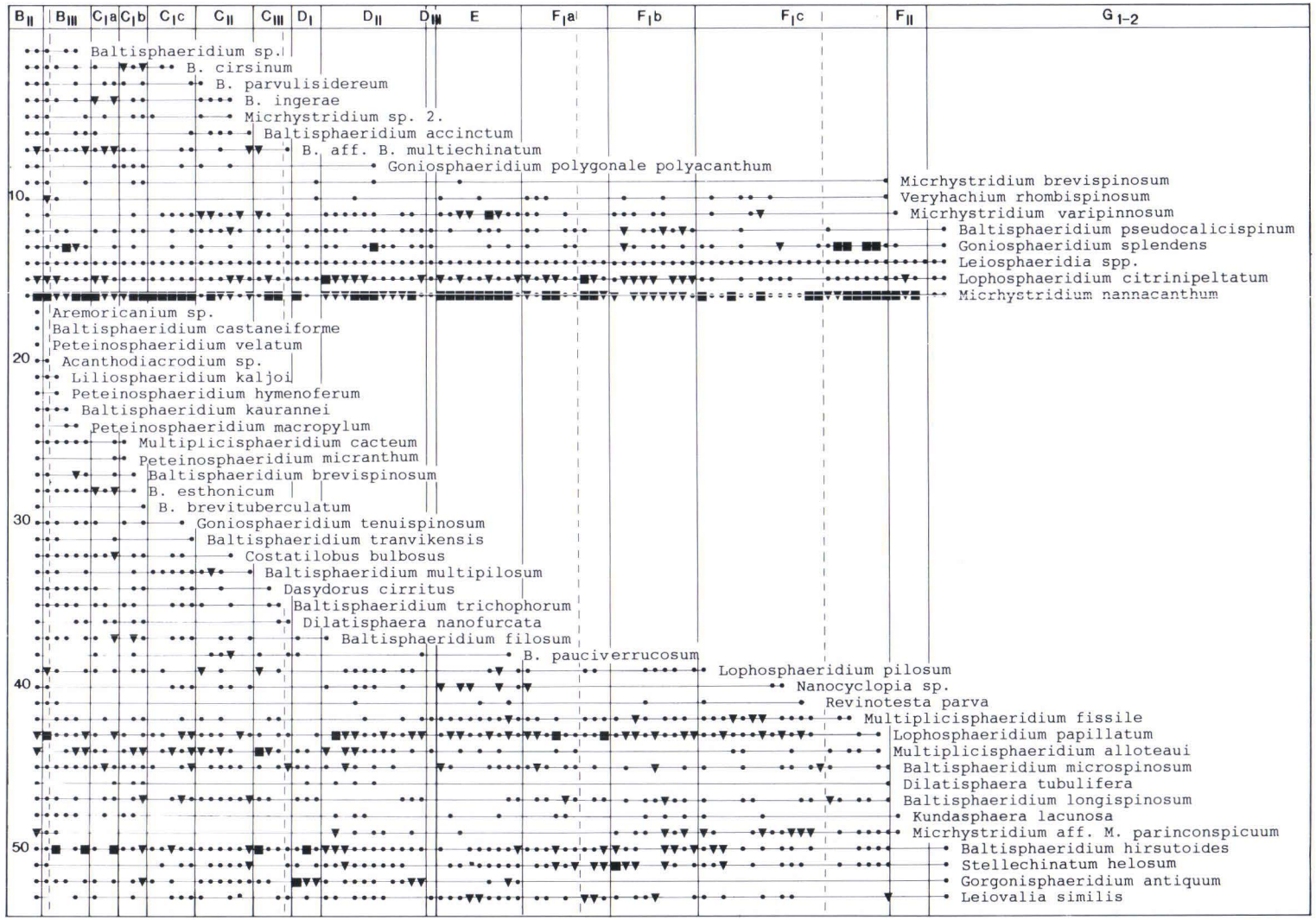

Fig. 4. Frequency of acritarchs in the Rapla borehole.

Fig. 4. Frequency of acritarchs in the Rapla borehole. (cont.)

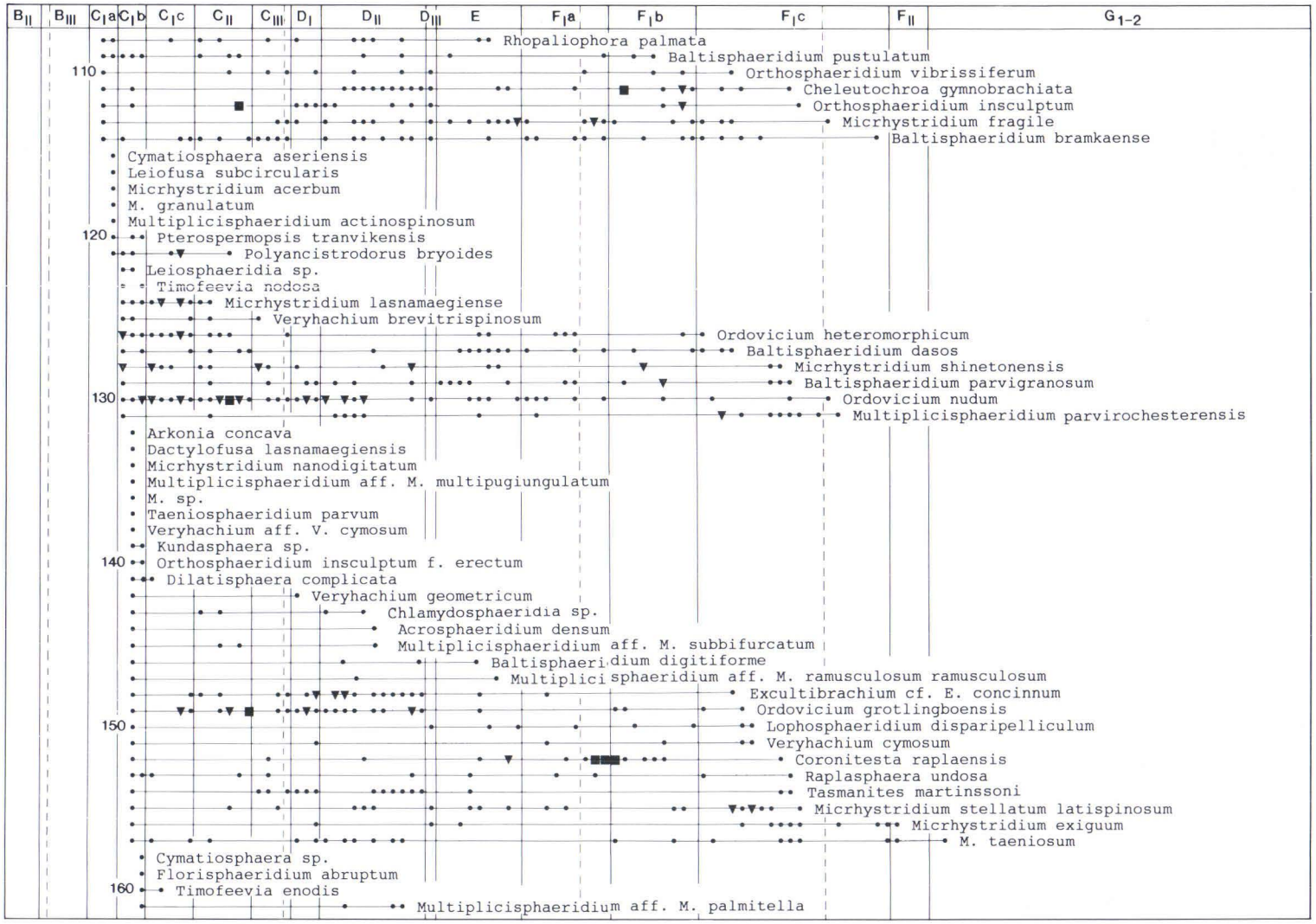

Fig. 4. Frequency of acritarchs in the Rapla borehole. (cont.)

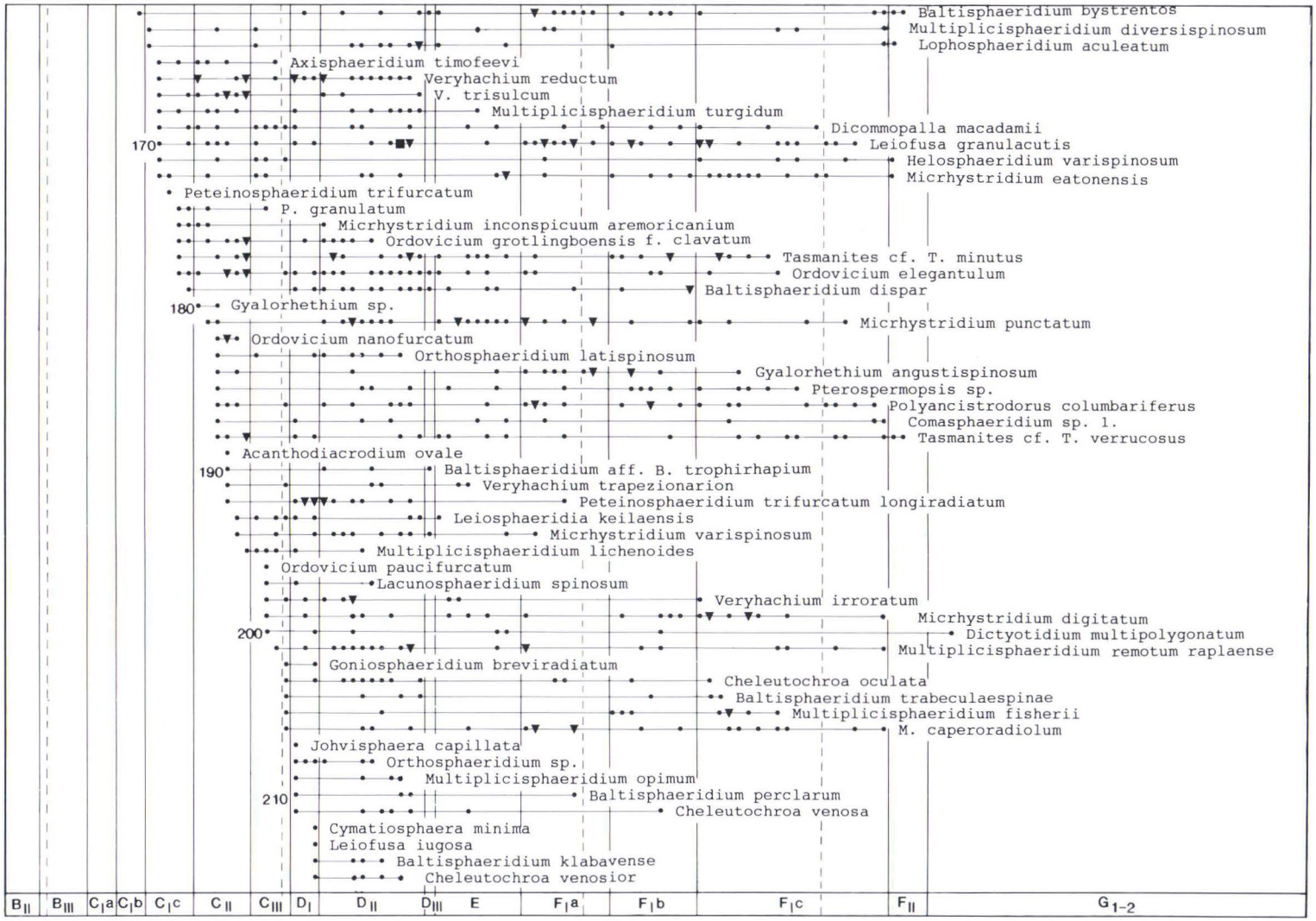

Fig. 4. Frequency of acritarchs in the Rapla borehole. (cont.)

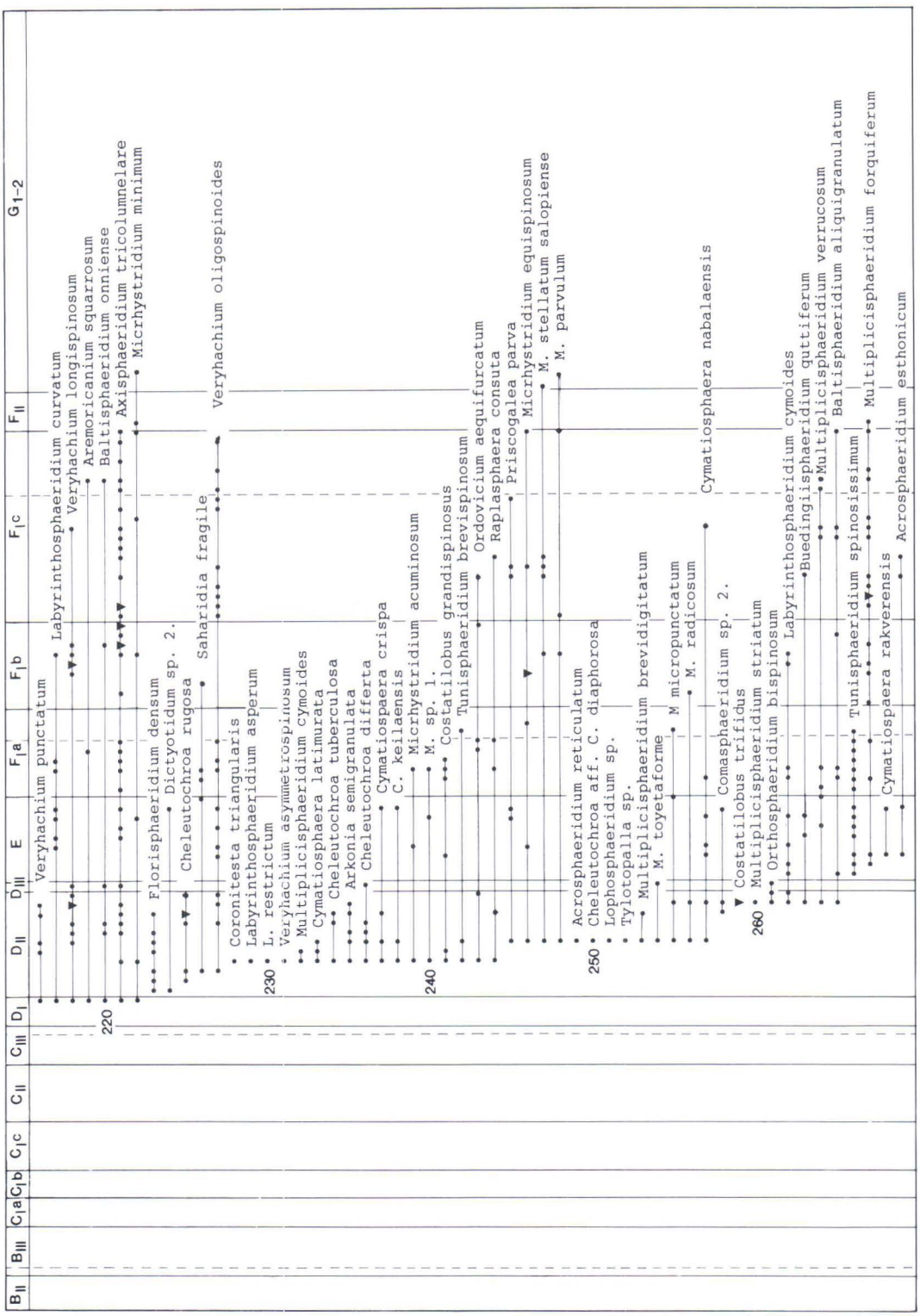

Fig. 4. Frequency of acritarchs in the Rapla borehole. (cont.)

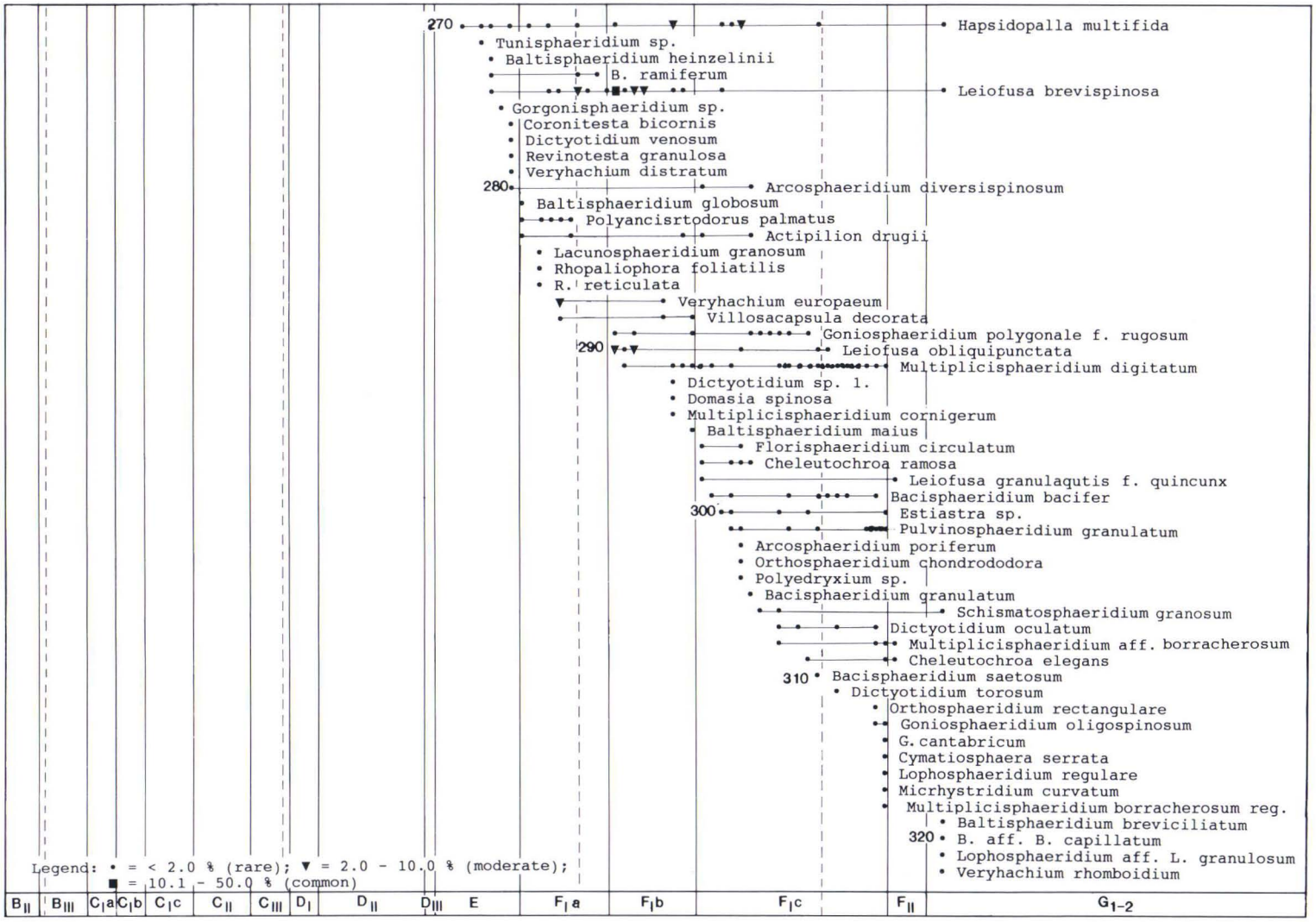

Fig. 4. Frequency of acritarchs in the Rapla borehole. (cont.)

The number of species is somewhat greater during the Lasnamägi Regional Stage, with the small acanthomorphs still common, large numbers of specimens of the genera *Baltisphaeridium, Ordovicidium* and *Veryhachium* are found, but representing only a limited range of species. *Dilatisphaera complicata* n. sp. is encountered only at the Lasnamägi — Uhaku transition. The species typical of the Uhaku Regional Stage are the same as the above, but their numbers are considerably reduced. The large acanthomorphs are moderate or common during the Kukruse, particularly *Baltisphaeridium hirsutoides, Ordovicidium groetlingboensis* and *O. nudum*. These are then displaced by the small acanthomorphs during the Idavere Regional Stage, this situation then continuing into the Jõhvi.

The number of species present increases markedly in the Keila, although none can be said to be dominant. Prominent genera are *Cheleutochroa, Labyrinthosphaeridium* n. gen., *Ordovicidium, Orthosphaeridium, Tasmanites* and *Veryhachium*. A reduction in the number of the species is then seen once more in the Oandu Regional Stage.

The small acanthomorphs that are dominant during the Rakvere, the genera *Micrhystridium* and *Multiplicisphaeridium* being common. *Baltisphaeridium* and *Ordovicidium* are rare among the genera of large acanthomorphs. The Nabala Regional Stage is of much the same character as its predecessor, but the herkomorphs *Goniosphaeridium* and *Multiplicisphaeridium* become common in the Vormsi Regional Stage. Of the acanthomorphs, *Baltisphaeridium* is fairly common, but *Ordovicidium* and *Orthosphaeridium* are rare. The Pirgu differs from the above in that the species range contracts and the genus *Goniosphaeridium* become rare.

The variety of species is restricted still further in the Porkuni Regional Stage, due at least in part to dolomitization, but the Juuru no longer differs from the Porkuni to any substantial degree.

Considering the whole species list, 41% of the species occur between the Volhov and Jõhvi regional stages inclusive, whereas only 19.6% are found in the Rakvere Regional Stage or thereafter.

Comparison of the rich, well preserved Rapla flora with results from other parts of the world shows this otherwise typical Baltic flora to stand out from earlier reports from the same area by virtue of its rich variety of species, even though the specimens as such are smaller in size. Few similarities are demonstrated with species lists from other parts of Europe, with the exception of Britain, where about 10% of its already established species were found, the still relatively small percentage being attributable to the fact that there were studied only the Caradocian.

About 20% of the previously identified species were common to the Rapla core and deposits in the U.S.A. or Canada, and some even occurred during the same time interval, but the majority were present at Rapla earlier than in America, partly due to the poverty of research into Lower and Middle Ordovician on the American continent.

Reports regarding Palaeozoic acritarch in Africa, Australia, Asia and South America offer few similarities with the Rapla flora.

COMPARISON OF THE ACRITARCHS

The Rapla core in Estonia represents one of the best preserved and most complete section in the world which covers the whole of the Ordovician. Microfossils are preserved well in aphanit-

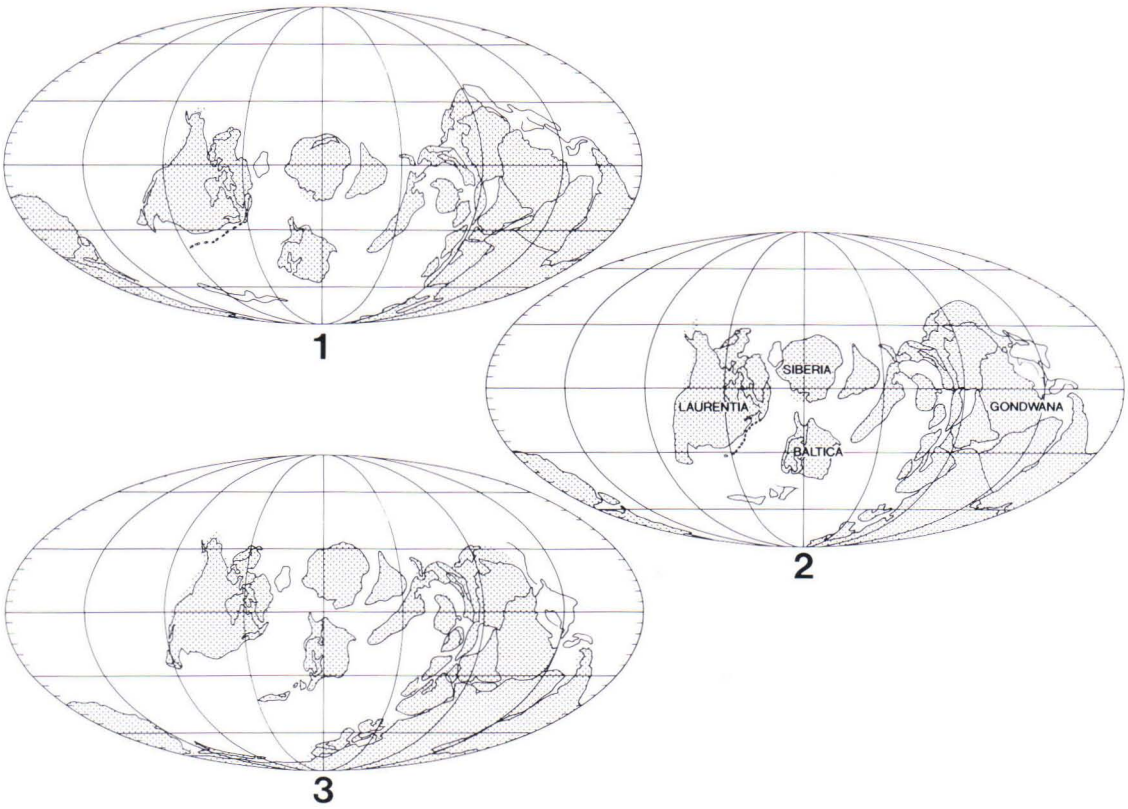

Fig. 5. Position of the continents during the Early (1), Middle (2) and Late (3) Ordovician (Scotese & McKerrow 1990).

ic limestones or marls, and the low incidence of tectonic movements has spared the present specimens from overdue fragmentation. The Palaeozoic sediments of northern Estonia were accumulated in an epicontinental marine shore zone (Männil 1966, Nestor & Einasto 1977).

Comparison with earlier research is possible in a geographical sense only to a limited degree, as no deposits containing such large numbers of microfossils in such a good state of preservation are to be found elsewhere, in addition to which methodological differences can lead to discrepancies in the results obtained from such investigations. Sample size is a significant factor when studying an exposure which is susceptible to weathering, as the samples should be some 10 — 15 times larger. It should also be remembered that microscopes have developed enormously since the time when Eisenack began his work, and the use of electron microscopy is absolutely essential for modern microfossil research. Similarly, major advances have been made in acritarch research and the instruments required for it, so that critical evaluation of the early work done in this field does not by any means do justice to its achievements.

The positions of the continents during Ordovician, as depicted in Fig. 5, would appear to explain some of the similarities and differences in the species lists presented.

The Baltic and Scandinavia

Genera typical of the acritarchs of the Baltic region are *Baltisphaeridium, Goniosphaeridium, Ordovicidium, Orthosphaeridium* and *Peteinosphaeridium*. Differences occur between individual species in the timing of their occurrence. Thus *Goniosphaeridium polygonale, Peteinosphaeridium macropylum, P. trifurcatum longispinosum, Tasmanites martinssoni* and *T. verrucosus* are found over a longer interval at Rapla than elsewhere in the Baltic, *Bacisphaeridium bacifer, Baltisphaeridium latiradiatum* and *B. multipilosum* over a shorter interval and *Goniosphaeridium oligospinosum* somewhat earlier. One salient feature by comparison with earlier findings in Estonia (Eisenack 1965a, 1970, Bockelie & Kjellström 1979), Gotland (Kjellström 1971a,b, Cramer *et al.* 1979, Górka 1987), Öland (Kjellström 1972, Eisenack 1976) and Västergötland (Kjellström 1976) in Sweden, Åland in Finland (Tynni 1982) and Poland (Górka 1969, 1979, 1980) is the exceptionally wide range of species identified at Rapla, about half of which are small in size, less than 20 µm in diameter. This may well be due partly to the preparation techniques and equipment used and partly to the environmental conditions, since oxidizing conditions are apt to destroy microfossils possessing an organic shell, and the Rapla deposit contained remarkably few such reddish horizons whereas they are more common in Sweden and Finland.

Other parts of Europe

The microfossils in Palaeozoic deposits in Europe are in general poorly preserved, fragmented and in some cases charred, so that it is difficult to identify them and to distinguish their surface patterning. This has particularly proved to be the case in Belgium (Martin 1966a,b, 1968, Stockmans & Willière 1967) and Spain (Cramer 1964), for instance, whereas the Tremadocian and Caradocian deposits in Shropshire, England (Rasul 1979, Turner 1984), constitute an exception to this rule.

Few similarities with the Tremadocian portion of the Shropshire deposit exist, as the Rapla core does not contain any material of that age, but the Caradocian portion does feature the genera *Baltisphaeridium (/Baltisphaerosum), Goniosphaeridium (/Stellechinatum), Orthosphaeridium* and *Peteinosphaeridium (/Ordovicidium),* although represented by far fewer species. Likewise the genera *Lophosphaeridium, Micrhystridium* and *Multiplicisphaeridium,* which are typical of the Rapla core but are generally absent from other sites in the Baltic and Scandinavia, have been documented in Shropshire.

Africa

Little research of this kind has been done in Africa, the only reports to date concerning sites in Algeria (Jardiné *et al.* 1974), Libya (Deunff & Massa 1975), Morocco (Cramer *et al.* 1974, Cramer & Díez 1977, Deunff 1977) and Tunisia (Deunff 1966), and there are very few species reported which were also found at Rapla. This is chiefly due to the fact that Jardiné *et al.* (1974) studied Silurian and Devonian acritarchs and Cramer *et al.* (1974) and Cramer & Díez (1977) Arenigian deposits from the upper part of the Lower Ordovician, strata which are either poor in species or lacking altogether in the Rapla core. The species list of Deunff (1977) contains only one species in common with Rapla, *Baltisphaeridium klabavense.*

The U.S.A. and Canada

The microfossils in the Middle and Upper Ordovician deposits of Oklahoma and the Indiana-Ohio-Kentucky region and the Middle Silurian deposit of New York are well preserved and have been investigated thoroughly (Loeblich 1970a, Loeblich & Tappan 1969, 1971, 1978, Tappan & Loeblich 1971, Jacobson 1978, Colbath 1979, 1980), as also have those in Canada (Martin 1980, 1983, Legault 1982, Jacobson & Achab 1985).

Excluding the new species proposed here, about 20% of the Rapla species may be said to be common to both the Baltic — Scandinavia region and the U.S.A. — Canada region. Some of these existed at the same period in both (e.g. *Aremoricanium squarrosum, Baltisphaeridium trophirhapium, Orthosphaeridium chondrododora, O. insculptum),* while others (i.e. *Actipilion druggii, Baltisphaeridium bystrentos, B. parvigranosum, B. trabeculaespinae, Dicommopalla macadami, Gorgonisphaeridium antiquum, Leiovalia similis, Lophosphaeridium disparipelliculum, L. granulosum, Multiplicisphaeridium bifurcatum, Ordovicidium elegantulum, O. groetlingboensis, Orthosphaeridium rectangulare, O. vibrissiferum, Polyancistrodorus columbariferus, P. intricatus, Veryhachium irroratum* and *V. oklahomense,* are longer-lived in the Baltic. The majority of the common species occur earlier in the Baltic than on the American continent (e.g. *Akomachra ovula, Baltisphaeridium accinctum, B. aliquigranulum, B. annelieae, B. dasos, B. ingerae, B. klabavense, B. oligopsakium, B. parvulisidereum, B. perclarum, Cheleutochroa gymnobrachiata, Excultibrachium concinnum, Leiofusa granulacutis, Multiplicisphaeridium alloiteaui, M. caperoradiolum, M. fisherii, M. fissile, M. forquiferum, M. gotlandicum, M. palmitella, M. parvirochesterensis, M. radicosum, M. ramusculosum microcladum, Solisphaeridium nanum, Veryhachium brevitrispinum, V. cymosum* and *V. trapezionarion).* One reason for these discrepancies may lie in the fact that little work has been done on Lower and Middle Ordovician acritarchs in America.

Australia

The acritarch species of the Ordovician in Australia differ markedly from those found in the Baltic, the only species in common to both regions being *Dasydorus cirritus, Rhopaliophora palmata* and *R. pilata,* all of which appear at an earlier point in time in Australia, *Lophosphaeridium disparipelliculum,* which continues for longer in the Baltic, and *Dictyotidium torosum* and *Solisphaeridium inaffectum,* which are Devonian in Australia (Combaz & Peniguel 1972, Playford & Martin 1984, Playford & Dring 1981).

South America

Only a few microfossil investigations have been carried out in South America, and the species obtained to date differ almost entirely from the Baltic ones, the only species occurring in common being *Veryhachium trapezionarion,* which is Middle Ordovician in the Baltic and Silurian in Argentina (Pöthe de Baldis 1975).

Asia

Martin and Yin (1988) list Ordovician acritarchs identified in the province of Jin in southern China, but only *Rhopaliophora palmata* and *R. pilata* are also found in Estonia, where they are Middle Ordovician, being Lower Ordovician in China.

DESCRIPTION OF THE ACRITARCHS

Genus *Acanthodiacrodium* Timofeev 1958

***Acanthodiacrodium ovale* n. sp.**

Pl. I:1 (Fig. 4. No. 189)

Diagnosis: The oval vesicle has 18 thin, flagelliform processes with acuminate distal terminations which do not communicate with the interior of the vesicle. There is a narrow zone in the centre of the vesicle, probably of secondary origin, which has no processes. The surface of the vesicle is shagrinate and the processes psilate.

Dimensions: length of vesicle 108 µm, width of vesicle 55 µm, length of process 26 — 39 µm, number of processes 18. Specimens measured: 1.

Holotype: GSF Prep. 1106 (SEM); Pl. I:1. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 161.0 m, Kukruse Regional Stage, Middle Ordovician. Rare.

Etymology: *ovale* from the Latin *ovum*, 'egg', + *-ale*, suffix meaning 'having the nature or quality of'.

Comparison: Resembles *Acanthodiacrodium angustizonale* Burmann 1968, which also has a narrow central zone without processes, but has more processes and is considerably smaller in size (length 29 µm, width 25 µm).

***Acanthodiacrodium* sp.**

Pl. I:2 (Fig. 4. No. 20)

Description: The ends of the oval vesicle feature simple conical processes with acuminate distal terminations which probably communicate with the vesicle interior. Processes are absent from approx. the middle third of the vesicle. The processes are shorter than the width of the vesicle. The surfaces of the vesicle and processes are microgranulate.

Dimensions: length of vesicle 28 — 30 µm, width of vesicle 15 — 16 µm, length of process 10 -12 µm, number of processes 25 — 30. Specimens measured: 2.

Occurrence: Rapla borehole, depths 189.0 — 188.6 m, Volhov Regional Stage to Kunda Regional Stage, Sillaoru Formation, Lower Ordovician. Rare.

Comparison: *Vavrdovella areniga* (Vavrdová) Loeblich & Tappan 1976 (*In* Colbath 1979, pl. 12:1) is similar in shape, although it does not correspond to the description of Vavrdová (1973 p. 288, *Tetradinium arenigum). Actinotodissus crassus* Loeblich & Tappan 1978 has a psilate surface and longitudinal striae in the central area of the vesicle. It also has longer and more flagelliform processes with whip-like distal terminations. *Acanthodiacrodium tasselii* Martin 1968 has echinate processes. *A. petrovi* Timofeev 1958 is larger. *A. evexum* Rasul 1979 is broader, as also is *A. formosum* Górka 1967.

Genus *Acrosphaeridium* n. gen.

Type species: *Acrosphaeridium esthonicum* n. sp., designated here.

Other new species of the genus: *A. reticulatum* and *A. densum*

Diagnosis: The vesicle is spherical, with numerous simple processes of variable length and thickness within the same individual. The surfaces of the vesicle and processes are tubercular throughout. It is uncertain whether the processes communicate with the vesicle interior. The vesicle is less than 20 µm in diameter.

Etymology: *Acrosphaeridium* from the Greek *akros,* 'top, first, highest', + Latin *sphaera* (Gr. *sphaira),* 'ball', + Latin *-idium,* diminutive.

Comparison: This new genus is equally as small as *Micrhystridium* Deflandre 1937, but differs from it in having a tubercular surface texture. The Cretaceous genus *Microbaculidinium* Habib & Knapp 1982 has better developed processes and a baculate surface.

Acrosphaeridium densum n. sp.

Pl. I:3 (Fig. 4. No. 144)

Diagnosis: The small spherical vesicle has a dense cover of short processes (length about 1/8 of the vesicle diameter). These are cylindrical, with a small swelling distally. The processes vary slightly in width within the same individual. Their surface is psilate, while that of the vesicle is entirely covered by processes. A median split has been observed.

Dimensions: vesicle diameter 8 µm, length of process 1.0 -1.5 µm, process diameter 0.25 µm. Specimens measured: 2.

Holotype: GSF Prep. 1116 (SEM), Pl. I:3. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 178.0 — 136.0 m, Lasnamägi to Keila regional stages, Middle Ordovician. Rare.

Etymology: *densum* from the Latin, 'thick, close'.

Comparison: The species differs from *Acrosphaeridium esthonicum* n. sp., which has a lesser number of thicker processes.

Acrosphaeridium esthonicum n. sp.

Pl. I:4a, b (Fig. 4. No. 269)

Diagnosis: The vesicle is spherical, with numerous clearly distinguishable evexate processes (about 50 in the optical section) of length about 1/6 of the vesicle diameter. The processes are virtually constant in thickness throughout their length, broadening just a little proximally. All the processes are identical within the same individual. The surfaces of the vesicle and processes have a dense covering of rounded tubercles. No pylome was observed.

Dimensions: vesicle diameter 6 — 11 µm, process length 1.0 — 1.5 µm, distance between processes 0.1 — 2.0 µm. Specimens measured: 4.

Holotype: GSF Prep. 1053 (SEM); Pl. I:4a, b. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 121.0 — 62.0 m, Rakvere Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare.

Etymology: *esthonicum* from the neo-Latin *Esthonia,* 'Estonian'.

Comparison: Differs from the Cretaceous *Microbaculidinium cornutum* Habib & Knapp 1982, which has sparser tubercles on its surface and less processes.

Acrosphaeridium reticulatum n. sp.

Pl. I:5 (Fig. 4. No. 249)

Diagnosis: The small vesicle is spherical and densely covered by processes of varying thickness and length, the longest also being thickest. The processes are densely granulated. No median split was observed.

Dimensions: vesicle diameter 7 µm, length of process, longer: 4 — 5 µm, shorter: 1 — 2.5 µm. Specimens measured: 1.

Holotype: GSF Prep. 1091 (SEM); Pl. I:5. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 136.0 m,

Keila Regional Stage, Middle Ordovician. Rare.

Etymology: *reticulatum* from the Latin *rete,* 'net', + *-culum,* diminutive, + *-atum,* 'having the nature of'.

Comparison: Differs from *Comasphaeridium* sp. 1, the processes of which are variable in thickness but consistent in length and have a psilate surface.

Genus *Actipilion* Loeblich 1970

Actipilion druggii Loeblich 1970

Pl. II:8 (Fig. 4 No. 283)

1970: *Actipilion druggii* Loeblich, p. 711.

Description: The double outer shell of the subspherical vesicle is slightly thinner than in the original description. The processes are thin-walled and flagelliform. They are of almost constant thickness throughout their length, broadening very slightly proximally. They are virtually the same as the diameter of the vesicle in length or slightly longer. The vesicle and process surfaces are tubercular.

Dimensions: vesicle diameter 60 — 70 µm, process length 66 — 68 µm. Specimens measured: 7.

Occurrence: Rapla borehole, depths 108.0 — 66.0 m, Nabala Regional Stage, Paekna Formation to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare.

Previous records: Upper Ordovician: U.S.A. (Loeblich 1970a, Wright & Meyers 1981).

Genus *Akomachra* Colbath 1979

Akomachra ovula Colbath 1979

Pl. II:9 (Fig. 4. No. 64)

1979: *Akomachra ovula* Colbath, p. 8.

Description: The pear-shaped vesicle is more lanceolate than in the original diagnosis. The narrower apical end is relatively psilate, but elsewhere its surface is tubercular. The anapical end is slightly concave and has denser tubercles than elsewhere on the vesicle. It may also have a pylome opening.

Dimensions: vesicle length 32 — 49 µm, vesicle width 22 — 26 µm, distance between tubercles 0.8 — 2.0 µm. Specimens measured: 11.

Occurrence: Rapla borehole, depths 188.6 — 171.0 m, Kunda Regional Stage, Sillaoru Formation to Uhaku Regional Stage, Lower to Middle Ordovician. Rare to moderate.

Previous records: Upper Ordovician: U.S.A. (Colbath 1979).

Genus *Arcosphaeridium* n. gen

Type species: *Arcosphaeridium poriferum* n. sp., designated here.

Other new species of the genus: *A. diversispinosum*

Diagnosis: The small vesicle is spherical to oval in shape and its processes have grown together in places to form arches.

Etymology: *Arcosphaeridium* from the Latin *arcus,* 'bow, arch', + Latin *sphaera* (Gr. *sphaira),* 'ball', + Latin *-idium,* diminutive.

Comparison: The genus differs from *Ooidium* Timofeev 1957, which has an arcuate structure only at one end of the oval. *Aureasphaera* Cramer *et al.* 1976 has a polygonal reticulate pat-

tern and small tubercles on the vesicle in addition to the arcuate pattern.

Arcosphaeridium diversispinosum n. sp.

Pl. I:6 (Fig. 4. No. 280)

Diagnosis: The oval vesicle has numerous short, flagelliform processes (about 1/4 of the vesicle diameter in length), some of which have grown together to form arches. This effect is irregular in distribution, however, as is the point of fusion on the process. The processes have acuminate distal terminations with no furcations. The vesicle and process surfaces are shagrinate.

Dimensions: vesicle length 7 — 8 µm, vesicle width 5.5 — 6.5 µm, length of archs 1 — 2 µm. Specimens measured: 4.

Holotype: GSF Prep. 1053 (SEM); Pl. I:6. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, 111.0 — 66.0 m, Rakvere Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare.

Etymology: *diversispinosum* from the Latin *diversus,* 'different', + *spinosum,* 'thorny'.

Comparison: Differs from *Arcosphaeridium poriferum* n. sp., the more delicate processes on which have more often grown together into arches, and which has a reticulate surface. The processes of *Micrhystridium parinconspicuum* Deflandre 1945 are broader proximally and do not form arches.

Arcosphaeridium poriferum n. sp.

Pl. I:7a, b (Fig. 4. No. 302)

Diagnosis: The subspherical vesicle has numerous short, thin processes which form irregular arches either singly or by fusion. The vesicle surface is reticulate, with pores of varying size. The processes are psilate.

Dimensions: vesicle length 9 µm, vesicle width 7 µm, length of archs 1 µm. Specimens measured: 1.

Holotype: GFS Prep. 1053 (SEM); Pl. I:7a, b. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 66.0 m, Pirgu Regional Stage, Moe Formation, Upper Ordovician. Rare.

Etymology: *poriferum* from the Latin *porus,* 'hole, passage', + *-ferum,* suffix meaning 'bear, have'.

Comparison: Differs from *Arcosphaeridium diversispinosum* n. sp., which has thicker processes and a shagrinate surface.

Genus *Aremoricanium* Deunff 1955

Aremoricanium deflandrei Henry 1969

Pl. II:10 (Fig. 4. No. 107)

1969: *Aremoricanium deflandrei* Henry, p. 78.

Description: The large spherical vesicle has numerous delicate, flagelliform processes (more than 30). These have a wide base and are shorter than the diameter of the vesicle. The outer shell and processes are psilate.

Dimensions: vesicle diameter 53 — 58 µm, length of process 25 — 37 µm, length of extension 25 — 30 µm. Specimens measured: 8.

Occurrence: Rapla borehole, depths 181.0 — 168.0 m, Aseri to Uhaku regional stages, Middle Ordovician. Rare to moderate.

Previous records: Lower Ordovician: Morocco (Cramer & Díez 1977). Middle Ordovician: Sweden (Kjellström 1971b, 1972, 1976, Górka 1987); France (Henry 1969).

Aremoricanium rigaudae Deunff 1955

Pl. II:11 (Fig. 4. No. 100)

1955: *Aremoricanium rigaudae* Deunff, p. 228.

Description: The spherical vesicle features 10—15 delicate, flagelliform processes which are wider at the base, and a cylindrical extension. The processes are about a half of the vesicle diameter in length. The outer shell and processes are psilate.

Dimensions: outer vesicle diameter 30 — 40 µm, length of process 14—18 µm, length of extension 20 — 25 µm. Specimens measured: 21.

Occurrence: Rapla borehole, depths 182.0 — 152.0 m, Aseri Regional Stage to Idavere Regional Stage, Tatruse Formation, Middle Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Sweden (Kjellström 1971b); France (Deunff 1955, 1958, Henry 1969); U.S.A. (Loeblich & MacAdam 1971).

Aremoricanium squarrosum Loeblich & MacAdam 1971

Pl. II:12 (Fig. 4. No. 219)

1971: *Aremoricanium squarrosum* Loeblich & MacAdam, p. 4.

Description: The large, spherical vesicle is practically psilate with occasional tubercles. The 15 processes are more robust than in the original diagnosis. The species also resembles the psilate *A. syringosagis* Loeblich & MacAdam 1971, but this has less processes.

Dimensions: vesicle diameter 40 — 60 µm, length of process 30 — 58 µm, number of processes 9 — 12, length of cylindrical extension 30 — 35 µm. Specimens measured: 3.

Occurrence: Rapla borehole, depths, 146,2 — 46.0 m, Jõhvi Regional Stage to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare.

Previous records: Upper Ordovician: U.S.A. (Loeblich & MacAdam 1971).

Aremoricanium sp.

Pl. III:24 (Fig. 4. No. 17)

Description: The subspherical vesicle has numerous processes in the optical section (20—30) and a cylindrical extension. These delicate processes can be simple, bifurcated or trifurcated, and are about 1/3 of the vesicle diameter in length. The cylindrical extension corresponds in length to 1/3 — 1/2 of the vesicle diameter. The surfaces of the vesicle, processes and extension are psilate.

Dimensions: vesicle diameter 33 — 35 µm, length of process 6 — 10 µm, length of extension 10 — 13 µm, extension diameter 8 — 9 µm. Specimens measured: 3.

Occurrence: Rapla borehole, depth 189.0 m, Volhov Regional Stage, Lower Ordovician. Rare.

Comparison: Differs from *Aremoricanium cylindricosum* (Eisenack 1963), the processes of which are thinner, regularly furcated and very much more numerous.

Genus *Arkonia* Burmann 1970

Arkonia concava n. sp.

Pl. III:25 (Fig. 4. No. 132)

Diagnosis: The triangular vesicle has a single process with an acuminate distal termination at each corner. Its sides are slightly concave and its surface has fine striae and strings of granulae running parallel to the sides. The surfaces of the processes are psilate.

Dimensions: length of side 25 — 31 µm, length of process 20 µm, distance between processes 65 — 75 µm. Specimens measured: 1.

Holotype: GFS Prep. 1116 (SEM); Pl. III:25. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 178.0 m, Lasnamägi Regional Stage, Middle Ordovician. Rare.

Etymology: *concava* from the Latin *concavus,* 'hollow'.

Comparison: Resembles *Veryhachium trispinosum* (Eisenack) Deunff 1954 in shape, but the surface of the latter is psilate. The processes of *Arkonia vigrata* Burmann 1970 are longer and flagelliform distally.

Arkonia semigranulata n. sp.

Pl. III:26 (Fig. 4. No. 235)

Diagnosis: The sides of the thin, triangular vesicle are practically straight, and there is a process with an acuminate distal termination at each corner. The junctions between the processes and the vesicle are sometimes indeterminate. The sides of the vesicle have a fine striation running more or less parallel with them, and there is a triangular granulation in the centre which continues to the tips of the processes.

Dimensions: length of side 25 — 30 µm, length of process 13 — 20 µm, distance between processes 50 — 75 µm. Specimens measured: 13.

Holotype: GFS Prep. 1093 (SEM); Pl. III:26. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 140.0 — 128.0 m, Keila Regional Stage, Middle Ordovician. Rare to moderate.

Etymology: *semigranulata* from the Latin *semi,* 'half', + Latin *granulata,* 'granulated'.

Comparison: Slightly resembles *Striatotheca triangulata* (Cramer *et al.* 1974), except for its central triangular granulation. Its shape is somewhat reminiscent of *Goniosphaeridium cantabricum* (Cramer & Díez 1976) n. comb. and *V. trispinosum gerdospinum* Cramer & Díez 1972, but has shorter processes and a striated and granulated patterning.

Genus *Axisphaeridium* Eisenack 1967

Axisphaeridium timofeevi Eisenack 1967

Pl. II:13 (Fig. 4. No. 165)

1967: *Axisphaeridium timofeevi* Eisenack, p. 398.

Description: The spherical vesicle features a large collared pylome. The processes are shorter and stouter than in the original diagnosis (about 1/20 of the diameter) and triangular or rectangular in cross-section, with short tangential branches distally. The vesicle surface is shagrinate.

Dimensions: vesicle diameter 60 — 77 µm, length of process 4 — 6 µm, distance between processes 5 — 7 µm, pylome diameter 10 µm. Specimens measured: 6.

Occurrence: Rapla borehole, depths 173.0 — 152.0 m, Uhaku Regional Stage to Idavere Regional Stage, Tatruse Formation, Middle Ordovician. Rare.

Previous records: Middle Ordovician: Estonia (Eisenack 1967).

Axisphaeridium tricolumnelare Uutela 1989

Pl. II:14 (Fig. 4. No. 221)

1989: *Axisphaeridium tricolumnelare* Uutela, pp. 22—23.

Description: The vesicle is spherical and its surface psilate. The processes are triangular and formed of three thin, echinate vela, tapering to a pyramid on the proximal side. The processes are solid. The pylome opens out with a collar and the other has a cover with irregular nets and a collar. The shaggy appearance of the processes is characteristic of *A. tomentum* Colbath 1979.

Dimensions: vesicle diameter 32 — 60 µm, lenght of process 2 — 5 µm, pylome diameter 8 — 14 µm. Specimens measured: 62.

Occurrence: Rapla borehole, depths 145.5 — 36.8 m, Keila Regional Stage to Pirgu Regional Stages, Adila Formation, Middle to Upper Ordovician. Rare to common.

Previous records: Ordovician erratics: Finland (Uutela 1989).

Genus *Bacisphaeridium* Eisenack 1962

Bacisphaeridium bacifer Eisenack (1934) 1962

Pl. II:15 (Fig. 4. No. 299)

1934: *Bion (Ovum?) bacifer* Eisenack, p. 66.

1962: *Bacisphaeridium bacifer* Eisenack, p. 356.

Description: The spherical vesicle has one tapering process which can either have an acuminate distal termination or be evexate, even with a widening at the tip. Occasionally two processes are found. The processes vary greatly in length, from 1/5 of the vesicle diameter to 2/3, i.e. more than in the original diagnosis. In the specimens with two processes one is usually shorter than the other. The shell is thin-walled and easily crushed. The process evidently communicates with the interior of the vesicle, although the original diagnosis maintains that it should be solid rather than hollow (Eisenack 1962). It is probably that the originally hollow process has been filled secondarily by precipitation. The surfaces of the vesicle and process are seen in SEM image to be coarse or indeterminately tubercular. The species was found only in the Chitinozoa slides of J. Nõlvak.

Deunffia brevispinosa Downie 1960 resembles the single process specimen of *Bacisphaeridium,* but differs at least in having an oval vesicle. *Pirea colliformis* (Burmann) Vavrdová 1977 is also more oval in shape and smaller. *Allumiella baltica* Fanderflit 1971 is a smaller.

Dimensions: vesicle diameter 60 — 105 µm, length of process 10 — 70 µm. Specimens measured: 16.

Occurrence: Rapla borehole, depths 72.0 — 48.5 m, Pirgu Regional Stage, Moe to Adila Formations, Upper Ordovician. Rare.

Previous records: Middle and Upper Ordovician: Estonia (Eisenack 1962).

Bacisphaeridium granulatum n. sp.

Pl. III:27 (Fig. 4. No. 305)

Diagnosis: The spherical vesicle has a process which communicates directly with its interior. The distal part of the process narrows in a stepwise manner to a lanceolate tip. The surface of the vesicle has a clear, although sparse, granulation. The shell is relatively thin-walled.

Dimensions: vesicle diameter 104 µm, length of process 21 µm, process diameter 14 µm. Specimens measured: 1.

Holotype: GSF Prep. 1052 (SEM); Pl. III:27. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 64.0 m, Pirgu Regional Stage, Moe Formation, Upper Ordovician. Rare.

Etymology: *granulatum* from the Latin *granum,* 'grain', + *-ulum,* diminutive, + *-atum,* 'having the nature of'.

Comparison: The form of the vesicle resembles the type form of the genus *Pirea* Vavrdová 1972, but differs from it in the spherical nature of the vesicle. Still further it resembles *Bacisphaeridium bacifer* Eisenack (1934) 1962, although does not have a clearly granulated vesicle.

Bacisphaeridium saetosum n. sp.

Pl. III:28 (Fig. 4. No. 310)

Diagnosis: The vesicle is spherical and has two processes with curved proximal contacts on one half. The processes widen slightly distally. The vesicle surface has a dense cover of spikes about 4 µm, in length, while the processes are relatively psilate. The processes probably communicate with the interior of the vesicle. The shell is thin-walled.

Dimensions: vesicle diameter 70 — 82 µm, length of process 25 — 37 µm, process diameter 18 µm. Specimens measured: 2.

Holotype: GSF Prep. 1045/1044 (SEM/J. Nõlvak); Pl. III:28. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 49.0 m, Pirgu Regional Stage, Moe Formation, Upper Ordovician. Rare.

Etymology: *saetosum* from the Latin *saeta,* 'bristle', + Latin *-osum,* 'full of'.

Comparison: The species resembles *Domasia bispinosa* Downie 1960, differing from it in its

spherical shape. *Pirea ornata* (Burmann) Vavrdová 1972 differs from the present species in having only one process. The species has some features in common with *Bacisphaeridium bacifer* Eisenack (1934) 1962, but differs from the two-process forms of this species in having its processes closer together and of similar size. There are also differences in surface texture.

Genus *Baltisphaeridium* Eisenack 1958, emend. Eisenack 1969

Baltisphaeridium accinctum Loeblich & Tappan 1978

Pl. II:16 (Fig. 4. No. 6)

1978: *Baltisphaeridium accinctum* Loeblich & Tappan, p. 1246—1247.

Description: The short processes on the spherical vesicle are slightly sharper than in the original diagnosis, and the processes have a denser cover of tubercles than the vesicle. The vesicle of *B. annelieae* (Kjellström) Bockelie & Kjellström 1979 is psilate, and the processes of *B. ingerae* Kjellström 1971 are markedly longer and more slender.

Dimensions: vesicle diameter 35 — 62 µm, length of process 4 — 12 µm, width of process approx. 1.5 µm. Specimens measured: 18.

Occurrence: Rapla borehole, depths 188.9 — 157.0 m, Volhov to Kukruse regional stages, Lower to Middle Ordovician. Rare.

Previous records: Upper Ordovician: U.S.A. (Loeblich & Tappan 1978).

Baltisphaeridium aliquigranulum Loeblich & Tappan 1978

Pl. II:17 (Fig. 4. No. 265)

1978: *Baltisphaeridium aliquigranulum* Loeblich & Tappan, p. 1247.

Description: The surface of the thick-walled, spherical vesicle is psilate. The 8—10 long processes are granulate with an acuminate distal termination, and they do not communicate with the interior of the vesicle.

Dimensions: vesicle diameter 57 — 60 µm, length of process 57 — 60 µm. Specimens measured: 11.

Occurrence: Rapla borehole, depths 128.0 — 36.8 m, Keila Regional Stage to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare.

Previous records: Upper Ordovician: U.S.A. (Loeblich & Tappan 1978).

Baltisphaeridium annelieae (Kjellström) Bockelie & Kjellström 1979

Pl. II:18 (Fig. 4. No. 65)

1976: *Baltisphaeridium annelieae* Kjellström, pp. 10—12.

1979: *Baltisphaeridium annelieae* (Kjellström) Bockelie & Kjellström, pp. 205—207.

Description: The surface of the spherical vesicle is psilate, and those of the numerous processes spiny. The processes are shorter than in the original diagnosis (1/4 of the vesicle diameter). The vesicle is smaller in size than as described by Kjellström (1976) and Boecklie and Kjellström (1979).

Dimensions: vesicle diameter 47 — 56 µm, length of process 8 — 15 µm, base diameter 1 µm, distance between processes 5 — 10 µm. Specimens measured: 13.

Occurrence: Rapla borehole, depths 188.6 — 163.0 m, Kunda Regional Stage, Sillaoru Formation to Kukruse Regional Stage, Lower to Middle Ordovician. Rare.

Previous records: Middle Ordovician: Estonia (Bockelie & Kjellström 1979); Sweden (Kjellström 1976, Górka 1987); Finland (Tynni 1982); Poland (Górka 1979); Britain (Turner 1984). Upper Ordovician: U.S.A. (Jacobson 1978).

Baltisphaeridium bramkaense Górka 1979

Pl. II:19 (Fig. 4. No. 114)

1979: *Baltisphaeridium bramkaense* Górka, p. 358.

Description: The vesicle is large, the processes broad and with acuminate distal terminations, and some of them are furcated. The Rapla specimens have processes which are longer than the diameter of the vesicle, and in this sense differs from the original diagnosis. *B. constrictum* Kjellström 1971 also has its processes longer than the vesicle diameter, but they are psilate and no furcation has been encountered.

Dimensions: vesicle diameter 50 — 75 µm, length of process 60 — 84 µm, base diameter 10 — 12. Specimens measured: 34.

Occurrence: Rapla borehole, depths 181.0 — 38.0 m, Aseri Regional Stage to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Sweden (Górka 1987); Poland (Górka 1969).

Baltisphaeridium brevicilatum (Staplin) Downie & Sarjeant 1963

Pl. II:20 (Fig. 4. No. 319)

1961: *Micrhystridium breviciliatum* Staplin, p. 408.

1963: *Baltisphaeridium breviciliatum* (Staplin) Downie & Sarjeant, p. 90.

Description: The practically spherical vesicle has numerous short, conical flagelliform processes (about 1/5 of the vesicle diameter). The vesicle and process surfaces are psilate.

Dimensions: vesicle diameter 34 µm, length of process 7 µm, distance between processes 6 µm. Specimens measured: 1.

Occurrence: Rapla borehole, depth 28.0 m, Juuru Regional Stage, Lower Silurian. Rare.

Previous records: Ordovician — Silurian: Belgium (Martin 1968, *B.* aff. *breviciliatum).* Upper Devonian: Canada (Staplin 1961).

Baltisphaeridium brevispinosum Eisenack (1931) 1958

Pl. II:21 (Fig. 4. No. 27)

1931: *Ovum hispidum brevispinosum* Eisenack, p. 111.

1958: *Baltisphaeridium brevispinosum* Eisenack, p. 400.

Description: The vesicle is thick-walled and spherical and the processes rounded at the distal termination and in some cases furcated. The processes are about 1/3 of the diameter of the vesicle in length. The vesicle and process surfaces are shagrinate.

Dimensions: vesicle diameter 42 — 66 µm, length of process 18 — 22 µm. Specimens measured: 11.

Occurrence: Rapla borehole, depths 189.0 — 180.0 m, Volhov to Lasnamägi regional stages, Lower to Middle Ordovician. Rare to moderate.

Previous records: Lower Ordovician: Poland (Górka 1969); Czechoslovakia (Vavrdová 1965); France (Deunff 1958). Middle Ordovician: Sweden (Kjellström 1971a, 1972, 1976); Finland (Tynni 1982). Ordovician Baltic erratics (Eisenack 1931, 1938, 1958, 1959, 1965a, 1968, 1969, Uutela 1989).

Baltisphaeridium brevituberculatum Kjellström 1971

Pl. II:22 (Fig. 4. No. 29)

1971: *Baltisphaeridium brevituberculatum* Kjellström, pp. 10—12.

Description: The large spherical vesicle is thick-walled and covered by numerous short processes rounded at the distal termination. The vesicle and process surfaces are shagrinate.

Dimensions: vesicle diameter 60 — 80 µm, height of process 2 — 3 µm. Specimens measured: 3.

Occurrence: Rapla borehole, depths 189.0 — 176.0 m, Volhov to Lasnamägi regional stages, Lower to Middle Ordovician. Rare.

Previous records: Middle Ordovician: Sweden (Kjellström 1971b, 1972, 1976); Finland (Tynni 1982).

Baltisphaeridium bystrentos Loeblich & Tappan 1978

Pl. II:23 (Fig. 4. No. 162)

1978: *Baltisphaeridium bystrentos* Loeblich & Tappan, pp. 1248—1251.

1984: *Baltisphaerosum bystrentos* (Loeblich & Tappan) Turner, p. 102.

Description: The processes on the spherical vesicle are about a half of the vesicle diameter in length. The Rapla species differs from the original diagnosis in having more processes, which are shorter and narrower. Both the vesicle and the processes have a tubercular surface. No median split was observed.

Remarks: Turner (1984) distinguishes a genus *Baltisphaerosum* from *Baltisphaeridium* on the basis of the presence of a median split. This is not borne out by the Rapla material, however, as individuals of the same species may be found with and without a median split.

Dimensions: vesicle diameter 50 — 61 µm, length of process 25 — 27 µm. Specimens measured: 24.

Occurrence: Rapla borehole, depths 176.0 — 35.0 m, Lasnamägi to Porkuni regional stages, Middle to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician: U.S.A. (Loeblich & Tappan 1978); Britain (Turner 1984, 1985).

Baltisphaeridium aff. *B. capillatum* Jardiné, Combaz, Magloire, Peniguel & Vachey 1974

Pl. IV:32 (Fig. 4. No. 320)

Description: The spherical vesicle has numerous cylindrical, flagelliform processes with a whip-like distal termination. The surface of the vesicle has microgranulations, but the processes are psilate.

Dimensions: vesicle diameter 41 µm, length of process 11 µm, processs base diameter 1.0 — 1.5 µm. Specimens measured: 1.

Remarks: This species is slightly larger than *B. capillatum* in the original diagnosis (ø 28 — 36 µm).

Occurrence: Rapla borehole, depth 28.0 m, Juuru Regional Stage, Lower Silurian. Rare.

Baltisphaeridium castaneiforme n. sp.

Pl. III:29 (Fig. 4. No. 18)

Diagnosis: The spherical vesicle has numerous short, thin processes (about 70 in the optical section, and about 1/6 of the vesicle diameter in length). These do not communicate with the interior of the vesicle. The processes are simple and homomorphic, with acuminate distal terminations and broad proximal contacts. Both the vesicle and the processes have a granulated surface. A median split was observed.

Dimensions: vesicle diameter 48 µm, length of process 5 — 8 µm, distance between processes 8 — 10 µm. Specimens measured: 1.

Holotype: GSF Prep. 1126 (SEM); Pl. III:29. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 189.0 m, Volhov Regional Stage, Lower Ordovician. Rare.

Etymology: *castaneiforme* from the Latin *castanea,* 'chestnut', + *-forme,* suffix meaning 'having the form of'.

Comparison: Differs from *Baltisphaeridium trichophorum* (Eisenack) Kjellström 1971, which has a shagrinate vesicle and process surface. The processes on *B. castaneiforme* n. sp. are of the same type as on *B. castaneum* (Eisenack) Downie & Sarjeant 1963, but the latter is very much larger in size and nothing is said in the diagnosis about its surface texture.

Baltisphaeridium cirsinum n. sp.

Pl. III:30a,b (Fig. 4. No. 2)

Diagnosis: The spherical vesicle has numerous short processes (about 100 in the optical section) with a length of about 1/5 of the vesicle diameter. The processes, which are simple and homomorphic and have acuminate distal terminations and only slightly broadened proximal contacts with a plug, do not communicate with the vesicle interior. The surfaces of both the vesicle and the processes have whip-like spikes of length about 2 µm. A median split was observed.

Dimensions: vesicle diameter 38 — 60 µm, lenght of process 6 — 8 µm, process base diameter 2 — 3 µm, distance between processes 5 µm. Specimens measured: 33.

Holotype: GSF Prep. 1116 (SEM); Pl. III:30a, b. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 189.0 — 171.0 m, Volhov to Uhaku regional stages, Lower to Middle Ordovician. Rare to moderate.

Etymology: *cirsinum* from the Latin *cirsium*, 'thistle', + *-inum*, 'pertaining to'.

Comparison: Differs from *Baltisphaeridium accinctum* Loeblich & Tappan 1978, the vesicle surface of which is granulate and lacking in whiplike spikes. *B. ingerae* Kjellström 1976 has longer, flagelliform processes. The more stout processes of *B. dasos* Colbath 1979 are echinate.

Baltisphaeridium dasos Colbath 1979

Pl. IV:33 (Fig. 4. No. 127)

1979: *Baltisphaeridium dasos* Colbath, p. 11.

Description: The spherical to subspherical vesicle has numerous short processes with acuminate distal terminations and angular proximal contacts (about 120 processes in the optical section, measuring 1/5 — 1/7 of the vesicle diameter). The processes are simply and homomorphic, and do not communicate with the interior of the vesicle. The vesicle and process surfaces are echinate, those of the processes more so. A median split was observed.

Dimensions: vesicle diameter 40 — 52 µm, length of process 8 — 10 µm, width of processes 1.6 — 2.0 µm. Specimens measured: 22.

Occurrence: Rapla borehole, depths 180.0 — 68.0 m, Lasnamägi Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Upper Ordovician: U.S.A. (Colbath 1979, 1980).

Baltisphaeridium digitiforme Górka 1969

Pl. IV:34 (Fig. 4. No. 146)

1969: *Baltisphaeridium digitiforme* Górka, pp. 42—43.

Description: The processes on the spherical vesicle are stout and rounded at the distal termination. Both the vesicle and the processes have a shagrinate or microgranulate surface.

Dimensions: vesicle diameter 60 — 70 µm, lenght of process 30 — 50 µm, number of processes 8 — 9. Specimens measured: 4.

Occurrence: Rapla borehole, depths 178.0 — 117.0 m, Lasnamägi to Rakvere regional stages, Middle Ordovician. Rare.

Previous records: Middle Ordovician: Sweden (Kjellström 1971b, 1972). Ordovician: Poland (Górka 1969).

Baltisphaeridium dispar (Turner) n. comb.

Pl. IV:35 (Fig. 4. No. 179)

1984: *Baltisphaerosum dispar* Turner, pp. 103—104.

Description: The spherical vesicle is microgranular, the tubercles on the processes being slightly larger and more frequent. The constrictions at the proximal contacts of the processes are not as distinct as in the original description by Turner (1984). An occasional process may be furcated.

Remarks: In the Rapla material individuals of *B. dispar* may be found with and without a median split.

Dimensions: vesicle diameter 55 — 70 µm, length of process 42 — 50 µm, process base diameter 7 — 9 µm, number of processes 7 — 9. Specimens measured: 30.

Occurrence: Rapla borehole, depths 168.0 — 76.0 m, Uhaku to Vormsi regional stages, Middle to Upper Ordovician. Rare to common.

Previous records: Middle Ordovician: Britain (Turner 1984).

Baltisphaeridium eisenackianum (Deunff) Downie & Sarjeant 1963

Pl. IV:36 (Fig. 4. No. 92)

1958: *Hystrichosphaeridium eisenackianum* Deunff, pp. 23—24.

1963: *Baltisphaeridium eisenackianum* Downie & Sarjeant, p. 90.

Description: The processes of irregular length on the spherical vesicle do not communicate with the vesicle interior, confirming the report of Elaoud-Debbaj (1978). In this respect the species departs from the original diagnosis of Deunff

(1958). It is also larger in size. The vesicle and process surfaces are shagrinate.

Dimensions: vesicle diameter 40 — 65 µm, max. length of process 65 — 70 µm, process base diameter 4.5 µm, number of processes 4 — 6. Specimens measured: 16.

Occurrence: Rapla borehole, depths 184.0 — 127.1 m, Kunda Regional Stage, Loobu Formation to Keila Regional Stage, Middle Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Britain (Lister *et al.* 1969). Upper Ordovician: France (Deunff 1958, Paris & Deunff 1970); Czechoslovakia (Konzalova-Mazancova 1969, Vavrdová 1965).

Baltisphaeridium esthonicum n. sp.

Pl. III:31 (Fig. 4. No. 28)

Diagnosis: The vesicle is spherical, with 5—7 processes (in the optical section). These vary in length, but are at maximum less than the diameter of the vesicle. There are also some smaller processes (length 1/10 of the vesicle diameter). The processes are simple, conical in shape, with acuminate distal terminations and curved proximal contacts and a proximal contact plug. The surfaces of the vesicle and processes are densely echinate. A median split was observed.

Dimensions: vesicle diameter 34 — 45 µm, max. length of process 25 — 30 µm, process base diameter 3 — 4 µm, thickness of vesicle approx. 1 µm. Specimens measured: 16.

Holotype: GSF Prep. 1116 (SEM); Pl. III:31. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 189.0 — 178.0 m, Volhov to Lasnamägi regional stages, Lower to Middle Ordovician. Rare to moderate.

Etymology: *esthonicum* from the neo-Latin *Esthonia,* 'Estonian'

Comparison: Differs from *Baltisphaeridium pseudocalicispinum* Górka 1980, these processes of which are all of more or less the same length. The processes of *B. klabavense* (Vavrdová 1965) are constricted at the proximal contact.

Baltisphaeridium filosum Kjellström 1971

Pl. IV:37 (Fig. 4. No. 37)

1971: *Baltisphaeridium filosum* Kjellström, p. 65.

Description: The spherical vesicle has numerous thin, whip-like processes of length approx. 1/4 of the vesicle diameter. The specimens are smaller than that described by Kjellström (1971a).

Dimensions: vesicle diameter 50 — 53 µm, lenght of process 12 — 13 µm. Specimens measured: 24.

Occurrence: Rapla borehole, depths 189.0 — 145.5 m, Volhov to Keila regional stages, Lower to Middle Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Finland (Tynni 1982); Sweden (Kjellström 1971a, Górka 1987); Poland (Górka 1979); Britain (Turner 1984). Ordovician erratics: Finland (Tynni 1975, Uutela 1989).

Baltisphaeridium flexuosum n. sp.

Pl. V:48 (Fig. 4. No. 66)

Diagnosis: The spherical vesicle has numerous flagelliform processes (about 25 in the optical section) which even at their maximum do not exceed the vesicle diameter in length. The processes, which do not communicate with the vesicle interior, are simple and homomorphic, with acuminate or slightly rounded distal terminations and curved proximal contacts. The surfaces of the vesicle and processes are microgranulated. No median split was encountered.

Dimensions: vesicle diameter 35 — 43 µm, lenght of process 15 — 26 µm, distance between processes 6 — 20 µm. Specimens measured: 13.

Holotype: GSF Prep. 1125 (SEM); Pl. V:48. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 188.6 — 157.0 m, Kunda Regional Stage, Sillaoru Formation to Kukruse Regional Stage, Lower to Middle Ordovician. Rare.

Etymology: *flexuosum* from the Latin *flexus,* 'bend', + *-osum* 'full of'.

Comparison: Differs from *Baltisphaeridium hirsutoides* Eisenack (1931) 1959, the processes

of which are not flagelliform and the surface of which is psilate, also from *B. flagellicum* Kjellström 1971, which has also a psilate surface and has more, shorter processes.

Baltisphaeridium globosum Tynni 1975, emended

Pl. IV:38 (Fig. 4. No. 281)

1975: *Baltisphaeridium globosum* Tynni, p. 12.

Emended diagnosis: The vesicle is entirely spherical and has a shell of thickness 1.5 µm. The processes are curved, broadening at the proximal contact and acuminate at the distal termination. They vary greatly in size, but their length does not exceed the diameter of the vesicle. They do not communicate with the vesicle interior.

Dimensions: vesicle diameter 47—60 µm, length of process 10 — 40 µm. Specimens measured: 5.

Occurrence: Rapla borehole, depth 108.0 m, Nabala Regional Stage, Paekna Formation, Middle Ordovician. Moderate.

Comparison: Resembles *Baltisphaeridium hirsutoides* Eisenack (1931) 1958, but has processes which are more flagelliform and of differing sizes. The type of process is similarly to that found in *B. disparicanale* Loeblich & Tappan, but this species has very many more of them (24—25). The specimens are smaller than that originally described by Tynni (1975), in which the vesicle diameter is 60 — 70 µm and the process length 50 — 70 µm.

Previous records: Ordovician erratics: Finland (Tynni 1975).

Baltisphaeridium hamatum (Downie) Kjellström 1976

Pl. IV:39 (Fig. 4. No. 81)

1958: *Hystrichosphaeridium hirsutoides* var. *hamatum* Downie, p. 335.

1964: *Baltisphaeridium hirsutoides* var. *hamatum* Downie & Sarjeant, p. 91.

1965: *Micrhystridium hamatum* Deflandre & Deflandre, Fig. 2248.

1966: *Baltisphaeridium hirsutoides hamatum* Downie & Ford, p. 313.

1976: *Baltisphaeridium hamatum* (Downie) Kjellström, p. 18.

Description: The spherical vesicle has processes of variable size. Kjellström (1976) based his new species on the nature of the processes, which have rather a broad base. The species indentified here has processes of a more variable length than is described by Kjellström (1976) and Górka (1979). The vesicle surface is psilate.

Dimensions: vesicle diameter 42 — 50 µm, lenght of process 5 — 10 µm. Specimens measured: 4.

Occurrence: Rapla borehole, depths 188.0 — 171.0 m, Kunda Regional Stage, Loobu Formation to Uhaku Regional Stage, Middle Ordovician. Rare.

Previous records: Lower Ordovician: Britain (Downie 1959, Downie & Ford 1966). Middle Ordovician: Finland (Tynni 1982); Sweden (Kjellström 1976, Górka 1987); Poland (Górka 1979). Ordovician erratics: Finland (Uutela 1989).

Baltisphaeridium heinzelinii Stockmans & Willière 1969

Pl. IV:40 (Fig. 4. No. 272)

1969: *Baltisphaeridium heinzelinii* Stockmans & Willière, pp. 15—16.

Description: This exceptionally small *Baltisphaeridium* is spherical and has numerous short processes of length 1/5 — 1/3 of the diameter of the vesicle. The processes vary in length on the same individual and are slighly more stout than in the original diagnosis of Stockmans & Willière (1969). The surfaces of both the vesicle and the processes are psilate.

Dimensions: vesicle diameter 25 — 26 µm, length of process 5 — 8 µm. Specimens measured: 2.

Occurrence: Rapla borehole, depth 115.0 m, Rakvere Regional Stage, Middle Ordovician. Rare.

Previous records: Upper Devonian: Belgium (Stockmans & Willière 1969).

Baltisphaeridium hirsutoides Eisenack (1931) 1958

Pl. IV:41 (Fig. 4. No. 50)
1931: *Ovum hispidum* cf. *hirsutum* Eisenack, p. 111.
1958: *Baltisphaeridium hirsutoides* Eisenack, p. 400.

Description: The vesicle is spherical and the processes do not exceed its diameter in length. The surfaces of the vesicle and processes are psilate or shagrinate.

Dimensions: vesicle diameter 40 — 60 µm, process length 27 — 40 µm. Specimens measured: 281.

Occurrence: Rapla borehole, depths 189.0 — 28.0 m, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian. Rare to common.

Previous records: Common in Baltic Ordovician deposits (Eisenack *et al.* 1973).

Baltisphaeridium ingerae Kjellström 1976

Pl. IV:42 (Fig. 4. No. 4)
1976: *Baltisphaeridium ingerae* Kjellström, p. 21.

Description: The spherical vesicle is seen at 3000 x magnification to be covered with hairy spines, which have more the appearance of tubercles at 780 x magnification. The processes are curved at the proximal contact but otherwise thin and flagelliform and covered with the same hairy spines as the vesicle. They do not exceed the vesicle diameter in length. The processes are slightly more numerous than in the original diagnosis of Kjellström (1976).

Dimensions: vesicle diameter 60 — 74 µm, length of process 32 — 36 µm. Specimens measured: 37.

Occurrence: Rapla borehole, depths 189.0 — 161.0 m, Volhov to Kukruse regional stages, Lower to Middle Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Estonia (Bockelie & Kjellström 1979); Sweden (Kjellström 1976). Upper Ordovician: U.S.A. (Jacobson 1978).

Baltisphaeridium kaurannei n. sp

Pl. V:49a, b (Fig. 4. No. 23)

Diagnosis: The spherical vesicle has about 10 processes equal to or slightly greater than the vesicle diameter in length. These processes are simple and homomorphic with acuminate distal terminations and slightly constricted at the proximal contact. They are very thin-walled and thus slightly flagelliform. The surfaces of the vesicle and processes have whip-like spines increasing in length to 6 µm towards the distal ends of the processes. A median split was observed.

Dimensions: vesicle diemeter 50 — 64 µm, length of process 45 — 60 µm, process base diameter 10 — 11 µm, distance between processes 10 — 30 µm, number of processes 10. Specimens measured: 10.

Holotype: GSF Prep. 1126 (SEM); Pl. V:49a, b. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 189.0 — 186.0 m, Volhov Regional Stage to Kunda Regional Stage, Loobu Formation, Lower to Middle Ordovician. Rare.

Etymology: *kaurannei* in honour of Prof. L.K. Kauranne, former Director of the Geological Survey of Finland.

Comparison: Differs in surface texture from *Baltisphaeridium bramkaense* Górka 1979, which is granulate, and still more from *B. perclarum* Loeblich & Tappan 1978, the vesicle of which is psilate, and *B. constrictum* Kjellström 1971, the processes of which are psilate.

Baltisphaeridium klabavense (Vavrdová) Kjellström 1971

Pl. IV:43 (Fig. 4. No. 214)
1965: *Baltisphaeridium klabavense* Vavrdová, p. 353.
1971: *Baltisphaeridium klabavense* (Vavrdová) Kjellström, p. 14.

Description: The spherical vesicle has a dense cover of hairy spines arranged virtually in rows. The spines of the processes are smaller and more spaced out. The processes are constricted at the proximal contact and do not exceed the vesicle diameter in length.

Dimensions: vesicle diameter 53 — 60 µm,

length of process 30 — 35 µm. Specimens measured: 7.

Occurrence: Rapla borehole, depths 146.2 — 134.0 m, Jõhvi to Keila regional stages, Middle Ordovician. Rare.

Previous records: Lower Ordovician: Czechoslovakia (Vavrdová 1965). Middle Ordovician: Sweden (Kjellström 1971b, 1972), Morocco (Deunff 1977). Upper Ordovician: U.S.A. (Jacobson 1978).

Baltisphaeridium latiradiatum (Eisenack) Staplin, Jansonius & Pocock 1965

Pl. IV:44 (Fig. 4. No. 69)

1959: *Baltisphaeridium longispinosum* forma *latiradiata* Eisenack, p. 110.

1965: *Baltisphaeridium latiradiatum* (Eisenack) Staplin, Jansonius & Pocock, p. 189.

Description: The spherical vesicle is fairly thick, with a shagrinate surface. The thin-walled processes are psilate and constricted at the proximal contact. They are more or less equal to the vesicle diameter in length. According to the diagnosis of Kjellström (1971a) they ought to be longer, but these specimens are assigned to *B. latiradiatum* on the grounds of identity on all other morphological criteria.

Dimensions: vesicle diameter 40 — 60 µm, lenght of processes 47 — 70 µm. Specimens measured: 14.

Occurrence: Rapla borehole, depths 188.6 — 136.0 m, Kunda Regional Stage, Sillaoru Formation to Keila Regional Stage, Lower to Middle Ordovician. Rare.

Previous records: Middle Ordovician: Finland (Tynni 1982); Sweden (Kjellström 1971a, 1972, 1976, Eisenack 1976, Górka 1987); Poland (Górka 1979). Ordovician Baltic erratics (Eisenack 1959, 1963, 1965a, 1968, 1969, Tynni 1975, Uutela 1989).

Baltisphaeridium longispinosum longispinosum (Eisenack 1951) Górka 1969

Pl. IV:45 (Fig. 4. No. 47)

1959: *Baltisphaeridium longispinosum* forma *filifera* Eisenack, p. 195.

1969: *Baltisphaeridium longispinosum longispinosum* (Eisenack 1951) Górka, pp. 34—35.

Description: The processes on the spherical vesicle are greater in length than the vesicle diameter. The vesicle and process surfaces are psilate or shagrinate.

Dimensions: vesicle diameter 57 — 64 µm, length of process 63 — 92 µm. Specimens measured: 58.

Occurrence: Rapla borehole, depths 189.0 — 36.8 m, Volhov Regional Stage to Pirgu Regional Stage, Adila Formation, Lower to Upper Ordovician. Rare to moderate.

Previous records: Lower Ordovician to Lower Silurian deposits in the Baltic area and Europe (Eisenack *et al.* 1973).

Baltisphaeridium maius n. sp.

Pl. V:50 (Fig. 4. No. 295)

Diagnosis: The spherical vesicle is very large and has processes which are smaller than the vesicle diameter, with acuminate distal terminations. The processes have an angular proximal contact and do not communicate with the vesicle interior. The surfaces of the vesicle and processes are microgranulate. Only one specimen was found, and this was broken. It is therefore impossible to state the number of processes the species has or whether it has a median split or a pylome.

Dimensions: vesicle diameted approx. 100 µm, length of process 65 µm, base diameter 13 µm. Specimens measured: 1.

Holotype: GSF Prep. 1058; Pl. V:50. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 76.0 m, Vormsi Regional Stage, Upper Ordovician. Rare.

Etymology: *maius*, from the Latin, 'greater'.

Comparison: Such a large *Baltisphaeridium* is a rarity. The only one described earlier is *B. bo-*

hemicum (Eisenack) Downie & Sarjeant 1963, but its numerous processes are narrower.

Baltisphaeridium microspinosum (Eisenack) Downie 1959

Pl. IV:46 (Fig. 4. No. 45)

1954: *Hystrichosphaeridium microspinosum* Eisenack, pp. 209—210.

1959: *Baltisphaeridium microspinosum* (Eisenack) Downie, p. 60.

Description: The thin-walled, spherical vesicle is large in size and has numerous short, delicate processes with acuminate distal terminations.

Dimensions: vesicle diameter 60 — 75 µm, length of process 7 — 9 µm. Specimens measured: 92.

Occurrence: Rapla borehole, depths 189.0 — 36.8 m, Volhov Regional Stage to Pirgu Regional Stage, Adila Formation, Lower to Upper Ordovician. Rare to moderate.

Previous records: Lower Ordovician to Upper Silurian deposits in the Baltic area and Europe (Eisenack *et al.* 1973).

Baltisphaeridium aff. *B. multiechinatum* Kjellström (1971) 1974

Pl. IV:47 (Fig. 4. No. 7)

Description: The spherical vesicle is covered with acuminate tubercles. The processes are psilate.

Dimensions: vesicle diameter 40 — 58 µm, length of process 25 — 55 µm. Specimens measured: 45.

Remarks: The species as presented by Kjellström (1971a) has slightly shorter and stouter processes and they are more numerous.

Occurrence: Rapla borehole, depths 189.9 — 151.0 m, Volhov Regional Stage to Idavere Regional Stage, Vasavere Formation, Lower to Middle Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Sweden (Kjellström 1971a). Ordovician Baltic erratics: Finland (Uutela 1989).

Baltisphaeridium multipilosum Eisenack (1931) 1958

Pl. VI:56 (Fig. 4. No. 33)

1931: *Ovum hispidum multipilosum* Eisenack, p. 111.

1958: *Baltisphaeridium multipilosum* Eisenack, p. 400.

Description: The thick-walled, spherical vesicle has a dense covering of short, thin processes. It is very much smaller in size than in the original diagnosis of Eisenack (1931) but fulfils all the other morphological criteria.

Dimensions: vesicle diameter 48 — 60 µm, length of process 13 — 15 µm. Specimens measured: 24.

Occurrence: Rapla borehole, depths 189.0 — 157.0 m, Volhov to Kukruse regional stages, Lower to Middle Ordovician. Rare to moderate.

Previous records: Lower Orodvician to Lower Silurian deposits in the Baltic area and Europe (Eisenack *et al.* 1973).

Baltisphaeridium nanninum Eisenack 1965

Pl. VI:57 (Fig. 4. No. 71)

1965: *Baltisphaeridium nanninum* Eisenack, p. 260.

Description: The spherical vesicle is covered with short, thin, hairy processes. These are 2 µm in length in some specimens, i.e. larger than in the specimens described by Kjellström (1971a) but very much shorter than in those of Górka (1987, Pl. II:45).

Dimensions: vesicle diameter 44 — 64 µm, length of process 1 — 2 µm. Specimens measured: 56.

Occurrence: Rapla borehole, depths 188.6 — 126.6 m, Kunda Regional Stage, Sillaoru Formation to Oandu Regional Stage, Lower to Middle Ordovician. Rare.

Previous records: Middle Ordovician: Sweden (Kjellström 1971a, 1976, Górka 1987); Finland (Tynni 1982). Upper Ordovician: Sweden (Eisenack 1968). Ordovician Baltic erratics: Finland (Tynni 1975, Uutela 1989). Lower Silurian: Sweden (Eisenack 1965a, Schultz 1967).

Baltisphaeridium oligopsakium Loeblich & Tappan 1978

Pl. VI:58 (Fig. 4. No. 72)

1978: *Baltisphaeridium oligopsakium* Loeblich & Tappan, p. 1252.

Description: The spherical vesicle has numerous processes, which are shorter than its diameter. There is an obvious plug at the distal contact of each process. The surfaces of both the vesicle and the processes are granulate.

Dimensions: vesicle diameter 48 — 75 µm, length of process 16 — 35 µm. Specimens measured: 18.

Occurrence: Rapla borehole, depths 188.6 — 78.0 m, Kunda Regional Stage, Sillaoru Formation to Vormsi Regional Stage, Lower to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Finland (Tynni 1982). Upper Ordovician: U.S.A. (Loeblich & Tappan 1978).

Baltisphaeridium onniense (Turner 1984) n. comb.

Pl. VI:59 (Fig. 4. No. 220)

1984: *Baltisphaerosum onniense* Turner, pp. 104—105.

Description: The spherical vesicle contains processes that are shorter in length than its diameter. The processes are thicker than those of *B. hirsutoides* Eisenack (1931) 1958. The surfaces of both the vesicle and the processes are psilate.

Remarks: The specimens of *B. onniense* in the Rapla material only exceptionally have a median split and are therefore attributed to the genus *Baltisphaeridium*.

Dimensions: vesicle diameter 50 — 62 µm, length of process 25 — 30 µm. Specimens measured: 6.

Occurrence: Rapla borehole, depths 146.2 — 46.0 m, Jõhvi Regional Stage to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare.

Previous records: Middle Ordovician: Britain (Turner 1984, 1985).

Baltisphaeridium parvigranosum Loeblich & Tappan 1978

Pl. VI:60 (Fig. 4. No. 129)

1978: *Baltisphaeridium parvigranosum* Loeblich & Tappan, pp. 1252—1253.

Description: The spherical vesicle has numerous processes of varying length, but always less than the vesicle diameter. Furcation of the processes is extremely rare. The surfaces of both the vesicle and the processes are tubercular. The species identified in the Rapla material is somewhat smaller than in the original diagnosis of Loeblich and Tappan (1978).

Dimensions: vesicle diameter 40 — 50 µm, length of process 10 — 34 µm. Specimens measured: 24.

Occurrence: Rapla borehole, depths 180.0 — 56.0 m, Lasnamägi Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Sweden (Górka 1987); U.S.A. (Loeblich & Tappan 1978).

Baltisphaeridium parvulisidereum Colbath 1979

Pl. VI:61 (Fig. 4. No. 3)

1979: *Baltisphaeridium parvulisidereum* Colbath, pp. 12—13.

Description: The subspherical vesicle has approx. 20 processes with an acuminate distal termination and a plug at the proximal contact. The process surfaces are echinate and that of the vesicle almost psilate.

Dimensions: vesicle diameter 40 — 65 µm, length of process 40 — 45 µm. Specimens measured: 19.

Occurrence: Rapla borehole, depths 189.9 — 167.0 m, Volhov to Kukruse regional stages, Lower to Middle Ordovician. Rare.

Previous records: Upper Ordovician: U.S.A. (Colbath 1979, 1980).

Baltisphaeridium pauciverrucosum Kjellström 1971

Pl. VI:62 (Fig. 4. No. 38)

1971: *Baltisphaeridium pauciverrucosum* Kjellström, p. 17.

Description: The spherical vesicle has numerous flagelliform processes which taper at the distal termination. Their length is more or less equal to the diameter of the vesicle. The vesicle has a shagrinate surface, but the processes are markedly verrucate.

Dimensions: vesicle diameter 40 — 60 µm, length of process 33 — 50 µm. Specimens measured: 12.

Occurrence: Rapla borehole, depths 189.0 — 111.0 m, Volhov to Rakvere regional stages, Lower to Middle Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Sweden (Kjellström 1971a, 1972); Britain Turner (1984). Ordovician Baltic erratics: Finland (Uutela 1989).

Baltisphaeridium perclarum Loeblich & Tappan 1978

Pl. VI:63 (Fig. 4. No. 210)

1978: *Baltisphaeridium perclarum* Loeblich & Tappan, p. 1253.

Description: The large spherical vesicle has 5—6 processes, some of which have a secondary branch. The species found in the Rapla material has shorter processes than in the original diagnosis, and the constriction is less obvious. The vesicle surface is psilate, the processes microgranulate and their secondary branches more markedly granulate.

Dimensions: vesicle diameter 50 — 70 µm, length of process 40 — 50 µm. Specimens measured: 4.

Occurrence: Rapla borehole, depths 150.0 — 98.0 m, Johvi Regional Stage to Nabala Regional Stage, Paekna Formation, Middle Ordovician. Rare.

Previous records: Upper Ordovician: U.S.A. (Loeblich & Tappan 1978, Wright & Meyers 1981).

Baltisphaeridium pseudocalicispinum Górka 1980

Pl. VI:64 (Fig. 4. No. 12)

1980: *Baltisphaeridium pseudocalicispinum* Górka, pp. 266—267.

Description: The spherical vesicle has numerous processes with acuminate distal terminations and an obvious plug at the proximal contact, but no constriction at the contact. The surfaces of the vesicle and processes are echinate.

Dimensions: vesicle diameter 54 — 60 µm, length of process 50 — 63 µm. Specimens measured: 71.

Occurrence: Rapla borehole, depths 189.9 — 28.0 m, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian. Rare to moderate.

Previous records: Middle Ordovician: Estonia (Bockelie & Kjellström 1979); Sweden (Kjellström 1971a, 1976, Górka 1987); Finland (Tynni 1982); Poland (Górka 1980). Ordovician Baltic erratics: Finland (Tynni 1975, Uutela 1989).

Baltisphaeridium pustulatum Kjellström 1971

Pl. VI:65 (Fig. 4. No. 109)

1971: *Baltisphaeridium pustulatum* Kjellström, pp. 18—20.

Description: The spherical vesicle and processes with acuminate distal terminations are densely granulate in texture. The processes do not exceed the vesicle diameter in length.

Dimensions: vesicle diameter 40 — 50 µm, length of process 25 — 30 µm. Specimens measured: 15.

Occurrence: Rapla borehole, depths 181.0 — 78.0 m, Aseri to Vormsi regional stages, Middle to Upper Ordovician. Rare.

Previous records: Middle Ordovician; Sweden (Kjellström 1971b, 1972); Finland (Tynni 1982).

Baltisphaeridium ramiferum n. sp.

Pl. V:51 (Fig. 4. No. 273)

Diagnosis: The spherical vesicle is thick-walled, with numerous processes (approx. 20), more or less equal in length to the diameter of the vesi-

cle. The processes are simple or bifurcated, with some branching still further. This furcation begins around the middle of the process or more distally. The broader among these heteromorphic processes show the greatest propensity for furcation. The distal terminations of the processes are acuminate and the proximal contact with the vesicle angular, and they do not communicate with the interior of the vesicle. The surfaces of the vesicle and processes are microgranulate. A median split is observed.

Dimensions: vesicle diameter 55 — 70 µm, lenght of process 30 — 50 µm, process base diameter 6 µm, distance between processes 20 — 25 µm. Specimens measured: 3.

Holotype: GSF Prep. 1070 (SEM); Pl. V:51. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 115.0 — 95.0 m, Rakvere Regional Stage to Nabala Regional Stage, Saunja Formation, Middle to Upper Ordovician. Rare.

Etymology: *ramiferum* from the Latin *ramus*, 'branch', + *-ferum*, suffix meaning 'bear, have'.

Comparison: Certain *Baltisphaeridium* species have furcation in some of their processes, e.g. *B. parvigranosum* Loeblich & Tappan 1978, in which this applies to the minority of them. *B. perclarum* Loeblich & Tappan 1978 and *B. bramkaense* Górka 1979 has broader, longer processes.

Baltisphaeridium trabeculaespinae Górka 1969

Pl. VI:66 (Fig. 4. No. 204)

1969: *Baltisphaeridium trabeculaespinae* Górka, p. 364.

Description: The spherical vesicle has numerous processes of a trabeculate structure. Otherwise the species resembles *B. hirsutoides* Eisenack (1931) 1958. The surfaces of the vesicle and processes are psilate.

Dimensions: vesicle diameter 60 — 62 µm, length of process 40 — 45 µm. Specimens measured: 7.

Occurrence: Rapla borehole, depths 151.0 — 70.0 m, Idavere Regional Stage, Vasavere Formation to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare.

Previous records: Middle Ordovician: Sweden (Górka 1987); Poland (Górka 1969, 1979, 1980); Canada (Legault 1982).

Baltisphaeridium tranvikensis Tynni 1982

Pl. VI:67 (Fig. 4. No. 31)

1982: *Baltisphaeridium tranvikensis* Tynni, p. 69.

Description: The spherical vesicle has about 40 conical processes with acuminate distal terminations and curved proximal contacts, which do not communicate with the vesicle interior. The processes vary in size within the same individual, but are at their longest no more than half the diameter of the vesicle. The surface of the vesicle around the processes is irregularly echinate with fine hexagonal protuberances, and the processes themselves feature a few small spines. The one specimen identified at Rapla is slightly smaller than in the type description from Tranvik in Finland (Tynni 1982).

Dimensions: vesicle diameter 38 — 50 µm, length of process 5 — 15 µm, medium lenght of process 12 µm, distance between processes approxim. 6 µm. Specimens measured: 8.

Occurrence: Rapla borehole, depths 189.0 — 168.0 m, Volhov to Uhaku regional stages, Lower to Middle Ordovician. Rare.

Previous records: Middle Ordovician: Finland (Tynni 1982).

Baltisphaeridium trichophorum (Eisenack) Kjellström 1971

Pl. VI:68 (Fig. 4. No. 35)

1965: *Baltisphaeridium multipilosum* f.*trichophora* Eisenack, pp. 135—136.

1971: *Baltisphaeridium trichophorum* (Eisenack) Kjellström, p. 40.

Description: The spherical vesicle has numerous short processes with a curved proximal contact. They are slightly shorter than in the original diagnosis of Kjellström (1971a). The vesicle surface is shagrinate and that of the processes psilate.

Dimensions: vesicle diameter 38 — 42 µm, length of process 4 — 11 µm. Specimens measured: 18.

Occurrence: Rapla borehole, depths 189.0 — 152.0 m, Volhov Regional Stage to Idavere Regional Stage, Tatruse Formation, Lower to Middle Ordovician. Rare.

Previous records: Lower Ordovician: Sweden (Kjellström 1971a). Ordovician Baltic erratics: Germany (Eisenack 1965a).

Baltisphaeridium aff. *B. trophirhapium* Loeblich & Tappan 1978

Pl. VI:69 (Fig. 4. No. 190)

Description: The processes on the spherical vesicle are smaller than the vesicle diameter. The distal termination of each process features a small echinate or blunt spinule. The surfaces of the vesicle and processes are microgranulate.

Dimensions: vesicle diameter 57 — 60 µm, length of process 48 — 52 µm, width of process 10 — 19 µm. Specimens measured: 4.

Remarks: *Baltisphaeridium trophirhapium* Loeblich & Tappan 1978 has smooth processes with blunt spinules.

Occurrence: Rapla borehole, depths 161.0 — 126.6 m, Kukruse to Oandu regional stages, Middle Ordovician. Rare.

Baltisphaeridium verrucatum Kjellström 1971

Pl. VI:70 (Fig. 4. No. 67)

1971: *Baltisphaeridium verrucatum* Kjellström, pp. 41—42.

Description: The spherical vesicle is thick and its surface granulate. There are about 10 granulate processes, less than in the original diagnosis of Kjellström (1971a). The vesicle has a median split.

Dimensions: vesicle diameter 52 — 54 µm, length of process 52 — 60 µm. Specimens measured: 15.

Occurrence: Rapla borehole, depths 188.6 — 146.2 m, Kunda Regional Stage, Sillaoru Formation to Jõhvi Regional Stage, Lower to Middle Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Sweden (Kjellström 1971a, Górka 1987); Finland (Tynni 1982). Ordovician Baltic erratics: Finland (Tynni 1975, Uutela 1989).

Baltisphaeridium sp.

Pl. V:52 (Fig. 4. No. 1)

Description: The spherical vesicle has numerous short, conical processes (about 50 in the optical section) with a plug at the proximal contact. The processes are about 1/6 of the vesicle diameter in length. The surfaces of the vesicle and processes are granualte.

Dimensions: vesicle diameter 28 — 40 µm, length of process 3 — 8 µm, distance between processes approx. 5 µm. Specimens measured: 11.

Occurrence: Rapla borehole, depths 189.9 — 184.0 m, Volhov Regional Stage to Kunda Regional Stage, Loobu Formation, Lower to Upper Ordovician. Rare.

Comparison: The processes of *Baltisphaeridium coutissianum* Martin 1968 are longer, more flagelliform and more markedly granulate. *B. hirsutoides* Eisenack (1931) 1958 has a psilate surface.

Genus *Buedingiisphaeridium* Schaarschmidt 1963, emend. Staplin 1965, Lister 1970

Buedingiisphaeridium balticum n. sp.

Pl. V:53 (Fig. 4. No. 75)

Diagnosis: The vesicle is spherical to subspherical, thin-walled and shagrinate. It is covered with regular hollow pyramidal outgrowths (approx. 50 in the optical section), usually small and of equal size. There is usually a solid nipple on the top of the outgrowth. No pylome or median split is recorded.

Dimensions: vesicle diameter 11 — 22 µm, length of process 1 — 3 µm, process base diameter 1 — 3 µm, distance between processes 2 — 4 µm. Specimens measured: 27.

Holotype: GSF prep. 1061 (SEM); Pl. V:53. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 188.6 — 40.0 m, Kunda Regional Stage, Sillaoru Formation to Pirgu Regional Stage, Adila Formation, Lower to Upper Ordovician. Rare.

Etymology: *balticum* from the neo-Latin 'Baltic'.

Comparison: Resembles *Tylotopalla caelamenicutis* Loeblich 1970, but lacks the radial straiation at the proximal contact of the processes which is typical of the genus *Tylotopalla*. It also partially resembles *Protosphaeridium fuscipetiolatum* Cramer & Díez 1977 (only individual Pl. 3:5), but this is very much larger in size and has more numerous, smaller and more irregular processes.

Previous records: Ordovician Baltic erratics: Finland (*Buedingiisphaeridium* sp. *In* Uutela 1989).

Buedingiisphaeridium guttiferum n. sp.

Pl. V:54 (Fig. 4. No. 263)

Diagnosis: The small, spherical vesicle has a dense covering of small, rounded tubercles of equal thickness. These tubercles have a radial striation at the base and are otherwise psilate. The surface of the vesicle is covered with rounded tubercles of irregular size. It is unclear whether the processes communicate with the interior of the vesicle. No median split has been observed.

Dimensions: vesicle diameter 9 — 10 µm, length of process 0.5 — 0.6 µm, process diameter 0.3 — 0.4 µm, distance between processes 0.3 — 0.5 µm. Specimens measured: 4.

Holotype: GSF Prep. 1078 (SEM); Pl. V:54. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 130.0 — 66.0 m, Keila Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare.

Etymology: *guttiferum* from the Latin *gutta,* 'drop', + *-ferum,* 'bear, have'.

Comparison: *Buedingiisphaeridium deerlijkianum* Martin 1974 is larger in size and has angular processes and a hairy surface.

Genus *Cheleutochroa* Loeblich & Tappan 1978

Cheleutochroa aff. *C. diaphorosa* Turner 1984

Pl. VI:71 (Fig. 4. No. 250)

Description: The small, subspherical vesicle has a reticulate surface. The processes are either simple or furcated and have a curved proximal contact.

Dimensions: vesicle diameter 10 µm, length of process 7 — 10 µm, length of pinnula 4 µm, number of processes 14. Specimens measured: 1.

Remarks: Furcation can take place at either one or two points on the process, i.e. it is more pronounced than in the diagnosis of *C. diaphorosa* Turner 1984.

Occurrence: Rapla borehole, depth 136.0 m, Keila Regional Stage, Middle Ordovician. Rare.

Cheleutochroa differta n. sp.

Pl. V:55 (Fig. 4. No. 236)

Diagnosis: The subspherical polygonal vesicle has numerous processes (about 40 in the optical section), the curved proximal contacts of which have almost fused together. The majority of the conical processes with acuminate distal terminations are simple, but some are bifurcated or trifurcated. The processes communicate with the interior of the vesicle, and their proximal contacts have radial striae which occupy the whole surface of the vesicle. The processes are otherwise microgranulate.

Dimensions: vesicle diameter 10 — 12 µm,

length of process 4 — 5 µm, process base diameter 2 — 3 µm. Specimens measured: 5.

Holotype: GSF Prep. 1091 (SEM); Pl. V:55. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 140.0 — 126.6 m, Keila to Oandu regional stages, Middle Ordovician. Rare.

Etymology: *differta* from the Latin, 'stuffed, full'.

Comparison: Differs from *Cheleutochroa diaphorosa* Turner 1984, the processes of which are less numerous, longer and more often furcated.

Cheleutochroa elegans n. sp.

Pl. VII:72 (Fig. 4. No. 309)

Diagnosis: The subspherical vesicle has flagelliform processes with acuminate distal terminations which occur at irregular intervals and are less than the diameter of the vesicle in length. Most of these processes are simple, but some are furcated, and even second order furcations are observed. The curved proximal contacts of the processes are surrounded by radial striae, and the surface of the vesicle has a reticulate pattern with tubercles.

Dimensions: vesicle diameter 20 — 22 µm, length of process 10 — 16 µm, number of processes 13 — 28. Specimens measured: 3.

Holotype: GSF Prep. 1037 (SEM); Pl. VII:72. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 52.0 — 36.1 m, Pirgu Regional Stage, Moe Formation to Porkuni Regional Stage, Upper Ordovician. Rare.

Etymology: *elegans* from the Latin, 'graceful, elegant'.

Comparison: Differs from *Cheleutochroa cymnobrachiata* Loeblich & Tappan 1978, the processes of which are stouter and have no furcations, nor are there any tubercles on the reticulate surface. Also resembles *Multiplicisphaeridium micraulaxum* Colbath 1979, although this lacks the reticulate surface.

Cheleutochroa gymnobrachiata Loeblich & Tappan 1978

Pl. XII:114 (Fig. 4. No. 111)

1978: *Cheleutochroa gymnobrachiata* Loeblich & Tappan, pp. 1254—1257.

1984: *Cheleutochroa meionia* Turner, p. 107.

Description: The small, spherical vesicle has a reticulate surface with about 10 psilate processes which communicate with the central vesicle interior. The Rapla species is markedly smaller than that described by Loeblich & Tappan (1978), but obviously attributable to the same species. The whole Rapla material is smaller in size than the specimens found elsewhere, so that considerable size variations have been allowed for in the identifications. *Cheleutochroa meionia* Turner 1984 (ø 12—19 µm) is regarded as a synonym.

Dimensions: vesicle diameter 17 — 20 µm, length of process 10 — 15 µm, number of processes 9 — 10. Specimens measured: 37.

Occurrence: Rapla borehole, depths 181.0 — 56.0 m, Aseri Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Britain (Turner 1984). Upper Ordovician: U.S.A. (Loeblich & Tappan 1978); Canada (Jacobson & Achab 1985).

Cheleutochroa oculata n. sp.

Pl. VII:73a, b (Fig. 4. No. 203)

Diagnosis: The spherical vesicle has 6—10 fairly stout heteromorphic processes of lengths which do not exceed the vesicle diameter. The processes are simple, bifurcated or with second-order furcations, the furcations being relatively thick and rigid. The processes communicate with the vesicle interior. The surface of the vesicle is foveolate, the foveoles possessing a radial striation. The processes are also striated, and a median split has been observed in the vesicle.

Dimensions: vesicle diameter 18 — 20 µm, length of process 11 — 17 µm, number of processes 6 — 10. Specimens measured: 14.

Holotype: GSF Prep. 1091 (SEM); Pl. VII:73a, b. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 151.0 — 72.0 m, Idavere Regional Stage, Vasavere Formation to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare.

Etymology: *oculata* from the Latin *oculus,* 'eye', + *-ata* 'having the nature of'.

Comparison: *Cheleutochroa gymnobrachiata* Loeblich & Tappan 1978 has a reticulate patterning on the vesicle, is not foveolate and its processes are thinner and simple throughout.

Cheleutochroa ramosa n. sp.

Pl. VII:74 (Fig. 4. No. 297)

Diagnosis: The small, subspherical vesicle has numerous processes with long, thin, flagelliform second order furcations. The vesicle surface has a reticulate pattern combined with radial striations on the process bases. The surfaces of the processes are psilate.

Dimensions: vesicle diameter 13 — 14 μm, length of process 6 — 7 μm, number of processes 12 — 13. Specimens measured: 8.

Holotype: GSF Prep. 1057 (SEM); Pl. VII:74. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 74.0 — 66.0 m, Pirgu Regional Stage, Moe Formation, Upper Ordovician. Rare.

Etymology: *ramosa* from the Latin *ramus,* 'branch'.

Comparison: Differs from *Cheleutochroa elegans* n. sp., the processes of which are less branched and the vesicle tuberculous as well as reticulate.

Cheleutochroa rugosa n. sp.

Pl. VII:75 (Fig. 4. No. 225)

Diagnosis: The hollow subcircular vesicle carries short, simple or bifurcated hollow processes which communicate freely with the vesicle interior. The process length does not exceed the vesicle diameter. The processes have acuminate distal terminations and a curved proximal contact with the vesicle. The vesicle surface is distinctly reticulate, but the reticulum breaks up in the vicinity of the processes to allow the muriform ridges to converge towards the base of each process. The processes are costate.

Dimensions: vesicle diameter 17 — 22 μm, length of process 10 — 18 μm, number of processes 10 — 12. Specimens measured: 10.

Holotype: GSF Prep. 1088 (SEM); Pl. VII:75. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 144.0 — 127.1 m, Keila Regional Stage, Middle Ordovician. Rare.

Etymology: *rugosa* from the Latin *ruga,* 'wrinkle', + *-osa,* 'full of'.

Comparison: Differs from *Cheleutochroa gymnobrachiata* Loeblich & Tappan 1978 (syn. *C. meionia* Turner 1984) in having bifurcated processes as well.

Cheleutochroa tuberculosa n. sp.

Pl. VII:76 (Fig. 4. No. 234)

Diagnosis: The small, practically spherical vesicle is pronouncedly tuberculate (tubercles of size 0.5 — 1.0 μm). The processes are simple, with acuminate distal terminations, radial ridges at the base and microgranulate surfaces.

Dimensions: vesicle diameter 13 — 17 μm, length of process 5 — 10 μm, number of processes 6 — 8. Specimens measured: 3.

Holotype: GSF Prep. 1093 (SEM); Pl. VII:76. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 140.0 — 130.0 m, Keila Regional Stage, Middle Ordovician. Rare.

Etymology: *tuberculosa* from the Latin *tuber,* 'a swelling, bulb', + *-culum,* diminutive, + *-osa,* 'full of'.

Comparison: Differs from *Cheleutochroa venosa* n. sp., which has a striated surface texture and more processes, and differs still more from the other *Cheleutochroa* species proposed to date. *Micrhystridium varispinosum* n. sp. lacks the radial ridges at the processes contacts.

***Cheleutochroa venosa* n. sp.**

Pl. VII:77 (Fig. 4. No. 211)

Diagnosis: The polygonal vesicle has numerous processes of varying length but short and with acuminate distal terminations, which are mostly simple but can occasionally be bifurcated. The pronounced radial striation setting out from the curved proximal contacts of the processes covers the whole surface of the vesicle. The surfaces of the processes are microgranulate.

Dimensions: vesicle diameter 8 — 13 µm, length of process 4 — 15 µm, number of processes 14 — 25. Specimens measured: 8.

Holotype: GSF Prep. 1093 (SEM); Pl. VII:77. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 150.0 — 82.0 m, Jõhvi to Vormsi regional stages, Middle to Upper Ordovician. Rare.

Etymology: *venosa* from the Latin *vena,* 'vein', + *-osa,* 'full of'.

Comparison: Differs from *Cheleutochroa venosior* n. sp., which has a more pronounced striation pattern and sturdier processes with rounded distal terminations.

***Cheleutochroa venosior* n. sp.**

Pl. VII:78 (Fig. 4. No. 215)

Diagnosis: The polygonal vesicle is covered with long, pronounced, elevated ridges and has less than 10 broad, simple or bifurcated processes. Some second-order bifurcations have also been seen. The furcations of the processes are intact, stout digital projections. The processes communicate with the interior of the vesicle. The ridges on the vesicle are covered by transverse striae and also have a dense reticulate pattern on their surface. The processes feature longitudinal striae.

Dimensions: vesicle diameter 18 — 25 µm, length of process 13 — 20 µm, number of processes 8 — 9. Specimens measured: 6.

Holotype: GSF Prep. 1093 (SEM); Pl. VII:78. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 146.2 — 130.0 m, Jõhvi to Keila regional stages, Middle Ordovician. Rare.

Etymology: *venosior* from the Latin *venosus,* 'veiny', + *-ior,* 'full of'.

Comparison: The vesicle of *Cheleutochroa rugosa* n. sp. also has a pronounced surface texture, but it is reticulate. The ridges on *C. venosa* n. sp. are psilate on the surface and the processes are short, with acuminate distal terminations.

Genus *Chlamydosphaeridia* Eisenack 1971

***Chlamydosphaeridia* sp.**

Pl. VII:79 (Fig. 4. No. 143)

Description: The outer surface of the spherical vesicle consists of a thin, undulating membrane. The surface is psilate. The pylome is round and has a thickening at the edge.

Dimensions: vesicle diameter 40 — 52 µm, pylome diameter 10 µm. Specimens measured: 5.

Occurrence: Rapla borehole, depths 178.0 — 138.0 m, Lasnamägi to Keila regional stages, Middle Ordovician. Rare.

Comparison: *Dicommopalla macadamii* Loeblich 1970 has a more even surface with a fine intersecting patterning detectable at high magnification. *Chlamydosphaerida baltica* Eisenack 1971 has more pronounced folding on the surface and is larger in size (ø 72 µm).

Genus *Comasphaeridium* Staplin, Jansonius & Pocock 1965

***Comasphaeridium bacillum* n. sp.**

Pl. VIII:80 (Fig. 4. No. 91)

Diagnosis: The spherical vesicle has numerous evenly-spaced, short, hairy processes (about 140 in the optical section) with curved proximal con-

tacts. The processes are solid. The surface of the vesicle is shagrinate and the vesicle has a median split.

Dimensions: vesicle diameter 25 — 33 µm, length of process 1.5 — 2.5 µm, distance between processes 3 — 4 µm. Specimens measured: 4.

Holotype: GSF Prep. 1122 (SEM); Pl. VIII:80. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 184.0 — 169.0 m, Kunda Regional Stage, Loobu Formation to Uhaku Regional Stages, Middle Ordovician. Rare.

Etymology: *bacillum* from the Latin *baculum,* 'staff, stick', + *-illum,* diminutive.

Comparison: Differs from *Baltisphaeridium castaneiforme* n. sp., the hollow processes on which are longer and thicker. *Filisphaeridium brevispinosum* Lister 1970 has processes of consistent thickness and without any curved proximal contact.

***Comasphaeridium* sp. 1.**

Pl. VIII:81 (Fig. 4. No. 187)

Description: The spherical vesicle has a dense covering of short, flagelliform processes of length about 1/5 of the vesicle diameter. These conical structures with acuminate distal terminations are practically joined together at their proximal contacts. They vary in width, the smallest being about 1/3 of the width of the largest, and show no particular organization in their distribution on the vesicle. The processes are of the same length regardless of their width. The vesicle and processes have psilate surfaces. No median split has been observed.

Dimensions: vesicle diameter 30 — 34 µm, length of process 4 — 6 µm, width of process 0.5 — 1.5 µm. Specimens measured: 10.

Occurrence: Rapla borehole, depths 163.0 — 36.8 m, Kukruse Regional Stage to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare.

Comparison: Differs from *Baltisphaeridium filosum* Kjellström 1971, the hollow, flagelliform processes of which are consistent in thickness and less numerous. The processes of *Elektoriskos orientis* Colbath 1979 are also of consistent thickness.

***Comasphaeridium* sp. 2.**

Pl. VIII:82 (Fig. 4. No. 258)

Description: The spherical vesicle possesses processes of two sizes, the larger ones being more sparsely distributed and the smaller ones densely distributed. The processes are simple, delicate structures and easily break off. The vesicle surface is shagrinate and the processes psilate. The pylome is rounded, and a pseudopylome has also been observed.

Dimensions: vesicle diameter 12 — 14 µm, length of process (longer) 1 µm, (shorter) 0.2 µm. Specimens measured: 4.

Occurrence: Rapla borehole, depths 132.0 — 111.0 m, Keila to Rakvere regional stages, Middle Ordovician. Rare.

Comparison: Differs from *Micrhystridium eatonensis* Downie 1959, which has processes of only one type distributed evenly over the vesicle.

Genus *Coronitesta* n. gen

Type species: *Coronitesta raplaensis* n. sp., designated here.

Other new species of the genus: *C. bicornis* and *C. triangularis*

Diagnosis: The small oval vesicle has two or three long, membraneous processes which are conical in shape and have acuminate distal terminations. The processes are greater in length than the longer dimension of the oval vesicle and do not communicate with the vesicle interior. The vesicle has a pylome surrounded by a »crown» of small conical spikes.

Etymology: *Coronitesta* from the Latin *corona,* 'crown', + *-testa,* 'urn, brick, shell, skull'.

Comparison: The genus *Triangulina* Cramer

1964 = *Tyligmasoma* Playford 1977 has three processes, but these are formed from the outer shell of the vesicle and there is no pylome. The vesicle is also very much larger. Specimens of the genus *Revinotesta* Vanguestaine 1974 are small in size and have a pylome, but they have no separate longer processes.

Coronitesta bicornis n. sp.

Pl. VIII:83a, b (Fig. 4. No. 276)

Diagnosis: The small, oval vesicle has two long processes at one end and a crown of numerous small spines at the other. The simple processes have broad base, but do not communicate with the vesicle inetrior. They are hollow, conical and membraneous, and are one and a half times greater than the longer dimension of the vesicle. The small spines surround a circular opening (pylome). The vesicle surface is granulate and the processes irregularly granulate.

Dimensions: vesicle diameter 7 — 10 µm, vesicle width 7 — 8 µm, length of process 11 — 13 µm, pylome diameter 3 µm. Specimens measured: 2.

Holotype: GSF Prep. 1077 (SEM); Pl. VIII:83a, b. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 111.0 m, Rakvere Regional Stage, Middle Ordovician. Rare.

Etymology: *bicornis* from the Latin *bis, bi-,* 'twice, two', + *-cornum,* 'horn'.

Comparison: Differs from *C. raplaensis* n. sp., which has three processes.

Coronitesta raplaensis n. sp.

Pl. VIII:84 (Fig. 4. No. 152)

Diagnosis: The small oval vesicle has two long processes on its longer sides, a slightly shorter process on one shorter side and a crown of 4—7 small spines opposite this. The simple processes are situated equatorially on the vesicle and perpendicular to each other, if the crown is counted as a process. They have such broad bases that they almost fused together, but they do not communicate with the vesicle interior. The processes are hollow, conical and membraneous. The longer ones are one and a half times greater than the longer dimension of the vesicle and the shorter ones equal to the longer dimension. The spines of the crown are one sixth of the longer side in length and appear to surround a circular opening (pylome). The vesicle surface is baculate and the processes irregularly granulate.

Dimensions: vesicle length 9 — 10 µm, vesicle width 7 — 8 µm, length of process: longer 13 — 15 µm, shorter 9 — 10 µm, pylome diameter 5 µm. Specimens measured: 77.

Holotype: GSF Prep. 1102 (SEM); Pl. VIII:84. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 178.0 — 58.0 m, Lasnamägi Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to common.

Etymology: *raplaensis* from Rapla borehole, + *-ensis,* 'belonging to'.

Comparison: *Micrhystridium robustum* Downie 1958 has more numerous and more flexible processes, while *M. tetraxis* Sarjeant 1960 has a psilate vesicle surface and more flexible processes. *Demorhethium lappaceum* Loeblich & Wicander 1976 has 5 to 7 processes which terminate in a ring of 4 to 6 small spinules and has bacules rising from the ridges on its vesicle surface. It differs from *Coronitesta bicornis* n. sp. in having three processes instead of two.

Coronitesta triangularis n. sp.

Pl. VIII:85 (Fig. 4. No. 228)

Diagnosis: The virtually triangular vesicle has processes attached to it with small bands at two corners. The third corner features two processes with a pylome between them, surrounded by smaller conical spinules. The processes are simple and conical in shape, narrowing to flagelliform at their distal terminations, and do not communicate with the vesicle interior. The surfaces of the vesicle and processes are echinate, as also are the spinules surrounding the pylome.

Dimensions: vesicle length 12 µm, vesicle width 10 µm, length of process 14 µm, pylome diameter 5 µm, length of spinules round the pylome 7 µm. Specimens measured: 1.

Holotype: GSF Prep. 1093 (SEM); Pl. VIII:85. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 140.0 m, Keila Regional Stage, Middle Ordovician. Rare.

Etymology: *triangularis* from the Latin *triangulus*, 'having three angles', + *-aris*, 'having the nature or quality of'.

Comparison: Differs from *Coronitesta bicornis* n. sp., which has two processes, and *C. raplaensis* n. sp., which has three processes. Also resembles *Tyligmasoma* sp. (Playford & Dring 1981), which has three processes and no pylome. The vesicle may be a bilayer structure, but this cannot be ascertained from the SEM image.

Genus *Costatilobus* Playford 1977

Costatilobus bulbosus n. sp.

Pl. VIII:86 (Fig. 4. No. 32)

Diagnosis: The vesicle is slightly polygonal and has 9—34 conical, hollow, bulbous processes with striated surfaces. The processes are equivalent to about 1/2 of the vesicle diameter in length and communicate with the vesicle interior. Some of them have a short distal bifurcation. The surface of the vesicle is shagrinate, and a median split has been observed.

Dimensions: vesicle diameter 48 — 70 µm, length of process 30 — 35 µm. Specimens measured: 58.

Holotype: GSF Prep. 1125 (SEM); Pl. VIII:86. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 189.0 — 161.0 m, Volhov to Kukruse regional stages, Lower to Middle Ordovician. Rare to moderate.

Etymology: *bulbosus* from the Latin *bulbus*, 'a swelling', + *-osus*, 'full of'.

Comparison: Differs from *Goniosphaeridium mochtiensis* (Górka 1969), the processes of which are not striated. *Costatilobus undulatus* Playford 1977 has longer processes which are less numerous and a rugulate or rugulate to granulate vesicle surface. *Duplicisphaeridium spinigerum* Górka (1969) 1987 has a spiny surface to its processes and a reticulate vesicle, and the processes do not communicate with the vesicle interior.

?Costatilobus grandispinosus n. sp.

Pl. VIII:87 (Fig. 4. No. 241)

Diagnosis: The small, spherical vesicle has numerous long, slightly flagelliform processes with acuminate or slightly rounded distal terminations. The homomorphic processes are simple and identical in length and their surfaces carry a longitudinal striation and microgranulation. The vesicle surface is rough and uneven. The processes are assumed from their broad proximal contacts to communicate with the interior of the vesicle. If they do not, the species may be identified to the genus *Lanveocia* Deunff 1978.

Dimensions: vesicle diameter 10 — 12 µm, length of process 15 — 17 µm, process base diameter 3 µm, number of processes 10 — 12. Specimens measured: 6.

Holotype: GSF Prep. 1093 (SEM); Pl. VIII:87. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 140.0 — 102.0 m, Keila Regional Stage to Nabala Regional Stage, Paekna Formation, Middle Ordovician. Rare.

Etymology: *grandispinosus* from the Latin *grandis*, 'great', + *spinosus*, 'spiny'.

Comparison: Differs from *Costatilobus undulatus* Playford 1977, which is larger in size and has processes which vary in length on the same individual.

?Costatilobus trifidus n. sp.

Pl. IX:88 (Fig. 4. No. 259)

Diagnosis: The triangular vesicle has a simple

process at each corner with a straited surface. The vesicle surface is uneven. The processes probably communicate with the interior of the vesicle.

Dimensions: vesicle diameter 20 — 22 µm, length of process 20 — 24 µm. Specimens measured: 5.

Holotype: GSF Prep. 1088 (SEM); Pl. IX:88. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 130.0 m, Keila Regional Stage, Middle Ordovician. Moderate.

Etymology: *trifidus* from the Latin *tri-* (from *tres*) 'three' + *-fid-*, stem of *findere*, 'to split'.

Comparison: The form of the vesicle is reminiscent of the genera *Veryhachium* Deunff 1954 and *Arkonia* Burmann 1970, except that the surface texture of these does not include longitudinal striation on the processes. The diagnosis of the genus *Costatilobus* Playford 1977 presupposes a spherical or almost spherical vesicle. The specimen described here may well be a borderline case.

Genus *Cycloposphaeridium* n. gen

Type species: *Cycloposphaeridium auriculatum* n. sp., designated here.

Diagnosis: The vesicle is double-walled, consisting of a spherical inner body to which are attached numerous, irregularly spaced flat membraneous outer wall processes. The circular pylome is 1/3 of the diameter of the vesicle.

Etymology: *Cycloposphaeridium* from the Latin *Cyclops*, 'mythical one-eyed giant', + *-sphaera* (Gr. *sphaira)*, 'ball', + *-idium* (Gr. *-idion)*, diminutive.

Comparison: The genus differs from *Pterospermopsis* W. Wetzel 1952 in having numerous membraneous extensions not only equatorially but all over on the vesicle surface. Also, *Pterospermopsis* has no pylome. The genera *Polyancistrodorus* Loeblich & Tappan 1969 and *Asketopalla* Loeblich & Tappan 1969 have hollow processes, not flat ones.

Cycloposphaeridium auriculatum n. sp.

Pl. IX:89a, b. (Fig. 4. No. 61)

Diagnosis: The numerous membraneous processes are flat, have circular, indented edges and are constricted proximally. The processes are about a half of the vesicle diameter in length. The vesicle surface and processes are irregularly microechinate. The circular pylome measures one third of the vesicle diameter.

Dimensions: vesicle diameter 30 — 35 µm, length of process 15 — 20 µm, pylome diameter 10 — 11 µm. Specimens measured: 10.

Holotype: GSF Prep. 1125 (SEM); Pl. IX:89a,b. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 188.6 — 181.0 m, Volhov to Aseri regional stages, Lower to Middle Ordovician. Rare.

Etymology: *auriculatum* from the Latin *auris*, 'ear', *auricula*, diminutive, 'lobe of the ear', + *-atum*, 'having the nature of'.

Comparison: Differs from *Polyancistrodorus phylloides* n. sp. which has petaloidal processes, not flat, foliate ones.

Genus *Cymatiosphaera* O. Wetzel 1933, emend. Deflandre 1954

?Cymatiosphaera aseriensis n. sp.

Pl. IX:90 (Fig. 4. No. 115)

Diagnosis: The small, spherical vesicle consists of a set of »cups» composed of thin, reticulate walls and forming polygons of varying shapes and sizes. These walls are attached to one another but come apart easily.

Dimensions: vesicle diameter 7 — 10 µm, polygon diameter approx. 2 µm, wall height 1 µm,

number of polygons in the optical section 18 — 29. Specimens measured: 3.

Holotype: GSF Prep. 1118 (SEM); Pl. IX:90. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 180.3 m, Aseri Regional Stage, Middle Ordovician. Rare.

Etymology: *aseriensis* from the Estonian Aseri Regional Stage, + *-ensis,* from the Latin 'belonging to'.

Comparison: Since the polygons are composed of easily removable »cups», the identification of this species to the genus *Cymatiosphaera* is somewhat uncertain. The porous, reticulate walls have not been seen in other species. The partial porrosity of the walls in *C. minima* n. sp. may be a consequence of erosion.

Cymatiosphaera crispa n. sp.

Pl. IX:91 (Fig. 4. No. 237)

Diagnosis: The low, undulating folds of the muri of the spherical vesicle form fixed lacunae of varying sizes. The base of each lacuna contains a protrusion which practically covers it. Both the bases and the muri of the lacunae are psilate.

Dimensions: vesicle diameter 8 — 9 µm, lacuna diameter 2 — 3 µm, heigth of muri approx. 1 µm, number of polygons in the optical section 16 — 22. Specimens measured: 4.

Holotype: GSF Prep. 1093 (SEM); Pl. IX:91. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 140.0 — 111.0 m, Keila to Rakvere regional stages, Middle Ordovician. Rare.

Etymology: *crispa,* from the Latin, 'wrinkled, curled'.

Comparison: The swelling in the polygon of *Cymatiosphaera maculosiverticilla* Wicander & Loeblich 1977 consists of three distinct rings, while the muri and polygon base in *C. aseriensis* n. sp. are evenly reticulate. *C. miocaemica* Hajós 1966 has folded muri and only a small internal swelling.

Cymatiosphaera keilaensis n. sp.

Pl. IX:92 (Fig. 4. No. 238)

Diagnosis: The surface of the polygonal vesicle features polygonal depressions, or lacunae, of varying sizes, the bases of which are shallow and psilate and the muri about 1 µm in thickness.

Dimensions: vesicle diameter 10 — 14 µm, diameter of lacuna 4 — 9 µm, height of murus approx. 2 µm, number of lacunae in the optical section 4 — 10. Specimens measured: 3.

Holotype: GSF Prep. 1093 (SEM); Pl. IX:92. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 140.0 — 111.0 m, Keila to Rakvere regional stages, Middle Ordovician. Rare.

Etymology: *keilaensis* from the Estonian Keila Regional Stage, + *-ensis,* from the Latin, 'belonging to'.

Comparison: Differs from *Cymatiosphaera latimurata* n. sp., in which the lacunae are deeper and the muri dividing them stand out clearly.

Cymatiosphaera latimurata n. sp.

Pl. IX:93 (Fig. 4. No. 233)

Diagnosis: The practically spherical vesicle features thick-walled polygonal lacunae of varying sizes. The bases of these have irregular tubercles and the upper parts of the muri are slightly crimped.

Dimensions: vesicle diameter 16 — 18 µm, diameter of lacuna 3 — 6 µm, height of murus approx. 2 µm, lacunae in the optical section 9 — 11 µm. Specimens measured: 4.

Holotype: GSF Prep. 1093 (SEM); Pl. IX:93. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 140.0 — 136.0 m, Keila Regional Stage, Middle Ordovician. Rare.

Etymology: *latimurata* from the Latin *latus,* 'broad', + *-murus,* 'wall', + *-ata,* 'having the nature of'.

Comparison: Differs from *Cymatiosphaera nabalaensis* n. sp., the muri of which are thinner and the tubercles in the lacunae more regularly distributed and smaller in size.

Cymatiosphaera minima n. sp.

Pl. IX:94 (Fig. 4. No. 212)

Diagnosis: The small, spherical vesicle has a pattern of lacunae formed by high, perpendicular muri. The muri and lacunae are microgranulate, and the pore visible in them may be attributable to erosion.

Dimensions: vesicle diameter 8 µm, diameter of lacuna 3 µm, lacunae in the optical section 7. Specimens measured: 1.

Holotype: GSF Prep. 1097 (SEM); Pl. IX:94. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 146.2 m, Jõhvi Regional Stage, Middle Ordovician. Rare.

Etymology: *minima* from the Latin, 'least'.

Comparison: Differs from *?Cymatiosphaera aseriensis* n. sp., the polygonal »cups» of which are structurally looser, smaller in size, shallower and more numerous.

Cymatiosphaera nabalaensis n. sp.

Pl. IX:95 (Fig. 4. No. 257)

Diagnosis: The polygonal vesicle is formed of 4—6 angular »cups» attached to each other by their muri. These lacunae vary in size, with the rectangles usually the smallest. The bases of the lacunae have a tuberculate or reticulate patterning, while the muri are finely striated and microfolded at their upper edges.

Dimensions: vesicle diameter 18 — 22 µm, diameter of lacuna 2 — 9 µm, height of murus 2 — 3 µm, lacunae in the optical section 13. Specimens measured: 7.

Holotype: GSF Prep. 1073 (SEM); Pl. IX:95. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 136.0 — 56.0 m, Keila Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare.

Etymology: *nabalaensis* according to the holotype, from the Estonian Nabala Regional Stage, + *-ensis,* from the Latin, 'belonging to'.

Comparison: Differs from *Cymatiosphaera latimurata* n. sp., the muri of which are stouter and the whole structure more solid.

Cymatiosphaera pavimenta Deflandre (1945) 1954

Pl. XII:115 (Fig. 4. No. 78)

1945: *Micrhystridium pavimentum* Deflandre, p. 68.

1954: *Cymatiosphaera pavimenta* Deflandre, p. 258.

Description: The spherical vesicle is covered by regular pentagonal lacunae, which can be up to 50% of the vesicle diameter in depth. The vesicle surface is psilate or shagrinate and the muri psilate. The dimensions correspond to those described by Downie (1959).

Dimensions: vesicle diameter 10 — 20 µm, diameter of lacuna 3 — 6 µm, height of muri 2 — 5 µm. Specimens measured: 25.

Occurrence: Rapla borehole, depths 188.6 — 36.1 m, Kunda Regional Stage, Sillaoru Formation to Porkuni Regional Stage, Lower to Upper Ordovician. Rare.

Previous records: Ordovician, Silurian and Lower Devonian deposits in Europe (Eisenack *et al.* 1973).

Cymatiosphaera rakverensis n. sp.

Pl. X:96 (Fig. 4. No. 268)

Diagnosis: The polygonal vesicle features a pattern of shallow pentagonal or hexagonal lacunae, the bottoms and muri of which are shagrinate, while the outer edges of the muri possess acuminate, bulbous or bifurcated tubercles of size 1/3 — 1/2 µm.

Dimensions: vesicle diameter 8 — 14 µm, diameter of lacuna 4 — 5 µm, height of murus approx. 2 µm, lacunae in the optical section 4 — 5. Specimens measured: 2.

Holotype: GSF Prep. 1077 (SEM); Pl. X:96. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 121.0 — 111.0 m, Rakvere Regional Stage, Middle Ordovician. Rare.

Etymology: *rakverensis* from the Estonian Rakvere Regional Stage, + *-ensis,* from the Latin 'belonging to'.

Comparison: Differs from *Cymatiosphaera serrata* n. sp., the muri of which are higher and have serrated upper edges.

Cymatiosphaera serrata n. sp.

Pl. X:97 (Fig. 4. No. 315)

Diagnosis: The polygonal vesicle is slightly

elongated and its muri are high, with uneven, virtually serrated outer edges.

Dimensions: length of vesicle 14 µm, width of vesicle 15 µm, max. diameter of lacuna 9 µm, height of murus 5 µm, lacunae in the optical section 5. Specimens measured: 1.

Holotype: GSF Prep. 1038 (SEM); Pl. X:96. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 36.8 m, Pirgu Regional Stage, Adila Formation, Upper Ordovician. Rare.

Etymology: *serrata* from the Latin *serra,* 'saw', + *-ata,* 'having the nature of'.

Comparison: Differs from *Cymatiosphaera rakverensis* n. sp., the muri of which are lower and have smaller tubercles on their outer edges. *Polyedryxium bathyaster* Deunff 1961 has the same type of serrated edge to its murus, but the muri themselves are lower and the vesicle surface granulated. It is also very much larger (ø 92 — 95 µm).

***Cymatiosphaera* sp.**

Pl. X:98 (Fig. 4. No. 158)

Description: The thickish walls of the spherical vesicle form regular pentagons. The outer edges of the muri are markedly tuberculate, and some of the tubercles bifurcated. Similar tubercles are found on the bases of the lacunae, but the vesicle itself and its walls are shagrinate.

Dimensions: vesicle diameter 18 µm, diameter of lacuna 7 µm, height of murus 3 µm, lacunae in the optical section 8. Specimens measured: 1.

Occurrence: Rapla borehole, depth 176.0 m, Lasnamägi Regional Stage, Middle Ordovician. Rare.

Comparison: Resembles *Cymatiosphaera rakverensis* n. sp., which has the same type of ornamentation on the edges of its muri but shagrinate bases to the lacunae. *Cymatiosphaera pavimenta* Deflandre (1945) 1954 is psilate on the surface but otherwise resembles the present species morphologically.

Genus *Dactylofusa* Brito & Santos 1965, emend. Combaz *et al.* 1967, restr. Cramer 1970

***Dactylofusa lasnamaegiensis* n. sp.**

Pl. X:99 (Fig. 4., No. 133)

Diagnosis: The vesicle is fusiform, i.e. elongated and with pointed poles of different size, one being 1/2 — 2/3 longer than the other. The vesicle bears numerous short, claviform processes of equal thickness and has 3—6 small spines on its distal termination. The processes are less numerous and smaller on the pointed poles. They are not distinctly situated in longitudinal rows, and they are hollow, communicate freely with the vesicle cavity and have angular contacts. The vesicle surface and processes are psilate. No excystment structure is observed.

Dimensions: vesicle lenght 56 — 63 µm, vesicle width 21 — 27 µm, length of smaller pole 5 — 8 µm,, length of longer pole 10 -15 µm, total length 70 — 76 µm, max. length of process 2 — 3 µm. Specimens measured: 12.

Holotype: GSF Prep. 1115 (SEM); Pl. X:99. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 178.0 m, Lasnamägi Regional Stage, Middle Ordovician. Rare.

Etymology: *lasnamaegiensis* from the Estonian Lasnamägi Regional Stage, + *-ensis,* from the Latin, 'belonging to'.

Comparison: Differs from *Dactylofusa maranhensis* Brito & Santos 1965 in the form of its vesicle, which has more distinct poles and more irregular processes. The genus *Pheoclosterium* Tappan & Loeblich 1971 has no pointed poles. *Poikilofusa spinata* Loeblich & Tappan 1978 has simple acuminate processes arranged in short rows.

Genus *Dasydorus* Playford & Martin 1984

Dasydorus cirritus Playford & Martin 1984

Pl. XII:116 (Fig. 4. No. 34)

1984: *Dasydorus cirritus* Playford & Martin, p. 198.

Description: 3/4 of the surface of the ovular vesicle is covered by short, evexate or slightly branched processes, the remaining, more tapering area being devoid of processes. The vesicle surface is psilate or covered by small tubercles.

Dimensions: vesicle length 35 — 44 µm, vesicle width 23 — 27 µm, length of process 2 — 4 µm. Specimens measured: 15.

Occurrence: Rapla borehole, depths 189.0 — 154.0 m, Volhov Regional Stage to Idavere Regional Stage, Tatruse Formation, Lower to Middle Ordovician. Rare.

Previous records: Lower Ordovician: Britain (Molyneux 1987). Lower and Middle Ordovician: Australia (Playford & Martin 1984).

Genus *Dicommopalla* Loeblich 1970

Dicommopalla macadamii Loeblich 1970

Pl. XII:117 (Fig. 4. No. 169)

1970: *Dicommopalla macadamii* Loeblich, pp. 39—43.

Description: The thin outer shell of the double-layered spherical or almost spherical vesicle forms a veil around it. The pylome has a distinct neck, and some specimens have two pylomes. The specimens found here are smaller than those described by Loeblich (1970).

Dimensions: vesicle diameter 40 — 51 µm, pylome diameter 8 — 13 µm. Specimens measured: 25.

Occurrence: Rapla borehole, depths 173.0 — 50.0 m, Uhaku Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare.

Previous records: Upper Ordovican: U.S.A. (Loeblich 1970b, Jacobson 1978, Colbath 1979, 1980). Ordovician: Canada (Martin 1983). Ordovician Baltic erratics: Finland (Tynni 1975, Uutela 1989).

Genus *Dictyosphaeridium* W. Wetzel 1952

Dictyosphaeridium reticulatum n. sp.

Pl. X:100 (Fig. 4. No. 105)

Diagnosis: The spherical to subspherical vesicle bears a dense cover of short, simple conical processes with curved vesicle contacts. The processes probably communicate with the vesicle interior. Process length is 1/5 of the vesicle diameter. The bases of the processes and vesicle surface are decorated with a dense, radiating reticular ornamentation. The processes are microgranulate.

Dimensions: vesicle diameter 10 — 12 µm, length of process approx. 2 µm. Specimens measured: 9.

Holotype: GSF Prep. 1093 (SEM); Pl. X:100. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 182.0 — 66.0 m, Aseri Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare.

Etymology: *reticulatum* from the Latin *rete,* 'net', + *-culum,* diminutive, + *-atum,* 'having the nature of'.

Comparison: Resembles *Micrhystridium parvulum* n. sp., except that the latter has a psilate vesicle and process surface.

Genus *Dictyotidium* Eisenack 1955, emend. Staplin 1961

Dictyotidium multipolygonatum n. sp.

Pl. X:101 (Fig. 4. No. 200)

Diagnosis: The spherical or subspherical vesicle has a double-layered shell, the outer layer of which consists of a polygonal network which is attached to the inner shell of the pillars. The polygons are usually hexagonal, but irregular patterns are also found. Conical pillars are located at the intersections of the polygons.

Dimensions: vesicle diameter 8 — 14 µm, polygon diameter 0.5 — 3.0 µm. Specimens measured: 7.

Holotype: GSF Prep. 1077 (SEM); Pl. X:101. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 154.0 — 28.0 m, Idavere Regional Stage, Tatruse Formation to Juuru Regional Stage, Middle Ordovician to Lower Silurian. Rare.

Etymology: *multipolygonatum* from the Latin *multus,* 'numerous, many', + *polygonum,* 'many angles', + *-atum,* 'having the nature of'.

Comparison: Resembles *Dictyotidium stenodictyotum* Eisenack 1965, although the latter is very much larger and does not have a double shell.

Dictyotidium oculatum n. sp.

Pl. X:102 (Fig. 4. No. 307)

Diagnosis: The spherical vesicle is covered by a thick wall forming a network. This is normally attached to the vesicle, but can in places form arches, which may be secondary. The areoles are rounded or elongated and vary greatly in size. The vesicle surface and network are shagrinate. A median split has been observed.

Dimensions: vesicle diameter 10 — 20 µm, areole diameter 0.5 — 2.0 µm. Specimens measured: 4.

Holotype: GSF Prep. 1043 (SEM); Pl. X:102. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 58.0 — 38.0 m, Pirgu Regional Stage, Moe to Adila Formations, Upper Ordovician. Rare.

Etymology: *oculatum* from the Latin *oculus,* 'eye', + *-atum,* 'having the nature of'.

Comparison: Differs from *Dictyotidium torosum* Playford 1981, which has areoles of a size smaller than the thickness of the polygonal wall.

Dictyotidium torosum? Playford 1981

Pl. XII:118 (Fig. 4. No. 311)

Description: The small vesicle is almost spherical. The low walls form a dense, irregular polygonal pattern around the it. The polygons are extremely small in size, often of diameter less than the thickness of the polygonal wall.

Dimensions: vesicle diameter 12 µm. Specimens measured: 1.

Remarks: *D. torosum* Playford 1981 has a very thick shell, but the thickness of the present specimen is not known as it was found only in an electron microscope preparation. The Rapla specimen is very much smaller in size than *D. torosum.*

Occurrence: Rapla borehole, depth 46.0 m, Pirgu Regional Stage, Adila Formation, Upper Ordovician. Rare.

Dictyotidium venosum n. sp.

Pl. X:103 (Fig. 4. No. 277)

Diagnosis: The spherical polygon is divided into polygons of variable size by shallow membranes, the bottoms of the polygons being densely covered by rounded tubercles of varying size. The membrane walls are psilate and the small filaments by which they are attached to the vesicle can be detected in places. A median split can be seen.

Dimensions: vesicle diameter 13 µm, height of membrane approx. 1 µm, number of polygons in the optical section 5. Specimens measured: 1.

Holotype: GSF Prep. 1077 (SEM); Pl. X:103. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 111.0 m, Rakvere Regional Stage, Middle Ordovician. Rare.

Etymology: *venosum* from the Latin *vena,* 'vein', + *-osum,* 'full of'.

Comparison: Differs from *Lophosphaeridium disparipelliculum* Playford & Martin 1984, which lacks the shallow dividing walls and is considerably larger in size. *Kundasphaera lacunosa* n. sp. has a microgranulate bottom to the polygons and not tubercular.

Dictyotidium sp. 1.

Pl. X:104 (Fig. 4. No. 292)

Description: The spherical vesicle has small, round or pointed tubercles with a network of thin gathering fibres between them. The patterning of the network varies from triangular to pentangular. The tubercular bed is usually porous, but not always, so that this may be a secondary feature.

Dimensions: vesicle diameter 16.5 µm, height of tubercles 0.5 µm, distance of nots of net 1.6 µm. Specimens measured: 1.

Occurrence: Rapla borehole, depth 82.0 m, Vormsi Regional Stage, Upper Ordovician. Rare.

Comparison: Differs from *Dictyotidium dictyotum* (Eisenack 1938), the polygons on which have higher dividing walls and which is also considerably larger in size.

Dictyotidium sp. 2.

Pl. XI:105 (Fig. 4. No. 224)

Description: The spherical vesicle is small in size and covered by shallow polygons, usually 5 or 6-sided, although irregular combinations are also found.

Dimensions: vesicle diameter 7 — 9 µm, polygon diameter approx. 1 µm, height of polygon-wall 0.5 µm. Specimens measured: 2.

Occurrence: Rapla borehole, depths 145.5 — 111.0 m, Keila to Rakvere regional stages, Middle Ordovician. Rare.

Comparison: Differs from *Labyrinthosphaeridium curvatum* n. sp., in which the shallow walls form a labyrinthine pattern rather than a polygonal one.

Genus *Dilatisphaera* Lister 1970

Dilatisphaera complicata n. sp.

Pl. XI:106 (Fig. 4. No. 141)

Diagnosis: The spherical vesicle has numerous short, cylindrical processes which are open at the distal end (approx. 60 in the optical section). These are irregularly distributed over the vesicle, often fused together in pairs or groups of as many as four at a time. The surfaces of the vesicle and processes are psilate.

Dimensions: vesicle diameter 10 — 16 µm, length of process 0.5 — 0.8 µm, process diameter 0.5 — 0.8 µm, distance between prosesses 0 — 4.0 µm. Specimens measured: 3.

Holotype: GSF Prep. 1116 (SEM); Pl. XI:106. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 178.0 — 175.0 m, Lasnamägi to Uhaku regional stage, Middle Ordovician. Rare.

Etymology: *complicata* from the Latin *complico,* 'to fold or tie together'.

Comparison: Differs from *Dilatisphaera tubulifera* n. sp., the longer processes of which are regularly spaced over the vesicle and have not be seen to fuse together.

Dilatisphaera nanofurcata n. sp.

Pl. XI:107 (Fig. 4. No. 36)

Diagnosis: The small, spherical vesicle has a dense covering involving numerous short, cylindrical processes (about 80 — 100 in optical section) which are open at their distal end. They do not communicate with the interior of the vesicle.

The surfaces of the vesicle and processes are shagrinate. The vesicle has been observed to possess a median split.

Dimensions: vesicle diameter 14 — 22 µm, length of process 1.7 — 3.0 µm, process diameter 0.5 — 1.0 µm, distance between processes 1.5 — 2.0 µm. Specimens measured: 11.

Holotype: GSF Prep. 1116 (SEM); Pl. XI:107. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 189.0 — 151.0 m, Volhov Regional Stage to Idavere Regional Stage, Vasavere Formation, Lower to Middle Ordovician. Rare.

Etymology: *nanofurcata* from the Latin *nanus,* 'dwarf', + *-furca,* 'fork', + *-ata,* 'having the nature of'.

Comparison: Differs from *Dilatisphaera tubulifera* n. sp., which has thicker and less numerous processes.

***Dilatisphaera tubulifera* n. sp.**

Pl. XI:108 (Fig. 4. No. 46)

Diagnosis: The small, hollow vesicle bears numerous subcylindrical processes which are open distally (60 in optical section). Their length is 1/10 of the vesicle diameter. The processes do not communicate with the vesicle interior, but have an angular vesicle contact. The vesicle surface is psilate or shagrinate and the processes are psilate. No excystment structure is observed.

Dimensions: vesicle diameter 14 — 15 µm, length of process approx. 2 µm, process diameter 1 µm. Specimens measured: 12.

Holotype: GSF Prep. 1038 (SEM); Pl. XI:108. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 189.0 — 36.1 m, Lasnamägi Regional Stage to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare.

Etymology: *tubulifera* from the Latin *tubus,* 'pipe', + *-ulus,* diminutive, + *-fera,* 'bearing, having'.

Comparison: *Dilatisphaera laevigata* Lister 1970 and *Dilatisphaera (Hystrichosphaeridium) willierae* (Martin) Lister 1970 have larger and less numerous processes.

Genus *Domasia* Downie 1960

***Domasia spinosa* n. sp.**

Pl. XI:109 (Fig. 4. No. 293)

Diagnosis: The oval vesicle has three larger processes, the longest of which is located at the posterior pole and the other two anteriorly. The processes are long, flagelliform and broader at the proximal contact. The distal terminations of the anterior processes are thin and flagelliform. The vesicle also has a number of short, simple, irregularly distributed processes. The anterior end bears a corona of small spines, the crack at the centre of which may be of secondary origin. The vesicle surface is clearly granulated, there are distinct smooth rings at the junctions of the processes and the processes are microgranulated at the base and slightly more strongly so in their distal parts. The smaller processes are microgranulated throughout.

Dimensions: vesicle length 11 µm, vesicle width 8 µm, length of posterior processes 14 µm, length of anterior process 10 µm, diameter of corona circle 5 µm. Specimens measured: 1.

Holotype: GSF Prep. 1061 (SEM); Pl. XI:109. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 82.0 m, Vormsi Regional Stage, Upper Ordovician. Rare.

Etymology: *spinosa* from the Latin *spina,* 'thorn', + *-osa,* 'full of'.

Comparison: Differs from *Domasia elongata* Downie 1960, in which the posterior process is shorter than the others and elongated in form and the smaller additional processes are absent.

Genus *Estiastra* Eisenack 1959

***Estiastra* sp.**

Pl. XI:110 (Fig. 4. No. 300)

Description: The vesicle is star-shaped in three dimensions, with 4—6 points. In the 4-pointed form the sharp-pointed conical processes are at an ange of approx. 120° to each other. The sides of the vesicle between the tips of the processes are relatively straight and form an obtuse angle about half-way along. In the 6-pointed form the processes extend in six directions at equal intervals, at an angle of 120°. The vesicle is delicate and thin-walled, and collapses upon drying. The surface is weakly granulated and the tips of the processes dark in colour.

Dimensions: total diameter 120 — 260 µm. Specimens measured: 5.

Occurrence: Rapla borehole, depths 68.0 — 37.4—5 m, Pirgu Regional Stage, Moe Formation, Upper Ordovician. Rare. The species is large in size, and was found only in J. Nõlvak's Chitinozoa preparations.

Comparison: *Estiastra magna* Eisenack 1959 is similar in dimensions, but its processes are broader at the base.

E. granulata Downie 1963 has more processes. *Veryhachium rhombispinosum* Tynni 1982 is a smaller form. *Goniosphaeridium oligospinosum* Eisenack (1934) 1969 has blunter processes.

Genus *Excultibrachium* Loeblich & Tappan 1978

***Excultibrachium* cf. *E. concinnum* Loeblich & Tappan 1978**

Pl. XII:119a, b (Fig. 4. No. 148)

Description: The spherical vesicle has thin, cylindrical processes branching into 3—8 pinnulae distally with a vasiform depression between them. The processes do not communicate with the vesicle interior.

Dimensions: vesicle diameter 32 — 50 µm, length of process 20 — 28 µm, length of pinnula approx. 10 µm, number of pinnulae 3 — 8. Specimens measured: 38.

Remarks: These specimens differ from *Excultibrachium concinnum* Loeblich & Tappan 1978 in that they can have only 6 processes with varying numbers of distal pinnulae within the same individual. The surface of the vesicle is psilate or shagrinate and that of the processes scrabate.

Occurrence: Rapla borehole, depths 178.0 — 68.0 m, Lasnamägi Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Sweden (Górka 1987). Upper Ordovician: U.S.A. (Loeblich & Tappan 1978, Colbath 1979, 1981).

Genus *Florisphaeridium* Lister 1970

***Florisphaeridium abruptum* n. sp.**

Pl. XI:111 (Fig. 4. No. 159)

Diagnosis: The small, subspherical vesicle has numerous short, cylindrical processes (approx. 40 in the optical section), with a small opening at the slightly roseate distal termination. The surfaces of the vesicle and processes are granulated. A median split has been observed.

Dimensions: vesicle diameter 13 µm, length of process 1 µm, process base diameter 1 µm, dis-

tance between processes 1 µm. Specimens measured: 1.

Holotype: GSF Prep. 1115 (SEM); Pl. XI:111. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 176.0 m, Lasnamägi Regional Stage, Middle Ordovician. Rare.

Etymology: *abruptum,* from the Latin, 'broken off'.

Comparison: Differs from *Florisphaeridium densum* n. sp., which has more processes and its vesicle and processes are striated.

Florisphaeridium circulatum n. sp.

Pl. XI:112 (Fig. 4. No. 296)

Diagnosis: The subspherical vesicle has very short open-ended processes with a distal ring which does not broaden out. The surface of the vesicle is psilate or shagrinate and the outer rings on the processes are granulate.

Dimensions: vesicle diameter 10 — 25 µm, length of process 1 — 2 µm, outer diameter of processes 3.5 — 4.0 µm, diameter of process hole 1.5 — 1.7 µm, number of processes in the optical section 3 — 4. Specimens measured: 3.

Holotype: GSF Prep. 1053 (SEM); Pl. XI:112. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 74.0 — 66.0 m, Pirgu Regional Stage, Moe Formation, Upper Ordovician. Rare.

Etymology: *circulatum* from the Latin *circulus,* diminutive of *circus,* 'ring', + *-atum,* 'having the nature of'.

Comparison: Differs from *Florisphaeridium castellum* Lister 1970, which has more processes, with their edges broadening outwards.

Florisphaeridium densum n. sp.

Pl. XI:113 (Fig. 4. No. 223)

Diagnosis: The small, practically spherical vesicle has numerous short, cylindrical processes (approx. 60 in the optical section), with a small hole in the ring at the distal termination. The surfaces of the processes have raised striae which extend radially across the surface of the vesicle, joining the processes together.

Dimensions: vesicle diameter 13 — 20 µm, length of process 1.0 — 1.5 µm, process diameter approx. 1 µm, distance between processes approx. 2 µm. Specimens measured: 7.

Holotype: GSF Prep. 1091 (SEM); Pl. XI:113. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 145.5 — 130.0 m, Keila Regional Stage, Middle Ordovician. Rare.

Etymology: *densum,* from the Latin, 'thick, close'.

Comparison: Differs from *Florisphaeridium circulatum* n. sp., which has only a few processes and lacks the radial surface patterning.

Genus *Goniosphaeridium* Eisenack 1969

Goniosphaeridium breviradiatum n. sp.

Pl. XIII:129 (Fig. 4. No. 202)

Diagnosis: The vesicle is a slightly rounded polygon with a varying number of short, broad-based but fairly slim processes (length about 1/3 of the vesicle diameter) which are rounded at the distal termination. All the processes are simple and they communicate directly with the interior of the vesicle. The surfaces of the vesicle and processes are shagrinate.

Dimensions: vesicle diameter 20 — 36 µm, length of process 6 — 12 µm, number of processes in the optical section 13 — 20. Specimens measured: 3.

Holotype: GSF Prep. 1097 (SEM); Pl. XIII:129. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 151.0 — 146.2 m, Idavere Regional Stage, Vasavere Formation to Jõhvi Regional Stage, Middle Ordovician. Rare.

Etymology: *breviradiatum* from the Latin *brevis,* 'short', + *-radiatus,* 'furnished with rays'.

Comparison: Resembles *Micrhystridium digitatum* n. sp., although the latter has stouter,

cylindrical processes, some of which are bifurcated, and is smaller in size, always less than 20 µm. *Multiplicisphaeridium malum* (Cramer 1964) can have granules or small spines on the ends of its processes. The processes of *Micrhystridium stellatum* f.*latispinosum* n. f. are only slightly shorter than the diameter of the vesicle and some of them may be furcated.

Goniosphaeridium cantabricum (Cramer 1964) n. comb.

Pl. XII:120 (Fig. 4. No. 314)

1964: *Baltisphaeridium cantabricum* Cramer, p. 290.

Description: The subspherical vesicle has broad-based processes which narrow progressively towards the tip to form sharp points. The processes are almost twice the vesicle diameter in length and probably communicate with the vesicle interior. There were 7 processes visible. The vesicle and processes are relatively thin and psilate. The processes of the Rapla species are longer in relation to the vesicle than those of the holotype. The original diagnosis does not mention any communication between the processes and the vesicle, but the morphology suggests that this is possible.

Dimensions: vesicle diameter 25 µm, length of process 40 µm. Specimens measured: 1.

Occurrence: Rapla borehole, depth 37.2—3 m (J. Nõlvak), Pirgu Regional Stage, Adila Formation, Upper Ordovician. Rare.

Previous records: Upper Silurian — Devonian: Spain (Cramer 1964).

Goniosphaeridium mochtiensis (Górka) Kjellström 1971

Pl. XII:121 (Fig. 4. No. 90)

1969: *Baltisphaeridium mochtiensis* Górka, pp. 43—44.

1971: *Goniosphaeridium mochtiensis* (Górka) Kjellström, p. 26.

Description: The thick, round vesicle has numerous bulbous processes which comunicate with the vesicle interior and are slightly greater than the diameter of the vesicle in length. The vesicle and processes are shagrinate.

Dimensions: vesicle diameter 50 — 55 µm, length of process 30 — 46 µm. Specimens measured: 17.

Occurrence: Rapla borehole, depths 184.0 — 176.0 m, Kunda Regional Stage, Loobu Formation to Lasnamägi Regional Stage, Middle Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Finland (Tynni 1982); Sweden (Kjellström 1971b, 1972, 1976, Eisenack 1976, Górka 1987); Poland (Górka 1969, 1979, 1980). Ordovician Baltic erratics: Finland (Tynni 1975, Uutela 1989).

Goniosphaeridium oligospinosum Eisenack (1934) 1969

Pl. XII:122 (Fig. 4. No. 313)

1934: *Ovum hispidum oligospinosum* Eisenack, p. 64.

1954: *Veryhachium oligospinosum* Deunff, p. 306.

1954: *Pulvinosphaeridium oligospinosum* Eisenack, p. 210.

1969: *Goniosphaeridium oligospinosum* Eisenack, p. 256.

1985: *Estiastra oligospinosa* Jacobson & Achab, p. 182.

Description: The largish tetrahedral to octahedral vesicle has braod-based protrusions, i.e. processes, at its corners. These processes are situated three-dimensionallly at regular intervals: those with four processes tetrahedrally, those with five processes in a square with one occurring perpendicularly to the others, and those with 8 processes octahedrally (Cramer 1970). The Rapla material contained 1 specimen with 6 processes and 1 with 4 processes.

Dimensions: total vesicle diameter 188 — 250 µm. Specimens measured: 2.

Occurrence: Rapla borehole, depths 37.5 — 36.6 m, Pirgu Regional Stage, Adila Formation, Upper Ordovician. Rare.

Previous records: Upper Ordovician: Canada (Jacobson & Achab 1985). Ordovician erratics: Poland (Górka 1969). Silurian: Sweden (Eisenack 1934, 1938, 1954); Canada (Cramer 1970, Cramer & Díez 1972b).

***Goniosphaeridium parvispinosum* n. sp.**

Pl. XIII:130 (Fig. 4. No. 57)

Diagnosis: The spherical vesicle has numerous short, conical processes which have bulbous distal terminations and communicate with the vesicle interior. The surfaces of the vesicle and processes are shagrinate.

Dimensions: vesicle diameter 56 — 60 µm, length of process 7 — 10 µm, number of processes in the optical section 20. Specimens measured: 3.

Holotype: GSF Prep. 1125:2; Pl. XIII:130. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 188.6 m, Kunda Regional Stage, Sillaoru Formation, Lower Ordovician. Rare.

Etymology: *parvispinosum* from the Latin *parvus,* 'small', + *spinosus,* 'spiny'.

Comparison: Differs from *Goniosphaeridium mochtiensis* (Górka) Kjellström 1971, which has considerably longer processes. The processes of *Baltisphaeridium brevispinosum* Eisenack (1931) 1958 do not communicate with the interior of the vesicle.

***Goniosphaeridium pellicidum* (Timofeev) Tynni 1975**

Pl. XII:123 (Fig. 4. No. 87)

1959: *Archaeohystrichosphaeridium pellicidum* Timofeev, p. 40.

1971: *Goniosphaeridium conjunctum* Kjellström, pp. 43—44.

1974: *Goniosphaeridium dentatum* Rauscher, p. 61.

1975: *Goniosphaeridium pellicidum* (Timofeev) Tynni, p. 20.

Description: The polygonal vesicle has straight, somewhat slender, conical processes with acuminate distal terminations which are slightly greater than the diameter of the vesicle in length. The surfaces of the vesicle and processes are shagrinate.

Dimensions: vesicle diameter 25 — 40 µm, length of process 20 — 35 µm. Specimens measured: 99.

Occurrence: Rapla borehole, depths 188.0 — 28.0 m, Kunda Regional Stage, Loobu Formation to Juuru regional stages, Middle Ordovician to Lower Silurian. Rare to common.

Previous records: Lower Ordovician: U.S.S.R. (Timofeev 1959). Middle Ordovician: Sweden (Kjellström 1971a). Ordovician: France (Rauscher 1974). Ordovician Baltic erratics: Finland (Tynni 1975).

***Goniosphaeridium polygonale* Eisenack (1931) 1969**

Pl. XII:124 (Text-Fig. 4. No. 77)

1931: *Ovum hispidum polygonale* Eisenack, p. 113.

1969: *Goniosphaeridium polygonale* Eisenack, p. 257.

Description: The large, thin-walled, polygonal vesicle possesses numerous thin-walled, conical processes which are either acuminate, bulbous or infilled distally. The surfaces of the vesicle and processes are psilate or shagrinate.

Remarks: The species shows great variety with respect to the number of processes and their relative length. The species with less processes have a more polygonal vesicle, approaching the angular types *Veryhachium estrellitae* Cramer 1964 and *V. octoaster* Staplin 1961. Related but smaller species are *Goniosphaeridium pellicidum* (Timofeev) Tynni 1975 and *G. splendens* (Paris & Deunff) Turner 1984.

Dimensions: vesicle diameter 77 — 150 µm, length of process 80 — 100 µm. Specimens measured: 295.

Occurrence: Rapla borehole, depths 188.6 — 36.8 m, Volhov Regional Stage to Pirgu Regional Stage, Adila Formation, Lower to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician to Lower Silurian deposits in Europe (Eisenack *et al.* 1973).

***Goniosphaeridium polygonale polyacanthum* (Eisenack 1965)**

Pl. XII:125 (Fig. 4. No. 8)

1931: *Ovum hispidum polygonale* Eisenack, p. 113.

1938: *Hystrichosphaeridium polygonale* Eisenack, p. 12.

1959: *Baltisphaeridium polygonale* Eisenack, pp. 199—200.

1963: *Veryhachium polygonale* Eisenack, p. 209.

1965: *Baltisphaeridium polygonale* f.*polyacantha* Eisenack, pp. 136—137.

1973: *Goniosphaeridium polygonale polyacanthum* (Eisenack 1965) Eisenack, Cramer & Díez, pp. 501—502.

Description: The vesicle is polygonal and has 12—19 conical processes with acuminate distal terminations which communicate with the vesicle interior. The surface of the vesicle is microgranulate and the processes distinctly echinate.

Dimensions: vesicle diameter 29 — 36 µm, length of process 20 — 21 µm. Specimens measured: 16.

Occurrence: Rapla borehole, depths 189.9 — 136.0 m, Volhov to Keila regional stages, Lower to Middle Ordovician. Rare.

Previous records: Lower Ordovician: Poland (Górka 1969). Middle Ordovician: Finland (Tynni 1982). Ordovician Baltic erratics (Eisenack 1931, 1938, 1959, 1963, 1965a, 1968, Górka 1969, Uutela 1989).

Goniosphaeridium polygonale f. *rugosum* n. forma

Pl. XIII:131 (Fig. 4. No. 289)

Description: The subpolygonal vesicle has broad-based processes approx. 1/3 of the vesicle diameter in length. The surfaces of processes and vesicle are wrinkled.

Dimensions: vesicle diameter 60 — 80 µm, length of process 23 — 40 µm, total diameter 120 — 129 µm. Specimens measured: 10.

Holotype of forma: GSF Prep. 1045:1; Pl. XIII:131. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 92.0 — 50.0 m, Vormsi Regional Stage to Pirgu Regional Stage, Moe Formation, Upper Ordovician. Rare.

Etymology: *rugosa* from the Latin *ruga*, 'wrinkle', + *-osum*, 'full of'.

Remarks: This species corresponds to the *Goniosphaeridium polygonale* Eisenack (1931) 1969 morphologically but the vesicle and processes are of a wrinkled surface texture.

A secondary deformation origin for the surface texture would require small-scale shrinking of the shell structure, which seems highly unlikely in the absence of any corresponding examples.

Goniosphaeridium splendens (Paris & Deunff) Turner 1984

Pl. XII:126 (Fig. 4. No. 13)

1970: *Veryhachium splendens* Paris & Deunff, p. 27.

1984: *Goniosphaeridium splendens* Turner, pp. 113—114.

Description: The thin, polygenic vesicle possesses evenly distributed conical processes with acuminate distal terminations and of a length which does not exceed the vesicle diameter. We observe here the definition of Turner (1984), but include individuals with only 9 processes. The surfaces of the vesicle and processes are psilate or shagrinate.

Dimensions: vesicle diameter 23 — 30 µm, length of process 8 — 10 µm. Specimens measured: 105.

Occurrence: Rapla borehole, depths 189.9 — 28.0 m, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian. Rare to common.

Previous records: Middle Ordovician: Britain (Turner 1984, 1985); France (Paris & Deunff 1970, Rauscher 1973).

Goniosphaeridium tenuispinosum n. sp.

Pl. XIII:132 (Text-Fig. 4. No. 30)

Diagnosis: The slightly polygonal vesicle has numerous broad-based but otherwise slender processes (approx. 25) corresponding in length to about 1/2 of the vesicle diameter. These have acuminate distal terminations and some narrow to the extent of becoming flagelliform. The vesicle and processes are microgranulate.

Dimensions: vesicle diameter 30 — 40 µm, length of process 17 — 20 µm, process base diameter 2 — 3 µm, number of processes 22. Specimens measured: 10.

Holotype: GSF Prep. 1115 (SEM); Pl. XIII:132. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 189.0 — 171.0 m, Volhov to Uhaku regional stages, Lower to Middle Ordovician. Rare.

Etymology: *tenuispinosum* from the Latin *tenuis*, 'thin', + *-spinosum*, 'spiny'.

Comparison: Differs from *Goniosphaeridium polygonale polyacanthum* (Eisenack 1965) and *G. uncinatum* (Downie 1958), which have broader processes and an echinate surface and are also slightly larger in size. *G. elongatum* Turner 1984 has longer processes. The species also resembles *Baltisphaeridium tranvikensis* Tynni 1982, the processes of which vary in size and do not communicate with the interior of the vesicle while the vesicle is irregularly echinate and a few spines on the processes can be distinguished by light microscopy.

Genus *Gorgonisphaeridium* Loeblich & Tappan 1978

Gorgonisphaeridium antiquum Loeblich & Tappan 1978

1978: *Gorgonisphaeridium antiquum* Loeblich & Tappan, p. 1268.

Pl. XII:127 (Fig. 4. No. 52)

Description: The spherical vesicle has numerous short processes which are markedly stouter than those of *Baltisphaeridium nanninum* Eisenack 1965. The surfaces of the vesicle and processes are granulate.

Dimensions: vesicle diameter 60 — 65 µm, length of process 3 — 5 µm. Specimens measured: 102.

Occurrence: Rapla borehole, depths 189.0 — 28.0 m, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian. Rare to moderate.

Previous records: Middle Ordovician. Sweden (Górka 1987); U.S.A. (Loeblich & Tappan 1978).

Gorgonisphaeridium spiralispinosum n. sp.

Pl. XIII:133 (Fig. 4. No. 95)

Diagnosis: The vesicle is spherical to oval, with short, conical processes, some of which are twisted in a spiral manner. These processes are fully enclosed, vary in size and are situated at irregular intervals. The surface of the vesicle is irregularly granulate, and psilate around the processes, but increasingly more granulate in the intervening spaces depending on the size of the space. The processes are psilate. A median split has been observed.

Dimensions: vesicle diameter 40 — 48 µm, length of process 3.0 — 3.5 µm, distance between processes 4.0 µm. Specimens measured: 13.

Holotype: GSF Prep. 1078 (SEM); Pl. XIII:133. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 184.0 — 52.0 m, Kunda Regional Stage, Loobu Formation to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician.

Etymology: *spiralispinosum* from the Latin *spiralis*, 'spiral', + *-spinosum*, 'spiny'.

Comparison: Resembles *Gorgonisphaeridium antiquum* Loeblich & Tappan 1978, the processes of which are longer, more slender and more obviously flagelliform, with no spiral features.

Gorgonisphaeridium sp.

Pl. XIII:134 (Fig. 4. No. 275)

Description: The spherical vesicle has numerous simple processes of greatly varying size (about 35 in the optical section). These are acuminate at their distal terminations and broad at the base and are surrounded by polygons composed of low, irregular elevations. These polygons also vary in size. In addition to the polygons, the surface of the vesicle also features tubercles of varying size and an uneven microgranulation. The surfaces of the processes are microgranulate.

Dimensions: vesicle diameter 28 µm, length of process: longer 6 µm, shorter 1 — 2 µm. Specimens measured: 1.

Occurrence: Rapla borehole, depth 113.0 m,

Rakvere Regional Stage, Middle Ordovician. Rare.

Comparison: Differs from *Gorgonisphaeridum suecicum* Górka 1987, which has heteromorphic processes with no polygonal reticulate patterning on the vesicle surface.

Genus *Gyalorhethium* Loeblich & Tappan 1978

Gyalorhethium angustispinosum n. sp.

Pl. XIII:135 (Fig. 4. No. 184)

Diagnosis: The subspherical vesicle has numerous long, thin, flagelliform processes, of length greater than the vesicle diameter, with acuminate distal terminations and communicating with the interior of the vesicle. The surfaces of the vesicle and processes are covered with small spinules.

Dimensions: vesicle diameter 42 — 57 µm, length of process 54 — 65 µm, number of processes in the optical section 10 — 13. Specimens measured: 22.

Holotype: GSF Prep. 1053 (SEM); Pl. XIII:135. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 163.0 — 66.0 m, Kukruse Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to moderate.

Etymology: *angustispinosum* from the Latin *angustus,* 'narrow', + *-spinosum,* 'spiny'.

Comparison: *Gyalorhethium spinuliferum* Loeblich & Tappan 1978 has broader processes which are psilate at the distal termination. The vesicle is covered with spinules.

Gyalorhethium sp.

Pl. XIII:136 (Fig. 4. No. 180)

Description: The polygonal vesicle has processes with broad proximal contacts and acuminate distal terminations and communicating with the vesicle interior. They are slightly greater than the vesicle diameter in length. The surfaces of vesicle and processes are echinate, the spinules being longest at the proximal contacts of the processes, 1 µm.

Dimensions: vesicle diameter 30 — 40 µm, length of process 40 — 43 µm, number of processes in the optical section 7—8. Specimens measured: 3.

Occurrence: Rapla borehole, depths 167.0 — 163.0 m, Kukruse Regional Stage, Middle Ordovician. Rare.

Comparison: The processes of *Gyalorhethium spinuliferum* Loeblich & Tappan 1978 are considerably longer than the diameter of the vesicle and the individual is larger in size.

Genus *Hapsidopalla* Playford 1977

Hapsidopalla multifida n. sp.

Pl. XIII:137 (Fig. 4. No. 270)

Diagnosis: The hollow, spherical vesicle has arborescent processes which communicate freely with the vesicle inetrior. The process length is about 2/3 of the vesicle diameter. The first pinnae are about a halfway along the process, which is multifurcated to the third order. The vesicle surface is distinctly reticulate to foveolate, the process base psilate and the furcas microgranulate. No excystment structure has been observed.

Dimensions: vesicle diameter 18 — 24 µm, length of process 17 — 21 µm, number of processes 6 — 11. Specimens measured: 21.

Holotype: GSF Prep. 1943 (SEM); Pl. XIII:137. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 121.0 —

28.0 m, Rakvere to Juuru regional stages, Middle Ordovician to Lower Silurian. Rare to moderate.

Etymology: *multifida* from the Latin *multus,* 'numerous, many', + *-fid,* stem of *findere,* 'to split'.

Comparison: Differs from *Multiplicisphaeridium frondis* Cramer & Díez 1972 in having a reticulate vesicle surface. *Piliferosphaera setosa* (Loeblich 1970) has longer processes and a spinose vesicle ornamentation.

Genus Helosphaeridium Lister 1970

Helosphaeridium varispinosum n. sp.

Pl. XIV:138 (Fig. 4. No. 171)

Diagnosis: The small, spherical, shagrinate vesicle is covered with short, unevenly spaced, claviform processes of variable size. No pylome has been observed.

Dimensions: vesicle diameter 20 — 25 µm, height of process 0.4 µm, process diameter 0.3 — 0.7 µm, distance between processes 1.0 — 2.0 µm. Specimens measured: 14.

Holotype: GSF Prep. 1057 (SEM); Pl. XIV:138. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 173.0 — 36.1 m, Uhaku to Porkuni regional stages, Middle to Upper Ordovician. Rare.

Etymology: *varispinosum* from the Latin *varis,* 'varied', + *spinosum,* 'spiny'.

Comparison: Differs from *Helosphaeridium latispinosum* Lister 1970, the processes of which are of equal size.

Genus *Jœhvisphaera* n. gen

Type species: *Jœhvisphaera capillata* n. sp., designated here.

Diagnosis: The surface of the spherical vesicle carries cupolar tubercles with thin flagella at their distal terminations. The rounded pylome is thickened at the edge.

Etymology: *Jœhvisphaera* from the Estonian Jõhvi Regional Stage, + *sphaera* from the Latin (Gr. *sphaira),* 'ball', + *-idium,* diminutive.

Comparison: Differs from the genus *Lophosphaeridium* Timofeev 1959, which has simple tubercles with no flagellum and lacks the pylome. The genus *Dicommopalla* Loeblich 1970 has a spherical pylome, but its outer shell consists of a veil.

Jœhvisphaera capillata n. sp.

Pl. XIV:139 (Fig. 4. No. 207)

Diagnosis: The surface of the spherical vesicle carries cupolar tubercles of varying size with a thin flagelliform filament issuing from their distal terminations. The vesicle is shagrinate and the tubercles psilate. The pylome is round and thickened at the edge.

Dimensions: vesicle diameter 48 µm, height of tubercles 1 — 3 µm, max. length of flagellum 10 µm, distance between tubercles 1 — 3 µm, pylome diameter 11 µm. Specimens measured: 1.

Holotype: GSF Prep. 1099 (SEM); Pl. XIV:139. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 150.0 m, Jõhvi Regional Stage, Middle Ordovician. Rare.

Etymology: *capillata* from the Latin *capillus,* 'hair', + *-ata,* 'having the nature of'.

Comparison: *Lophosphaeridium disparipelliculum* Playford & Martin 1984 has tubercles of varying size but they have no filament, and the species has no pylome.

Genus *Kundasphaera* Uutela 1989, emended

Type species: *Kundasphaera lacunosa* n. sp., designated here.

Diagnosis: The surface of the small spherical vesicle carries low membrane walls which form areas of irregular size and form. The membranes are attached to the vesicle with small filaments, and are perpendicular to it.

Etymology:: *Kundasphaera* from Estonian Kunda Regional Stage, + *sphaera* from the Latin (Gr. *sphaira),* 'ball', + *-idium,* diminutive.

Comparison: The genus differs from *Pterospermopsis* W. Wetzel 1956 the membrane of which is concentrated in the equatorial area. The genus *Cymatiosphaera* O. Wetzel 1933 has more solid membrane walls with a column at the joint.

Kundasphaera lacunosa n. sp.

Pl. XIV:140a, b (Fig. 4. No. 48)

1989: *Kundasphaera* sp., Uutela pp.30—31.

Diagnosis: The small spherical vesicle is ornamented with a low membrane which organizes the irregularly shaped and irregularly sized polygons. The membrane is fixed to the vesicle surface with tiny filaments. The vesicle surface is microgranulate and the membrane psilate. No pylome is observed.

Dimensions: vesicle diameter 12 — 19 µm, membrane height 1.5 — 2.0 µm. Specimens measured: 23.

Holotype: GSF Prep. 1116 (SEM); Pl. XIV:140a, b. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 189.0 — 36.1 m, Volhov to Porkuni regional stages, Lower to Upper Ordovician. Rare.

Etymology: *lacunosa* from the Latin *lacuna,* 'cavity, cavern', + *-osa,* suffix meaning 'full of'.

Comparison: Differs from *Dictyotidium venosum* n. sp. in that the low irregular polygon bottoms of the latter are tuberculous. In *Cymatiosphaera canadensis* Deunff 1961, from the Devonian, the low polygons are attached directly to the vesicle rather than by filaments, and this species is considerably larger.

Previous records: Ordovovician Baltic erratics: Finland (*Kundasphaera* sp. *in* Uutela 1989).

Kundasphaera sp.

Pl. XIV:141 (Fig. 4. No. 139)

Description: The surface of the small spherical vesicle carries low membrane walls which form polygons of irregular shape and size. The membranes are fixed to the vesicle by tiny filaments: otherwise they are psilate. The vesicle surface, formed by the bottoms of the polygons, is tuberculous or rugulate.

Dimensions: vesicle diameter 14 — 18 µm, polygon diameter 3 — 10 µm, height of membrane-wall 2.5 — 4.0 µm, number of polygons in the optical section 5 — 7. Specimens measured: 3.

Occurrence: Rapla borehole, depths 178.0 — 176.0 m, Lasnamägi Regional Stage, Middle Ordovician. Rare.

Comparison: *Kundasphaera lacunosa* n. sp. has lower membraneous walls, usually larger polygons and a more psilate vesicle.

Genus *Labyrinthosphaeridium* n. gen

Type species: *Labyrinthosphaeridium curvatum* n. sp., designated here.

Other new species of the genus: *L. asperum, L. cymoides, L. restrictum*

Diagnosis: The small, hollow, spherical to subspherical vesicle is ornamented with irregular, low ridges, which form a wider or narrower labyrinthic pattern. An excystment structure is present as a median split.

Etymology: *Labyrinthosphaeridium* from the Latin *labyrinthus,* 'labyrinth', + *-sphaera* (Gr. *sphaira),* 'ball', + *-idium,* diminutive.

Comparison: The genus resembles *Dictyotidium* (Eisenack) Staplin *et al.* 1965, which has lacunal areas as polygons and is not labyrinthic. The genus *Cymatiosphaera* O. Wetzel 1933 has an even more regular polygonal pattern than either this genus or *Dictyotidium*.

Labyrinthosphaeridium asperum n. sp.

Pl. XIV:142 (Text-Fig. 4. No. 229)

Diagnosis: The small, hollow, spherical vesicle is ornamented with straight, low ridges which form partly triangular, rhomboidal or polygonal and partly labyrinthic patterns. The areas between the ridges are distinct. The vesicle surface is granulate and the ridges psilate. No excystment structure is observed.

Dimensions: vesicle diameter 11 µm, height of ridge 0.5 µm. Specimens measured: 1.

Holotype: GSF Prep. 1093 (SEM); Pl. XIV:142. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 140.0 m, Keila Regional Stage, Middle Ordovician. Rare.

Etymology: *asperum* from the Latin, 'rough, harsh'.

Comparison: Differs from *Labyrinthosphaeridium cymoides* n. sp. in that the latter has thin, sinuous walls.

Labyrinthosphaeridium curvatum n. sp.

Pl. XIV:143 (Fig. 4. No. 217)

Diagnosis: The thin (0.5 µm), hollow, spherical to subspherical vesicle is ornamented with low curving and forking ridges that form a labyrinthic pattern with narrow winding passages. The vesicle surface and ridges are psilate. An excystment structure is found as a median split.

Dimensions: vesicle diameter 12 — 13 µm. Specimens measured: 9.

Holotype: GSF Prep. 1077 (SEM); Pl. XIV:143. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 146.2 — 82.0 m, Jõhvi to Vormsi regional stages, Middle to Upper Ordovician. Rare.

Etymology: *curvatum* from the Latin *curvo,* 'bend, bow, crook'.

Comparison: Differs from *Labyrinthosphaeridium cymoides* n. sp., which has higher walls and a larger area between them.

Labyrinthosphaeridium cymoides n. sp.

Pl. XIV:144 (Text-Fig. 4. No. 262)

Diagnosis: The surface of the spherical vesicle carries long, winding, irregular walls which form areas of irregular shape. A median split is observed.

Dimensions: vesicle diameter 12 — 18 µm, height of labyrinthic wall 1.5 — 2.0 µm, width of labyrinthic passage 2.0 µm. Specimens measured: 10.

Holotype: GSF Prep. 1973 (SEM); Pl. XIV:144. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 130 .0 — 84.0 m, Keila to Vormsi regional stages, Middle to Upper Ordovician. Rare.

Etymology: *cymoides* from the Greek *kyma,* 'wave', + *-oides* from the Latin (Gr. *-eides),* 'like'.

Comparison: Differs from *Cymatiosphaera densa* Cookson & Eisenack 1970 and *C. undulata* Hajós 1966, which are even larger in size and the latter of which has a more regular polygonal patterning. The lower walls of *Labyrinthosphaeridium curvatum* n. sp. mark off narrower intermediate areas.

Labyrinthosphaeridium restrictum n. sp.

Pl. XIV:145 (Fig. 4. No. 230)

Diagnosis: The small, spherical vesicle carries low, thick, fragmentary walls of irregular size and form which fill almost the entire vesicle surface, with only narrow labyrinthic passages between them. The walls vary in shape from tuberculous to long and straight or flexible.

Dimensions: vesicle diameter 12 µm. Specimens measured: 1.

Holotype: GSF Prep. 1093 (SEM); Pl. XIV:145. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 140.0 m, Keila Regional Stage, Middle Ordovician. Rare.

Etymology: *restrictum* from the Latin, 'pinched, contracted'.

Comparison: Differs from *Lophosphaeridium papillatum* (Staplin) Downie 1963 in that the latter has only individual tubercles, and from *Labyrinthosphaeridium curvatum* n. sp., which has thinner walls which are not as fragmentary.

Genus *Lacunosphaeridium* n. gen

Type species: *Lacunosphaeridium spinosum* n. sp., designated here.

Other new species of the genus: *L. granosum*

Diagnosis: The vesicle is spherical, with processes or tubercles on the surface, surrounded by a polygon net consisting of small ridges, a feature typical of the species.

Etymology: *Lacunosphaeridium* from the Latin *lacuna,* 'cavern, cavity', + *sphaera* (Gr. *sphaira),* 'ball', + *-idium,* diminutive.

Comparison: The species *Cymatiosphaeromopsis* Mädler 1963 has a polygonal pattern on the vesicle surface consisting of thick walls or membranes. The polygonal net of the genus *Acrum* Fombella 1977 has a membraneous process attached to it.

Lacunosphaeridium granosum n. sp.

Pl. XV:146a, b (Fig. 4. No. 284)

Diagnosis: The spherical vesicle carries low, bulbous tubercles which are surrounded by an irregular net pattern. These vary in size and are unevenly distributed. A median split is observed.

Dimensions: vesicle diameter 34 — 50 µm, lacunae diameter 1 — 2 µm, tubercle diameter 0.5 — 1.4 µm, distance between tubercles 1 — 3 µm. Specimens measured: 2.

Holotype: GSF Prep. 1073 (SEM); Pl. XV:146a,b. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 104.0 m, Nabala Regional Stage, Paekna Formation, Middle Ordovician. Rare.

Etymology: *granosum* from the Latin *granum,* 'grain', + *-osum,* suffix 'full of'.

Comparison: Differs from *Lophosphaeridium papillatum* (Staplin) Downie 1963 in that the latter has no net pattern surrounding its rounded tubercles.

Lacunosphaeridium spinosum n. sp.

Pl. XV:147 (Fig. 4. No. 197)

Diagnosis: The hollow vesicle is subspherical. Tiny double ridges form hexagonal patterns on its surface, and there is a short process of length about 1/10 of the diameter in the middle of each hexagon. The processes are blunt or clavate and hollow, but do not communicate with the vesicle interior. The vesicle surface and processes are psilate. An excystment structure is found as a median split.

Dimensions: vesicle diameter 40 — 42 µm, length of process 5 — 7 µm, hexagon diameter 8 — 10 µm. Specimens measured: 3.

Holotype: GSF Prep. 1091 (SEM); Pl. XV:147. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 154.0 — 138.0 m, Idavere Regional Stage, Tatruse Formation to Keila Regional Stage, Middle Ordovician. Rare.

Etymology: *spinosum* from the Latin *spina,* 'thorn', + *-osum,* suffix 'full of'.

Comparison: Differs from *Cymatiosphaeromopsis punctifera* (Deflandre & Cockson 1955), which has only a thickening in the middle of the polygon field.

Genus *Leiofusa* Eisenack 1938, restr. Eisenack 1965, emend. & restr. Combaz *et al.* 1967, Cramer 1970

Leiofusa brevispinosa n. sp.

Pl. XV:148 (Fig. 4. No. 274)

Diagnosis: There are conical processes at both ends of the lanceolate vesicle, their length being about half that of the vesicle itself. The vesicle surface is echinate, the spines diminishing in size towards the processes, the distal terminations of which are psilate.

Dimensions: vesicle length 18 — 21 µm, vesicle width 8 — 11 µm, length of process 7 — 9 µm. Specimens measured: 25.

Holotype: GSF Prep. 1073 (SEM); Pl. XV:148. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 115.0 — 28.0 m Rakvere to Juuru regional stage, Middle Ordovician to Lower Silurian. Rare to common.

Etymology: *brevispinosa* from the Latin *brevis,* 'short', + *spinosa,* 'spiny'.

Comparison: Differs from *Leiofusa granulacutis* Loeblich 1970, which has longer processes and a granulated surface.

Leiofusa granulacutis Loeblich 1970

Pl. XII:128 (Fig. 4. No. 170)

1970: *Leiofusa granulacutis* Loeblich, pp. 723—724.

Description: The roundish or fusiform vesicle has a long hollow process at each end. These communicate with the vesicle interior. The granulae on the vesicle surface do not form any regular pattern. The form encountered in the Rapla material is considerable smaller than that in the original diagnosis of Loeblich (1970).

Dimensions: vesicle length 13 — 20 µm, vesicle width 15 — 20 µm, process length 21 — 23 µm, total length 60 — 66 µm. Specimens measured: 87.

Occurrence: Rapla borehole, depth 173.0 — 42.0 m, Uhaku Regional Stage to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare to common.

Previous records: Upper Ordovician: U.S.A. (Colbath 1979). Ordovician Baltic erratics (Uutela 1989). Middle Silurian: U.S.A. (Loeblich 1970a).

Leiofusa granulacutis f. *quincunx* Uutela 1989

Pl. XVII:161 (Fig. 4. No. 298)

1989: *Leiofusa granulacutis* f.*quincunx,* Uutela, p. 31.

Description: The central body is fusiform with a long hollow process at each pole, the surface is ornamented by numerous small, scattered tubercles with a regularly quincuncial pattern. The regular ornamentation can be seen only by SEM image. Forma differs from *L. granulacutis* Loeblich 1970 in having a regularly quincuncial tubercle pattern in its surface ornamentation. Its dimensions are also smaller.

Dimensions: vesicle length 23 — 27 µm, vesicle width 14 — 17 µm, length of process 20 — 30 µm. Specimens measured: 3.

Occurrence: Rapla borehole, depths 74.0 — 36.1 m, Pirgu Regional Stage, Moe Formation to Porkuni Regional Stage, Upper Ordovician. Rare.

Previous records: Ordovician Baltic erratics: Finland (Uutela 1989).

Leiofusa iugosa n. sp.

Pl. XV:149a, b (Fig. 4. No. 213)

Diagnosis: The vesicle is elongated and fusiform, both ends having a long, broad-based process with acuminate distal terminations and communicating with the vesicle interior. The surface of the vesicle and the processes is covered with lengthy laths located at regular intervals but in an irregular position in relation to each other.

Dimensions: vesicle length 32 µm, vesicle width 11 µm, length of process 28 µm, total length 88 µm, length of ridge approx. 0.6 µm, height of ridges approx. 0.3 µm. Specimens measured: 1.

Holotype: GSF Prep. 1097 (SEM); Pl. XV:149a,b. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 146.2 m, Jõhvi Regional Stage, Middle Ordovician. Rare.

Etymology: *iugosa* from the Latin *iugum,* 'yoke, ridge', + *-osa,* suffix 'full of'.

Comparison: In form, the species resembles *Leiofusa granulacutis* Loeblich 1970, the surface of which is granulated, but not covered with strips. This new species was found in a SEM sample, and it is evident that the lath-like surface did not show up well by light microscopy. Thus the species can obviously be easily confused with *Leiofusa granulacutis* and *L. granulacutis* f. *quincunx.*

Leiofusa obliquipunctata n. sp.

Pl. XV:150 (Fig. 4. No. 290)

Diagnosis: The vesicle is fusiform and narrows steadily towards both poles. Its surface is covered with a regular tuberculous pattern in which the tubercles are located in lines and at 90° angles to each other. They decrease in size towards the poles.

Dimensions: vesicle length 312 — 347 µm, vesicle width 40 — 40 µm, height of tubercel approx. 1 µm. Specimens measured: 13.

Holotype: GSF Prep. 1053 (SEM); Pl. XV:150. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 92.0 — 46.0 m, Vormsi to Pirgu Regional Stage, Adila Formation, Upper Ordovician. Rare to moderate.

Etymology: *obliquipunctata* from the Latin *obliquus,* 'slanting', + *punctata,* 'punctated'.

Comparison: The species is identical in shape to *Leiofusa fusiformis* Eisenack (1934) 1938, but the latter has a psilate surface.

Leiofusa subcircularis n. sp.

Pl. XV:151 (Fig. 4. No. 116)

Diagnosis: The large spherical vesicle has two long, clearly distinctive processes and a reticular pattern of tubercles. The processes are unevenly microgranulate and have a thin outer shell.

Dimensions: vesicle length 60 µm, vesicle width 50 µm, length of process 50 µm, process base diameter 8 µm, total length 160 µm. Specimens measured: 1.

Holotype: GSF Prep. 1118 (SEM); Pl. XV:151. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 180.3 m, Lasnamägi Regional Stage, Middle Ordovician. Rare.

Etymology: *subcircularis* from the Latin *sub-,* 'somewhat', + *circularis,* 'circular'.

Comparison: Differs from *Leiofusa globulina* Cramer & Díez 1976, which has a psilate outer shell, except for striae radiating from the bases of the processes.

Genus *Leiosphaeridia* Eisenack 1958

Leiosphaeridia keilaensis n. sp.

Pl. XV:152 (Fig. 4. No. 193)

Diagnosis: The large spherical vesicle has a thick wall (about 5 µm,). The vesicle surface is partly psilate and partly microgranulate. The surface of the vesicle is corrugated, and a median split has been observed in some individuals, although without any distinct pylome.

Dimensions: vesicle diameter 200 — 300 µm. Specimens measured: 10.

Holotype: GSF Prep. 1086:1; Pl. XV:152. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 159.0 — 125.0 m, Kukruse to Rakvere regional stages, Middle Ordovician. Rare.

Etymology: *keilaensis* from the Estonian Keila Regional Stage, + *-ensis* from the Latin, suffix 'belonging to'.

Comparison: *Leiosphaeridia baltica* Eisenack 1958 and the psilate *L. granulata* Eisenack (1938)

1958 are evenly granulated and are both considerably smaller than *L. keilaensis* n. sp.

?Leiosphaeridia sp.

Pl. XVI:153 (Fig. 4. No. 122)

Description: The spherical thin-walled vesicle has a pylome tear with its walls constricted in a curved manner. There are tubercles varying in size from 0.2 µm to 0.4 µm and with acuminate or bulbous distal terminations situated irregularly on the vesicle surface.

Dimensions: vesicle diameter 10 — 20 µm, pylome diameter 5 — 8 µm. Specimens measured: 2.

Occurrence: Rapla borehole, depths 180.0 — 178.0 m, Lasnamägi Regional Stage, Middle Ordovician. Rare.

Comparison: *Leiosphaeridia tubulosa* Eisenack 1963 has a distinct pylome tube and is considerably larger in size (ø 62—68 µm). The genus *Lophosphaeridium* Timofeev 1959 has no pylome.

Leiosphaeridia spp.

(Fig. 4. No. 14)

Description: The surface of the spherical to subspherical vesicle is psilate to slightly granulate.

Remarks: The genus *Leiosphaeridia* is treated collectively here without identification to species because it is of no importance for dating purposes.

Diameter varies from 5 to 200 µm. There is no difference in size between the horizons. Specimens measured: 2069.

Occurrence: Rapla borehole, depths 189.0 — 28.0 m, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian. Rare to common.

Genus *Leiovalia* Eisenack 1965

Leiovalia similis Eisenack 1965

Pl. XVII:162 (Fig. 4. No. 53)

1965: *Leiovalia similis* Eisenack, p. 139.

1984: *Navifusa similis* Turner, p. 122.

Description: The vesicle, with a thick outer shell, is oval and bulbous, and its sides are only slightly distended. Turner (1984) regards the *L. similis* of Tynni (1975), for example, a *Navifusa similis,* although its length/width ratio is 1.87 whereas that of *Leiovalia similis* as originally diagnosed by Eisenack (1965) is 2.3, and that of *Navifusa* Combaz, Lange & Pansart 1967 is usually 3 or more.

Dimensions: vesicle length 100 — 200 µm, vesicle width 42 — 52 µm. Specimens measured: 75.

Occurrence: Rapla borehole, depths 189.0 — 28.0 m, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian. Rare to moderate.

Previous records: Middle Ordovician: Finland (Tynni 1982); Sweden (Eisenack 1965b, Górka 1987); Australia (Combaz & Peniguel 1972, Playford & Martin 1984). Upper Ordovician: U.S.A. (Jacobson 1978). Ordovician Baltic erratics: Finland (Tynni 1975, Uutela 1989).

Genus *Liliosphaeridium* n. gen

Type species: *Liliosphaeridium kaljoi* n. sp., designated here.

Diagnosis: The vesicle is subspherical, with numerous easily distinguishable processes. The distal heads of the processes spread out in a funnel-shaped manner, the bottom of the fun-

nel being closed. The processes do not communicate with the vesicle interior.

Etymology: *Liliosphaeridium* from the Latin *lilium,* 'lily', + *sphaera* (Gr. *sphaira),* 'ball', + *-idium,* diminutive.

Comparison: In the genus *Umbellasphaeridium* Jardiné *et al.* 1972 the funnel-shaped bottom of the process is open, as also in the genus *Skiagia* Downie 1982. The processes of *Dilatisphaera* Lister 1970 are completely cylindrical without the funnel-shaped distal broadening, and they do not communicate with the vesicle interior. The processes of *Florisphaeridium* Lister 1970 do communicate with the vesicle interior.

Liliosphaeridium kaljoi n. sp.

Pl. XVI:154a, b (Fig. 4. No. 21)

Diagnosis: The subspherical vesicle bears 7—9 funnel-shaped processes. The processes are thin-walled with longitudinal thickenings and hollow, but they do not communicate with the vesicle inetrior. The funnel-shaped form begins about halfway along the process interior. The processes are distally furcated at first, with 5 to 6 broad furcae which bifurcate twice. The extreme distal termination has small spines. The process length does not exceed the vesicle diameter, most often being about a half of it. The vesicle surface is granulate and the processes psilate. No pylome is observed.

Dimensions: vesicle diameter 30 — 53 µm, length of process 24 — 33 µm, process base diameter 8 — 11 µm, distal width of process 20 — 36 µm. Specimens measured: 17.

Holotype: GSF Prep. 1126 (SEM); Pl. XVI:154a,b. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 189.0 — 188.0 m, Volhov Regional Stage to Kunda Regional Stage, Loobu Formation, Lower to Middle Ordovician. Rare.

Etymology: *kaljoi* in honour of Prof. Dimitri Kaljo, former Director of the Institute of Geology, Estonian Academy of Sciences.

Comparison: Differs from *Polyancistrodorus phylloides* n. sp. which has petaloidal processes spreading distally, but not furcating.

Genus *Lophosphaeridium* Timofeev 1959, emend. Lister 1970

Lophosphaeridium aculeatum n. sp.

Pl. XVI:155 (Fig. 4. No. 164)

Diagnosis: The spherical vesicle has small, slightly scattered tubercles with acuminate distal terminations. Some of the tubercles bifurcate, and they vary slightly in size with more furcation among the larger ones. The surfaces of the vesicle and tubercles are psilate or shagrinate.

Dimensions: vesicle diameter 18 — 30 µm,, height of tubercle 0.4 — 0.6 µm, distance between the tubercles 2.0 — 2.8 µm. Specimens measured: 35.

Holotype: GSF Prep. 1038 (SEM); Pl. XVI:155. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 175.0 — 35.0 m, Uhaku to Porkuni regional stages, Middle to Upper Ordovician. Rare.

Etymology: *aculeatum* from the Latin *aculeus,* 'thorn', + *-atum* suffix, 'having the nature of'.

Comparison: The species differs from *Lophosphaeridium papillatum* (Staplin) Downie 1963 in that the latter has bulbous tubercles located more densely. The corresponding tubercles of *Micrhystridium varipinnosum* n. sp. are known as processes because of their large size.

Lophosphaeridium aequicuspidatum Playford & Martin 1984

Pl. XVII:163 (Fig. 4. No. 98)

1984: *Lophosphaeridium aequicuspidatum* Playford & Martin, p. 202.

Description: The small spherical vesicle has densily located tubercles with acuminate distal terminations and curved proximal process con-

tacts. The vesicle and processes have psilate surfaces.

Dimensions: vesicle diameter 15 — 24 µm, height of tubercle 0.2 — 1.0 µm. Specimens measured: 5.

Occurrence: Rapla borehole, depths 182.7 — 130.0 m, Kunda Regional Stage, Loobu Formation to Keila Regional Stage, Middle Ordovician. Rare.

Previous records: Middle Ordovician: Australia (Playford & Martin 1984).

Lophosphaeridium citrinipeltatum Cramer & Díez 1972

Pl. XVII:164 (Fig. 4. No. 15)

1972: *Lophosphaeridium citrinipeltatum* Cramer & Díez, pp. 166—167.

Description: The spherical vesicle is covered with bulbous peltate sculptural elements.

Dimensions: vesicle diameter 35 — 60 µm. Specimens measured: 319.

Occurrence: Rapla borehole, depths 189.9 — 28.0 m, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian. Rare to common.

Previous records: Middle Ordovician: Finland (Tynni 1982). Ordovician Baltic erratics: Finland (Tynni 1975, Uutela 1989). Lower Silurian: U.S.A. (Cramer & Díez 1972b).

Lophosphaeridium deminutum Playford 1981

Pl. XVII:165 (Fig. 4. No. 79)

1981: *Lophosphaeridium deminutum* Playford pp. 42—43.

Description: The subspherical vesicle has short, even-headed but non-widening tubercles showing only slight variations in size. The surfaces of the vesicle and processes are reticulate and the proximal contacts of some of the processes show slight radiatng striae.

Dimensions: vesicle diameter 15 — 17 µm, height of tubercle 0.7 µm, tubercle diameter 0.7 µm, distance between tubercles 1.0 — 2.0 µm. Specimens measured: 17.

Occurrence: Rapla borehole, depths 188.6 — 28.0 m, Kunda Regional Stage, Sillaoru Formation to Juuru Regional Stage, Lower Ordovician to Lower Silurian. Rare.

Previous records: Upper Devonian: Australia (Playford & Dring 1981).

Lophosphaeridium disparipelliculum Playford & Martin 1984

Pl. XVII:166 (Text-Fig. 4. No. 150)

1984: *Lophosphaeridium disparipelliculum* Playford & Martin, pp. 202—204.

Description: The spherical vesicle has bulbous tubercles of different size at irregular intervals. The surfaces of the vesicle and processes are psilate.

Dimensions: vesicle diameter 11 — 29 µm, tubercle diameter 0.3 — 1.2 µm, distance between tubercles 0.3 — 1.3 µm. Specimens measured: 10.

Occurrence: Rapla borehole, depths 178.0 — 64.0 m, Lasnamägi Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Australia (Playford & Martin 1984).

Lophosphaeridium aff. *L. granulosum* (Staplin) Downie 1963

Pl. XVII:167 (Fig. 4. No. 321)

Description: The subspherical vesicle is densely covered with small, pellet-shaped tubercles of different sizes.

Dimensions: vesicle diameter 40 µm, tubercle diameter 0.2 — 0.7 µm, distance between tubercles 0.2 — 1.0 µm. Specimens measured: 1.

Remarks: Tubercles are smaller in the Rapla species than in *Lophosphaeridium granulosum* (Staplin) Downie 1963, the diagnosis of which does not indicate whether or not they are of equal size. The tubercles of *L. papulatum* Martin 1983 and *L. disparipelliculum* Playford & Martin 1984 are larger, as are those of *L. crassum* (Naumova) Umnova 1975.

Occurrence: Rapla borehole, depth 28.0 m, Juuru Regional Stage, Lower Silurian. Rare.

Lophosphaeridium papillatum (Staplin) Downie 1963

Pl. XVII:168 (Fig. 4. No. 43)

1961: *Protoleiosphaeridium papillatum* Staplin, pp. 406—407.

1963: *Lophosphaeridium* cf. *P. papillatum* Downie, pp. 629—631.

Description: The spherical vesicle is unevenly covered with bulbous tubercles. The material found at Rapla contained small specimens as well (ø 10 µm,) which were considered to belong to the same species.

Dimensions: vesicle diameter 10 — 30 µm, height of tubercles 0.5 — 1.0 µm. Specimens measured: 390.

Occurrence: Rapla borehole, depths 189.0 — 38.0 m, Volhov Regional Stage to Pirgu Regional Stage, Adila Formation, Lower to Upper Ordovician. Rare to common.

Previous records: Middle Ordovician: Sweden (Górka 1987); Poland (Górka 1979); France (Rauscher 1974). Ordovician Baltic erratics: Finland (Uutela 1989). Silurian: Belgium (Martin 1966b, 1967, 1968); Britain (Downie 1963). Devonian: Canada (Staplin 1961).

Lophosphaeridium pilosum Downie 1963

Pl. XVII:169 (Fig. 4. No. 39)

1963: *Lophosphaeridium pilosum* Downie, p. 631.

Description: The spherical vesicle is densely covered with small spines.

Dimensions: vesicle diameter 20 — 35 µm, lenght of spines 2.0 — 3.0 µm. Specimens measured: 63.

Occurrence: Rapla borehole, depths 189.0 — 74.0 m, Volhov Regional Stage to Pirgu Regional Stage, Moe Formation, Lower to Upper Ordovician. Rare to moderate.

Previous records: Lower Ordovician: Czechoslovakia (Vavrdová 1972). Ordovician Baltic erratics: Finland (Uutela 1989). Silurian: Britain (Downie 1963).

Lophosphaeridium regulare n. sp.

Pl. XVI:156 (Fig. 4. No. 316)

Diagnosis: The spherical vesicle has small spines of consistent thickness located in regular rows.

Dimensions: vesicle diameter 13 µm, height of tubercle 0.2 µm. Specimens measured: 1.

Holotype: GSF Prep. 1038 (SEM); Pl. XVI:156. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 36.8 m, Pirgu Regional Stage, Adila Formation, Upper Ordovician. Rare.

Etymology: *regulare* from the Latin *regula,* 'ruler', + *-are,* suffix 'pertaining to'.

Comparison: The species differs from *Lophosphaeridium pilosum* Downie 1963, in which the small spines are not located in regular rows.

Lophosphaeridium sp.

Pl. XVI:157 (Fig. 4. No. 251)

Description: The spherical vesicle has densely located conical tubercles of varying size occurring at regular intervals.

Dimensions: vesicle diameter 42 µm, height of tubercles 0.5 µm, distance between tubercles 1 µm. Specimens measured: 1.

Occurrence: Rapla borehole, depth 136.0 m, Keila Regional Stage, Middle Ordovician. Rare.

Comparison: The tubercles of *Lophosphaeridium disparipelliculum* Playford & Martin 1984 vary in size, but they are bulbous. The tubercles of *Lophosphaeridium pilosum* Downie 1963 are spiny and of the same size.

Genus *Micrhystridium* Deflandre 1937, emend. Sarjeant 1967

Micrhystridium acerbum Martin 1968

Pl. XVII:170 (Fig. 4. No. 117)

1968: *Micrhystridium acerbum* Martin, pp. 67—68.

Description: The spherical vesicle has numerous conical processes at irregular intervals (about 60 in the optical section). They are short, about 1/5 of the vesicle diameter, and their surfaces have small tubercles with acuminate distal terminations showing an increase in size towards the distal end. The vesicle surface is shagrinate or slightly rough.

Dimensions: vesicle diameter 15 µm, lenght of processes 3 µm. Specimens measured: 1.

Occurrence: Rapla borehole, depth 180.3 m, Aseri Regional Stage, Middle Ordovician. Rare.

Previous records: Silurian: Belgium (Martin 1968).

Micrhystridium acuminosum Cramer & Díez 1977

Pl. XVII:171 (Fig. 4. No. 239)

1977: *Micrhystridium acuminosum* Cramer & Díez, p. 347.

Description: The polygonal vesicle has homomorphic, conical processes with acuminate distal terminations occurring at regular intervals in a star-like arrangement. They have curved proximal contacts, communicate with the vesicle interior and are about 1/3 of the vesicle diameter in length. The surfaces of the vesicle and processes are granulated. The specimen found at Rapla is smaller than those in the original diagnosis.

Dimensions: vesicle diameter 10 — 14 µm, lenght of processes 4 — 5 µm, process base diameter 2 — 3 µm, number of processes 14 — 16, total diameter 18 — 22 µm. Specimens measured: 3.

Occurrence: Rapla borehole, depths 140.0 — 104.0 m, Keila Regional Stage to Nabala Regional Stage, Paekna Formation, Middle Ordovician. Rare.

Previous records: Lower Ordovician: Morocco (Cramer & Díez 1977).

Micrhystridium brevispinosum n. sp.

Pl. XVI:158 (Fig. 4. No. 9)

Diagnosis: The subspherical vesicle has numerous bulbous processes (about 100 in the optical section) which vary in size, the largest being about 1/10 of the vesicle diameter. The surfaces of the vesicle and processes are psilate or shagrinate. A median split is observed in the vesicle.

Dimensions: vesicle diameter 11 — 19 µm, length of process 1 — 2 µm, distance between processes 0.5 — 2.0 µm. Specimens measured: 17.

Holotype: GSF Prep. 1038 (SEM); Pl. XVI:158. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 189.9 — 36.8 m, Volhov Regional Stage to Pirgu Regional Stage, Adila Formation, Lower to Upper Ordovician. Rare.

Etymology: *brevispinosum* from the Latin *brevis,* 'short', + *spinosum,* 'spiny'.

Comparison: Differs from *Micrhystridium digitatum* n. sp., which has longer and less numerous processes. The processes of *Buedingiisphaeridium balticum* n. sp. are more regular in size and shape, and have solid nipples on the top of the outgrowths.

Micrhystridium curvatum n. sp.

Pl. XVI:159 (Fig. 4. No. 317)

Diagnosis: The almost spherical vesicle has densely occurring processes of two kinds: solid, conical ones which are doubled over distally, and some which are shorter and more delicate. These are also flexible and occur densely on the vesicle, almost growing together. The surfaces of the processes are psilate and that of the vesicle is invisible under a dense net of processes.

Dimensions: vesicle length/width 9/7 µm, lenght of longer processes 2 µm, process base diameter 0.6 µm, length of shorter processes 1 µm,

distance between processes 1.5 μm. Specimens measured: 1.

Holotype: GSF Prep. 1038 (SEM); Pl. XVI:159. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 36.8 m, Pirgu Regional Stage, Adila Formation, Upper Ordovician. Rare.

Etymology: *curvatum* from the Latin *curvo,* 'bend, bow, crook'.

Comparison: Differs from *Micrhystridium varispinosum* n. sp. in that the latter has a smaller number of larger, longer processes.

Micrhystridium digitatum n. sp.

Pl. XVI:160 (Fig. 4. No. 199)

Diagnosis: The small, subspherical vesicle has short, clearly distinguishable processes (1/4 — 1/5 of the vesicle diameter) which are distally bulbous. They are usually simple, but some are bifurcated and communicate with the vesicle interior, whereupon the base widens slightly. The number of processes varies from 10 — 12, and the thickness of the shell is about 0.5. μm. The surfaces of the vesicle and processes are psilate, shagrinate or irregularly microgranulate.

Dimensions: vesicle diameter 16 — 19 μm, length of process 3 — 6 μm. Specimens measured: 22.

Holotype: GSF Prep. 1093 (SEM); Pl. XVI:160. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 154.0 — 36.8 m, Idavere Regional Stage, Tatruse Formation to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare to moderate.

Etymology: *digitatum* from the Latin *digitus,* 'finger', + *-atum,* suffix 'having the nature of'.

Comparison: Differs from *Multiplicisphaeridium malum* (Cramer 1964) in that this has no bifurcated processes, although they may terminate in spines or granulae. It is also somewhat larger in size. The species also resembles *Goniosphaeridium breviradiatum* n. sp., which is always more than 20 μm in size and has more slender processes with wider proximal contacts.

Micrhystridium eatonensis Downie 1959

Pl. XVII:172 (Fig. 4. No. 172)

1959: *Micrhystridium eatonensis* Downie, p. 62.

Description: The small spherical vesicle has a dense covering of short stout processes with acuminate or slightly bulbous distal terminations.

Dimensions: vesicle diameter 9 — 13 μm, lenght of process 0.5 — 1.0 μm, distance between processes 0.5 — 1.0 μm. Specimens measured: 30.

Occurrence: Rapla borehole, depths 173.0 — 36.1 m, Uhaku to Porkuni regional stages, Middle to Upper Ordovician. Rare.

Previous records: Middle Ordovician: France (Rauscher 1974). Middle Silurian: Britain (Downie 1959, 1963).

Micrhystridium equispinosum Turner 1984

Pl. XVII:173 (Fig. 4. No. 246)

1984: *Micrhystridium equispinosum* Turner, pp. 16—17.

Description: The spherical vesicle carries numerous slightly flagelliform processes of about the same length as the vesicle diameter. The surfaces of the vesicle and processes are psilate.

Dimensions: vesicle diameter 15 — 19 μm, lenght of process 13 — 18 μm. Specimens measured: 9.

Occurrence: Rapla borehole, depths 136.0 — 36.8 m, Keila Regional Stage to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Britain (Turner 1984).

Micrhystridium exiguum Rasul 1979

Pl. XVII:174 (Fig. 4. No. 156)

1979: *Micrhystridium exiguum* Rasul, p. 55.

Description: The spherical vesicle has short, cylindrical, flagelliform processes (length about 1/4 of vesicle diameter) with whip-like distal terminations. The vesicle surface is microgranulate, visible only in SEM image, and the processes are psilate. A median split is observed.

Dimensions: vesicle diameter 10 — 24 μm, lenght of process 3 — 6 μm, distance between processes 1.3 — 4.0 μm. Specimens measured: 14.

Occurrence: Rapla borehole, depths 178.0 — 36.1 m, Lasnamägi to Porkuni regional stages, Middle to Upper Ordovician. Rare.

Previous records: Lower Ordovician: Britain (Rasul 1979).

Micrhystridium fragile Deflandre 1947

Pl. XVII:175 (Fig. 4. No. 113)

1947: *Micrhystridium fragile* Deflandre, p. 8.

Description: The spherical vesicle has approximately 18—23 thin, flagelliform processes of about the same length as the vesicle diameter or slightly smaller. The number of processes is somewhat higher than in the original definition of Deflandre (1947). The vesicle surface is slightly granulated and the processes are psilate.

Dimensions: vesicle diameter 10 — 12 μm, lenght of process 5 — 12 μm. Specimens measured: 30.

Occurrence: Rapla borehole, depth 181.0 — 48.0 m, Aseri Regional Stage to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician to Silurian: Belgium (Martin 1966a,b, 1968). Upper Ordovician: Czechoslovakia (Konzalová—Mazancová 1969). Devonian: Spain (Cramer 1963, 1964). Jurassic: France (Deflandre 1947); Britain (Sarjeant 1961).

Micrhystridium granulatum n. sp.

Pl. XVIII:177 (Fig. 4. No. 118)

Diagnosis: The small, spherical vesicle has short, conical processes with curved proximal contacts of widely varying size. The processes may be located at variable intervals on the vesicle. The vesicle and processes are granulated, and the processes have bulbous distal terminations.

Dimensions: vesicle diameter 12 — 14 μm, length of process 1 — 6 μm, width of process 1.5 — 2.0 μm, number of processes in the optical section 12 — 15. Specimens measured: 2.

Holotype: GSF Prep. 1118 (SEM); Pl. XVIII:177. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 180.3 m, Aseri Regional Stage, Middle Ordovician. Rare.

Etymology: *granulatum* from the Latin *granum*, 'grain', + *-ulum*, diminutive, + *-atum*, suffix 'having the nature of'.

Comparison: Resembles *Lecithodinium chondrosum* Habib & Knapp 1982, which has processes of similar size distributed evenly on the vesicle.

Micrhystridium henryi Paris & Deunff 1970

Pl. XVII:176 (Fig. 4. No. 54)

1970: *Micrhysridium henryi* Paris & Deunff, pp. 31—32.

Description: The small spherical vesicle has short processes with acuminate distal terminations and curved proximal contacts, and which have partly grown together. The processes vary slightly in length within the same specimen. The vesicle is psilate, shagrinate or microgranulate.

Dimensions: vesicle diameter 15 — 20 μm, lenght of process 1.0 — 2.5 μm. Specimens measured: 439.

Occurrence: Rapla borehole, depths 189.0 — 28.0 m, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian. Rare to common.

Previous records: Middle Ordovician: France (Paris & Deunff 1970, Rauscher 1973). Ordovician Baltic erratics: Finland (Uutela 1989).

Micrhystridium inconspicuum aremoricanum Paris & Deunff 1970

Pl. XIX:186 (Fig. 4. No. 175)

1970: *Micrhystridium inconspicuum aremoricanum* Paris & Deunff, p. 32.

Description: The small, spherical vesicle has numerous short, conical processes. According to the original diagnosis, the maximum length of the processes is half of the vesicle diameter, but the ratio is 1/2 — 2/3 in this material. Thirty processes of variable size can be seen in the optical section, some of them being bifurcated but most of

them simple. Many species have collapsed inwards.

Dimensions: vesicle diameter 10 — 15 µm, lenght of process 2 — 8 µm. Specimens measured: 7.

Occurrence: Rapla borehole, depth 169.0 — 145.5 m, Uhaku to Keila regional stages, Middle Ordovician. Rare.

Previous records: Lower Ordovician: Britain (Molyneux 1987). Middle Ordovician: France (Paris & Deunff 1970); Britain (Turner 1985). Ordovician Baltic erratics: Finland (Uutela 1989).

Micrhystridium lasnamaegiense n. sp.

Pl. XVIII:178 (Fig. 4. No. 124)

Diagnosis: The spherical vesicle has numerous short, bulbous, conical, flagelliform processes located at irregular intervals (about 60 in the optical section). They do not communicate with the vesicle interior. The processes and vesicle are shagrinate and microgranulate, and the vesicle has a median split.

Dimensions: vesicle diameter 11 — 14 µm, length of process 1 — 2 µm, distance between processes 2 — 4 µm. Specimens measured: 15.

Holotype: GSF Prep. 1116 (SEM); Pl. XVIII:178. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 180.0 — 165.0 m, Lasnamägi to Kukruse regional stages, Middle Ordovician. Rare to moderate.

Etymology: *lasnamaegiense* from the Estonian Lasnamägi Regional Stage, *-ense,* suffix from the Latin 'belonging to'.

Comparison: Differs from *Micrhystridium parinconspcuum* Deflandre 1945, which has 12—15 longer, more flagelliform processes.

Micrhystridium minimum n. sp.

Pl. XVIII:179 (Fig. 4. No. 222)

Diagnosis: The small, spherical vesicle has short, conical processes of length approximately 1/12 of the vesicle diameter. The width of the process base is a half of the length of the process. The vesicle is densely covered with granulae, the processes are almost psilate and a median split is observed.

Dimensions: vesicle diameter 6 — 11 µm, length of process 0.5 — 0.6 µm, distance between processes 1.0 — 1.5 µm. Specimens measured: 8.

Holotype: GSF Prep. 1032 (SEM); Pl. XVIII:179. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 145.5 — 28.0 m, Jõhvi to Juuru regional stages, Middle Ordovician to Lower Silurian. Rare.

Etymology: *minimum* from the Latin, 'least'.

Comparison: *Micrhystridium nannacanthum* Deflandre 1945 is psilate and its processes are located more densely on the vesicle.

Micrhystridium nannacanthum Deflandre 1945

Pl. XIX:187 (Fig. 4. No. 16)

1945: *Micrhystridium nannacanthum* Deflandre, p. 66.

Description: The small, spherical vesicle has small tubercles with acuminate distal terminations. The median split may be 2/3 of the vesicle diameter.

Dimensions: vesicle diameter 8 — 18 µm, lenght of process 0.5 — 1.0 µm. Specimens measured: 1203.

Occurrence: Rapla borehole, depths 189.9 — 28.0 m, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian. Rare to common.

Previous records: Ordovician and Silurian deposits in the Europe (Eisenack *et al.* 1979b).

Micrhystridium nanodigitatum n. sp.

Pl. XVIII:180 (Fig. 4. No. 134)

Diagnosis: The spherical vesicle has numerous short, simple, conical processes (approximately 1/5 of the vesicle diameter) with slightly bulbous distal terminations. The vesicle is thick (0.8 µm) and shagrinate, and a median split is observed.

Dimensions: vesicle diameter 13 µm, length of process 2.5 µm. Specimens measured: 1.

Holotype: GSF Prep. 1116 (SEM); Pl. XVIII:180. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 178.0 m,

Lasnamägi Regional Stage, Middle Ordovician. Rare.

Etymology: *nanodigitatum* from the Latin *nanus,* 'dwarf', + *digitus,* 'finger' + *-atum,* suffix 'having the nature of'.

Comparison: Differs from *Micrhystridium eatonensis* Downie 1959 in that the latter has shorter, more densely occurring processes. The processes of *Dilatisphaera nanofurcata* n. sp. are open at their distal terminations.

Micrhystridium aff. *M. parinconspicuum* Deflandre 1945

Pl. XIX:188 (Fig. 4. No. 49)

Description: The spherical vesicle has conical processes of length 1/5 — 1/6 of the vesicle diameter. The vesicle is psilate to slightly granulated.

Dimensions: vesicle diameter 12 — 14 µm, length of process 2.0 — 2.5 µm. Specimens measured: 44.

Remarks: The processes are shorter and more numerous (35—40) than in the definition of *Micrhystridium parinconspicuum* Deflandre (1945).

Occurrence: Rapla borehole, depths 189.0 — 36.1 m, Volhov to Porkuni regional stages, Lower to Upper Ordovician. Rare to moderate.

Micrhystridium parvulum n. sp.

Pl. XVIII:181 (Fig. 4. No. 248)

Diagnosis: The small, spherical vesicle has numerous short, conical processes (approximately 1/6 of the vesicle diameter) with acuminate distal terminations. They are located densely and at regular intervals, but without having grown together. The vesicle and processes are psilate, and no median split is observed.

Dimensions: vesicle diameter 9.0 — 9.5 µm, length of process 1.0 — 1.5 µm, distance between processes approx. 0.5 µm. Specimens measured: 4.

Holotype: GSF Prep. 1038 (SEM); Pl. XVIII:181. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 136.0 — 28.0 m, Keila to Juuru regional stages, Middle Ordovician to Lower Silurian. Rare.

Etymology: *parvulum* from the Latin, 'very small'.

Comparison: Differs from *Micrhystridium eatonensis* Downie 1959, the processes of which are not conical, and *M. henryi* Paris & Deunff 1970 the processes of which have more curved proximal contacts which have almost fused together.

Micrhystridium polygonale n. sp.

Pl. XVIII:182 (Fig. 4. No. 58)

Diagnosis: The polygonal vesicle has short, simple processes located at its corners. The cylindrical processes are slightly bulbous distally and apparently communicate with the vesicle interior. Their length is approximately 1/4 of the vesicle diameter. The vesicle and processes are psilate.

Dimensions: vesicle diameter 17 µm, length of process 4 µm, width of process 1.5 µm, number of processes in the optical section 8. Specimens measured: 1.

Holotype: GSF Prep. 1125 (SEM); Pl. XVIII:182. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 188.6 m, Kunda Regional Stage, Sillaoru Formation, Lower Ordovician. Rare.

Etymology: *polygonale* from the Latin *polygonum,* 'having many angles' (*poly,* 'many' + *gonos,* from stem of *gonia,* 'angle') + *-ale,* suffix 'pertaining to'.

Comparison: Differs from *Micrhystridium digitatum* n. sp., the vesicle of which is clearly spherical and which has twice as many processes.

Micrhystridium punctatum n. sp.

Pl. XVIII:183 (Fig. 4. No. 181)

Diagnosis: The small, spherical or subspherical vesicle has numerous conical processes with acuminate distal terminations, which may be furcated in some cases. The processes communicate with the vesicle interior and their length does not exceed that of the vesicle diameter. The vesicle

and processes are covered with irregular rows of tubercles.

Dimensions: vesicle diameter 9 — 16 µm, length of process 2 — 5 µm, process base diameter 1.5 — 3.0 µm, number of processes in the optical section 9 — 17. Specimens measured: 83.

Holotype: GSF Prep. 1091 (SEM); Pl. XVIII:183. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 165.0 — 42.0 m, Kukruse Regional Stage to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare to moderate.

Etymology: *punctatum* from the Latin *punctum,* 'point', + *-atum* suffix 'having the nature of'.

Comparison: The surface structure of the species resembles that of *Veryhachium punctatum* n. sp., the processes of which are fewer in number and longer.

Micrhystridium shinetonensis Downie 1958

Pl. XIX:189 (Fig. 4. No. 128)

1958: *Micrhystridium shinetonensis* Downie, p. 342.

Description: The small spherical vesicle has numerous simple processes of length approximately 60% of the vesicle diameter. Both the vesicle and the processes are psilate.

Dimensions: vesicle diameter 8 — 10 µm, lenght of process approx. 0.6 µm. Specimens measured: 40.

Occurrence: Rapla borehole, depths 180.0 — 56.0 m, Lasnamägi Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Ordovician and Silurian deposits in Europe (Eisenack *et al.* 1979b).

Micrhystridium stellatum Deflandre 1945

Pl. XIX:190 (Fig. 4. No. 80)

1945: *Micrhystridium stellatum* Deflandre, p. 476.

Description: The spherical vesicle has 10—15 simple processes with slightly curved proximal contacts and of length equal to or slightly less than the vesicle diameter. The vesicle and processes are shagrinate.

Dimensions: vesicle diameter 15 — 20 µm, lenght of process 10 — 17 µm. Specimens measured: 516.

Occurrence: Rapla borehole, depths 188.6 — 28.0 m, Kunda Regional Stage, Sillaoru Formation to Juuru Regional Stage, Lower Ordovician to Lower Silurian. Rare to common.

Previous records: Ordovician to Jurassic deposits in Europe and Silurian deposits in North and South America (Eisenack *et al.* 1979a).

Micrhystridium stellatum f. *latispinosum* n. forma

Pl. XVIII:184 (Fig. 4. No. 155)

Description: The slightly polygonal vesicle has conical, somewhat bulbous, stout, mostly simple processes, some of which are bifurcated to form a stout branch. The processes, which communicate with the vesicle interior, do not exceed the vesicle diameter in length. The vesicle is granulate and the processes psilate.

Dimensions: vesicle diameter 10 — 19 µm, lenght of process 7 — 10 µm, number of processes in the optical section 8 — 10. Specimens measured: 24.

Holotype of forma: GSF Prep. 1061 (SEM); Pl. XVIII:184. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 178.0 — 54.0 m, Lasnamägi Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to moderate.

Etymology: *latispinosum* from the Latin *latus,* 'broad', + *spinosum,* 'spiny'.

Remarks: Differs from *Micrhystridium stellatum* Deflandre 1945 in that the latter has slightly curved, simple processes with acuminate distal terminations.

Micrhystridium stellatum salopiense Lister 1970

Pl. XIX:191 (Fig. 4. No. 247)

1970: *Micrhystridium stellatum salopiense* Lister, p. 82.

Description: The slightly polygonal vesicle has numerous simple, slightly flagelliform processes

which are shorter than the vesicle diameter. The vesicle and processes are microgranulate.

Dimensions: vesicle diameter 9 — 12 µm, lenght of process 6 — 10 µm, number of processes in the optical section 14 — 24. Specimens measured: 14.

Occurrence: Rapla borehole, depths 136.0 — 29.0 m, Keila to Juuru regional stages, Middle Ordovician to Lower Silurian. Rare to moderate.

Previous records: Upper Silurian: Britain (Lister 1970).

Micrhystridium taeniosum n. sp.

Pl. XVIII:185 (Fig. 4. No. 157)

Diagnosis: The subspherical vesicle has numerous short, homomorphic processes (approximately 80—100 in the optical section) with acuminate distal terminations which are attached to it with small fibres at their only slightly curved proximal contacts. The processes tend to be pressed against the vesicle surface. Apart from the attaching fibres, the vesicle and processes are psilate.

Dimensions: vesicle diameter 9 — 17 µm, length of process 2 — 7 µm, base diameter 0.5 — 1.0 µm, distance between processes 0.5 — 2.0 µm. Specimens measured: 23.

Holotype: GSF Prep. 1032 (SEM); Pl. XVIII:185. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 178.0 — 28.0 m, Lasnamägi to Juuru regional stages, Middle Ordovician to Lower Silurian. Rare.

Etymology: *taeniosum* from the Latin *taenia,* 'ribbon, fillet', + *-osum,* suffix 'provided with'.

Comparison: Differs from *Dictyosphaeridium reticulatum* n. sp. in that the latter has stouter, conical processes and a clear reticular patterning on the vesicle.

Micrhystridium varipinnosum n. sp.

Pl. XX:202 (Fig. 4. No. 11)

Diagnosis: The small, spherical vesicle has a varying number of processes, about 40—60 in the optical section, some of which are simple, conical ones and some cylindrical and bifurcated, including second-order furcation. The furcated processes are generally longer, but still only approximately 1/10 of the vesicle diameter. The vesicle is psilate or shagrinate and varies in thickness up to a maximum of 1.2 µm. A median split is observed.

Dimensions: vesicle diameter 14 — 18 µm, length of process 1.3 — 3.0 µm, distance between processes 2.0 — 3.5 µm. Specimens measured: 75.

Holotype: GSF Prep. 1116 (SEM); Pl. XX:202. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 189.9 — 36.1 m, Volhov to Porkuni regional stages, Lower to Upper Ordovician. Rare to moderate.

Etymology: *varipinnosum* from the Latin *varius,* 'varied', + *pinna,* 'feather, wing', + *-osum* suffix, 'full of'.

Comparison: Resembles *Micrhystridium henryi* Paris & Deunff 1970, except that the latter does not have furcated processes.

Micrhystridium varispinosum n. sp.

Pl. XX:203 (Fig. 4. No. 194)

Diagnosis: The spherical vesicle has processes of two sizes. The longer ones are simple, conical, slightly flagelliform and granulated, and are shorter than the vesicle diameter. The shorter processes are approximately 1/10 of the vesicle diameter, simple, with bulbous distal terminations and covered with small tubercles. The vesicle is granulated between the processes.

Dimensions: vesicle diameter 9 — 11 µm, length of longer processes 6 — 7 µm, length of shorter processes 1 µm. Specimens measured: 15.

Holotype: GSF Prep. 1093 (SEM); Pl. XX:203. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 159.0 — 106.0 m, Kukruse Regional Stage to Nabala Regional Stage, Paekna Formation, Middle Ordovician. Rare.

Etymology: *varispinosum* from the Latin *varius,* 'varied' + *spinosum,* 'spiny'.

Comparison: Differs from *Micrhystridium arsolatum granulosum* (Jardiné *et al.* 1974), which has longer processes with constricted proximal

contacts and lacks any smaller granulae. The genus *Percultisphaera* Lister 1970 has processes of two different sizes, but its overall size is more than 20 µm, and therefore the present type is assigned to the genus *Micrhystridium* Deflandre 1937.

***Micrhystridium* sp. 1.**

Pl. XX:204 (Fig. 4. No. 240)

Description: The small, spherical vesicle has numerous conical processes (approximately 40 in the optical section) with acuminate distal terminations and of length about 1/5 of the vesicle diameter. The vesicle and processes are microgranulate, and no pylome or median split has been observed.

Dimensions: vesicle diameter 9 — 12 µm, lenght of process 2.0 — 2.5 µm, distance between processes 2 µm. Specimens measured: 6.

Occurrence: Rapla borehole, depths 140.0 — 104.0 m, Keila Regional Stage to Nabala Regional Stage, Paekna Formation, Middle Ordovician. Rare.

Comparison: Resembles *Micrhystridium lasnamaegiense* n. sp., except that the processes of the latter have an angular proximal contact with the vesicle. In the case of *Micrhystridium* sp. 2, the processes are distally plugged and covered with small spikes.

***Micrhystridium* sp. 2.**

Pl. XX:205 (Fig. 4. No. 5)

Description: The spherical vesicle has numerous evexate processes (35—45 in the optical section) with curved proximal contacts and of length about 1/3—1/4 of the vesicle diameter. The vesicle is shagrinate and the proximal contacts of the processes psilate, while 2/3 of the distal end is covered with small spikes. A median split has been observed. One specimen has a covered round pylome containing a semicircular pylome lid, the edges of which include some smaller individual processes.

Dimensions: vesicle diameter 14 — 17 µm, lenght of process 1.5 — 4.0 µm, pylome diameter 10 µm. Specimens measured: 13.

Occurrence: Rapla borehole, depths 189.9 — 161.0 m, Volhov to Kukruse regional stages, Lower to Middle Ordovician. Rare to moderate.

Comparison: Resembles *Micrhystridium stellatun intonsurans* Lister 1970, except that this has longer processes.

Genus *Multiplicisphaeridium* Staplin 1961, restr. Staplin, Jansonius & Pocock 1965, emend. Eisenack 1969

***Multiplicisphaeridium actinospinosum* n. sp.**

Pl. XX:206 (Fig. 4. No. 119)

Diagnosis: The spherical vesicle has numerous short, stout processes (about 60 in the optical section) with palmate process terminations containing about 10 small pinnulae. The processes are irregularly spaced on the vesicle. The processes have a broad base and may communicate freely with the vesicle interior. The process length is 1/10 of the vesicle diameter and the surfaces of the vesicle and processes are shagrinate. No pylome is observed.

Dimensions: vesicle diameter 26 µm, length of process 3 µm, process base 2 µm. Specimens measured: 1.

Holotype: GSF Prep. 1118 (SEM); Pl. XX:206. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 180.3 m, Aseri Regional Stage, Middle Ordovician. Rare.

Etymology: *actinospinosum* from the Greek *aktis* + *-inos*, 'ray', + from the Latin *spinosum*, 'spiny, echinate'.

Comparison: Differs from *Multiplicisphaeridium palmitella* (Cramer & Díez 1972), the processes of which are longer, stouter and less numerous, and have more palmated pinnae. *M.*

raplaense n. sp. has more numerous processes with 5 to 6 small pinnae and is markedly smaller in size.

Multiplicisphaeridium alloiteaui (Deunff 1955)

Pl. XIX:192 (Fig. 4. No. 44)

1955: *Micrhystridium alloiteaui* Deunff, p. 148.

1973: *Multiplicisphaeridium alloiteaui* (Deunff 1955) Eisenack, Cramer & Díez, p. 521.

Description: The small, spherical vesicle has numerous short processes which communicate with the vesicle interior and are distally furcated to form two or three short branches. The surfaces of the vesicle and processes are psilate to shagrinate.

Dimensions: vesicle diameter 12 — 25 µm, length of process 4 — 5 µm. Specimens measured: 163.

Occurrence: Rapla borehole, depths 189.0 — 38.0 m, Volhov Regional Stage to Pirgu Regional Stage, Adila Formation, Lower to Upper Ordovician. Rare to common.

Previous records: Middle Ordovician: Sweden (Kjellström 1976); Britain (Lister *et al.* 1969). Ordovician: Belgium (Martin 1966a, 1968). Ordovician Baltic erratics: Finland (Uutela 1989). Silurian: Britain (Lister 1970). Devonian: Canada (Deunff 1955).

Multiplicisphaeridium bifurcatum Staplin, Jansonius & Pocock 1965

Pl. XIX:193 (Fig. 4. No. 55)

1965: *Multiplicisphaeridium bifurcatum* Staplin *et al.*, p. 182.

Description: The spherical vesicle has about 10 bifurcated processes which communicate with the vesicle interior and are more or less equal to the vesicle diameter in length. The surfaces of the vesicle and processes are psilate or shagrinate.

Dimensions: vesicle diameter 11 — 20 µm, length of process 9 — 17 — 25 µm. Specimens measured: 52.

Occurrence: Rapla borehole, depths 189.0 — 28.0 m, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian. Rare.

Previous records: Lower Ordovician: Britain (Lister *et al.* 1969). Middle Ordovician: Sweden (Kjellström 1971a); Canada (Staplin *et al.* 1965): Upper Ordovician: U.S.A. (Loeblich & Tappan 1978, Wright & Meyers 1981); Canada (Martin 1980). Ordovician Baltic erratics: Finland (Uutela 1989).

Multiplicisphaeridium bipalmatum n. sp.

Pl. XX:207 (Fig. 4. No. 106)

Diagnosis: The small, hollow, spherical vesicle has numerous processes of length 1/5 — 1/6 of the vesicle diameter. The processes have stellate swellings distally and medially, those in the latter position being the larger. The processes have curved contacts with the vesicle and may communicate freely with the vesicle interior. The surfaces of the vesicle and processes are psilate, and no pylome is observed.

Dimensions: vesicle diameter 12 — 20 µm, length of process 2 — 3 µm, distance between processes 2.0 — 2.5 µm. Specimens measured: 101.

Holotype: GSF Prep. 1091 (SEM); Pl. XX:207. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 182.0 — 28.0 m, Aseri to Juuru regional stages, Middle Ordovician to Lower Silurian. Rare to moderate.

Etymology: *bipalmatum* from the Latin *bis, bi-,* 'twice, two', + *palmatum,* 'having a palm-leaf pattern'.

Comparison: Resembles *Multiplicisphaeridium parvipinnatum* n. sp. and *M. palmatum* (Cramer & Díez 1972), but these have longer palmate distal furcations which do not have a stellate swelling medially.

Multiplicisphaeridium aff. *M. borracherosum* (Cramer) Lister 1970

Pl. XIX:194 (Fig. 4. No. 308)

Description: The spherical vesicle has short,

stout processes which are irregularly furcated to form short, stumpy branches and are about 10% of the vesicle diameter in length. The surface of processes are slightly granulate.

Dimensions: vesicle diameter 20 — 40 µm, length of process 2.4 — 4.0 µm. Specimens measured: 4.

Remarks: Prosesses are shorter than *Multiplicisphaeridium borracherosum* (Cramer) Lister 1970 and process surface is psilate.

Occurrence: Rapla borehole, depths 58.0 — 36.1 m, Pirgu Regional Stage, Moe Formation to Porkuni Regional Stage, Upper Ordovician.

Multiplicisphaeridium borracherosum f. *regulare* n. forma

Pl. XX:208 (Fig. 4. No. 318)

Description: The spherical vesicle has numerous short, stout, heteromophic processes (about 100 in the optical section) which are simple, conical or cylindrical and bi- or trifurcated to form short pinnae. These divide further to form extremely short bulbous furcations. There are numerous microgranulae on the bases of the processes, filling the entire vesicle. The processes are psilate, and a median split is observed.

Dimensions: vesicle diameter 39 µm, length of process 2 — 3 µm, width of process 1.5 µm, distance between processes 2 — 3 µm. Specimens measured: 1.

Holotype of forma: GSF Prep. 1038 (SEM); Pl. XX:208. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 36.8 m, Pirgu Regional Stage, Adila Formation, Upper Ordovician. Rare.

Etymology: *regulare* from the Latin *regula,* 'ruler', + *-are,* suffix 'pertaining to'.

Remarks: Differs from *Multiplicisphaeridium borracherosum* (Cramer) Lister 1970, the latter being psilate and its processes more irregular and furcated. *Gorgonisphaeridium frequens* Górka 1987 has homomorphic processes covered by small spikes.

Multiplicisphaeridium brevidigitatum n. sp.

Pl. XX:209 (Fig. 4. No. 253)

Diagnosis: The spherical vesicle has numerous short, stout processes (about 60 in the optical section), the distal terminations of which are usually tangentially trifurcated, and the furcations are further bifurcated. The processes are located unevenly on the vesicle and they have short, stout furcations. The vesicle and processes are psilate.

Dimensions: vesicle diameter 13 — 16 µm, length of process 2 — 3 µm, process base diameter 1.5 — 2.0 µm, distance between processses 3 µm. Specimens measured: 2.

Holotype: GSF Prep. 1088 (SEM); Pl. XX:209. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 136.0 — 130.0 m, Keila Regional Stage, Middle Ordovician. Rare.

Etymology: *brevidigitatum* from the Latin *brevis,* 'short', + *digitatum,* 'having toes'.

Comparison: Resembles slightly *Multiplicisphaeridium eisenacki* (Sanneman 1955), but the latter has fewer processes, which are not tangentially furcated, and it is also of considerable size.

Multiplicisphaeridium cacteum n. sp.

Pl. XX:210a, XXI:210b (Fig. 4. No. 25)

Diagnosis: The spherical vesicle is densely covered with solid tubercles of diameter about 1.0 µm. The hollow, subcylindrical, psilate processes are thick and short, of length equal to 1/5 of the vesicle diameter, and are distally furcated to form two or three short spines about 1.5 µm in length. The bases of the processes are costate. The processes may communicate with the vesicle interior. A circular pylome is observed.

Dimensions: vesicle diameter 30 — 60 µm, length of process 3 — 9 µm, process base 1 — 3 µm, distance between processes 1.5 — 10 µm, pylome diameter 10 µm. Specimens measured: 12.

Holotype: GSF Prep. 1125 (SEM); Pl. XX:210a, XXI:210b. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 189.0 —

180.0 m, Volhov to Lasnamägi regional stages, Lower to Middle Ordovician. Rare.

Etymology: *cacteum* from the Latin *cactus,* 'cactus', + *-eum,* suffix 'having the quality of'.

Comparison: Differs from *Multiplicisphaeridium acacianense* Playford & Martin 1984, which has a psilate, scrabate or granulate vesicle surface, and from *M. petalum* Wicander 1974, which has a corrugated-foveolate vesicle surface and less furcated processes.

Multiplicisphaeridium caperoradiolum (Loeblich 1970)

Pl. XIX:195 (Fig. 4. No. 206)

1970: *Diexallophasis caperoradiola* Loeblich, pp. 714—715.

1973: *Multiplicisphaeridium caperoradiolum* (Loeblich 1970) Eisenack, Cramer & Díez, p. 553.

Description: The subspherical vesicle has 7—9 hollow processes, some of which are furcated, the furcations of the second order being considerably short and monate. The processes are densely covered with tubercles of various sizes which have striated bases and are situated unevenly on the process surface. The Rapla specimen is markedly smaller than that described by Loeblich (1970).

Dimensions: vesicle diameter 17 — 21 µm, length of process 25 — 27 µm, total diameter 65 — 71 µm. Specimens measured: 23.

Occurrence: Rapla borehole, depths 151.0 — 36.8 m, Idavere Regional Stage, Vasavere Formation to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Middle Silurian: U.S.A. (Loeblich 1970a).

Multiplicisphaeridium cornigerum n. sp.

Pl. XXI:211 (Fig. 4. No. 294)

Diagnosis: The spherical vesicle has stout, heteromorphic processes which are somewhat longer than the its diameter. The processes are simple and have two or more furcations, which are long and highly distinctive, the angle between them being approximately 45°. The surface of the vesicle is slightly reticulate and those of the processes microgranulate.

Dimensions: vesicle diameter 16 µm, length of process 19 µm, base diameter 4 µm, number of processes in the optical section 7. Specimens measured: 1.

Holotype: GSF Prep. 1061 (SEM); Pl. XXI:211. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 82.0 m, Vormsi Regional Stage, Upper Ordovician. Rare.

Etymology: *cornigerum* from the Latin *cornu,* 'horn', + *-gerum,* suffix 'bear, have'.

Comparison: Differs from *Multiplicisphaeridium ramusculosum insolitum* (Cramer & Díez 1972) the vesicle and processes of the latter being psilate, and *M. ramibrachium* (Wicander 1974), the vesicle of which is granulate and its processes stouter. The latter species is also considerably larger.

Multiplicisphaeridium cymoides n. sp.

Pl. XXI:212 (Fig. 4. No. 232)

Diagnosis: The polygonal vesicle has stout processes situated unevenly on the vesicle. These are either simple or bi- or trifurcated distally with slightly bulbous distal terminations. The simple processes are smaller than the furcated ones, the length of which is approximately 1/5 of the vesicle diameter. The processes communicate with the vesicle interior, the vesicle surface is microgranulate and no median split is observed.

Dimensions: vesicle diameter 15 — 20 µm, length of process 5 — 6 µm, number of processes in the optical section 20. Specimens measured: 3.

Holotype: GSF Prep. 1093 (SEM); Pl. XXI:212. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 140.0 — 138.0 m, Keila Regional Stage, Middle Ordovician. Rare.

Etymology: *cymoides* from the Greek *kyma,* 'wave', + *-oides* from Gr. *-eides,* 'like'.

Comparison: Resembles morphologically *Multiplicisphaeridium cymosum* (Loeblich 1970), but the latter is of considerable size (72—90 µm) with

a granulate vesicle surface and a verrucate process surface. The processes of *M. raquelinae* Cramer & Díez 1972 are more irregularly furcated, and this species is also larger (30—45 µm).

Multiplicisphaeridium digitatum Eisenack (1938) 1969

Pl. XIX:196 (Fig. 4. No. 291)

1938: *Hystrichosphaeridium digitatum* Eisenack, p. 20.
1959: *Baltisphaeridium digitatum* Eisenack, p. 200.
1969: *Multiplicisphaeridium digitatum* Eisenack, p. 259.

Description: The rounded vesicle has several processes with curved proximal contacts usually dicotomously bifurcated distally. The number of processes in the rounded vesicle is approximately 10—20, while a form with less process, approximately 8, has a subpolygonal vesicle. The process stems vary greatly in thickness, and the surfaces of the vesicle and processes are rough with tubercular bases.

Dimensions: vesicle diameter 80 — 130 µm, length of process 40 — 62 µm, total diameter 170 — 240 µm. Specimens measured: 26.

Occurrence: Rapla borehole, depths 90.0 — 37.4 m, Vormsi Regional Stage to Pirgu Regional Stage, Adila Formation, Upper Ordovician. Rare.

Previous records: Upper Ordovician: Estonia (Eisenack 1938). Ordovician deposits in Europe and Silurian deposits in U.S.A. (Eisenack *et al.* 1976).

Multiplicisphaeridium diversispinosum n. sp.

Pl. XXI:213 (Fig. 4. No. 163)

Diagnosis: The hollow, spherical to subspherical vesicle is densely covered with small, hollow, heteromorphic processes with broad bases. The processes are simple, asymmetrical, bi- or trifurcated, conical or blunt with palmately furcated terminations consisting of up to six small pinnae. Process length is about 1/5—1/7 of the vesicle diameter and the processes do not communicate with the vesicle interior. The vesicle surface is psilate or shagrinate, and the processes are psilate. A circular pylome with a collar is observed.

Dimensions: vesicle diameter 30 — 65 µm, length of process 1.5 — 5.0 µm, pylome diameter 10 — 12 µm. Specimens measured: 6.

Holotype: GSF Prep. 1080 (SEM); Pl. XXI:213. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 175.0 — 36.8 m, Uhaku Regional Stage to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare.

Etymology: *diversispinosum* from the Latin *diversus*, 'different', + *spinosum*, 'thorny'.

Comparison: Resembles *Multiplicisphaeridium acacianense* Playford & Martin 1984, which has less variable and longer processes and no circular pylome.

Multiplicisphaeridium ferum (Martin 1968)

Pl. XIX:197 (Fig. 4. No. 76)

1968: *Baltisphaeridium ferum* Martin, p. 52.
1973: *Multiplicisphaeridium ferum* (Martin 1968) Eisenack, Cramer & Díez, p. 633.

Description: The spherical vesicle has numerous heteromorphic processes (approximately 50 in the optical section), the length of which is about 1/5 of the vesicle diameter. The processes are simple or furcated, forming 2—4 rather short pinnae. The surface of the vesicle is granulate and the processes have small spikes unevenly distributed on them.

Dimensions: vesicle diameter 20 — 48 µm, length of process 4 — 10 µm, distance between processes 9 — 10 µm. Specimens measured: 19.

Occurrence: Rapla borehole, depths 188.6 — 42.0 m, Kunda Regional Stage, Sillaoru Formation to Pirgu Regional Stage, Adila Formation, Lower to Upper Ordovician. Rare to moderate.

Previous records: Lower Ordovician: Belgium (Martin 1968).

Multiplicisphaeridium fisherii (Cramer 1968)

Pl. XIX:198 (Fig. 4. No. 205)

1968: *Baltisphaeridium fisherii* Cramer, p. 73.

1973: *Multiplicisphaeridium fisherii* (Cramer 1968) Eisenack, Cramer & Díez, pp. 635—637.

Description: This species is taken to incorporate *Multiplicisphaeridium brazosdesnudum* (Cramer 1964) and *M. fermosum* (Cramer 1970), as is morphologically possible according to Cramer (1970). The spherical vesicle has a varying number of heteromorphic processes which are as long as the vesicle diameter or longer. The processes are simple but mostly furcated, forming second-order pinnae. The surfaces of the vesicle and processes are microgranulate or psilate.

Dimensions: vesicle diameter 13 — 23 µm, length of process 12 — 20 µm. Specimens measured: 12.

Occurrence: Rapla borehole, depths 151.0 — 56.0 m, Idavere Regional Stage, Vasavere Formation to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Upper Ordovician: U.S.A. (Jacobson 1978). All previous records of the other associated species are from Silurian deposits in Europe and the U.S.A. (Cramer 1964, 1968, 1970, Cramer *et al.* 1979).

Multiplicisphaeridium fissile (Stockmans & Willière 1963)

Pl. XIX:199 (Fig. 4. No. 42)

1963: *Baltisphaeridium fissile* Stockmans & Willlière, pp. 458—459.

1973: *Multiplicisphaeridium fissile* (Stockmans & Willière 1963) Eisenack, Cramer & Díez, pp. 639—640.

Description: The subspherical vesicle has 10—17 heteromorphic processes of length nearly corresponding to or slightly less than the vesicle diameter. The processes are simple but mostly bi- or trifurcated, with their pinnae spread well apart. The surfaces of the vesicle and processes are psilate or microgranulate.

Dimensions: vesicle diameter 13 — 17 µm, length of process 8 — 13 µm. Specimens measured: 72.

Occurrence: Rapla borehole, depths 189.0 — 44.0 m, Volhov Regional Stage to Pirgu Regional Stage, Adila Formation, Lower to Upper Ordovician. Rare to moderate.

Previous records: Ordovician: Belgium (Martin 1968). Silurian: Belgium (Stockmans & Willière 1963); U.S.A. (Cramer & Díez 1972b).

Multiplicisphaeridium forquiferum (Cramer & Díez 1972)

Pl. XIX:200 (Fig. 4. No. 267)

1972: *Baltisphaeridium forquiferum* Cramer & Díez, p. 151.

1973: *Multiplicisphaeridium forquiferum* (Cramer & Díez 1972) Eisenack, Cramer & Díez, pp. 641—642.

Description: The spherical vesicle has 8—9 processes of length about equal to the vesicle diameter. The processes are heteromorphic and simple, but mostly furcated forming second-order pinnae. The processes and their pinnae in particular are slender and flagelliform. The surfaces of the vesicle and processes are psilate or microgranulate.

Dimensions: vesicle diameter 13 — 16 µm, length of process 10 — 16 µm. Specimens measured: 20.

Occurrence: Rapla borehole, depths 123.0 — 36.1 m, Rakvere to Porkuni regional stages, Middle to Upper Ordovician. Rare to moderate.

Previous records: Silurian: Sweden (Cramer *et al.* 1979); U.S.A. (Cramer & Díez 1972b).

Multiplicisphaeridium gotlandicum (Eisenack 1954)

Pl. XIX:201 (Fig. 4. No. 101)

1954: *Hystrichosphaeridium gotlandicum* Eisenack, p. 209.

1963: *Baltisphaeridium gotlandicum* Downie & Sarjeant, p. 90.

1973: *Multiplicisphaeridium gotlandicum* (Eisenack 1954) Eisenack, Cramer & Díez, pp. 651—652.

Description: The spherical shell has numerous hollow, cylindrical processes expanded distally and with an incipient palmate branching pattern.

Dimensions: vesicle diameter 60 — 65 µm, length of process 6 — 8 µm. Specimens measured: 21.

Occurrence: Rapla borehole, depths 182.0 — 130.0 m, Aseri to Keila regional stages, Middle Ordovician. Rare.

Previous records: Middle Ordovician: Finland (Tynni 1982); Sweden (Górka 1987). Silurian: Sweden (Eisenack 1954, 1965b); Spain (Cramer 1967); U.S.A. (Cramer 1970, Cramer & Díez 1972b).

Multiplicisphaeridium irregulare Staplin, Jansonius & Pocock 1965

Pl. XXII:219 (Fig. 4. No. 88)

1965: *Multiplicisphaeridium irregulare* Staplin, Jansonius & Pocock, p. 183.

Description: The thin, subspherical vesicle has hollow processes which are either simple or bifurcated, rarely branching any further. The surfaces of the vesicle and processes are psilate, and the species is slightly smaller than that described by Staplin *et al.* (1965).

Dimensions: vesicle diameter 16 — 20 µm, length of process 10 — 16 µm, length of pinna approx. 8 µm. Specimens measured: 442.

Occurrence: Rapla borehole, depths 188.0 — 28.0 m, Kunda Regional Stage, Loobu Formation to Juuru Regional Stage, Middle Ordovician to Lower Silurian. Rare to common.

Previous records: Middle Ordovician: Britain (Turner 1984); Canada (Staplin *et al.* 1965). Upper Ordovician: U.S.A. (Wright & Meyers 1981). Ordovician Baltic erratics: Finland (Tynni 1975, Uutela 1989).

Multiplicisphaeridium lichenoides n. sp.

Pl. XXI:214 (Fig. 4. No. 195)

Diagnosis: The hollow, thick-walled, spherical to subspherical vesicle is densely covered with short processes, some of which are simple but most bifurcated, all having stellate distal terminations. The processes are of length about 1/10 of the vesicle diameter, they are thin-walled and do not communicate with the vesicle interior. The vesicle surface is granulate and that of the processes echinate. An excystment structure is a median split.

Dimensions: vesicle diameter 40 — 60 µm, length of process 6 — 8 µm, width of process ca. 2 µm, distance between processes 5 — 10 µm. Specimens measured: 6.

Holotype: GSF Prep. 1104 (SEM); Pl. XXI:214. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 157.0 — 138.0 m, Kukruse to Keila regional stages, Middle Ordovician. Rare.

Etymology: *lichenoides* from the Latin *lichen,* 'lichen', + *-oides,* suffix 'like'.

Comparison: The processes of *Multiplicisphaeridium gotlandicum* (Eisenack 1954), with a scarcely noticable palmate pattern, are never bifurcated, and its vesicle surface is psilate. The processes of *Multiplicisphaeridium ferum* (Martin 1968) are longer and irregularly furcated.

Multiplicisphaeridium martae Cramer & Díez 1972

Pl. XXII:220 (Fig. 4. No. 56)

1972: *Multiplicisphaeridium martae* Cramer & Díez, pp. 1—4.

Description: The spherical or subspherical vesicle has numerous short processes with curved proximal contacts (24—60 in the optical section), which usually branch into two or sometimes three short pinnae near the distal termination. The surfaces of the vesicle and processes are psilate or shagrinate.

Dimensions: vesicle diameter 8 — 11 µm, length of process 3 — 4 µm. Specimens measured: 18.

Occurrence: Rapla borehole, depths 189.0 — 28.0 m, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian. Rare.

Previous records: Middle Ordovician: Spain (Cramer & Díez 1972a).

Multiplicisphaeridium micropunctatum n. sp.

Pl. XXI:215 (Fig. 4. No. 255)

Diagnosis: The small, subspherical vesicle has

numerous short processes (about 50 in the optical section) which have palmate distal furcations forming 3—5 short, sharp pinnae. The vesicle is covered with regular microgranulate ornamentations, and the processes are psilate. A median split is observed.

Dimensions: vesicle diameter 8 — 10 µm, length of process ca. 1 µm, distance between processes 1 — 2 µm. Specimens measured: 4.

Holotype: GSF Prep. 1088 (SEM); Pl. XXI:215. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 136.0 — 97.0 m, Keila Regional Stage to Nabala Regional Stage, Saunja Formation, Middle to Upper Ordovician. Rare.

Etymology: *micropunctatum* from the Greek *mikros,* 'small', + from the Latin *punctatus,* 'punctated'.

Comparison: Resembles *Multiplicisphaeridium rigidum ludlovensis* (Lister 1970), but the latter is larger and may also be psilate, but not covered by a regular tubercular pattern.

Multiplicisphaeridium aff. *M. multipugiunculatum* Cramer & Díez 1977

Pl. XXII:221 (Fig. 4. No. 135)

Description: The small spherical vesicle has numerous processes with curved distal terminations and furcated distally to form 4—6 short, palmate pinnae, usually 5.

Dimensions: vesicle diameter 13 — 14 µm, length of process 3 — 4 µm. Specimens measured: 3.

Remarks: *Multiplicisphaeridium multipugiunculatum* Cramer and Díez (1977) has 6 or more pinnae in this position, and is also larger in size (35—45 µm).

Occurrence: Rapla borehole, depths 178.0 m, Lasnamägi Regional Stage, Middle Ordovician. Rare.

Multiplicisphaeridium opimum n. sp.

Pl. XXI:216 (Fig. 4. No. 209)

Diagnosis: The hollow, spherical vesicle has stout, hollow, heteromorphic processes perpendicular to it and standing out distinctly from it. The smaller processes are simple and the larger ones irregularly furcated, with 4—6 finger-shaped pinnae extending perpendicular to them. The length of the longer processes is about a half of the vesicle diameter and the width about a half of the length. The processes communicate freely with the vesicle interior. The vesicle surface and process bases are microgranulate and the processes distally psilate. No pylome or median split is observed.

Dimensions: vesicle diameter 18 — 22 µm, length of simple processes 6 — 10 µm, length of furcated processes 10 — 12 µm, number of processes 7. Specimens measured: 4.

Holotype: GSF Prep. 1088 (SEM); Pl. XXI:216. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 150.0 — 130.0 m, Jõhvi to Keila regional stages, Middle Ordovician. Rare.

Etymology: *opimum* from the Latin, 'plentiful, abundant'.

Comparison: *Multiplicisphaeridium digitatum* Eisenack (1938) 1969 is of considerable size and has stout, furcated processes, but these are more numerous and do not stand out distinctly on the vesicle.

Multiplicisphaeridium aff. *M. palmitella* (Cramer & Díez 1972)

Pl. XXII:222 (Fig. 4. No. 161)

Description: The small, spherical vesicle has a dense formation of short, flagelliform, palmately furcated processes.

Dimensions: vesicle diameter 10 — 17 µm, length of process approx. 2 µm. Specimens measured: 4.

Remarks: *Multiplicisphaeridium palmitella* (Cramer & Diez 1972) is larger with longer processes. The specimens differ from the *M. raplaense* n. sp. found in the Rapla material as the latter has stouter, shorter processes with very short palmate furcations.

Occurrence: Rapla borehole, depths 176.0 — 130.0 m, Lasnamägi to Keila regional stages, Middle Ordovician. Rare.

Multiplicisphaeridium parvipinnatum n. sp.

Pl. XXI:217 (Fig. 4. No. 96)

Diagnosis: The small, spherical vesicle has numerous short processes (about 80 in the optical section), with distal terminations palmately furcated to form five or sometimes even six small pinnae. The processes communicate with the vesicle interior, are usually of consistent width and have only slightly curved proximal contacts. The surfaces of the vesicle and processes are psilate.

Dimensions: vesicle diameter 14 — 18 µm, length of process 1.6 — 2.0 µm, distance between processes approx. 2 µm. Specimens measured: 108.

Holotype: GSF Prep. 1088 (SEM); Pl. XXI:217. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 184.0 — 28.0 m, Kunda Regional Stage, Loobu Formation to Juuru Regional Stage, Middle Ordovician to Lower Silurian. Rare to common.

Etymology: *parvipinnatum* from the Latin *parvus,* 'small', + *pinna,* 'feather, wing', + *-atum,* suffix 'provided with'.

Comparison: Resembles *Multiplicisphaeridium canadense* Staplin, Jansonius & Pocock 1965, the processes of which are furcated distally to form 2—4 bulbous pinnae. *M. raplaense* n. sp. has stouter processes with more curved proximal contacts.

Multiplicisphaeridium parvirochesterensis (Cramer & Díez 1972)

Pl. XXII:223 (Fig. 4. No. 131)

1972: *Baltisphaeridium parvirochesterensis* Cramer & Díez, p. 154.

1973: *Multiplicisphaeridium parvirochesterensis* (Cramer & Díez 1972) Eisenack, Cramer & Díez, pp. 719—720.

Description: The spherical vesicle has simple or bifurcated flagelliform processes, some of which have second-order furcations. The conical processes are equal to about half of the vesicle diameter in length. The surfaces of the vesicle and processes are microgranulate.

Dimensions: vesicle diameter 9 — 11 µm, length of process 5 — 6 µm, number of processes in the optical section 25 — 33. Specimens measured: 17.

Occurrence: Rapla borehole, depths 180.0 — 46.0 m, Lasnamägi Regional Stage to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Lower Silurian: U.S.A. (Cramer & Díez 1972b).

Multiplicisphaeridium parvispinosum n. sp.

Pl. XXI:218 (Fig. 4. No. 104)

Diagnosis: The thick, spherical vesicle is densely covered with short processes, the average length of which is 1/10 of the vesicle diameter. The processes show slight palmate branching distally. The surface of the vesicle is irregularly verrucate, visible only by electron microscope, and the processes are psilate and do not communicate with the vesicle interior. The excystment structure takes the form of a median split.

Dimensions: vesicle diameter 25 — 38 µm, length of process 2 — 3 µm, wall thickness 0.5 µm. Specimens measured: 14.

Holotype: GSF Prep. 1088 (SEM); Pl. XXI:218. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 182.0 — 104.0 m, Aseri Regional Stage to Nabala Regional Stage, Paekna Formation, Middle Ordovician. Rare.

Etymology: *parvispinosum* from the Latin *parvus,* 'small', + *spinosum,* 'echinate'.

Comparison: Differs from *Multiplicisphaeridium alloiteaui* (Deunff 1955), as the latter has thicker processes which are fewer in number. *M. parvipinnatum* n. sp. also has thin processes, but they are less numerous. *Micrhystridium nanodigitatum* n. sp. has a vesicle of corresponding thickness, but its densely arranged processes have no furcations.

Multiplicisphaeridium radicosum Loeblich 1970

Pl. XXII:224 (Fig. 4. No. 256)

1970: *Multiplicisphaeridium radicosum* Loeblich, p. 730.

Description: The vesicle is subcircular, thin-

walled and wrinkled, its processes communicating with the interior. The processes are bi- or trifurcated, usually blunt, but sometimes with acuminate distal terminations.

Remarks: According to the catalogue of Eisenack *et al.* (1973), this is a junior synonym of *Multiplicisphaeridium corallinum* Eisenack 1959, but the present writers are inclined to disagree because of the different nature of the processes.

The species recorded here differs from *M. digitatum* Eisenack (1938) 1969, which has more clearly separated processes with longer, acuminate branches. *M. corallinum* Eisenack 1959 has long processes which are more branched. The species bears a greater resemblance to *M. visbyense* Eisenack 1959, but the processes stand out more clearly from the vesicle. Also, *M. visbyense* is of considerable size. As the Rapla material also includes smaller specimens of previously described larger species, we have combined the distinctly smaller individuals of *M. radicosum* within the same species.

Dimensions: vesicle diameter of smaller species 14 — 20 µm, vesicle diameter of larger species 47 — 85 µm, length of process of smaller species 10 — 13 µm, length of process of larger species 30 — 40 µm. Specimens measured: 4.

Occurrence: Rapla borehole, depths 136.0 — 130.0 m (smaller species), Keila Regional Stage, Middle Ordovician and depth 90.0 m (larger), Vormsi Regional Stage, Upper Ordovician. Rare.

Previous records: Upper Ordovician: U.S.A. (Loeblich 1970a); Canada (Martin 1980, 1983). Ordovician Baltic erratics: Finland (Uutela 1989).

Multiplicisphaeridium aff. *M. ramusculosum macrocladum* (Deunff 1955)

Pl. XXII:225 (Fig. 4. No. 147)

Description: The subspherical vesicle has short, stout processes (about half of the vesicle diameter in length) which bifurcate, some of them bifurcating further. The surfaces of the vesicle and processes are microgranulate.

Dimensions: vesicle diameter 11 — 12 µm, length of process 7 — 8 µm, number of processes in the optical section 8. Specimens measured: 3.

Remarks: These specimens differ from *Multiplicisphaeridium ramusculosum macrocladum* (Deunff 1955) being smaller in size.

Occurrence: Rapla borehole, depths 178.0 — 113.0 m, Lasnamägi to Rakvere regional stages, Middle Ordovician. Rare.

Previous records: Middle Devonian: Canada (Deunff 1955).

Multiplicisphaeridium raplaense n. sp.

Pl. XXIII:235 (Fig. 4. No. 84)

Diagnosis: The small, hollow, thick-walled vesicle is densely covered with numerous short processes (about 80 in the optical section), the length of which is 1/10 of the vesicle diameter. The processes have broad bases with curved proximal contacts, communicate freely with the vesicle interior and are palmately furcated distally to form 5 — 6 small branches. The vesicle surface and processes are psilate. No pylome or excystment structure is observed.

Dimensions: vesicle diameter 10 — 16 µm, length of process 1 — 2 µm. Specimens measured: 93.

Holotype: GSF Prep. 1091 (SEM); Pl. XXIII:235. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 188.0 — 60.0 m, Kunda Regional Stage, Loobu Formation to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to common.

Etymology: *raplaense* from the Estonian Rapla borehole, + *-ense,* from the Latin, suffix 'belonging to'.

Comparison: Differs from *Multiplicisphaeridium alloiteaui* (Deunff 1955) and *M. canadense* Staplin, Jansonius & Pocock 1965, which have less furcated processes. *M. palmitella* (Cramer & Díez 1972) has longer, more flexible processes and is larger. *M. waldronensis* (Tappan & Loeblich 1971) has distally similar processes, but these are less numerous and longer, and the species is also larger in size.

Multiplicisphaeridium raspa (Cramer 1964)

Pl. XXII:226 (Fig. 4. No. 86)

1964: *Baltisphaeridium raspa* Cramer, p. 301.

1973: *Multiplicisphaeridium raspa* (Cramer 1964) Eisenack, Cramer & Díez, pp. 767—768.

Description: The subspherical vesicle has numerous bifurcated processes which are further furcated two or three times at their distal terminations.

Dimensions: vesicle diameter 12 — 20 µm, length of process 6 µm. Specimens measured: 47.

Occurrence: Rapla borehole, depths 186.0 — 42.0 m, Kunda Regional Stage, Loobu Formation to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician to Lower Devonian deposits (Eisenack *et al.* 1973).

Multiplicisphaeridium remotum f. *raplaense* n. forma

Pl. XXIII:236 (Fig. 4. No. 201)

Description: The triangular, polygonal vesicle has 3—6 stout processes of variable size, the shortest of which are simple, while the longer ones bifurcate to form two stout pinnae. Their distal terminations are slightly bulbous. The surface of the vesicle is psilate or irregularly granulate and those of the processes are psilate.

Dimensions: vesicle diameter 12 — 23 µm, length of process 10 — 16 µm, total diameter 32 — 40 µm. Specimens measured: 29.

Holotype: GSF Prep. 1091 (SEM); Pl. XXIII:236. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 152.0 — 36.8 m, Idavere Regional Stage, Tatruse Formation to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare to moderate.

Etymology: *raplaense* from the Estonian Rapla borehole, + *-ense,* from the Latin, suffix 'belonging to'.

Remarks: Differs from *Multiplicisphaeridium remotum* (Deunff 1955), which has more processes which are longer and more often furcated, even forming second-order branches. *M. mucronatum* (Stockmans & Willière 1963) has longer, more slender and more furcated processes.

Multiplicisphaeridium spinosum n. sp.

Pl. XXIII:237 (Fig. 4. No. 62)

Diagnosis: The spherical vesicle has numerous short processes with palmate terminations (about 80 in the optical section), forming 4—5 whip-like, flagelliform branches, with second-order branches as well. The processes also have small, whip-like spikes. The surface of the vesicle is microgranulate.

Dimensions: vesicle diameter 43 — 46 µm, length of process 5 — 7 µm, distance between processes 5 µm. Specimens measured: 8.

Holotype: GSF Prep. 1125 (SEM); Pl. XXIII:237. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 188.6 — 180.3 m, Kunda Regional Stage, Loobu Formation to Aseri Regional Stage, Middle Ordovician. Rare to moderate.

Etymology: *spinosum* from the Latin, 'spiny, echinate'.

Comparison: Differs from *Multiplicisphaeridium palmitella* (Cramer & Díez 1972), the processes of which are longer but contain no whip-like spikes. The process terminations of *M. lichenoides* n. sp. form stellate furcations which are not whip-like.

Multiplicisphaeridium striatum n. sp.

Pl. XXIII:238 (Fig. 4. No. 260)

Diagnosis: The spherical vesicle has 6 stout, bifurcated processes, with pinnae originating irregularly from near the proximal contact, the middle of the process or the distal termination. The processes are bifurcated, some also forming stout second-order pinnae. The vesicle and processes have granulate striations which are only visible in SEM image.

Dimensions: vesicle diameter 13 — 19 µm, length of process 11 — 17 µm, total diameter 30 — 50 µm, number of processes in the optical section 6 — 8. Specimens measured: 2.

Holotype: GSF Prep. 1088 (SEM); Pl. XXIII:238. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 130.0 m, Keila Regional Stage, Middle Ordovician. Rare.

Etymology: *striatum* from the Latin *stria,* 'groove, channel, furrow', + *-atum,* suffix 'provided with'.

Comparison: Resembles *Multiplicisphaeridium caperoradiola* (Loeblich 1970) and *M. fermosum* (Cramer 1970), but their processes have thinner branches and are irregularly tubercular, tubercular only at the proximal contacts or psilate. The processes of *M. verrucosum* n. sp. are more furcated and the vesicle has tubercles of varying size.

Multiplicisphaeridium aff. *M. subbifurcatum* (Stockmans & Willière 1967)

Pl. XXII:227 (Fig. 4. No. 145)

Description: The spherical or subspherical vesicle has numerous stout processes, slightly shorter than the vesicle diameter, which are either simple or furcated, forming pinnae of almost equal length, with smaller additional pinnae originating from these.

Dimensions: vesicle diameter 11 — 14 µm, length of process 5 — 8 µm, number of processes in the optical section 11 — 17. Specimens measured: 6.

Remarks: The vesicle of *Multiplicisphaeridium subbifurcatum* (Stockmans & Willière 1967) is polyedrically globular in form.

Occurrence: Rapla borehole, depths 178.0 — 136.0 m, Lasnamägi to Keila regional stages, Middle Ordovician. Rare.

Multiplicisphaeridium toyetaforme n. sp.

Pl. XXIII:239 (Fig. 4. No. 254)

Diagnosis: The spherical vesicle has 3—5 stout processes with cauliflower-like furcations near their distal terminations. The surface of the vesicle is shagrinate and those of the processes psilate.

Dimensions: vesicle diameter 28 — 30 µm, length of process 10 — 14 µm, base diameter 4 µm, length of pinna 3 — 4 µm. Specimens measured: 3.

Holotype: GSF Prep. 1091 (SEM); Pl. XXIII:239. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 136.0 — 126.0 m, Keila to Oandu regional stages, Middle Ordovician. Rare.

Etymology: *toyetaforme,* resembles the species *Multiplicisphaeridium toyetae, -forme* from the Latin 'having the form of'.

Comparison: Resembles *Multiplicisphaeridium toyetae* (Cramer 1964), but the latter has rosette-like process terminations which are more furcated. *M. dicros* (Loeblich & Drugg 1968) has longer processes with a plug at the proximal contact.

Multiplicisphaeridium turgidum n. sp.

Pl. XXIII:240 (Fig. 4. No. 168)

Diagnosis: The polygonal vesicle has a varying number of heterogenic processes, some of which are conical with acuminate distal terminations and some cylindrical and bifurcated. The length of the processes varies, but does not exceed the vesicle diameter. The surfaces of the vesicle and processes are shagrinate and microgranulate, and the processes communicate with the vesicle interior.

Dimensions: vesicle diameter 11 — 14 µm, length of process 3 — 8 µm, base diameter 2.5 — 3.0 µm, number of processes in the optical section 5 — 15. Specimens measured: 13.

Holotype: GSF Prep. 1080 (SEM); Pl. XXIII:240. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 173.0 — 117.0 m, Uhaku to Rakvere regional stages, Middle Ordovician. Rare.

Etymology: *turgidum* from the Latin, 'swollen, distended'.

Comparison: Differs from *Multiplicisphaeridium continuatum* Kjellström 1971, which has longer processes which are all bifurcated. *M. malum* (Cramer 1964) has bulbous process terminations.

Multiplicisphaeridium verrucosum n. sp.

Pl. XXIII:241 (Fig. 4. No. 264)

Diagnosis: The subspherical vesicle has 4—5 stout processes with 2—6 irregular distal

branches, with up to third-order furcation occurring. Furcation invariably begins from almost the same level on the process, the terminations of the pinnae being slightly bulbous. The vesicle surface has bulbous tubercles of diameter 0.5—1.0 μm situated irregularly on it, and its processes are striated and microgranulate.

Dimensions: vesicle diameter 17 — 18 μm, length of process 15 — 20 μm, number of processes in the optical section 4 — 5. Specimens measured: 8.

Holotype: GSF Prep. 1073 (SEM); Pl. XXIII:241. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 130.0 — 46.0 m, Keila Regional Stage to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare.

Etymology: *verrucosum* from the Latin *verruca,* 'wart', + *-osum,* suffix 'full of'.

Comparison: Differs from *Multiplicisphaeridium micronatum* Stockmans & Willière 1963, the processes of which are longer and very much more slender. *M. dicros* (Loeblich & Drugg 1969) usually has 3 processes with a plug at the proximal contact.

***Multiplicisphaeridium* sp.**

Pl. XXIII:242 (Fig. 4. No. 136)

Description: The edges of the polygonal vesicle have stout, conical processes, the distal terminations of which furcate tangentially to form 4—6 branches. These then bifurcate further to form two pinnae which have small, third-order pinnae at their tips. The processes apparently communicate with the vesicle interior, and the surfaces of the vesicle and processes are shagrinate.

Dimensions: vesicle diameter 8 μm, length of process 4 μm, number of processes in the optical section 10. Specimens measured: 1.

Occurrence: Rapla borehole, depth 178.0 m, Lasnamägi Regional Stage, Middle Ordovician. Rare.

Comparison: Resembles *Multiplicisphaeridium lancaraeata* Cramer & Díez 1972, but the latter has a more spherical vesicle and more numerous, slightly flagelliform processes, and it is larger in size (ø 25—45 μm). *M. corallinum* (Eisenack 1959) is even larger still, with a diameter of about 100 μm.

Genus *Nanocyclopia* Loeblich & Wicander 1976

***?Nanocyclopia* sp.**

Pl. XXIII:243 (Fig. 4. No. 40)

Description: The spherical to subspherical vesicle has a dense ornamentation of tiny nubs or protensions. There is an operculum with a thicker, slightly elevated area. The vesicle wall is thick.

Dimensions: vesicle diameter 26 — 80 μm, wall thickness 2 — 6 μm, operculum diameter 10 — 22 μm. Specimens measured: 52.

Occurrence: Rapla borehole, depths 189.0 — 58.0 m, Volhov Regional Stage to Pirgu Regional Stage, Moe Formation, Lower to Upper Ordovician. Rare to moderate.

Comparison: Resembles the genus *Nanocyclopia* Loeblich & Wicander 1976, but it is impossible to verify by electron microscopy whether a fimbriate margin exists as seen by light microscopy. The specimens have a small, round, thicker, slightly elevated area in the operculum. The ornamentation of the vesicle also resembles that of the genus *Lophosphaeridium* Timofeev 1959, but occurs more densely.

Genus *Ordovicidium* Tappan & Loeblich 1971

Ordovicidium aequifurcatum (Kjellström) Loeblich & Tappan 1978

Pl. XXII:228 (Fig. 4. No. 243)

1971: *Peteinosphaeridium aequifurcatum* Kjellström, pp. 51—52.

1978: *Ordovicidium aequifurcatum* (Kjellström) Loeblich & Tappan, p. 1281.

Description: The spherical vesicle has about 10 cylindrical processes with bifurcated distal terminations.

Dimensions: vesicle diameter 40 — 80 µm, length of process 10 — 16 µm. Specimens measured: 7.

Occurrence: Rapla borehole, depths 140.0 — 66.0 m, Keila Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare.

Previous records: Middle Ordovician: Sweden (Kjellström 1971a).

Ordovicidium elegantulum Tappan & Loeblich 1971

Pl. XXII:229 (Fig. 4. No. 178)

1971: *Ordovicidium elegantulum* Tappan & Loeblich, pp. 389—400.

Description: The spherical vesicle has 10—15 stout processes with tangentially furcated distal terminations forming 3—4 branches. Both the vesicle and processes are granulate.

Dimensions: vesicle diameter 54 — 60 µm, length of process 20 — 30 µm. Specimens measured: 44.

Occurrence: Rapla borehole, depths 169.0 — 58.0 m, Uhaku Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Sweden (Górka 1987); Britain (Turner 1984, 1985); Canada (Martin 1983). Middle Ordovician: U.S.A. (Tappan & Loeblich 1971); Upper Ordovician: U.S.A. (Colbath 1979, 1980).

Ordovicidium groetlingboensis (Kjellström) Loeblich & Tappan 1978

Pl. XXII:230 (Fig. 4. No. 149)

1971: *Peteinosphaeridium groetlingboensis* Kjellström, pp. 52—53.

1978: *Ordovicidium groetlingboensis* (Kjellström) Loeblich & Tappan, p. 1281.

Description: The spherical vesicle has cylindrical processes with irregularly furcated distal terminations forming long branches. Second-order furcation also occurs. The surfaces of the vesicle and processes are microgranulate.

Dimensions: vesicle diameter 50 — 60 µm, length of process 18 — 20 µm. Specimens measured: 68.

Occurrence: Rapla borehole, depths 178.0 — 66.0 m, Lasnamägi Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to common.

Previous records: Middle Ordovician: Sweden (Kjellström 1971a, 1972, 1976). Upper Ordovician: U.S.A. (Jacobson 1978).

Ordovicidium groetlingboensis f. *clavatum* n. forma

Pl. XXVI:275 (Fig. 4. No. 176)

Description: The spherical vesicle has numerous heteromorphic processes, about 15, which form second-order and sometimes even third-order pinnae. The ends of the furcations often narrow like an eagle's talons. The processes vary in width and do not communicate with the vesicle interior. The surface of the vesicle is psilate or microgranulate and the processes are almost psilate at their proximal contacts, but clearly granulate distally.

Dimensions: vesicle diameter 35 — 43 µm, length of process 16 — 25 µm, process base diameter 4 — 5 µm, span of pinna tips 21 — 25 µm. Specimens measured: 29.

Holotype: GSF Prep. 1093 (SEM); Pl. XXVI:275. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 169.0 — 136.0 m, Uhaku to Keila regional stages, Middle Ordovician. Rare to moderate.

Etymology: *clavatum* from the Latin *clavus,* 'nail', + *-atum,* suffix 'provided with'.

Remarks: Resembles *Ordovicidium groetlingboensis* (Kjellström) Loeblich & Tappan 1978 in its greatly furcated processes, but the vesicle and processes of the latter are psilate and its pinnae do not have the form of talons.

Ordovicidium heteromorphicum (Kjellström) Loeblich & Tappan 1978

Pl. XXII:231 (Fig. 4. No. 126)

1971: *Peteinosphaeridium heteromorphicum* Kjellström, p. 53.

1978: *Ordovicidium heteromorphicum* (Kjellström) Loeblich & Tappan, p. 1281.

Description: The spherical vesicle has processes of two types which do not communicate with the vesicle interior. The surfaces of the vesicle and processes are psilate.

Dimensions: vesicle diameter 47 — 65 µm, length of processes 30 — 35 µm. Specimens measured: 24.

Occurrence: Rapla borehole, depths 180.0 — 74.0 m, Aseri Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Finland (Tynni 1982); Sweden (Kjellström 1971a, Górka 1987); Britain (Turner 1984). Ordovician Baltic erratics: Finland (Uutela 1989).

Ordovicidium nanofurcatum (Kjellström 1971) n. comb.

Pl. XXII:232 (Fig. 4. No. 182)

1971: *Peteinosphaeridium nanofurcatum* Kjellström, p. 55.

Description: The spherical vesicle has numerous short, thin processes with bifurcated, bulbous terminations. The surfaces of the vesicle and processes are psilate. The peteinos of the processes are not recorded and therefore the species is transferred to the genus *Ordovicidium.*

Dimensions: vesicle diameter 42 — 60 µm, length of process 3 — 8 µm. Specimens measured: 6.

Occurrence: Rapla borehole, depths 163.0 — 159.0 m, Kukruse Regional Stage, Middle Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Sweden (Kjellström 1971a); Britain (Turner 1984). Ordovician Baltic erratics: Finland (Uutela 1989).

Ordovicidium nudum (Eisenack) Loeblich & Tappan 1978

Pl. XXII:233 (Fig. 4. No. 130)

1959: *Baltisphaeridium trifurcatum nudum* Eisenack, p. 203.

1969: *Peteinosphaeridium nudum* Eisenack, p. 255.

1978: *Ordovicidium nudum* (Eisenack) Loeblich & Tappan, p. 1201.

Description: The spherical vesicle has numerous cylindrical processes which furcate distally to form 3—4 palmate branches. The surfaces of the vesicle and processes are psilate.

Dimensions: vesicle diameter 45 — 70 µm, length of process 20 — 30 µm. Specimens measured: 56.

Occurrence: Rapla borehole, depths 180.0 — 46.0 m, Lasnamägi Regional Stage to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare to common.

Previous records: Ordovician and Silurian deposits in Europe (Eisenack *et al.* 1973).

Ordovicidium paucifurcatum (Eisenack 1959) n. comb.

Pl. XXII:234 (Fig. 4. No. 196)

1959: *Baltisphaeridium trifurcatum* f. *paucifurcatum* Eisenack, p. 203.

1973: *Peteinosphaeridium paucifurcatum* (Eisenack 1959), Eisenack, Cramer & Díez, pp.919—920.

Description: The slender, fairly thick, shagrinate vesicle has slender, psilate processes, the length of which is less than the vesicle diameter. The processes lack peteinos, for this rea-

son the species is transferred to the genus *Ordovicidium*. No pylome is observed.

Dimensions: vesicle diameter 90 µm, length of process 20 µm. Specimens measured: 1.

Occurrence: Rapla borehole, depth 154.0 m, Idavere Regional Stage, Tatruse Formation, Middle Ordovician. Rare.

Previous records: Ordovician Baltic erratics: Estonia (Eisenack 1959); Finland (Tynni 1975, Uutela 1989).

Genus *Orthosphaeridium* Eisenack 1968, emend. Kjellström 1971

Orthosphaeridium bispinosum Turner 1984

Pl. XXIV:244 (Fig. 4. No. 261)

1984: *Orthosphaeridium bispinosum* Turner, pp. 125—126.

Description: The thick, subspherical vesicle has two long, flagelliform processes, and is bisected by a median split. The vesicle and processes are covered with small spinules.

Dimensions: vesicle length 60 — 75 µm, vesicle width 57 — 60 µm, length of process 120 — 150 µm. Specimens measured: 4.

Occurrence: Rapla borehole, depths 130.0 — 126.6 m, Keila to Oandu regional stages, Middle Ordovician. Rare.

Previous records: Middle Ordovician: Britain (Turner 1984).

Orthosphaeridium chondrododora Loeblich & Tappan 1971

Pl. XXIV:245 (Fig. 4. No. 303)

1971: *Orthosphaeridium chondrododora* Loeblich & Tappan, pp. 184—186.

Description: The vesicle resembles a rounded-off rectangle in form and has four long processes. The vesicle and processes have low, bulbous tubercles on the surface. The vesicle is bisected by a median split.

Dimensions: vesicle length 61 — 72 µm, vesicle width 50 — 55 µm, length of process 110 — 127 µm. Specimens measured: 2.

Occurrence: Rapla borehole, depth 66.0 m, Pirgu Regional Stage, Moe Formation, Upper Ordovician. Rare.

Previous records: Middle Ordovician: Britain (Turner 1984). Upper Ordovician: U.S.A. (Colbath 1979). Ordovician Baltic erratics: Finland (Tynni 1975).

Orthosphaeridium densiverrucosum Kjellström 1971

Pl. XXIV:246 (Fig. 4. No. 102)

1971: *Orthosphaeridium densiverrucosum* Kjellström, p. 30.

Description: The vesicle is slightly angular and almost divided into half by a partial rupture. It is covered with strong spinules, and the processes with smaller ones. The constricted proximal contact of the process with the vesicle has solid plugs.

Dimensions: vesicle diameter 36 — 40 µm, length of process 11 — 12 µm. Specimens measured: 8.

Occurrence: Rapla borehole, depths 182.0 — 126.6 m, Aseri to Oandu regional stages, Middle Ordovician. Rare.

Previous records: Middle Ordovician: Sweden (Kjellström 1971b); Poland (Górka 1980). Ordovician Baltic erratics: Finland (Uutela 1989).

Orthosphaeridium insculptum Loeblich 1970

Pl. XXIV:247 (Fig. 4. No. 112)

1970: *Orthosphaeridium insculptum* Loeblich, pp. 734—735.

Description: The slightly angular or spherically angular vesicle has 5—6 flagelliform processes of varying length, the longest of which are located at the corners. A median split is observed, and the surfaces of the vesicle and processes are granulate.

Dimensions: vesicle length 51 — 79 µm, vesicle width 50 — 75 µm, length of process 52 — 62 µm, length of shorter process 20 — 23 µm. Specimens measured: 24.

Occurrence: Rapla borehole, depths 181.0 — 54.0 m, Aseri Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Canada (Martin 1980). Upper Ordovician: U.S.A. (Loeblich 1970a). Ordovician Baltic erratics: Finland (Uutela 1989).

Orthosphaeridium insculptum f. *erectum* n. forma

Pl. XXVI:276 (Fig. 4. No. 140)

Description: The corners of the slightly angular vesicle have processes of slightly varying length but greater than the vesicle diameter. The processes are straight and have acuminate distal terminations with no clear constrictions at their proximal contacts. The surface of the vesicle is echinate, and the tubercles on the processes diminish in size from the base towards the distal termination. The vesicle has a median split.

Dimensions: vesicle length 45 — 49 µm, vesicle width 38 — 40 µm, length of process 50 — 55 µm, number of processes 8. Specimens measured: 3.

Holotype: GSF Prep. 1115 (SEM); Pl. XXVI:276. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 178.0 — 176.0 m, Lasnamägi Regional Stage, Middle Ordovician. Rare.

Etymology: *erectum* from the Latin, 'upright, erect'.

Remarks: Differs from *Orthosphaeridium insculptum* Loeblich 1970, the processes of which are flagelliform.

Orthosphaeridium latispinosum n. sp.

Pl. XXVI:277 (Fig. 4. No. 183)

Diagnosis: The subspherical or slightly rectangular vesicle has four stout, short processes with constricted proximal contacts. The processes are shorter than the vesicle diameter and have acuminate or slightly bulbous distal terminations. The surfaces of the vesicle and processes are granulate, and the vesicle is bisected by a median split.

Dimensions: vesicle length 45 — 64 µm, vesicle width 31 — 40 µm, length of process 30 — 38 µm, max. width of process 12 µm. Specimens measured: 8.

Holotype: GSF Prep. 1097 (SEM); Pl. XXVI:277. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 163.0 — 130.0 m, Kukruse to Keila regional stages, Middle Ordovician. Rare.

Etymology: *latispinosum* from the Latin *latus,* 'broad', + *spinosum,* 'spiny, echinate'.

Comparison: *Orthosphaeridium densiverrucosum* Kjellström 1971 also has its processes shorter than the vesicle diameter, but there are 8 of them and they are verrucate, as is the vesicle. In addition, it has a plug at the proximal contact of each processes.

Orthosphaeridium rectangulare Eisenack (1963) 1968

Pl. XXVI:248 (Fig. 4. No. 312)

1963: *Baltisphaeridium rectangulare* Eisenack, p. 211.

1968: *Orthosphaeridium rectangulere* Eisenack, p. 92.

Description: The rectangular vesicle has convex sides and features 4 hollow processes with closed proximal contacts at its corners. The length of the processes is about twice the vesicle diameter. The surfaces of the vesicle and processes are shagrinate or slightly coarse.

Dimensions: vesicle length 56 µm, vesicle width 47 µm, length of process 134 µm. Specimens measured: 1.

Occurrence: Rapla borehole, depth 37.2 m, Pirgu Regional Stage, Adila Formation, Upper Ordovician. Rare.

Previous records: Middle Ordovician: Sweden (Kjellström 1971b, 1972). Upper Ordovician: Estonia and Sweden (Eisenack 1963); U.S.A. (Loeblich 1970a).

Orthosphaeridium vibrissiferum Loeblich & Tappan 1971

Pl. XXVI:249 (Fig. 4. No. 110)

1971: *Orthosphaeridium vibrissiferum* Loeblich & Tappan, pp. 186—188.

Description: The subspherical vesicle has four long processes with distinct plugs at their proximal contacts. The vesicle has small spinules, and the processes are tubercular.

Dimensions: vesicle diameter 57 — 64 µm, length of process 63 — 85 µm, width of process 8 — 10 µm. Specimens measured: 12.

Occurrence: Rapla borehole, depths 181.0 — 68.0 m, Aseri Regional Stage to Pirgu Regional Stage, Moa Formation, Middle to Upper Ordovician. Rare.

Previous records: Middle Ordovician: Sweden (Górka 1987); Poland (Górka 1979); U.S.A. (Loeblich & Tappan 1971a). Ordovician Baltic erratics; Finland (Uutela 1989).

Orthosphaeridium sp.

Pl. XXVI:278 (Fig. 4. No. 208)

Description: The slightly oval vesicle has 5, possibly 6, simple processes with acuminate distal terminations and curved proximal contacts. The processes are greater than the vesicle diameter in length. The surfaces of the vesicle and processes are microgranulate, either irregularly or in regular rows. The vesicle is bisected by a median split.

Dimensions: vesicle diameter 48 — 55 µm, length of process 35 — 37 µm. Specimens measured: 6.

Occurrence: Rapla borehole, depths 150.0 — 136.0 m, Keila Regional Stage, Middle Ordovician. Rare.

Comparison: Resembles *Baltisphaeridium onniense* (Turner 1984) n. comb., but the latter has more processes and no median split, which is considered a typical feature of the genus *Orthosphaeridium* Eisenack 1968.

Genus *Peteinosphaeridium* Staplin, Jansonius & Pocock 1965, emend. Eisenack 1969

Peteinosphaeridium granulatum n. sp.

Pl. XXVI:279 (Fig. 4. No. 174)

Diagnosis: The spherical vesicle has numerous short, wide, angular processes which are evidently hollow. They have slightly curved distal terminations and are about 1/6 of the vesicle diameter in length. The surface of the vesicle is clearly granulate and the processes psilate. The pylome is circular with a low collar.

Dimensions: vesicle diameter 34 — 50 µm, length of process 6 — 12 µm. Specimens measured: 10.

Holotype: GSF Prep. 1102 (SEM); Pl. XXVI:279. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 169.0 — 154.0 m, Uhaku Regional Stage to Idavere Regional Stage, Tatruse Formation, Middle Ordovician. Rare.

Etymology: *granulatum* from the Latin *granum,* 'grain', + *-atum,* suffix 'having the nature of'.

Comparison: Resembles *Rhopaliophora palmata* (Combaz & Peniquel) Playford & Martin 1984, but the latter is echinate and its processes saccular.

Peteinosphaeridium hymenoferum Eisenack (1938) 1969

Pl. XXIV:250 (Fig. 4. No. 22)

1938: *Hystrichosphaeridium hymenoferum* Eisenack, p. 19.
1969: *Peteinosphaeridium hymenoferum* Eisenack, p. 254.

Description: The spherical vesicle has numerous processes consisting of three strips attached by their inner faces. The processes have acuminate distal terminations with no furcations. The surfaces of the vesicle and processes are psilate.

Dimensions: vesicle diameter 54 — 60 µm, length of process 20 — 22 µm. Specimens measured: 6.

Occurrence: Rapla borehole, depths 189.0 — 188.0 m, Volhov Regional Stage to Kunda Regional Stage, Loobu Formation, Lower to Middle Ordovician. Rare.

Previous records: Glaugonitic Baltic erratic, Lower Ordovician (Eisenack 1938).

Peteinosphaeridium macropylum Eisenack (1959) 1969

Pl. XXIV:251 (Fig. 4. No. 24)

1959: *Baltisphaeridium macropylum* Eisenack, p. 198.

1969: *Peteinosphaeridium macropylum* Eisenack, p. 254.

Description: The spherical vesicle has numerous small processes which are either simple or distally furcated to two small pinnae and have acuminate distal terminations. Several smaller processes occur round the circular opening, pylome. The surface of the vesicle is granulate and that of the processes psilate.

Dimensions: vesicle diameter 46 — 50 µm, length of process 7 — 8 µm, pylome diameter 14 — 23 µm. Specimens measured: 5.

Occurrence: Rapla borehole, depths 189.0 — 184.0 m, Volhov Regional Stage to Kunda Regional Stage, Loobu Formation, Lower to Middle Ordovician. Rare.

Previous records: Lower Ordovician: Sweden (Eisenack 1959, Kjellström 1971a). Ordovician Baltic erratics (Eisenack 1938, 1959, 1968).

Peteinosphaeridium micranthum (Eisenack 1959)

Pl. XXIV:252 (Fig. 4. No. 26)

1959: *Baltisphaeridium micranthum* Eisenack, p. 203.

1973: *Peteinosphaeridium micranthum* (Eisenack 1959) Eisenack, Cramer & Díez, pp. 913—914.

Description: The spherical vesicle wall is thick and densely covered with short, slender processes which furcate distally to form 3—4 branches. A circular pylome is recorded. The surfaces of the vesicle and processes are psilate.

Dimensions: vesicle diameter 50 — 80 µm, length of process 7 — 9 µm, pylome diameter 15 — 25 µm. Specimens measured: 5.

Occurrence: Rapla borehole, depths 189.0 — 180.0 m, Volhov to Lasnamägi regional stages, Lower to Middle Ordovician. Rare.

Previous records: Lower Ordovician: Estonia (Eisenack 1959). Ordovician Baltic erratics: Finland (Tynni 1975, Uutela 1989).

Peteinosphaeridium trifurcatum Eisenack (1931) 1969

Pl. XXIV:253 (Fig. 4. No. 173)

1931: *Ovum hispidum trifurcatum* Eisenack, p. 112.

1969: *Peteinosphaeridium trifurcatum* Eisenack, pp. 254—255.

Description: The spherical vesicle has 14 slender, distally furcating processes enveloped by peteinos. The surface of the vesicle is shagrinate.

Dimensions: vesicle diameter 110 µm, length of process 45 µm. Specimens measured: 1.

Occurrence: Rapla borehole, depth 171.0 m, Uhaku Regional Stage, Middle Ordovician. Rare.

Previous records: Middle Ordovician to Lower Silurian deposits in the Baltic area and Europe (Eisenack *et al.* 1973).

Peteinosphaeridium trifurcatum longiradiatum (Eisenack 1959)

Pl. XXIV:254 (Fig. 4. No. 192)

1959: *Baltisphaeridium trifurcatum* forma *longiradiata* Eisenack, p. 202.

1973: *Peteinosphaeridium trifurcatum longiradiatum* (Eisenack 1959) Eisenack, Cramer & Díez, pp. 927—928.

Description: The spherical vesicle has numerous long, trifurcated processes with flexible branches. It differs from *Excultibrachium concinnum* Loeblich & Tappan 1978, which has processes with four to six branches and a plug at the distal end.

Dimensions: vesicle diameter 37 — 60 µm, length of process 20 — 30 µm, length of branch 12 — 13 µm. Specimens measured: 25.

Occurrence: Rapla borehole, depths 161.0 — 100.0 m, Lasnamägi Regional Stage to Nabala Regional Stage, Paekna Formation, Middle Ordovician. Rare to moderate.

Previous records: Upper Ordovician Baltic erratics (Eisenack 1959, 1965a). Ordovician Baltic erratics: Finland (Uutela 1989).

Peteinosphaeridium velatum Kjellström 1971

Pl. XXIV:255 (Fig. 4. No. 19)

1971: *Peteinosphaeridium velatum* Kjellström, p. 58.

Description: The spherical vesicle has numerous slender, trifurcated processes (about 25 in the optical section) surrounded by peteinos and of a length less than half the vesicle diameter. The surface of the vesicle is shagrinate.

Dimensions: vesicle diameter 47 — 50 µm, length of process 11 — 16 µm. Specimens measured: 2.

Occurrence: Rapla borehole, depth 189.0 m, Volhov Regional Stage, Lower Ordovician. Rare.

Previous records: Middle Ordovician: Sweden (Kjellström 1971a).

Genus *Pheoclosterium* Tappan & Loeblich 1971

Pheoclosterium clavatum n. sp.

Pl. XXVI:280 (Fig. 4. No. 89)

Diagnosis: The oval vesicle has numerous simple, homomorphic capitate processes with clavate distal terminations and a length corresponding on average to 1/10 of the vesicle width. The processes, distributed more densely at the poles, do not communicate with the vesicle interior. The surface of the vesicle is microgranulate.

Dimensions: vesicle length 34 — 37 µm, vesicle width 20 — 21 µm, length of process 2.0 µm, distance between processes 1.5 — 4.0 µm. Specimens measured: 7.

Holotype: GSF Prep. 1122 (SEM); Pl. XXVI:280. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 184.0 m, Kunda Regional Stage, Loobu Formation, Middle Ordovician. Rare.

Etymology: *clavatum* from the Latin *clavus,* 'nail', + *-atum,* suffix 'provided with'.

Comparison: The process terminations of *Pheoclosterium fuscinulaegerum* Tappan & Loeblich 1971 are furcated to form 5—6 branches, and the processes are evenly distributed on the vesicle.

Genus *Polyancistrodorus* Loeblich & Tappan 1969

Polyancistrodorus bryoides n. sp.

Pl. XXVI:281a, b (Fig. 4. No. 121)

Diagnosis: The spherical vesicle has numerous, short, triangular processes (about 120 in the optical section) with serrated edges. The processes are distributed unevenly on the vesicle, the suface of which is densely covered with thin, flagelliform spinules (length about 1 µm). The pylome is round and does not have a lid.

Dimensions: vesicle diameter 50 — 53 µm, length of process 4 — 6 µm, width of process 2 µm, distance between processes 5 µm, pylome diameter 14 µm. Specimens measured: 10.

Holotype: GSF Prep. 1116 (SEM); Pl. XXVI:281a,b. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 180.3 — 161.0 m, Aseri to Kukruse regional stages, Middle Ordovician. Rare to moderate.

Etymology: *bryoides* from the Latin *bryon,* 'moss', + *-oides,* 'like'.

Comparison: Resembles *Axisphaeridium tricolumnelare* Uutela 1989, which has triangular processes of the same kind, but a psilate vesicle and two differing pylomes. The processes of

Peteinosphaeridium micranthum (Eisenack 1959) are quadrilateral in cross-section and distally furcated.

Polyancistrodorus columbariferus Loeblich & Tappan 1969

Pl. XXIV:256 (Fig. 4. No. 186)

1969: *Polyancistrodorus columbariferus* Loeblich & Tappan, p. 52.

Description: The spherical vesicle has numerous processes of triangular of quadrilateral cross-section and with furcated distal terminations. The circular pylome has a collar. The surface of the vesicle is shagrinate and the processes psilate.

Dimensions: vesicle diameter 41 — 60 µm, length of process 10 — 20 µm, pylome diameter 10 µm. Specimens measured: 41.

Occurrence: Rapla borehole, depths 163.0 — 38.0 m, Kukruse Regional Stage to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare to common.

Previous records: Middle Ordovician: U.S.A. (Loeblich & Tappan 1969).

Polyancistrodorus aff. *P. intricatus* Colbath 1979

Pl. XXIV:257 (Fig. 4. No. 94)

Description: The spherical vesicle has numerous short, serrated processes of triangular or quadrilateral cross-section and furcated terminations. The surface of the vesicle is reticulate.

Dimensions: vesicle diameter 45 — 60 µm, length of process 7 — 10 µm, pylome diameter 10 — 13 µm. Specimens measured: 24.

Remarks: *Polyancistrodorus intricatus* Colbath 1979 has a psilate surface.

Occurrence: Rapla borehole, depths 184.0 — 62.0 m, Kunda Regional Stage, Loobu Formation to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to moderate.

Polyancistrodorus magnispinosus n. sp.

Pl. XXVI:282a, XXVII:282b (Fig. 4. No. 97)

Diagnosis: The hollow, thick, spherical vesicle has numerous solid, triangular processes with distinctly indented sides and furcated distally to form 3 to 5 long branches. The processes are 1/2 — 1/3 of the vesicle diameter in length. The surface of the vesicle is shagrinate to microgranulate and the processes psilate.

Dimensions: vesicle diameter 50 — 63 µm, length of process 20 — 30 µm, distance between processes 13 — 17 µm, pylome diameter 20 — 24 µm. Specimens measured: 20.

Holotype: GSF Prep. 1116 (SEM); Pl. XXVI:282a, XXVII: 282b. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 182.7 — 163.0 m, Kunda Regional Stage, Loobu Formation to Kukruse Regional Stage, Middle Ordovician. Rare.

Etymology: *magnispinosus* from the Latin *magnus,* 'large', + *spinosus,* 'spiny, echinate'.

Comparison: Differs from *Polyancistrodorus columbariferus* Loeblich & Tappan 1969, which has shorter, less furcated processes without indented sides.

Polyancistrodorus palmatus n. sp.

Pl. XXVII:283 (Fig. 4. No. 282)

Diagnosis: The spherical vesicle has numerous short, stout, angular processes, (about 60 in the optical section) with palmate distal furcations forming 4—6 pinnae. The pylome is small and round and does not have a collar. The surfaces of the vesicle and processes are psilate.

Dimensions: vesicle diameter 40 — 69 µm, length of process 4 — 6 µm, distance between processes 7 — 10 µm, pylome diameter 6 — 8 µm. Specimens measured: 5.

Holotype: GSF Prep. 1070 (SEM); Pl. XXVII:283. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 108.0 — 98.0 m, Nabala Regional Stage, Paekna Formation, Middle Ordovician. Rare.

Etymology: *palmatus* from the Latin *palma,* 'palm-tree', + *palmatus,* 'having a palm-leaf pattern'.

Comparison: Differs from *Polyancistrodorus columbariferus* Loeblich & Tappan 1969, which has longer processes with longer pinnae. Resembles *Peteinosphaeridium palmatum* var. *strictum* Combaz & Peniguel 1972, but the latter has hollow processes.

Polyancistrodorus phylloides n. sp.

Pl. XXVII:284 (Fig. 4. No. 99)

Diagnosis: The hollow, subspherical vesicle has numerous petaloid, triangular, distally widening processes with no furcations. The processes are 1/2 — 1/3 of the vesicle diameter in length and have an angular contact with the vesicle. The circular pylome has a striated thickening and is 1/5 to 1/3 of the vesicle diameter in size. The surface of the vesicle is granulate and the processes psilate or slightly granulate, and may also be indented.

Dimensions: vesicle diameter 40 — 50 µm, length of process 12 — 20 µm, pylome diameter 8 — 18 µm. Specimens measured: 39.

Holotype: GSF Prep. 1118 (SEM); Pl. XXVII:284. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 182.0 — 176.0 m, Aseri to Lasnamägi regional stages, Middle Ordovician. Rare to common.

Etymology: *phylloides* from the Greek *phyllon,* 'leaf' + *-eides, (-oides* in the Latin), 'like'.

Comparison: Resembles *Cycloposphaeridium auriculatum* n. sp., but the processes of the latter are leaf-like, not petaloidic. The processes of *Polyancistrodorus columbariferus* Loeblich & Tappan 1969 and *P. intricatus* Colbath 1979 have distal furcations.

Genus *Polyedryxium* Deunff 1954, emend. Deunff 1971

Polyedryxium sp.

Pl. XXVII:285 (Fig. 4. No. 304)

Description: The vesicle is polyhedric, its three to five-sided faces being attached by their sides to form polygonal patterns of varying size and form. The surfaces of the polygonal fields are microgranulate, and the polygons may come apart.

Dimensions: vesicle diameter 20 µm, polygon diameter 13 µm. Specimens measured: 1.

Occurrence: Rapla borehole, depth 66.0 m, Pirgu Regional Stage, Moe Formation, Upper Ordovician. Rare.

Comparison: Differs from *Cymatiosphaera rakverensis* n. sp., which is spherical in form and has tubercles on the edges of its polygon walls.

Genus *Polygonium* Vavrdová 1975

Polygonium delicatum Rasul 1979

Pl. XXIV:258 (Fig. 4. No. 70)

1979: *Polygonium delicatum* Rasul, p. 60.

Description: The thin polygonal vesicle has about 10 thin, flagelliform processes with curved proximal contacts and acuminate distal terminations. The surfaces of the vesicle and processes are psilate.

Dimensions: vesicle diameter 40 — 45 µm, length of process 30 — 50 µm, number of processes 11. Specimens measured: 19.

Occurrence: Rapla borehole, depths 188.6 — 127.1 m, Kunda Regional Stage, Sillaoru Formation to Keila Regional Stage, Lower to Middle Ordovician. Rare to moderate.

Previous records: Lower Ordovician: Britain (Rasul 1979).

Genus *Priscogalea* Deunff 1961

Priscogalea parva n. sp.

Pl. XXVII:286 (Fig. 4. No. 245)

Diagnosis: The vesicle is small and subspherical, due to the existence of a large pylome with a lid, the diameter of the pylome being 2/3 of the vesicle diameter. The vesicle has small, conical processes with acuminate distal terminations, and there are holes of various sizes often situated concentrically in the pylome. The vesicle and processes are shagrinate and the pylome lid shagrinate or irregularly rough and wrinkled.

Dimensions: vesicle diameter 6 — 11 µm, pylome diameter 4 — 5 µm, length of spinules 0.4 — 1.0 µm. Specimens measured: 8.

Holotype: GSF Prep. 1077 (SEM); Pl. XXVII:286. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 136.0 — 50.0 m, Keila Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare.

Etymology: *parva* from the Latin, 'small'.

Comparison: The processes are similar to those of *Micrhystridium nannacanthum* Deflandre 1945, but the latter has no pylome. *Revinotesta granulosa* n. sp. is oval and has an open pylome.

Priscogalea perforata Uutela 1989, emend.

Pl. XXVII:287 (Fig. 4. No. 68)

1989: *Priscogalea perforata* Uutela, p. 39.

Emended diagnosis: The small, subspherical vesicle has a pylome with a diameter of about 1/2 of that of the vesicle. The conical processes are attached to the vesicle with small, easily breakable filaments. The pylome edges have shorter, conical or flagelliform projections, also attached to the vesicle with small filaments. The processes do not comunicate with the vesicle interior, and there are granulae at the base where a process has broken off. The vesicle has a somewhat regular, reticulate spotted pattern.

Dimensions: vesicle diameter 10 — 12 µm, length of process 4 — 6 µm, process base diameter 1 µm, length of processes round the pylome 2 — 3 µm, pylome diameter 5 — 6 µm. Specimens measured: 7.

Occurrence: Rapla borehole, depths 188.6 — 140.0 m, Kunda Regional Stage, Sillaoru Formation to Keila Regional Stage, Lower to Middle Ordovician. Rare.

Comparison: Differs from *Priscogalea parva* n. sp., which has shorter processes solidly attached to the vesicle, so that they do not come off as easily as in the case of *P. perforata*. There are smaller projections around the pylome, resembling those of *Coronitesta bicornis* n. sp. and *C. raplaensis* n. sp., which only have two or three larger processes. The proximal process contacts of *Micrhystridium taeniosum* n. sp. have similar attaching filaments, but the species differs from *Priscogalea perforata* in that the former has more processes and no pylome.

Genus *Pterospermopsis* W. Wetzel 1952

Pterospermopsis tranvikensis (Tynni 1982) n. comb.

Pl. XXIV:259a, XXV:259b (Fig. 4. No. 120)

1982: *Pterospermella tranvikensis* Tynni, p. 79.

Description: The vesicle has a thin, wrinkled surface, and is surrounded by a thin, psilate membrane with radial wrinkles. The vesicle has spikes and tubercles near the point at which the membrane is attached.

Dimensions: vesicle diameter 38 — 60 µm, width of membrane 20 — 28 µm, total diameter 70 — 114 µm. Specimens measured: 3.

Occurrence: Rapla borehole, depths 178.0 —

176.0 m, Lasnamägi Regional Stage, Middle Ordovician. Rare.

Previous records: Middle Ordovician: Finland (Tynni 1982).

Pterospermopsis sp.

Pl. XXVII:288 (Fig. 4. No. 185)

Description: The small, thin, spherical vesicle has a thin, radially folded margin, of a width equal to almost a half of the vesicle diameter. Both the central body and the margin are transparent.

Dimensions: total diameter 8 — 20 µm. Specimens measured: 16.

Occurrence: Rapla borehole, depths 163.0 — 54.0 m, Kukruse Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare.

Comparison: Most of the *Pterospermopsis* (or *Pterospermella*) species are large. The smallest ones, *P. bernadinae* (Cramer) Eisenack 1972 and *P. guapita* (Cramer) Eisenack 1972, do not have a transparent central body. The description of *P. timofeevi* (Deunff 1966) Eisenack 1972 does not discuss the character of the central body. All these species are of Silurian age or younger.

Genus *Pulvinosphaeridium* Eisenack 1954, restr. Deunff 1954

Pulvinosphaeridium granulatum n. sp.

Pl. XXVII:289 (Fig. 4. No. 301)

Diagnosis: The polygonal, pillow-like vesicle has concave sides and usually 6—7 broadly rounded processes situated at the edges. The vesicle is totally covered with tubercles of size 0.5—2.0 µm and is seen in light microscopy to have a thin, transparent shell. In addition to the rounded processes, the same specimen may also have some processes with bluntly pointed tips. Processes otherwise similar to these but principally with bluntly pointed tips are found under corresponding circumstances, so that this may represent different stages of development of the same form.

Dimensions: total vesicle diameter 110 — 150 µm. Specimens measured: evexate distal termination of the processes 13 ind., bluntly pointed termination of the processes 6 ind.

Holotype: GSF Prep. 1054 (SEM); Pl. XXVII:289. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 68.0 — 36.6 m, Pirgu Regional Stage, Moe and Adila Formations, Upper Ordovician. Rare. The species is of considerable size and was found only in the chitinozoa preparations of J. Nõlvak.

Etymology: *granulatum* from the Latin *granum,* 'grain', + *-ulum,* diminutive, + *-atum,* suffix 'having the nature of'.

Comparison: Closely resembles *Pulvinosphaeridium pulvinellum* Eisenack 1954 in terms of size and morphology, but the surface structure in the description is based on SEM image. The surface structure of the slender, transparent specimen is not shown as clearly in optical examination, but the species may correspond.

Rhiptosocherma (ex-Estiastra) improcera (Loeblich 1970) Loeblich & Tappan 1978 also has rounded processes with bluntly pointed tips.

Genus *Raplasphaera* n. gen

Type species: *Raplasphaera undosa* n. sp., designated here.
Other new species of the genus: *R. consuta*

Diagnosis: The spherical vesicle has two halves: one with a polygonal pattern consisting of short membrane walls bordering on an equatorial area in which the membranes of which are funnel-

shaped, and the other with no ornamentation. The funnel-shaped membranes form a veil around the vesicle.

Etymology: *Raplasphaera,* Rapla from the Estonian Rapla borehole, + *sphaera* from the Latin (Gr. *sphaira),* 'ball', + *-idium,* diminutive.

Comparison: The half with the polygonal pattern consisting of membrane walls resembles the genus *Cymatiosphaera* O. Wetzel 1933, and the other the genus *Pterospermopsis* W. Wetzel 1952. The genus *Riculasphaera* Loeblich & Drugg 1968 has only two funnel-shaped projections situated on the vesicle.

Raplasphaera consuta n. sp.

Pl. XXVII:290 (Fig. 4. No. 244)

Diagnosis: The equatorial zone of the small, spherical vesicle has a thin veil with radial thickenings. The membranous veil is closely attached to the vesicle, but there are also small attaching fibres, with similar fibres occurring on thickenings in the veil as well. The surface of the vesicle is psilate and the membrane veil has small granulae located on it unevenly. A polygonal membrane network similar to that of *Raplasphaera undosa* n. sp. may be found on the other side of the vesicle.

Dimensions: vesicle diameter 7.5 — 30 µm, height of membrane 4 — 6 µm. Specimens measured: 5.

Holotype: GSF Prep. 1088 (SEM); Pl. XXVII:290. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 140.0 — 62.0 m, Keila Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare.

Etymology: *consuta* from the Latin *consuo,* 'to sew together'.

Comparison: Differs from *Raplaspahera undosa* n. sp., the membrane wall of the latter being thinner and without radial thickenings.

Raplasphaera undosa n. sp.

Pl. XXVIII:291a, b (Fig. 4. No. 153)

Diagnosis: The small central vesicle is surrounded by a thin edge. This is situated only in the equatorial area on one side of the vesicle, while on the other side there is a polygonal pattern of opened out veil funnels. The veil is composed of cylinders attached to each other which open out partially to form funnels in the equator area and totally on the other side of the vesicle. The surface of the vesicle is psilate or slightly porous, with a small round pylome on the side where the veil occurs only in the equatorial area. There are small tubercles with acuminate distal terminations on the bottoms of the polygons on the other side of the vesicle. The granulae on the veil form seam-like lines and the opened-out edges of the veil are covered by small granulae.

Dimensions: vesicle diameter 7 — 8 µm, height of membrane 5 µm. Specimens measured: 11.

Holotype: GSF Prep. 1116 (SEM); Pl. XXVIII:291a,b. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 178.0 — 54.0 m, Lasnamägi Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare.

Etymology: *undosa* from the Latin *unda,* 'wave', + *-osa,* suffix 'full of'.

Comparison: *Cymatiosphaera striata* Eisenack & Cookson 1960 resembles the side of the vesicle where the membrane walls form plygonal patterns, but it is considerable large (total diameter about 70 µm).

Genus *Revinotesta* Vanguestaine 1974

Revinotesta granulosa n. sp.

Pl. XXVIII:292 (Fig. 4. No. 278)

Diagnosis: The oval vesicle has densely located conical processes. The pylome hole is about 1/2 of the vesicle width and is lined with small processes similar to those on the vesicle. The surfaces of the vesicle and processes are shagrinate.

Dimensions: vesicle length 6 µm, vesicle width 5 µm, pylome diameter 2 µm. Specimens measured: 1.

Holotype: GSF Prep. 1077 (SEM); Pl. XXVIII:292. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 111.0 m, Rakvere Regional Stage, Middle Ordovician. Rare.

Etymology: *granulosa* from the Latin *granum,* 'grain', + *-ulum,* diminutive, + *-osa,* suffix 'having the nature of'.

Comparison: Differs from *Micrhystridium nannacanthum* Deflandre 1945, which has a round vesicle but no pylome.

Revinotesta parva n. sp.

Pl. XXVIII:293 (Fig. 4. No. 41)

Diagnosis: The oval vesicle has numerous conical, slightly flagelliform processes (about 80 in the optical section). The round pylome is about 1/3 of the vesicle diameter and is surrounded by processes similar to those on the vesicle. The surfaces of the vesicle and processes are microgranulate.

Dimensions: vesicle diameter 6 — 9 µm, length of process 1.0 — 1.5 µm, pylome diameter 2 µm. Specimens measured: 16.

Holotype: GSF Prep. 1077 (SEM); Pl. XXVIII:293. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 189.0 — 54.0 m, Volhov Regional Stage to Pirgu Regional Stage, Moe Formation, Lower to Upper Ordovician. Rare.

Etymology: *parva* from the Latin, 'small'.

Comparison: Differs from *Micrhystridium parinconspicuum* Deflandre 1945 which has fewer processes and no pylome.

Genus *Rhopaliophora* Tappan & Loeblich 1971

Rhopaliophora foliatilis Tappan & Loeblich 1971

Pl. XXV:260 (Fig. 4. No. 285)

1971: *Rhopaliophora foliatilis* Tappan & Loeblich, pp. 404—405.

Description: The spherical vesicle has short processes of varying size which do not communicate with the vesicle interior. The pylome has a collar. The surfaces of the vesicle and processes are slightly granulate.

Dimensions: vesicle diameter 38 — 60 µm, length of process 2 — 4 µm, pylome diameter 10 µm. Specimens measured: 6.

Occurrence: Rapla borehole, depth 104.0 m, Nabala Regional Stage, Paekna Formation, Middle Ordovician. Rare.

Previous records: Upper Ordovician: U.S.A. (Tappan & Loeblich 1971, Colbath 1979, 1980). Ordovician Baltic erratics, Finland (Uutela 1989).

Rhopaliophora palmata (Combaz & Peniguel) Playford & Martin 1984

Pl. XXV:261 (Fig. 4. No. 108)

1972: *Peteinosphaeridium palmatum* Combaz & Peniguel, p. 136.

1984: *Rhopaliophora palmata* (Combaz & Peniguel) Playford & Martin, pp. 210—212.

Description: The spherical vesicle has numerous short, thin processes which are often flattened. The pylome is circular, and the surface of the vesicle is echinate and the processes psilate.

Dimensions: vesicle diameter 26 — 45 µm, length of prosess 3 — 10 µm. Specimens measured: 13.

Occurrence: Rapla borehole, depths 181.0 — 115.0 m, Aseri to Rakvere regional stages, Middle Ordovician. Rare.

Previous records: Lower Ordovician: China (Martin & Yin 1988). Lower and Middle Ordovician: Australia (Combaz & Peniguel 1972, Play-

ford & Martin 1984). Ordovician Baltic erratics: Finland (Uutela 1989).

Rhopaliophora pilata (Combaz & Peniguel) Playford & Martin 1984

Pl. XXV:262 (Fig. 4. No. 93)

1972: *Peteinosphaeridium pilata* Combaz & peniguel, pp. 136—137.

1984: *Rhopaliophora pilata* (Combaz & Peniguel) Playford & Martin, pp. 212—214.

Description: The spherical vesicle has short processes of quadrilateral cross-section and a round pylome. The surface of the vesicle is psilate to shagrinate and the processes psilate.

Dimensions: vesicle diameter 29 — 45 µm, length of process 2.0 µm, pylome diameter 7 µm. Specimens measured: 20.

Occurrence: Rapla borehole, depths 184.0 — 82.0 m, Kunda Regional Stage, Loobu Formation to Vormsi Regional Stage, Middle to Upper Ordovician. Rare.

Previous records: Lower Ordovician (Martin & Yin 1988). Lower and Middle Ordovician: Australia (Combaz & Peniguel 1972, Playford & Martin 1984). Ordovician Baltic erratics, Finland (Uutela 1989).

Rhopaliophora reticulata n. sp.

Pl. XXVIII:294 (Fig. 4. No. 286)

Diagnosis: The hollow, thick-walled vesicle is subspherical and distinctly reticulate. The processes are hollow, thin-walled and short with blunt terminations and are about 1/10 of the vesicle diameter in length. The processes are psilate and do not communicate with the vesicle interior. A circular pylome with a collar is observed.

Dimensions: vesicle diameter 66 — 100 µm, length of process 4 — 6 µm, width of process 2 — 3 µm, pylome diameter 20 — 30 µm. Specimens measured: 4.

Holotype: GSF Prep. 1073 (SEM); Pl. XXVIII:294. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 104.0 m, Nabala Regional Stage, Paekna Formation, Middle Ordovician. Rare.

Etymology: *reticulata* from the Latin *rete*, 'net', + *-ulum*, diminutive, + *-ata*, suffix 'having the nature of'.

Comparison: Differs from *Rhopaliophora foliatilis* Tappan & Loeblich 1971, the processes of which are of varying size and the vesicle and processes slightly striated.

Genus *Saharidia* Combaz 1967

Saharidia fragile (Downie) Combaz 1967

Pl. XXV:263 (Fig. 4. No. 226)

1958: *Leiosphaeridia fragile* Downie, pp. 344—345.

1967: *Saharidia fragile* Combaz, p. 117.

Description: The thin, spherical vesicle is granulate and folded. The pylome is circular.

Dimensions: vesicle diameter 51 — 64 µm, pylome diameter 10 — 12 µm. Specimens measured: 5.

Occurrence: Rapla borehole, depths 142.0 — 88.0 m, Keila to Vormsi regional stages, Middle to Upper Ordovician. Rare.

Previous records: Lower Ordovician: Britain (Downie 1958); Czechoslovakia (Vavrdová 1972); Algeria (Combaz 1966, 1967).

Genus *Schismatosphaeridium* Staplin, Jansonius & Pocock 1965

Schismatosphaeridium granosum n. sp.

Pl. XXVIII:295 (Fig. 4. No. 306)

Diagnosis: The spherical or subspherical vesicle has a simple, circular pylome and a linear split. The vesicle has a thickness of about 2.5 µm and its surface is microgranulate.

Dimensions: vesicle diameter 40 — 80 µm, pylome diameter 10 — 27 µm. Specimens measured: 4.

Holotype: GSF Prep. 1032 (SEM); Pl. XXVIII:295. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 62.0 — 28.0 m, Pirgu Regional Stage, Moe Formation to Juuru Regional Stage, Upper Ordovician to Lower Silurian. Rare.

Etymology: *granosum* from the Latin *granum,* 'grain', + *-osum,* suffix 'full of'.

Comparison: Closely resembles *Schismatosphaeridium perforatum* Staplin, Jansonius & Pocock 1965, but the latter has a thickening around the pylome.

Genus *Solisphaeridium* Staplin, Jansonius & Pocock 1965

Solisphaeridium inaffectum Playford & Dring 1981

Pl. XXV:264 (Fig. 4. No. 85)

1981: *Solisphaeridium inaffectum* Playford & Dring, p. 56.

Description: The spherical vesicle has numerous simple, conical processes (about 14—17) of varying length, being about 1/2 of the vesicle diameter at most. The processes are hollow, have acuminate or slightly bulbous distal terminations and communicate with the vesicle interior. The surfaces of the vesicle and processes are psilate, shagrinate or microgranulate.

Dimensions: vesicle diameter 14 — 18 µm, length of process 2 — 6 µm. Specimens measured: 241.

Occurrence: Rapla borehole, depths 188.0 — 44.0 m, Kunda Regional Stage, Loobu Formation to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare to common.

Previous records: Devonian: Australia (Playford & Dring 1981).

Solisphaeridium nanum (Deflandre) Turner 1984

Pl. XXV:265 (Fig. 4. No. 60)

1945: *Hystrichosphaeridium brevispinosum nanum* Deflandre, pp. 62—63.

1959: *Baltisphaeridium brevispinosum nanum* Downie, p. 59.

1978: *Polygonium nanum* Jacobson, pp. 297—298.

1984: *Solisphaeridium nanum* Turner, pp. 136—137.

Description: The subspherical vesicle has numerous conical processes which communicate with the vesicle interior. The vesicle is slightly granulate and the processes more so than suggested in the definition of Turner (1984). *Solisphaeridium apodasmion* (Wicander) Wicander & Loeblich 1977 is psilate and smaller.

Dimensions: vesicle diameter 27 — 30 µm, length of process 9 — 10 µm. Specimens measured: 8.

Occurrence: Rapla borehole, depths 188.6 — 184.0 m, Kunda Regional Stage, Sillaoru and Loobu Formations, Lower to Middle Ordovician. Rare.

Previous records: Lower and Middle Ordovician: France (Rauscher 1974). Middle Ordovician: Sweden (Kjellström 1971a); Britain (Turner 1984, 1985). Upper Ordovician: U.S.A. (Jacobson 1978). Silurian: France (Deflandre 1947); Britain (Downie 1958). Silurian to Devonian: Belgium (Stockmans & Willière 1960, 1962).

Genus *Stellechinatum* Turner 1984

Stellechinatum helosum Turner 1984

Pl. XXV:266 (Fig. 4. No. 51)

1984: *Stellechinatum helosum* Turner, p. 139.

Description: The vesicle is polygenic and has numerous conical processes which are distinctly tuberculous on the surface. The tubercles on the central part of the vesicle are smaller and more irregularly distributed and fine striae can be seen on this part at high magnification.

Dimensions: vesicle diameter 26 — 40 µm, length of process 17 — 23 µm. Specimens measured: 103.

Occurrence: Rapla borehole, depths 189.0 — 28.0 m, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian. Rare to moderate.

Previous records: Middle Ordovician: Britain (Turner 1984).

Genus *Stelliferidium* Deunff, Górka & Rauscher 1974

Stelliferidium aff. *S. modestum* (Górka) Deunff, Górka & Rauscher 1974

Pl. XXV:267 (Fig. 4. No. 59)

Description: The vesicle is pot-shaped, and the pylome has a fine, radial lining on the vesicle side of its wall. The vesicle is tubercular and has depressions surrounded by delicate radial lines.

Dimensions: vesicle width 59 µm, vesicle height 49 µm, pylome diameter 50 µm. Specimens measured: 1.

Remarks: The reticulate pattern of *Stelliferidium modestum* (Górka) Deunff, Górka & Rauscher 1974 does not occur in the specimen found in Rapla, which is larger.

Occurrence: Rapla borehole, depth 188.6 m, Kunda Regional Stage, Sillaoru Formation, Lower Ordovician. Rare.

Genus *Taeniosphaeridium* n. gen

Type species: *Taeniosphaeridium parvum* n. sp., designated here.

Diagnosis: The small, spherical vesicle has low, beam-like, possibly solid ridges irregularly oriented with respect to each other. No pylome is observed.

Etymology: *Taeniosphaeridium* from the Latin *taenia,* 'ribbon', + *sphaera* from the Latin (Gr. *sphaira),* 'ball', + *-idium,* diminutive.

Comparison: Differs from the genus *Lophosphaeridium* (Timofeev 1959) Lister 1970 in that its vesicle has ridges and not tubercles as is characteristic of the new genus.

Taeniosphaeridium parvum n. sp.

Pl. XXVIII:296 (Fig. 4. No. 137)

Diagnosis: The small, spherical vesicle has low ridges irregularly oriented with respect to each other but a regular distance apart. The ridges are three to four times longer than they are wide and twice as long as they are high, and may be solid, with an angular contact with the vesicle. The surface of the vesicle is microgranulate. No pylome is observed.

Dimensions: vesicle diameter 8 µm, ridge length 0.5 µm, ridge height 0.3 µm, distance between ridges 1 µm. Specimens measured: 1.

Holotype: GSF Prep. 1116 (SEM); Pl. XXVIII:296. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 178.0 m, Lasnamägi Regional Stage, Middle Ordovician. Rare.

Etymology: *parvum* from the Latin, 'small'.

Comparison: Differs from *Labyrinthosphaeridium restrictum* n. sp. which has thicker, more irregular ridges located densely on the vesicle.

Genus *Tasmanites* Newton 1875

Tasmanites martinssoni Eisenack 1958

Pl. XXV:268 (Fig. 4. No. 154)

1958: *Tasmanites martinssoni* Eisenack, pp. 6—7.

Description: The large spherical shell has some pores visible. No pylome has been observed in any specimen.

Dimensions: vesicle diameter 230 — 250 µm, wall thickness ca. 6 µm. Specimens measured: 22.

Occurrence: Rapla borehole, depths 178.0 — 56.0 m, Lasnamägi Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare.

Previous records: Lower Ordovician: Poland (Górka 1969). Middle and Upper Ordovician: Baltic (Eisenack 1958, 1965b). Silurian: Poland (Górka 1969).

Tasmanites cf. *T. minutus* Eisenack 1965

Pl. XXV:269 (Fig. 4. No. 177)

Description: The thick-walled spherical vesicle has a psilate or shagrinate surface. Median split observed.

Dimensions: vesicle diameter 30 — 65 µm. Specimens measured: 61.

Remarks: The specimens corresponding to that presented by Eisenack but without a pylome in any of the specimens examined.According to Eisenack (1965) forms of this kind may immature and lie below the size limit for the species.

Occurrence: Rapla borehole, depths 169.0 — 60.0 m, Uhaku Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Ordovician Baltic erratics (Eisenack 1965b, Tynni 1975).

Tasmanites cf. *T. verrucosus* Eisenack 1962

Pl. XXV:270 (Fig. 4. No. 188)

Description: The thick, spherical, verrucose vesicle has a pseudopylome-like thickening with or without a rim.

Dimensions: vesicle diameter 50 — 80 µm, pylome diameter 10 — 20 µm. Specimens measured: 26.

Occurrence: Rapla borehole, depths 163.0 — 35.0 m, Kukruse to Porkuni regional stages, Middle to Upper Ordovician. Rare to moderate.

Previous records: Upper Ordovician: Sweden (Eisenack 1968). Ordovician Baltic erratics (Eisenack 1962); Finland (Uutela 1989).

Genus *Timofeevia* Vanguestaine 1978

Timofeevia enodis n. sp.

Pl. XXVIII:297 (Fig. 4. No. 160)

Diagnosis: The subspherical to subpolygonal vesicle is covered with polygons, the corners of which have psilate, heteromorphic, simple or bifurcated hollow processes with a broad base. The walls of the polygons are formed by sutures and there are about ten polygons in the optical section. The surface of the vesicle is granulate.

Dimensions: vesicle diameter 11 — 15 µm, length of process 2 — 6 µm, polygon diameter 2 — 10 µm. Specimens measured: 3.

Holotype: GSF Prep. 1115 (SEM); Pl. XXVIII:297. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 176.0 — 173.0 m, Lasnamägi to Uhaku regional stages, Middle Ordovician. Rare.

Etymology: *enodis* from the Latin *e(x)-*, 'free', + *nodis* from *nodus,* 'knot'.

Comparison: Differs from *Timofeevia phosphoritica* Vanguestaine 1978, the processes of which are more furcated, and *T. nodosa* n. sp., the polygons of which are smaller and the processes shorter, blunt and granulate.

Timofeevia nodosa n. sp.

Pl. XXVIII:298 (Fig. 4. No. 123)

Diagnosis: The spherical vesicle is covered with polygons, the corners of which have homomorphic, simple, hollow processes with a broad base and echinate distal terminations. The polygons, formed by psilate sutures, vary in size and form, their number being about 25 in the optical section.

Dimensions: vesicle diameter 13 — 14 µm, length of process 1.5 — 2.0 µm, area of polygon 2 x 4 — 3 x 6 µm. Specimens measured: 10.

Holotype: GSF Prep. 1115 (SEM); Pl. XXVIII:298. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 180.0 — 176.0 m, Lasnamägi Regional Stage, Middle Ordovician. Rare.

Etymology: *nodosa* from the Latin *nodus,* 'knot', + *-osa,* suffix 'full of'.

Comparison: Differs from *Timofeevia enodis* n. sp. in having more clearly separated and slender processes with spines at their distal terminations.

Genus *Tranvikium* Tynni 1982

Tranvikium polygonale Tynni 1982

Pl. XXV:271 (Fig. 4. No. 63)

1982: *Tranvikium polygonale* Tynni, p. 81.

Description: The form of the vesicle is a combination of a bell-shaped hemisphere and a plane surface, the latter of which has a hexagonal pattern and a large pylome. A smaller pylome is situated on the opposite side of the vesicle.

Dimensions: vesicle diameter 57 — 66 µm, pylome diameter 14 — 17 µm. Specimens measured: 5.

Occurrence: Rapla borehole, depths 188.6 — 178.0 m, Kunda Regional Stage, Sillaoru Formation to Lasnamägi Regional Stage, Lower to Middle Ordovician. Rare.

Previous records: Middle Ordovician: Finland (Tynni 1982). Ordovician Baltic erratics: Finland (Uutela 1989).

Genus *Tunisphaeridium* Deunff & Evitt 1968

Tunisphaeridium brevispinosum n. sp.

Pl. XXIX:299 (Fig. 4. No. 242)

Diagnosis: The spherical vesicle has numerous short, cylindrical processes of length 1/25 of the vesicle diameter, attached to each other with thin fibres. The processes are distally open and are located evenly on the vesicle. The surfaces of the vesicle and processes are psilate. A median split is observed.

Dimensions: vesicle diameter 15 µm, length of process 0.6 µm, distance between processes 1 µm. Specimens measured: 3.

Holotype: GSF Prep. 1093 (SEM); Pl. XXIX:299. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 140.0 — 97.0 m, Keila Regional Stage to Nabala Regional Stage, Saunja Formation, Middle to Upper Ordovician. Rare.

Etymology: *brevispinosum* from the Latin *brevis,* 'short', + *spinosum,* 'spiny, echinate'.

Comparison: Differs from *Dilatisphaera complicata* n. sp., the short processes of which are not attached to each with thin fibres but may have grown together over their entire length. The open processes of *D. nanofurcata* n. sp. and *D. tubulifera* n. sp. are longer and they again are not attached to each other.

Tunisphaeridium spinosissimum n. sp.

Pl. XXIX:300 (Fig. 4. No. 266)

Diagnosis: The spherical vesicle is densely covered with small, cylindrical, distally furcated processes of length about 1/10 of the vesicle diameter. The whip-like distal terminations of the branches are attached to each other. Bifurcated processes with second-order furcations are in the majority, although also some simple and purely bifurcated processes also occur. The branches on the processes correspond in length to the process stems. The surface of the vesicle is shagrinate and the processes psilate. A median split is observed.

Dimensions: vesicle diameter 19 — 21 µm, length of process 2 — 3 µm, length of process furcation 2 — 3 µm. Specimens measured: 15.

Holotype: GSF Prep. 1077 (SEM); Pl. XXIX:300. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 125.0 — 97.0 m, Rakvere Regional Stage to Nabala Regional Stage, Saunja Formation, Middle to Upper Ordovician. Rare.

Etymology: *spinosissimum* from the Latin, 'highly echinate'.

Comparison: The processes of *Tunisphaeridium tentaculaferum* Martin (1968) 1978 are considerably longer. The furcations of *Multiplicisphaeridium alloiteaui* (Deunff 1955) are shorter, stouter and are not attached to each other.

Tunisphaeridium sp.

Pl. XXIX:301 (Fig. 4. No. 271)

Description: The spherical vesicle has densely arranged cylindrical processes attached to each other distally. The furcations of the second order processes originate almost at the same level, near the distal termination, and the furcations are flagelliform.

Dimensions: vesicle diameter 15 µm, length of process 3 µm. Specimens measured: 1.

Occurrence: Rapla borehole, depth 117.0 m, Rakvere Regional Stage, Middle Ordovician. Rare.

Comparison: Differs from *Tunisphaeridium spinosissimum* n. sp., which has wider, less furcated processes. The furcations of *Multiplicisphaeridium raspa* (Cramer 1964) have not grown together.

Genus *Tylotopalla* Loeblich 1970

Tylotopalla sp.

Pl. XXIX:302 (Fig. 4. No. 252)

Description: The small, spherical vesicle has button-like, low elevations with a small hole at the edge of each (ø 0.1 µm). The surfaces of the vesicle and elevations are shagrinate.

Dimensions: vesicle diameter 11 µm, elevation diameter 0.7 — 1.0 µm, height of elevations 0.3 — 0.5 µm. Specimens measured: 1.

Occurrence: Rapla borehole, depth 136.0 m, Keila Regional Stage, Middle Ordovician. Rare.

Comparison: Differs from *Florisphaeridium abruptum* n. sp., which has higher, cylindrical tubercles with the hole invariably situated in the middle.

Genus *Veryhachium* Deunff 1954

?Veryhachium asymmetrospinosum n. sp.

Pl. XXIX:303 (Fig. 4. No. 231)

Diagnosis: The triangular vesicle has long, flagelliform processes with acuminate distal terminations. The processes are situated at two corners and the third corner has only small, finger-like projections, of length about 2 µm and numbering 5 in the only specimen found, although they may be more numerous (the plate is a SEM image). The processes are about 3 times the vesicle diameter in length, and it is uncertain whether they communicate with the vesicle interior. The vesicle has convex sides and is densely tubercular. The processes do not have their tubercles situated so densely and have psilate proximal contacts.

Dimensions: length of vesicle side 9 µm, length of process 27 µm, total diameter 60 µm. Specimens measured: 1.

Holotype: GSF Prep. 1093 (SEM); Pl. XXIX:303. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depth 140.0 m, Keila Regional Stage, Middle Ordovician. Rare.

Etymology: *asymmetrospinosum* from the Greek *asymmetros,* 'without symmetry', + *spinosum* from the Latin, 'echinate'.

Comparison: Differs from *Veryhachium trisulcum* Deunff (1958), which has three long, flagelliform, psilate processes. *V. longispinosum* Jardiné *et al.* 1974 has four long processes. If the processes do not communicate with the vesicle interior, the genus is *Coronitesta* n. gen

Veryhachium brevitrispinum Staplin 1961

Pl. XXV:272 (Fig. 4. No. 125)

1961: *Veryhachium brevitrispinum* Staplin, p. 412.

Description: The extremely short processes situated at each corner of the triangular, shagrinate vesicle have acuminate distal terminations and communicate with the vesicle interior. The specimens are rather poorly preserved and may be broken, which impedes identification.

Dimensions: length of vesicle side 30 — 33 µm, length of process 3 — 4 µm. Specimens measured: 5.

Occurrence: Rapla borehole, depths 180.0 — 156.0 m, Lasnamägi Regional Stage to Idavere Regional Stage, Tatruse Formation, Middle Ordovician. Rare.

Previous records: Devonian: Canada (Staplin 1961).

Veryhachium cymosum Wicander & Loeblich 1977

Pl. XXV:273 (Fig. 4. No. 151)

1977: *Veryhachium cymosum* Wicander & Loeblich, p. 155.

Description: The vesicle has processes situated at the corners, at the same level as a further three processes located in the middle of the vesicle, but longer. The vesicle and processes are psilate.

Dimensions: length of vesicle side 20 — 25 µm, length of process at the corners 17 — 25 µm, length of intermediate process 14 — 17 µm. Specimens measured: 6.

Occurrence: Rapla borehole, depths 178.0 — 64.0 m, Lasnamägi Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare.

Previous records: Upper Devonian: U.S.A. (Wicander & Loeblich 1977).

Veryhachium aff. *V. cymosum* Wicander & Loeblich 1977

Pl. XXV:274, Pl. XXX:308 (Fig. 4. No. 138)

Description: The triangular vesicle has simple processes at its corners, shorter than the vesicle sides, and a smaller process in the middle. In addition, three processes with vault-like attachments originate from the middle of the vesicle, two of them being furcated. The surfaces of the vesicle and processes are shagrinate, with unevenly distributed, slender granulae. The small proto-

processes are granulate, and a split is observed in the vesicle.

Dimensions: length of vesicle side 26 µm, length of main process 19 µm, length of second process 14 µm, length of sources of processes 3 µm. Specimens measured: 1.

Remarks: The specimen resembles *Veryhachium cymosum* Wicander & Loeblich 1977, but the latter has a process in the central area and smaller spikes, and *V. downiei* Stockmans & Willière 1961, which has further processes in addition to the three main ones, although smaller than those presented here.

Occurrence: Rapla borehole, depth 178.0 m, Lasnamägi Regional Stage, Middle Ordovician. Rare.

Veryhachium europaeum Stockmans & Willière 1960

Pl. XXX:309 (Fig. 4. No. 287)

1960: *Veryhachium europaeum* Stockmans & Willière, p. 3.

Description: The triangular vesicle has long processes at the corners, with a fourth process rising from the middle. The surfaces of the vesicle and processes are granulate, and the species is slightly smaller than that suggested by the original definition of Stockmans and Willière (1960).

Dimensions: length of vesicle side 11 — 14 µm, length of process 18 — 20 µm. Specimens measured: 4.

Occurrence: Rapla borehole, depths 100.0 — 82.0 m, Nabala Regional Stage, Paekna Formation to Vormsi Regional Stage, Middle to Upper Ordovician. Rare to moderate.

Previous records: Lower Ordovician to Lower Permian deposits, more common in the Silurian deposits (Eisenack *et al.* 1979b).

Veryhachium geometricum (Deflandre) Deunff 1954

Pl. XXX:310 (Fig. 4. No. 142)

1942: *Hystrichosphaeridium geometricum* Deflandre, p. 476.

1954: *Veryhachium geometricum* (Deflandre) Deunff, p. 306.

Description: The triangular vesicle has a process at each corner, with nerves of a darker colour than the vesicle formed between these. The surfaces of the vesicle and processes are microgranulate.

Dimensions: length of vesicle side 20 — 27 µm, length of process 20 — 25 µm. Specimens measured: 3.

Occurrence: Rapla borehole, depths 178.0 — 150.0 m, Lasnamägi to Jõhvi regional stages, Middle Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Sweden (Górka 1987); Finland (Tynni 1982). Ordovician Baltic erratics: Finland (Uutela 1989). Silurian: France (Deflandre 1942, 1945, Deunff, 1954a). Devonian: Poland (Górka 1974); France (Rauscher *et al.* 1965); Canada (Deunff 1954b).

Veryhachium irroratum Loeblich & Tappan 1969

Pl. XXX:311 (Fig. 4. No. 198)

1969: *Veryhachium irroratum* Loeblich & Tappan, pp. 56—57.

Description: The sides of the vesicle are straight or slightly convex, with a slender, flagelliform process at each corner. The surfaces of the vesicle and processes are covered by small granulae and longish laths with no regular pattern.

Dimensions: length of vesicle side 15 — 25 µm, length of process 20 — 29 µm, distance between tips of adjacent processes 60 — 71 µm. Specimens measured: 10.

Occurrence: Rapla borehole, depths 154.0 — 74.0 m, Idavere Regional Stage, Tatruse Formation to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Britain (Turner 1984); U.S.A. (Loeblich & Tappan 1969); Libya (Deunff & Massa 1975).

Veryhachium lairdi Deunff 1958

Pl. XXX:312 (Fig. 4. No. 73)

1958: *Veryhachium lairdi* Deunff, pp. 28—29.

Description: The square vesicle has a conical process at each corner. These processes vary in length and width. The surfaces of the vesicle and processes are psilate or microgranulate.

Dimensions: length of vesicle side 10 — 30 µm, total diameter 20 — 52 µm, length of process 5 — 6 µm. Specimens measured: 71.

Occurrence: Rapla borehole, depths 188.6 — 56.0 m, Kunda Regional Stage, Sillaoru Formation to Pirgu Regional Stage, Moe Formation, Lower to Upper Ordovician. Rare to moderate.

Previous records: Lower Ordovician to Permian deposits (Eisenack *et al.* 1979b).

Veryhachium longispinosum Jardiné, Combaz, Peniguel & Vachey 1974

Pl. XXX:313 (Fig. 4. No. 218)

1974: *Veryhachium longispinosum* Jardiné *et al.*, p. 116.

Description: The rectangular vesicle has a long, flagelliform process at each corner, communicating with the vesicle interior. The processes are 3 times longer than the side of the vesicle, and the vesicle and processes have a very thin, psilate shell. The vesicle is considerably smaller than in the original definition, but the specimens are nevertheless considered to belong to *V. longispinosum,* as the Rapla material is characterised by individuals smaller than the type specimens presented in the literature.

Dimensions: length of vesicle side 9 — 10 µm, total diameter 73 µm, length of process 20 — 32 µm. Specimens measured: 16.

Occurrence: Rapla borehole, depths 146.2 — 56.0 m, Johvi Regional Stage to Pirgu Regional Stage, Moe Formation, Middle to Upper Ordovician. Rare to moderate.

Previous records: Lower/Middle Ordovician: Czechoslovakia (Vavrdová 1977). Middle Ordovician: Britain (Turner 1984). Middle/Upper Ordovician: Algeria (Jardiné *et al.* 1974).

Veryhachium oklahomense Loeblich 1970

Pl. XXX:314 (Fig. 4. No. 74)

1970: *Veryhachium oklahomense* Loeblich, pp. 742—743.

Description: The thin-walled, rectangular vesicle has a long, flagelliform process at each corner. The surfaces of the vesicle and processes are psilate or microgranulate.

Dimensions: length of vesicle side 15 — 20 µm, length of process 20 — 25 µm. Specimens measured: 46.

Occurrence: Rapla borehole, depths 188.6 — 56.0 m, Kunda Regional Stage, Sillaoru Formation to Pirgu Regional Stage, Moe Formation, Lower to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Britain (Turner 1984). Upper Ordovician: U.S.A. (Loeblich 1970a, Wright & Meyers 1981). Ordovician Baltic erratics: Finland (Uutela 1989).

Veryhachium oligospinoides n. sp.

Pl. XXIX:304 (Fig. 4. No. 227)

Diagnosis: The polygonal vesicle has six to seven processes which are shorter than the side of the square and have dark brown thickenings at their distal ends. The surface of the vesicle is psilate, shagrinate or microgranulate and is brownish in colour. The processes are microgranulate.

Dimensions: length of vesicle side 50 — 80 µm, total diameter 110 — 200 µm, length of process 25 — 50 µm. Specimens measured: 43.

Holotype: GSF Prep. 1077 (SEM); Pl. XXIX:304. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 142.0 — 37.4 m, Keila Regional Stage to Pirgu Regional Stage, Adila Formation, Middle to Upper Ordovician. Rare.

Etymology: *oligospinoides* from *Goniosphaeridium oligospinosum* + *-oides* from the Latin, 'like'.

Comparison: The species recorded here is synonymous with *Veryhachium oligospinosum* in the material of Górka (1969, pp. 55—56) and Tynni (1975, p. 38; 1982, pp. 83—84). It resembles *V. lairdi* Deunff 1958, although the latter has only

four processes. It also resembles *V. cuneidentatum* (Timofeev) Umnova 1975, which is smaller (diameter 25—50 µm), and *V. estrellitea* Cramer 1964 (max diameter 50 µm).

Resembles *Goniosphaeridium oligospinosum* Eisenack (1934) 1969 which could be combined with *Veryhachium,* but is related to *G. polygonale* by virtue of its process thickenings. This has affected its systematics (Eisenack 1969), but the main reason for the creation of such accumulations was the large vesicle size and processes which narrow to spikes.

The specimens found in the Rapla material nevertheless deviated from the typical *G. oligospinosum* which is tetrahedral or octahedral.

Veryhachium oligospinosoides and *Goniosphaeridium polygonale* have an angular vesicle with relatively few processes, 9 at most, constituting a gradual transitional series with no distinctive boundary forms.

Veryhachium punctatum n. sp.

Pl. XXIX:305 (Fig. 4. No. 216)

Diagnosis: The slightly angular vesicle has 4—5 conical processes of nearly the same length as the vesicle diameter, with acuminate distal terminations.

Dimensions: vesicle diameter 10 — 20 µm, length of process 10 — 20 µm. Specimens measured: 7.

Holotype: GSF Prep. 1088 (SEM); Pl. XXIX:305. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 146.2 — 127.1 m, Jõhvi to Keila regional stages, Middle Ordovician. Rare.

Etymology: *punctatum* from the Latin *punctum,* 'point', + *-atum,* suffix 'having the nature of'.

Comparison: Differs from *Micrhystridium punctatum* n. sp., which has a similar surface structure but shorter, more numerous processes.

Veryhachium reductum Deunff 1958

Pl. XXX:315 (Fig. 4. No. 166)

1958: *Veryhachium trisulcum* var. *reductum* Deunff, p. 27.

1961: *Veryhachium reductum* de Jekhowsky, pp. 210—212.

Description: Each corner of the swollen, triangular vesicle has a short process with an acuminate distal termination. The surfaces of the vesicle and processes are granulate.

Dimensions: length of vesicle side 20 — 26 µm, length of process 10 — 15 µm. Specimens measured: 25.

Occurrence: Rapla borehole, depths 173.0 — 128.0 m, Uhaku to Keila regional stages, Middle Ordovician. Rare to moderate.

Previous records: Middle Ordovician to Triassic deposits (Eisenack *et al.* 1979b).

Veryhachium rhombispinosum Tynni 1982

Pl. XXX:316 (Fig. 4. No. 10)

1982: *Veryhachium rhombispinosum* Tynni, p. 84.

Description: The vesicle is composed of two regular triangles at different levels and rotated by 60° in relation to each other. The processes are longer than the vesicle diameter and have broad bases. The surfaces of the vesicle and processes are granulate.

Dimensions: length of vesicle side 25 — 28 µm, length of process 20 — 35 µm. Specimens measured: 24.

Occurrence: Rapla borehole, depths 189.9 — 36.8 m, Volhov Regional Stage to Pirgu Regional Stage, Adila Formation, Lower to Upper Ordovician. Rare to moderate.

Previous records: Middle Ordovician: Finland (Tynni 1982). Ordovician Baltic erratics: Finland (Uutela 1989).

Veryhachium rhomboidium Downie 1959

Pl. XXX:317 (Fig. 4. No. 322)

1959: *Veryhachium rhomboidium* Downie, pp. 62—63.

Description: The rhomboid vesicle has four processes at the same level with one process situated perpendicular to these on either side or on just one side. The surfaces of the vesicle and processes are psilate.

Dimensions: length of vesicle side 20 — 25 µm,

length of process 17 — 25 µm, number of processes 5 — 6. Specimens measured: 3.

Occurrence: Rapla borehole, depth 28.0 m, Juuru Regional Stage, Lower Silurian. Rare.

Previous records: Lower Ordovician: Czechoslovakia (Vavrdová 1965); France (Rauscher 1971, 1974). Middle Ordovician: Britain (Turner 1984). Upper Ordovician: Czechoslovakia (Vavrdová 1965). Silurian: Britain (Downie 1959, 1963, Lister & Downie 1967); Belgium (Stockmans & Willière 1960, Martin 1966a,b, 1968).

Veryhachium trapezionarion Loeblich 1970

Pl. XXX:318 (Fig. 4. No. 191)

1970: *Veryhachium trapezionarion* Loeblich, pp. 743—744.

Description: The rectangular or rhomboidal vesicle has a process situated at the same level at each corner and 1—3 processes in the middle, giving a maximum number of 7. The surfaces of the vesicle and processes are psilate.

Dimensions: length of vesicle side 20 — 29 µm, length of processes 5 — 20 µm. Specimens measured: 8.

Occurrence: Rapla borehole, depths 161.0 — 119.0 m, Kukruse to Rakvere regional stages, Middle Ordovician. Rare.

Previous records: Silurian: U.S.A. (Loeblich 1970a); Argentina (Pöthe de Baldis 1975).

Veryhachium trispinosum (Eisenack) Deunff 1954

Pl. XXX:319 (Fig. 4. No. 83)

1938: *Hystrichosphaeridium trispinosum* Eisenack, pp. 14—16.

1954: *Veryhachium trispinosum* Deunff, p. 307.

Description: The triangular vesicle has concave sides with a process at each corner. The surfaces of the vesicle and processes are psilate or slightly granulate.

Dimensions: length of vesicle side 10 — 27 µm, length of process 15 — 35 µm. Specimens measured: 49.

Occurrence: Rapla borehole, depths 188.0 — 98.0 m, Kunda Regional Stage, Loobu Formation to Nabala Regional Stage, Paekna Formation regional stages, Middle Ordovician. Rare to moderate.

Previous records: Ordovician to Devonian deposits (Eisenack *et al.* 1979b).

Veryhachium trispinosum granulatum Tynni 1982, emend.

Pl. XXX:320a, b (Fig. 4. No. 103)

1982: *Veryhachium trispinosum granulatum* Tynni, p. 85.

Emended diagnosis: Each corner of the triangular vesicle has a long, slender process which communicates with the vesicle interior. The surfaces of the vesicle and processes are granulate, and there is a split on the side of the vesicle between the processes and an over-flap, or epityche, in the wall. The processes are longer than the side of the vesicle.

Dimensions: length of vesicle side 17 — 20 µm, length of process 24 — 50 µm. Specimens measured: 23.

Occurrence: Rapla borehole, depths 182.0 — 108.0 m, Aseri Regional Stage to Nabala Regional Stage, Paekna Formation, Middle Ordovician. Rare to moderate.

Comparison: The length of the processes in the species presented by Tynni (1982) does not exceed that of the vesicle side, and it is also larger, so that it may even be an entirely different species. *Veryhachium piriferum* Martin 1965 is larger, echinate and its processes are stouter.

Previous records: Middle Ordovician: Finland (Tynni 1982).

Veryhachium trisulcum Deunff (1958)

Pl. XXX:321 (Fig. 4. No. 167)

1954: *Veryhachium trisulcum* Deunff, p. 306 [nomen nudum]

1958: *V. trisulcum* Deunff, p. 27.

Description: The triangular vesicle has convex sides with a long, thin, flagelliform process at each corner. The surfaces of the vesicle and processes are psilate.

Dimensions: length of vesicle side 27 — 40 µm, length of process 45 — 70 µm. Specimens measured: 29.

Occurrence: Rapla borehole, depths 173.0 — 127.1 m, Uhaku to Keila regional stages, Middle Ordovician. Rare to moderate.

Previous records: Lower Ordovician to Lower Devonian deposits (Eisenack *et al.* 1979b).

Genus *Villosacapsula* Loeblich & Tappan 1972

Villosacapsula decorata n. sp.

Pl. XXIX:306 (Fig. 4. No. 288)

Diagnosis: The hollow, triangular vesicle is slightly convex and has a hollow process at each corner, communicating freely with the vesicle interior. The processes are simple, microgranulate, of a length almost equal to that of the vesicle side, and have acuminate distal terminations. The vesicle is ornamented with microspines and tubercles without any definite pattern.

Dimensions: vesicle side 14 — 20 µm, process length 13 — 19 µm. Specimens measured: 3.

Holotype: GSF Prep. 1061B (SEM); Pl. XXIX:306. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 98.0 — 76.0 m, Nabala Regional Stage, Paekna Formation to Vormsi Regional Stage, Middle to Upper Ordovician. Rare.

Etymology: *decorata* from the Latin *decoro,* 'adorn'.

Comparison: The vesicle and processes of *Villosacapsula setosapellicula* (Loeblich 1970) Loeblich & Tappan 1976 are microechinate.

Genus *Vulcanisphaera* Deunff 1961

Vulcanisphaera minor n. sp.

Pl. XXIX:307 (Fig. 4. No. 82)

Diagnosis: The subspherical vesicle has numerous short processes (about 40—60 in the optical section) which are distally furcated, usually forming two short branches, but sometimes even 4—5 furcating from the same level. The processes are distributed irregularly on the vesicle, the surface of which is shagrinate or microgranulate.

Dimensions: vesicle diameter 10 — 12 µm, height of process 0.6 — 1.0 µm, distance between processes 1.5 — 2.0 µm. Specimens measured: 6.

Holotype: GSF Prep. 1116 (SEM); Pl. XXIX:307. Type locality: Estonia, Rapla borehole.

Occurrence: Rapla borehole, depths 188.0 — 140.0 m, Aseri to Keila regional stages, Middle Ordovician. Rare.

Etymology: *minor* from the Latin, 'smaller'.

Comparison: Differs from *Multiplicisphaeridium alloiteaui* (Deunff 1955), which has longer processes, as does *M. canadense* Staplin *et al.* 1965.

Genus *Winwaloeusia* Deunff 1977

Winwaloeusia distrata Deunff (1966) 1977

Pl. XXX:307 (Fig. 4. No. 279)

1966: *Veryhachium distratum* Deunff, p. 22.

1977: *Winwaloeusia distrata* Deunff (1966), p. 467.

Description: The small, rectangular vesicle has processes with curved proximal contacts and acuminate distal terminations, merging into the vesicle without borders. The vesicle has a ridge pattern with three branches, and it is granulate,

as are the processes. The vesicle is larger and the processes longer than in the original diagnosis of Deunff (1966), but an exceptional triletes pattern can be seen.

Dimensions: length of vesicle side 6 µm, total diameter 22 µm, length of process 9 — 10 µm. Specimens measured: 1.

Occurrence: Rapla borehole, depth 111.0 m, Rakvere Regional Stage, Middle Ordovician. Rare.

Previous records: Devonian: Tunis (Deunff 1966).

SUMMARY

Ninety-nine samples obtained from the Rapla borehole in Estonia were analysed for Palaeozoic acritarchs. The Rapla borehole penetrates from Lower Ordovician (Arenigian) to Lower Silurian (Llandoverian) carbonate rocks, which contine a rich, well preserved acritarch flora. The acritarch species identified were typical of the Palaeozoic in the Baltic area but smaller in size than those observed elsewhere in the Baltic. A total of 322 species are described and analysed stratigraphically, including 134 established as new species and 6 as new formas. Ten new genera are proposed. The new formas, species and genera are:

Acanthodiacrodium ovale, ACROSPHAERIDIUM n. gen, *Acrosphaeridium densum, A. esthonicum, A. reticulatum, ARCOSPHAERIDIUM* n. gen, *Arcosphaeridium diversispinosum, A. poriferum, Arkonia concava, A. semigranulata, Bacisphaeridium granulatum, B. saetosum, Baltisphaeridium castaneiforme, B. cirsinum, B. esthonicum, B. flexuosum, B. kaurannei, B. maius, B. ramiferum, Buedingiisphaeridium balticum, B. guttiferum, Cheleutochoroa differta, C. elegans, C. oculata, C. ramosa, C. rugosa, C. tuberculosa, C. venosa, C. venosior, Comasphaeridium bacillum, CORONITESTA* n. gen, *Coronitesta bicornis, C. raplaensis, C. triangularis, Costatilobus bulbosus, ?C. grandispinosus, ?C. trifidus, CYCLOPOSPHAERIDIUM* n. gen, *Cycloposphaeridium auriculatum, ?Cymatiosphaera aseriensis, C. crispa, C. keilaensis, C. latimurata, C. minima, C. nabalaensis, C. rakverensis, C. serrata, Dactylofusa lasnamaegiensis, Dictyosphaeridium reticulatum, Dictyotidium multipolygonatum, D. oculatum, D. venosum, Dilatisphaera complicata, D. nanofurcata, D. tubulifera, Domasia spinosa, Florisphaeridium abruptum, F. circulatum, F. densum, Goniosphaeridium breviradiatum, G. parvispinosum, G. polygonale* f.*rugosum* n. f., *G. tenuispinosum, Gorgonisphaeridium spiralispinosum, Gyalorhethium angustispinosum, Hapsidopalla multifida, Helosphaeridium varispinosum, JŒHVISPHAERA* n. gen, *Jœhvisphaera capillata, Kundasphaera lacunosa, LABYRINTHOSPHAERIDIUM* n. gen, *Labyrinthosphaeridium asperum, L. curvatum, L. cymoides, L. restrictum, LACUNOSPHAERIDIUM* n. gen, *Lacunosphaeridium granosum, L. spinosum, Leiofusa brevispinosa, L. iugosa, L. obliquipunctata, L. subcircularis, Leiosphaeridia keilaensis, LILIOSPHAERIDIUM* n. gen, *Liliosphaeridium kaljoi, Lophosphaeridium aculeatum, L. regulare, Micrhystridium brevispinosum, M. curvatum, M. digitatum, M. granulatum, M. lasnamaegiense, M. minimum, M. nanodigitatum, M. parvulum, M. polygonale, M. punctatum, M. stellatum* f. *latispinosum* n. f., *M. taeniosum, M. varipinnosum, M. varispinosum, Multiplicisphaeridium actinospinosum, M. bipalmatum, M. borracherosum* f. *regulare* n. f., *M. brevidigitatum, M. cacteum, M. cornigerum, M. cymoides, M. diversispinosum, M. lichenoides, M. micropunctatum, M.*

opimum, M. parvipinnatum, M. parvispinosum, M. raplaense, M. remotum f.*raplaense* n. f., *M. spinosum, M. striatum, M. toyetaforme, M. turgidum, M. verrucosum, Ordovicidium groetlingboensis* f. *clavatum* n. f., *Orthosphaeridium insculptum* f. *erectum* n. f., *O. latispinosum, Peteinosphaeridium granulatum, Pheoclosterium clavatum, Polyancistrodorus bryoides, P. magnispinosus, P. palmatus, P. phylloides, Priscogalea parva, Pulvinosphaeridium granulatum, RAPLASPHAERA* n. gen, *Raplasphaera consuta, R. undosa, Revinotesta granulosa, R. parva, Rhopaliophora reticulata, Schismatosphaeridium granosum, TAENIOSPHAERIDIUM* n. gen, *Taeniosphaeridium parvum, Timofeevia enodis, T. nodosa, Tunisphaeridium brevispinosum, T. spinosissimum, Veryhachium asymmetrospinosum, V. oligospinoides, V. punctatum, Villosacapsula decorata and Vulcanisphaera minor.*

It is impossible to establish floristic zones with any degree of certainty by reference to the Rapla core alone without carrying out any comparative studies. The number of species attributable to the Volhov Regional Stage of the Lower Ordovician is low (partly because of dolomitization). Common species in this stage are the sphaeromorphs and members of the genus *Baltisphaeridium* among the acanthomorphs. The Kunda Regional Stage is dominated by the small acanhomorphs, while the larger species are less numerous, with the exception of *Baltisphaeridium hirsutoides.* The sphaeromorphs are also common.

The flora of the Aseri Regional Stage greatly resembled that of the Kunda. The number of species is somewhat greater in the Lasnamägi Regional Stage, with the small acanthomorphs still common, large numbers of specimens of the genera *Baltisphaeridium, Ordovicidium* and *Veryhachium* are found, but representing only a limited range of species. The species typical of the Uhaku Regional Stage are the same as the above, but their numbers are considerably reduced.

The large acanthomorphs are moderate or common during the Kukruse, particularly *Baltisphaeridium hirsutoides, Ordovicidium groetlingboensis* and *O. nudum.* These are then displaced by the small acanthomorphs during the Idavere Regional Stage, this situation then continuing into the Jõhvi.

The number of species present increases markedly in the Keila, although none can be said to be dominant. Prominent genera are *Cheleutochroa, Labyrinthosphaeridium* n. gen, *Ordovicidium, Orthosphaeridium, Tasmanites* and *Veryhachium.* A reduction in the species range is then seen once more in the Oandu Regional Stage.

It is the small acanthomorphs that are dominant during the Rakvere, the genera *Micrhystridium* and *Multiplicisphaeridium* being common. *Baltisphaeridium* and *Ordovicidium* are rare among the genera of large acanthomorphs. The Nabala Regional Stage is of much the same character as its predecessor, but the herkomorphs *Goniosphaeridium* and *Multiplicisphaeridium* become common in the Vormsi stage. Of the acanthomorphs, *Baltisphaeridium* is fairly common, but *Ordovicidium* and *Orthosphaeridium* are rare. The Pirgu differs from the above in that the species range contracts and the genus *Goniosphaeridium* become rare.

The variety of species is restricted still further in the Porkuni Regional Stage, due at least in part to dolomitization, but the Juuru Stage no longer differs from the Porkuni to any substantial degree.

Comparison of the rich, well preserved Rapla flora with results from other parts of the world shows this otherwise typical Baltic flora to stand out from earlier reports from the same area by virtue of its rich variety of species, even though the specimens as such are smaller in size. Few similarities are demonstrated with species lists from other parts of Europe, with the exception of Britain, where about 10% of its already established species were found, the still relatively small percentage being attributable to the fact

that the deposit studied there represented only the Caradocian.

About 20% of the previously identified species were common to the Rapla core and deposits in the U.S.A. or Canada, and some even occurred during the same time interval, but the majority were present at Rapla earlier than in America, partly due to the poverty of research into Lower and Middle Ordovician deposits on the American continent.

Reports regarding Palaeozoic deposits in Africa, Australia, Asia and South America offer few similarities with the Rapla flora.

ADDENDUM

Recently, the excellent paper by Alain Le Herissé (1989) has been issued dealing with Silurian acritarchs in Gotland. Some of new species are very similar in Rapla and Gotland. i.g.:

Kundasphaera lacunosa = *?Cymatiosphaera imperfecta* Le Herissé 1989

Dilatisphaera tubulifera = *Dilatisphaera tubula* Le Herissé 1989, forme A

Hapsidopalla multifida = *Multiplicisphaeridium mingusi* Le Herissé 1989

Le Herissé, A., 1989. Acritarches et kystes d'algues Prasinophycées du Silurien de Gotland, Suède. Palaeontographia Italica 76, 57—302.

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Plates

Plate I

1. *Acanthodiacrodium ovale* n. sp., holotype **2.** *Acanthodiacrodium* sp. **3.** *Acrosphaeridium densum* n. sp., holotype **4a,b.** *A. esthonicum* n. sp., holotype **5.** *A. reticulatum* n. sp., holotype **6.** *Arcosphaeridium diversispinosum* n. sp., holotype **7a,b.** *A. poriferum* n. sp., holotype. The scale bar equals 10 µm. The doublebar equals 1 µm.

Plate II

8. *Actipilion druggii* Loeblich 1970 **9.** *Akomachra ovula* Colbath 1979 **10.** *Aremoricanium deflandrei* Henry 1969 **11.** *A. rigaudae* Deunff 1955 **12.** *A. squarrosum* Loeblich & MacAdam 1971 **13.** *Axisphaeridium timofeevi* Eisenack 1967 **14.** *A. tricolumnelare* Uutela 1989 **15.** *Bacisphaeridium bacifer* Eisenack (1934) 1962 **16.** *Baltisphaeridium accinctum* Loeblich & Tappan 1978 **17.** *B. aliquigranulum* Loeblich & Tappan 1978 **18.** *B. annelieae* (Kjellström) Bockelie & Kjellström 1979 **19.** *B. bramkaense* Górka 1979 **20.** *B. breviciliatum* (Staplin) Downie & Sarjeant 1963 **21.** *B. brevispinosum* Eisenack (1931) 1958 **22.** *B. brevituberculatum* Kjellström 1971 **23.** *B. bystrentos* Loeblich & Tappan 1978. The scale bar equals 10 µm. The doublebar equals 1 µm.

Plate III

24. *Aremoricanium* sp. **25.** *Arkonia concava* n. sp., holotype **26.** *A. semigranulata* n. sp., holotype **27.** *Bacisphaeridium granulatum* n. sp., holotype **28.** *B. saetosum* n. sp., holotype **29.** *Baltisphaeridium castaneiforme* n. sp., holotype **30a,b.** *B. cirsinum* n. sp., holotype **31.** *B. esthonicum* n. sp., holotype. The scale bar equals 10 µm. The doublebar equals 1 µm.

Plate IV

32. *Baltisphaeridium* aff. *B. capillatum* Jardiné *et al.* 1974 **33.** *B. dasos* Colbath 1979 **34.** *B. digitiforme* Górka 1969 **35.** *B. dispar* Turner 1984 **36.** *B. eisenackianum* (Deunff) Downie & Sarjeant 1963 **37.** *B. filosum* Kjellström 1971 **38.** *B. globosum* Tynni 1975 **39.** *B. hamatum* (Downie) Kjellström 1976 **40.** *B. heinzelinii* Stockmans & Willière 1969 **41.** *B. hirsutoides* Eisenack (1931) 1958 **42.** *B. ingerae* Kjellström 1976 **43.** *B. klabavense* (Vavrdová) Cramer 1970 **44.** *B. latiradiatum* (Eisenack) Staplin *et al.* 1965 **45.** *B. longispinosum longispinosum* (Eisenack) Górka 1969 **46.** *B. microspinosum* (Eisenack) Downie 1959 **47.** *B.* aff. *B. multiechinatum* Kjellström (1971) 1974. The scale bar equals 10 µm. The doublebar equals 1 µm.

Plate V

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Plate VI

56. *Baltisphaeridium multipilosum* Eisenack (1931) 1958 **57.** *B. nanninum* Eisenack 1965 **58.** *B. oligopsakium* Loeblich & Tappan 1978 **59.** *B. onniense* Turner 1984 **60.** *B. parvigranosum* Loeblich & Tappan 1978 **61.** *B. parvulisidereum* Colbath 1979 **62.** *B. pauciverrucosum* Kjellström 1971 **63.** *B. perclarum* Loeblich & Tappan 1978 **64.** *B. pseudocalicispinum* Górka 1980 **65.** *B. pustulatum* Kjellström 1971 **66.** *B. trabeculaespinae* Górka 1969 **67.** *B. tranvikensis* Tynni 1982 **68.** *B. trichophorum* (Eisenack) Kjellström 1971 **69.** *B.* aff. *B. trophirhapium* Loeblich & Tappan 1978 **70.** *B. verrucatum* Kjellström 1971 **71.** *Cheleutochroa* aff. *C. diaphorosa* Turner 1984. The scale bar equals 10 µm. The doublebar equals 1 µm.

Plate VII

72. *Cheleutochroa elegans* n. sp., holotype **73.** *C. oculata* n. sp., holotype **74.** *C. ramosa* n. sp., holotype **75.** *C. rugosa* n. sp., holotype **76.** *C. tuberculosa n . sp.* **77.** *C. venosa* n. sp., holotype **78.** *C. venosior* n. sp., holotype **79.** *Chlamydosphaeridia* sp. The scale bar equals 10 µm. The doublebar equals 1 µm.

Plate VIII

80. *Comasphaeridium bacillum* n. sp., holotype **81.** *Comasphaeridium* sp. 1. **82.** *Comasphaeridium* sp. 2. **83a,b.** *Coronitesta bicornis* n. sp., holotype **84.** *C. raplaensis* n. sp., holotype **85.** *C. triangularis* n. sp., holotype **86.** *Costatilobus bulbosus* n. sp., holotype **87.** *?C. grandispinosus* n. sp., holotype. The scale bar equals 10 µm. The doublebar equals 1 µm.

Plate IX

88. *?Costatilobus trifidus* n. sp., holotype **89a,b.** *Cycloposphaeridium auriculatum* n. sp., holotype **90.** *?Cymatiosphaera aseriensis* n. sp., holotype **91.** *C. crispa* n. sp., holotype **92.** *C. keilaensis* n. sp., holotype **93.** *C. latimurata* n. sp., holotype **94.** *C. minima* n. sp., holotype **95.** *C. nabalaensis* n. sp., holotype. The scale bar equals 10 µm. The doublebar equals 1 µm.

Plate X

96. *Cymatiosphaera rakverensis* n. sp., holotype **97.** *C. serrata* n. sp., holotype **98.** *Cymatiosphaera* sp. **99.** *Dactylofusa lasnamaegiensis* n. sp., holotype **100.** *Dictyosphaeridium reticulatum* n. sp., holotype **101.** *Dictyotidium multipolygonatum*

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Plate XII

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129. *Goniosphaeridium breviradiatum* n. sp., holotype **130.** *G. parvispinosum* n. sp., holotype **131.** *G. polygonale* f. *rugosum* n. f. **132.** *G. tenuispinosum* n. sp., holotype **133.** *Gorgonisphaeridium spiralispinosum* n. sp., holotype **134.** *Gorgonisphaeridium* sp. **135.** *Gyalorhethium angustispinosum* n. sp., holotype **136.** *Gyalorhethium* sp. **137.** *Hapsidopalla multifida* n. sp., holotype. The scale bar equals 10 μm. The doublebar equals 1 μm.

Plate XIV

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146a,b. *Lacunosphaeridium granosum* n. sp., holotype **147.** *L. spinosum* n. sp., holotype **148.** *Leiofusa brevispinosa* n. sp., holotype **149a,b.** *L. iugosa* n. sp., holotype **150.** *L. obliquipunctata* n. sp., holotype **151.** *L. subcircularis* n. sp., holotype **152.** *Leiosphaeridia keilaensis* n. sp., holotype. The scale bar equals 10 μm. The doublebar equals 1 μm.

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153. *?Leiosphaeridia* sp. **154a,b.** *Liliosphaeridium kaljoi* n. sp., holotype **155.** *Lophosphaeridium aculeatum* n. sp., holotype **156.** *L. regulare* n. sp., holotype **157.** *Lophosphaeridium* sp. **158.** *M. brevispinosum* n. sp., holotype **159.** *M. curvatum* n. sp., holotype **160.** *M. digitatum* n. sp., holotype. The scale bar equals 10 μm. The doublebar equals 1 μm.

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161. *Leiofusa granulacutis* f. *quincunx* Uutela 1989 **162.** *Leiovalia similis* Eisenack 1965 **163.** *Lophosphaeridium aequicuspidatum* Playford & Martin 1984 **164.** *L. citrinipeltatum* Cramer & Díez 1972 **165.** *L. deminutum* Playford 1981 **166.** *L. disparipelliculum* Playford & Martin 1984 **167.** *L.* aff. *L. granulosum* (Staplin) Downie 1963 **168.** *L. papillatum* (Staplin) Downie 1963 **169.** *L. pilosum* Downie 1963 **170.** *Micrhystridium acerbum* Martin 1968 **171.** *M. acuminosum* Cramer & Díez 1977 **172.** *M. eatonensis* Downie 1959 **173.** *M. equispinosum* Turner 1984 **174.** *M. exiguum* Rasul 1979 **175.** *M. fragile* Deflandre 1947 **176.** *M. henryi* Paris & Deunff 1970. The scale bar equals 10 μm. The doublebar equals 1 μm.

Plate XVIII

177. *Micrhystridium granulatum* n. sp., holotype **178.** *M. lasnamaegiense* n. sp., holotype **179.** *M. minimum* n. sp., holotype **180.** *M. nanodigitatum* n. sp., holotype **181.** *M. parvulum* n. sp., holotype **182.** *M. polygonale* n. sp., holotype **183.** *M. punctatum* n. sp., holotype **184.** *M. stellatum* f. *latispinosum* n. f. **185.** *M. taeniosum* n. sp., holotype. The scale bar equals 10 μm. The doublebar equals 1 μm.

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186. *Micrhystridium inconspicuum aremoricanum* Paris & Deunff 1970 **187.** *M. nannacanthum* Deflandre 1945 **188.** *M.* aff. *M. parinconspicuum* Deflandre 1945 **189.** *M. shinetonensis* Downie 1958 **190.** *M. stellatum* Deflandre 1945 **191.** *M. stellatum salopiense* Lister 1970 **192.** *Multiplicisphaeridium alloiteaui* (Deunff 1955) **193.** *M. bifurcatum* Staplin *et al.* 1965 **194.** *M. borracherosum* (Cramer) Lister 1970 **195.** *M. caperoradiolum* (Loeblich 1970) **196.** *M. digitatum* Eisenack (1938) 1969 **197.** *M. ferum* (Martin 1968) **198.** *M. fisherii* (Cramer 1968) **199.** *M. fissile* (Stockmans & Willière 1963) **200.** *M. forquiferum* (Cramer & Díez 1972) **201.** *M. gotlandicum* (Eisenack 1954). The scale bar equals 10 μm. The doublebar equals 1 μm.

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202. *Micrhystridium varipinnosum* n. sp., holotype **203.** *M. varispinosum* n. sp., holotype **204.** *Micrhystridium* sp. 1. **205.** *Micrhystridium* sp. 2. **206.** *Multiplicisphaeridium actinospinosum* n. sp., holotype **207.** *M. bipalmatum* n. sp., holotype **208.** *M.* aff. *M. borracherosum* f. *regulare* n. f. **209.** *M. brevidigitatum* n. sp., holotype **210a.** *M. cacteum* n. sp., holotype. The scale bar equals 10 µm. The doublebar equals 1 µm.

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210b. *Multiplicisphaeridium cacteum* n. sp., holotype **211.** *M. cornigerum* n. sp., holotype **212.** *M. cymoides* n. sp., holotype **213.** *M. diversispinosum* n. sp., holotype **214.** *M. lichenoides* n. sp., holotype **215.** *M. micropunctatum* n. sp., holotype **216.** *M. opimum* n. sp., holotype **217.** *M. parvipinnatum* n. sp., holotype **218.** *M. parvispinosum* n. sp., holotype. The scale bar equals 10 µm. The doublebar equals 1 µm.

Plate XXII

219. *Multiplicisphaeridium irregulare* Staplin *et al.* 1965 **220.** *M. martae* Cramer & Díez 1972 **221.** *M.* aff. *M. multipugiunculatum* Cramer & Díez 1977 **222.** *M.* aff. *M. palmitella* (Cramer & Díez 1972) **223.** *M. parvirochesterensis* (Cramer & Díez 1972) **224.** *M. radicosum* Loeblich 1970 **225.** *M.* aff. *M. ramusculosum macrocladum* (Deunff 1955) **226.** *M. raspa* (Cramer 1964) **227.** *M.* aff. *M. subbifurcatum* (Stockmans & Willière 1963) **228.** *Ordovicidium aequifurcatum* (Kjellström) Loeblich & Tappan 1978 **229.** *O. elegantulum* Tappan & Loeblich 1971 **230.** *O. groetlingboensis* (Kjellström) Loeblich & Tappan 1978 **231.** *O. heteromorphicum* (Kjellström) Loeblich & Tappan 1978, **232.** *O. nanofurcatum* (Kjellström 1971) n. comb. **233.** *O. nudum* (Eisenack) Loeblich & Tappan 1978 **234.** *O. paucifurcatum* (Eisenack 1959) n. comb. The scale bar equals 10 µm. The doublebar equals 1 µm.

Plate XXIII

235. *Multiplicisphaeridium raplaense* n. sp., holotype **236.** *M. remotum* f. *raplaense* n. f. **237.** *M. spinosum* n. sp., holotype **238.** *M. striatum* n. sp., holotype **239.** *M. toyetaforme* n. sp., holotype **240.** *M. turgidum* n. sp., holotype **241.** *M. verrucosum* n. sp., holotype **242.** *Multiplicisphaeridium* sp. **243.** *?Nanocyclopia* sp. The scale bar equals 10 µm. The doublebar equals 1 µm.

Plate XXIV

244. *Orthosphaeridium bispinosum* Turner 1984 **245.** *O. chondrododora* Loeblich & Tappan 1971 **246.** *O. densiverrucosum* Kjellström 1971 **247.** *O. insculptum* Loeblich 1970 **248.** *O. rectangulare* (Eisenack 1963) **249.** *O. vibrissiferum* Loeblich & Tappan 1971 **250.** *Peteinosphaeridium hymenoferum* Eisenack (1938) 1969 **251.** *P. macropylum* Eisenack (1959) 1969 **252.** *P. micranthum* (Eisenack 1959) **253.** *P. trifurcatum* Eisenack (1931) 1969 **254.** *P. trifurcatum longiradiatum* (Eisenack 1959) **255.** *P. velatum* Kjellström 1971 **256.** *Polyancistrodorus columbariferus* Loeblich & Tappan 1969 **257.** *P.* aff. *P. intricatus* Colbath 1979 **258.** *Polygonium delicatum* Rasul 1979 **259a.** *Pterospermopsis tranvikensis* (Tynni 1982) n. comb. The scale bar equals 10 µm. The doublebar equals 1 µm.

Plate XXV

259b. *Pterospermopsis tranvikensis* (Tynni 1982) n. comb. **260.** *Rhopaliophora foliatilis* Tappan & Loeblich 1971 **261.** *R. palmata* (Combaz & Peniguel) Playford & Martin 1984 **262.** *R. pilata* (Combaz & Peniguel) Playford & Martin 1984 **263.** *Saharidia fragile* (Downie) Combaz 1967 **264.** *Solisphaeridium inaffectum* Playford 1981 **265.** *S. nanum* (Deflandre) Turner 1984 **266.** *Stellechinatum helosum* Turner 1984 **267.** *Stelliferidium* aff. *S. modestum* (Górka) Deunff, Górka & Rauscher 1974 **268.** *Tasmanites martinssoni* Eisenack 1958 **269.** *T.* cf. *T. minutus* Eisenack 1965 **270.** *T.* cf. *T. verrucosus* Eisenack 1962 **271.** *Tranvikium polygonale* Tynni 1982 **272.** *Veryhachium brevitrispinum* Staplin 1961 **273.** *V. cymosum* Wicander & Loeblich 1977 **274.** *V.* aff. *V. cymosum* Wicander & Loeblich 1977. The scale bar equals 10 µm. The doublebar equals 1 µm.

Plate XXVI

275. *Ordovicidium groetlingboensis* f. *clavatum* n. f. **276.** *Orthosphaeridium insculptum* f. *erectum* n. f. **277.** *O. latispinosum* n. sp., holotype **278.** *Orthosphaeridium* sp. **279.** *Peteinosphaeridium granulatum* n. sp., holotype **280.** *Pheoclosterium clavatum* n. sp., holotype **281a,b.** *Polyancistrodorus bryoides* n. sp., holotype **282a.** *P. magnispinosus* n. sp., holotype. The scale bar equals 10 µm. The doublebar equals 1 µm.

Plate XXVII

282b. *Polyancistrodorus magnispinosus* n. sp., holotype **283.** *P. palmatus* n. sp., holotype **284.** *P. phylloides* n. sp., holotype **285.** *Polyedryxium* sp. **286.** *Priscogalea parva* n. sp., holotype **287.** *P. perforata* Uutela 1989, emended **288.** *Pterospermopsis* sp. **289.** *Pulvinosphaeridium granulatum* n. sp., holotype **290.** *Raplasphaera consuta* n. sp., holotype. The scale bar equals 10 µm. The doublebar equals 1 µm.

Plate XXVIII

291a,b. *Raplasphaera undosa* n. sp., holotype **292.** *Revinotesta granulosa* n. sp., holotype **293.** *R. parva* n. sp., holotype

294. *Rhopaliophora reticulata* n. sp., holotype **295.** *Schismatosphaeridium granosum* n. sp., holotype **296.** *Taeniosphaeridium parvum* n. sp., holotype **297.** *Timofeevia enodis* n. sp., holotype **298.** *T. nodosa* n. sp., holotype. The scale bar equals 10 μm. The doublebar equals 1 μm.

Plate XXIX

299. *Tunisphaeridium brevispinosum* n. sp., holotype **300.** *T. spinosissimum* n. sp., holotype **301.** *Tunisphaeridium* sp. **302.** *Tylotopalla* sp. **303.** *Veryhachium asymmetrospinosum* n. sp., holotype **304.** *V. oligospinoides* n. sp., holotype **305.** *V. punctatum* n. sp., holotype **306.** *Villosacapsula decorata* n. sp., holotype **307.** *Vulcanisphaera minor* n. sp., holotype. The scale bar equals 10 μm. The doublebar equals 1 μm.

Plate XXX

308. *Veryhachium* aff. *V. cymosum* Wicander & Loeblich 1977 **309.** *V. europaeum* Stockmans & Willière 1960 **310.** *V. geometricum* (Deflandre) Deunff 1954 **311.** *V. irroratum* Loeblich & Tappan 1969 **312.** *V. lairdi* Deunff 1958 **313.** *V. longispinosum* Jardine *et al.* 1974 **314.** *V. oklahomense* Loeblich 1970 **315.** *V. reductum* Deunff 1958 **316.** *V. rhombispinosum* Tynni 1982 **317.** *V. rhomboidium* Downie 1959 **318.** *V. trapezionarion* Loeblich 1970 **319.** *V. trispinosum* (Eisenack) Deunff 1954 **320a,b.** *V. trispinosum granulatum* Tynni 1982 **321.** *V. trisulcum* Deunff (1958) **322.** *Winwaloeusia distrata* (Deunff 1966). The scale bar equals 10 μm. The doublebar equals 1 μm.

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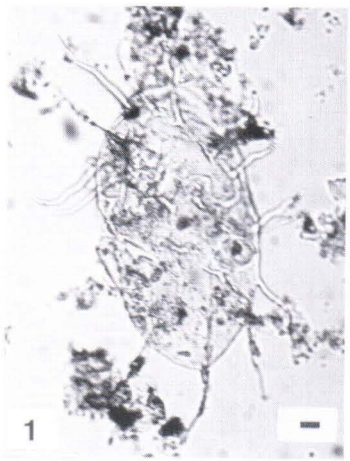
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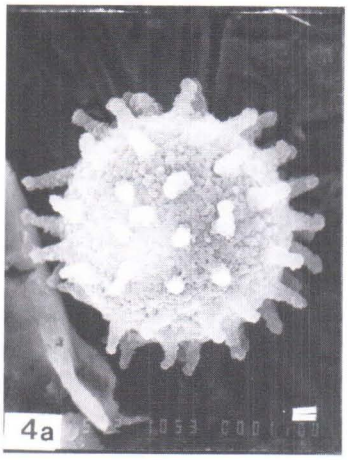
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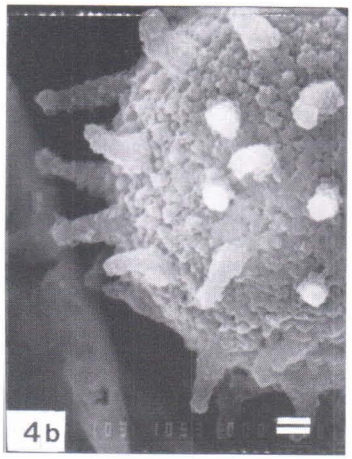
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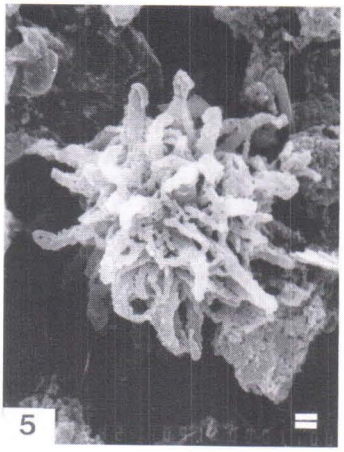
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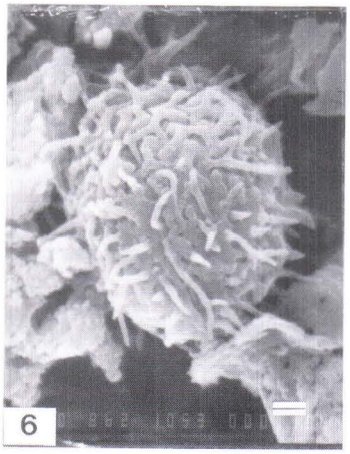
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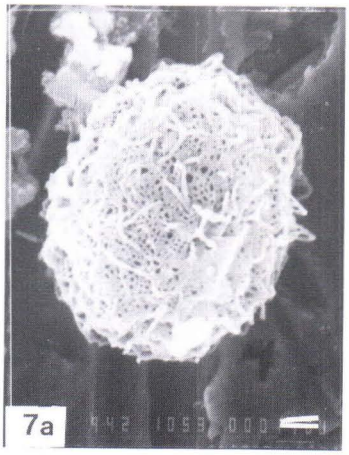
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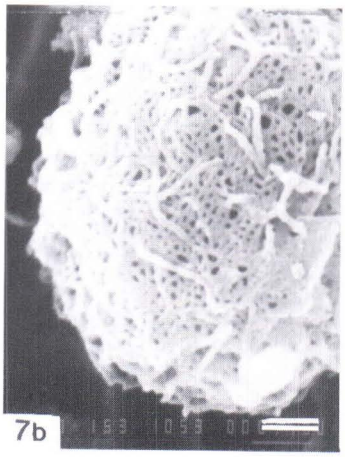
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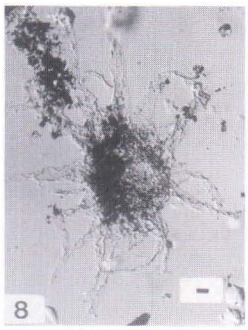
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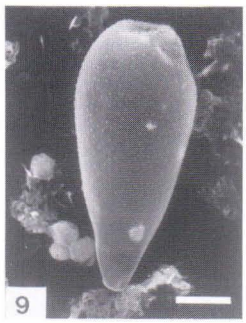
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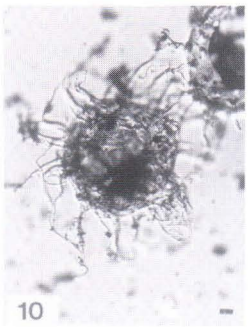
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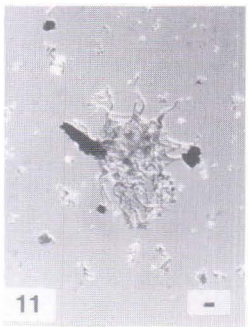
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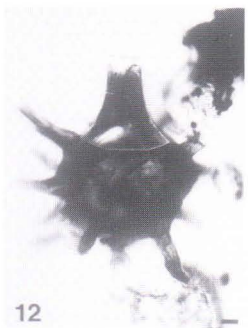
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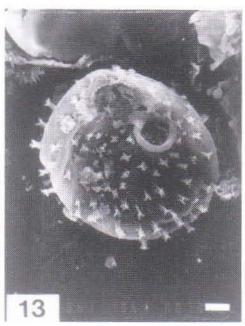
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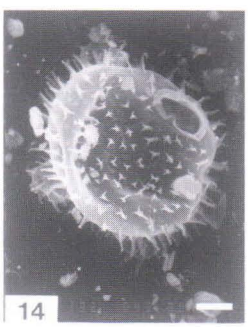
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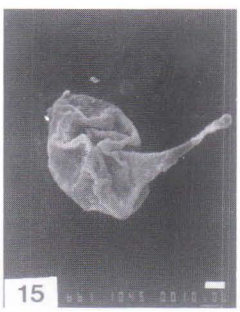
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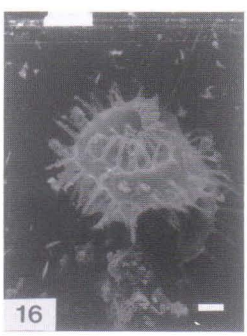
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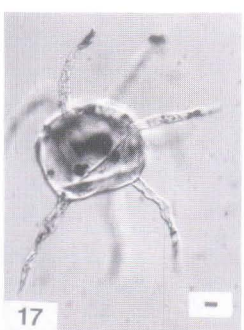
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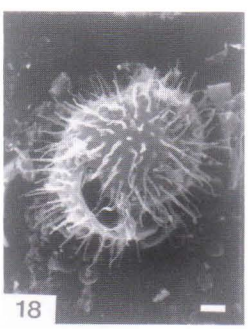
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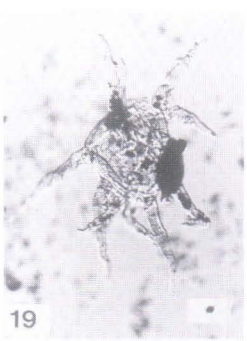
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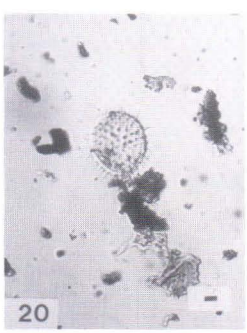
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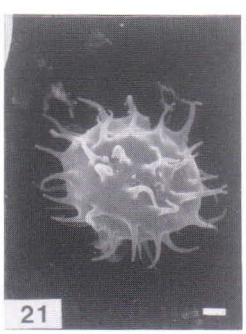
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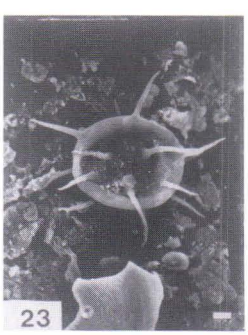
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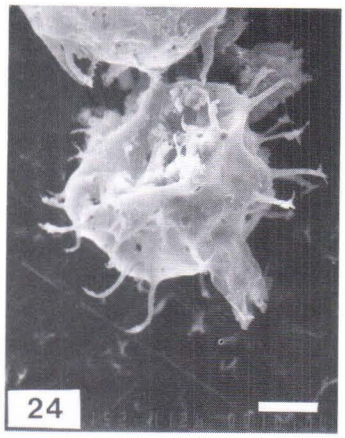
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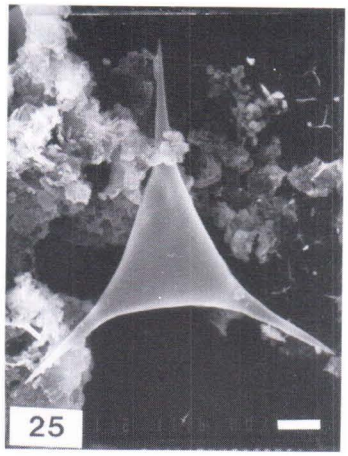
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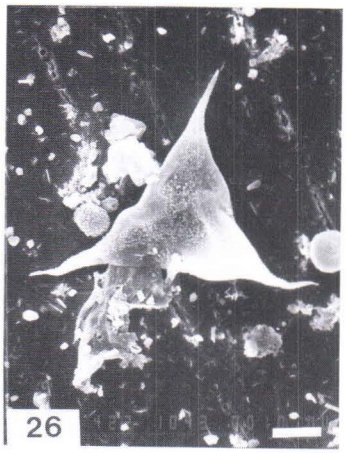
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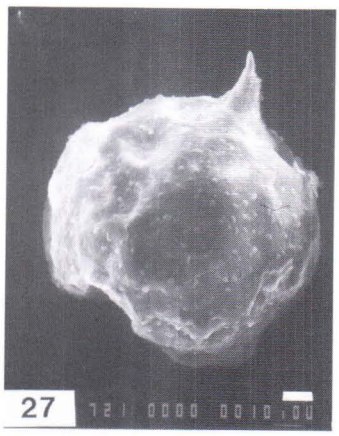
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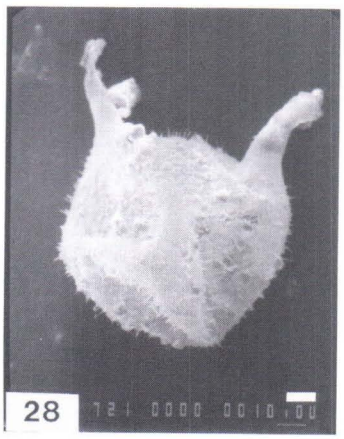
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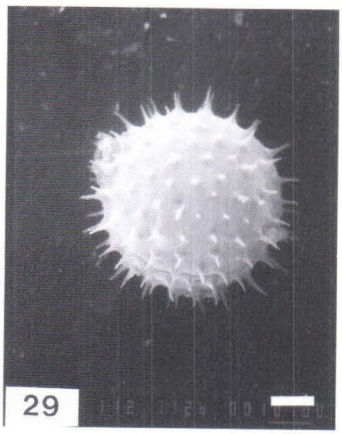
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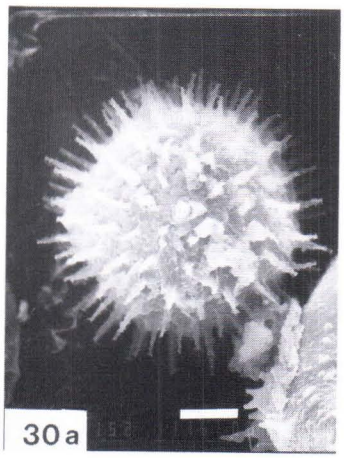
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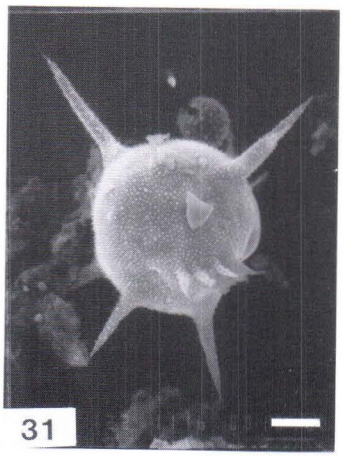
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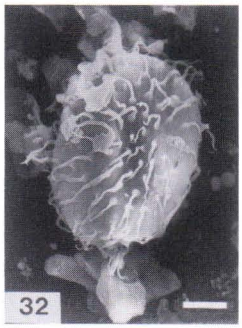
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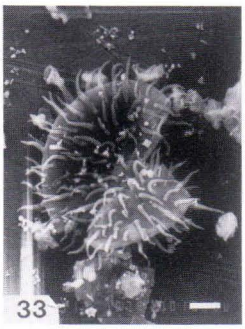
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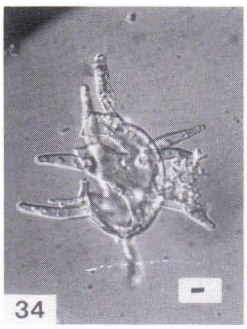
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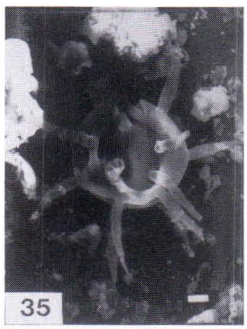
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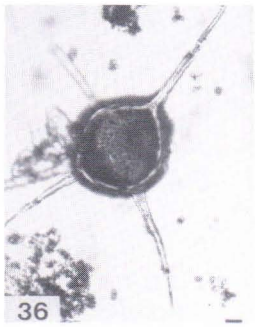
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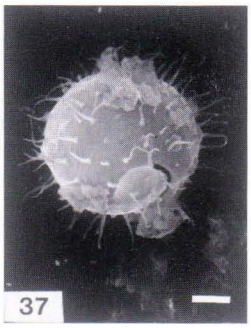
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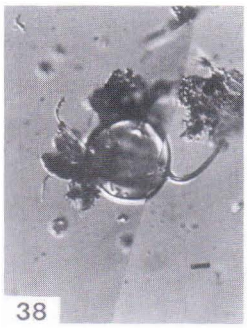
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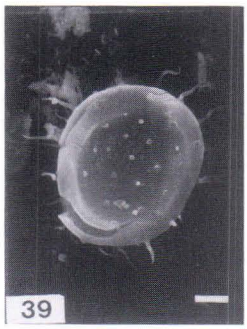
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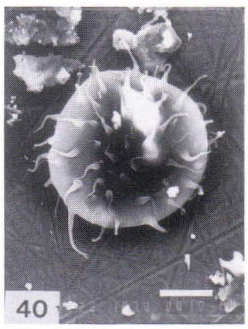
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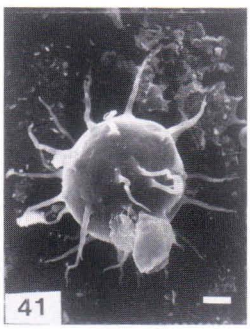
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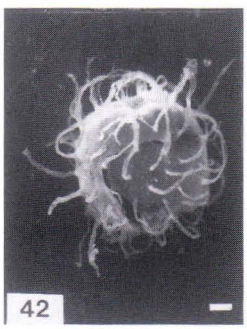
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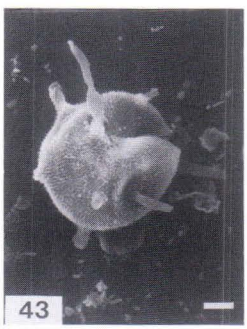
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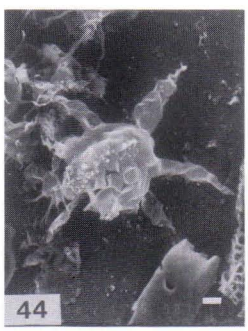
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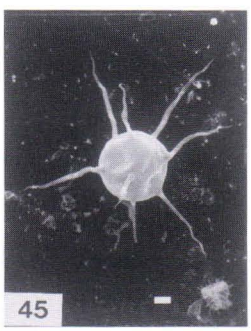
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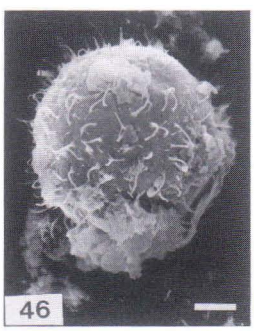
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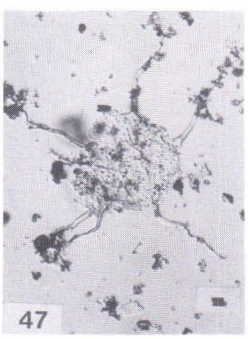
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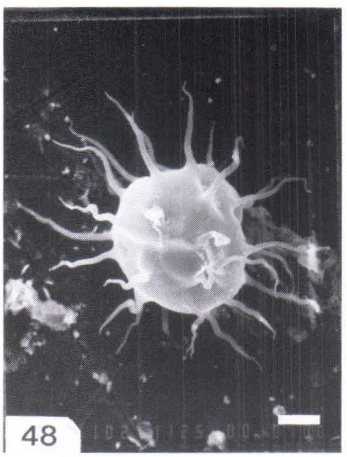
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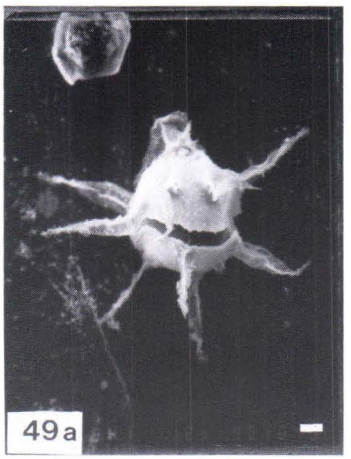
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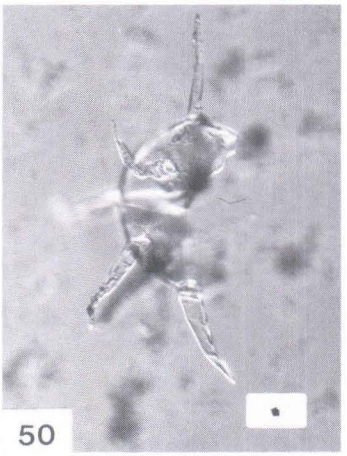
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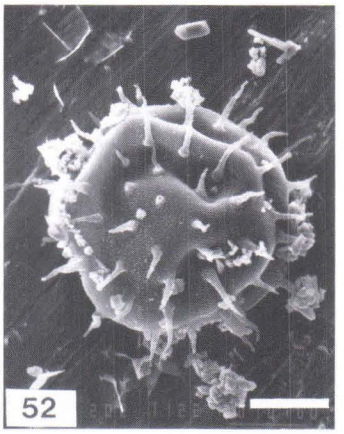
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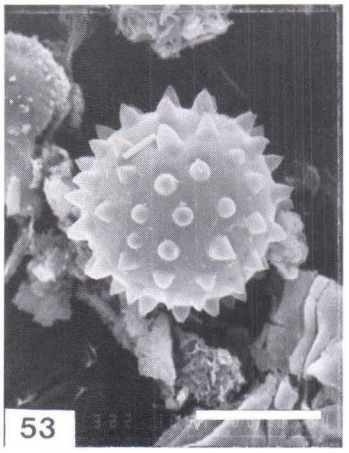
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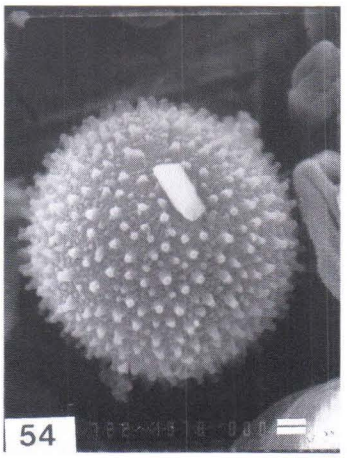
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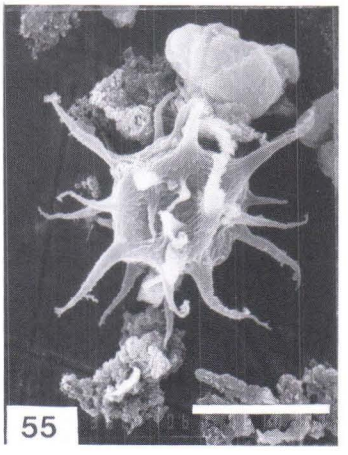
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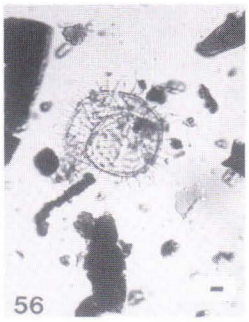
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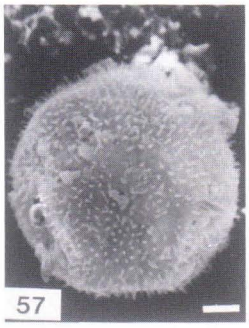
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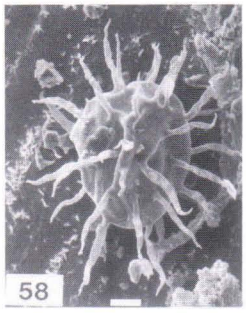
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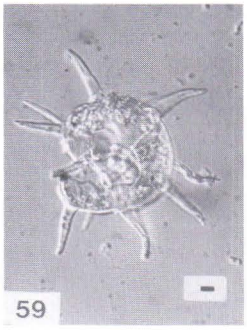
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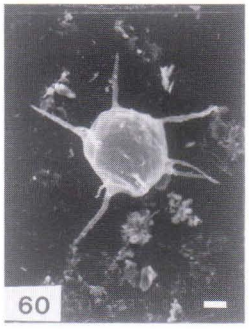
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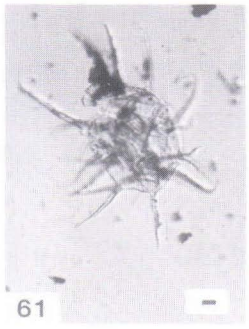
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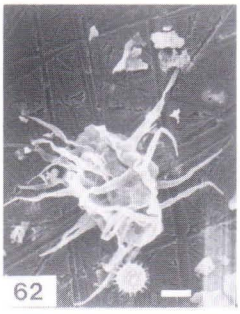
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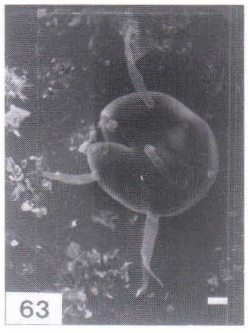
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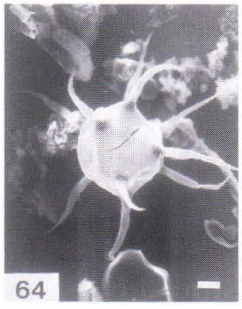
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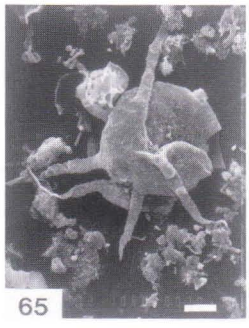
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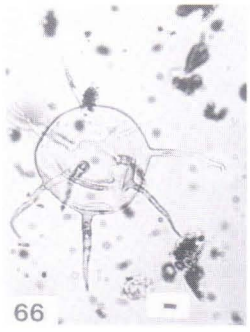
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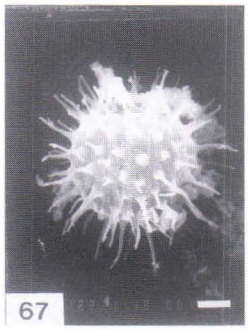
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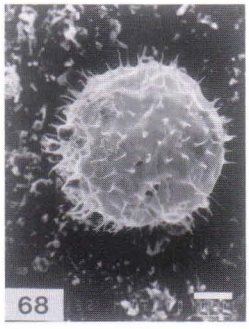
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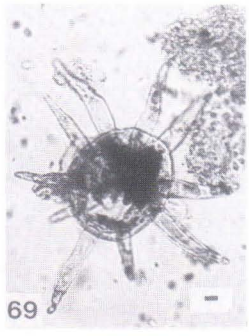
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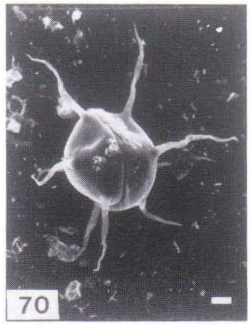
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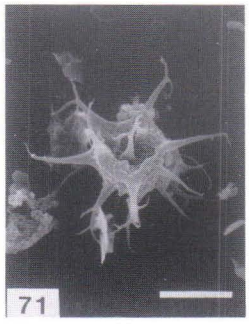
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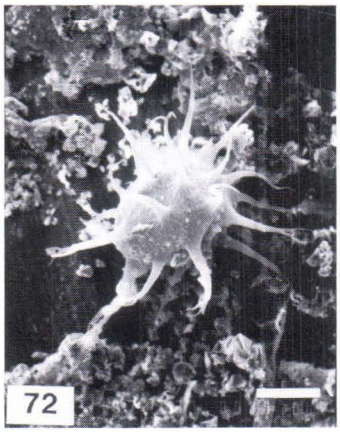
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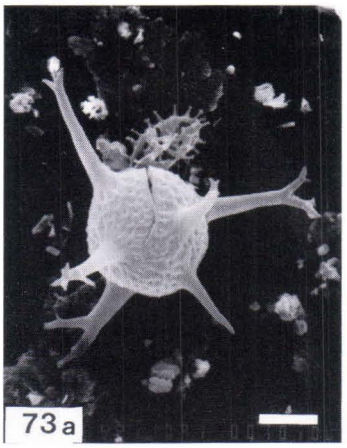
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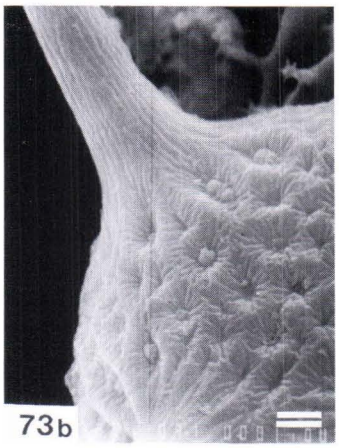
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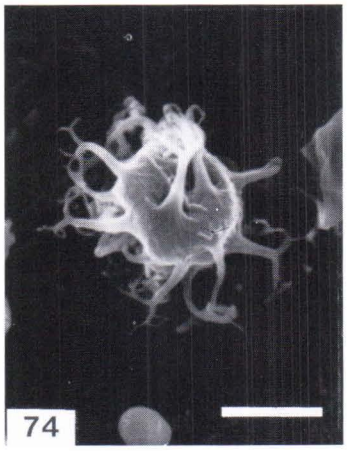
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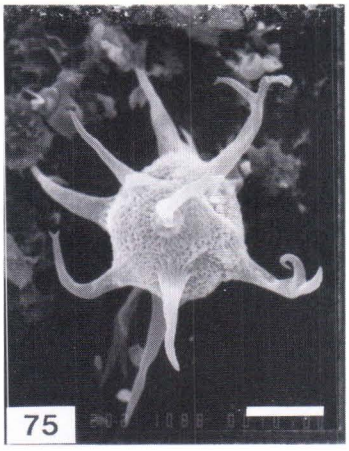
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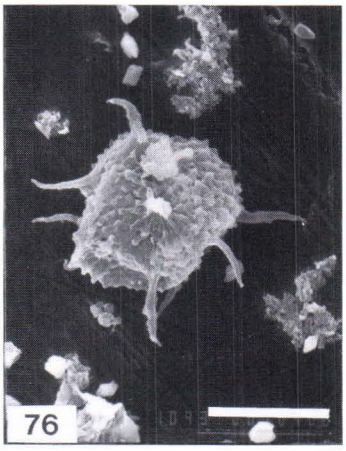
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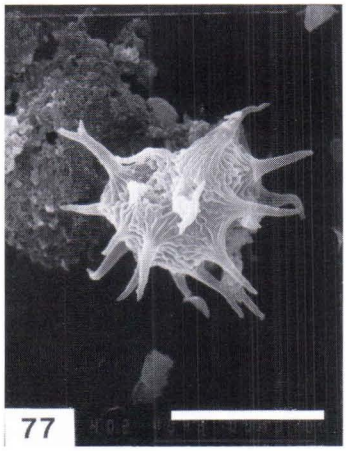
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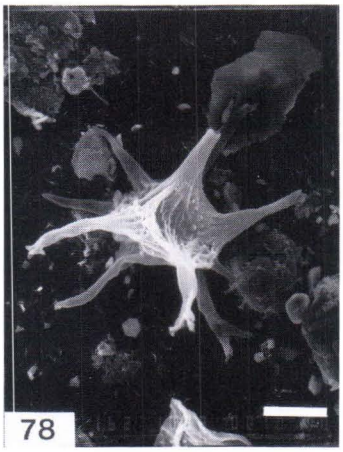
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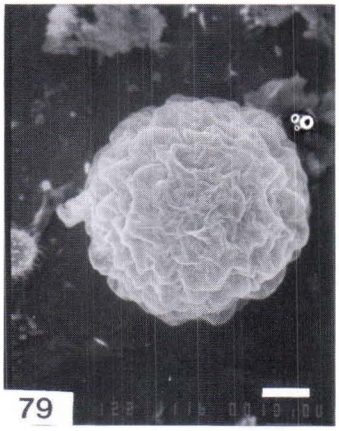
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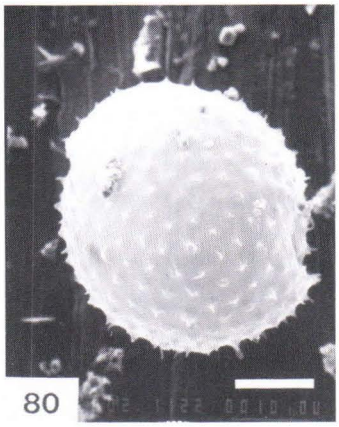
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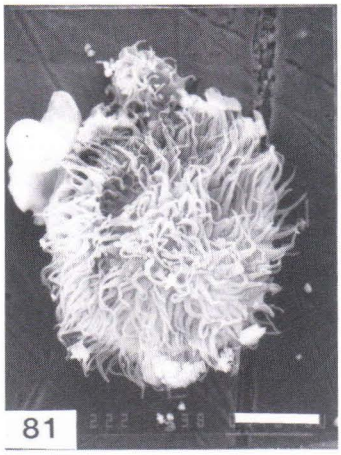
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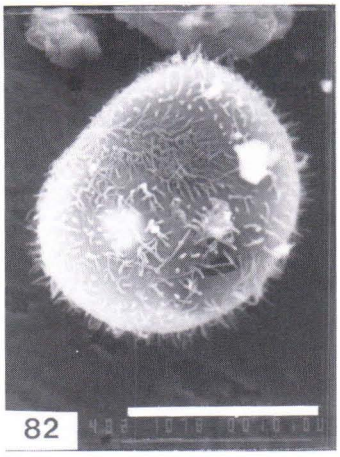
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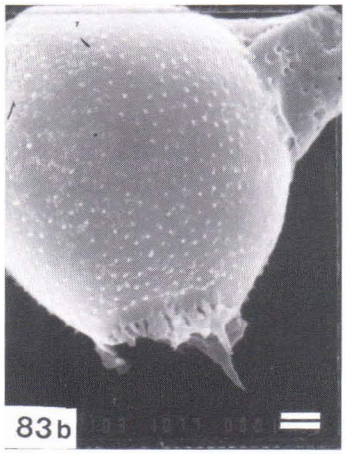
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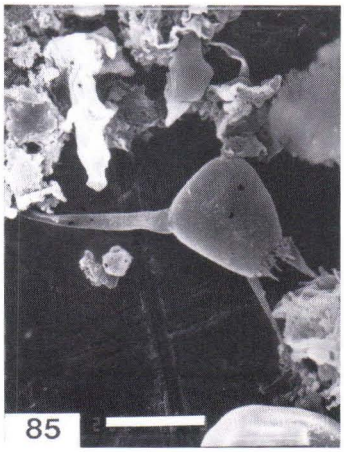
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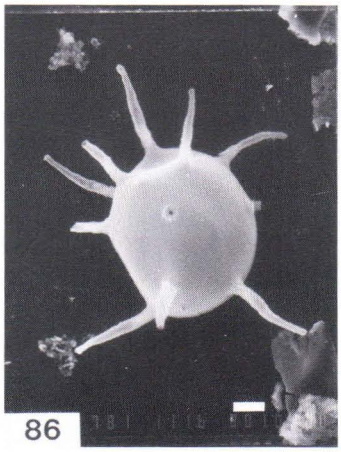
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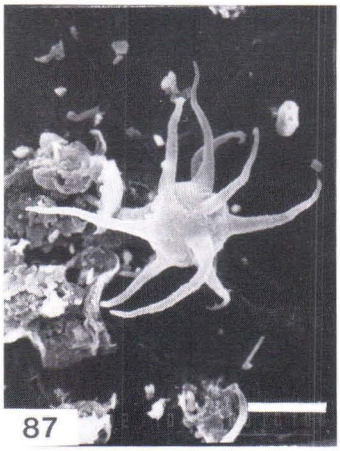
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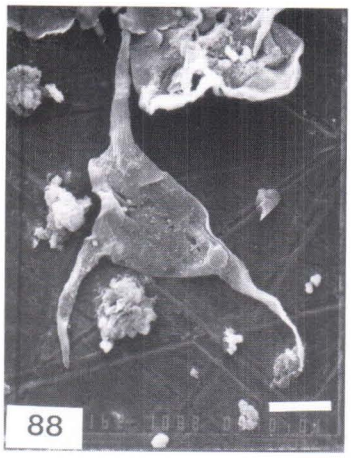
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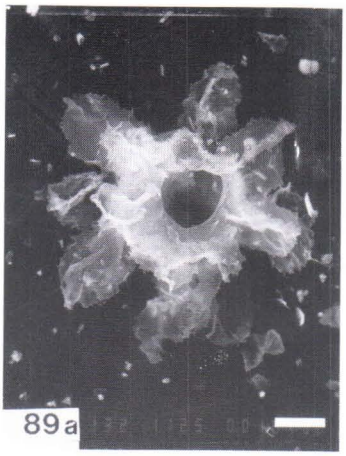
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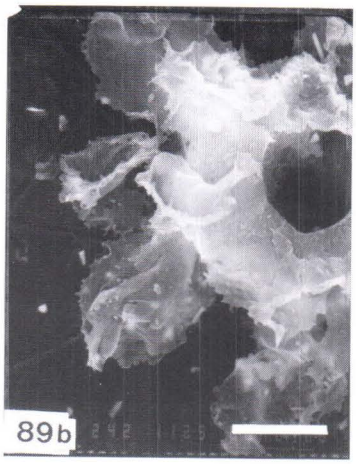
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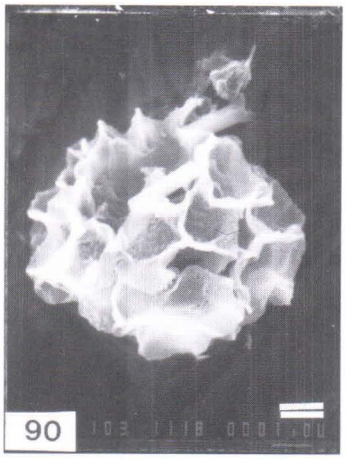
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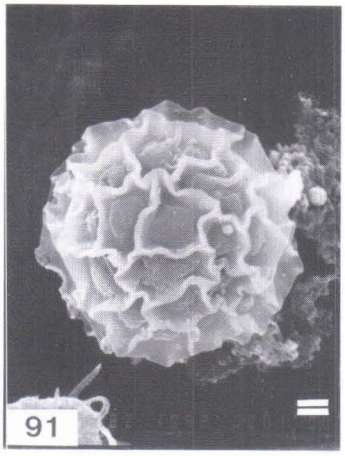
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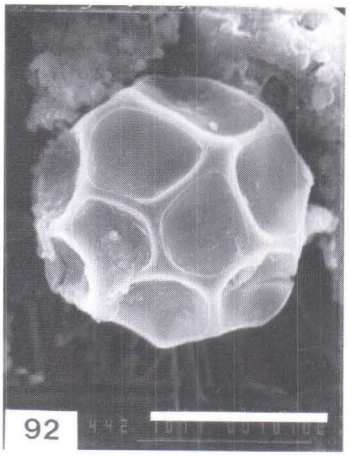
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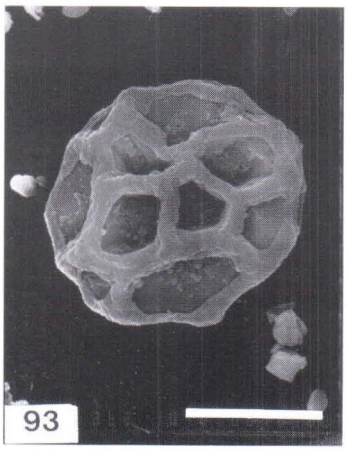
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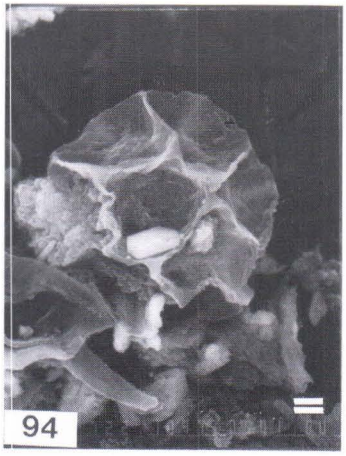
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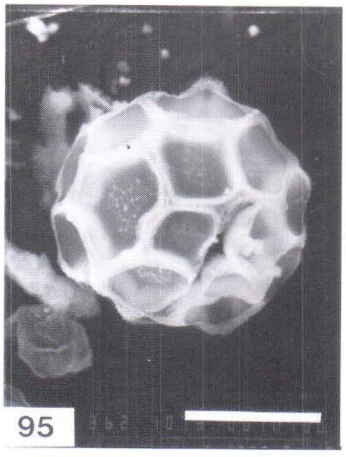
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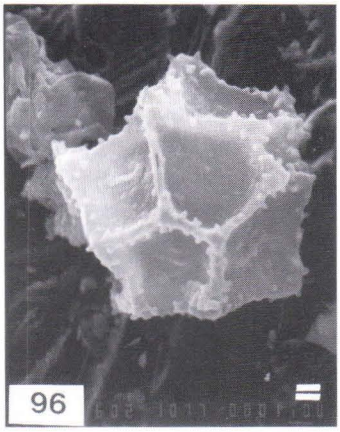
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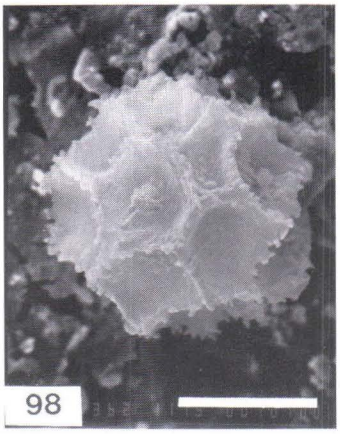
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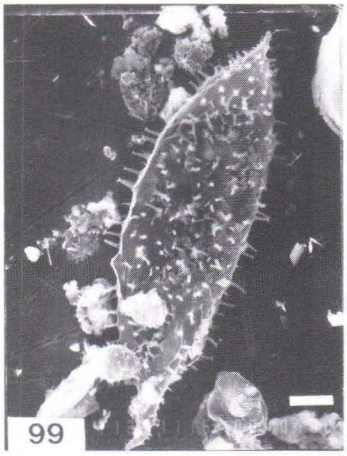
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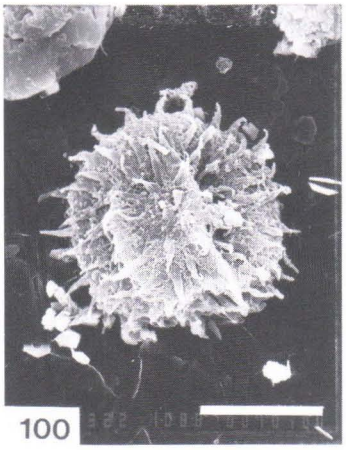
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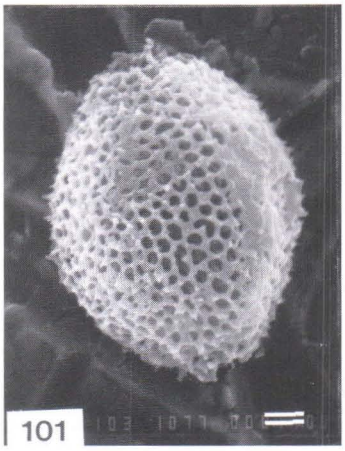
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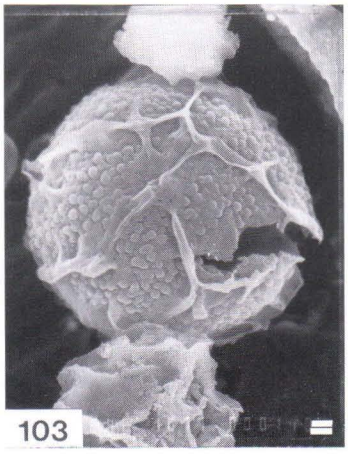
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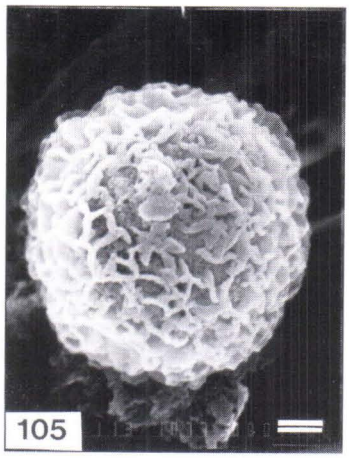
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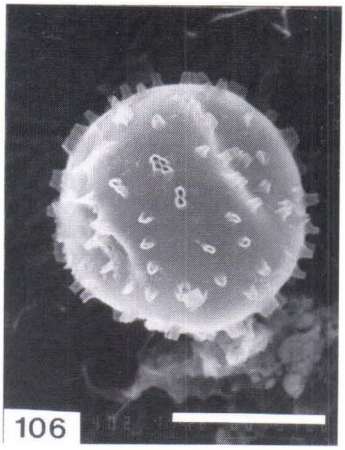
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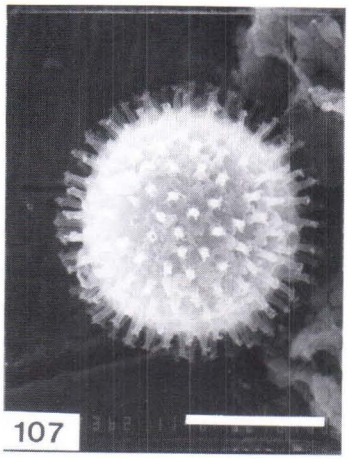
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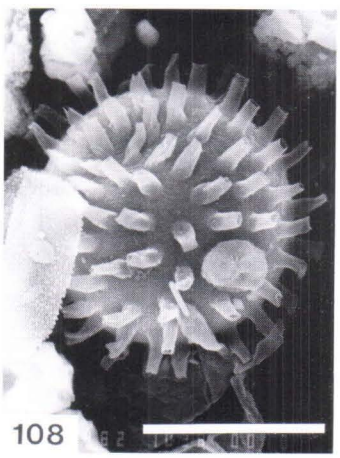
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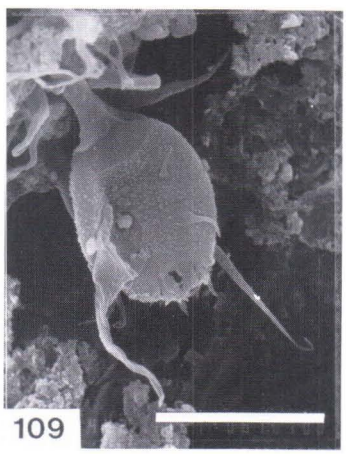
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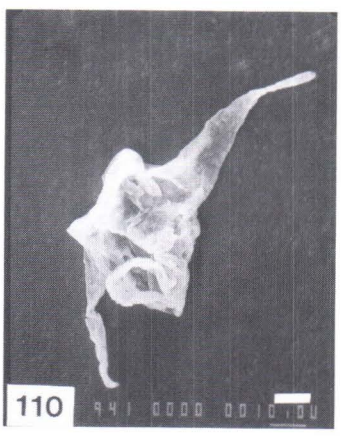
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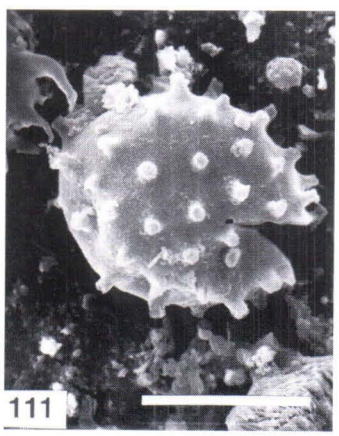
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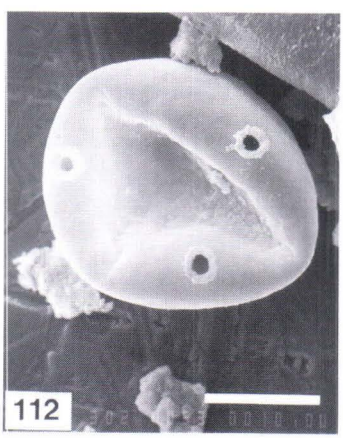
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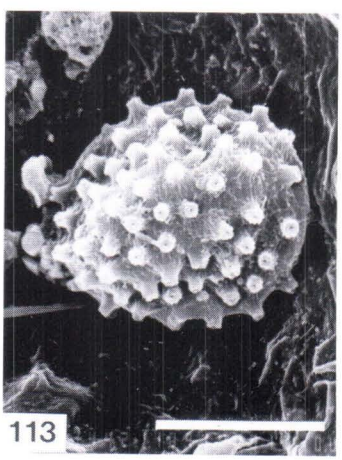
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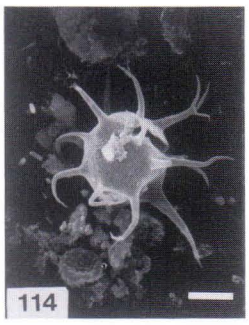
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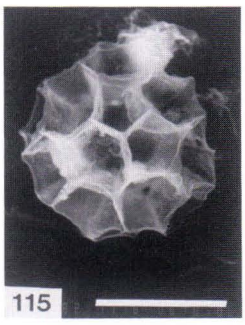
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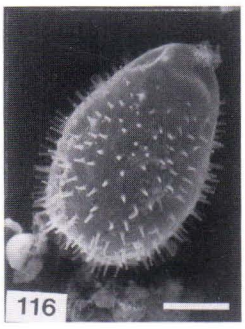
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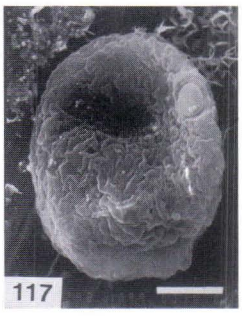
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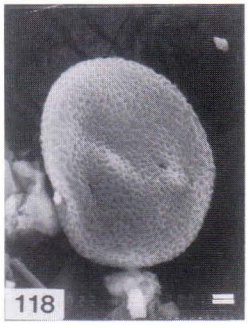
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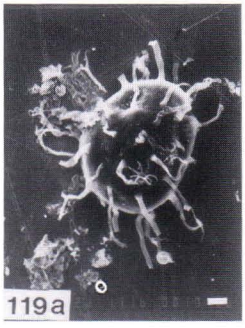
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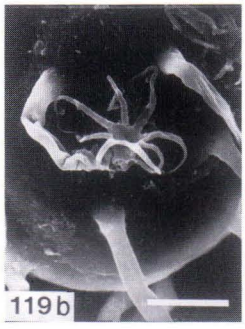
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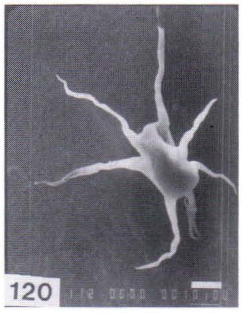
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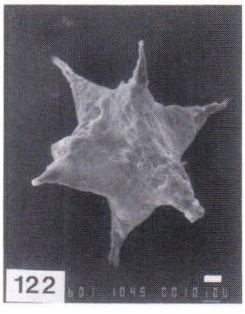
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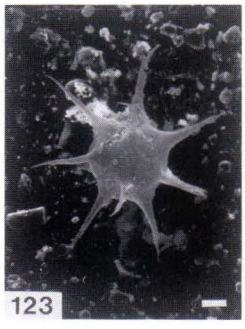
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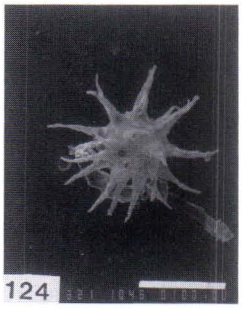
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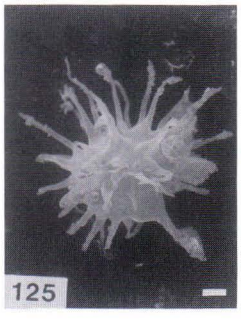
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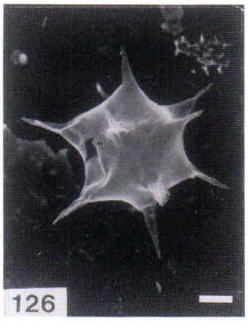
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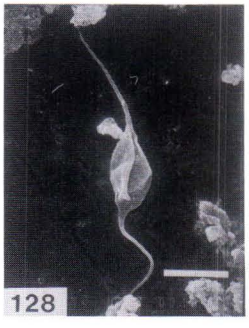
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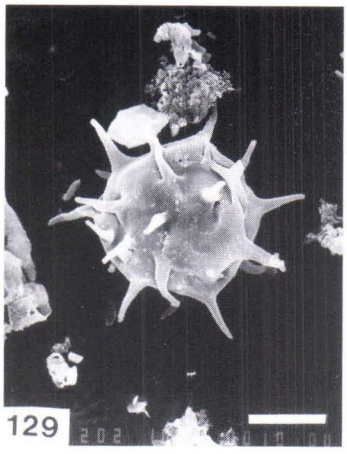
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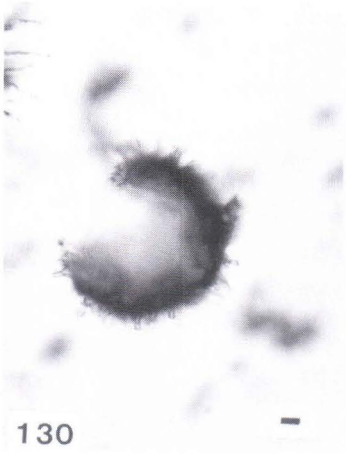
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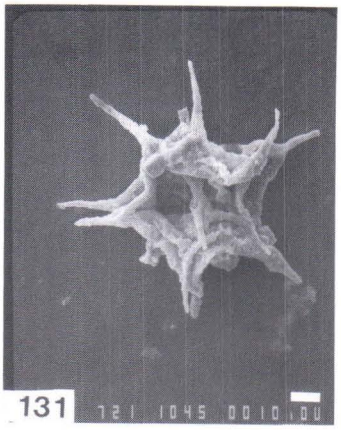
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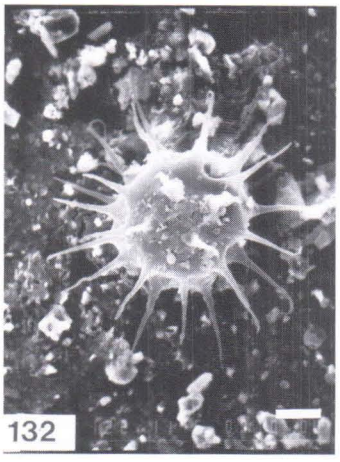
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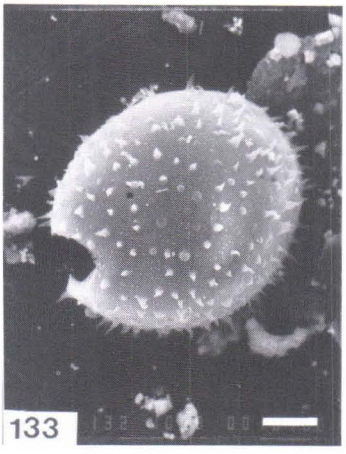
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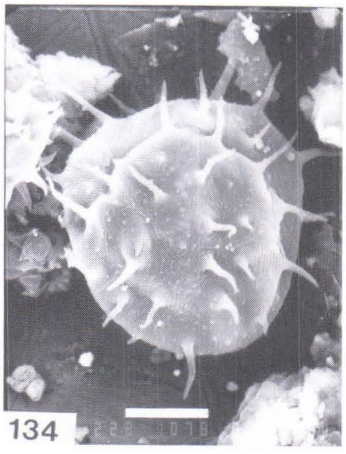
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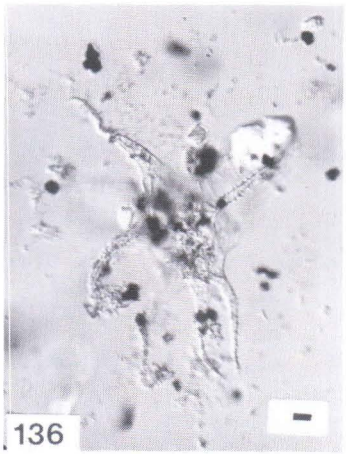
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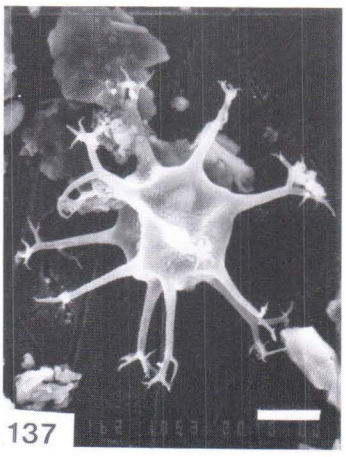
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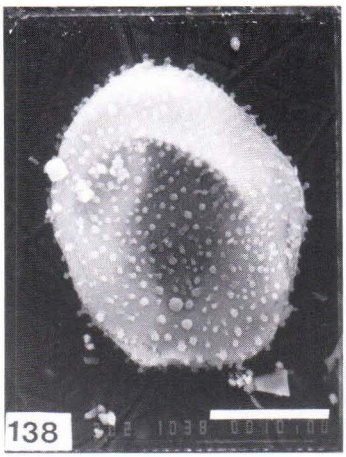
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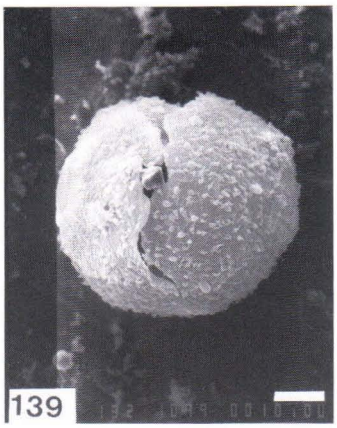
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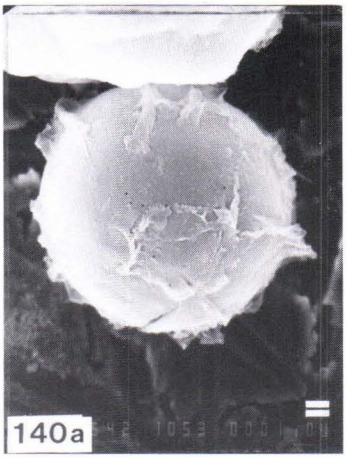
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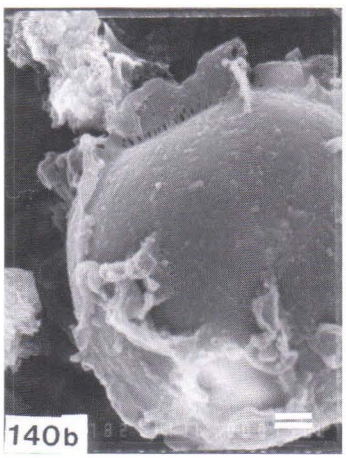
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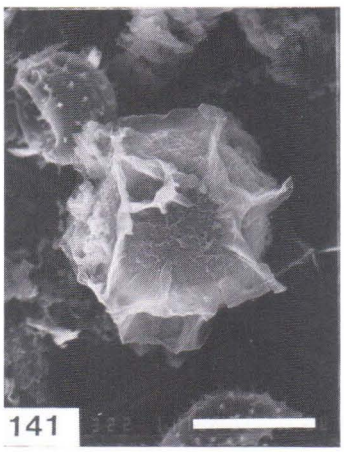
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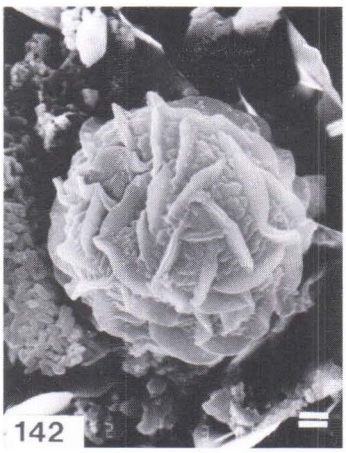
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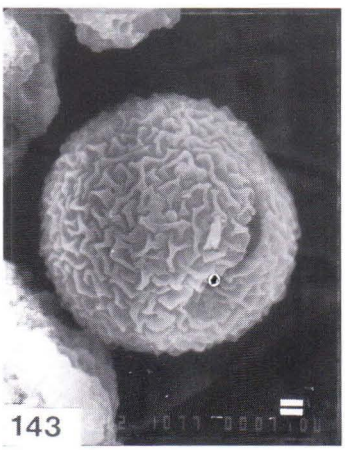
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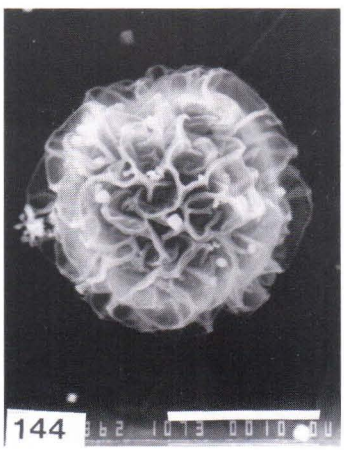
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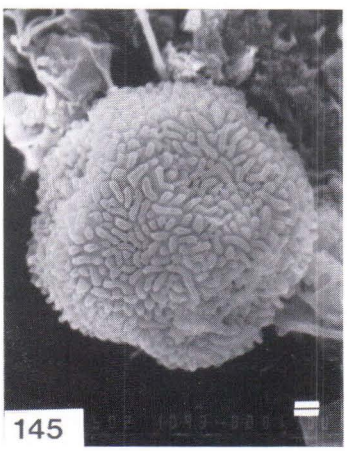
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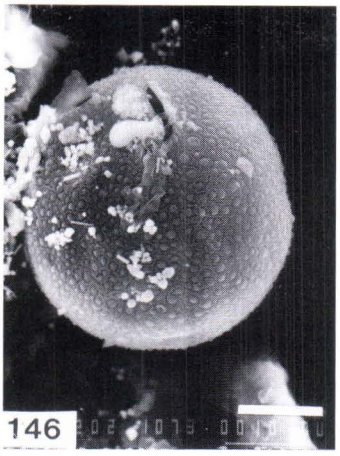
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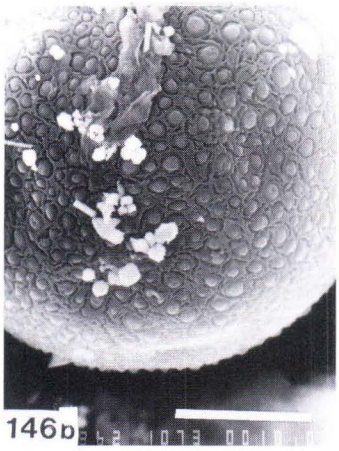
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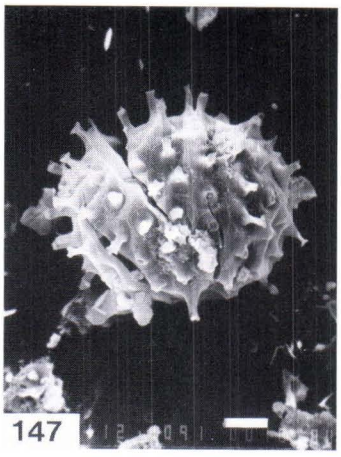
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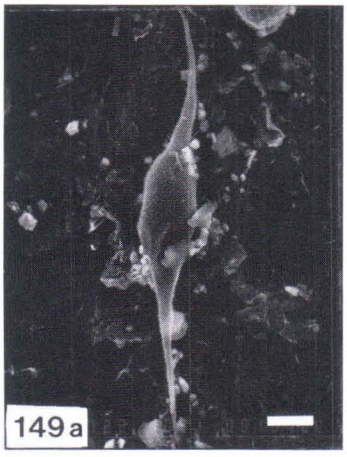
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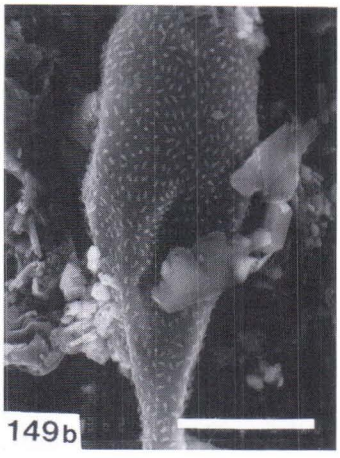
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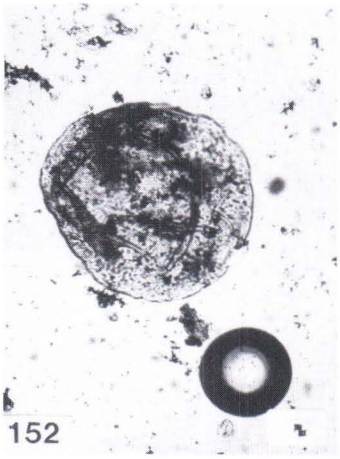
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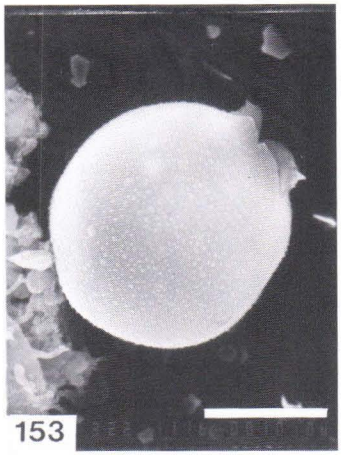
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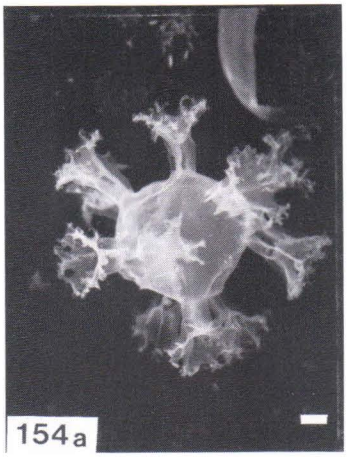
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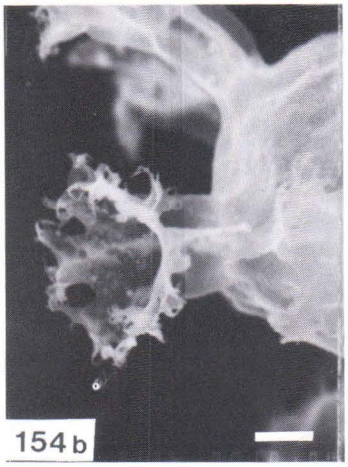
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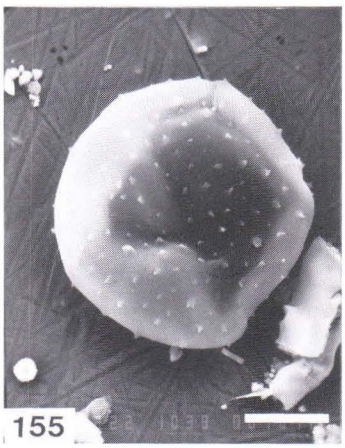
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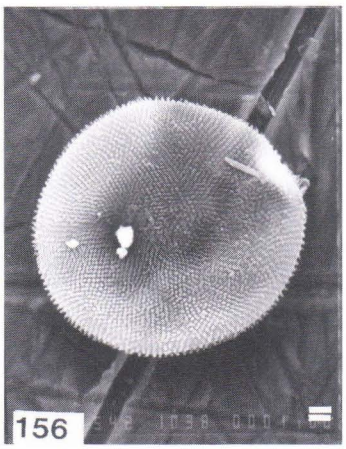
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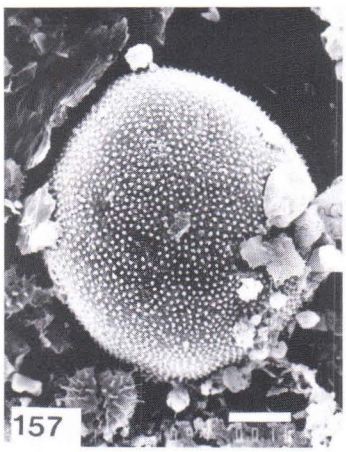
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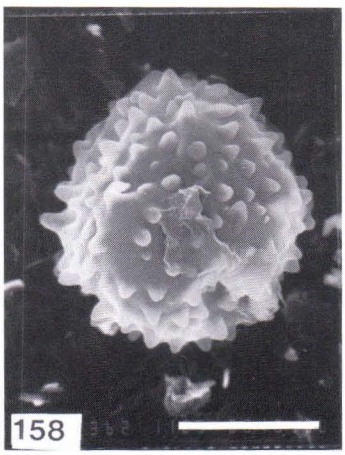
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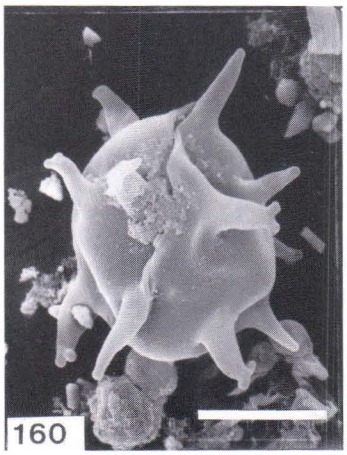
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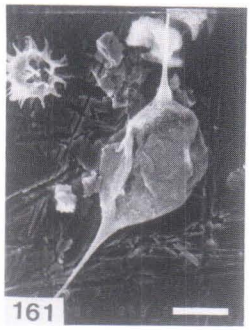
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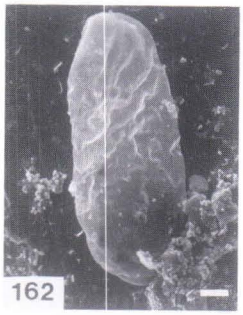
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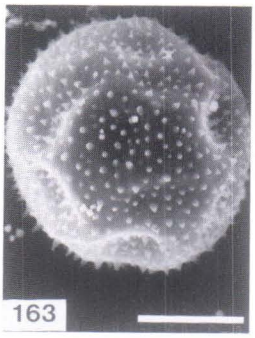
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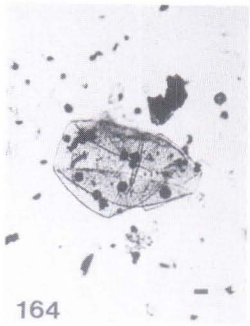
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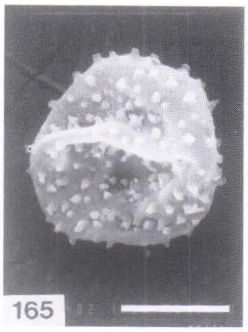
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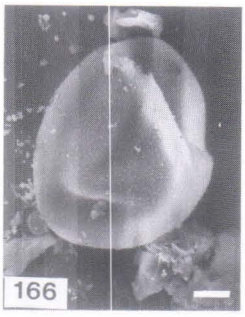
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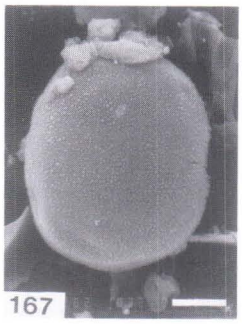
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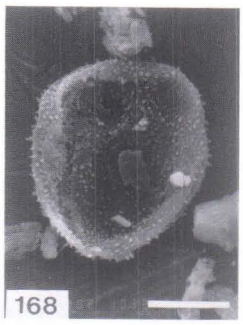
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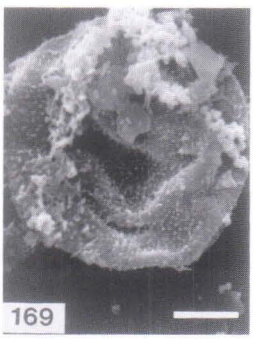
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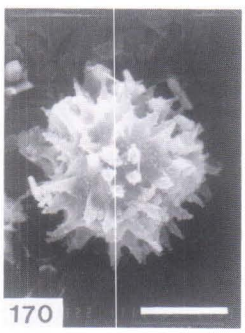
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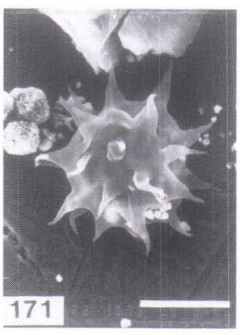
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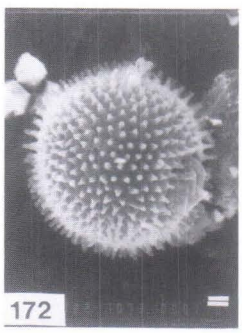
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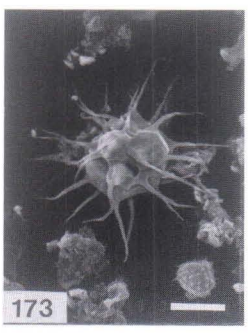
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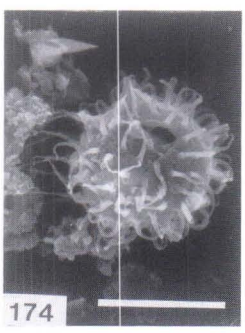
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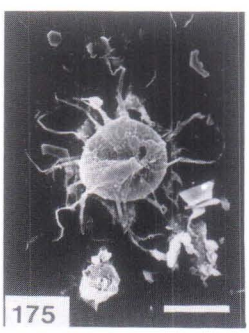
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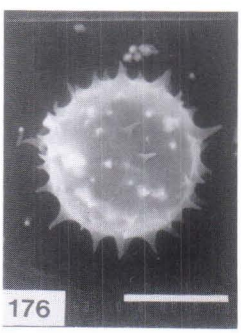
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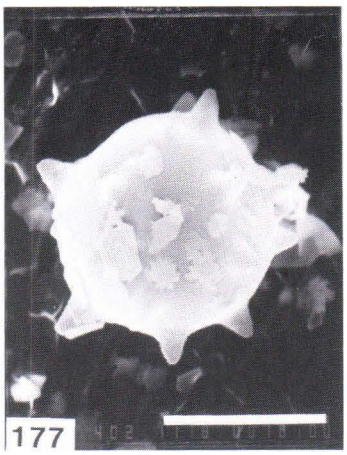
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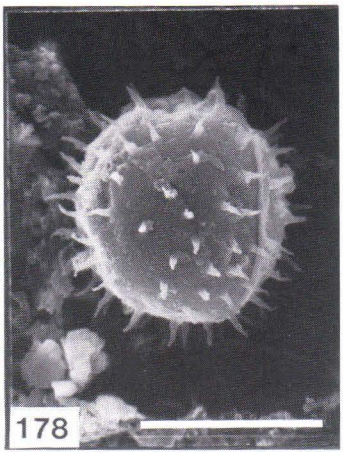
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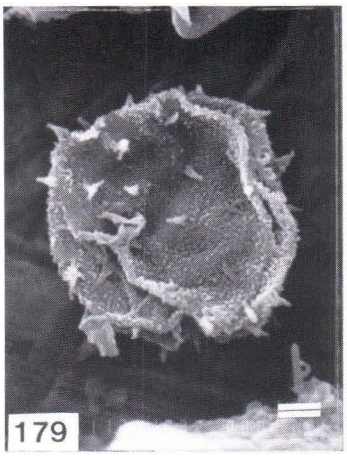
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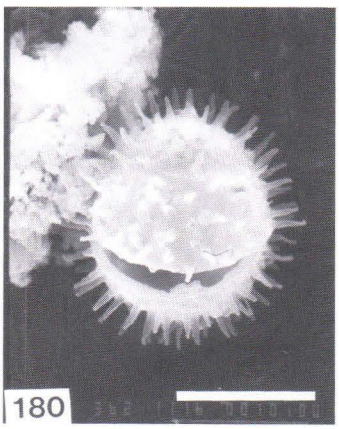
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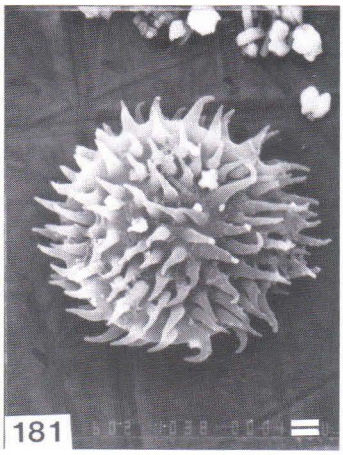
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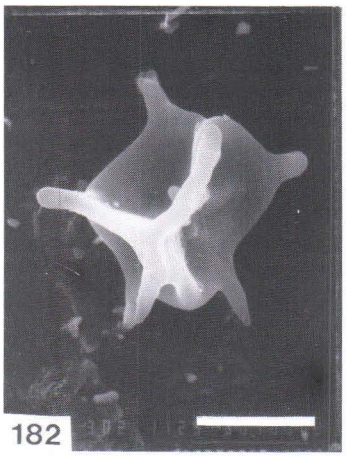
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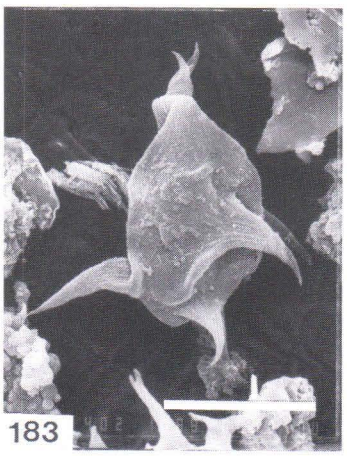
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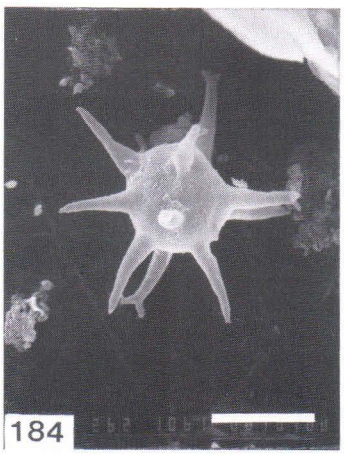
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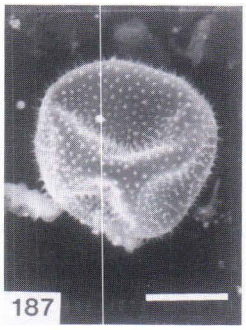
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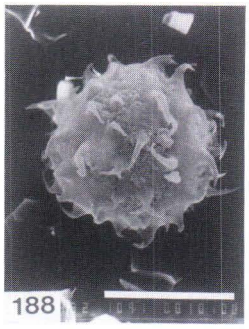
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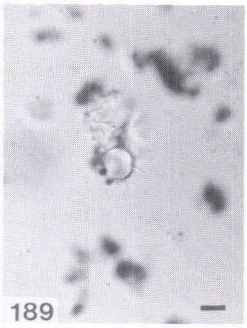
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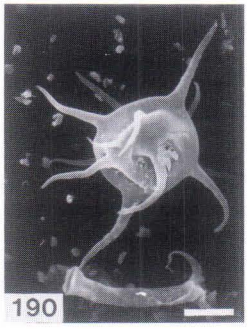
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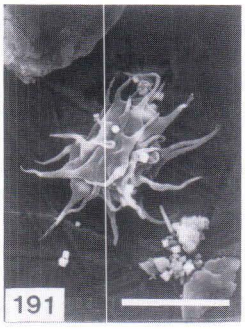
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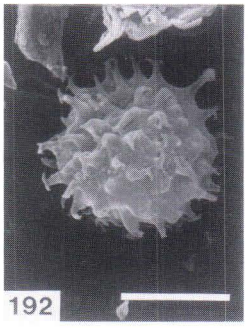
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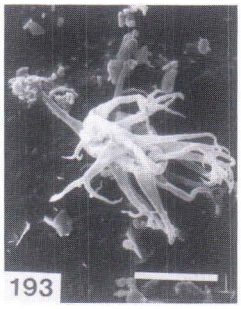
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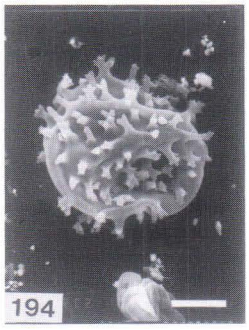
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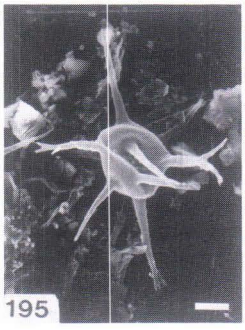
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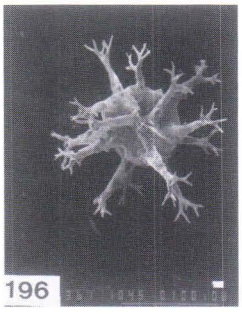
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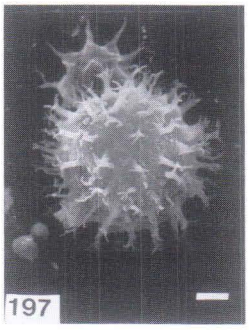
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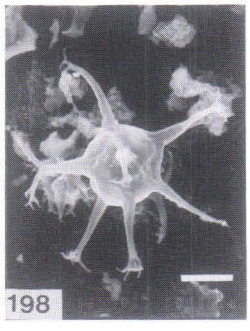
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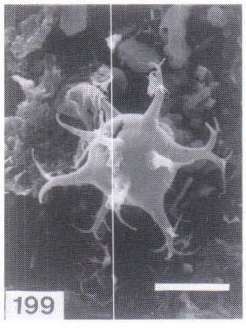
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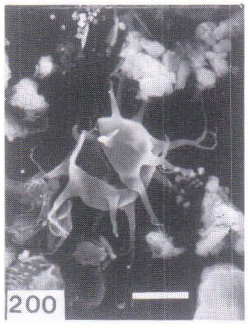
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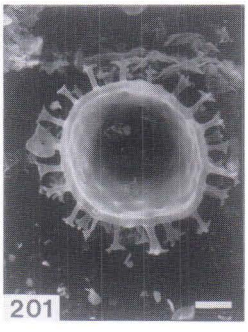
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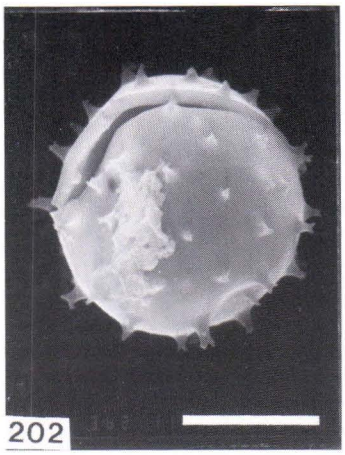
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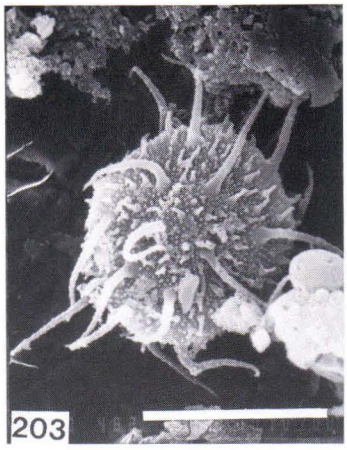
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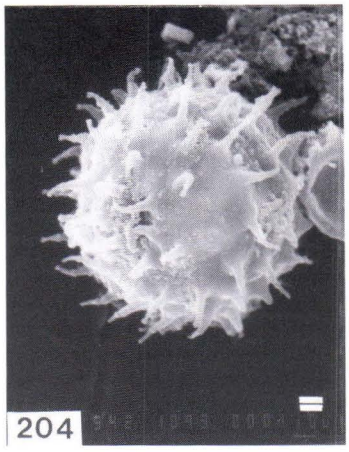
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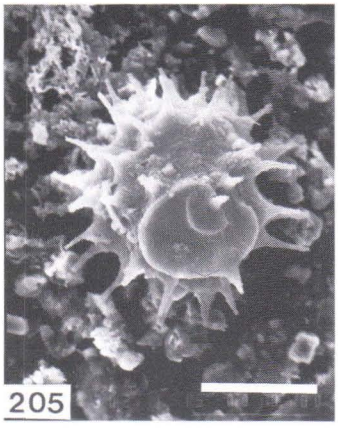
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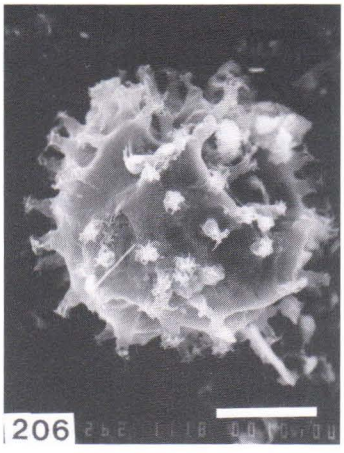
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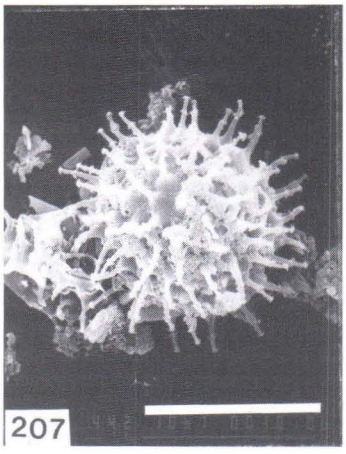
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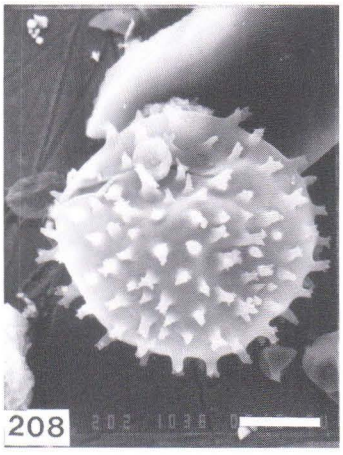
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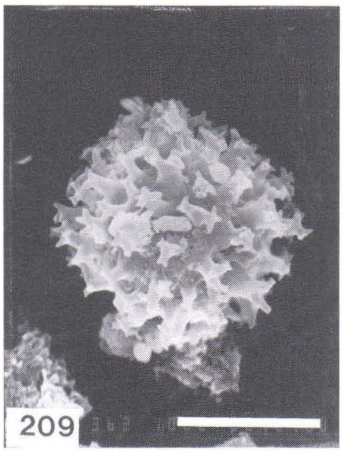
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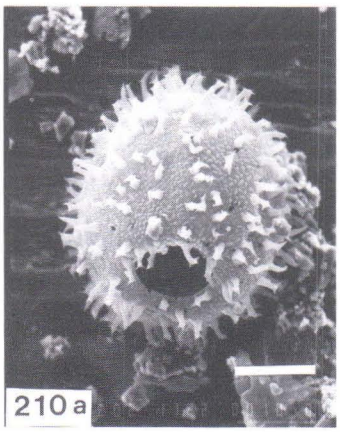
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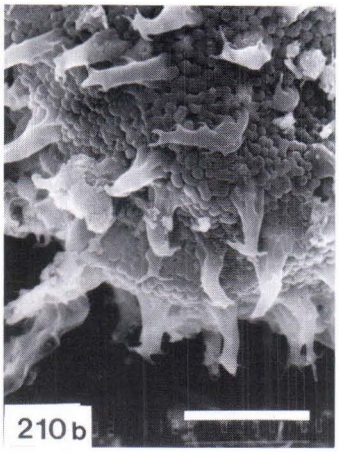
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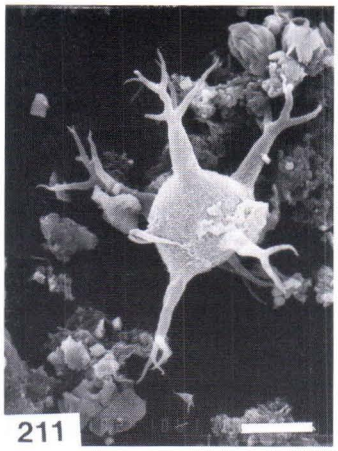
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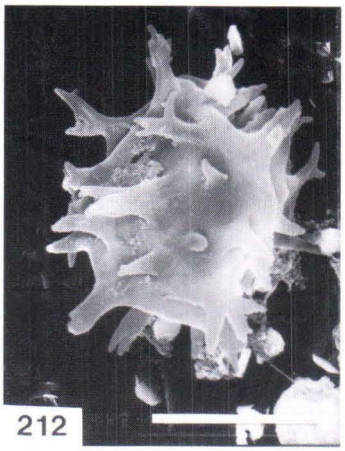
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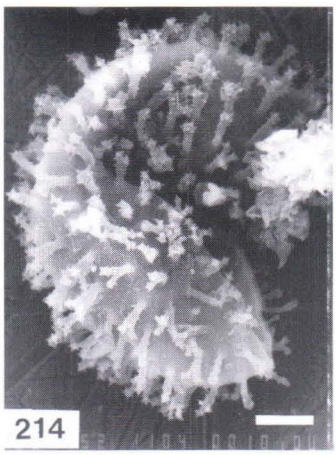
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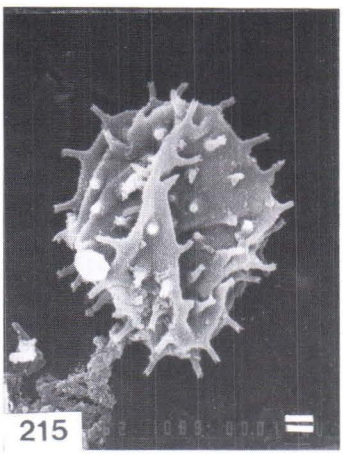
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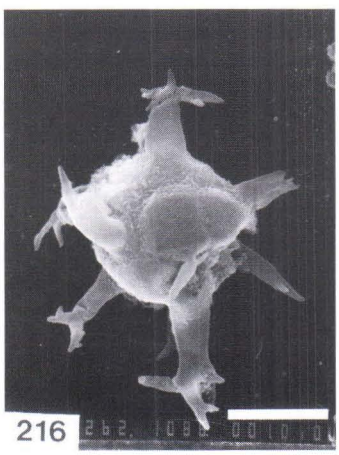
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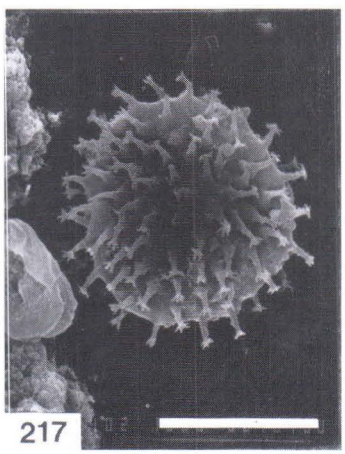
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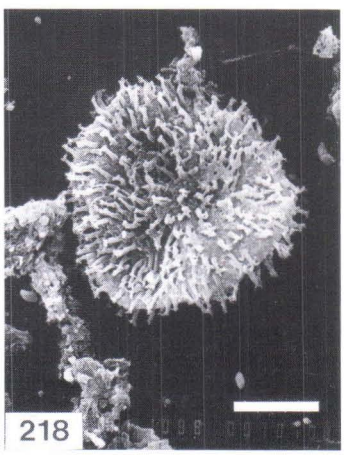
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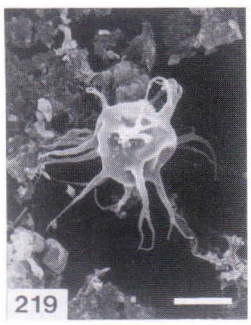
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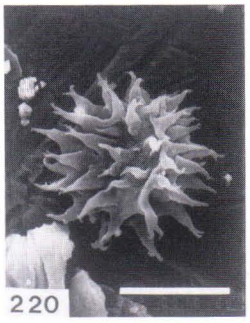
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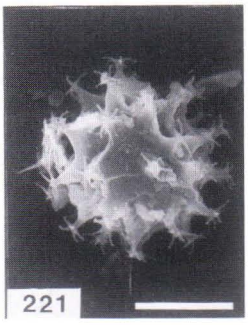
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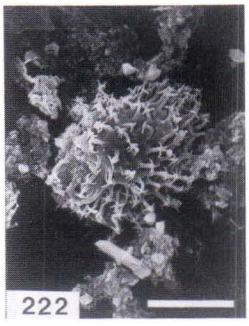
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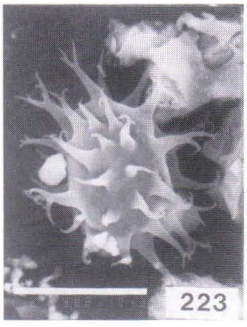
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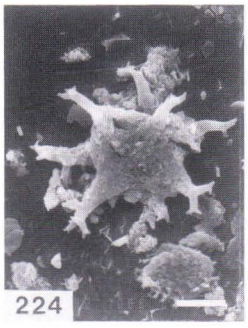
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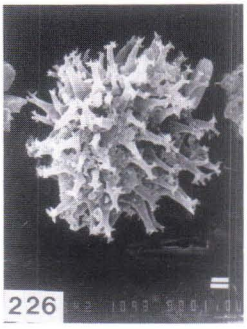
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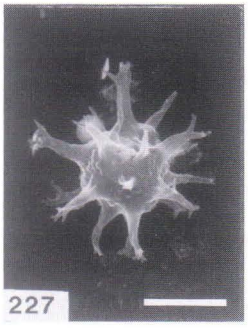
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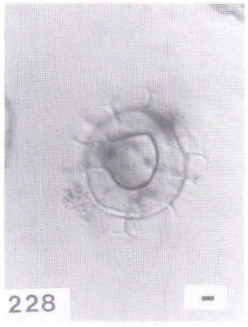
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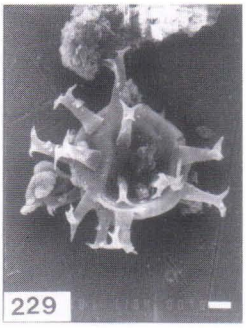
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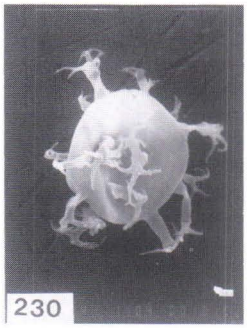
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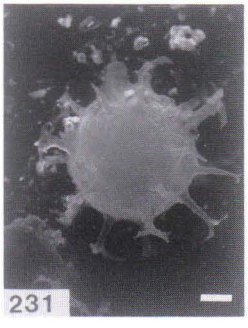
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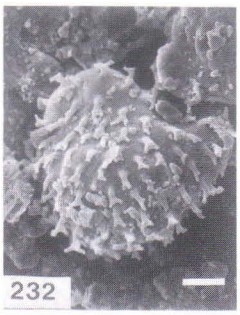
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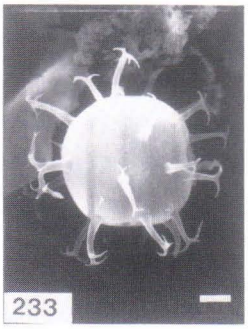
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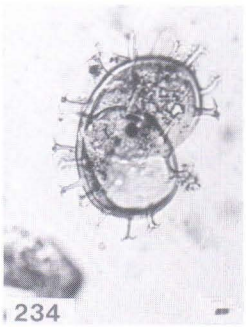
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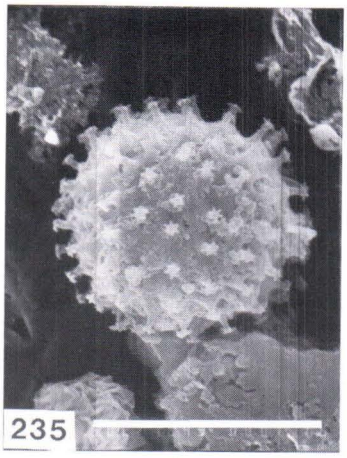
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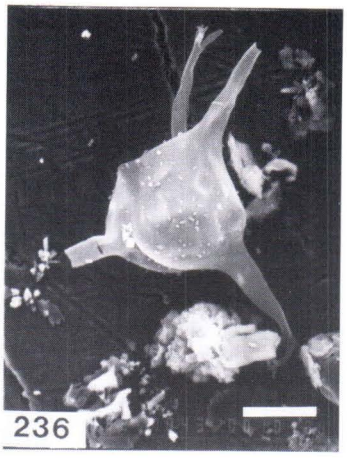
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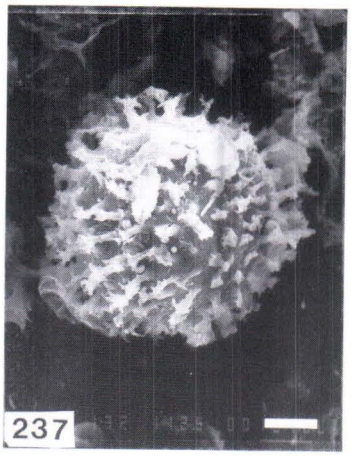
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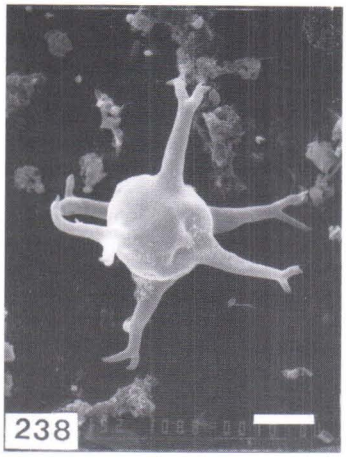
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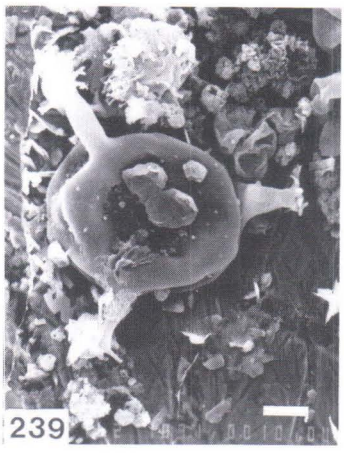
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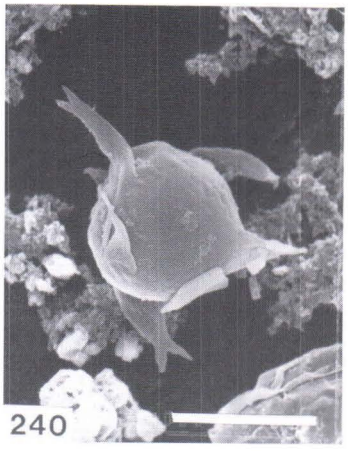
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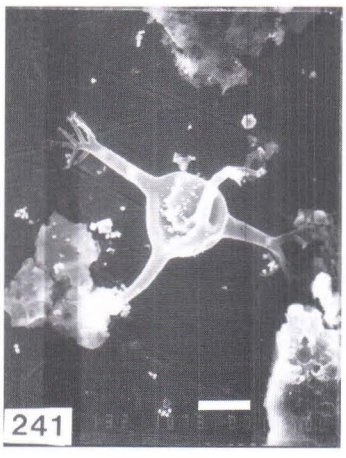
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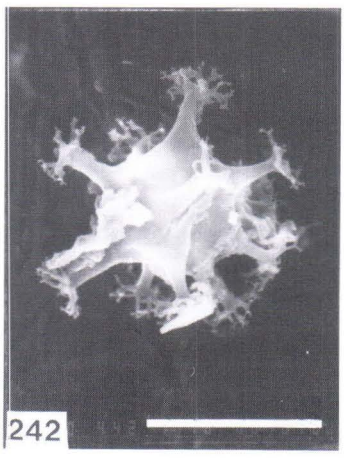
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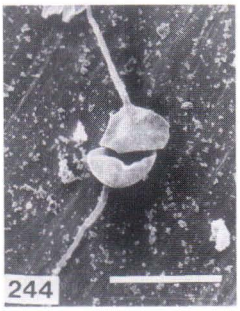
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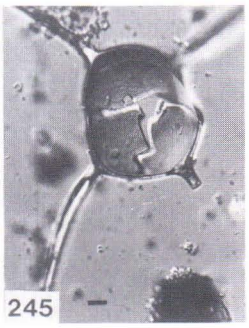
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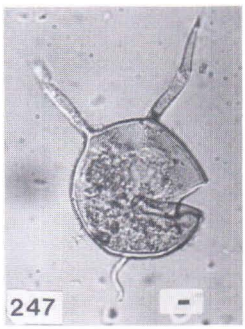
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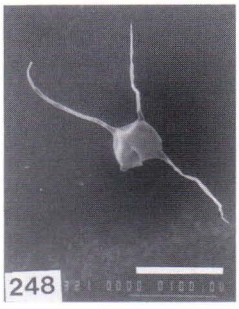
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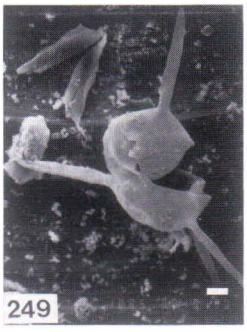
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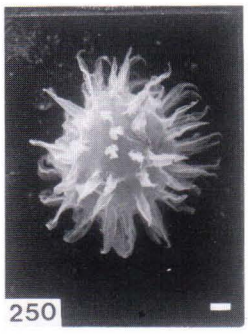
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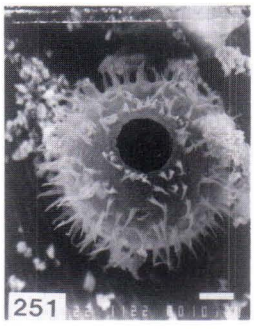
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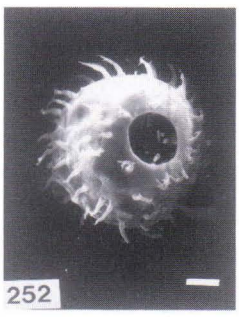
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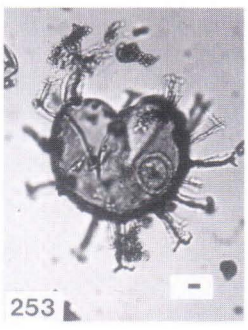
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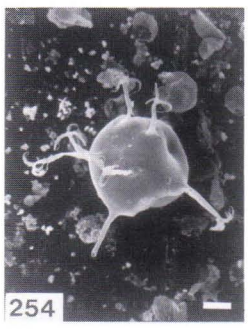
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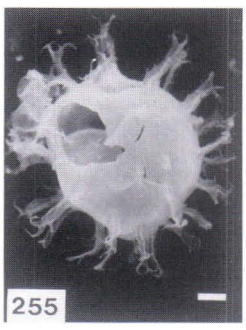
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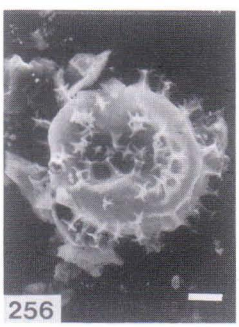
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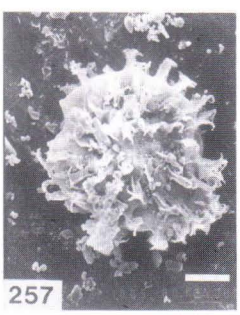
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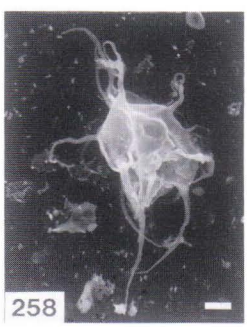
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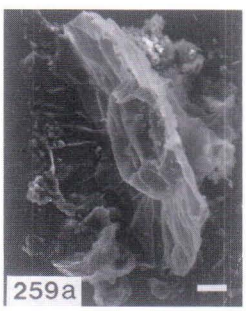
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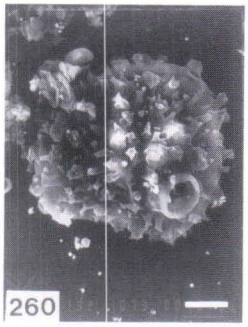
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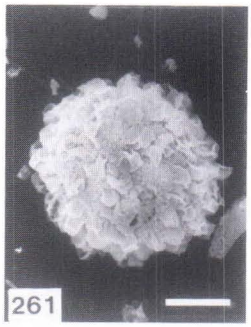
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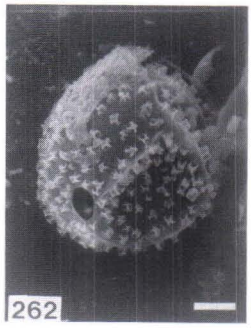
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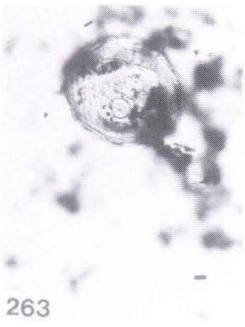
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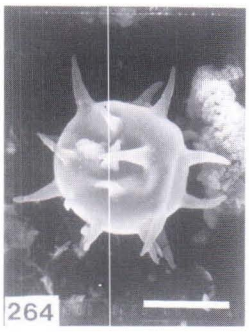
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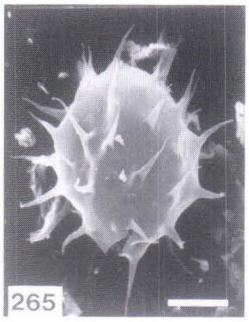
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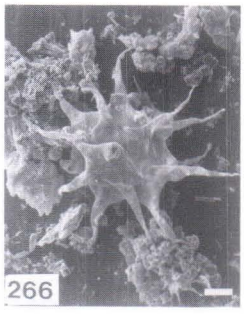
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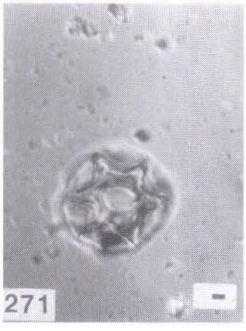
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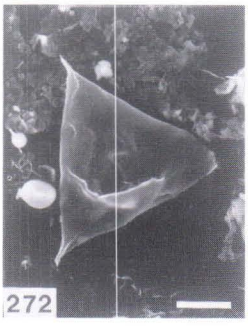
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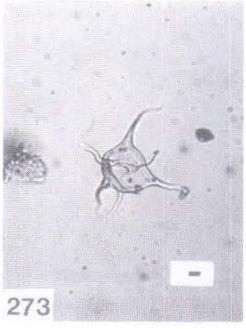
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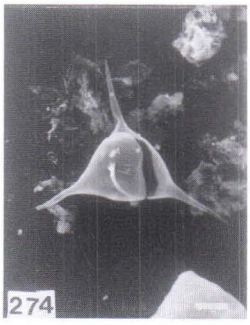
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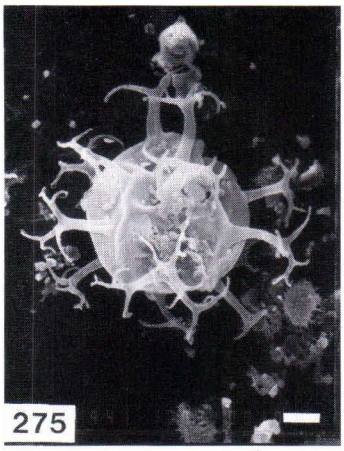
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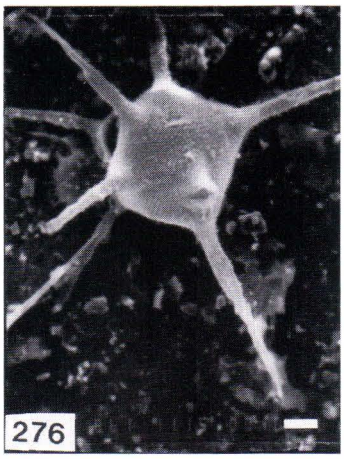
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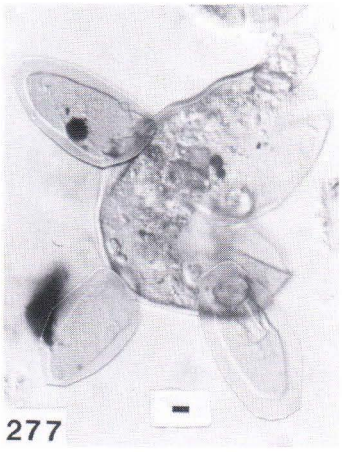
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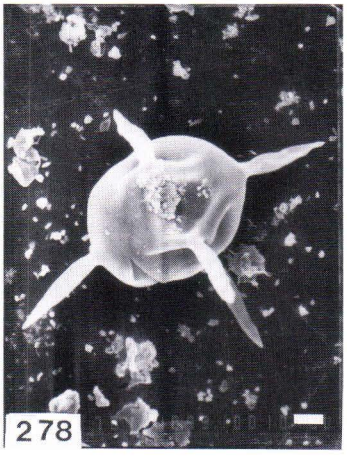
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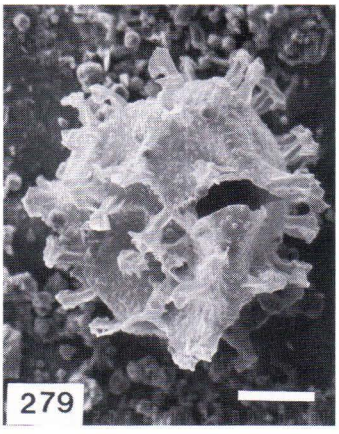
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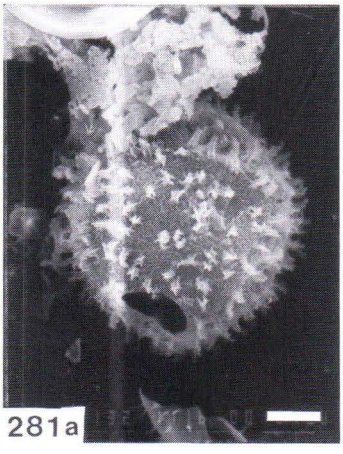
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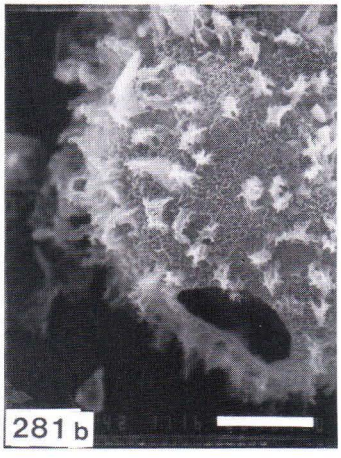
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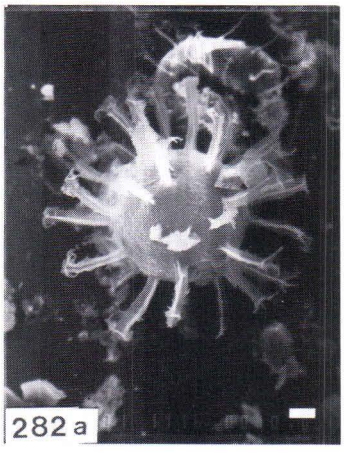
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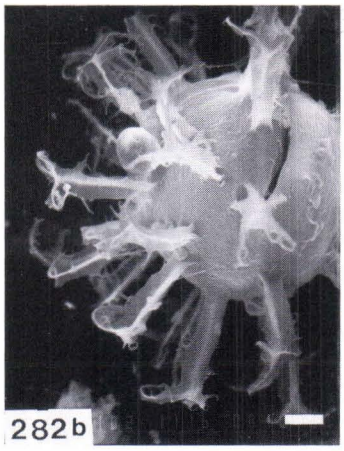
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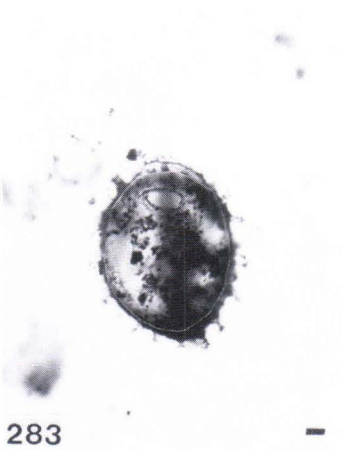
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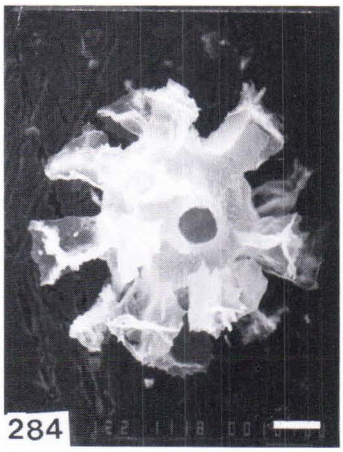
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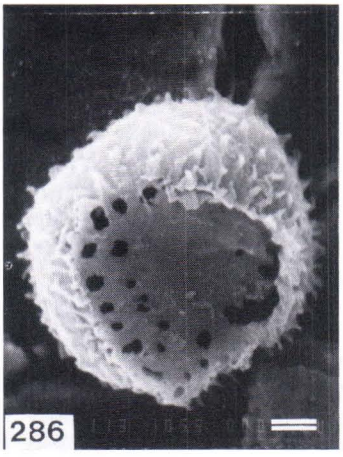
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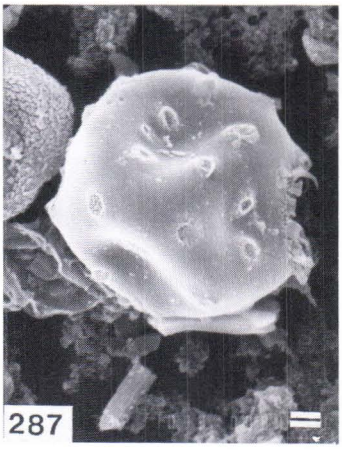
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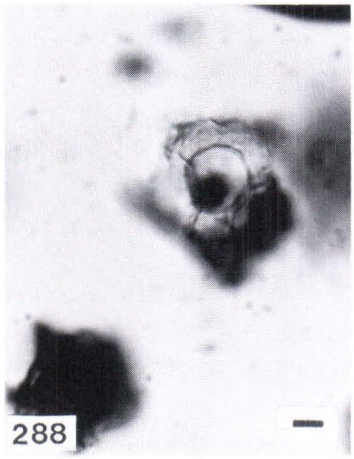
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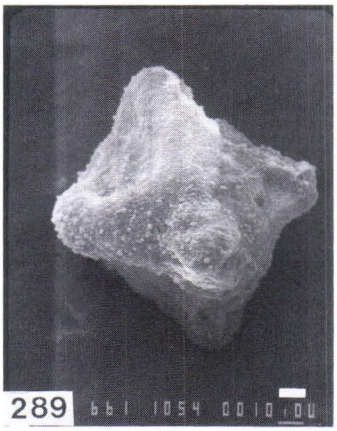
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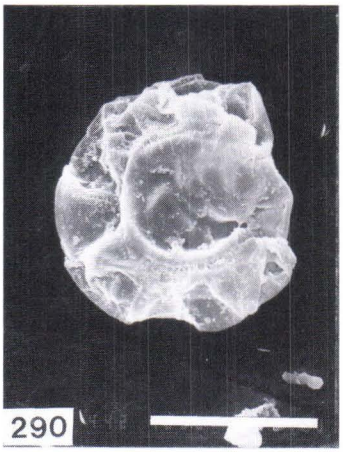
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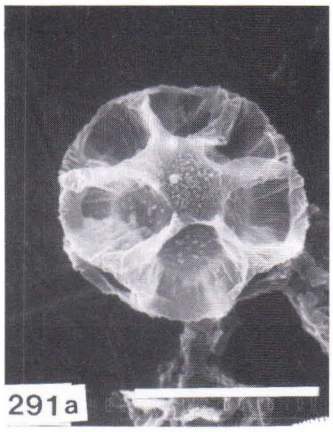
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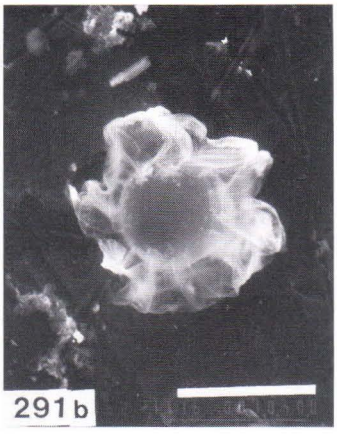
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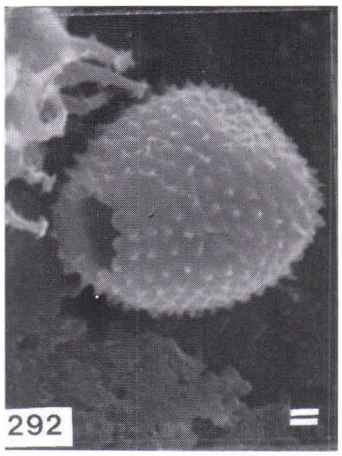
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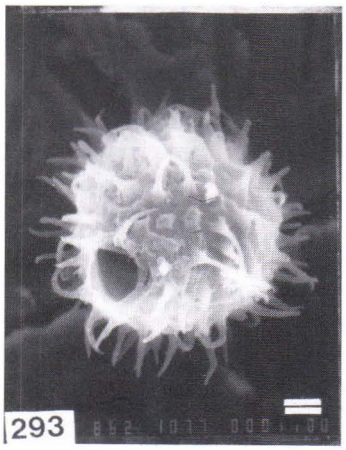
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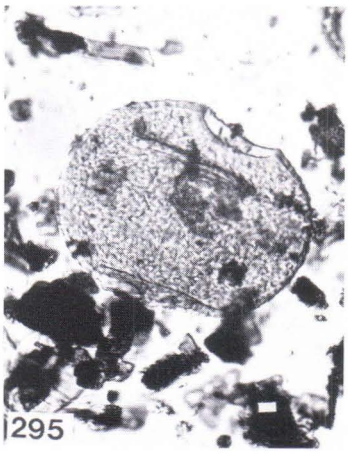
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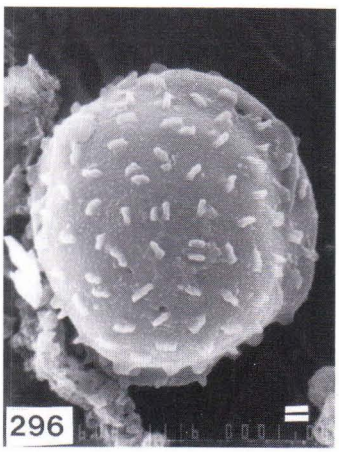
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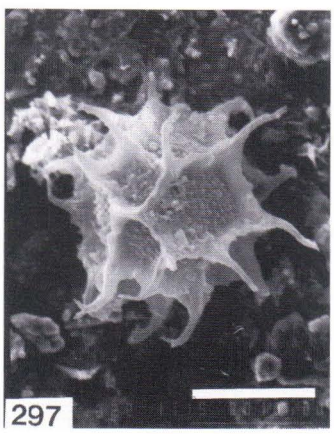
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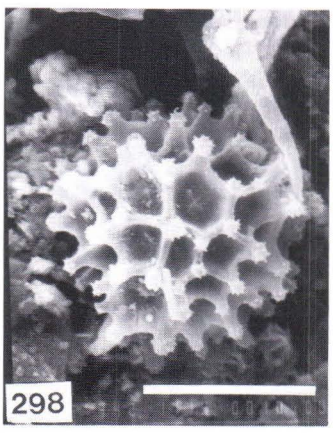
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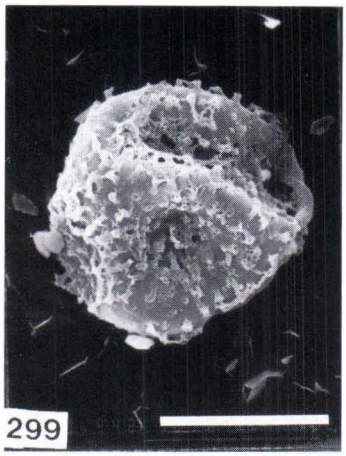
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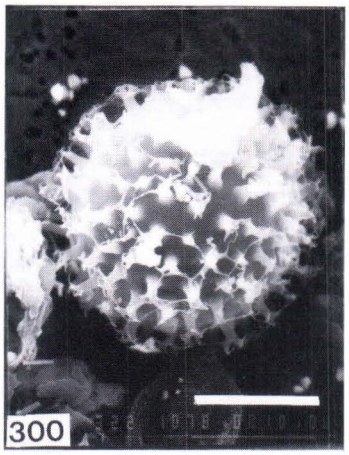
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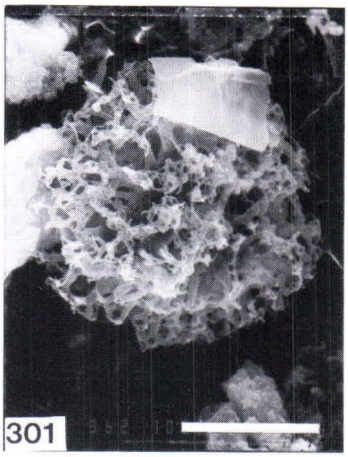
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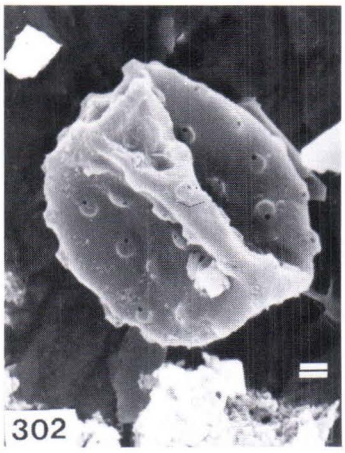
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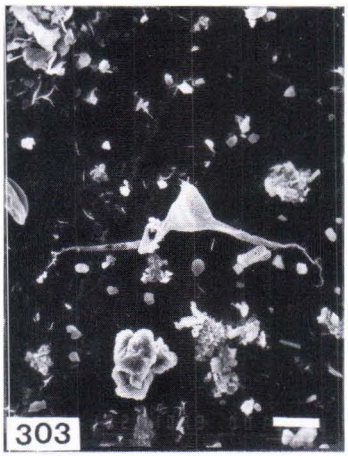
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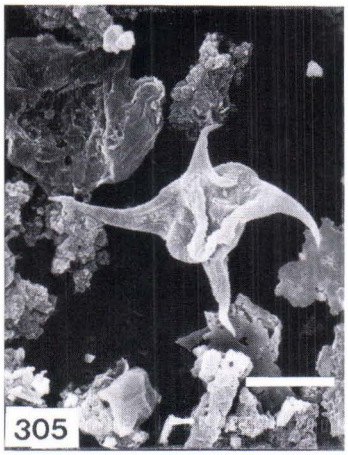
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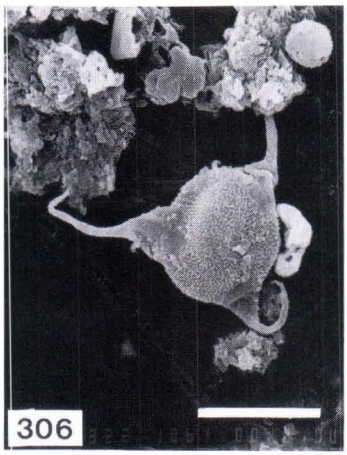
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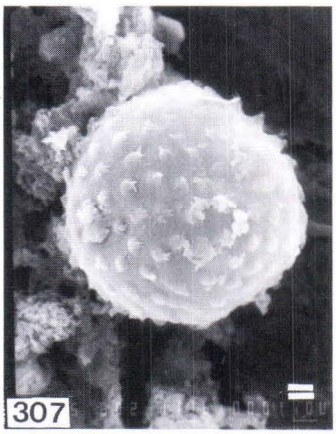
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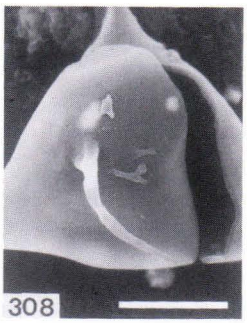
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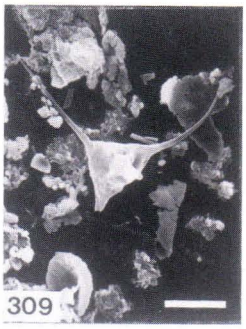
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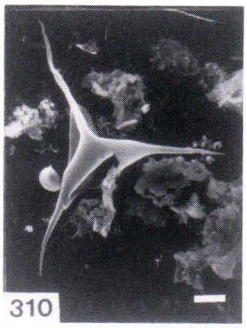
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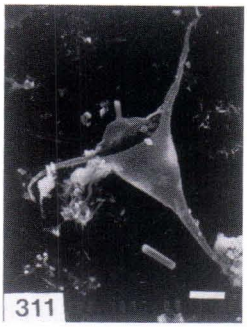
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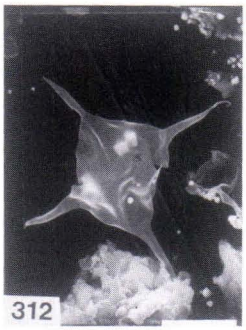
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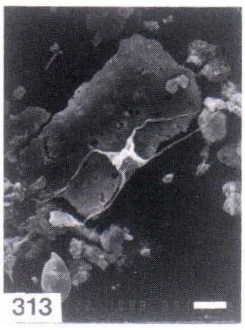
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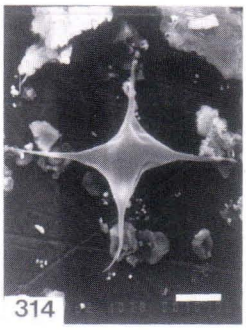
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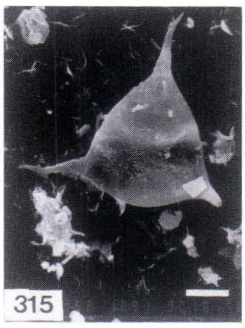
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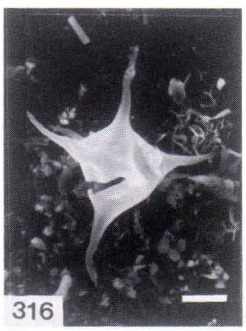
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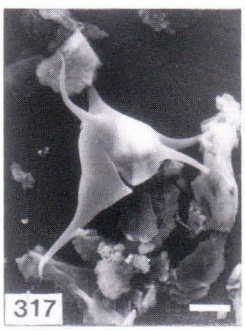
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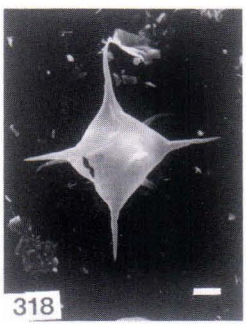
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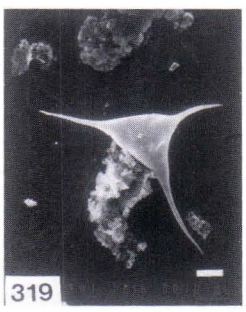
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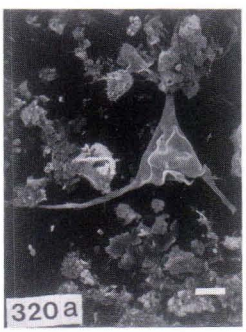
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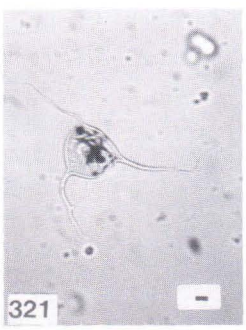
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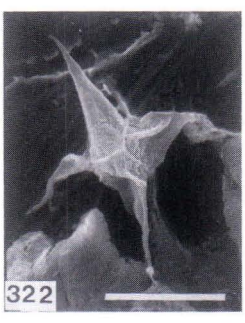
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GEOLOGIAN
TUTKIMUSKESKUS (GTK)
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☎ 90-46931
Teleksi: 123 185 geolo sf
Telekopio: 90-462 205

GTK, Väli-Suomen
aluetoimisto
Kirjasto
PL 1237
70101 Kuopio
☎ 971-205 111
Telekopio: 971-205 215

GTK, Pohjois-Suomen
aluetoimisto
Kirjasto
PL 77
96101 Rovaniemi
☎ 960-297 219
Teleksi: 37 295 geolo SF
Telekopio: 960-297 289

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