Geological Survey of Finland

Bulletin 349

Age and dispersal of sedimentary erratics on the coast of southwestern Finland

by Anneli Uutela

Geologian tutkimuskeskus
Espoo 1989

Geological Survey of Finland, Bulletin 349

AGE AND DISPERSAL OF SEDIMENTARY ERRATICS ON THE COAST OF SOUTHWESTERN FINLAND

by

ANNELI UUTELA

with 44 figures, 2 tables in the text and
13 plates and one appendix

GEOLOGIAN TUTKIMUSKESKUS
ESPOO 1989

Vammala 1989, Vammalan Kirjapaino Oy

Uutela, Anneli, 1989. Age and dispersal of sedimentary erratics on the coast of southwestern Finland. *Geological Survey of Finland, Bulletin 349*, 100 pages, 44 figures, 2 tables, 13 plates and one appendix.

The material studied comprises a total of 2244 erratics of Palaeozoic sedimentary rocks from the coast of southwestern Finland. They are distributed unevenly along the coast, being fairly common between Luvia and Kustavi, rare in the area between Kustavi and Kemiö and more frequent again in the Bromarv — Hanko area.

The sedimentary rocks were dated by reference to the acritarchs and chitinozoans contained in 26 out of the 62 specimens examined. The species identified were typical of the Palaeozoic in the Baltic area, differing from the material from Sweden and Estonia only in that the range of the species was somewhat wider, or else the material was redeposited, and the individuals were smaller in size.

The 98 species of acritarchs belong to the genera *Aremoricanium, Axisphaeridium, Baltisphaeridium, Buedingiisphaeridium, Comasphaeridium, Cymatiosphaera, Dicommopalla, Dictyosphaeridium, Dictyotidium, Goniosphaeridium, Hapsidopalla, Helosphaeridium, Leiofusa, Leiosphaeridia, Leiovalia, Lophosphaeridium, Micrhystridium, Multiplicisphaeridium, Nanocyclopia, Orthosphaeridium, Peteinosphaeridium, Pheoclosterium, Pirea, Polyancistrodorus, Priscogalea, Pterospermopsis, Rhopaliophora, Stelliferidium, Tasmanites, Timofeevia, Tranvikium* and *Veryhachium.* Three new genera of acritarchs are reported here, *Kundasphaera, Nodusosphaeridium* and *Raplasphaera*, and six new species: *Axisphaeridium tricolumnelare, Comasphaeridium varispinosum, Kundasphaera lacunosa, Nodusosphaeridium rubus, Peteinosphaeridium parvispinosum* and *Priscogalea perforata* and one new forma, *Leiofusa granulacutis quincunx.*

The 19 species of chitinozoans belong to the genera *Conochitina, Cyathochitina, Desmochitina, Eisenachitina, Lagenochitina* and *Rhabdochitina.* No new genera or species are reported.

The species composition of the samples is indicative of sedimentation in shallow water under variable conditions and in a generally turbulent environment. The difference between the specimens, assessed in term of species composition, genera or the most common species, were so slight that they may represent no more than random variation.

The greenish grey marl was dated to the Kunda to Kukruse of the Estonian regional stages, the Lower/Middle to Middle Ordovician, the grey marl to the Aseri — Lasnamägi transition to the Nabala regional stage of the Middle to Middle/Upper Ordovician and the yellowish grey calcilutite/calcarenitic calcilutite of the Baltic limestone to the Kunda to Pirgu regional stages of the Lower/Middle to Upper Ordovician.

The reddish grey calcilutite/calcarenitic calcilutite did not contain any organic microfossils.

The sources of the erratics are discussed in the light of theories of short—distance and long—distance glacial transport.

Key words: microfossils, acritarchs, new taxa, chitinozoans, sedimentary rodes, erratics, Ordovician, southwestern Finland

Anneli Uutela Geological Survey of Finland SF—02150 Espoo, Finland

ISBN 951-690-359-2
ISSN 0367-522-X

CONTENTS

INTRODUCTION

The existence of Paleozoic sedimentary rock formations on the bottom of the Bothnian sea has been verified first by studying glacial erratics. Thus Kulling (1926) discovered a limestone outcrop in the Lumparn basin following observations of erratics recorded by Wiik (1878), de Geer (1881) and Wiman (1905), and in the same way the Palaeozoic sedimentary rocks of the Bothnian Sea were first described from erratics (Gripenberg 1934; Backlund 1937; Rudberg 1954; Veltheim 1962) and only later by means of echosoundings (Winterhalter 1967, 1972; Kukkonen 1969; Axberg 1980).

Borings have now be made through this deposit in the sea area off Sweden (Thorslund & Axberg 1979; Tjernvik & Johanson 1980). No Palaeozoic sedimentary rocks *in situ* have been discovered on land in southwestern Finland, even though erratics of sedimentary limestone (Gylling 1891; Sederholm 1910; Martinsson 1955, 1956a, b; Kärkkäinen 1983; Alviola 1988) and Cambrian sandstone have been found (Edelman 1951; Marmo & Laitakari 1952; Lonka & Papunen 1968; Niemelä *et al.* 1985).

Since radiometric dating procedures are applicable to Palaeozoic sedimentary rocks only in exceptional cases (Kunk & Sutter 1984), better opportunities for dating are offered by the macrofossils contained in the rock and the microfossils, the use of which has increased markedly. Among the latter, the acritarchs form the subject of a four-volume catalogue published by the pioneer of microfossil studies, A. Eisenack, together with Cramer and Diez (1973, 1976, 1979a, b). Following this work, a number of significant pieces of research have been published, and these are discussed in connection with the individual species descriptions. Eisenack had also begun studying the Chitinozoa in the 1930's, and the periods of occurrence of the species described to date were published by Jenkins and Legault (1979). Complementary data have subsequently appeared on this group, and these are also discussed in more detail in connection with the species descriptions.

The aim of the present work was to undertake a systematic search for Palaeozoic sedimentary rocks in southwestern Finland and fill out the material on this topic which had accumulated in the course of earlier investigations. It has been suggested that the isolated erratics that have been found originate from the known deposits in the Bothnian Sea (Hellaakoski 1930; Martinsson 1955, 1956a, b; Lonka & Papunen 1968; Lehtovaara 1982), but certain facts emerged in the course of the present investigation which cast doubt on this assumption, and thus some discussion is entered into regarding possible alternative sources in the light of existing theories of glacial transport.

Since the samples were dated by reference to the acritarchs and Chitinozoa that they contained, it was also possible at the same time to test the applicability of the global life-spans reported for these to the dating of deposits in the Baltic basin. Important comparative material for this purpose is provided by the Rapla core from Estonia (Uutela & Tynni; Nolvak, in preparation).

THE AREA STUDIED

In view of the concentration of earlier reliable observations of Palaeozoic sedimentary rocks exclusively in a strip of the coast of southwestern Finland about 50 km wide between Tammisaari and Pori, 59°30'—61°50'N, 21°00'—23°30'E (Fig. 1), the present investigation was focused on this area.

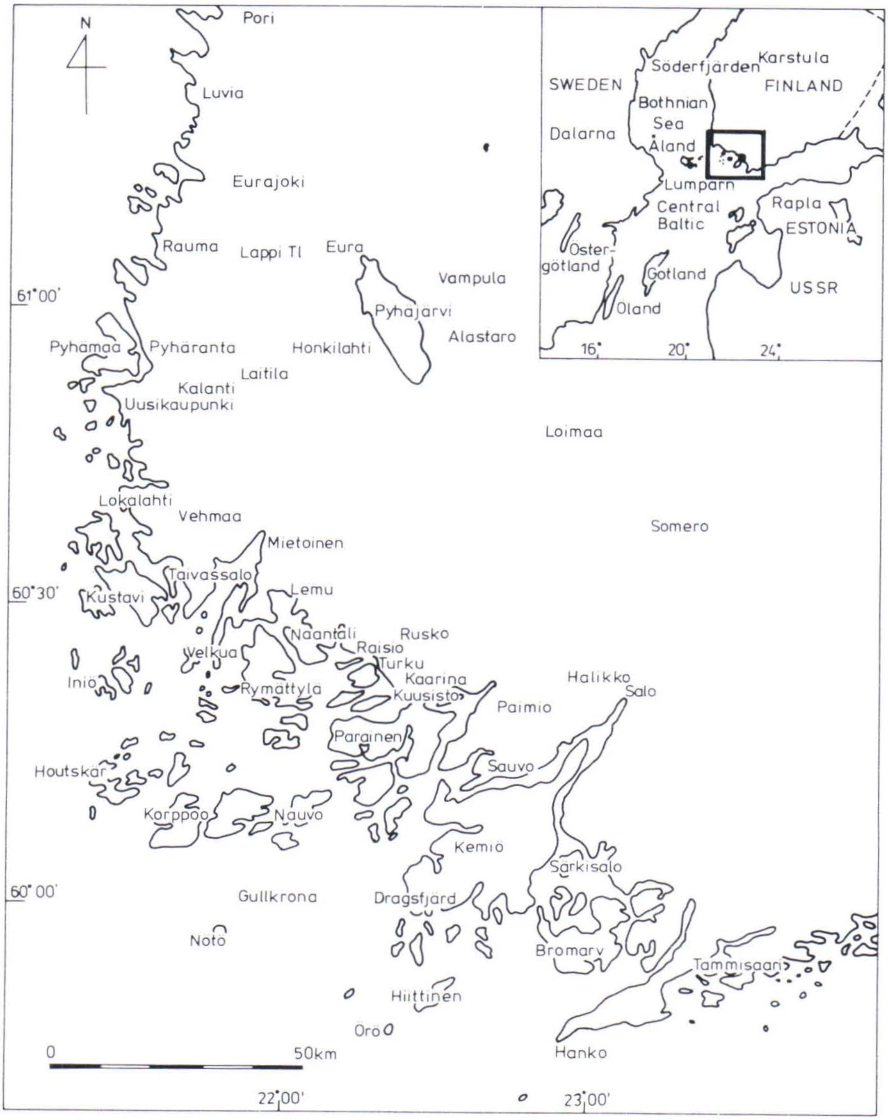


Fig. 1. The area studied.

General geological environment

Bedrock

Bedrock maps of the area to a scale of 1:400 000 have been published by Sederholm (1903) and Härme (1958), but no detailed bedrock map is available of the adjacent sea area apart from the account of the Bothnian Sea deposits provided by Winterhalter (1972).

The bedrock of the mainland area studied and the adjacent sea area is composed of rapakivi and other granites, schists and basic vulcanites. The only sedimentary rock known to exist in the area is the Jotnian sandstone of Satakunta, while both this and the Laitila rapakivi granite are penetrated by a younger diabase (Härme 1958, 1960). Palaeozoic sedimentary deposits are to be found in the Bothnian

Sea, however (Winterhalter 1972, Axberg 1980), at a minimum distance of over 80 km from the coast and at a distance of over 110 km in the predominant direction of ice movement, northwestern. Palaeozoic sedimentary rocks have been identified on the mainland of southern Finland only from the Cambrian, at Söderfjärden south of Vaasa (Lauren *et al.* 1978; Tynni 1978, 1982a), while the Lauhavuori sandstone would seem to be either Early Cambrian or Late Precambrian (Simonen & Kouvo 1955; Tynni & Hokkanen 1982). Erratics have been found at Karstula in Central Finland which point to a deposit of Cambrian age, but the deposit itself has not yet been located (Sauramo 1916; Simonen & Kouvo 1955), and there is evidently a similar occurrence southwest of Hiittinen (Edelman 1951).

In the course of the present work information was received on the existence of some sandstone veins in the limestone quarry of Oy Partek Ab at Vampula (R.Harinen, pers. comm.) which did not contain any microfossils but were probably of Cambrian origin. Cambrian sandstone veins have been encountered on the coast at the Parainen limestone quarry (Hausen 1934), at Vestanfjärden on the island of Kemiö (Eskola 1913), on Sejsan off Hiittinen (Edelman 1956) and on Skarvkyrkan (Sederholm 1913), Ören and Morgonlandet (Martinsson 1956b) off the Hanko peninsula.

Fracture lines and zones

The Baltic Shield was worn down by Precambrian erosion to a flat peneplain, in which fractures of varying severity developed as a result of tectonic movements (Hausen 1968). As a consequence of this, the area studied here has a detailed network of cracks, faults and fracture zones of various orders (Härme 1961; Tuominen *et al.* 1973; Vuorela 1982). The most common and most pronounced direction of fracturing is NE-SW, the more minor directions represented being NW-SE and N-S. The faults are not absolutely linear but are composed of short sequences running in broadly the same direction, which have then been gouged out by erosion. Some of the faults and fractures originate from before the Palaeozoic Era (Edelman 1949, 1985; Härme 1961), whereas the 40—60 m deep graben at Gulkrona postdates the Subcambrian and may even be Tertiary, and the N-S faults around Dragsfjärd are post-Cambrian (Edelman 1949).

The floor of the graben in which the Satakunta sandstone occurs lies about 20 m below its surroundings. According to Laitakari (1925) the sinking took place after deposition of the sandstone bed, and the formation was once covered by younger deposits as well. The boundaries of the most common lithological units of different ages run parallel to the prevailing fault directions both on the mainland and on the sea bed (Härme 1961; Tuominen *et al.* 1973; Axberg 1980). The general orientation of the Subcambrian veins in the Åland archipelago is N-S or ENE-WSW (Bergman & Lindberg 1979; Bergman 1982) and veins in the Lumparn basin N-S and WNW-ESE (Winterhalter 1982).

The Cambrian veins on the islands south of the Hanko peninsula have orientations of N-S, NNW-SSE, WNW-ESE, ENE-WSW and W-E (Martinsson 1956b). Correspondingly, the main directions of Precambrian fractures in Central Sweden are NNE-SSW, WNW-ESE and N-S, in addition to which post-Ordovician cracking has then taken place along these older fractures and in E-W and NE-SW directions (Fromm 1971a, 1972; Gorbatschev 1976; Karis & Magnusson 1972, 1973; Bruun & Dahlman 1980; Bruun 1985).

The fracture depth data presented in Fig. 2 are only estimates, and with the exception of a few measurements extending into the bedrock, represent minimum depths for the fractures in question (Edelman 1949, 1960, 1985; Järvimäki 1968; Gardemeister 1973; Matisto 1973, Lindroos 1977; Tikkanen 1977, 1981; Häkkinen 1982; Hämäläinen 1985; Niemelä *et al.* 1987; Nautic charts 1: 50 000, Hanko—Paraistenportti, Turunmaan saaristo, Selkämeri; coring and seismic sounding data from the archives of the Departments of Geophysics, Exploration and Quaternary Geology, Geological Survey of Finland).

In Sweden, Palaeozoic sedimentary rocks have been preserved from glacial erosion in graben formations in Siljan, Närke and Östergötland, while the hills of Fallbyden, Kinnekulle and Hunneberg have been protected by the presence of dolerite. The grabens in Närke and Östergötland have their floors at levels of –150 — –10 m relative to sea

Fig. 2. Fracture zones
the area and their depth

level, the mean level being –30 — –10 m (Fromm 1971b; Magnusson 1972a,b; Dahlman 1977).

Quaternary deposits

The area has characteristically thin Quaternary deposits with large numbers of bedrock outcrops, while the highly broken up nature of the bedrock means that the fracture basins which are encountered in places may be filled with extremely deep fine-grained sediments (Lindroos *et al.* 1983; Perttuner *et al.* 1984). The thickest coverings of loose deposit are to be found in the Satakunta sandstone area i.e approx. 100 m (Lindroos 1977; Tikkanen 1981 Lindroos *et al.* 1983; Hämäläinen 1986).

Glacial erosion and direction of ice movement

The bedrock topography has not been greatly altered by glacial erosion, which has mainly had the

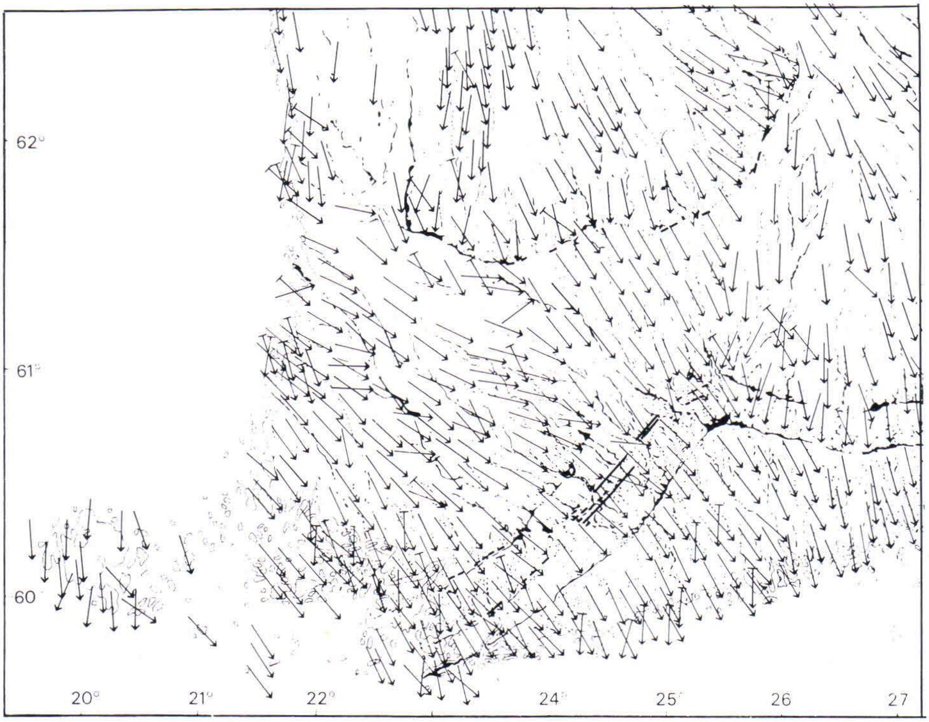


Fig. 3. Orientations of striae in southwestern Finland (Geological Survey of Finland, Department of Quaternary Geology 1986).

effect of lowering the bedrock surface by anything up to ten metres. The most pronounced erosion evidently occurred in the fracture zones running parallel to the direction of ice movement, these having been deepened considerably, while those running transverse to the movement of the ice tended to be filled in.

The oldest direction of ice movement in the Rauma—Kokemäki area was from the north (350°—360°), the next powerful active phase from the NNW (320°—340°), the following active phase from the NW (290°—310°) and the youngest, representing the melting and glacial retreat phase, from the WNW (260°—310°) (Lindroos *et al.* 1983). Correspondingly, the principal direction of movement in the Uusikaupunki—Yläne area was from the NW (305°—320°), that around Kustavi from the NNW (315°—335°) and that east of Taivassalo 335°—345°. The oldest orientation of striae at Mynämäki was a westerly one (275°) (Perttunen *et al.* 1984).

The most westerly of the younger directions of ice movement, WNW (305°—310°) is encountered at Rymättylä, while in the district around Parainen and Turku the direction is from the NNW (320°—340°), as also in the Sauvo—Salo area (320°—330°) and around Tammisaari (310°—320°) and Hanko (330°) (Niemelä *et al.* 1987; Kielosto & Kukkonen, in prep.). Edelman (1951) also describes older westerly directions of glacial movement in the Rymättylä—Nauvo area. On the mainland such orientations of striae have been observed at Hålsnaistenniemi (275°) and Storhållsnäs (260°) (map sheet 2014 12, unpublished field maps of the Department of Quaternary Geology, Geological Survey of Finland). The principal glacial movement in the area of Loimaa and Somero was from a direction 300°—310° (Haavisto *et al.* 1980). Orientations of striae in southwestern Finland (Geological Survey of Finland, Department of Quaternary Geology 1986) are presented in Figure 3.

METHODS

Field methods

Examples of Palaeozoic sedimentary rocks were searched for in the field amongst shore boulders, in road cuttings and gravel pits, amongst the stones piled up at the edges of fields and on the shores of rivers and lakes that had been dredged. The sites were chosen by random sampling, on account of the extent of the total area involved, and all the specimens were recovered from surface positions, no pits being dug for sampling purposes.

Stone counts were also performed at 31 randomly selected sites, one for each 40 km^2 of the area studied, located in gravel or till cuttings or boulder fields on the shore. 100 stones in the size range 2—20 cm were counted at each site. The rock type classification employed for this purpose comprised plutonic rocks, metamorphic rocks and sedimentary rocks, of which the first are represented by granites, diorite, gabbro and peridotite, the second by gneisses, phyllite, leptite and quartzite and the last-mentioned by Jotnian sandstone, i.e. the Satakunta sandstone, and the palaeozoic sedimentary rocks, i.e. Cambrian sandstone and Ordovician limestone. As the research advanced it was found to be impossible to calculate half-distances for the rocks represented at the stone-count sites in the absence of more detailed bedrock maps, and thus the work was based on the results of earlier research performed in southwestern Finland by Hellaakoski (1930) and Salonen (1986). Reference was made for comparison purposes to work on the glacial transport of mineral material in the Häme region (Virkkala 1958; Perttunen 1977; Kinnunen 1979).

Laboratory methods

Slides for the study of microfossils were made from a selection of 62 erratics, which were then used to classify the remaining finds on the basis of their external properties. The preparation methods are explained in detail by Tynni (1981). About 25 g of sample was treated first with 10 % HCl to dissolve out the calcite and then with 40—45 % HF for two hours to separate the microfossils from the mineral material. Following this, the sample was boiled in 10 % HCl, changing the solution from time to time until it remained clear in appearance. Before heavy liquid treatment the water was removed with isopropanol. The heavy liquid used was a mixture of bromoform and isopropanol, specific gravity 2.0. This caused enrichment of both acritarchs and Chitinozoa upon centrifugation at low speeds. The sample was then rinsed several times in isopropanol in order to remove the bromoform, and finally in ionized water. A similar Clophenharpix medium was employed in the slides for light microscopy as was used by Tynni (1975, 1982b), although this proved in the course of the examinations to have been a bad choice on account of its index of refraction, which made it difficult to distinguish the thinner-walled microfossils. No attempt was made at that stage to change the medium, however, as the works of Tynni were being used as the principal reference material.

In order to eliminate errors and examine the species range in greater detail, 10 slides were prepared for electron microscopy using the same technique but performing the last rinse with distilled water and coating the bronze stub with gold to enhance its electrical conductivity.

A maximum of 200 acritarchs per slide were counted (all the acritarchs if less than this number were present), and their percentage distributions by species were calculated. All the Chitinozoa were counted, but no percentages determined because of the small numbers of individuals involved. Size measurements were made with respect to the distinguishing characteristics of the various species, e.g. vesicle diameter and lengths, breadths and number of the processes in the case of the acritarchs and length and breadth of the chamber, breadth of the aperture and lengths of any processes in the Chitinozoa.

Light microscopy was performed on a Leitz

Wetzlar Orthoplan research microscope and photographs taken on Kodak Panatomic-X 32 film using a Leica camera. The electron microscope was a JEOL Superprobe 733, using Polaroid type 55 film and Kodak TMAX 400 cine film.

It has become apparent through later research that the preparation methods employed here are unsuitable for Chitinozoa, since the heavy liquid caused enrichment only of the smallest and lightest species and individuals. Also, the identification of Chitinozoa by light microscopy is an uncertain procedure since it is impossible to distinguish their surface texture or to turn the individuals under the microscope to facilitate examination of their characteristic features (Nolvak, pers. comm.).

RESULTS

The search described above yielded a total of 671 specimens of Ordovician sedimentary limestone from 38 locations in the area (Appendix 1.). These were complemented with 163 specimens obtained by the Geological Survey of Finland from amateur samplers over the years 1949—1986 or collected by N. Kärkkäinen, geologist in the Exploration Department of the Geological Survey, in 1983, or by K. Hokkanen, research assistant with the Quaternary Department, in 1981—1984. Information on a further 26 finds was obtained from Oy Partek Ab. The author had found 473 examples of her own in the course of the years 1984—1985. In addition, 9 samples of Palaeozoic sedimentary limestone had been discovered earlier in connection with mapping of the bedrock and Quaternary deposits. A total of 1573 Cambrian sandstone specimens were obtained.

The specimens varied in size from a few centimetres across to 1.0 metre. It is impossible to depict the percentage distribution of the sedimentary limestone samples in a statistical sense on a map as their frequency of occurrence was usually below 1.0 %. Perhaps a sufficiently descriptive account of their incidence would be the statement that on average one erratic was found in every strip of land one kilometre long and 10 metres wide, except in the surrounding areas of the towns of Rauma and Uusikaupunki.

Sources of error: It is possible that some of the calcareous rocks may have been brought to the Finnish coast as ballast in the holds of sailing ships, for Uusikaupunki, Rauma and Luvia are all old trading ports. All possible secondary material, including flintstones, was taken into account in the survey, but such anomalous examples still comprise an tiny fraction of the total material and are inconsequential as far as the whole is concerned, especially when it seems that if a number of samples of differing age originate from the same site the only one to differ in nature from the deposits of the Bothnian Sea itself is the flintstone. According to the findings of Kinnunen *et al.* (1985) flintstones have been found on the islands of Iso-Vehanen off Uusikaupunki and Reposaari off Pori, but no Ordovician chert has been encountered. Inland, flintstones have been found in association with prehistoric dwelling sites (Vuorinen 1982), but none were found in the inland area in connection with the present survey.

Some flintstone thought to have served as ballast in sailing ships has also been discovered at Tulliniemi on the Hanko peninsula (Hokkanen, pers. comm.), but none on the islands south of Hanko, only closer to the coast at Lapväärtti.

Since the carbon dioxide in sea water and groundwater dissolves calcareous rock, examples are usually to be found only from depths of about 0.5 m downwards (Gripenberg 1934; Gillberg 1965; Ignatius *et al.* 1980).

A further problem is that limestone used to be used in the coastal area for calcination, so that some potential samples will have been lost in the course of time.

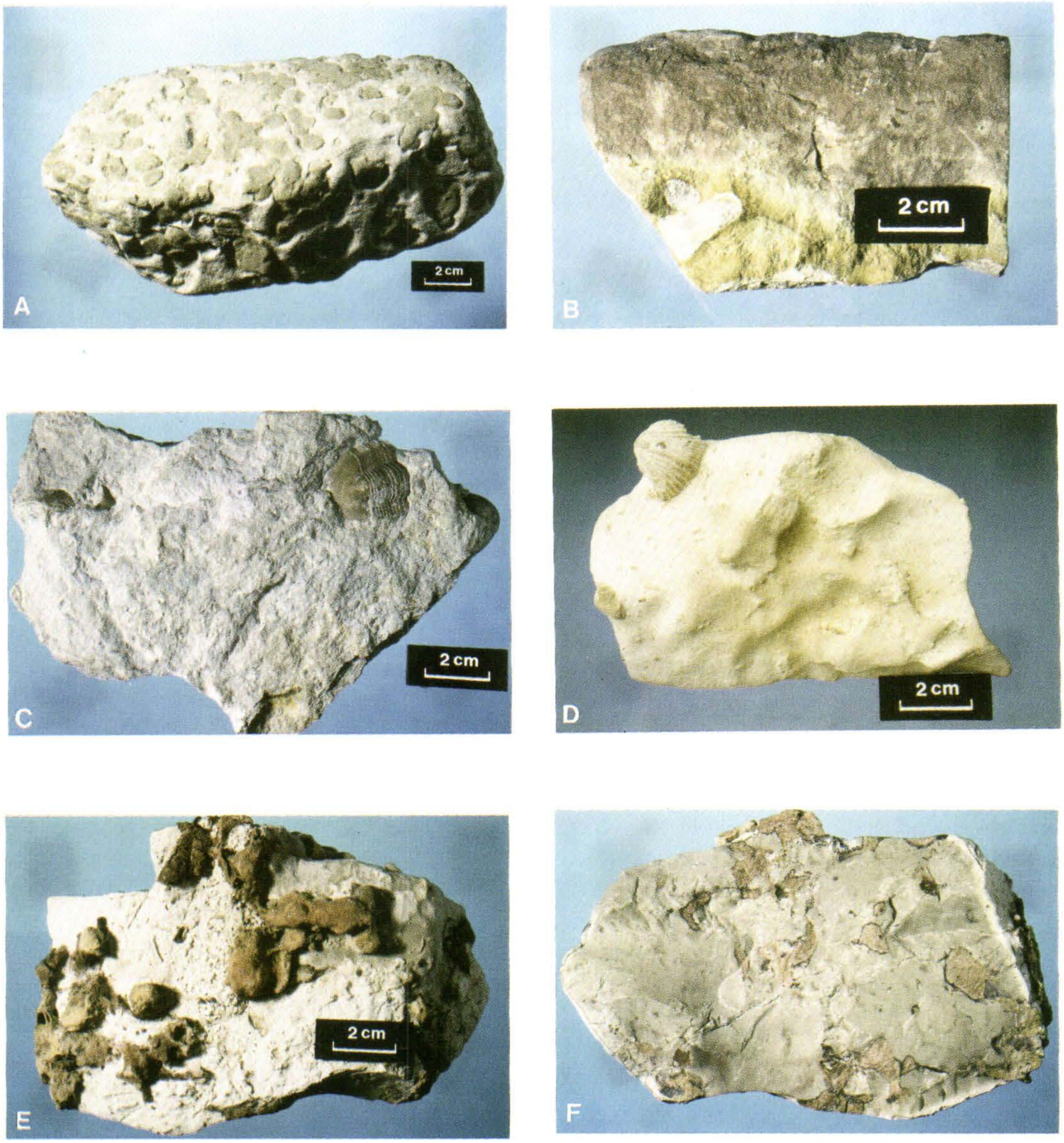


Fig. 4. The classification of the sedimentary rocks. A. Cambrian sandstone. B. Reddish brown and greenish grey marl. C. Grey marl. D. Yellowish grey calcilutite / calcarenitic calcilutite of the Baltic limestone. E and F. Reddish grey calcilutite / calcarenitic calcilutite of the Baltic limestone (Photos by Jari Väätäinen).

Classification of the sedimentary rocks

Since the terminology for sedimentary limestones is not yet firmly established, it is used here purely in a descriptive sense. The classification employed is based on the assumption that the various types will have been laid down in different sedimentary environments and will be of differing ages.

The Cambrian sandstone is light-grey, greenish grey or brownish in colour (Fig. 4a). Its medium coarse or coarse mineral grains are chiefly quartz, with small amounts of feldspar, mica, carbonate and glauconite. The grains are usually highly rounded. It is clastic in structure (Kärkkäinen 1983) and usually contains no organic microfossils.

The reddish brown or greenish grey marl (Fig. 4b; PO or VO in the Appendix 1.) is an earthy calcilutite which frequently contains fragments of fossils with calcareous shells. Its principal mineral is calcium carbonate, the greenish type also containing a little glauconite and possibly some quartz grains (Lindström 1963, 1979; Kärkkäinen 1983). The colour of the reddish variety is derived from haematite, and in this case the organic microfossils have been destroyed by oxidation. This type is also known as orthoceratite limestone and dates from the Arenigian stage of the Lower Ordovician (Lindström 1963, 1979; Männil 1966).

The grey marl (Fig. 4c; C in the Appendix 1.) contains clay minerals in addition to calcium carbonate. Wiman (1893) referred to this type as Chasmops limestone after the trilobites to be found in it. It was deposited during the Caradocian stage of the Middle Ordovician in the Bothnian Sea area (Axberg 1980) and the Kukruse regional stage (Llandeilian) in Estonia (Orviku 1929).

The older part of the Baltic limestone complex consists of a yellowish grey calcilutite or calcarenitic calcilutite (Fig. 4d; S in the Appendix 1.) This is composed of calcium carbonate and according to Merrill (1979) was deposited on Åland during the Llanvirnian stage of the Middle Ordovician. The younger part is a reddish grey calcilutite or calcarenitic calcilutite (Figs. 4e and f; L in the Appendix 1.) which contains haematite in addition to the calcium carbonate, and sometimes also dolomite (Kärkkäinen 1983). Merrill (1979) has shown by means of conodont datings that this was deposited during the Caradocian stage of the Middle Ordovician. Remains of calcareous fossil shells are frequently found in both of these types of Baltic limestone.

Distribution of the Palaeozoic sedimentary rocks

The distribution of sedimentary rocks, classified in the manner set out just previously, is depicted in Figures 5—9, where the black circles denote positive identifications for each type and the adjacent numbers the places in which they were discovered, the keys to which are to be found in the Appendix 1. The small open circles indicate negative findings. The appendix list both the names of the places and also the map sheet and coordinates for each site, a code letter for the limestone type. Some of the samples handed in by amateur samplers and some finds arising from early surveys are omitted from the maps and tables on account of the incomplete data available, as also are the observations of Martinsson (1955, 1956a) made off the coast of Hanko because the rock types indicated by him cannot be associated with corresponding types recognized here with any degree of certainty. No separate list of locations is drawn up for the Cambrian sandstone finds, as the total of 1573 was sufficient to allow percentage distributions to be calculated for them (Fig. 5). The distribution of Cambrian sandstones is discussed in connection with the stone counts.

Finds of reddish brown or greenish grey marl are rare, and comprise here only small, isolated boulders found principally on or close to the coast. This type accounts for 2.9 % of all finds of calcareous rocks (Fig. 6). The grey marl erratics were concentrated in the area around Hanko, with only a few found elsewhere on the coast. This type accounted for 3.6 % of all the limestone finds (Fig. 7.).

A difference in distribution between the yellowish grey and reddish grey calcilutites of the Baltic limestone emerges only in the Hanko area, where only two specimens of the reddish grey variety were found in addition to one at Morgonlandet in the commune of Dragsfjärd, whereas 81.8 % of the calcareous erratics in the Hanko area were of the yellowish grey variety. Over the whole area studied here, yellow grey calcilutite accounted for 50.7 % of the limestone rock samples and reddish grey calcilutite for 49.3 % (Figs. 8—9).

The stratigraphy of the Rapla core used for

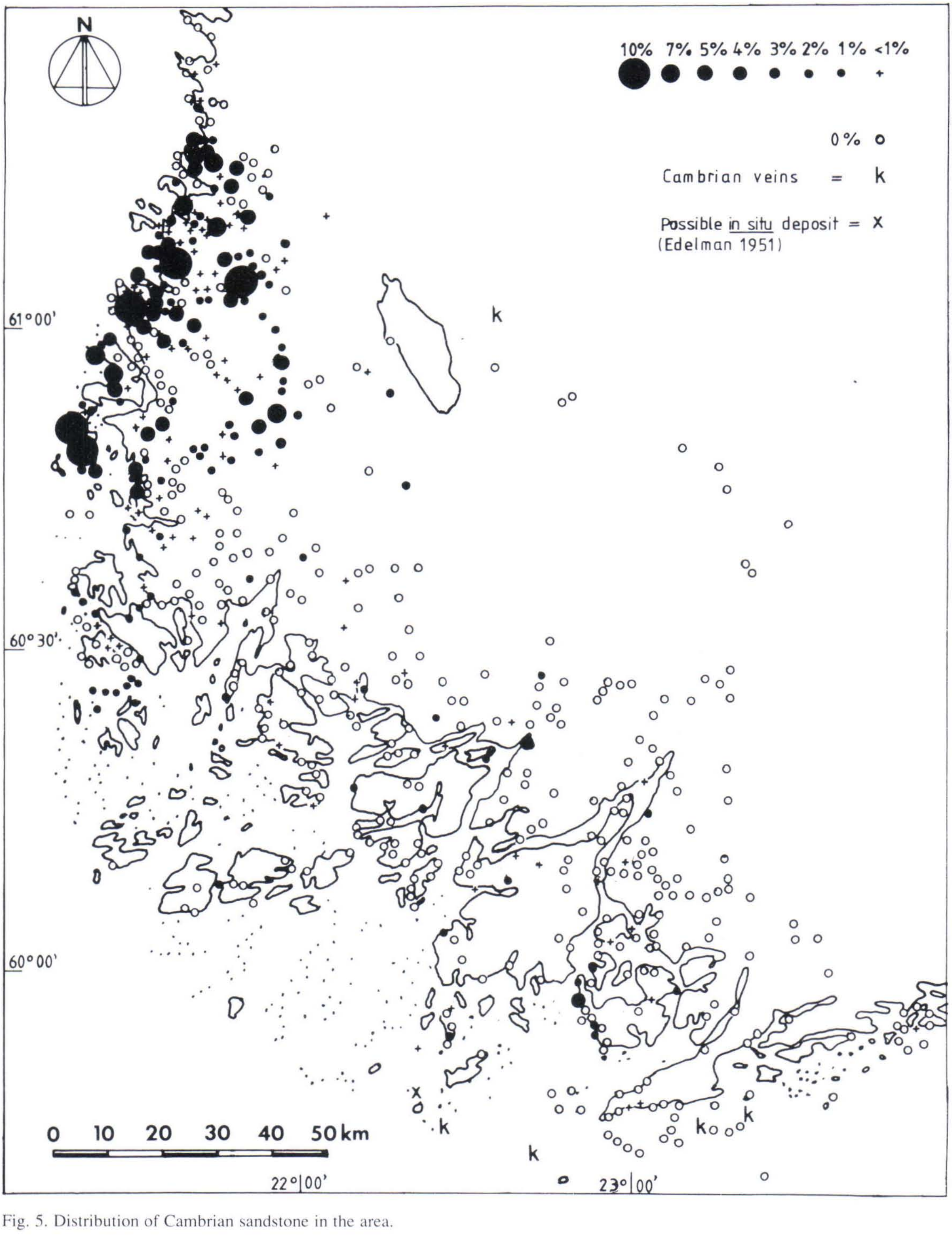


Fig. 5. Distribution of Cambrian sandstone in the area.

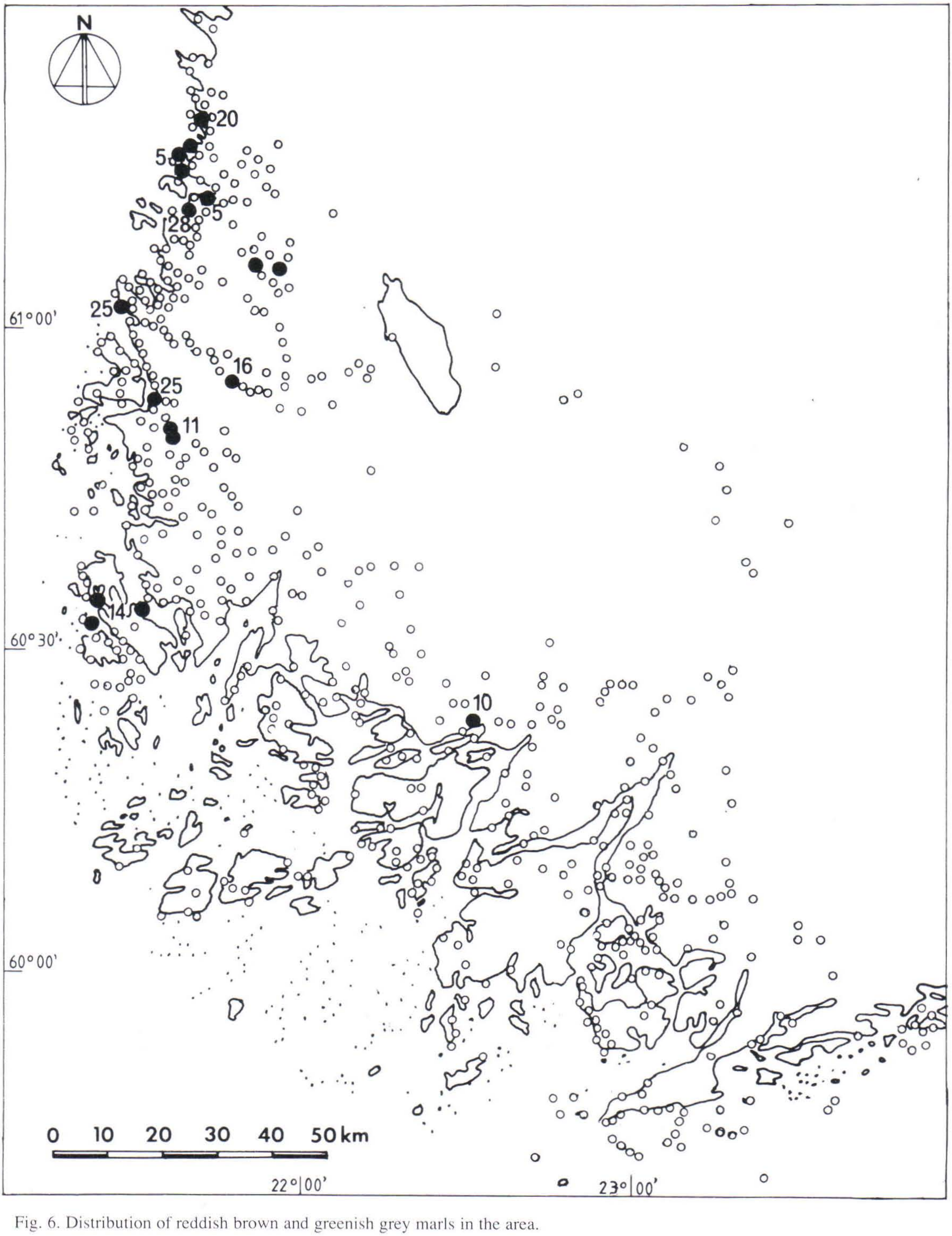


Fig. 6. Distribution of reddish brown and greenish grey marls in the area.

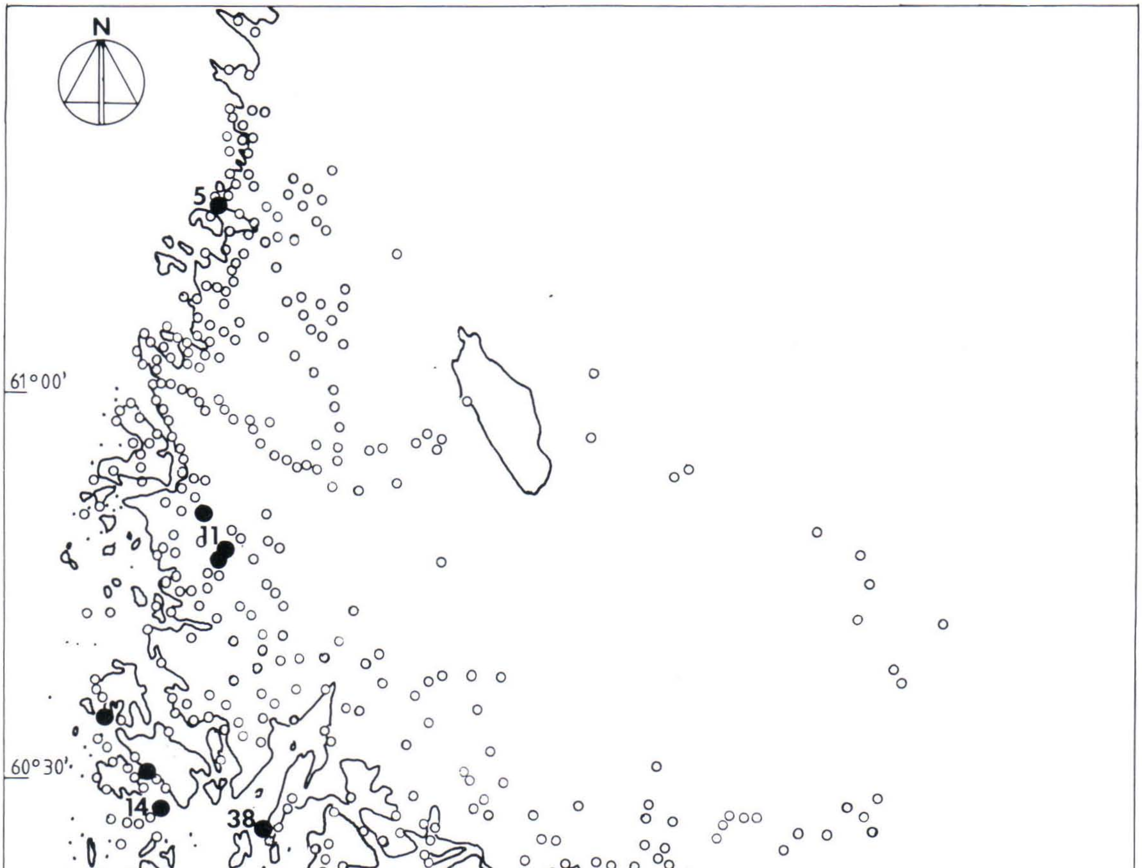


Fig. 7. Distribution of grey marl in the area.

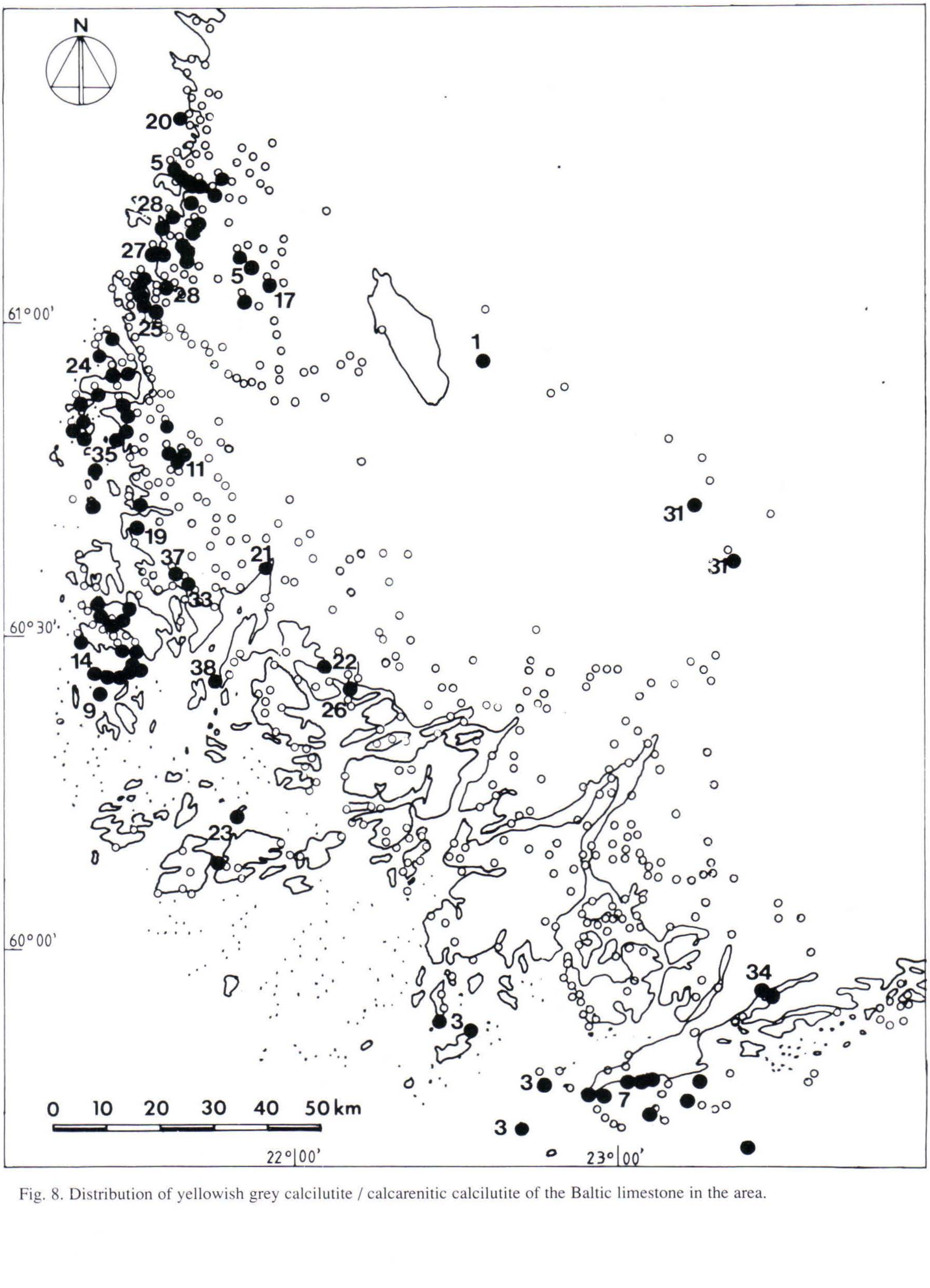


Fig. 8. Distribution of yellowish grey calcilutite / calcarenitic calcilutite of the Baltic limestone in the area.

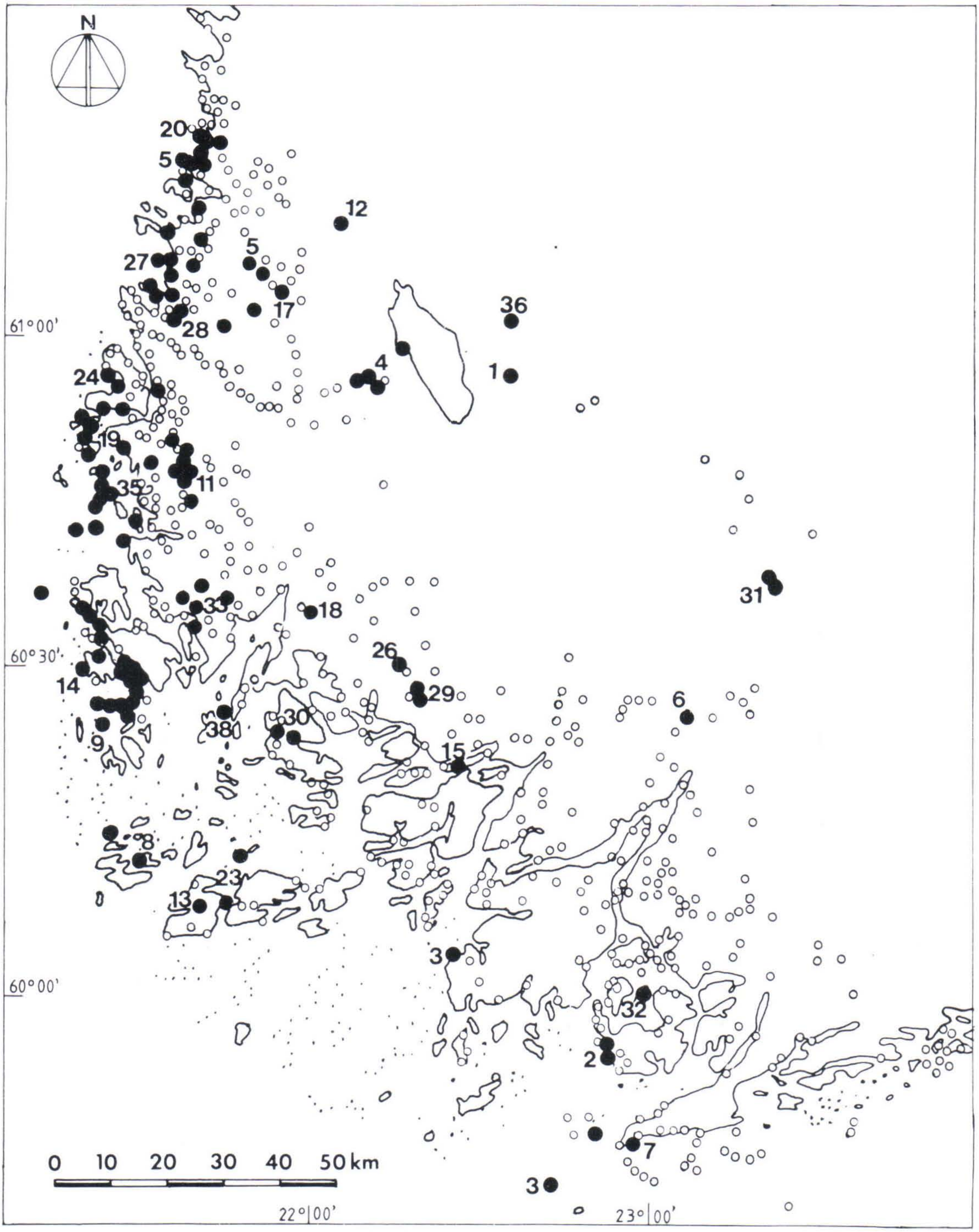


Fig. 9. Distribution of reddish grey calcilutite / calcarenitic calcilutite of the Baltic limestone in the area.

comparison purposes contains alternating layers of grey marl and yellowish grey calcilutite of the Baltic limestone extending from the Kunda regional stage of the Lower Ordovician to the Pirgu regional stage of the Upper Ordovician, while the Central Balto-Scandian confacies in the Gotska Sandön core features a sharp boundary between the grey marl and yellowish grey calcilutite at the transition from the Middle to the Upper Ordovician (Geology Department of Uppsala University, Sweden). The Rapla core has no reddish grey calcilutite, which is uppermost in the Lumparn stratigraphy, nor any orthoceratite marl as found at the base of this stratigraphy both at Lumparn (Tynni 1982b) and on Finngrundet in the Bothnian Sea (Tjernvik & Johansson 1980).

One striking feature about the distribution of the sedimentary rocks is its irregularity. There are numerous observations from the coast between Luvia and Kustavi, just occasional instances between Kustavi and Kemiö, and large numbers again between Bromarv and Hanko. Thus the Gullkrona problem in the distribution of plants is evident in geological and not only phytogeographical terms (Eklund 1934, 1946a,b, 1948).

Stone counts

A generalized impression of the bedrock of southwestern Finland and the Bothnian Sea is given in Figs. 10 and 11, and the results of the stone counts in Fig. 12.

The proportion of plutonic rocks is higher than that of metamorphic rocks throughout, presumably due both to the nature of the bedrock and to the greater resistance to erosion of the former (Erdmann 1897). Greater attention should nevertheless be paid to the sedimentary rocks in these counts, i.e. the Jotnian sandstone, Cambrian sandstone and limestone. High proportions of Jotnian sandstone are to be found in the areas of Eura and Pori, 30.0—70.0 % (stone counts 20 and 2), which lie on the Satakunta sandstone deposit, and unusually high numbers of 11.0—20.0 % are also recorded in Kustavi (stone count 17), Bromarv (stone count 21), Halikko (stone count 26) and Salo (stone count 29). Kustavi lies about at a distance of 60 km from the Bothnian Sea and Bromarv 160 km, while Halikko and Salo are situated 60—75 km from the distal side of the Satakunta sandstone area and Bromarv about 100 km, in addition to which transport would have presupposed a glacial movement from the north. Leskelä and Niemelä (1972) and Niemelä *et al.* (1987) also describe high Jotnian sandstone concentrations (15.0—36.0 %) in the area around Salo.

The proportions of Cambrian sandstone at the sites studied were estimated by counting 100 randomly collected stones at each site, without attempting to identify the other rocks to type. The results of the fieldwork and stone counts as regards the distribution of Cambrian sandstone are presented in Fig. 5. It occurs in greatest abundance right on the coast between Luvia and Uusikaupunki, the highest percentages, around 10.0 %, being encountered at Pietinaro in the commune of Laitila and Petäs near Rauma. Its proportion declines between Turku and Parainen, and the numbers further east among the islands are 1.0 % in Kemiö (fieldwork observations), 2.0 % in Dragsfjärd (stone count 16) and 5.0 % in Bromarv (stone count 21). On the mainland the proportions are usually below 1.0 %, with the exception of Paimio, where a number of 4.0 % was recorded (stone count 28). The islands south of Hanko had only occasional Cambrian sandstone erratics, and the area of Pyhäjärvi, Loimaa and the Somero basin none at all. Hanko lies some 240 km away from the distal margin of the Cambrian sandstone deposit beneath the Bothnian Sea and the Pyhäjärvi district 160—200 km away.

Edelman (1951) suggests that there may be an in situ Cambrian sandstone deposit in a depression close to the northeastern side of Örö in view of the high amounts of erratics found there.

Palaeozoic sedimentary limestones were identified in the stone counts in the areas of Eurajoki, 2.0 % (stone count 6), Uusikaupunki, 1.0 % (stone count 9), and Bromarv somewhat further east,

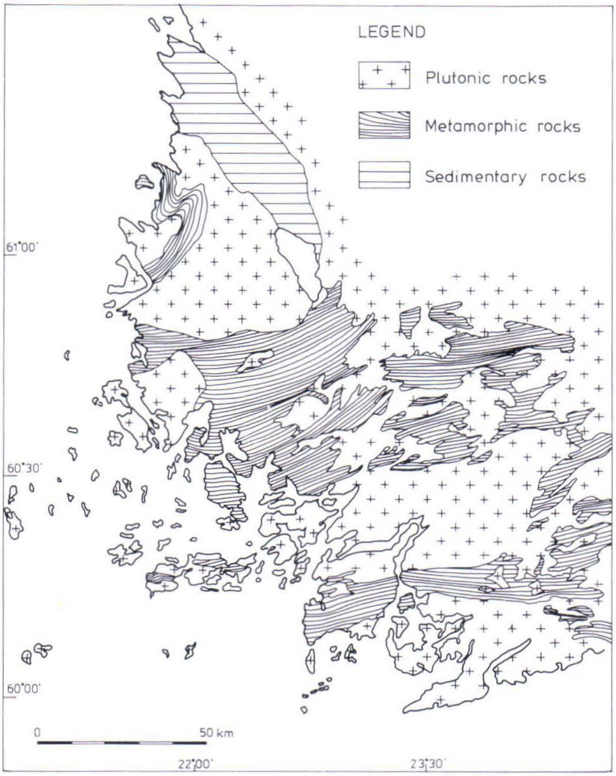


Fig. 10. The bedrock of southwestern Finland, simplified after Simonen (1980).

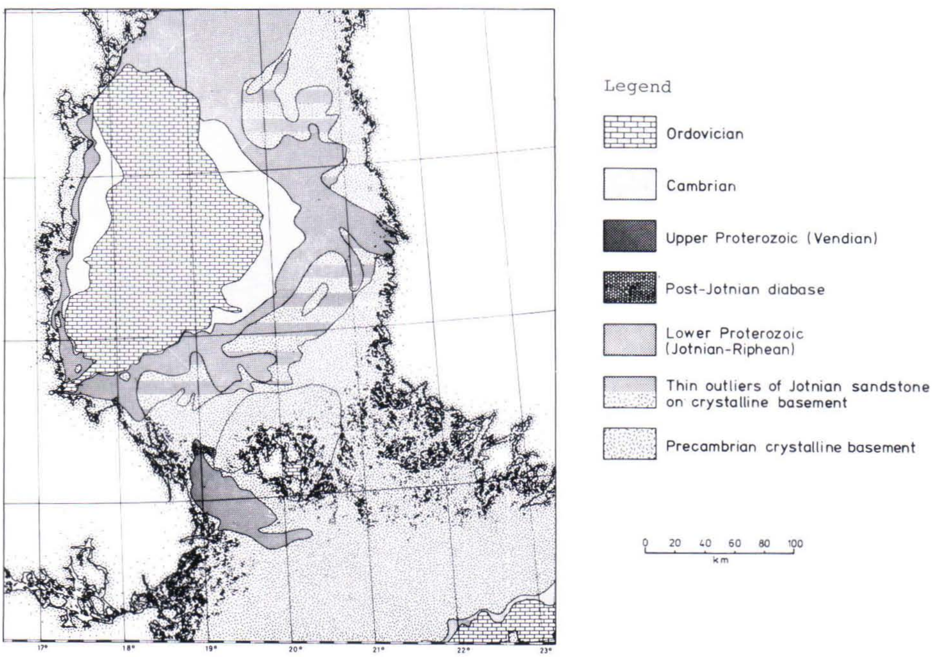


Fig. 11. The bedrock of the Bothnian Sea (Winterhalter *et al.* 1981).

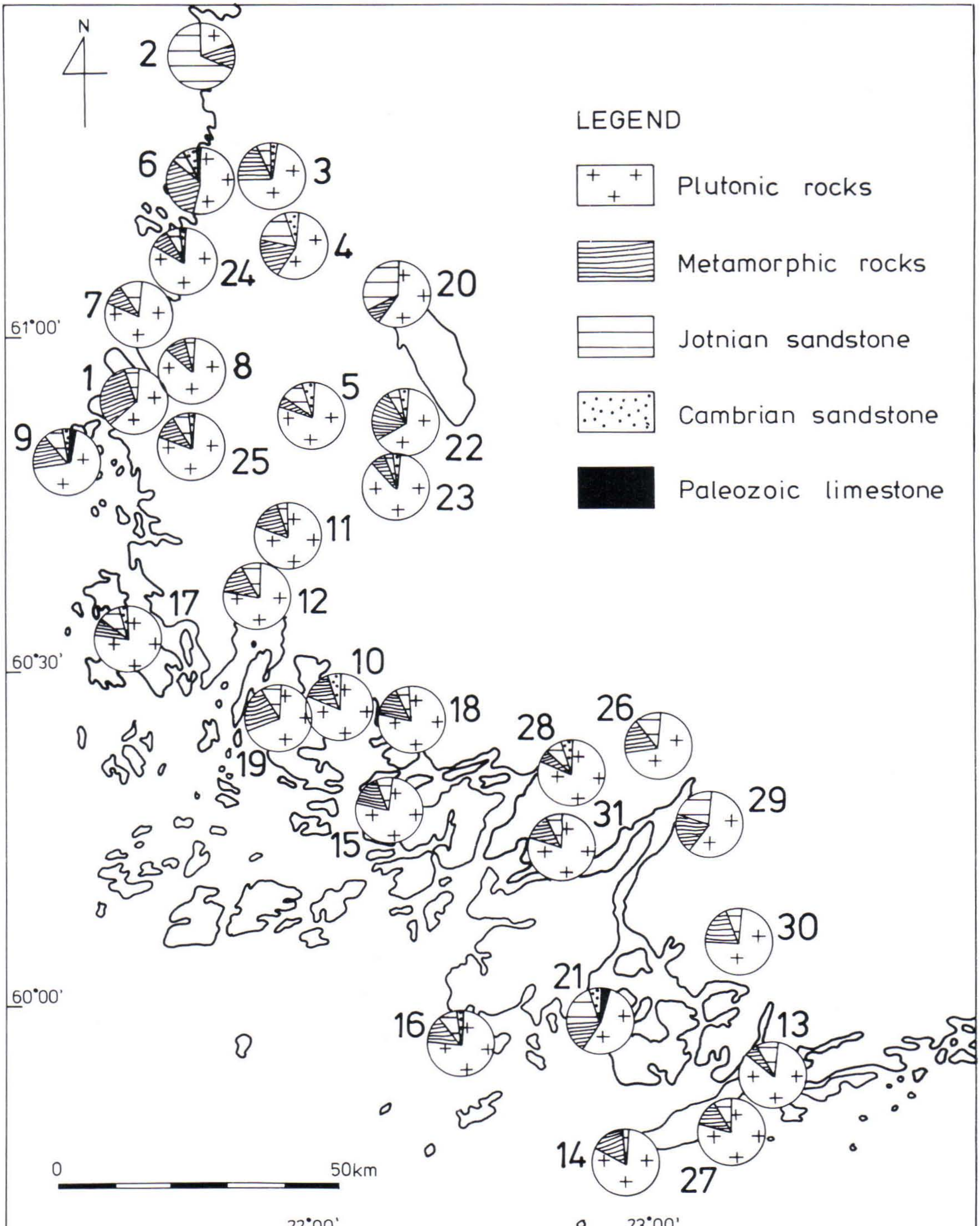


Fig. 12. Results of stone counts.

1.0 % (stone count 21). Eurajoki and Uusikaupunki are situated some 180 km from the distal margin of the limestone deposits beneath the Bothnian Sea and 90 km from the proximal margin, and Bromarv 300 km from the distal margin and 230 km from the proximal margin. The proportion of sedimentary limestone in the older till at Vampula is 6.0 % (Nenonen, pers. comm.), this site being 240 km from the distal margin of the Bothnian Sea deposits in the direction of glacial movement and 160 km from the proximal margin.

Few examples of Palaeozoic sedimentary rocks were found at the randomly selected stone count sites, a fact which may help to explain the scarcity of earlier observations in Finland.

Reasons for the infrequent occurrence of sedimentary rocks among erratics may include the small size of the parent formation or its location in a depression, fault or dyke, in which case it can be expected to be poorly indicated (Virkkala 1958; Persson 1973; Puranen 1988). Also this material breaks down more easily in transport processes than e.g. granite (Erdmann 1879, Gillberg 1967). It may also be that calcareous sedimentary rocks are not to be found anywhere on the mainland of Finland.

Microfossils

Comparative material for the species identifications made here was obtained from the as yet unpublished acritarch and Chitinozoa analyses of the Rapla core from the northern Estonian S.S.R. (Uutela & Tynni; Nolvak), but which has been dated by reference to the shelly fossils contained in it (Põlma 1972). The concept of the Baltic area employed below when discussing the species distributions concerns the marine sedimentation basin as it existed in the Cambrian and Ordovician, and is broader than the present-day geographical definition.

Acritarchs

Genus AREMORICANIUM DEUNFF 1955
Type species: *A. rigaudae* DEUNFF 1955, p. 228.
Fig. 1—3.

Aremoricanium sp.
Pl. I:1

Description: The thin outer shell is angular. It is eroded, broken and partly wrinkled. The surface of the cylindrical neck-like extention is slightly granulate and the vesicle wall is striated. The processes are slender and flagelliforme.

Dimensions: Vesicle diameter 29 μ, process length 20 μ, base of processes 6 μ, length of neck-like extention 10 μ and width of aperture 8 μ. Specimens measured: 1.

Remarks: Identification of the only individual is uncertain. It is eroded, broken and partly wrinkled.

The species resembles morphologically *Aremoricanium rigaudae* DEUNFF 1955 (ø 53—59 μ) and A. deflandrei HENRY 1969 (ø 42—55 μ), but these are of markedly greater dimensions. Deunff (1958) has nevertheless recorded *A. rigaudae* of size 30—55 μ and Henry (1969) still smaller, 10—11 μ. Only three of the processes are left in the species recorded here. It also resembles *Aremoricanium sp.* described by Tynni (1982b), although the latter has stronger processes.

Occurrence: Rare (<0.5 %), only in prep. 712.

Not recorded at Rapla borehole.

Genus AXISPHAERIDIUM EISENACK 1967
Type species: *A timofeevi* EISENACK 1967, p. 398.

Axisphaeridium tricolumnelare n. sp.
Pl. I:2

Diagnosis: 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 or has a cover with irregular nets and a collar.

Dimensions: Vesicle diameter 30—60 μ, process length 2—6 μ, pylome diameter about 10 μ. Specimens measured: 18.

Remarks: The identification to the genus *Axisphaeridium* EISENACK 1967 follows the most important structural features in the original description of the genus.

The specimen observed here is smaller in size than *Axisphaeridium timofeevi* EISENACK 1967 (ø 71 μ). It differs from *Polyancistrodorus columbariferus* LOEBLICH & TAPPAN 1969 in having triangular, rather than quadratic processes, which are also shorter.

Occurrence: Rare (<0.5—1.0 %).

Derivation of name: *Tri* L. three, *columelare*, L. pillar; describing the nature of the processes.

Holotype: GFS prep. 715. The specimen is illustrated on Pl. I:2. Locus typicus: Erratic from Kalanti, South-West Finland, Middle Ordovician.

Distribution in Estonia: Rapla borehole, Kukruse to Pirgu regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Genus BALTISPHAERIDIUM EISENACK 1958

Type species: 1. Lost holotype: *B. (ex-Ovum-hispidum) longispinosum* EISENACK 1931, p. 110, Pl. 5:10. 2. Neotype: *B. longispinosum (ex-filifera) longispinosum* (EISENACK 1959) GORKA 1969, pp. 34—35, Pl. 6:2, 7:1—5, Fig. 9.

Baltisphaeridium brevifilicum? KJELLSTRÖM 1971
Pl. I:3.

Baltisphaeridium brevifilicum KJELLSTRÖM 1971, pp. 17—18, Pl. 1:1

Remarks: A subspherical shagrinate vesicle with simple processes having acuminate distal terminations and curved proximal process contact. Some of the specimens are so flattened that no excystment structure can be recorded. Its dimensions are smaller than those described by Kjellström (1971a, ø 77—86 μ) and are similar to individuals described by Gorka (1979) and Tynni (1982b).

Dimensions: Vesicle diameter 45—60 μ, process length 10—12 μ, process width 0.2—0.5 μ, distance between processes 5—7 μ. Specimens measured: 4.

Occurrence: Rare (<0.5 %).

Distribution in the Baltic area: Finland: Åland borehole, Ordovician (Tynni 1982b). Sweden: Gotland borehole, Viruan, Middle Ordovician (Kjellström 1971a). Poland: Olsztyn borehole, Llandeilian and Caradocian, Middle Ordovician (Gorka 1979).

Not recorded outside the Baltic area.

Baltisphaeridium brevispinosum EISENACK (1931) 1958
Pl. I:4.

Synonyms: *Ovum hispidum brevispinosum* EISENACK 1931, p. 111, Pl. 5:3—5. *Hystrichosphaeridium brevispinosum* EISENACK 1938, p. 12, Pl. 1:10. *Baltisphaeridium brevispinosum* EISENACK 1958, p. 400.

Remarks: Dark brown, thick walled shagrinate vesicle with short, proximally curved processes having bulbous distal terminations, not recorded as bilobate or trilobate. Sometimes the vesicle is broken. The dimensions are variable, and some rather small individuals has been identified.

Dimensions: Vesicle diameter 30—88 μ, process length 6—20 μ, process width 2—4 μ, distance between processes 6—21 μ. Specimens measured: 22.

Occurrence: Rare to moderate (0.5—4.0 %, commonly <1.0 %).

Distribution in the Baltic area: Finland: erratic boulders from the Bothnian Sea, Ordovician (Tynni 1975); Åland borehole Middle Ordovician (Tynni 1982b). Sweden: Gotland borehole (Kjellström 1971a); Västergötland borehole (Kjellström 1976) both Lower Viruan, Middle Ordovician; Linköping, Ljungsbro subsurface, Lower Ordovician (Fromm & Kjellström 1976). Estonia: Estonian glauconite limestone, Volhov regional stage, Lower Ordovician (Eisenack 1958); Rapla borehole, Volhov to Lasnamägi regional stages, Lower to Middle Ordovician (Uutela & Tynni, in preparation). Poland: Podborowisko borehole, Arenigian, Lower Ordovician (Gorka 1969). Ordovician Baltic erratics (Eisenack 1931, 1938, 1959a, 1976).

Distribution in Europe: France: Aquitaine basin, Ordovician (Rauscher 1973).

Baltisphaeridium clavicinctum W. WETZEL 1967
Pl. I:5

Baltisphaeridium clavicinctum W. WETZEL 1967, p. 41, Pl. 2:14.

Remarks: The thick spherical vesicle is dark brown and densely covered with short, hollow processes having bulbous distal terminations. No pylome is recorded.

Dimensions: Vesicle diameter 46 μ, process length 10 μ, process width 2 μ and distance between processes 6 μ, thickness of wall 3 μ. Specimens measured: 1.

Occurrence: Rare (<0.5 %), only in prep. 701.

Distribution in the Baltic area: Estonia, Reval (=Tallinn), Vaginaten limestone, Kunda regional stage, Lower/Middle Ordovician (Wetzel 1967).

Not recorded outside the Baltic area.

Baltisphaeridium aff. *B. constrictum* KJELLSTRÖM 1971
Pl. I:6

Baltisphaeridium aff. *constrictum* KJELLSTRÖM 1971, pp. 22—23, Pl. 1:5—7.

Remarks: The subspherical vesicle is clearly granulate but not as thick as in *B. constrictum* KJELLSTRÖM 1971, resembling *B.* aff. *constrictum* (Kjellström 1971a, p. 23). The processes are slightly granulated, not psilate as in the original diagnosis. The figures disagree with the descriptions both in Kjellström (1971a) and in the catalogue of Eisenack *et al.* (1973).

The species differs from *B. latiradiatum* (EISENACK 1959) STAPLIN, JANSONIUS & POCOCK 1965 in having a granulated surface on both the vesicle and the processes, and from the entirely granulated *B. pseudocalicispinum* GORKA 1969 in its constricted proximal process contact. It also differs from *B. bramkaense* GORKA 1979 in its ratio of vesicle to processes and the fact that some of the processes are not as wide as in the latter. According to the diagnosis of *B. bramkaense* by Gorka (1979), there is no separation of the processes from the vesicle cavity, but in that case the genus must be different. The species also differs from *B. trophirhapium* LOEBLICH & TAPPAN 1978 in having longer and more slender processes with small granules. *B. perclarum* LOEBLICH & TAPPAN 1978 has longer processes, which are commonly bifurcate or subsidiarily branched and the vesicle is smooth.

All the specimens recorded here are smaller in size than those of mentioned before.

Dimensions: Vesicle diameter 40—60 μ, process length 50—80 μ, process width 8—15 μ, distance between processes 20—35 μ. Specimens measured: 3.

Occurrence: Rare (<0.5 %).

Distribution in the Baltic area: Sweden: Gotland borehole, Lower Viruan, Middle Ordovician (Kjellström 1971a).

Not recorded outside the Baltic area.

Baltisphaeridium filosum KJELLSTRÖM 1971
Pl. I:7

Baltisphaeridium filosum KJELLSTRÖM 1971, p. 24, Pl. 1:9.

Remarks: The thin spherical to subspherical vesicle is densely covered with thin flagelliforme processes of length about 1/3—

1/2 of the vesicle diameter. The processes are hollow, hence the diagnosis by Kjellström (1971a) as *Baltisphaeridium*. Some of the individuals were 50 % smaller than in the original diagnosis.

Dimensions: Some specimens are much smaller than the original dimensions (ø 61—70 x 73—84 μ). Vesicle diameter 30—80 μ, length of processes 10—40 μ, width of processes 1 μ. 90 % of the species are smaller in size than in the original type description. Specimens measured: 10.

Occurrence: Rare (<0.5 %—2.0 %).

Distribution in the Baltic area: Finland: erratic boulders from the Bothnian sea, Middle Ordovician (Tynni 1975); Åland borehole, Middle Ordovician (Tynni 1982b). Sweden: Gotland borehole, Viruan, Middle Ordovician (Kjellström 1971a). Estonia: Rapla borehole, Volhov to Keila regional stages, Lower to Middle Ordovician (Uutela & Tynni, in preparation). Poland: Olsztyn borehole, Llandeilian, Middle Ordovician (Gorka 1979).

Not recorded outside the Baltic area.

Baltisphaeridium hamatum (DOWNIE 1958) KJELLSTRÖM 1976

Pl. I:8

Synonyms: *Hystrichosphaeridium hirsutoides* var. *hamatum* DOWNIE 1958, p. 335, Pl. 16:2, Fig. 2 j,k. *Baltisphaeridium hirsutoides* var. *hamatum* DOWNIE & SARJEANT 1964, p. 91. *Micrhystridium hamatum* DEFLANDRE & DEFLANDRE 1965, Fig. 2248. *Baltisphaeridium hirsutoides hamatum* DOWNIE & FORD 1966, p. 313. *Baltisphaeridium hamatum* (Downie 1958) Kjellström 1976, p. 18.

Remarks: The spherical vesicle has processes of variable size. Kjellström (1976) based his new species on the nature of the processes, which have quite a broad base. Species here has processes of a more variable length than is described by Kjellström (1976) and Gorka (1979). Different sizes and lengths of processes may be seen in the one individual. The vesicle surface is psilate.

Dimensions. Vesicle diameter 22—25 μ, process length 3—6 μ, process width 1 μ, distance between processes 5—7 μ, number of processes 12—15 Specimens measured: 2.

Occurrence: Rare (<0.5 %), only in prep. 715.

Distribution in the Baltic area: Finland: Åland borehole, Middle Ordovician (Tynni 1982b). Sweden: Östergötland borehole, Lower Viruan, Middle Ordovician (Kjellström 1976). Estonia: Rapla borehole, Lasnamägi to Uhaku regional stages, Middle Ordovician (Uutela & Tynni, in preparation). Poland: Olsztyn borehole, Llanvirnian, Middle Ordovician (Gorka 1979).

Distribution in Europe: Britain: Shineton Shales borehole, Upper Tremadocian, Lower Ordovician (Downie 1958); Isle of Man, Tremadocian, Lower Ordovician (Downie & Ford 1966).

Baltisphaeridium hirsutoides (EISENACK 1931) 1958

Pl. II:9

Synonyms: *Ovum hispidum* cf. *hirsutum* (EHRENBERG) EISENACK 1931, p. 111, Pl. 5:19. *Hystrichosphaeridium* cf. *hirsutum* EISENACK 1938, p. 12, Pl. 1:11. *Hystrichosphaeridium hirsutoides* EISENACK 1951, pp. 189—190, Pl. 3:8. *Hystrichosphaeridium* cf. *hirsutoides* SANNEMANN 1955, pp. 328—329, Pl. 3:9; 5:3, 4, Fig. 11. *Baltisphaeridium hirsutoides* EISENACK 1958, p. 400.

Remarks: The spherical vesicle has numerous processes, which length does not exceed vesicle diameter. *B. hirsutoides* comprises a great variety of transitional forms (Kjellström 1971a). The thick—walled form (wall thickness 2—5 μ) is common in the present material and the thin—walled form rare (wall thickness under 1 μ). The processes are variable in length and number. The surface of the vesicle and the processes varies from psilate to granulate.

Dimensions: Vesicle diameter 20—80 μ, process length 6—50 μ, process width 1—6 μ, distance between processes 8— 30 μ, number of processes 8—22. There is no correlation between thickness of the vesicle and number of processes, i.e. thin vesicles can have few or many processes, as also can thick vesicle. 90 % of the specimens are 20—40 μ in size in the samples where occurrence is over 7.0 %. Specimens measured: 242.

Occurrence: Rare to common (<0.5 %—32.2 %).

Distribution in Estonia, Rapla borehole, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian (Uutela & Tynni, in preparation).

Earlier observations concern from many Lower and Middle Ordovician deposits elsewhere in the Baltic area and Europe (Eisenack *et al.* 1973).

Distribution outside Europe: U.S.A., Kentucky, Edenian, Upper Ordovician (Jacobson 1978).

Baltisphaeridium latiradiatum (EISENACK 1959) STAPLIN, JANSONIUS & POCOCK 1965

Pl. II:10

Synonyms: *Ovum hispidum longispinosum* EISENACK 1931, p. 110, Pl. 5:14, 15. *Hystrichosphaeridium longispinosum* EISENACK 1938, p. 12; Pl. 1:1—3. *Baltisphaeridium longispinosum latiradiata* EISENACK 1959, p. 195, Pl. 15:4. *Baltisphaeridium latiradiatum* STAPLIN, JANSONIUS & POCOCK 1965, p. 189, Pl. 20:3—5, 9, Fig. 13.

Remarks: The thin, dark brown, spherical vesicle has few broad processes constricted at the base. The psilate vesicle is broken in every individual recorded here. The vesicle wall is thinner than in *B. longispinosum* (EISENACK 1959) GORKA 1969, but not that as described by Eisenack (1959a). The process wall is thinner than that of the vesicle. The vesicle is smaller in diameter than in the original diagnosis (ø 60—87 μ). Martin (1973) describes the species as small as 22 μ in diameter, but with its processes quite thick and not so clearly separated.

Dimensions: Vesicle diameter 50 μ, process length 50 μ, process width 8 μ, distance between processes 20—26 μ. Specimens measured: 3.

Occurrence: Rare (0.5—1.0 %), only in preps. 701 and 713.

Distribution in the Baltic area: Finland: erratic boulder from the Bothnian Sea, Ordovician (Tynni 1975); Åland borehole, Middle Ordovician (Tynni 1982b). Sweden: Gotland borehole, Lower Viruan, Middle Ordovician (Kjellström 1971a). Estonia: Rapla borehole, Kunda to Keila regional stages, Lower/Middle to Middle Ordovician (Uutela & Tynni, in preparation). Ordovician Baltic erratics (Eisenack 1931, 1938, 1959a).

Distribution in Europe: U.S.S.R., Moscow syneclise, Lower to Middle Ordovician (Umnova 1975). France: Aquitaine basin, Ordovician (Rauscher 1973). Belgium: Silurian (Martin 1973).

Baltisphaeridium longispinosum subsp. *longispinosum* (EISENACK 1959) GORKA 1969

Pl. II:11

Synonyms: *Ovum hispidum longispinosum* EISENACK 1931, p. 110, Pl. 5:5—12. *Hystrichosphaeridium longispinosum* EISENACK 1938, p. 12, Pl. 1:4, 6, 7; (not: Pl. 1:1:). *Baltisphaeridium longispinosum* forma *filifera* EISENACK

1959, p. 195, Pl. 15:1. *Baltisphaeridium longispinosum* EISENACK 1962, p. 75. *Baltisphaeridium longispinosum* subsp. *longispinosum* GORKA 1969, pp. 34—35, Pl. 6:2; 7:1—5, Fig. 9.

Remarks: The spherical vesicle has numerous long processes. The species recorded here has a thick, granulate vesicle and there differs from the diagnosis of Eisenack (1959a). The processes are of variable length, usually exceeding the diameter, although there can also be shorter processes in the same individual. The species is closely related to those described by Gorka (1969). Loeblich and Tappan (1978) describe a quite similar species, B. aliquigranulum, with broader processes ornamented with scattered grana.

Dimensions: Vesicle diameter 34—60 µ, process length 36—80 µ, process width 2—6 µ, distance between processes 13—30 µ, number of processes 6—20. 75 % of the species are smaller in size than in the original type description. Specimens measured: 27.

Occurrence: Rare to moderate (<0.5—3.5 %).

Distribution in Estonia, Rapla borehole, Volhov to Pirgu regional stages, Lower to Upper Ordovician (Uutela & Tynni, in preparation).

Earlier observations also in Lower Ordovician to Upper Silurian deposits elsewhere in the Baltic area and Europe (Eisenack *et al.* 1973).

Baltisphaeridium microspinosum (EISENACK 1954) DOWNIE 1959
Pl. II:12

Synonyms: *Hystrichosphaeridium microspinosum* EISENACK 1954, pp. 209—210, Pl. 1:8. *Baltisphaeridium microspinosum* DOWNIE 1959, p. 60, Pl. 10:10.

Remarks: A thin-walled spherical vesicle has numerous short processes. Dimensions vary in the present material more than in the specimens described by Kjellström (1971a, ø 61—76 µ) and Tynni (1975, ø 60 µ).

Dimensions: Vesicle diameter 24—74 µ, process length 2—12 µ, process width 1—2 µ, distance between processes 2—6 µ. 90 % of the species are smaller in size than in the original type description. Specimens measured: 45.

Occurrence: Rare to moderate (<0.5—4.9 %).

Distribution in Estonia, Rapla borehole, Kunda to Pirgu regional stages, Lower/Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Previous observations reported also in Lower Ordovician to Lower Silurian deposits elsewhere in the Baltic area and Lower Silurian deposits in Europe (Eisenack *et al.* 1973).

Baltisphaeridium cf. B. multiechinatum KJELLSTRÖM (1971) 1974
Pl. II:13

Synonyms: *Baltisphaeridium echinatum* KJELLSTRÖM 1971, pp. 23—24, Pl. 1:8. *Baltisphaeridium multiechinatum* KJELLSTRÖM 1974, p. 211.

Remarks: The thin-walled, spherical, echinate vesicle is often broken and eroded. The specimens have more slender processes than those described by Kjellström (1971a), and closely resemble those described by Gorka (1979).

Dimensions: Vesicle diameter 36—78 µ, process length 20—40 µ, process width 1—3 µ, distance between processes 14—16 µ. Specimens measured: 9.

Occurrence: Rare to moderate (1 ind.—5.6 %), only in preps. 661, 669 and 712.

Distribution in the Baltic area: Finland: erratics from the Bothnian Sea, Ordovician (Tynni 1975). Sweden: Gotland borehole, Viruan, Middle Ordovician (Kjellström 1971a). Estonia: Rapla borehole, Kunda to Kukruse regional stages, Lower/Middle to Middle Ordovician (Uutela & Tynni, in preparation). Poland: Olsztyn borehole, Llandeilian and Caradocian, Middle Ordovician (Gorka 1979).

Not recorded outside the Baltic area.

Baltisphaeridium multipilosum EISENACK (1931) 1958
Pl. II:14

Synonyms: *Ovum hispidum multipilosum* EISENACK 1931, p. 111, Pl. 5:20—22. *Hystrichosphaeridium multipilosum* EISENACK 1938, p. 12, Pl. 1:12—13. *Baltisphaeridium multipilosum* EISENACK 1958, p. 400.

Remarks: The thick spherical vesicle has numerous short processes. The specimens in the present material closely resemble those described by Kjellström (1971a), but no pylome is recorded. The thickness of the spherical vesicle can be as much as 5 µ. The process-length varies from 1/9 of the diameter in the smaller specimens to 1/10 in the larger ones, and the diameter varies more than in the original diagnosis (ø 70—86 µ), although Martin (1973) and Cocchio (1981) also describes minor variation around a diameter of 35 µ.

Dimensions: Vesicle diameter 34—58 µ, process length 4—6 µ, process width 1 µ. Specimens measured: 9.

Occurrence: Rare (<0.5 %—1.0 %).

Distribution in Estonia, Rapla borehole, Volhov to Kukruse regional stages, Lower to Middle Ordovician (Uutela & Tynni, in preparation).

Previous observations reported also in Lower to Middle Ordovician deposits elsewhere in the Baltic area and from Lower Ordovician to Lower Silurian deposits in Europe (Eisenack *et al.* 1973).

Baltisphaeridium nanninum EISENACK 1965
Pl. II:15

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

Remarks: The wall of the spherical vesicle is shagrinate, and the processes are short, although longer than those described by Kjellström (1971a) and equal to those of Kjellström (1976). It is impossible to verify the hollowness of the processes because of their smallness and thinness, but the species differs from Gorgonisphaeridium antiquum LOEBLICH & TAPPAN 1978, which has longer, solid processes with a bulbous base.

Dimensions: All the specimens are much smaller than in the original diagnosis (ø 92—101 µ). Vesicle diameter 50—70 µ, process length 1—3 µ.

Specimens measured: 13.

Occurrence: Rare (<0.5—1.8 %).

Distribution in the Baltic area. Finland: erratics from the Bothnian Sea, Ordovician (Tynni 1975); Åland borehole, Middle Ordovician (Tynni 1982b). Sweden: Gotland borehole, Viruan Middle Ordovician (Kjellström 1971a); Dalarna, Lower Silurian (Schulz 1967).

Estonia: Rapla borehole, Kunda to Oandu regional stages, Lower/Middle to Middle Ordovician (Uutela & Tynni, in preparation). Lower Silurian erratics (Eisenack 1965a, 1968, 1969).

Not recorded outside the Baltic area.

Baltisphaeridium pachyacanthum EISENACK (1963) 1965
Pl. II:16

Synonyms: *Hystrichosphaeridium longispinosum* EISENACK 1938, p. 12, Pl. 1:8, Fig. 9. *Baltisphaeridium longispinosum* forma *robusta* EISENACK 1959, p. 195, Pl. 15:3, 5. *Baltisphaeridium robustum* EISENACK 1963, p. 212, Pl. 19:6, 7. *Baltisphaeridium pachyacanthum* EISENACK 1965, p. 134, Pl. 13:6, 7.

Remarks: The spherical vesicle has numerous processes with axial thread structure in the hollow stem. The vesicle is not as thick as that described by Kjellström (1971a) and Tynni (1975), but closely resembles that of the species reported by Gorka (1969). A axial thread structure is clearly visible in the processes by light microscopy.

The diameter is not always as large as in the original diagnosis (ø 70—85 µ) but Martin (1973), for example, describes specimens as small as 37 µ.

Dimensions: Vesicle diameter 55—80 µ, process length 35—75 µ, process width 2—3 µ, number of processes 9—15. Specimens measured: 7.

Occurrence: Rare (<0.5 %).

Distribution in the Baltic area: Finland: erratics from the Bothnian Sea, Ordovician (Tynni 1975). Sweden: Gotland borehole (Kjellström 1971a), and Östergötland, Ekön borehole (Kjellström 1976), all Lower Viruan, Middle Ordovician; Linköping, Ljungsbro subsurface, Lower Ordovician (Fromm & Kjellström 1976). Estonia: Odinsholm subsurface, Lower Viruan, Middle Ordovician (Bockelie & Kjellström 1979). Poland: Podborowisko borehole, Arenigian; Kerrzyn borehole, Llandeilian; Goldap borehole, Caradocian, Lower to Middle Ordovician (Gorka 1969). Ordovician Baltic erratics (Eisenack 1938, 1951, 1959a, 1963, 1965a, 1968, 1969).

Distribution in Europe: U.S.S.R., Moscow syneclise, Lower to Middle Ordovician (Umnova 1975). France: Aquitaine basin, Ordovician (Rauscher 1973).

Baltisphaeridium pauciverrucosum KJELLSTRÖM 1971
Pl. II:17

Baltisphaeridium pauciverrucosum KJELLSTRÖM 1971, p. 17, Fig. 9.

Remarks: The spherical, shagrinate vesicle has numerous verrucate processes. The three specimens recorded in this material closely resemble the original holotype, except that the number of processes is smaller (here 13, in holotype 22), as in the material of Gorka (1980).

Dimensions: Vesicle diameter 35—45 µ, process length 35—45 µ, process width 3—4 µ, number of processes 13. Specimens measured: 2.

Occurrence: Rare (0.5 %), only in preps. 701 and 704.

Distribution in the Baltic area: Finland: erratics from the Bothnian Sea, Ordovician (Tynni 1975). Sweden: Gotland, borehole, Viruan, Middle Ordovician (Kjellström 1971a). Estonia: Rapla borehole, Volhov to Rakvere regional stages, Lower to Middle Ordovician (Uutela & Tynni, in preparation). Poland: Strabla borehole, Llanvirnian, Middle Ordovician (Gorka 1980).

Not recorded outside the Baltic area.

Baltisphaeridium podboroviscensis? GORKA 1969
Pl. III:18

Baltisphaeridium podboroviscensis GORKA 1969, p. 45, Pl. 15:7—10.

Remarks: The spherical vesicle has thick, short processes with acuminate distal terminations. All four specimens are of the type with short, thick processes. They are also eroded and damaged to a greater or lesser extent, the vesicle wall is porous, possibly secondarily, and shagrinate, but not obviously reticulate. The species differs from *B. brevispinosum* EISENACK (1931) 1958 in having shorter processes without a bulbous distal terminations, although these may be eroded and broken species of *B. brevispinosum*, which is also recorded in the same specimen.

Dimensions: Vesicle diameter 50—70 µ, process length 3—10 µ, process width 2—5 µ, distance between processes 15—20 µ. Specimens measured: 4.

Occurrence: Rare (<0.5 %), only in prep. 712.

Distribution: Reported earlier only in the Arenigian, Lower Ordovician Podborowisko borehole in Poland (Gorka 1969).

Baltisphaeridium pseudocalicispinum GORKA 1980
Pl. III:19

Baltisphaeridium pseudocalicispinum GORKA 1980, p. 266, Pl. 32:4.

Remarks: The echinate vesicle has numerous echinate processes. *B. calicispinae* GORKA 1969 has a porous vesicle wall.

The specimens recorded here differ markedly from *B. parvinogranosum* LOEBLICH & TAPPAN 1978, which has a larger number of processes, which are more variable in length, and a more finely sculptured vesicle and processes. *B. oligopsakium* LOEBLICH & TAPPAN 1978 has more processes. *B. bystrentos* LOEBLICH & TAPPAN 1978 is quite similar to *B. pseudocalicispinum* / *B. calicispinae*, since both have plugging at the base of the processes. Internal thickening of the vesicle wall can also be seen in the specimen described by Gorka (1980, Pl. 31:3), without being mentioned in the diagnosis.

Dimensions: Vesicle diameter 35—50 µ, process length 20—60 µ, number of processes average 10, distance between processes 12—40 µ, width of processes 2—10 µ. Specimens measured: 10.

Occurrence: Rare (0.5 %—2.0 %).

Distribution in the Baltic area (only those accepted by Gorka (1980) are reported): Sweden: Gotland borehole, Viruan, Middle Ordovician (Kjellström 1971a); Östergötland, Ekön borehole, Lower Viruan, Middle Ordovician (Kjellström 1976); Linköping, Ljungsbro subsurface, Lower Ordovician (Fromm & Kjellström 1976). Estonia: Odinsholm Middle Ordovician erratics (Bockelie & Kjellström 1979). Poland: Strabla borehole, Llanvirnian, Middle Ordovician (Gorka 1980).

Recorded also at Rapla borehole, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian (Uutela & Tynni, in preparation).

Not recorded outside the Baltic area.

Baltisphaeridium verrucatum? KJELLSTRÖM 1971
Pl. III:20

Baltisphaeridium verrucatum KJELLSTRÖM 1971, pp. 41—42, Pl. 3:2.

Remarks: The spherical, verrucate vesicle has verrucate processes. The dimensions of the only specimen found here is smaller in size than in the original diagnosis (ø 70 µ). Process length does not exceed vesicle diameter, dimensions disagree with the description in the original diagnosis by Kjellström (1971a). It is difficult to verify the douple-walled vesicle.

Dimensions: Vesicle diameter 40 μ, the length of the processes 30—40 μ, the width of the processes 4 μ, the number of the processes 10, distance between processes 12 μ. Specimens measured: 1.

Occurrence: Rare (<0.5 %), only in prep. 654.

Distribution in the Baltic area: Finland: erratics from the Bothnian Sea, Ordovician (Tynni 1975). Sweden; Gotland borehole, Viruan, Middle Ordovician (Kjellström 1971a). Estonia, Rapla borehole, Kunda to Johvi regional stages, Lower/ Middle to Middle Ordovician (Uutela & Tynni, in preparation). Poland: Olsztyn borehole, Llandelian and Caradocian, Middle Ordovician (Gorka 1979).

Not recorded outside the Baltic area.

Baltisphaeridium sp. 1.
Pl. III:21

Description: The spherical to subspherical vesicle is covered with numerous processes which have a curved proximal contact but do not communicate with the interior of the vesicle. The surfaces of the vesicle and processes are echinate.

Remarks: The species differs from *Baltisphaeridium granosum* KJELLSTRÖM 1971 in having an echinate vesicle and smaller dimensions. *B. anneliae* KJELLSTRÖM (1971) BOCKELIE & KJELLSTRÖM 1976 and *B. ingerae* KJELLSTRÖM 1971 have an angular proximal process contact with the vesicle and the processes are more numerous. *B. accinctum* LOEBLICH & TAPPAN 1978 has wider processes, also with an angular proximal contact.

Dimensions: Vesicle diameter 20—50 μ, process length 10—17 μ, ornamentation height 1.5 μ, average number of processes 50. Specimens measured: 51.

Occurrence: Common (25.5 %), but only in prep. 712.

Distribution in Estonia, Rapla borehole, Volhov to Uhaku regional stages, Lower to Middle Ordovician (Uutela & Tynni, in preparation).

Baltisphaeridium sp. 2.
Pl. III:22

Description: The spherical vesicle is granulated and covered with numerous small granulated processes (length 1/4 of the vesicle diameter) with angular proximal process contact.

Dimensions: Vesicle diameter 47—55 μ, process length 17—20 μ, number of processes 120. Specimens measured: 2.

Remarks: The two individuals observed differ from *B. accintum* LOEBLICH & TAPPAN 1978 in having more slender, acuminate and shorter processes. The vesicle diameter is also smaller. Spinules are more numerous on both the vesicle and the processes. The specimen differs more obviously from *B. anneliae* (KJELLSTRÖM 1971) BOCKELIE & KJELLSTRÖM 1979, which has a psilate vesicle, longer processes, a partial rupture as an excystment structure and greater dimensions. It also differs from *B. ingerae* KJELLSTRÖM 1971, which has longer but less numerous processes and is of greater dimensions.

Occurrence: Rare (<0.5 %), only in preps. 654 and 715.

Distribution Estonia: Rapla borehole, Lasnamägi to Nabala regional stages, Middle to Middle/Upper Ordovician (Uutela & Tynni, in preparation).

Genus BUEDINGIISPHAERIDIUM SCHAARSCHMIDT 1963, emended by STAPLIN *et al.* 1965 and by LISTER 1970
Type species: *B. permicum* SCHAARSCHMIDT 1963, p. 70.

Buedingiisphaeridium sp.
Pl. III:23

Diagnosis: The vesicle is subspherical to spherical, thin-walled and shagrinate. It is covered with hollow pyramidal outgrowths, usually small and of equal size (variation 0.5 μ), although in one species the variation is 1—3 μ.

Dimensions: Vesicle diameter 11—22 μ, length of processes 1—3 μ, width of process base 1—3 μ, distance between processes 2—4 μ. Specimens measured: 7.

Remarks: These species with outgrowths of equal size closely resemble the *Buedingiisphaeridium sp.* (ø 35 μ) of Tynni (1982b). P. 70, Pl. XI:72) except that they are much smaller in size. They differ from *B. pyramidale* LISTER 1970 (ø 27— 37 μ) in having less numerous outgrowths and bases that are not coincident. One species with variable outgrowths included in the same species may be interpreted as a transitional form.

Occurrence: Rare (<0.5—1.0 %).

Distribution in Estonia, Rapla borehole, Kunda to Pirgu regional stages, Lower/Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Genus COMASPHAERIDIUM STAPLIN, JANSONIUS & POCOCK 1965
Type species: *C. cometes* (VALENSI 1949, p. 545, fig. 5:6) STAPLIN, JANSONIUS & POCOCK 1965, p. 192.

Comasphaeridium varispinosum n. sp.
Pl. III:24

Diagnosis: The spherical vesicle has a dense covering of simple, flagelliforme, solid processes of irregularly variable length and width. The processes have accuminate distal terminations.

Dimensions: Vesicle diameter 12—40 μ, process length 1—10 μ. Specimen measured: 26.

Remarks: The species belongs to the genus *Comasphaeridium* STAPLIN, JANSONIUS & POCOCK 1965 in that it has a spherical vesicle covered with solid, flagelliforme processes. The present study extends the diagnosis of the genus to concern the width and length of the processes, which are variable in size. The species closely resembles *Elektoriskos intonsus* LOEBLICH & WICANDER 1976 in having processes of variable length, although Eisenack *et al.* (1976) regard the genus *Elektoriskos* as a junior synonym of *Comasphaeridium.*

Occurrence: Rare to common (<0.5—2.2 %).

Not recorded at Rapla borehole.

Derivation of name: *Vari* L. variable, *spinosum* L. processes.

Holotype: GSF prep. 715, Pl. The specimen is illustrated on Pl. III: 24.

Locus typicus: Erratic from Kalanti, southwestern Finland, Middle Ordovician.

Genus CYMATIOSPHAERA (O. WETZEL 1933) DEFLANDRE 1954
Type species: *C. radiata* O. WETZEL 1933, p. 27, Pl. 4:8.

Cymatiosphaera pavimenta DEFLANDRE (1945) 1954
Pl. III:25

Synonyms: *Micrhystridium pavimentum* DEFLANDRE 1945,

p. 68. *Cymatiosphaera pavimenta* DEFLANDRE 1954, p. 258.

Remarks: The spherical vesicle has its external surface divided into polygonal fields by membranes running perpendicular to the surface. There is no equatorial differentation of the fields, and the polygons are hexagonal. The surfaces of the vesicle and membranes are smooth. The species differs from *C. multisepta* DEUNFF 1955 in having less polygons.

Dimensions: Vesicle diameter 8—10 µ, membrane height 2 µ. Specimens measured: 17.

Occurrence: Rare (<0.5—1.5 %).

Distribution in Estonia, Rapla borehole, Kunda to Porkuni regional stages, Lower/Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Distribution in Europe: Ordovician, Silurian and Lower Devonian deposits in Western Europe (Eisenack *et al.* 1973).

Cymatiosphaera aff *C. striata* EISENACK & COOKSON 1960
Pl. III:26

Cymatiosphaera striata EISENACK & COOKSON 1960, p. 9, Pl. 3:10—11.

Remarks: The small spherical vesicle has 6—8 pentagonal polygons divided by striated membrane walls. The vesicle surface is echinate.

The specimens differ from *C. octoplana* DOWNIE 1959 in having pentagonal fields rather than rectangular ones. The specimens recorded in the present material have a lower membrane and are distinctly smaller than in the original description (overall diameter 60—76 µ).

Dimensions: Vesicle diameter with membrane 20 µ, membrane wall height 2—3 µ. Specimens measured: 2.

Occurrence: Rare (<0.5 %), only in prep. 648.

Not recorded at Rapla borehole.

Distribution: Recorded earlier only in Cretaceous sediments in Australia (Eisenack *et al.* 1973).

Genus DICOMMOPALLA LOEBLICH 1970

Type species: *D. macadamii* LOEBLICH 1970, p. 39—40, Pl. 1:1—4; 2:5—8; 3:9—11.

Dicommopalla macadamii LOEBLICH 1970
Pl. IV:27

Synonyms: *Dicommopalla macadamii* LOEBLICH 1970, p. 39—40, Pl. 1:1—4, 2:5—8, 3:9—11. *Granomarginata* sp. 1. TYNNI 1975, p. 21, Fig. 18.

Remarks: The spherical vesicle has the pylome rounded by the rim. The description corresponds to the original one except for the dimensions (ø 58—100 µ). This material includes some small individuals (<20 µ). The smallest diameter recorded earlier is 30 µ in the Eden shale, Indiana (Colbath 1979).

Dimensions: Vesicle diameter 13—53 µ, width of "keel" 1—4 µ, pylome diameter 4—12 µ. Specimens measured: 20.

Occurrence: Rare to moderate (<0.5—4.8 %).

Distribution in the Baltic area: Finland: erratic boulders from the Bothnian Sea (Tynni 1975). Estonia; Rapla borehole, Uhaku to Pirgu regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Distribution outside Europe: U.S.A.: Indiana, Dillsboro Formation, Upper Ordovician (Loeblich 1970a); Kentucky, Clays Ferry Formation, Edenian, Upper Ordovician (Jacobson 1978); Indiana, Eden shale borehole, Upper Ordovician (Colbath 1979). Canada: Quebec, Montreal and Ottawa, Ordovician (Martin 1983).

Genus DICTYOSPHAERIDIUM W. WETZEL 1952

Type species: *D. deflandrei* W. WETZEL 1952, p. 406, Pl. A:12 a,b.

Dictyosphaeridium sp.
Pl. IV:28

Description: The spherical vesicle is covered with short, simple, psilate processes, the bases of which have a star-shaped ornamentation, while a reticulate ornamentation is found between the processes. The processes have acuminate distal terminations and an angular proximal contact. They obviously do not communicate with the vesicle interior. No pylome is observed.

Dimensions: Vesicle diameter 15 µ, process length about 2 µ. Specimens measured: 3.

Remarks: The ornamentation of the vesicle resembles that of the genus *Stelliferidium* DEUNFF, GORKA & RAUSCHER 1974, but the typical feature of a pylome is not recorded.

Occurrence: Rare (<0.5 %), only in prep. 648.

Distribution in Estonia, Rapla borehole, Aseri to Pirgu regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Genus DICTYOTIDIUM EISENACK 1955
emended by STAPLIN 1961

Type species: *(Leiosphaera=) D. dictyotum* (EISENACK 1938), pp. 27—28, Pl. 3:8a—c.

Dictyotidium dictyotum EISENACK (1938) 1958
Pl. IV:29

Synonyms: *Leiosphaera dictyota* EISENACK 1938, pp. 27—28, Pl. 3:8a—c. *Dictyotidium dictyotum* EISENACK 1955, pp. 179—180, Pl. 4:12, 13.

Remarks: The vesicle is spherical, the sides of the polygons are curvilinear and the polygons are variable in size and form. The diameter is smaller than in the original description (60—100 µ), but the same as described by Martin (1966a, 1968).

Dimensions: Diameter 14—42 µ. Specimens measured: 33.

Occurrence: Rare to moderate (<0.5—4.8 %).

Distribution in the Baltic area: Sweden: Gotland subsurface, Wenlockian, Lower Silurian (Eisenack 1965b).

Baltic erratics, Ludlovian, Upper Silurian (Eisenack 1955a).

Recorded also from Cambrian to Upper Silurian deposits in Europe and from Upper Silurian to Middle Devonian deposits in the U.S.A. (Eisenack *et al.* 1979a).

Dictyotidium polygonium STAPLIN 1961
Pl. IV:30

Dictyotidium polygonium STAPLIN 1961, p. 417, Pl. 49:14.

Remarks: The spherical vesicle has an ornamentation of polygons which are thick-walled and smaller than in the original diagnosis. Some of the polygons lack any small granule in the centre, perhaps because of erosion.

Dimensions: Diameter 30 μ, polygonal area about 1 μ across. Specimens measured: 2.

Occurrence: Rare (<0.5 %), only in preps. 655 and 703.

Distribution: Not recorded earlier either in the Baltic area or in Europe.

Distribution outside Europe: Canada: Alberta, Upper Devonian (Staplin 1961). Previous records also from Argentina, Los Espejos Formation, Middle Silurian and from Brazil, Bacia de Maranhao, Middle Devonian (Eisenack *et al.* 1979a, *ref.* Pöthe de Baldis 1975, Brito 1969).

Dictyotidium reticulatum EISENACK (1938) 1955
Pl. IV:31

Synonyms: *Leiosphaera reticulata* EISENACK 1938, p. 27, Pl. 3:7a, b. *Leiosphaeridia reticulata* EISENACK 1958, p. 9. *Dictyotidium reticulatum* EISENACK, CRAMER & DIEZ 1979, pp. 167—168.

Remarks: The spherical vesicle is covered with an irregular reticulate and verrucate ornamentation, which may to some extent be the result of erosion. The vesicle is thin and single—layered. The present species conforms to the original description.

Dimensions: Vesicle diameter 20—90 μ. Specimens measured: 4.

Occurrence: Rare (<0.5—0.5 %).

Distribution in the Baltic area: Baltic Ordovician erratics (Eisenack 1938, 1959a). Also recorded in Queensland, Australia, Ordovician (Eisenack *et al.* 1979a, *ref.* Combaz 1965).

Dictyotidium stenodictyum EISENACK 1965
Pl. IV:32

Dictyotidium stenodictyum EISENACK 1965, pp. 264—265, Pl. 22:2, 3.

Remarks: The spherical vesicle has an ornamentation of polygons and thorns are clearly visible in the intersections of the ridges although some have been eroded away. Very small in diameter compared with the original description (60 μ). The species described by Martin (1968) is also rather small in diameter (20—35 μ).

Dimensions: Diameter 13 μ. Specimens measured: 1.

Occurrence: Rare (<0.5 %), only in prep. 663.

Distribution in the Baltic area: Sweden, Gotland subsurface, Silurian (Eisenack 1965a).

Distribution in Europe: Belgium: Silurian (Martin 1966a, 1967).

Genus GONIOSPHAERIDIUM EISENACK 1969

Type species: 1. Holotype (lost): *G. (ex-Ovum hispidum) polygonale* EISENACK 1931, p. 113, Pl. 4:19. 2. Neotype: *G. (ex-Baltisphaeridium) polygonale* EISENACK 1959, p. 199, Pl. 16:8.

Goniosphaeridium mochtiensis (GORKA 1969)
Pl. IV:33

Synonym: *Baltisphaeridium mochtiensis* GORKA 1969 pp. 43—44, Pl. 11:1; 12:2, Fig. 15.

Remarks: The spherical vesicle has numerous processes with free communication to the interior of the vesicle. All the specimens are referable to the type species except that the vesicle diameter is smaller (ø 63—83 μ in the original description).

Dimensions: Vesicle diameter 20—60 μ, process length 10—34 μ, process width 1—6 μ, distance between processes 6— 30 μ, number of processes 9—16. Specimens measured: 33.

Occurrence: Rare to common (0.5 %—12.6 %).

Distribution in the Baltic area: Finland; erratic boulders from the Bothnian Sea, Ordovician (Tynni 1975); Åland borehole Middle Ordovician (Tynni 1982b). Sweden: Gotland borehole (Kjellström 1971b); Öland borehole (Kjellström 1972); Västergötland borehole (Kjellström 1976) all Lower Viruan, Middle Ordovician.

Estonia, Rapla borehole, Kunda to Lasnamägi regional stages, Lower/Middle to Middle Ordovician (Uutela & Tynni, in preparation).

Poland: Ordovician erratic boulders, and Mielnik borehole, Caradocian (Gorka 1969); Olztyn borehole, Llanvirnian to Caradocian (Gorka 1979); Strabla borehole, Llanvirnian and Caradocian (Gorka 1980).

Not recorded outside the Baltic area.

Goniosphaeridium polygonale EISENACK (1931) 1969
Pl. IV:34

Synonyms: *Ovum hispidum polygonale* EISENACK 1931, p. 113, Pl. 4:17, 19; 5:18. *Baltisphaeridium polygonale* EISENACK 1959, pp. 199—200, Pl. 16:8—9. *Veryhachium polygonale* DEFLANDRE & DEFLANDRE 1964, fiche 2061. *Goniosphaeridium polygonale* EISENACK 1969, p. 257.

Remarks: The thin-walled subspherical vesicle is of variable size with processes having a broad base. There are many transitional forms belonging to this species.

Dimensions: Vesicle diameter 36—84 μ, process length 10—50 μ. Specimens measured: 55.

Occurrence: Rare to moderate (<0.5 %—7.5 %, commonly under 2.0 %).

Distribution in Estonia, Rapla borehole, Volhov to Pirgu regional stages, Lower to Upper Ordovician (Uutela & Tynni, in preparation).

Distribution also from Lower Ordovician to Lower Silurian elsewhere in the Baltic area and Europe (Eisenack *et al.* 1973).

Goniosphaeridium polygonale polyacanthum? EISENACK (1931) 1965
Pl. IV:35

Synonyms: *Ovum hispidum polygonale* EISENACK 1931, p. 113, Pl. 4:16, 18, 20. *Hystrichosphaeridium polygonale* EISENACK 1938, p. 12, Pl. 4:1, 2. *Baltisphaeridium polygonale* EISENACK 1959, pp. 199—200, Pl. 16:6. *Veryhachium polygonale* EISENACK 1963, p. 209, Pl. 19:2. *Baltisphaeridium polygonale* forma *polyacantha* EISENACK 1965, pp. 136—137, Pl. 13:3—4. *Goniosphaeridium uncinatum* (DOWNIE 1958) KJELLSTRÖM 1971, pp. 27—28, Fig. 18.

Remarks: The subspherical vesicle has processes with broad base and free communication with the vesicle interior. The only possible *G. uncinatum* (DOWNIE 1958) KJELLSTRÖM 1971 in the present material is combined with *G. polygonale polyacanthum* (EISENACK 1965). These two species differ in the number and length of processes. The surfaces of the vesicle and processes of *G. uncinatum* are echinate according to Cramer (1970), Downie (1958) and Martin (1966a), but the vesicle is psilate and processes echinate as in *G. polygonale polyacantum* (EISENACK 1965) GORKA 1969 according to Kjellström (1971b). The species recorded here has a slightly echinate vesicle and processes and it may be a transitional form between two species. Maybe it is possible to combine these three specimens to *G. tenuispinosum n. sp.* in the Rapla material. The conical form of the processes varies from broad to quite slim, but it clearly communicates with the body cavity. The size of the vesicle is similar to *G. tenuispinosum*, but according to the original diagnosis, the species is smaller in size than *G. polygonale polyacanthum* (ø 50 µ) or *G. uncinatum* of size 30—50 µ.

Dimensions: Vesicle diameter 25—35 µ, length of processes 15—20 µ, width of base 4 µ, distance between processes 15 µ, number of processes 27—30. Specimens measured: 3.

Occurrence: Rare (<0.5 %), in preps. 648, 652 and 654.

Distribution in the Baltic area: Finland, erratic boulders from the Bothnian Sea, Ordovician (Tynni 1975); Åland borehole Middle Ordovician (Tynni 1982b). Sweden: Gotland borehole, Lower Viruan, Middle Ordovician (Kjellström 1971b). Estonia: Odinsholm subsurface, Lower Viruan, Middle Ordovician (Bockelie & Kjellström 1979); Rapla borehole, Volhov to Keila regional stages, Lower to Middle Ordovician (Uutela & Tynni, in preparation).

Ordovician and Silurian Baltic erratics (Eisenack 1931, 1938, 1959a, 1963, 1965a, 1968). Poland: Ordovician erratic boulders and Arenigian, Podborowisko borehole, Lower Ordovician (Gorka 1969).

Goniosphaeridium splendens (PARIS & DEUNFF 1970) TURNER 1984

Pl. V:36

Synonyms: *Veryhachium splendens* PARIS & DEUNFF 1970, p. 27, Pl. 1:4. *Goniosphaeridium splendens* TURNER 1984, pp. 113—114, Pl. 13:14—15.

Remarks: The thin, psilate, polygonal vesicle has 10—18 conical processes. The vesicle and process walls are undifferentiated, merging imperceptibly via a curving contact. No excystment structure is observed. The processes are shorter than the vesicle radius.

The species differs from the original description in being smaller in size and processes are shorter, not longer, than vesicle diameter. There is some disagreement between the text and the given dimensions in the original description. Turner (1984) mentions both smaller and larger specimens (ø 19—35 µ, process length 11—32 µ) and regards the species as a synonym of *Goniosphaeridium polygonale* EISENACK (1931) 1969. Eisenack (1976) regards *G. connectum* KJELLSTRÖM 1971 and *G. conjunctum* KJELLSTRÖM 1971 as synonyms of *G. polygonale*. The present author considers *Veryhachium splendens* PARIS & DEUNFF 1970 and *G. splendens* (PARIS & DEUNFF 1970) TURNER 1984 to be synonyms of the *G. splendens* recorded here.

Dimensions: Vesicle diameter 12—24 µ, process length 6—20 µ. Specimens measured: 100.

Occurrence: Rare to common (0.5—19.5 %).

Distribution in Estonia, Rapla borehole, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian (Uutela & Tynni, in preparation).

Distribution in Europe: Britain: Shropshire, Caradocian, Middle Ordovician (Turner 1984). France: Vieux—Vy-sur-Couesnon Llanvirnian, Middle Ordovician (Paris & Deunff 1970).

Genus HAPSIDOPALLA PLAYFORD 1977

Type species: *H. sannemannii* (DEUNFF 1976) PLAYFORD 1977, p. 25 Pl. 10:7—13, Fig. 13.

Hapsidopalla sp.

Pl. V:37

Description: The subspherical vesicle has a reticulate, rosette-like sculpture. It is covered with numerous simple and bifurcated processes.

Remarks: The specimen resembles *Cheleutochroa gymobrachiata* LOEBLICH & TAPPAN 1978, which is nevertheless larger in size and has only simple processes. *Cratersphaeridium scrucegrovense* (STAPLIN 1961) TURNER 1986 has a foveolate vesicle and the processes have longer and more numerous furcas. The Estonian Rapla material (Uutela & Tynni, in preparation) includes a specimen with less ornamentation of the vesicle and longer processes, and also a slightly larger vesicle diameter.

Dimensions: Vesicle diameter 15 µ, process length 5 µ. Specimens measured: 1.

Occurrence: Rare (<0.5 %), only in prep. 715.

Not recorded at Rapla borehole.

Genus HELOSPHAERIDIUM LISTER 1970

Type species: *H. clavispinosum* LISTER 1970, p. 76.

Helosphaeridium sp.

Pl. V:38

Description: The small, spherical, shagrinate vesicle is covered with short, claviforme processes of variable size. They are unevenly spaced.

Dimensions: Vesicle diameter 12 µ, process height 0.4 µ, process diameter 0.1—0.6 µ. Specimen measured: 1.

Remarks: The species resembles the genus *Rhopaliophora* LOEBLICH & TAPPAN 1971 in having processes of variable size, but differs from *R. foliatilis* in having distinctly smaller processes. The genus *Lophosphaeridium* TIMOFEEV 1959 is not recorded as having claviforme processes, whereas the genus *Helosphaeridium* LISTER 1970 does, but they are evenly-spaced and of equal size. All the above-mentioned genera are larger in size than the present species.

Occurrence: Rare (<0.5 %), only in prep. 655.

Distribution in Estonia, Rapla borehole, Uhaku to Pirgu regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Genus: KUNDASPHAERA n. g.

Type species: *K. lacunosa* UUTELA & TYNNI (in preparation)

Kundasphaera sp.

Pl. V: 39

Description: The spherical to subspherical vesicle is divided into 5—6 fields by striated membranes. The polygons are large and irregular in shape. The membrane is 1/5 of the vesicle diameter in height and is connected to the vesicle by tiny filaments. The vesicle surface is shagrinate to slightly granulate. No pylome is observed.

Dimensions: Vesicle diameter 10—12 µ, membrane height 2—3 µ. Specimens measured: 3.

Remarks: This genus differs from the genus *Pterospermopsis*

(W. WETZEL 1952) SARJEANT 1984 in having membrane-wall all over the vesicle, not only equatorially, and the genus *Cymatiosphaera* W. WETZEL 1933 in having membranes connected to the vesicle by tiny filaments.

Umnova (1975) describes the forms with irregularly placed membranes, not only equatorially, as belonging to the genus *Pterospermopsis*, but they are distinctly larger in size than the present species.

Occurrence: Rare (<0.5 %), only in preps. 654 and 706.

Distribution in Estonia, Rapla borehole, Volhov to Pirgu regional stages, Lower to Upper Ordovician (Uutela & Tynni, in preparation).

Genus LEIOFUSA EISENACK 1938

Restricted by EISENACK 1965, emended and restricted by COMBAZ, LANGE & PANSART 1967 and CRAMER 1970

Type species: *L. fusiformis* (EISENACK) EISENACK 1938, p. 28, Pl. 4, Fig. 10. *Ovum hispidum fusiformis* EISENACK 1934, p. 65, Pl. 4, Fig. 19.

Leiofusa granulacutis LOEBLICH 1970

Pl. V:40

Leiofusa granulacutis LOEBLICH 1970, p. 723—724, Pl. 18:A-E.

Remarks: The granulated, fusiform vesicle has a pointed, simple process at each pole. The species recorded here is referable to the type species presented by Loeblich (1970b), except that the dimensions are smaller.

Dimensions: Vesicle length 20—22 μ, process length 20—22 μ. Specimens measured: 10

Occurrence: Rare (<0.5—0.5 %).

Distribution in the Baltic area: Finland; Åland borehole, Middle Ordovician (Tynni 1982b). Estonia: Rapla borehole, Uhaku to Pirgu regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Distribution outside Europe: U.S.A.: New York, Marplewood shale, Middle Silurian (Loeblich 1970b); Indiana, Eden shale, Upper Ordovician (Colbath 1979).

Leiofusa granulacutis forma *quincunx* n. forma

Pl. V:41

Diagnosis: The central body is fusiform with a long hollow process at each pole, surface ornamented by numerous small scattered grana with a regularly quincucial pattern.

Dimensions: Vesicle length 12 μ, process length 17 μ. Specimens measured: 2.

Remarks: The form differs from *L. granulacutis* LOEBLICH 1970 in having a regularly quincucial grana pattern in its surface ornamentation. Also the dimensions are smaller.

Occurrence: Rare (<0.5 %), only in preps. 652 and 715.

Distribution in Estonia, Rapla borehole, Vormsi to Pirgu regional stages, Upper Ordovician (Uutela & Tynni, in preparation).

Genus LEIOSPHAERIDIA EISENACK 1958 emended by DOWNIE & SARJEANT 1963

Type species: *L. baltica* EISENACK 1958, p. 8, Pl. 2, Fig. 5.

Leiosphaeridia sp. 1.

Pl. V:42

Description: The subspherical vesicle is wrinkled so that they form four to seven polygonal areas with irregular shape. The surface of the vesicle is shagrinate to slightly granulate.

Dimensions: Vesicle diameter 16—30 μ. Specimens measured: 20.

Remarks: Fromm and Kjellström (1976) describes *Leiosphaeridia sp.* similarly wrinkled from the Lower Ordovician deposits of Ljungsbro, Central Sweden.

Occurrence: Common (10.0 %), but only in prep. 663, absent elsewhere.

Leiosphaeridia spp.

Pl. V:43

Remarks: Specimens assignable to this genus are moderate to common in all the positive samples. Diameter varies from 6 to 180 μ. The genus *Leiosphaeridia* is treated collectively here without identification to species because it is of no importance as a dating species. For the same reason it is not included in the percentage ratios.

Ordovician *Leiosphaeridia baltica* EISENACK 1958 has not been recorded in the present material.

Specimens measured: 3557.

Genus LEIOVALIA EISENACK 1965

Type species: *(Leiofusa=) L. ovalis* (EISENACK 1938, pp. 28—29, Pl. 4:9).

Leiovalia ovalis EISENACK (1938) 1965

Pl. V:44

Synonym: *Leiofusa ovalis* EISENACK 1938, pp. 28—29, Pl. 4:9.

Remarks: The thin psilate, oval vesicle has rounded poles and is more circular in form than *Leiovalia similis* EISENACK 1965. The length-width ratio varies 1.7—1.8:1 and is a little larger than in the original description. The dimensions are also more variable.

Dimensions: Length 36—100 μ, width 12—55 μ. Specimens measured: 11.

Occurrence: Rare (<0.5 %) in preps. 663, 695 and 697.

Distribution in the Baltic area: Poland: Podborowisko borehole, Upper Tremadocian, Lower Ordovician (Gorka 1969). Baltic erratics, Lower to Middle Ordovician (Eisenack 1938, 1959a, 1968).

Leiovalia similis EISENACK 1965

Pl. VI:45

Leiovalia similis EISENACK 1965, pp. 139—140, Pl. 12:5, 6.

Remarks: The thin, oval vesicle has rounded poles. The length-width ratio varies 2.0—3.0:1 (2.2—2.5:1 in the original diagnosis).

Dimensions: Length 32—125 μ, width 15—55 μ. Specimens measured: 62.

Occurrence: Rare to moderate (<0.5 %—8.5 %, usually under 2.0 %).

Distribution in the Baltic area: Finland, erratics from the

Bothnian Sea, Ordovician (Tynni 1975); Åland borehole Middle Ordovician (Tynni 1982b). Estonia: Rapla borehole, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian (Uutela & Tynni, in preparation). Ordovician Baltic erratics (Eisenack 1965a).

Distribution outside Europe: U.S.A.: Kentucky, Clays Ferry Formation, Upper Ordovician (Jacobson 1978).

Genus LOPHOSPHAERIDIUM TIMOFEEV 1959 emended by LISTER 1970

Type species (designated by DOWNIE 1963): *L. rarum* TIMOFEEV 1959, p. 29, Pl. 2:5.

Lophosphaeridium citrinipeltatum CRAMER & DIEZ 1972
Pl. VI:46

Lophosphaeridium citrinipeltatum CRAMER & DIEZ 1972, pp. 166—167, Pl. 35:58, 59.

Remarks: The light yellow spherical or subspherical vesicle is covered with small tubercles without any definite pattern. The vesicle wall is thin and often folded. The dimensions vary more than in the original description (ø 30—50 μ), larger specimens also being found here.

Dimensions: Vesicle diameter 30—96 μ. Specimens measured: 30.

Occurrence: Rare to moderate (0.5 %—3.5 %).

Distribution in the Baltic area: Finland: Ordovician erratic boulders from the Bothnian Sea (Tynni 1975); Åland borehole, Middle Ordovician (Tynni 1982b). Estonia: Rapla borehole, Volhov to Juuru regional stages, Lower Ordovician to Lower Silurian (Uutela & Tynni, in preparation).

Distribution outside Europe: U.S.A. and Canada, Silurian (Cramer & Diez 1972).

Lophosphaeridium papillatum (STAPLIN 1961) DOWNIE 1963
Pl. VI:47

Synonyms: *Protoleiosphaeridium papillatum* STAPLIN 1961, pp. 406—407, Pl. 48:10, 11. *Lophosphaeridium* cf. *P. papillatum* DOWNIE 1963, pp. 629—631, Pl. 92:12. *Leiosphaeridia papillata* DOWNIE & SARJEANT 1964, p. 125. *Lophosphaeridium papillatum* BAIN & DOUBINGER 1965, p. 18, Pl. 1:4, 5.

Remarks: The spherical to subspherical vesicle is covered with blunt tubercles of variable size and without any definite pattern. The vesicle diameter is very much smaller than in the original diagnosis (ø 27—38 μ), but Rauscher (1973) has also recorded smaller individuals (ø 15—30 μ). In contrast, Gorka (1979) has described distinctly larger individuals (44—64 μ).

Dimensions: Vesicle diameter 7—28 μ, maximum heigth of papillae 0.2 μ. Specimens measured: 73.

Occurrence: Rare to moderate (<0.5 %—4.8 %).

Distribution in the Baltic area: Estonia, Rapla borehole, Volhov to Pirgu regional stages, Lower to Upper Ordovician (Uutela & Tynni, in préparation). Poland: Olsztyn borehole, Llanvirnian to Llandeilian, Middle Ordovician (Gorka 1979). Distribution in Europe: Britain: Lower Silurian (Downie 1963). Belgium: Silurian (Martin 1966a, 1967, 1968). France: Silurian (Moreau—Benoit 1974); Montagne Noire and May-sur-Orne, Middle Ordovician (Rauscher 1973).

Distribution outside Europe: Canada: Alberta, Upper Devonian (Staplin 1961).

Lophosphaeridium pilosum DOWNIE 1963
Pl. VI:48

Lophosphaeridium pilosum DOWNIE 1963, p. 631, Pl. 92:2.

Remarks: The spherical vesicle is covered with closely spaced solid spines.

Dimensions: Vesicle diameter 24—40 μ, spine length 2,5—4 μ. Specimens measured: 25.

Occurrence: Rare to moderate (0.5—2.0 %).

Distribution in Estonia, Rapla borehole, Volhov to Pirgu regional stages, Lower to Upper Ordovician (Uutela & Tynni, in preparation).

Distribution in Europe: U.S.S.R.: Moscow syneclise, Ordovician (Umnova 1975). Britain: Wenlock, Wenlockian, Silurian (Downie 1963). France: Anjou, Siegenian and Emsian, Devonian (Moreau-Benoit 1967). Czechoslovakia, Klabava shales, Arenigian, Lower Ordovician (Vavrdova 1972).

Genus MICRHYSTRIDIUM (DEFLANDRE 1937) DOWNIE & SARJEANT 1963

Type species: *M. inconspicuum* DEFLANDRE 1937, p. 79, = *Hystrichosphaera inconspicua* DEFLANDRE 1935, p. 233, Pl. 9, figs. 11, 12.

Micrhystridium henryi PARIS & DEUNFF 1970
Pl. VI:49

Micrhystridium henryi PARIS & DEUNFF 1970, pp. 31—32, Pl. 2:2, 10, 14, 15, 18; 3:7.

Remarks: The small, spherical is covered with small processes. It differs from *M. nannacanthum* DEFLANDRE 1942 in having longer processes with wider bases. Remarkably common in the present material and in Estonia, Rapla borehole in view of the fact that it has not been recorded earlier in the Baltic area.

Dimensions: Vesicle diameter 8—20 μ, only one individual as small as 4 μ, length of processes 2—5 μ, base of processes 2—3 μ. Specimens measured: 258.

Occurrence: Rare to common (0.7 %—19.5 %).

Distribution in Estonia, Rapla borehole, Kunda to Juuru regional stages, Lower/Middle Ordovician to Lower Silurian (Uutela & Tynni, in preparation).

Distribution in Europe: France: Brittany, Llanvirnian (Paris & Deunff 1970); May-sur-Orne, Llanvirnian, Middle Ordovician (Raucher 1973).

Micrhystridium inconspicuum aremoricanum PARIS & DEUNFF 1970
Pl. VI:50

Micrhystridium inconspicuum aremoricanum PARIS & DEUNFF 1970 p. 32, Pl. 2:20

Remarks: The small, spherical vesicle has numerous conical, short processes. According to the original diagnosis the maximum length of the processes is a half of the vesicle diameter, but the length is 1/2—2/3 of the diameter in this material. Thirty processes of variable size can be seen distinctly in the optical section, some bifurcated, but most simple. All the specimens have collapsed inwards.

Dimensions: Vesicle diameter 10—15 μ, length of processes 5—8 μ. Specimens measured: 3.

Occurrence: Rare (<0.5 %).

Distribution in Estonia, Rapla borehole, Uhaku to Keila regional stages, Middle Ordovician (Uutela & Tynni, in preparation).

Distribution in Europe: France: Brittany, Llanvirnian, Middle Ordovician (Paris & Deunff 1970).

Micrhystridium nannacanthum DEFLANDRE 1942
Pl. VI:51

Micrhystridium nannacanthum DEFLANDRE 1942, p. 476, Fig. 13.

Remarks: The small, spherical vesicle is covered with tiny spines. In the present material a median split is a common feature, its length sometimes exceeding 2/3 of the vesicle diameter. Dimensions are more variable than in the original diagnosis (ø 10—14 μ).

Dimensions: Vesicle diameter 6—20 μ, length of processes about 1 μ. Specimens measured: 2193.

Occurrence: Rare to dominant (0.7—76.0 %).

Distribution in the Baltic area: Finland, erratics from the Bothnian Sea, Ordovician (Tynni 1975); Åland borehole, Middle Ordovician (Tynni 1982b). Estonia: Rapla borehole, Volhov to Juuru regional stages (Uutela & Tynni, in preparation).

Also reported in many Ordovician to Silurian deposits in Europe (Eisenack *et al.* 1979a).

Micrhystridium robustum DOWNIE 1958
Pl. VI:52

Micrhystridium robustum DOWNIE 1958, p. 344, Pl. 17:5, Figs. 3 a, b.

Remarks: The spherical vesicle is granulated and covered with hollow, psilate processes of length is 1/3 to 1/1 of the vesicle diameter and numbering 22 in an optical section. The species differs from the original diagnosis on having some branched processes.

The species differs from *Cheleutochroa gymnobrachiata* LOEBLICH & TAPPAN 1978, which is larger in size and has simple processes. *Percultisphaera stiphospinata* LISTER 1970 has shorter and slimmer processes, and *Multiplicisphaeridium areolatum granulosum* JARDINE, COMBAZ, MAGLOIRE, PENIQUEL & VACHEY 1974 has a basal constriction in each process, as does *Micrhystridium pellitum* MARTIN 1975.

Dimensions: Vesicle diameter 15—20 μ, process length 10—15 μ. Specimens measured: 3.

Occurrence: Rare (<0.5 %), only in preps. 652, 654 and 715.

Distribution in Europe: Belgium: Tremadocian and Ordovician/Silurian deposits (Martin 1966b, 1968, 1973). Britain: Shineton shales, Lower Tremadocian, Lower Ordovician (Downie 1958). France: Montagne Noire, Arenigian, Lower Ordovician (Rauscher 1973).

Micrhystridium stellatum DEFLANDRE 1942
Pl. VI:53

Micrhystridium stellatum DEFLANDRE 1942, p. 476, Fig. 7, 8.

Remarks: The spherical vesicle has numerous conical processes. The description conforms to the original diagnosis, except that the wall is dark yellow in colour and only exceptionally brownish and the spines are the same colour and never almost black. The dimensions are more variable than in the original diagnosis (ø 11—16 μ). Martin (1966a, b, 1968) also describes smaller forms (ø 9—20 μ) but with longer processes (1.5 x vesicle diameter).

Dimensions: Vesicle diameter 8—20 μ, length of processes 6—15 μ, width of processes 1—4 μ, distance between processes 2—6 μ, number of processes 6—28. Specimens measured: 589.

Occurrence: Rare to dominant (1.0 %—61.8 %, usually under 10.0 %).

Distribution in the Baltic area: Finland: Ordovician erratics from the Bothnian Sea (Tynni 1975); Åland borehole, Middle Ordovician (Tynni 1982b). Estonia: Rapla borehole, Kunda to Juuru regional stages, Lower/Middle Ordovician to Lower Silurian (Uutela & Tynni, in preparation).

Also reported in many Ordovician to Silurian deposits in Europe (Eisenack *et al.* 1979a).

Genus MULTIPLICISPHAERIDIUM STAPLIN 1961
Type species: *M. ramispinosum* STAPLIN 1961, p. 411, Pl. 48, Fig. 24, Text-Fig. 9 (g—h).

Multiplicisphaeridium alloiteaui DEUNFF 1955
Pl. VII:54

Synonyms: *Micrhystridium alloteaui* DEUNFF 1955, p. 148, Pl. 4:3. *Micrhystridium* cf. *alloiteaui* DEUNFF 1958, p. 32, Pl. 7:67; 10:94, 95. *Baltisphaeridium alloiteaui* DOWNIE & SARJEANT 1963, p. 89. *Micrhystridium raspa* MARTIN 1965, p. 7, Fig. 5. *Hystrichosphaeridium, Micrhystridium* cf. *alloiteaui* LISTER, COCKS & RUSHTON 1969, p. 602. *(Ammonidium =) Multiplicisphaeridium rigidium ludlovensis* LISTER 1970, p. 50. Pl. 1, Figs. 6, 12—14.

Remarks: The small spherical vesicle is covered with numerous small bifurcated or trifurcated processes. The vesicle wall is thick and possesses an excystment structure in the form of a partial rupture.

The present species differs from *M. palmitella* (CRAMER & DIEZ 1972) in having less numerous processes with trifurcated distal terminations. It resembles *M. saharicum* LISTER 1970, but has more numerous processes with furcated distal terminations. *M. waldronensis* TAPPAN & LOEBLICH 1971 has longer and less numerous processes with six small branches. The species differs from all previously mentioned species, being smaller in size, since the diameter of *M. alloteaui* is in range 25—30 μ according to the original description.

Dimensions: Vesicle diameter 8—28 μ, length of processes 2—6 μ, width of processes 1—2 μ. Specimens measured: 34.

Occurrence: Rare to moderate (<0.5 %—3.0 %, usually under 1.0 %).

Distribution in the Baltic area: Finland: Ordovician erratic boulders from the Bothnian Sea (Tynni 1975): Åland borehole, Middle Ordovician (Tynni 1982b). Sweden: Östergötland, Ekön borehole, Lower Viruan, Middle Ordovician (Kjellström 1976). Estonia: Rapla borehole, Volhov to Pirgu regional stages, Lower to Upper Ordovician (Uutela & Tynni, in preparation).

Distribution elsewhere in Europe: Belgium: Kortrijk Ordovician (Martin 1966a, 1968). Britain: Kent, Caradocian (Lister *et. al* 1969).

Recorded also in Middle Devonian deposits in Canada (Deunff 1955).

Multiplicisphaeridium bifurcatum STAPLIN, JANSONIUS & POCOCK 1965
Pl. VII:55

Multiplicisphaeridium bifurcatum STAPLIN, JANSONIUS & POCOCK 1965, p. 182, Pl. 18:13.

Remarks: The spherical to subspherical vesicle has numerous bifurcated processes. The species recorded here has processes shorter than a half of the diameter. Bifurcation of the pocesses is irregular and the branches are variable in length. Some very small individuals are also recorded.

Thusu (1973) also describes a species *Multiplicisphaeridium bifurcatum (ex-Filisphaeridium bifurcatum),* the genus has been changed by Eisenack *et al.* (1976, p. 449, maybe by mistake), with rather short processes and it is different from the species of Staplin *et al.* (1965).

Dimensions: Vesicle diameter 8—30 μ, length of processes 4—20 μ, distance between processes 4—14 μ. Specimens measured: 95.

Occurrence: Rare (<0.5—1.5 %).

Distribution in the Baltic area: Finland: erratics from the Bothnian Sea, Ordovician (Tynni 1975); Åland borehole, Middle Ordovician (Tynni 1982b). Estonia: Rapla borehole, Kunda to Juuru regional stages, Lower/Middle Ordovician to Lower Silurian (Uutela & Tynni, in preparation).

Distribution outside Europe: Canada: Anticosti Island, subsurface, Middle Ordovician (Staplin *et. al* 1965); Quebec, Caradoc and Ashgill (Martin 1980). U.S.A.: Central North America, Middle and Upper Ordovician (Loeblich & Tappan 1978).

Multiplicisphaeridium irregulare STAPLIN, JANSONIUS & POCOCK 1965
Pl. VII:56

Multiplicisphaeridium irregulare STAPLIN, JANSONIUS & POCOCK 1965, p. 183, Pl. 18:17, 18.

Remarks: The subspherical vesicle has numerous irregularly furcated processes. The processes in some individuals are a little firmer in the present material than in the original diagnosis.

Dimensions: Diameter 15—20 μ, length of processes 10—20 μ, number of processes 5—10. Specimens measured: 6.

Occurrence: Rare to moderate (<0.5—11.0 %).

Distribution in the Baltic area: Finland: erratics from the Bothnian Sea, Ordovician (Tynni 1975). Estonia: Rapla borehole, Kunda to Juuru regional stages, Lower/Middle Ordovician to Lower Silurian (Uutela & Tynni, in preparation).

Distribution in Europe: U.S.S.R.: Moscow syneclise, Caradocian, Middle Ordovician (Umnova 1975). Belgium: Silurian (Martin 1968).

Distribution outside Europe: Canada: Anticosti Island, subsurface, Middle Ordovician (Staplin *et. al* 1965); Quebec, Caradoc and Ashgill (Martin 1980). U.S.A.: Central North America, Middle and Upper Ordovician (Loeblich & Tappan 1978).

Multiplicisphaeridium radicosum LOEBLICH 1970
Pl. VII:57

Multiplicisphaeridium radicosum Loeblich 1970, p. 730, Figs. 23 A—E.

Remarks: The vesicle is subcircular, thin-walled and wrinkled, with the processes communicating with the vesicle cavity. The processes have bifurcated or trifurcated, usually blunt, sometimes acuminate, distal terminations. According to the catalogue of Eisenack *et al.* (1973) it is a junior synonym of *M. corallinum* EISENACK 1959, but the present writer is inclined to disagree because of the different nature of the processes.

The species recorded here differs from *M. digitatum* EISENACK 1938, which has more clearly separated processes with longer, acuminate branches. *M. corallinum* EISENACK 1959 has long processes which are more branched. It bears a greater resemblance to *M. visbyense* EISENACK 1959, but the processes separate more clearly from the vesicle. *M. visbyense* is of considerable size.

Dimensions: Vesicle diameter 40—70 μ, length of processes 9—24 μ. Total diameter in 100 μ. Specimens measured: 6.

Occurrence: Moderate (6.3 %), but only in prep. 718, elsewhere absent.

Distribution in Estonia, Rapla borehole, Keila and Vormsi regional stages, Middle and Upper Ordovician (Uutela & Tynni, in preparation).

Distribution outside Europe: U.S.A.: Oklahoma, Sylvan Shale, Upper Ordovician (Loeblich 1970b). Canada: Montreal and Quebec, Ordovician (Martin 1983).

Multiplicisphaeridium ramusculosum ramusculosum (CRAMER & DIEZ 1972)
Pl. VII:58

Synonym: *Baltisphaeridium ramusculosum ramusculosum* Cramer & Diez 1972, pp. 156—157, Pl. 35:41, fig. 8.

Remarks: The spherical vesicle has clearly differentiated and irregularly branched processes. The number of processes seen in an optical section is 11. All the specimens recorded are smaller than in the original description (ø 40—55 μ), and not all of the processes exceed the vesicle diameter.

Dimensions: Vesicle diameter 15 μ, process length 8—20 μ. Specimens measured: 3.

Occurrence: Rare (<0.5 %), only in preps. 652 and 654.

Distribution outside Europe: U.S.A.: Ohio, Kentucky, Indiana, Maine and Canada: Quebec, all Llandoverian, Lower Silurian (Eisenack *et al.* 1973).

Multiplicisphaeridium raspa CRAMER 1964
Pl. VII:59

Synonyms: *Baltisphaeridium raspa* CRAMER 1964, Pl. 2:16—19. *Micrhystridium raspa* DEFLANDRE & DEFLANDRE 1965, fiches 2488, 2489.

Remarks: The spherical vesicle has numerous conical processes which may furcate to the second or third order. The individuals recorded are similar to those of Cramer (1964) and the description conforms to the original diagnosis.

Dimensions: Vesicle diameter 10—12 μ, length of processes 2—4 μ. Specimens measured: 3.

Occurrence: Rare (<0.5—0.5 %), in preps. 654, 663 and 704.

Distribution of the Baltic area: Finland: Åland borehole, Middle Ordovician (Tynni 1982b). Estonia: Rapla borehole, Kunda to Pirgu regional stages, Lower/Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Distribution in Europe: Spain: Leon, Devonian (Cramer 1964). Belgium: Ordovician and Silurian (Martin 1966a, b, 1968). France: Montagne Noire, Arenigian, Lower Ordovician (Rauscher 1973).

Distribution outside Europe: U.S.A.: Indiana, Eden Shale borehole, Upper Ordovician (Colbath 1979).

Multiplicisphaeridium sp 1.
Pl. VII:60

Description: The thick spherical vesicle is densely covered with short processes, of average length 1/10 of the vesicle diameter. The processes are slightly branched palmately at their distal point. The surface of the vesicle is irregularly verrucate, visible only by the electron microscope, and the processes are psilate. The processes do not communicate with the interior of the vesicle. The excystment structure forms a median split.

Dimensions: Vesicle diameter 25—38 μ, process length 2—3 μ, wall thickness 0.5 μ. Specimens measured: 22.

Remarks: The species found in the present material has the same kind of processes as *M. gotlandicum* (EISENACK 1954) EISENACK, CRAMER & DIEZ 1973, but differs in having more of them, and also a granulated surface, and being smaller in size. *Peteinosphaeridium breviradiatum* EISENACK (1959) 1969 has less obviously furcated processes and a round pylome, with no median split.

Occurrence: Rare to common (0.5—12.0 %), only in preps. 648 and 654.

Distribution in Estonia, Rapla borehole, Kunda to Nabala regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Multiplicisphaeridium sp. 2.
Pl. VII:61

Description: The small, spherical vesicle is covered with numerous, small regularly palmately branched processes which communicate freely with the interior of the vesicle. The vesicle surface and processes are psilate.

Dimensions: Vesicle diameter 9—12 μ, length of processes 1.5—2.0 μ, width of processes 0.3—0.5 μ, distance between processes 1—2 μ, number of processes visible in equatorial section 40—100. Specimens measured: 2.

Remarks: The species closely resembles *Multiplicisphaeridium palmitella* CRAMER & DIEZ 1972, but furcation of the processes is regularly palmate, forming six small branches as in *M. waldronensis* TAPPAN & LOEBLICH 1971, but differing from the latter in having a greater number of processes which nearly join together. It also resembles *M. carrascum* CRAMER 1967, but its processes are not regularly furcated and it is still larger in size. The species recognized here is distinctly smaller size than those mentioned before.

Occurrence: Rare (<0.5 %). Specimens are so small that they can be discerned only in the SEM image. They may thus be more common than indicated here.

Distribution in Estonia, Rapla borehole, Kunda to Pirgu regional stages, Lower/Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Genus NANOCYCLOPIA LOEBLICH & WICANDER 1976
Type species: *N. aspiratilis* LOEBLICH & WICANDER 1976, pp. 18—19, Pl. 6:4—7.

Nanocyclopia sp.
Pl. VII:62

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, but a small, round pylome opening is also recorded. The vesicle wall is thick.

Dimensions: Vesicle diameter 26—80 μ, wall thickness 2—6 μ, operculum diameter 10—22 μ, pylome diameter 3—5 μ. Specimens measured: 13.

Remarks: The species resembles the genus *Nanocyclopia* LOEBLICH & WICANDER 1976, but it is impossible to verify by electron microscopy whether a fimbriate margin exists as is seen by light microscopy. Some of the specimens in the present material also have a small, round pylome in addition to the thicker, slightly elevated area of the operculum. The ornamentation of the vesicle also resembles that of the genus *Lophosphaeridium* TIMOFEEV 1959, but covers it more densely.

Occurrence: Rare (0.5—1.5 %).

Distribution in Estonia, Rapla borehole, Volhov to Pirgu regional stages, Lower to Upper Odovician (Uutela & Tynni, in preparation).

Genus NODUSOSPHAERIDIUM n.g.
Type species; *N. rubus* n. sp., here designated.

Nodusosphaeridium rubus n. sp.
Pl. VIII:63

Diagnosis: The subspherical vesicle has a large pylome, equal on average to a half of the vesicle diameter. The vesicle is covered with numerous outward swellings of variable size, which carry small, thin, bifurcated processes which do not communicate with the swelling. The vesicle surface is psilate.

Dimensions: Vesicle diameter 40 μ, pylome diameter 23 μ, swelling diameter 3—5 μ, process length 3.5 μ. Specimens measured: 1.

Remarks: The genus *Stelliferidium* DEUNFF, GORKA & RAUSCHER 1974 has a large pylome but its ornamentation has a striated pattern. The genus *Cymatiogalea* DEUNFF 1961 also has a large pylome, but the processes form a polygonal pattern on the vesicle surface. *Multiplicisphaeridium mutabile* (SANNEMAN 1955) EISENACK, CRAMER & DIEZ 1973 and *Vulcanisphaera (=ex-Baltisphaeridium) tuberata* (DOWNIE 1958) EISENACK, CRAMER & DIEZ 1973 have larger outward swellings with a communicating process and no pylome.

Occurance: Rare (<0.5 %), only in prep. 712.

Not recorded at Rapla borehole.

Derivation of name: *Nodus* L. a rounded swelling, *sphaeridium* L. spherical, *rubus* L.raspberry.

Holotype: GSF prep. 712. The specimen is illustrated on Pl. VIII:63

Locus typicus: Erratic boulder from Kalanti, OTR-21-NKK, Middle Orcovician.

Genus ORTHOSPHAERIDIUM EISENACK 1968 emended by KJELLSTRÖM 1971
Type species: *O. (ex-Baltisphaeridium) rectangulare* EISENACK 1963, P. 211, PL 20:1.

Orthosphaeridium densiverrucosum KJELLSTRÖM 1971 Pl. VIII:64

Orthosphaeridium densiverrucosum KJELLSTRÖM 1971, p. 30, Fig. 20.

Remarks: The vesicle is slightly angular and almost divided in half by a partial rupture. It is covered with strong spinules, and the processed by smaller ones. The constricted proximal process junction has solid plugs at the base with the vesicle. The vesicle wall is thinner and the 6 processes are slimmer than those described by Kjellström (1971a) and Gorka (1980).

Loeblich and Tappan (1971) note the strong ornamentation and less numerous processes on the genus *Orthosphaeridium* as a typical feature in the lower part of the Middle Ordovician, whereas number of processes increases in younger deposits. This pattern does not hold good in the Baltic area.

Dimensions: Vesicle diameter 40 x 50—50 x 60 μ, length of processes 20—40 μ, width of processes 5 μ. Specimens measured: 2.

Occurrance: Rare (<0.5 %), only in preps. 648 and 652.

Distribution in the Baltic area: Sweden: Gotland borehole, Lower Viruan, Middle Ordovician (Kjellström 1971b). Estonia: Rapla borehole Aseri to Oandu regional stages, Middle Ordovician (Uutela & Tynni, in preparation). Poland: Strabala borehole, Llanvirnian, Middle ordovician (Gorka 1980).

Not recorded outside the Baltic area.

Orthosphaeridium insculptum LOEBLICH 1970
Pl. VIII:65

Orthosphaeridium insculptum LOEBLICH 1970, pp. 734—735, Pl. 30:A—E.

Remarks: The subquadratic vesicle has eigth distally whip-like processes and is ornamented with grana. The processes are slightly granulated, with psilate distal terminations and seem to be equal in length but of varying width.

Dimensions: Vesicle diameter 50 μ, length of processes 55—80 μ, width of processes 8 μ, number of processes 8. Specimens measured: 3.

Occurrence: Rare (<0.5 %), only in preps. 652 and 654.

Distribution in Estonia: Rapla borehole, Aseri to Pirgu regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Distribution outside Europe: U.S.A.: Sylvan shale, Upper Ordovician (Loeblich 1970b). Canada: Quebeck, Caradocian and Ashgillian, Middle and Upper Ordovician (Martin 1980).

Orthosphaeridium vibrissiferum LOEBLICH & TAPPAN 1971
Pl. VIII:66

Orthosphaeridium vibrissiferum LOEBLICH & TAPPAN 1971, pp. 186—188, fig. 7—12.

Remarks: The subquadratic vesicle has four long processes. The vesicle and processes are granulated from the base to the middle, but the ornamentation is not so pronounced as in the individuals described by Loeblich and Tappan (1971). The processes exceed the vesicle diameter.

Dimensions: Vesicle diameter 45—60 μ, length of processes 50—80 μ, width of processes 7—10 μ, number of processes 4 (5 in one specimen). Specimens measured: 3.

Occurrence: Rare (<0.5 %), only in preps. 648, 654 and 701.

Distribution in the Baltic area: Estonia: Rapla borehole, Aseri to Pirgu regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation). Poland: Olsztyn borehole, Caradocian, Middle Ordovician (Gorka 1979).

Distribution outside Europe: U.S.A.: Oklahoma, Bromide Formation, Middle Ordovician (Loeblich & Tappan 1971).

Genus PETEINOSPHAERIDIUM STAPLIN, JANSONIUS & POCOCK 1965 emended EISENACK 1969

Type species: *P. trifurcatum (ex-bergströmii)* STAPLIN, JANSONIUS & POCOCK 1965, p. 194, Pl. 20:13.

Peteinosphaeridium heteromorphicum KJELLSTRÖM 1971
Pl. VIII:67

Peteinosphaeridium heteromorphicum KJELLSTRÖM 1971, p. 53, Pl. 4:2.

Remarks: The spherical vesicle has two different types of processes, which do not communicate with the interior of the vesicle. Process length varies more than in the species described by Kjellström (1971a), some individuals being as small as 30 μ in diameter (67—76 μ in the original diagnosis).

Dimensions: Vesicle diameter 30—60 μ, length of processes 8—30 μ, width of processes 2—6 μ, distance between processes 7—20 μ, number of processes 9—21. Specimens measured: 17.

Occurrence: Rare to moderate (<0.5 %—3.5 %, usually under 1.0 %).

Distribution in the Baltic area: Finland: erratic boulders from the Bothnian Sea, Ordovician (Tynni 1975); Åland borehole, Ordovician (Tynni 1982b). Sweden: Gotland borehole, Lower Viruan, Middle Ordovician (Kjellström 1971a). Estonia: Rapla borehole, Aseri to Pirgu regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Peteinosphaeridium micranthum (EISENACK 1959)
Pl. VIII:68

Synonym: *Baltisphaeridium micranthum* EISENACK 1959, p. 203, Pl. 17:13.

Remarks: The spherical vesicle wall is thick and densely covered with short, slender processes with furcated distal terminations. A circular pylome is often recorded. The species differs from *Axisphaeridium tricolumnelare n. sp.* in having processes of different kinds, they may be triangled or quadratic-shaped in the same individual and have broad or furcated distal terminations. The pylome is large.

Dimensions: Vesicle diameter 40—80 μ, length of processes 2—6 μ, pylome diameter 20 μ. Specimens measured: 5.

Occurrence: Rare (0.5—1.0 %).

Distribution in the Baltic area: Finland: Ordovician erratics from the Bothnian Sea (Tynni 1975). Estonia: Reval (=Tallinn), Megalaspis limestone, B_{II}, Lower Ordovician (Eisenack 1959a); Rapla borehole, Kunda to Johvi regional stages, Lower/Middle to Middle Ordovician (Uutela & Tynni, in preparation).

Peteinosphaeridium nanofurcatum KJELLSTRÖM 1971
Pl. VIII:69

Peteinosphaeridium nanofurcatum KJELLSTRÖM 1971, p. 55, Pl. 4:5.

Remarks: The spherical vesicle has numerous small, bifurcated processes with bulbous distal terminations. Description conforms to the original one except that the processes are a little longer, 1/10 of the vesicle diameter.

Dimensions: The only specimen is smaller than in the original description (ø 60—71 μ), vesicle diameter 54 μ, length of processes 5 μ, width of processes 1 μ, distance between processes 5 μ. Specimens measured: 2.

Occurrence: Rare (<0.5—0.7 %), only in preps. 712 and 715.

Distribution in the Baltic area: Sweden: Gotland borehole, Lower Viruan, Middle Ordovician (Kjellström 1971a). Estonia: Odinsholm subsurface, Lower Viruan, Middle Ordovician (Bockelie & Kjellström 1979); Rapla borehole, Kukruse regional stage, Middle Ordovician (Uutela & Tynni, in preparation).

Not recorded outside the Baltic area.

Peteinosphaeridium nudum (EISENACK 1959) 1969
Pl. VIII:70

Synonyms: *Baltisphaeridium trifurcatum nudum* EISENACK 1959, p. 203, Pl. 17:4—6. *Baltisphaeridium trifurcatum* forma *nuda* DOWNIE & SARJEANT 1963, p. 90. *Baltisphaeridium trifurcatum* subsp. *nudum* DOWNIE & SARJEANT 1964, p. 98. *Baltisphaeridium nudum* STAPLIN, JANSONIUS & POCOCK 1965, pp. 190—191, Pl. 20:2, 6—8, fig. 12. *Peteinosphaeridium nudum* EISENACK 1969, p. 25. *Ordovicium elegantulum* TAPPAN & LOEBLICH 1971, pp. 398—400, Pl. 7: 1—7.

Remarks: The spherical vesicle of the present species has both a psilate and a granulate surface. The species *Ordovicium elegantulum* TAPPAN & LOEBLICH 1971 and *P. nudum* EISENACK (1959) 1969 are combined here because the granulation of the vesicle and processes is too slight to enable identification as *O. elegantulum*. The granules are distinctly smaller than in the species described by Tappan and Loeblich (1971). *P. nudum* has slimmer processes than *O. elegantulum*, but no difference in the width of the processes exists here between the granulated and psilate forms. No inconsistency in dating arises from the decision to combine these two species. Martin (1973) describes some still smaller individuals (ø 22—45 µ) than in the present study.

Dimensions: Vesicle diameter 33—68 µ, length of processes 4—30 µ, width of processes 2—4 µ, distance between processes 6—26 µ, number of processes 7—24. 97 % of the species are smaller than 60 µ in size. Specimens measured: 38.

Occurrence: Rare to moderate (0.5 %—4.5 %).

Distribution in the Baltic area: Finland: erratic boulders from the Bothnian Sea, Ordovician (Tynni 1975); Åland borehole, Middle Ordovician (Tynni 1982b). Sweden: Gotland borehole (Kjellström 1971a); Öland borehole (Kjellström 1972); Västergötland borehole (Kjellström 1976), all Lower Viruan, Middle Ordovician. Estonia: Odinsholm subsurface, Lower Viruan, Middle Ordovician (Bockelie & Kjellström 1979); Rapla borehole, Lasnamägi to Pirgu regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation). Estonia and Latvia, Middle Ordovician (Umnova 1975). Poland: Zebrac borehole, Llandeilian and Mielnik borehole, Caradocian (Gorka 1969); Olsztyn borehole, Llanvirnian to Caradocian (Gorka 1979); Strabala borehole, Llanvirnian, all Middle Ordovician (Gorka 1980).

Distribution in Europe: France: Montagne Noire, Arenigian (Rauscher 1973). Belgium: Deerlijk, Ordovician and Silurian (Martin 1973). Bulgaria: Iskar Gorge, Caradocian, Middle Ordovician (Kalvacheva 1986).

Peteinosphaeridium parvispinosum n. sp.
Pl. VIII:71

Diagnosis: The spherical vesicle has a dense covering of numerous short, thin, trifurcated processes which do not communicate with the interior of the vesicle. No pylome is observed.

Dimensions: Vesicle diameter 25—40 µ, process length 4—5 µ, furca length 0.5—1 µ, wall whickness 0.5 µ. Specimens measured: 4.

Remarks: The species resembles *P. hystrichoreticulatum* (EISENACK 1938) EISENACK, CRAMER & DIEZ 1973 in having small hairy processes, but differs in the absence of reticulate areas on the vesicle. It also differs from *P. breviradiatum* EISENACK (1959) 1969 in having thinner and more numerous processes. *Baltisphaeridium multipilosum* EISENACK (1931) 1958 has simple processes, not trifurcated.

Occurrence: Rare (<0.5 %), in preps. 648, 654 and 715.

Not recorded at Rapla borehole.

Derivation of name: *Parvi* L. small, *spinosum* L. process.

Holotype: GSF prep. 648, The specimen is illustrated on Pl. VIII:71.

Locus typicus: Erratic from the island of Spikarna, Hanko, southwestern Finland, Middle Ordovician.

Peteinosphaeridium paucifurcatum (EISENACK 1959)
Pl. IX:72

Synonyms: *Baltisphaeridium trifurcatum* forma *paucifurcatum* EISENACK 1959, p. 203, Pl. 17:8—10, fig. 10. *Baltisphaeridium bifurcatum paucifurcatum* STOCKMANS & WILLIERE 1960, p. 5. *Peteinosphaeridium paucifurcatum* EISENACK *et al.* 1973, p. 919.

Remarks: The spherical, rather thick, shagrinate vesicle has slender, psilate processes, smaller than the vesicle diameter. The processes are less numerous than in *P. trifurcatum typicum* (EISENACK 1959) GORKA 1969, and the furcations are shorter and lack the peteinos found in *P. trifurcatum longiradiatum* (EISENACK 1959). No pylome observed.

Dimensions: Vesicle diameter 50—60 µ, process length 20—40 µ. Specimens measured: 2.

Occurrence: Rare (<0.5 %), only in preps. 648 and 715.

Distribution in the Baltic area: Finland: Ordovician erratics from the Bothnian Sea (Tynni 1975). Estonia: Rapla borehole, Idavere regional stage, Middle Ordovician (Uutela & Tynni, in preparation). Estonia; erratics, Latorp regional stage, Lower Ordovician (Eisenack 1959a).

Distribution in Europe: U.S.S.R.: Moscow syneclise, Lower to Middle Ordovician (Umnova 1975).

Peteinosphaeridium trifurcatum? EISENACK (1931) 1969
Pl. IX:73

Synonyms: *Ovum hispidum trifurcatum* EISENACK 1931, p. 231. *Hystrichosphaeridium trifurcatum* EISENACK 1938, p. 8. *Baltisphaeridium trifurcatum* f. *typica* EISENACK 1959, p. 202. *Peteinosphaeridium bergstromii* STAPLIN, JANSONIUS & POCOCK 1965, p. 194. *Peteinosphaeridium trifurcatum* EISENACK 1969, pp. 254—255.

Remarks: The spherical vesicle has seven to nine slender and distally furcating processes, whose length does not exceed the vesicle diameter. Processes has no peteinos and therefore identification is unsure. The surface of the vesicle is shagrinate to microgranulate and processes are psilate. No pylome observed.

Dimensions: Vesicle diameter 30—50 µ, process length 12—30 µ. Specimens measured: 6.

Occurrence: Rare to moderate (0.5—2.7 %), only in preps. 701 and 718.

Distribution in Estonia, Rapla borehole, Uhaku regional stage, Middle Ordovician (Uutela & Tynni, in preparation).

Also reported in many Ordovician to Silurian deposits in Europe (Eisenack *et al.* 1979a).

Peteinosphaeridium trifurcatum longiradiatum (EISENACK 1959)
Pl. IX:74

Synonym: *Baltisphaeridium trifurcatum* forma *longiradiata* EISENACK 1959, p. 202.

Remarks: The spherical vesicle has numerous long and trifurcated processes. The description conforms to the original one. The process wall is thinner than that of the central body. No pylome is usually recorded.

Dimensions: Vesicle diameter 30—40 μ, length of processes 20 μ, width of processes 1 μ, number of processes 10—14 (40 in the original description). Specimens measured: 3.

Occurrence: Rare (<0.5 %), in prep. 696.

Distribution in the Baltic area: Estonia: Rapla borehole, Lasnamägi to Nabala regional stages, Middle to Middle/Upper Ordovician (Uutela & Tynni, in preparation). Baltic Ordovician erratics (Eisenack 1965a).

Not recorded outside the Baltic area.

Genus PHEOCLOSTERIUM TAPPAN & LOEBLICH 1971
Type species: *P. fusinulaegerum* TAPPAN & LOEBLICH 1971, p. 400, Pl. 6:1—7.

Pheoclosterium sp. 1.
Pl. IX:75

Description: The ovoid vesicle is covered with numerous short, claviform processes which are distributed more densely at the narrower point. The processes do not communicate with the interior of the vesicle. The surface of the vesicle is shagrinate to slightly granulate.

Dimensions: Vesicle diameter 25 x 35—30 x 45 μ, process length 4—5 μ. Specimens measured: 2.

Remarks: The genus *Pheoclosterium* TAPPAN & LOEBLICH 1971 has processes which communicate with the interior of the vesicle interior. According to Cramer & Diez (1979, p. 114), some genera can include forms with and without the communication, so that this should not be taken as a taxonomic criterion by as a chronological, regional or environmental oddity. These two specimens are therefore both identified to the genus *Pheoclosterium*.

The species differs from *P. fusinulaegerum* TAPPAN & LOEBLICH 1971 in having claviform processes which are more numerous of the narrower point, and from *Pirea ornata* (BURMANN 1970) VAVRDOVA 1972 in having no apical horn.

Occurrence: Rare (<0.5 %), in preps. 648 and 654.

Not recorded at Rapla borehole.

Pheoclosterium sp. 2.
Pl. IX:76

Description: The ovate vesicle is covered with numerous simple, capitate processes with clavate distal terminations and of a length corresponding on average to 1/10 of the vesicle width. The processes, which are distributed more densely at both poles, do not communicate with the interior of the vesicle. The vesicle surface is microgranulate.

Dimensions: Vesicle length 32—36 μ, vesicle width 22—27 μ, process length 2—2.7 μ. Specimens measured: 2.

Remarks: The species differs from *Pheoclosterium fuscinulaegerum* TAPPAN & LOEBLICH 1971 in having capitate processes, which are distributed more densely at the both poles. It differs from *Pheoclosterium sp.* 1. in that the ovate vesicle has its processes more densely distributed at the poles.

Occurrence: Rare (<0.5 %), only in prep. 654.

Distribution in Estonia, Rapla borehole, Kunda regional stage, Lower/Middle Ordovician (Uutela & Tynni, in preparation).

Genus PIREA VAVRDOVA 1972
Type species: *P. dubia* VAVRDOVA 1972, p. 83.

Pirea sp.
Pl. IX:77

Description; The bottle-shaped vesicle is ornamented with small spines, which are getting smaller on the apical horn.

Dimensions: Length of vesicle (without process) 25—30 μ, width of vesicle 20 μ, length of process 8 μ, width of process 5 μ, height of ornamentation up to 1 μ. Specimens measured: 3.

Remarks: The description conforms to *Pirea sp.* A by Playford and Martin (1984) more than *P. ornatissima* CRAMER & DIEZ 1977.

Occurrence: Rare (<0.5 %), in prep. 654.

Not recorded at Rapla borehole.

Genus POLYANCISTRODORUS LOEBLICH & TAPPAN 1969
Type species: *P. columbariferus* LOEBLICH & TAPPAN 1969, p. 52, Pl. 2:1—5.

Polyancistrodorus cf. P. columbariferus LOEBLICH & TAPPAN 1969
Pl. IX:78

Polyancistrodorus columbariferus LOEBLICH & TAPPAN 1969, p. 52, Pl. 2:1—5.

Remarks: The spherical vesicle is psilate and covered with numerous short, solid processes, quadrate in cross-section and quadrifurcated distally. The pylome is small and circular, with a collar.

The species differs from *P. columbariferus* TAPPAN & LOEBLICH 1969 in having distinctly shorter processes with shorter furcations, and more obviously from *Peteinosphaeridium breviradiatum* EISENACK (1959) 1969 and *Axisphaeridium timofeevi* EISENACK 1967 in having solid, quadrate processes.

Dimensions: Vesicle diameter 55—65 μ, process length 0.5 μ and width 0.25 μ, pylome diameter 10 μ. Specimens measured: 17.

Occurrence: Rare to moderate (0.5—8.5 %). Only in preps. 652, 696 and 715.

Distribution in Estonia, Rapla borehole, Lasnamägi to Pirgu regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Distribution outside Europe: U.S.A.: Oklahoma, Bromide Formation, Middle Ordovician (Loeblich & Tappan 1969).

Polyancistrodorus intricatus COLBATH 1979
Pl. IX:79

Polyancistrodorus intricatus COLBATH 1979, pp. 24—25, Pl. 10:1—4.

Remarks: The spherical vesicle has numerous thin and furcated processes. Most of the spherical specimens have processes smaller than the 1/2 of the vesicle diameter. The vesicle wall is microgranulate and process margins are serrated. A round pylome has a collar.

Dimensions: Vesicle diameter 32—60 μ, process length 15—30 μ, process width 5—8 μ, pylome diameter 15—25 μ. Specimens measured 4.

Occurrence: Rare (<0.5 %—0.5 %).

Distribution in Estonia, Rapla borehole, Kunda to Pirgu regional stages, Lower/Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Distribution outside Europe: U.S.A.: Indiana, Eden Shale, Ashgillian, Upper Ordovician (Colbath 1979).

Genus PRISCOGALEA DEUNFF 1961

Type species: *P. (=Multiplicisphaeridium) barbara* DEUNFF 1961, p. 41, Pl. 1:7.

Priscogalea perforata n. sp.

Pl. IX:80

Diagnosis: The small, spherical vesicle is covered with numerous simple processes of length equal on average to a half of the vesicle diameter. The pylome is about 1/3 of the vesicle diameter and is covered with tongue-shaped parts some of which carry a process. The surface of the vesicle is denticulate, with a quincucial pattern. The processes are echinate with an acuminate distal termination and an angular proximal process contact. The processes on the cover of the pylome are smaller than on the vesicle.

Dimensions: Vesicle diameter 10 μ, process length 5 μ, pylome diameter 4 μ. Specimens measured: 1.

Remarks: The species differs from the genus *Cymatiogalea* DEUNFF 1961 in having no polygonal fields on the vesicle and a cover on the pylome. The genus *Stelliferidium* DEUNFF, GORKA & RAUSCHER 1974 has a striated ornamentation on the vesicle and a larger, open pylome. The species is so small that its features are visible only by electron microscopy.

Occurrence: Rare (<0.5 %), only in prep. 654.

Distribution in Estonia, Rapla borehole, Kunda to Keila regional stages, Lower/Middle to Middle Ordovician (Uutela & Tynni, in preparation).

Derivation of name: *Perforo* L. bore, pierce.

Holotype, GSF prep. 654. The specimen is illustrated on Pl. IX:80.

Locus typicus: Erratic from Vitfågelskär, Dragsfjärd, southwestern Finland, Middle Ordovician.

Genus PTEROSPERMOPSIS W. WETZEL 1952, emend. SARJEANT 1984

Type species: *P. danica* W. WETZEL 1952, emend. SARJEANT 1984, pp. 145—146, Pl. 8:1—2, 5, Figs. 14—15.

Pterospermopsis sp.

Pl. X:81

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 μ. Specimens measured: 37.

Remarks: Most of the *Pterospermopsis* (ex-*Pterospermella*) (SARJEANT 1984) species are large in size. The smallest ones (ø 20—25 μ) such as *P. bernardinae* CRAMER 1964 and *P. guapita* CRAMER 1964 have no transparent central body. The description of *P. timofeevi* DEUNFF 1966 makes no mention of the character of the central body. All these species are of Silurian age or younger.

Occurrence: Rare to moderate (<0.5—6.5 %).

Distribution in Estonia, Rapla borehole, Kukruse to Pirgu regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Genus: RAPLASPHAERA n. g.

Type species: *R. undosa* UUTELA & TYNNI (in preparation)

Raplasphaera sp.

Pl. X:82

Description: The psilate, subhemispherical vesicle has a equatorial membrane which consists of seven funnel-shaped "processes" connected to each other at the base and top. The processes seem to be open and are ornamented with lines of granules. They are connected to the vesicle by small fibres. The pylome opening is also situated equatorially.

Dimensions: Vesicle diameter 6 μ, process length 3.5 μ, pylome opening diameter 2 μ. Specimens measured: 1.

Remarks: The genus *Cymatiogalea* DEUNFF 1961 has a large pylome, but the processes are not situated equatorially, while the genus *Duvernaysphaera* STAPLIN 1961 has an equatorial membrane with radial thickenings, although these are different from the open funnels and there is no pylome. The genus *Umbellasphaeridium* JARDINE, COMBAZ, MAGLOIRE, PENIGUEL & VACHEY 1972 has funnel-shaped processes, but they are not connected equatorially, and again no pylome is observed.

Occurrence: Rare (<0.5 %), only in prep. 654.

Distribution in Estonia, Rapla borehole, Lasnamägi to Pirgu regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Genus RHOPALIOPHORA TAPPAN & LOEBLICH 1971

Type species: *R. foliatilis* TAPPAN & LOEBLICH 1971, pp. 404—405, Pl. 9:1—6.

Rhopaliophora foliatilis TAPPAN & LOEBLICH 1971

Pl. X:83

Rhopaliophora foliatilis TAPPAN & LOEBLICH 1971, pp. 404—405, Pl. 9:1—6.

Remarks: The vesicle is spherical to subspherical and the processes hollow and variable in size and form, being largely short and stout. No pylome is observed.

The processes are more numerous and the diameter smaller than in the species described by Tappan and Loeblich (1971).

Dimensions: Vesicle diameter 25 μ, process heigth 2—3 μ, process diameter 1.5—3 μ. Specimens measured: 1.

Occurrence: Rare (<0.5 %), only in prep. 654.

Distribution in Estonia, Rapla borehole, Nabala regional stages, Middle/Upper Ordovician (Uutela & Tynni, in preparation).

Distribution outside Europe: U.S.A.: Indiana, Eden Formation, Upper Ordovician (Tappan & Loeblich 1971).

Rhopaliophora palmata (COMBAZ & PENIGUEL 1972) PLAYFORD & MARTIN 1984

Pl. X:84

Synonyms: *Peteinosphaeridium palmatum* COMBAZ & PENIGUEL 1972, p. 136. *Rhopaliophora palmata* PLAYFORD & MARTIN 1984, pp. 210—212.

Remarks: The spherical vesicle has numerous thin-walled and hollow processes with rounded distal terminations and constricted proximal base. The processes are psilate and the vesicle surface is irregularly granulate.

Dimensions: Vesicle diameter 42 μ, process length 5 μ. Specimens measured: 1.

Occurrence: Rare (<0.5 %) only in prep. 654.

Distribution in Estonia, Rapla borehole, Aseri to Rakvere regional stages, Middle Ordovician (Uutela & Tynni, in preparation).

Distribution outside Europe: Australia: Canning basin, Lower to Middle Ordovician (Combaz & Peniguel 1972, Playford & Martin 1984).

Rhopaliophora pilata (COMBAZ & PENIGUEL 1972) PLAYFORD & MARTIN 1984

Pl. X:85

Synonyms: *Peteinosphaeridium pilatum* COMBAZ & PENIGUEL 1972, pp. 136—137. *Rhopaliophora pilata* PLAYFORD & MARTIN 1984, pp. 212—214.

Remarks: The small, spherical to subspherical vesicle is covered with numerous short, broad, hollow processes which are often flattened. The processes do not communicate with the interior of the vesicle. The pylome is small and round.

Dimensions: Vesicle diameter 20—45 μ, process length 2—5 μ, process width 2—4 μ, pylome diameter 5 μ, wall thickness 0.5—1 μ. Specimens measured: 4.

Occurrence: Rare (<0.5 %), only in preps. 648, 654 and 663.

Distribution in Estonia, Rapla borehole, Kunda to Vormsi regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Distribution outside Europe: Australia: Canning Basin, Lower to Middle Ordovician (Combaz & Peniguel 1972, Playford & Martin 1984).

Genus STELLIFERIDIUM DEUNFF, GORKA & RAUSCHER 1974

Type species: *S. striatulum* (VAVRDOVA 1966) DEUNFF, GORKA & RAUSCHER 1974

Stelliferidium modesta (GORKA 1967) DEUNFF, GORKA & RAUSCHER 1974

Pl. X:86

Synonym: *Cymatiogalea modesta* GORKA 1967, pp. 3—4, Pl. 1:7—9.

Remarks: The spherical vesicle is covered with small tubercles which are connected radially by low crests, a typical feature of this genus. The large pylome, another typical feature, is not recorded in the one specimen found here. The specimen is smaller in size than has been recorded earlier (ø 32.5 μ). It is difficult to distinguish these small forms from *Micrhystridium nannacanthum* by light microscopy, as the low radial crests are visible only by scanning microscopy.

Dimensions: Vesicle diameter 15 μ, verrucae height 0.5 μ. Specimens measured: 1.

Occurrence: Rare (<0.5 %), only in prep. 652.

Distribution in the Baltic area: Estonia: Rapla borehole, Kunda regional stage, Lower/Middle Ordovician (Uutela & Tynni, in preparation). Poland: Tremadocian, Lower Ordovician deposits at Wysoczki and Zalesie (Gorka 1969).

Genus TASMANITES NEWTON 1875

Type species: *T. punctatus* NEWTON 1875, p. 339.

Tasmanites cf. T. verrucosus EISENACK 1962

Pl. X:87

Tasmanites verrucosus EISENACK 1962, p. 62—63, Pl. 2:5; 3:4—6.

Remarks: The spherical, thick vesicle has a pseudopylome-like thickening without rim, or in some cases a pylome with rim, often also with a median split. The SEM images show a surface which is not exactly verrucate (term used by Kjellström 1971a, pp. 11—13), but something between shagrinate and granulate depending on the degree of corrosion. Under light microscopy it does appear to be verrucate, however, and resembles the individuals described by Eisenack (1962c, Pl. 2:5, Pl. 3:4—6; 1968a, Pl. 25:7). Eisenack also describes some less verrucate forms (1965a, Pl. 12:2) as does Tynni (1982b, Figs 17A—D).

Dimensions: Vesicle diameter 14—80 μ, thickness of vesicle 2—6 μ, pylome diameter 8—22 μ. Specimens measured: 24.

Occurrence: Rare to moderate (0.5—3.5 %), only in preps. 652 and 723.

Distribution in the Baltic area: Sweden, Gotland, Porkuni regional stage, Upper Ordovician (Eisenack 1968). Estonia: Rapla borehole, Kukruse to Porkuni regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Not recorded outside the Baltic area.

Tasmanites spp.

Remarks: The spherical vesicle is thick and more or less porous. Most of the *Tasmanites* species are large in size, in the present material diameter varies 10—30μ. The identification was impossible because of erosion and therefore it is treated collectively. It is included in presentage ratios, however, for later investigations.

Specimens measured: 111.

Genus: TIMOFEEVIA VANGUESTAINE 1978

Type species: *T. (= Multiplicisphaeridium) lancarae* CRAMER & DIEZ 1972, p. 42, Pl. 1:1—4, 6, 8.

Timofeevia sp. 1

Pl. X:88

Description: The subspherical vesicle is covered with polygons, the corners of which have psilate, simple, homomorphic, hollow processes with a broad base. The walls of the polygons are formed by sutures. The vesicle surface is shagrinate.

Dimensions: Vesicle diameter 11—12 μ, process length 2 μ, area of polygons 2 x 4 μ. Specimens measured: 2.

Remarks: This species differs from *T. phosphoritica* VANGUESTAINE 1978 in having shorter, homomorphic processes and a lower suture. Its dimensions are also smaller (18—30 μ).

Occurrence: Rare (<0.5—0.5 %), in preps. 648, 652 and 654.

Distribution in Estonia, Rapla borehole, Lasnamägi to Kukruse regional stages, Middle Ordovician (Uutela & Tynni, in preparation).

Timofeevia sp. 2

Pl. X:89

Description: The spherical vesicle is covered with polygons, the corners of which have simple, homomorphic, hollow processes with a broad base and echinate distal terminations. These polygons, formed by sutures, are variable in size and form.

Dimensions: Vesicle diameter 13—15 μ, process length 2 μ, area of polygon 2 x 4—3 x 6 μ. Specimens measured: 17.

Remarks: This species differs from *Timofeevia sp.* 1. in having more clearly separated and slender processes with spines at their distal terminations.

Occurrence: Rare (<0.5 %), only in preps. 648 and 654.

Distribution in Estonia, Rapla borehole, Lasnamägi to Uhaku regional stages, Middle Ordovician (Uutela & Tynni, in preparation).

Genus TRANVIKIUM TYNNI 1982

Type species: *T. polygonale* TYNNI 1982, p. 81, Pl. XVI:122

Tranvikium polygonale TYNNI 1982

Pl. XI:90

Tranvikium polygonale TYNNI 1982, s. 81, Fig. 19, Pl. XV:112—121, XVI:122, XVII:130, 131, XIX:160.

Remarks: The bell-shaped vesicle is often dark brown and the description follows that given originally, although the dimensions vary a little more (ø 35—70 μ).

Dimensions: Equatorial vesicle diameter 30—86 μ, aperture diameter of bottom 6—34 μ, aperture diameter of spherical surface 2—24 μ. Specimens measured: 4.

Occurrence: Rare (0.5—1.0 %), only in preps. 648 and 654.

Distribution in the Baltic area: Finland: Åland borehole, Middle Ordovician (Tynni 1982b). Estonia: Rapla borehole, Kunda to Aseri regional stages, Lower/Middle to Middle Ordovician (Uutela & Tynni, in preparation).

Not recorded outside the Baltic area.

Genus VERYHACHIUM DEUNFF (1954) 1958
emended by DOWNIE & SARJEANT 1963

Type species: *V. (= Hystrichosphaeridium) trisulcum* DEUNFF (1951), 1959, p. 27, Pl. 1, figs. 4, 13; fixed by DOWNIE 1959, p. 62.

Veryhachium geometricum (DEFLANDRE 1945) DEUNFF 1954

Pl. XI:91

Synonyms: *Hystrichosphaeridium geometricum* DEFLANDRE 1945, pp. 64—65, Pl. 2:2—5. *Veryhachium geometricum* DEUNFF 1954, p. 306.

Remarks: The triangular vesicle has a stronge nerve on the surface of the vesicle towards the horns. The vesicle wall is thin and psilate. The species conforms to the original diagnosis, but is a little larger in size.

Dimensions: Central body diameter 20 μ, horn length 20—30 μ. Specimens measured: 2.

Occurrence: Rare (<0.5 %), only preps. 654 and 701.

Distribution in the Baltic area: Sweden: Gotland, Llanvirnian, Middle Ordovician (Gorka 1987). Estonia: Rapla borehole, Lasnamägi to Johvi regional stages, Middle Ordovician (Uutela & Tynni, in preparation).

Distribution in Europe: Belgium: Kortrijk, Silurian (Stockmans & Williere 1963). France: Montagne Noire, Silurian (Deflandre 1945, Rauscher 1973).

Veryhachium irroratum LOEBLICH & TAPPAN 1969

Pl. XI:92

Veryhachium irroratum LOEBLICH & TAPPAN 1969, pp. 56—57, Pl. 3:1—9; 4:1—4.

Remarks: The triangular vesicle has three clearly differentiated, hollow processes. The specimens in the present material are referable to the original description.

Dimensions: Vesicle diameter 20 μ, length of processes 20 μ. Specimens measured: 1.

Occurrence: Rare (<0.5 %), in prep. 648.

Distribution in Estonia, Rapla borehole, Idavere to Pirgu regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Distribution outside Europe: U.S.A.: Oklahoma, Bromide Formation, Middle Ordovician (Loeblich & Tappan 1969); Ohio, grapt. z. 18—22, Silurian. Africa: Libya: Dieffara Formation, Caradocian, Middle Ordovician (Eisenack *et al.* 1979b).

Veryhachium lairdi DEUNFF 1958

Pl. XI:93

Veryhachium lairdi DEUNFF 1958, pp. 28—29, Pl. 8:75—79.

Remarks: The quadratic vesicle has four processes in the each corner and they communicate freely with the vesicle interior. The surface of the vesicle is slightly robust. The length of the processes does not exceed the vesicle diameter.

Dimensions: Vesicle diameter 35 μ, process length 20 μ. Specimens measured: 1.

Occurrence: Rare (0.5 %), only in prep. 685.

Distribution in Estonia, Rapla borehole, Kunda to Pirgu regional stages, Lower/Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Recorded also from the Ordovician to the Permian deposits in Europe (Eisenack *et al.* 1979b).

Veryhachium oklahomense LOEBLICH 1970

Pl. XI:94

Veryhachium oklahomense LOEBLICH 1970, pp. 742—743.

Remarks: The vesicle form is nearly quadratic and it has four long and flexible processes in the each corner. The vesicle surface and processes are psilate. The process length exceeds the vesicle diameter.

Dimensions: Vesicle diameter 8—10 μ, process length 10—15 μ. Specimens measured: 2.

Occurrence: Rare (0.5 %), only in preps. 663 and 689.
Distribution in Estonia, Rapla borehole, Kunda to Pirgu regional stages, Lower/Middle to Upper Ordovician (Uutela & Tynni, in preparation).
Distribution in Europe: Britain: Middle Ordovician (Turner 1984).
Distribution outside Europe: U.S.A.: Oklahoma, Upper Ordovician (Loeblich 1970b).

Veryhachium oligospinosum (EISENACK 1934) GORKA 1969
Pl. XI:95
Non-synonym: *Goniosphaeridium oligospinosum* (EISENACK 1934, p. 64, Pl. 4:15—18).
Synonyms: *Veryhachium oligospinosum* (Gorka 1969, pp. 55—56, Pl. XV:11, Fig. 21. *V. oligospinosum* (Tynni 1975, p. 38, Fig. 41c; Tynni 1982b, pp. 83—84, Pl. XVII:134).
Remarks: The vesicle is quadratic with six processes, one in each corner and one in the middle of each side. The vesicle surface is shagrinate and brownish in colour. The processes are shorter than the side of the square. As in the material of Gorka (1969) and Tynni (1975, 1982b), the species recorded here is combined with the genus *Veryhachium* because it resembles *V. lairdi* (DEFLANDRE 1935) DEUNFF 1959, although the latter has only four processes. *Goniosphaeridium oligospinosum* (EISENACK 1934) 1963 is distinctly larger.
Dimensions: Side of square 40 µ, process length 30 µ. Specimens measured: 1.
Occurrence: Rare (0.5 %), only in prep. 706.
Distribution in the Baltic area: Finland: Ordovician erratics from the Baltic Sea (Tynni 1975); Åland borehole, Middle Ordovician (Tynni 1982b). Estonia: Rapla borehole, Keila to Pirgu regional stages, Middle to Upper Ordovician (Uutela & Tynni, in preparation).

Veryhachium reductum DEUNFF 1958
Pl. XI:96
Synonyms: *Veryhachium trisulcum* var. *reductum* DEUNFF 1958, p. 27. *Veryhachium reductum* DE JEKHOWSKY 1961, pp. 210—212.
Remarks: The triangular vesicle has sides and processes of the equal length, and its surface is slightly granular.
Dimensions: Length of side 12—20 µ, process length 12—20 µ. Specimens measured: 4.
Occurrence: Rare (<0.5 %), in preps. 654 and 701.
Distribution in Estonia, Rapla borehole, Uhaku to Keila regional stages, Middle Ordovician (Uutela & Tynni, in preparation).
Recorded from many Ordovician to Permian deposits in Europe and elsewhere in the world (Eisenack *et al.* 1979b).

Veryhachium rhombispinosum TYNNI 1982
Pl. XI:97
Veryhachium rhombispinosum TYNNI 1982, p. 84, Pl. XVII:135.
Remarks: The polygonal vesicle has six processes lying in two levels. Description corresponds to the original one.
Dimensions: Vesicle diameter 25—28 µ, length of processes 20—25 µ. Specimens measured: 9.
Occurrence: Rare to common (0.5—12.0 %).
Distribution in the Baltic area: Finland: Åland borehole, Middle Ordovician (Tynni 1982b). Estonia: Rapla borehole, Volhov to Pirgu regional stages, Lower to Upper Ordovician (Uutela & Tynni, in preparation).

Veryhachium trispinosum (EISENACK 1938) DEUNFF 1954
Pl. XI:98
Synonyms: *Hystrichosphaeridium trispinosum* EISENACK 1938, pp. 14—16. *Veryhachium trispinosum* DEUNFF 1954, p. 307.
Remarks: The triangle vesicle is very thin and has a process in the each corner. The sides of the vesicle are concave. The vesicle surface and the processes are psilate.
Dimensions: Vesicle diameter 12—30 µ, process length 12—26 µ. Specimens measured: 8.
Occurrence: Rare (<0.5—1.5 %), only in preps. 701 and 704.
Distribution in Estonia, Rapla borehole, Kunda to Pirgu regional stages, Lower/Middle to Upper Ordovician (Uutela & Tynni, in preparation).
Recorded also in many Ordovician to Devonian deposits in Europe (Eisenack *et al.* 1979b).

Veryhachium trisulcum DEUNFF (1951) 1958
Pl. XI:99
Synonyms: *Hystrichosphaeridium trisulcum* DEUNFF 1951, pp. 322—323, Fig. 3. (nomen nudum). *Veryhachium trisulcum* DEUNFF 1954, p. 306 (nomen nudum). *V. trisulcum* DEUNFF 1958, p. 27, Pl. 1:4—13.
Remarks: The thin triangle vesicle has a process in the each corner. Processes are slender and flexible. The sides of the vesicle are convex. The vesicle surface and the processes are psilate.
Dimensions: Vesicle diameter 25 µ, process length 40 µ. Specimens measured: 2.
Occurrence: Rare (<0.5 %), only in prep. 701.
Distribution in Estonia, Rapla borehole, Uhaku to Keila regional stages, Middle Ordovician (Uutela & Tynni, in preparation).
Recorded also from the Lower Ordovician to the Lower Devonian deposits in Europe (Eisenack *et al.* 1979b).

Chitinozoa

Genus CONOCHITINA EISENACK 1931, restricted 1955
Type species: C. *claviformis* 1931, p. 84, Pl. 1:17.

Conochitina cactacea EISENACK 1937
Pl. XII:100
Synonyms: *Conochitina cactacea* EISENACK 1937, p. 222—223, Pl. 15, Figs. 11—15. *C. hirsuta* LAUFELDT 1967, pp. 304—305, Fig. 12.
Remarks: The conical body has a rounded basal edge and a cylindrical neck which widens slightly towards a finely fimbriate aperture. The body is covered with spines of variable size becoming smaller in an oral direction. All the spines are simple, and the maximum height of the ornamentation is a little greater than in the forms described by Grahn (1981a, 1982a).
Dimensions: Total length 110—200 µ, width of base 70—

100 μ, width of aperture 30—70 μ, height of ornamentation 8—20 μ.

Occurrence: 12 ind., max in one sample 4 ind.

Distribution in the Baltic area: Finland: erratics from the Bothnian Sea, Ordovician (Tynni 1975). Sweden; Dalarna boreholes (Laufeld 1967); Öland, Middle Caradocian erratics (Grahn 1981a); Gotland borehole, Caradocian, Middle Ordovician (Grahn 1982a). Estonia: Rapla borehole, Lasnamägi to Nabala regional stages, Middle to Upper Ordovician (Nolvak, in preparation). Baltic Ordovician erratics (Eisenack 1937, 1959b, 1962a, 1965a).

Also reported in the U.S.A.: Oklahoma, Sylvan Shale, Lower Ashgillian (Jenkins 1970). Canada: Quebec and Ontario, Trenton Group and Utica Formation, Caradocian (*C.* aff. *cactacea*, Martin 1975).

Conochitina conulus EISENACK 1955
Pl. XII:101

Synonyms: *Conochitina conulus* EISENACK 1955, p. 312, Pl. 1:1—3. *Euconochitina conulus* RAUSCHER & DOUBINGER 1967, p. 478, Pl. 3:3.

Remarks: The conical body has a convex base with a few small, simple spines. The cylindrical neck widens at a fringed aperture. Ornamentation is something between the forms in Figs 31-J and 3K-L of Grahn (1981b).

Dimensions: Total length 50—300 μ, width of base 20—120 μ, width of aperture 16—80 μ.

Occurrence: 137 ind., max. in one sample 32 ind.

Distribution in the Baltic area: Finland: erratics from the Bothnian Sea, Ordovician (Tynni 1975). Sweden: Öland borehole, Upper Llanvirnian to Middle Caradocian (Grahn 1981a); Västergötland borehole, from Lower Llandeilian to Middle Caradocian, Middle Ordovician (Grahn 1981b). Estonia: from Aseri to Uhaku regional stages, Middle Ordovician (Eisenack 1955b); Tallinn area: Lasnamägi regional stage, Middle Ordovician (Grahn 1984); Rapla borehole, Lasnamägi to Kukruse regional stages, Middle Ordovician (Nolvak, in preparation). Distribution in Europe: France: Normandy, Llanvirnian Middle Ordovician (Rauscher & Doubinger 1967).

Conochitina cucumis GRAHN 1984
Pl. XII:102

Conochitina cucumis GRAHN 1984, p. 13, Pl. I, J—L.

Remarks: The subcylindrical body has a rounded basal edge and a basal process. The aperture is straight. The only species recorded here differs from the forms described by Grahn (1984) in having a more distinct neck and slimmer vesicle.

Dimensions: Total length 230 μ, width 30 μ, width of aperture 25 μ.

Occurrence: Only one, in prep. 711.

Distribution in Estonia: Tallinn-area, Volhov regional stage, Lower Ordovician (Grahn 1984); Rapla borehole, Volhov to Kunda regional stages, Lower Lower/Middle Ordovician (Nolvak, in preparation).

Conochitina elegans EISENACK 1931
Pl. XII:103

Synonyms: *Conochitina elegans* EISENACK 1931, p. 87, Pl. 2:4. *Rhabdochitina conocephala* EISENACK 1934, pp. 61—62, Fig. 32, Pl. 4:10—12.

Remarks: The body is conical, slender and elongated with a rounded basal edge. The cylindrical neck widens slightly at a straight aperture. The length of the neck is about a half of that of the vesicle. The size is variable (cf. Jenkins 1970).

Dimensions: Total length 70—400 μ, width of base 16—60 μ, width of aperture 10—48 μ.

Occurrence: 13 ind., max. in one sample 3 ind.

Distribution in Estonia: Rapla borehole, Kunda to Keila regional stages, Lower/Middle to Middle Ordovician (Nolvak, in preparation). Recorded earlier from many Llandeilian to Ashgillian, Middle to Upper Ordovician deposits elsewhere in the Baltic area (Grahn 1982a, 1984), Caradocian, Middle Ordovician deposits in Europe (Jenkins 1967) and Caradocian to Ashgillian, Middle to Upper Ordovician deposits in the U.S.A. and Canada (Jenkins 1970, Martin 1975, Grahn & Miller 1986).

Conochitina michracantha EISENACK 1931
Pl. XII:104

Synonyms: *Conochitina michracantha* EISENACK 1931, p. 84—85, Pl. 1:19—21; 2:20—22, 4:15. *Conochitina michracantha* ssp. *michracantha* EISENACK 1959, p. 7, Pl. 1:5. *Euconochitina michracantha* (EISENACK) TAUGOURDEAU 1966, p. 39. *Belonechitina michracantha* PARIS 1981, pp. 202—203.

Remarks: The conical body has a rounded base and a long, subcylindrical neck which widens slightly at the straight aperture. The whole vesicle is covered with spines of variable size but generally taller on the base. The specimens recorded here have ornamentation covering the whole vesicle, as typical of the western Baltic specimens in the Ontikan stage, Lower/Middle Ordovician (Grahn 1980).

Dimensions: Total length 110—400 μ, width of base 29—100 μ, width of aperture 26—80 μ.

Occurrence: 80 ind., max. in one sample 21 ind.

Distribution: The species is cosmopolitan and with a long range, and of little biostratigraphic value (Grahn 1984).

Distribution in Estonia: Rapla borehole, Uhaku to Pirgu regional steges, Middle to Upper Ordovician (Nolvak, in preparation). Recorded from Upper Arenigian to Upper Ashgillian, Lower to Upper Ordovician elsewhere in the Baltic area (Grahn 1982a), Llandeilian to Lower Ashgillian in Europe (Laufeldt 1971, Cramer & Diez 1972, Paris 1979) and in the U.S.A. (Jenkins 1969, Grahn & Bergström 1984, Grahn & Miller 1986).

Conochitina minnesotensis (STAUFFER 1933) EISENACK 1962
Pl. XII:105

Synonyms: *Rhabdochitina? minnesotensis* STAUFFER 1933, p. 1209, Pl. 60:39. *Conochitina minnesotensis* EISENACK 1962, pp. 353—354, Figs. 1—6.

Remarks: The elongated, gradually narrowing vesicle has a rounded basal edge and straight aperture. The copula is not well developed in this material, and the individuals are often broken or flattened. All the species recorded here are smaller than the largest ones recorded earlier (over 1300 μ by Grahn 1980, 1981ab, 1982a, over 1500 μ by Jenkins 1969, and over 2000 μ by Eisenack 1968a).

Dimensions: Total length 32—1160 μ, width of base 12—220 μ, width of aperture 10—150 μ.

Occurrence: 18 ind., max. in one sample 5 ind.

Distribution: The species is cosmopolitan, with a long range, and of little biostratigraphic value.

Distribution in Estonia: Rapla borehole, Aseri to Pirgu regional stages, Middle to Upper Ordovician (Nolvak, in preparation). Recorded from Upper Arenigian to Upper Ashgillian, Lower to Upper Ordovician deposits elsewhere in the Baltic area (Grahn 1982a), from Caradocian, Middle Ordovician deposits in Europe and Canada and in Llanvirnian to Caradocian deposits in the U.S.A. (Martin 1975, 1983, Jenkins & Legault 1979), and Arenigian to Llandeilian, Lower to Middle Ordovician deposits in Australia (Combaz & Peniguel 1972).

Conochitina primitiva EISENACK 1939
Pl. XII:106

Synonyms: *Conochitina primitiva* EISENACK 1939, pp. 139, 140, 142, Pl. B:7—8. *Euconochitina primitiva* RAUSCHER 1970, p. 122, Pl. 1:11—12.

Remarks: The conical body, with a rounded base, has no ornamentation. The neck is not clearly separated and in the present material the individuals are often badly eroded. The aperture is straight.

Dimensions: Total length 50—250 μ, width of base 20—120 μ, width of aperture 10—80 μ.

Occurrence: 47 ind., max. in one sample 12 ind.

Distribution in Estonia: Rapla borehole, Kunda to Keila regional stages, Lower/Middle to Middle Ordovician (Nolvak, in preparation). Recorded earlier from many Upper Arenigian to Upper Caradocian, Lower to Middle Ordovician deposits elsewhere in the Baltic area (Grahn 1982a, 1984) and Upper Arenigian to Caradocian, Lower to Middle Ordovician deposits in Europe (Paris 1981). Recorded also from Arenigian, Lower Ordovician deposits in Morocco (Elaoshad-Debbaj 1984) and Caradocian, Middle Ordovician deposits in Canada (Martin 1983).

Conochitina wesenbergensis EISENACK 1959
Pl. XII:107

Synonyms: *Conochitina micracantha* EISENACK 1931, pp. 84—85, Pl. 2:21—22. *Conochitina micracantha* subsp. *wesenbergensis* EISENACK 1959, p. 10, Pl. 1:11, Pl. 3:8. *Conochitina wesenbergensis* subsp. *brevis* EISENACK 1972, p. 125, Pl. 34:25—28, Pl. 37:2—3.

Remarks: The conical body has a rounded basal edge, and the neck widens slightly at the aperture. The body is covered with simple spines of different size, being longer on the base. The species differs from *C. micracantha* in having a less concave body and fringed aperture. On the basis of the ratio of length to width all the species recorded here belong to the forma brevis of Eisenack (1965a).

Dimensions: Total length 80—400 μ, width of base 20—150 μ, width of aperture 12—90 μ, height of ornamentation 4—10 μ.

Occurrence: 61 ind., max. in one sample 18 ind.

Distribution: The species is cosmopolitan with a long range, and of little biostratigraphical value.

Distribution in Estonia: Rapla borehole, Rakvere to Pirgu regional stages, Middle to Upper Ordovician (Nolvak, in preparation).

Recorded in many Arenigian to Ashgillian, Lower to Upper Ordovician deposits elsewhere in the Baltic area (Grahn 1982a, 1984), and in Europe (Umnova 1969, Laufeld 1971). Recorded outside Europe in Llanvirnian to Caradocian, Middle Ordovician deposits in the U.S.A. (Jenkins 1969, Grahn & Bergström 1984, Grahn & Miller 1986), and Canada (Martin 1983).

Genus CYATHOCHITINA EISENACK 1955

Type species: *C. (= Conochitina) campanulaeformis* (EISENACK 1931, p. 86, Pl. 2:1—2; 4:1, 11—14).

Cyathochitina campanulaeformis (EISENACK 1931) 1955
Pl. XII:108

Synonym: *Conochitina campanulaeformis* (EISENACK 1931, p. 86, Pl. 2:1—2; 4:1, 11—14).

Remarks: The bell-shaped conical body has a sharp basal edge with a carina. The aperture is straight. Longitudinal thickenings of flexure are discussed by Grahn (1980, 1981ab) and also recorded by Nolvak (1980), but are not visible here by light microscopy. The ratio of length to width varies 1.8—2.2:1, as is normal in Baltic specimens (Eisenack 1962c, Grahn 1980), but not in the Welsh ones (Jenkins 1967).

Dimensions: Total length 90—180 μ, width of the base 40—100 μ, width of aperture 22—40 μ.

Occurrence: 4 ind., 1—2 ind. in preps. 652, 654 and 655.

Distribution: The species is cosmopolitan with a long range, and of little biostratigraphical value.

Distribution in Estonia: Rapla borehole, Lasnamägi to Vormsi regional stages, Middle to Upper Ordovician (Nolvak, in preparation). Recorded also in many Lower Ordovician to Lower Silurian deposits in the Baltic area (Grahn 1982a, 1984) and Europe (Moreau-Benoit 1974, Jenkins & Legault 1979).

Distribution outside Europe: Africa, Sahara: Arenigian, Lower Ordovician (Benoit & Taugourdeau 1961), U.S.A.: New York, Lower Silurian (Miller & Eames 1982); Alabama, Middle Ordovician (Grahn & Bergström 1984). Australia: Canning basin, Middle Ordocivian (Combaz & Peniquel 1972).

Cyathochitina kuckersiana (EISENACK 1934) 1962
Pl. XII:109

Synonyms: *Conochitina kuckersiana* EISENACK 1934, pp. 62—63, Figs. 30—31, Pl. 4:14. *Cyathochitina kuckersiana* EISENACK 1962, pp. 298—300, Fig. 4, Pl. 14:8.

Remarks: The conical body has a sharp basal edge with a membranous flange. The aperture is straight. The ratio length: width varies 1.47—1.60:1 in the present material. Longitudinal ribbing is seen on the shoulder and neck, as described by Grahn (1981b, Fig. 51) and Jenkins (1967, forma *brevis*).

Dimensions: Total length 200—240 μ, width of base 130—150 μ, width of aperture 50—70 μ, width of carina 10—30 μ.

Occurrence: 3 ind., 1—2 ind. in preps. 648 and 654.

Distribution: The species is cosmopolitan, with a long range, and of little biostratigraphical value.

Distribution in Estonia: Rapla borehole, Rakvere to Vormsi regional stages, Middle to Upper Ordovician (Nolvak, in preparation). Recorded in many Upper Llanvirnian to Ashgillian, Middle to Upper Ordovician deposits elsewhere in the Baltic area (Grahn 1982a), Llanvirnian to Lower Ashgillian, Middle to Upper Ordovician deposits in Europe (Doubinger 1963, Rauscher & Doubinger 1967, Laufeldt 1971, Cramer & Diez 1972) and Llanvirnian to Lower Ashgillian, Middle to Upper Ordovician deposits outside Europe (Jenkins 1969, Martin 1975, Achab 1977, 1978, Grahn & Bergström 1984).

Cyathochitina latipatagium (JENKINS 1969) GRAHN 1981
Pl. XIII:110

Synonyms: *Cyathochitina kuckersiana* forma *brevis* EISENACK 1962, pp. 298—300, Fig. 5, Pl. 14:9; 1968, p. 89;

Cyathochitina kuckersiana subsp. *latipatagium* JENKINS 1969, pp. 19—20, Pl. 4:6—8, 10. *Cyathochitina latipatagium* GRAHN 1981a, pp. 32—33, Fig. 11I.

Remarks: The conical body has a sharp basal edge with a membranous flange. *C. latipatagium* differs from *C. kuckersiana* in having a ratio of length: width of about 1:1, as first described by Eisenack (1962c) forma *brevis*. Stratigraphically it is of more significance to separate these two forms than to combine them.

Dimensions: Total length 220—240 μ, max. width 220 μ, width of aperture 30 μ, width of carina 30 μ.

Occurrence: 4 ind., only in prep. 696.

Distribution in the Baltic area: Finland: Ordovician erratics from the Bothnian Sea (Tynni 1975). Sweden: Öland, Folkeslunda, Upper Llanvirnian to Lower Llandeilian and Dalby limestone; Upper Llandeilian and Lower Macrourus Siltstone, Middle Caradocian, erratics in Öland (Grahn 1981a); Gotland, Borkholmer, Porkuni regional stage, Upper Ashgillian (Eisenack 1962c). Estonia: Johvi to Oandu regional stages, Middle Ordovician (Eisenack 1962a); Rapla borehole, Johvi to Rakvere regional stages, Middle Ordovician (Nolvak, in preparation).

Distribution in Europe: Britain: Shropshire, Coston Beds to Onnia Beds, Caradocian (Jenkins 1967). France: Normandy, Calymene shale, Llanvirnian (Rauscher & Doubinger 1967); Normandy, Caradocian (Robardet *et al.* 1972). Portugal: Serra de Bucaco, Louredo Formation, Caradocian (Paris 1979).

Distribution outside Europe: U.S.A.: Oklahoma, Viola Limestone, Caradocian (Jenkins 1969). Canada: Ontario, Trenton Group to Utica Formation, Caradocian (Martin 1975); Anticosti Islands, Macasty Formation to Ellis Bay Formation, Upper Caradocian to Upper Ashgillian (Achab 1977, 1978); Quebec, Montreal and Ottawa, Caradocian to Ashgillian (Martin 1980, 1983).

Genus DESMOCHITINA EISENACK 1931

Type species: *D. nodosa* EISENACK 1931, p. 92, Pl. 3:2—4; 4:7—10.

Desmochitina amphorea EISENACK (1931) 1962

Pl. XIII:111

Synonym: *Desmochitina minor* f. *amphorea* EISENACK 1962, p. 304, Pl. 17:5—7.

Remarks: The vesicle is ellipsoidal and longitudinal axis gently curved. The only specimen recorded here is slimmer than those described by Tynni (1975), Grahn (1981ab, 1984) and Eisenack (1962a, 1965a). The basal edge is not so rounded as previously recorded, but the gently curved longitudinal axis identifies it as *D. amphorea* rather than *D. ovulum* EISENACK 1962.

Dimensions: Vesicle length 180 μ, width 140 μ, width of aperture 40 μ. Specimens measured: 1.

Occurrence: Only one specimen, recorded in prep. 652.

Distribution in the Baltic area: Finland: Ordovician erratics from the Baltic sea (Tynni 1975) and in South-West Finland (Eisenack 1965a). Sweden: Västergötland borehole, Upper Dalby Limestone (Grahn 1981b); Öland borehole, Seby to Folkeslunda and Persnäs to Dalby Limestone (Grahn 1981a), all Viruan, Middle Ordovician. Estonia: Aseri to Oandu regional stages, Middle Ordovician (Eisenack 1962a); Lasnamägi subsurface, Lasnamägi to Uhaku regional stages, Middle Ordovician; Sojamägi subsurface, Idavere to Johvi regional stages, Middle Ordovician (Grahn 1984); Rapla borehole, Idavere to Oandu regional stages, Middle Ordovician (Nolvak, in preparation). Ordovician Baltic erratics (Eisenack 1931).

Desmochitina cocca EISENACK 1931

Pl. XIII:112

Synonyms: *Desmochitina cocca* EISENACK 1931, p. 94, Pl. 3:14—15. *Desmochitina minor* f. *cocca* (Jenkins 1967, p. 460). *Pseudodesmochitina minor* f. *cocca* (Paris 1981, p. 120).

Remarks: The subspherical vesicle, with a rounded basal edge, has a short collar with a straight aperture. The vesicle is smooth or slightly verrucate. The material also contains smaller specimens than have been recorded earlier. Only single specimens were recorded, and no clusters, as by Grahn (1982a), or chains, as by Jenkins (1967).

Dimensions: Total length 36—120 μ, max. width 28—120 μ, width of aperture 24—70 μ.

Occurrence: 17 ind., max. in one sample 8 ind.

Distribution in the Baltic area: Sweden: Öland boreholes, Upper Langevoja to Lower Valaste, Upper Arenigian to Lower Llanvirnian and Upper Alnoja, Lower Llanvirnian and Seby to Dalby Limestones; Öland: Upper Llanvirnian to Upper Llandeilian and Caradocian erratics (Grahn 1981a, 1982a). Estonia: Aseri to Kukruse regional stages, Middle Ordovician (Eisenack 1931, 1962); Rapla borehole, Lasnamägi to Kukruse regional stages, Middle Ordovician (Nolvak, in preparation).

Distribution in Europe: U.S.S.R.: Moscow syneclise, C_1, Upper Llanvirnian to Lower Llandeilian (Umnova 1969). Britain: Shropshire, Glenburrel Beds, Lower Caradocian (Jenkins 1967). Belgium; Deerlijk, Ashgillian (Martin 1973). France: Veryhach, Ordovician (Deunff 1958); Menez-Belair, Upper Arenigian to Llandeilian (Paris 1981). Portugal: Bucaco, Llandeian to Caradocian (Paris 1979, 1981).

Desmochitina minor EISENACK 1931

Pl. XIII:113

Synonyms: *Desmochitina minor* EISENACK 1931, p. 93, Pl. 3:10—11. *Desmochitina minor* f. *typica* EISENACK 1958, p. 398, Pl. 2:29.

Remarks: The spherical to subspherical vesicle, with a rounded basal edge, has spinose ornamentation. The collar is variable but distinct. The aperture is straight. It often forms chains and clusters, but none are recorded in the present material.

Dimensions: Total length 80—170 μ, max. width 80—130 μ, width of aperture 50 μ.

Occurrence: 14 ind., only in prep. 648.

Distribution: The species is cosmopolitan, with a long range, and of little biostratigraphic value (Grahn & Miller 1986). Distribution in Estonia: Rapla borehole, Aseri to Idavere regional stages, Middle Ordovician (Nolvak, in preparation). Recorded earlier from many Upper Arenigian to Upper Ashgillian Lower to Upper Ordovician deposits elsewhere in the Baltic area (Grahn 1982a), Caradocian to Lower Ashgillian, Middle to Upper Ordovician deposits in Europe and in the U.S.A. (Jenkins & Legault 1979) and Caradocian, Middle Ordovician deposits in Canada (Martin 1983).

Desmochitina cf. *D. ovulum* EISENACK 1962

Pl. XIII:114

Synonym: *Desmochitina minor* f. *ovulum* EISENACK 1962, p. 305, Pl. 17:8—9.

Remarks: The vesicle is ellipsoidal to ovoid, with a rounded basal edge. A collar is variable in size, sometimes well developed. The aperture is straight and the vesicle surface smooth.

Dimensions: Total length 80—150 μ, max. width 60—120 μ, width of aperture 30—70 μ.

Occurrence: 46 ind., max. in one sample 43. ind.

Distribution in the Baltic area: Finland: Ordovician erratics from the Bothnian Sea (Tynni 1975, *D. minor* f. *ovulum*). Sweden: Öland boreholes, Upper Langevoja to Lower Valaste, Upper Arenigian to Lower Llanvirnian (Eisenack 1976, Grahn 1981a, 1982b) and Seby to Dalby Limestones, Upper Llanvirnian to Upper Llandeilian (Grahn 1981a). Estonia; Aseri to Kukruse regional stages Middle Ordovician (Eisenack 1962a); Rapla borehole, Lasnamägi to Keila regional stages, Middle Ordovician (Nolvak, in preparation). Distribution in Europe: U.S.S.R.; Moscow Syneclise, Volhov regional stage, Upper Arenigian (Umnova 1969). Portugal Serra de Bucaco; Louredo Formation, Caradocian (Paris 1979).

Desmochitina papilla? GRAHN 1984
Pl. XIII:115

Desmochitina papilla GRAHN 1984, p. 21, Pl. III I—J.

Remarks: The ellipsoidal vesicle has a slightly convex base. The basal process is not clearly visible, and consequently identification is uncertain. The neck is short, with a subcylindrical collar, and is not so distinct as in the species described by Grahn (1984).

Dimensions: Total length 80 μ, width 29 μ, width of aperture 20 μ.

Occurrence: Only one, in prep. 648.

Distribution in Estonia: Tallinn-area, Volhov regional stage, Lower Ordovician (Grahn 1984); Rapla borehole, Volhov regional stage, Lower Ordovician (Nolvak, in preparation).

Genus EISENACHITINA JANSONIUS 1964
Type species: *E. castor* JANSONIUS 1964, p. 912

Eisenachitina oelandica (EISENACK 1955) 1972
Pl. XIII:116

Synonyms: *Conochitina oelandica* EISENACK 1955, p. 312, Pl. 1:4—6. *Bursachitina oelandica* RAUCHER & DOUBINGER 1967, p. 310, Pl. 1:11. *Eisenachitina oelandica* EISENACK 1972, p. 123, Pl. 33:22—29.

Remarks: The subspherical body is short, with a short, cylindrical neck. The convex base has a rounded basal edge. The neck widens at the straight aperture.

Dimensions: Total length 110—120 μ, width of base 65—75 μ, width of aperture 40—60 μ.

Occurrence: 3 ind., only in prep. 654.

Distribution in the Baltic area: Sweden: Öland, Chasmops series Lower Caradocian (Eisenack 1955b) and uppermost Folkesunda to Furudal and Persnäs to Dalby Limestone, Upper Llanvirnian to Upper Llandeilian (Grahn 1981a). North Estonia: base of the Caradocian (Männil 1971, *C. oelandica*); Tallinn area: Kukruse regional stage, Middle Ordovician (Grahn 1984). Not recorded at Rapla borehole.

Distribution in Europe: France: Normandy, Calymene shale to Marrolithus shale, Llanvirnian to Llandeilian, Middle Ordovician (Rauscher & Doubinger 1967).

Genus LAGENOCHITINA EISENACK 1931
Type species: *L. baltica* EISENACK 1931, p. 80—81, Pl. 1:1—3.

Lagenochitina baltica EISENACK 1931
Pl. XIII:117

Lagenochitina baltica EISENACK 1931, p. 80—81, Pl. 1:1—3.

Remarks: The ovoid vesicle has a cylindrical neck about 1/3 of the total length. The basal edge and the flanks are broadly rounded. The aperture is straight.

Dimensions: Total length 80—250 μ, max. width 40—70 μ, width of aperture 22—40 μ.

Occurrence: 4 ind., 1—2 ind. in preps. 654, 696 and 701.

Distribution in Estonia: Rapla borehole, Nabala to Pirgu regional stages, Middle/Upper to Upper Ordovician (Nolvak, in preparation).

Recorded in many Middle Caradocian to Lower Ashgillian, Middle to Upper Ordovician deposits elsewhere in the Baltic area (Grahn 1982a), Caradocian to Lower Ashgillian, Middle to Upper Ordovician deposits in Europe, Llanvirnian to Llandeilian, Middle Ordovician deposits in the U.S.A. and Ashgillian, Upper Ordovician deposits in Canada (Jenkins & Legault 1979, Grahn & Bergström 1984). Reported also in Arenigian, Lower Ordovician deposits in the Sahara, Africa (Benoit & Taugourdeau 1961).

Genus RHABDOCHITINA EISENACK 1931
Type species: *Rh. magna* EISENACK 1931, p. 90—91, Figs. 3—5, Pl. 3:16—18.

Rhabdochitina gracilis EISENACK 1962
Pl. XIII:118

Rhabdochitina gracilis EISENACK 1962, pp. 307—308, Fig. 6, Pl. 14:2; 15:1.

Remarks: The long subcylindrical vesicle has a convex base with a rounded basal edge and straight aperture. Tynni (1975) also has observed smaller forms.

Dimensions: Total length 50—780 μ, width of base 12—80 μ, width of aperture 10—100 μ.

Occurrence: 131 ind., max. in one sample 37 ind.

Distribution in the Baltic area: Finland: Ordovician erratics from the Bothnian Sea (Tynni 1975). Sweden: Öland boreholes, Upper Langevojan to Lower Valastean and Seby to Lower Dalby Limestones, Upper Arenigian to Lower Caradocian (Grahn 1980, 1981a, 1982b) and Vaginatenkalk, Lower Llanvirnian (Eisenack 1976); Dalarna: Hunderumian, Arenigian/Llanvirnian (Eisenack 1962a); Västergötland borehole, Dalby to Bestorp, Caradocian to Lower Ashgillian (Grahn 1981b); Scania boreholes, Dalmatina Beds, Upper Ashgillian (Grahn 1978). Estonia: Kunda to Kukruse regional stages, Lower/Middle to Middle Ordovician (Eisenack 1962a), Kunda to Uhaku regional stages, Lower/Middle to Middle Ordovician (Eisenack 1968); Tallinn area, Kunda to Uhaku regional stages, Lower/Middle to Middle Ordovician (Grahn 1984); Rapla borehole, Kunda to Pirgu regional stages, Lower/Middle to Upper Ordovician (Nolvak, in preparation). Poland: Northern boreholes, Lower Caradocian, Middle Ordovician (Podhalanska 1979).

Baltic Ordovician erratics (Eisenack 1968a, Grahn 1981a). Distribution in Europe: France; Normandie, May-sur-Orne, Llanvirnian to Caradocian (Rauscher 1973); Orne and Mayonne, Arenigian to Llanvirnian (Paris 1981).

The percentages of the acritarch species in the samples examined are listed in Table 1, with the absolute figures for samples 661 and 707 in brackets on account of the small numbers involved. The occurrence of Chitinozoa is likewise denoted in absolute numbers.

The species identified here represent a typical Early Palaeozoic (Ordovician-Silurian) for the Baltic basin. The most significant difference with respect to the findings from Rapla (Uutela & Tynni, in preparation) and Odinsholm (Bockelie & Kjellström 1979) in Estonia and from Gotland and Östergötland in Sweden (Kjellström 1971a,b, 1976) lies in the abundance of small-sized species in southwestern Finland, species which are absent from the Gotland material entirely and are rare in the Rapla core. Similarly the species typical of the Baltic basin are smaller in size in this material than they are further south. It is interesting in this respect that some increase in size in the specimens of certain species is detectable in the younger sediments in the Rapla core.

Species to be found in this material which had previously been encountered only in post-Ordovician sediments are *Cymatiosphaera* cf. *C. striata, Dictyotidium polygonium, D. stenodictyotum* and *Multiplicisphaeridium ramusculosum ramusculosum.* New species identified were *Axisphaeridium tricolumnelare, Kundasphaera lacunosa* and *Priscogalea perforata* and one new forma *Leiofusa granulacutis* f. *quincunx* which were also found in the Rapla formation, but not *Comasphaeridium varispinosum, Nodusosphaeridium rubus* and *Peteinosphaeridium parvispinosum.* Three new genera identified were: *Kundasphaera, Nodusosphaeridium, Raplasphaera.*

Living environments of the acritarchs and Chitinozoa

Investigators differ in their opinions on the significance of acritarchs and Chitinozoa as indicators of sedimentary environments. Rauscher (1973) claims that no such thing as an acritarch or Chitinozoa facies exists and that they are to be found in sediments of all kinds, although he adds that their abundance tends to be a function of the calmness of the sedimentary environment, the microfossils being preserved better in still water than in flowing water. Wall (1965), on the other hand, suggests that the acritarchs can be classified into shallow, deep-water and indifferent species, and Grahn (1982b) makes the same claim for the Chitinozoa.

In connection with the present research the differences between the rock types were determined precisely with reference to the living environments of these microfossils. Table 2. represents an application of the environmental model proposed by Wall (1965) to the species identified in the present material. The predominant species in samples representing shallow-water conditions in bays or close to shores are the small acanthomorphs, usually of the genus *Michrystridium,* of which those with a longer process favour calm water, while those with a shorter process also occurr in sediments laid down under turbulent flow conditions. The sphaeromorphs are encountered in both shallow and deep water, but tend to be more numerous in deep water areas. The acanthomorphs with a slender process occur in low numbers of a broad area close to the shore, while the polyhedric species and those with a thick process are found further away from the shore and only in calm water. The classification employed in the table is rather subjective, since the echinate acanthomorphs with slender processes, for instance, differ from their smooth-surfaced counterparts in their floatational properties. Similarly the number of processes affects floatation, but since the number can vary markedly even between individuals of the same species, this aspect is not taken into account separately in the present classification.

The definition of the living environments of the species employed in the first part of Table 2 are adapted from features mentioned by Wall (*op.cit.*) and the species categorizations of Grahn (*op.cit.*), while the following part describes the occurrence of the species in the various limestone types on the basis first of the present results and finally of the Rapla borehole.

Microfossils in the sedimentary rocks

Microfossils in the Cambrian sandstones

The Cambrian sandstone specimens studied here did not contain any microfossils. This rock type

Table 1. Numbers of acritarchs and Chitinozoa in the samples studied.

	Aremoricanium sp.	Axisphaeridium tricolumnelare n. sp.	Baltisphaeridium brevifilicum	B. brevispinosum	B. calvicinctum	B. cf. B. constrictum	B. filosum	B. hamatum	B. hirsutoides	B. latiradiatum	B. longispinosum longispinosum	B. microspinosum	B. cf. B. multiechinatum	B. multipilosum	B. nanninum	B. pachyacanthum	B. pauciverrucosum	B. podborovisensis?	B. pseudocalicispinosum	B. verrucatum?	B. sp. 1.	B. sp. 2	Buedingiisphaeridium sp.	Comasphaeridium varispinosum n. sp.	Cymatiosphaera pavimenta	C. cf. C. striata	Dicommopalla macadamii	Dictyosphaeridium sp.	Dictyotidium dictyotum
648	—	—	—	1.5	—	—	2.0	—	2.5	—	1.5	4.0	—	—	—	—	—	—	2.0	—	—	—	—	2.0	1.0	<0.5	—	<0.5	—
651	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
652	—	<0.5	—	0.5	—	0.5	<0.5	—	0.5	—	0.5	0.5	—	—	0.5	—	—	—	0.5	—	—	—	0.5	<0.5	0.5	—	0.5	—	0.5
653	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
654	—	—	—	0.5	—	0.5	0.5	—	4.0	—	0.5	0.5	—	1.0	0.5	<0.5	—	—	1.0	<0.5	—	<0.5	0.5	0.5	0.5	—	—	—	1.0
655	—	—	—	—	—	—	—	—	0.5	—	—	0.5	—	—	0.5	—	—	—	0.5	—	—	—	0.5	<0.5	—	—	1.0	—	0.5
656	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
657	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
658	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
660	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
661	—	—	—	(1)	—	—	—	—	(1)	—	(2)	—	(1)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
662	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
663	—	—	—	0.5	—	—	<0.5	—	0.5	—	—	1.5	—	0.5	<0.5	—	—	—	—	—	—	—	<0.5	0.5	—	—	<0.5	—	—
664	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
681	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
682	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
683	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
684	—	—	—	0.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4.8	—	4.8
685	—	0.5	0.5	0.5	—	—	—	—	1.5	—	—	0.5	—	—	—	—	—	—	0.5	—	—	—	—	0.5	—	—	—	—	0.5
686	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
687	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
688	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
689	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.5	—	—	—	2.5
690	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
691	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
692	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
693	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
694	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
695	—	—	—	—	—	—	—	—	1.0	—	—	0.5	—	—	—	—	—	—	—	—	—	—	—	—	0.5	—	0.5	—	0.5
696	—	—	—	—	—	0.5	—	—	2.0	—	<0.5	<0.5	—	—	—	—	—	—	0.5	—	—	—	—	—	—	—	2.5	—	0.5
697	—	<0.5	—	—	—	—	—	—	—	—	—	—	—	0.5	<0.5	—	—	—	—	—	—	—	—	0.5	1.0	—	0.5	—	0.5
698	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
699	—	—	—	4.0	—	—	—	—	21.5	—	3.5	3.0	5.5	—	—	—	—	—	0.5	—	—	—	—	—	—	—	—	—	—
700	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
701	—	—	0.5	0.5	<0.5	—	—	—	9.0	0.5	2.0	2.5	—	—	0.5	—	0.5	—	0.5	—	—	—	—	1.0	—	—	—	—	—
703	—	—	—	—	—	—	—	—	1.5	—	—	1.5	—	—	—	—	—	—	0.5	—	—	—	0.5	1.5	—	—	0.5	—	<0.5
704	—	0.5	—	0.5	—	—	—	—	8.0	—	0.5	—	—	<0.5	—	<0.5	0.5	—	—	—	—	—	1.0	—	<0.5	—	—	—	0.5
705	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
706	—	—	0.5	—	—	—	—	—	2.5	—	0.5	0.5	—	—	—	<0.5	—	—	—	—	—	—	—	0.5	1.5	—	0.5	—	—
707	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	(6)	—	—	—	—	(1)
709	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
710	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
711	—	—	—	—	—	—	—	—	21.8	—	—	4.4	—	—	1.1	<0.5	—	—	—	—	—	—	—	2.2	—	—	—	—	0.5
712	<0.5	—	—	1.4	—	—	0.7	—	32.2	—	3.5	4.9	5.6	—	—	—	—	<0.5	—	—	25.5	—	—	—	0.7	—	—	—	0.7
713	—	1.0	—	—	—	—	—	—	12.5	1.0	0.5	0.5	—	1.0	1.0	—	—	—	0.5	—	—	—	—	—	—	—	0.5	—	—
714	—	—	—	—	—	—	—	—	1.6	—	—	—	—	—	—	—	—	—	—	—	—	—	0.8	—	—	—	—	—	0.8
715	—	<0.5	<0.5	0.5	—	<0.5	—	<0.5	7.0	—	0.5	2.0	—	—	—	<0.5	—	—	0.5	—	—	<0.5	—	<0.5	—	—	0.5	—	1.0
716	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
717	—	—	—	—	—	—	—	—	—	—	—	1.0	—	0.5	—	—	—	—	—	—	—	—	—	0.5	1.0	—	—	—	3.0
718	—	—	—	—	—	—	0.9	—	16.2	—	—	2.7	—	—	1.8	—	—	—	—	—	—	—	—	—	—	—	—	—	1.8
719	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
720	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
721	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
722	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
723	—	—	—	—	—	—	1.0	—	1.5	—	—	<0.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
724	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
725	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
726	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
727	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
728	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
729	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
791	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

D. polygonium	D. reticulatum	D. stenodictyotum	Goniosphaeridium mochtiensis	G. polygonale	G. cf. G. polygonale polyacanthtum	G. splendens	Hapsidopalla sp.	Helosphaeridium sp.	Kundasphaera sp.	Leiofusa granulacutis	L. granulacutis f. quincunx n. f.	Leiosphaeridia sp.	Leiosphaeridia ssp.	Leiovalia ovalis	L. similis	Lophosphaeridium citrinipeltatum	L. papillatum	L. pilosum	Micrhystridium henryi	M. inconspicuum aremoricanium	M. nannacanthum	M. robustum	M. stellatum	Multiplicisphaeridium alloteaui	M. bifurcatum	M. irregulare	M. radicosum	M. ramusculosum ramusculosum	M. raspa	M. sp. 1.
—	—	—	1.5	—	<0.5	1.0	—	—	—	—	—	—	38.2	—	0.5	1.0	0.5	1.0	12.0	—	34.5	—	4.5	2.0	1.0	—	—	—	—	12.0
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	0.5	2.0	<0.5	19.5	—	—	—	<0.5	<0.5	—	26.4	—	1.0	0.5	0.5	2.0	19.5	—	29.5	<0.5	1.5	0.5	0.5	<0.5	—	<0.5	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	0.5	—	<0.5	5.0	—	—	<0.5	—	—	—	30.3	—	0.5	1.0	1.0	0.5	6.5	—	53.0	<0.5	6.0	1.0	0.5	3.0	—	<0.5	<0.5	0.5
<0.5	<0.5	—	—	0.5	—	0.5	—	<0.5	—	<0.5	—	—	53.5	—	0.5	—	1.5	0.5	12.5	<0.5	69.0	—	6.0	2.5	1.0	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	(2)	—	—	—	—	—	—	—	—	—	(5)	—	—	(1)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	0.5	<0.5	—	0.5	—	2.0	—	—	—	<0.5	—	10.0	55.7	<0.5	1.5	—	1.5	0.5	3.5	<0.5	68.0	—	4.5	<0.5	0.5	0.5	—	—	<0.5	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	1.5	7.5	—	7.0	—	—	—	—	—	—	43.6	—	4.8	—	4.8	1.5	11.8	—	33.0	—	9.6	0.7	1.5	—	—	—	—	—
—	0.5	—	—	0.5	—	4.5	—	—	—	—	—	—	15.9	—	0.5	—	3.5	1.5	16.0	—	58.5	—	6.0	—	0.5	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	0.5	—	—	—	—	—	—	42.6	—	0.5	—	2.5	0.5	6.5	—	76.0	—	3.0	0.5	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	0.5	1.0	—	2.5	—	—	—	—	—	—	35.0	<0.5	8.5	1.0	4.0	—	9.5	—	43.0	—	19.5	1.0	1.0	—	—	—	—	—
—	—	—	—	—	—	1.5	—	—	—	—	—	—	22.1	—	0.5	0.5	2.5	0.5	3.5	—	74.5	—	2.0	1.0	0.5	1.0	—	—	—	—
—	—	—	—	0.5	—	1.5	—	—	—	0.5	—	—	38.8	<0.5	3.0	—	4.0	—	18.0	—	59.5	—	8.0	<0.5	0.5	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	2.0	0.5	—	1.0	—	—	—	—	—	—	74.4	—	2.0	1.5	1.5	—	—	—	47.5	—	1.0	0.5	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	1.5	—	—	5.0	—	—	—	<0.5	—	—	55.2	—	0.5	3.5	0.5	—	4.0	—	52.0	—	—	0.5	0.5	—	—	—	—	—
<0.5	—	—	—	0.5	—	3.0	—	—	—	—	—	—	54.7	—	5.0	—	4.5	—	3.0	—	43.5	—	19.5	3.0	0.5	—	—	—	—	—
—	0.5	—	0.5	2.0	—	8.0	—	—	—	<0.5	—	—	30.3	—	1.0	1.0	1.5	—	4.5	—	40.5	—	7.5	0.5	0.5	11.0	—	—	0.5	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	7.5	—	5.5	—	—	<0.5	—	—	—	38.9	—	8.5	—	2.0	—	6.0	—	42.5	—	18.0	1.5	0.5	—	—	—	—	—
—	—	—	(1)	(1)	—	(7)	—	—	—	—	—	—	(1)	—	—	—	—	(1)	—	—	(5)	—	(1)	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	5.0	—	7.8	—	—	—	—	—	—	66.4	—	—	0.5	—	—	1.1	—	32.8	—	15.6	—	0.5	—	—	—	—	—
—	—	—	12.6	1.4	—	0.7	—	—	—	—	—	—	46.8	—	—	—	—	—	0.7	<0.5	0.7	—	—	0.7	0.7	—	—	—	—	—
—	—	—	—	1.0	—	7.5	—	—	—	—	—	—	40.8	—	—	0.5	—	—	4.5	—	48.0	—	11.5	0.5	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	64.5	—	0.8	3.3	0.8	—	4.1	—	26.0	—	61.8	—	—	—	—	—	—	—
—	—	—	0.5	0.5	—	5.5	<0.5	—	—	—	<0.5	—	37.1	—	0.5	0.5	—	—	6.0	<0.5	24.0	<0.5	44.5	—	<0.5	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	3.5	—	—	—	—	—	—	37.9	—	2.0	—	1.0	—	4.5	—	71.0	—	9.5	—	—	—	—	—	—	—
—	—	—	—	0.9	—	3.6	—	—	—	—	—	—	55.2	—	—	—	3.6	—	6.3	—	34.3	—	11.7	—	—	1.8	6.3	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	<0.5	—	5.5	—	—	—	—	—	—	30.5	—	<0.5	1.0	<0.5	—	5.0	—	53.0	—	30.0	—	<0.5	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 1. cont.

	M. sp. 2.	Nanocyclopia sp.	Nodusosphaeridium rubus n. sp.	Orthosphaeridium densiverrucosum	O. insculptum	O. vibrissiferum	Peteinosphaeridium heteromorphicum	P. micranthum	P. nanofurcatum	P. nudum	P. parvispinosum n. sp.	P. paucifurcatum	P. trifurcatum?	P. trifurcatum longiradiatum	Pheoclosterium sp. 1.	P. sp. 2.	Pirea sp.	Polyancistrodorus cf. P. columbariferus	P. intricatus	Priscogalea perforata n. sp.	Pterospermopsis sp.	Raplasphaera sp.	Rhopliophora foliatilis	R. palmata	R. pilata	Stelliferidium modesta	Tasmanites cf. T. verrucosus	T. ssp.	Timofeevia sp. 1.
648	<0.5	1.5	—	<0.5	—	<0.5	3.5	0.5	—	3.0	<0.5	<0.5	—	—	<0.5	—	—	—	0.5	—	1.5	—	—	—	<0.5	—	—	0.5	<0.5
651	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
652	<0.5	0.5	—	<0.5	<0.5	—	0.5	—	—	1.5	—	—	—	—	—	—	—	8.5	0.5	—	—	—	—	—	—	<0.5	3.5	—	0.5
653	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
654	—	—	—	—	<0.5	<0.5	0.5	0.5	—	3.5	<0.5	—	—	—	<0.5	<0.5	<0.5	—	0.5	<0.5	—	<0.5	<0.5	<0.5	<0.5	—	—	2.0	0.5
655	<0.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	<0.5	—	—	—	—	—	—	1.5	—
656	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
657	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
658	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
660	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
661	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
662	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
663	0.5	—	—	—	—	—	<0.5	—	—	1.0	—	—	—	—	—	—	—	—	—	—	0.5	—	—	—	<0.5	—	—	0.5	—
664	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
681	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
682	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
683	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
684	—	1.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.5	—	—	—	—	—	—	3.0	—
685	—	—	—	—	—	—	—	—	—	0.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.5	—
686	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
687	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
688	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
689	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6.5	—
690	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
691	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
692	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
693	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
694	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
695	—	—	—	—	—	—	1.0	1.0	—	—	—	—	—	—	—	—	—	—	—	—	0.5	—	—	—	—	—	—	3.0	—
696	—	1.5	—	—	—	—	—	—	—	2.0	—	—	—	<0.5	—	—	—	0.5	0.5	—	—	—	—	—	—	—	—	1.5	—
697	—	—	—	—	—	—	0.5	—	—	0.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.5	—
698	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
699	—	0.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4.0	—
700	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
701	—	—	—	—	—	<0.5	1.0	—	—	1.0	—	—	0.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
703	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6.5	—	—	—	—	—	—	5.0	—
704	<0.5	1.5	—	—	—	—	1.0	—	—	1.0	—	—	—	—	—	—	—	—	—	—	0.5	—	—	—	—	—	—	3.0	—
705	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
706	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.0	—
707	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
709	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
710	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
711	—	—	—	—	—	—	—	—	—	4.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2.2	—
712	—	0.7	<0.5	—	—	—	—	0.7	0.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.2	—
713	—	—	—	—	—	—	1.5	—	—	0.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6.0	—
714	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
715	—	1.0	—	—	—	—	—	—	<0.5	2.0	<0.5	<0.5	—	—	—	—	—	0.5	—	—	—	—	—	—	—	—	—	2.0	—
716	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
717	—	—	—	—	—	—	—	—	—	1.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.5	—
718	—	—	—	—	—	—	—	—	—	—	—	—	2.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.4	—
719	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
720	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
721	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
722	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
723	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	<0.5	—	—	—	—	—	—	—	0.5	0.5	—
724	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
725	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
726	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
727	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
728	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
729	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
791	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

T. sp. 2.	Tranvikium polygonale	Veryhachium geometricum	V. irroratum	V. lairdi	V. oklahomense	V. oligospinosum	V. reductum	V. rhombispinosum	V. trispinosum	V. trisulcum	Conochitina cactacea	C. conulus	C. cucumis	C. elegans	C. micracantha	C. minnesotensis	C. primitiva	C. wesenbergensis	Cyathochitina campanulaeformis	C. kuckersiana	C. latipatagium	Desmochitina amphorea	D. cocca	D. minor	D. cf. D. ovulum	D. papilla?	Eisenachitina oelandica	Lagenochitina baltica	Rhabdochitina gracilis
<0.5	1.0	—	<0.5	—	—	—	—	—	—	—	—	(15)	—	—	(10)	—	—	—	—	(2)	—	—	(8)	(14)	(43)	(1)	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	1.5	—	—	(3)	(16)	—	—	(14)	(3)	(2)	(7)	(2)	—	—	(1)	(2)	—	—	—	—	—	(2)
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<0.5	0.5	<0.5	—	—	—	—	<0.5	1.5	—	—	—	(32)	—	(3)	(8)	(1)	(12)	(14)	(1)	(1)	—	—	—	—	(1)	—	(3)	—	(16)
—	—	—	—	—	—	—	—	—	—	—	—	(1)	—	(1)	(1)	(1)	(4)	—	(1)	—	—	—	(1)	—	—	—	—	(1)	(12)
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	0.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	(1)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	(1)
—	—	—	—	0.5	—	—	—	0.5	—	—	—	—	—	—	(1)	—	(2)	—	—	—	—	—	—	—	—	—	—	—	(10)
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	0.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	(3)	(6)	—	—	—	(3)	(1)	(18)	—	—	—	—	(1)	—	—	—	—	—	(8)
—	—	—	—	—	—	—	—	—	—	—	—	—	—	(1)	(2)	(2)	(2)	—	—	—	(4)	—	—	—	(1)	—	—	(1)	—
—	—	—	—	—	—	—	—	—	—	—	—	(2)	—	—	—	—	(1)	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	<0.5	—	—	—	—	<0.5	12.0	<0.5	<0.5	—	(16)	—	—	(6)	—	(5)	(2)	—	—	—	—	(2)	—	—	—	—	(2)	(1)
—	—	—	—	—	—	—	—	—	—	—	(1)	(1)	—	—	—	—	(1)	(1)	—	—	—	—	—	—	—	—	—	—	(5)
—	—	—	—	—	—	—	—	0.5	1.5	—	—	(7)	—	—	—	—	(6)	(1)	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	0.5	—	—	—	—	—	—	—	(1)	—	—	(3)	(12)	—	—	—	—	—	—	—	—	—	—	(7)
—	—	—	—	—	—	—	—	(1)	—	—	—	—	—	(1)	(1)	—	(2)	—	—	—	—	—	—	—	(1)	—	—	—	(15)
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	(1)	(1)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	(4)
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	(1)	(8)	—	—	(14)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	0.5	—	—	(4)	(31)	—	(3)	(21)	(2)	(1)	(6)	—	—	—	—	(1)	—	—	—	—	—	(12)
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	(1)	—	(2)	—	—	—	—	—	—	—	—	—	—	—	(1)
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	(1)	—	—	—	—	—	—	(1)	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	2.0	—	—	—	—	—	(3)	(1)	(5)	(3)	—	—	—	—	—	(1)	—	—	—	—	—	(37)
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 2. Living environments of the acritarchs and Chitinozoa after Wall (1965) and Grahn (1982b) and their occurrence in different calcareous rock types in the present material and in the Rapla core.

	Wall 1965 & Grahn 1982b			SW-Finland			Rapla, Estonia		
	1	2	3	VO	C	S	I	II	III
Aremoricanium sp.	+	+	+		+	+	+	+	+
Axisphaeridium tricolumnelare n. sp.		+			+	+		+	+
Baltisphaeridium brevifilicum		+			+	+			
B. brevispinosum			+	+	+	+	+	+	
B. clavicinctum		+			+				
B. cf. B. constrictum			+		+	+			
B. filosum		+		+	+	+		+	+
B. hamatum		+				+		+	
B. hirsutoides		+		+	+	+	+	+	+
B. latiradiatum			+		+	+		+	+
B. longispinosum longispinosum		+		+	+	+	+	+	+
B. microspinosum		+		+	+	+	+	+	+
B. cf. B. multiechinatum		+		+			+	+	+
B. multipilosum		+			+	+	+	+	+
B. nanninum		+			+	+		+	+
B. pachyacanthum		+			+	+		+	+
B. pauciverrucosum		+			+	+		+	+
B. podboroviscensis?		+		+					
B. pseudocalicispinum		+			+	+	+	+	+
B. verrucatum?		+				+		+	+
B. sp. 1		+		+		+	+	+	+
B. sp. 2.		+			+		+	+	+
Buedingiisphaeridium sp.	+				+	+		+	+
Comasphaeridium varispinosum n. sp.		+			+	+			
Cymatiosphaera pavimenta		+			+	+	+	+	+
C. cf. C. striata		+				+			
Dicommopalla macadamii	+				+	+		+	+
Dictyosphaeridium sp.	+				+			+	+
Dictyotidium dictyotum	+			+	+	+			
D. polygonium	+					+			
D. reticulatum	+				+	+			
D. stenodictum	+					+			
Goniosphaeridium mochtiensis			+	+	+	+	+	+	
G. polygonale			+	+	+	+	+	+	+
G. cf. G. polygonale polyacanthum			+	+	+		+	+	
G. splendens			+	+	+	+	+	+	+
Hapsidopalla sp.		+				+			
Helosphaeridium sp.		+			+			+	+
Kundasphaera sp.		+			+	+		+	+
Leiofusa granulacutis			+		+	+		+	+
L. granulacutis f. quincunx			+			+		+	+
Leiosphaeridia sp.	+					+			
Leiosphaeridia spp.	+			+	+	+	+	+	+
Leiovalis ovalis			+			+			
L. similis			+		+	+		+	+
Lophosphaeridium citrinipeltatum	+			+	+	+	+	+	+
L. papillatum	+			+	+	+	+	+	+
L. pilosum	+			+	+	+	+	+	+
Micrhystridium henryi	+			+	+	+	+	+	+
M. inconspicuum aremoricanium		+		+		+		+	+
M. nannacanthum	+			+	+	+	+	+	+
M. robustum		+			+	+			
M. stellatum		+		+	+	+	+	+	+
Multiplicisphaeridium alloteaui		+		+	+	+		+	+
M. bifurcatum		+		+	+	+		+	+
M. irregulare		+			+	+		+	+

Table 2. cont.

	Wall 1965 & Grahn 1982b			SW-Finland			Rapla, Estonia		
	1	2	3	VO	C	S	I	II	III
M. radicosum			+			+		+	
M. ramusculosum ramusculosum		+			+				
M. raspa		+			+	+		+	+
M. sp. 1.	+				+			+	+
M. sp. 2.	+				+	+		+	+
Nanocyclopia sp.	+			+	+			+	+
Nodusosphaeridium rubus n. sp.		+		+					
Orthosphaeridium densiverrucosum			+		+			+	+
O. insculptum			+		+			+	+
O. vibrissiferum			+		+			+	+
Peteinosphaeridium heteromorphicum			+		+	+		+	+
P. micranthum		+		+	+	+	+		
P. nanofurcatum		+		+				+	
P. nudum			+		+	+		+	+
P. parvispinosum		+			+	+			
P. paucifurcatum		+				+			
P. trifurcatum?		+			+	+		+	+
P. trifurcatum longiradiatum		+			+			+	+
Pheoclosterium sp. 1.		+			+				
Ph. sp. 2.		+			+			+	
Pirea sp. 1.		+			+				
Polyancistrodorus cf. P. columbariferus			+		+	+		+	+
P. intricatus			+		+			+	+
Priscogalea perforata n. sp.	+				+			+	+
Pterospermopsis sp.	+				+	+		+	+
Raplasphaera sp.		+			+			+	
Rhopaliophora foliatilis			+		+			+	+
Rh. palmata			+		+			+	+
Rh. pilata			+		+			+	+
Stelliferidium modesta	+				+			+	
Tasmanites cf. T. verrucosus	+				+			+	+
Tasmanites spp.									
Timofeevia sp. 1.		+			+			+	
T. sp. 2.		+			+			+	
Tranvikium polygonale	+				+		+	+	
Veryhachium geometricum			+		+			+	+
V. irroratum			+		+			+	+
V. lairdi			+		+			+	+
V. oklahomense			+			+		+	+
V. oligospinosum			+			+		+	+
V. reductum			+		+			+	+
V. rhombispinosum			+		+	+	+	+	+
V. trispinosum			+		+	+		+	+
V. trisulcum			+		+			+	+
Conochitina cactacea		n.d.			+	+		+	+
C. conulus		n.d.				+		+	+
C. cucumis	+				+	+		+	+
C. elegans	+	+	+		+	+		+	+
C. michracantha	+	+	+		+	+		+	+
C. minnesotensis	+	+	+		+	+		+	+
C. primitiva	+	+	+		+	+		+	+
C. wesenbergensis			+		+	+		+	+
Cyathochitina campanulaeformis	+	+	+		+	+		+	+
C. kuckersiana	+	+	+		+	+		+	+
C. latipatagium		n.d.			+			+	+
Desmochitina amphorea		n.d.			+			+	
D. cocca		n.d.			+	+		+	

Table 2. cont.

	Wall 1965 & Grahn 1982b			SW-Finland			Rapla, Estonia		
	1	2	3	VO	C	S	I	II	III
D. minor		n.d.			+			+	+
D. cf. D. ovulum		n.d.			+	+		+	+
D. papilla?		n.d.			+		+		
Eisenachitina oelandica		n.d.			+				
Lagenochitina baltica		n.d.			+	+		+	+
Rhabdochitina gracilis	+	+	+		+	+		+	+

Legend to Table 2.
Wall 1965 & Grahn 1982b:
1 = shallow, turbulent water
2 = near shore environment
3 = calm water
SW-Finland: VO = greenish grey marl
C = grey marl
S = yellow grey calcilutite
Rapla, Estonia (Polma 1972)
I = Limestone with silty fractions
II = argillaceous limestone with marly interbeddings
III = crypto- and microcrystalline limestone

may be identified to the Lower Cambrian on the basis of the literature (Lindström 1963).

Microfossils in the greenish grey marl

The characteristic feature of the specimens of greenish grey marl was the low incidence of acritarchs in terms of both the number of individuals and number of species. Of the 98 species identified in the total material, 29 are present in this rock type, 6—23 per preparation. No Chitinozoa were found. An exceptionally large number of species of the genus *Baltisphaeridium* are to be found in these rocks, principally *B. hirsutoides* (21.0—32.0 %). Although *B. brevispinosum, B. longispinosum* and *B. microspinosum* were slightly more frequent here than in the other rock types, they still accounted for only a few percent each. *Aremoricanium sp., Baltisphaeridium* cf. *B. multiechinatum, B. podboroviscensis?* and *B. sp. 1.* were exclusive to this rock type.

Microfossils in the grey marl

The grey marl specimens contained large numbers of acritarchs, representing a wide variety of species. Altogether 70 out of the 98 species occurred, with between 22 and 54 species per preparation. The percentages for the individual species were low in general, with the exception of *Micrhystridium nannacanthum,* which reached figures of 29.5—74.5 % in this rock type and was similarly dominant in the total material. It is only in the grey marl that the large-sized acanthomorphs of the genus *Orthosphaeridium,* with their thick processes, were found, and also *Goniosphaeridium polygonale polyacanthum* among the polygonomorphs, their proportions remaining below 1.5 % throughout, however. Other species restricted to this rock type were *Baltisphaeridium clavicinctum, B. verrucatum?, Dictyosphaeridium sp., Pirea sp., Rhopaliophora foliatilis, R. palmata, R. pilata, Stelliferidium modesta, Timofeevia sp. 2.* and *Tranvikium polygonale,* all of which had incidence numbers of less than 1.0 % and may well be accidental. Of the Chitinozoa, *Desmochitina amphorea* occurred only in this rock type.

Microfossils in the yellowish grey calcilutite

The material representing the yellowish grey calcilutite of the Baltic limestone is heterogeneous as far as its acritarch species are concerned and may fall into a number of distinct subtypes. 67 out of the 98 species were identified, with each preparation containing between 12 and 39 species. Their proportions varied markedly, however, so that it was more difficult to pick out any common features than for the greenish grey and grey marls. Even *Micrhystridium nannacanthum* and *M. henryi* were not dominant in all the specimens, their proportions varying from 26.0 to 78.5 %. The only consistent feature would seem to be the low proportion or complete absence of the acanthomorphs with thick processes. Species restricted only to this rock type were *Baltisphaeridium latiradiatum, Dictyotidium polygonatum, D. reticulatum, D. stenodictyotum, Hapsidopalla sp., Leiovalia ovalis* and *Peteinosphaeridium paucifurcatum,* but none of these exceeded 1.0 % of the total. The specimen 718 contained 6.3 % *Multiplicisphaeridium radicosum.* Among the Chitinozoa, *Conochitina cucumis* was found only in this rock type.

Microfossils in the reddish grey calcilutite

The oxidizing conditions prevailing in the reddish grey calcilutite of the Baltic limestone had destroyed all the organic microfossils. Deposition of this rocktype has been dated from conodont evidence to the Nabala regional stage (F_{1a}) of the Late Caradocian, on the border between the Middle and Upper Ordovician (Merrill 1979).

Classification of sedimentary limestones by reference to acritarch genera

In order to elucidate any differences between the limestones in terms of sedimentary environment, histograms were constructed to represent the occurrence of the genera *Baltisphaeridium, Cymatiosphaera, Goniosphaeridium, Micrhystridium, Multiplicisphaeridium, Orthosphaeridium, Peteinosphaeridium* and *Veryhachium* in each sample, in addition to which the sphaeromorphs *Dicomopalla, Dictyotidium, Lophosphaeridium, Nanocyclopia, Nodusosphaeridium, Pterospermopsis, Stelliferidium, Tasmanites* and *Tranvikium* were combined to form a single column in the diagram. The 'varia' class was then taken to include the genera *Aremoricanium, Axisphaeridium, Buedingiisphaeridium, Hapsidopalla, Helosphaeridium, Kundasphaera, Leiofusa, Pheoclosterium, Pirea, Polyancistrodorus, Priscogalea, Raplasphaera, Rhopaliophora* and *Timofeevia,* which although said by Wall (1965) to represent different sedimentary environments. Frequencies usually occur of less than 1.0 % in the present material, so that they are of little consequence for the overall result, the one exception to this is the 8.5 % frequency of *Polyancistrodorus* in sample 652 (Fig. 13).

The highest proportion of individuals usually belong to the genus *Micrhystridium,* with the exception of sample 712, the next most frequent genera being *Baltisphaeridium, Goniosphaeridium* and *Multiplicisphaeridium,* the order of abundance of which varies from one sample to another. The sphaeromorphs and varia normally occupied third to sixth place in the order of abundance.

The differences in species distribution between the rock types were small and possibly represent random variation, and thus no generalization can be made from these histograms. The grey marls tended to be more heterogeneous in the genera represented than did the yellowish grey calcilutites, for example (compare samples 648, 652, 654 and samples 655, 663, 689), but the situation could also be the reverse (compare samples 685, 696 with 704 and 718).

Classification of sedimentary limestones by reference to acritarch species

A scheme was constructed for elucidating the differences between the limestones in terms of the species distributions of the acritarchs based on calculation of the most common species, second most common species, etc. in each sample (Fig. 14). For this purpose it was necessary to combine certain morphologically similar species, principally *Micrhystridium stellatum* and *Goniosphaeridium splendens,* and in the same way *Baltisphaeridium hirsutoides, B.* cf. *B. multiechinatum* and *B. sp. 1.*

At level 1 the samples could be divided into three principal species groups. Group A: *Micrhystridium stellatum,* Group B: *Baltisphaeridium hirsutoides + B. sp. 1. + B.* cf. *B. multiechinatum,* and Group C: *Micrhystridium nannacanthum.*

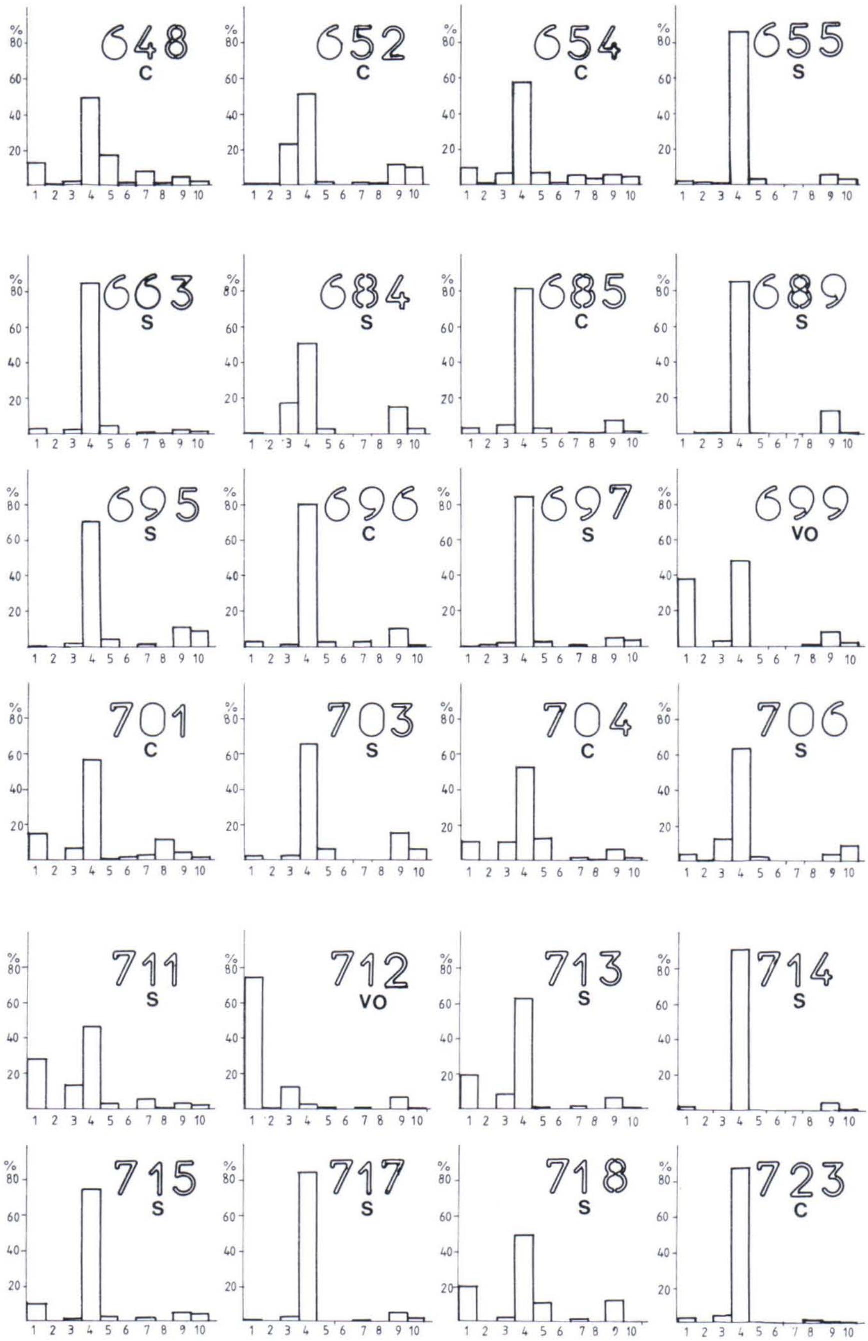


Fig. 13. Division of rock types by genera of acritarchs present. Legend: 1 = *Baltisphaeridium*, 2 = *Cymatiosphaera*, 3 = *Goniosphaeridium*, 4 = *Micrhystridium*, 5 = *Multiplicisphaeridium*, 6 = *Orthosphaeridium*, 7 = *Peteinosphaeridium*, 8 = *Veryhachium*, 9 = sphaeromorphs, 10 = class *'varia'*.Fig. 13. Division of rock types by genera of acritarchs present. Legend: 1 = *Baltisphaeridium*, 2 = *Cymatiosphaera*, 3 = *Goniosphaeridium*, 4 = *Micrhystridium*, 5 = *Multiplicisphaeridium*, 6 = *Orthosphaeridium*, 7 = *Peteinosphaeridium*, 8 = *Veryhachium*, 9 = sphaeromorphs, 10 = class *'varia'*.

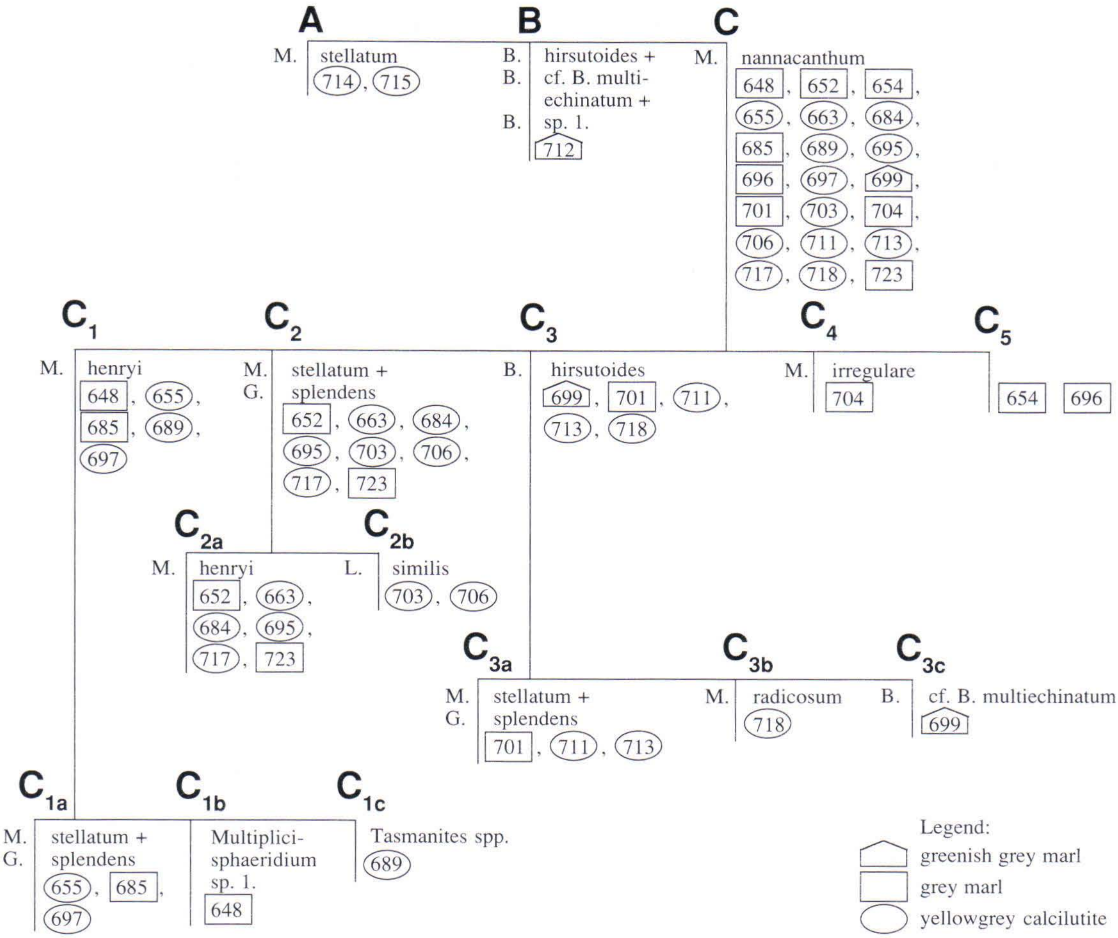


Fig. 14. Division of rock types by species of acritarchs present.

The only subdivision required at the level of the next most common species, level 2, concerned Group C: *M. nannacanthum,* to distinguish Group C1: *M. henryi,* Group C2: *M. stellatum + G. splendens,* Group C3: *Baltisphaeridium hirsuitoides,* Group C4: *Multiplicisphaeridium irregulare,* and as a separate unit Group C5: a compendium of species all accounting for small percentages of the total.

At level 3 the groups comprising a number of samples were divided into subgroups on the basis of the third most common acritarch species. This meant that three subgroups were distinguished within the *Micrhystridium henryi* group, Subgroup C1a: *M. stellatum + G. splendens,* Subgroup C1b: *Multiplicisphaeridium sp. 1,* and Subgroup C1c: *Tasmanites spp.* Similarly the *Micrhystridium stellatum + Goniosphaeridium splendens,* Group C2 was divided into Subgroup C2a: *M. henryi* and Subgroup C2b: *Leiovalia similis.* The heterogeneous Group C3: *B. hirsuitoides* then comprised Subgroup C3a: *M. stellatum + G. splendens,* and Subgroup C3b: *Multiplicisphaeridium radicosum* and Subgroup C3c: *Baltisphaeridium* cf. *B. multiechinatum.*

It is impossible to define the levels in terms of precise percentages as these vary so widely between the groups. The proportion of *Micrhystridium stellatum* at the first level varies in the range 44.5—61.8 %, while that of *Baltisphaeridium hirsuitoides* + *B*. cf. *B. multiechinatum* + *B. sp. 1.* is 63.1 % and those of *Micrhystridium nannacanthum* vary within the limits 29.5—76.0 %.

At level 2 the proportions of most of the species vary in the range 10.0—25.0 %, the exceptions being sample 723, in which *M. stellatum* and *Goniosphaeridium splendens* account for 35.5 % and samples 689 (*M. henryi* group), 663 and 717 (*M. stellatum*/*G. splendens* group), 701 (*B. hirsuitoides* group and the multi-species samples 654 and 696, where the proportions remained below 10.0 %.

By the third level the majority of the percentages were under 10.0 %, although again with some exceptions: sample 685 (*M. stellatum* + *G. splendens*), samples 652 and 684 (*M. henryi*) and samples 711, 713 and 718 (*B. hirsuitoides*), in which the figures varied between 10.5 % and 15.1 %.

The various limestone types were then marked with codes of their own. In terms of the classification of Wall (1965), the samples in Group A must have been laid down in calm, shallow water, those in Group C possible also in areas of turbulent water, and those of Group B somewhat further away from the shore although not yet under true open sea conditions. This classification does not suffice to point to the differences in sedimentary environment between the limestone types in the present material, however. In other words it is still not possible to state on the basis of the present material that the calcilutites were laid down in deeper water and further away from the shore than the marls, for instance.

Dating of the specimens

Based on the acritarchs (Uutela & Tynni, in preparation) and Chitinozoa (Nolvak, in preparation) identified in the Rapla core and as the principal comparative material, a dating scheme was drawn up to cover all the present samples containing acritarchs or chitinozoans. The results are represented by solid lines in the diagrams. Consequently the body of comparative material was extended at this point to include the works of Bockelie and Kjellström (1979) and Eisenack (1962c) in Estonia and Kjellström in Sweden (1971a,b, 1972, 1976) on the acritarchs and those of Grahn (1984) in the area of Tallinn and (1981a,b, 1982a) in Sweden on the Chitinozoa. These dates and records further away the Baltic area are indicated in the diagrams by broken line.

The thickness of the line is proportional to the frequency of occurrence of the species, represented in classes with the following boundary values: < 2.0 % = rare, 2.0—10.0 % = moderate, 10.1—50.0 % = common, and > 50.0 % = dominant.

Specimen no. 648, Hanko, Spikarna
Fig. 15.

Among the Ordovician-Silurian species, the acritarchs which are restricted to the lower part of the Middle Ordovician, i.e. the Volhov—Kukruse regional stages in the Rapla material, are *Baltisphaeridium brevispinosum, Timofeevia sp. 1., T. sp. 2.* and *Tranvikium polygonale,* while of the total of 93 chitinozoans present, one *Desmochitina papilla?* also falls into this category.

Preliminary examination of the Rapla core suggest that *Peteinosphaeridium nudum* (3.0 %) appears in the Lasnamägi regional stage.

The sample was dated to the Aseri — Lasnamägi transition, although *Pterospermopsis sp.* (1.5 %) appears at the Kukruse regional stage at Rapla borehole.

Also present in this sample are *Comasphaeridium varispinosum n. sp.* (2.0 %)and *Peteinosphaeridium parvispinosum n. sp.* (<0.5 %).

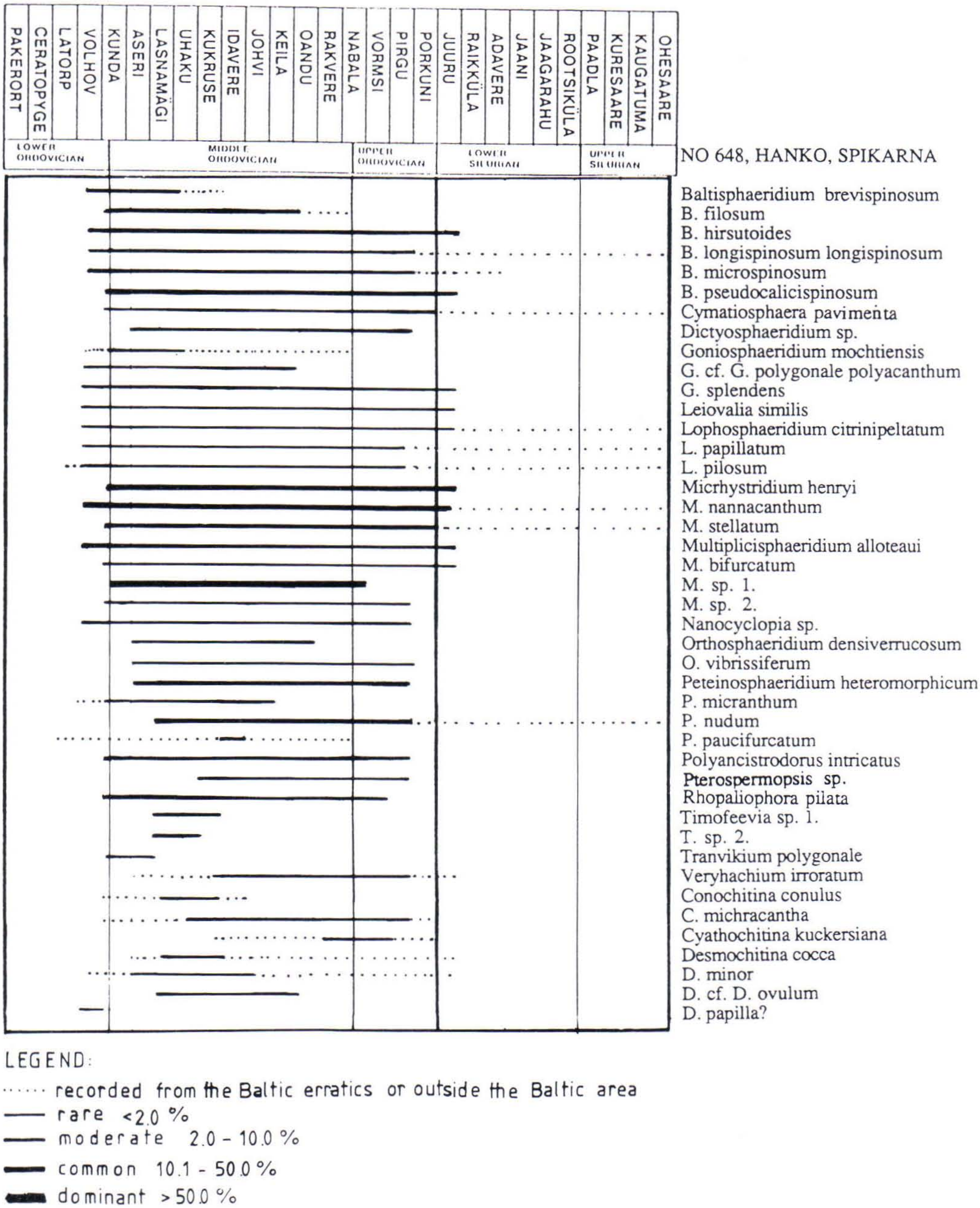


Fig. 15. Dating of the specimen no. 648: Hanko, Spikarna.

Specimen no. 651: Uusikaupunki, Valkiameri 12/ KH/80

No microfossils were found.

Specimen no. 652: Hanko, Stora Stenskär 9a1/ KH/80 Fig. 16.

The species present here are rather heterogeneous as far as dating is concerned. Those restricted to the lower part of the Middle Ordovician are *Baltisphaeridium brevispinosum,* and *Timofeevia sp. 1.*, but their total abundance remains 1.0 %. *Stelliferidium modesta* (frequency < 0.5 %) is known only from the Lower Ordovician, the Kunda regional stage at Rapla and the Arenigian in Poland (Gorka 1969). Of the Chitinozoa, *Conochitina conulus* (26 ind. present) lived during the Aseri and Keila regional stages.

Of the 52 chitinozoans identified, *Desmochitina amphorea* (1 ind.) has be found in the Idavere and Oandu regional stages at Rapla (Nolvak, in prep.) but in Idavere and Vormsi deposits at Tallinn (Grahn 1984). It evidently occurred earlier, in the Aseri and Uhaku regional stages, elsewhere in the Baltic (Eisenack 1962b).

Species restricted to the Upper Ordovician is *Leiofusa granulacutis* f. *quincunx n. f.* (<0.5 %). *Micrhystridium robustum* is recorded from the Lower Ordovician and the Ordovician Silurian transition, but not from the Middle Ordovician (Martin 1966a, 1968, 1972). *Multiplicisphaeridium ramusculosum ramusculosum* is recorded previously in the Lower Silurian (Cramer & Diez 1972).

This specimen evidently contains two bodies of material of differing age. One set of species may be dated to the Kukruse regional stage and *Stelliferidium modesta* would be reworked material. The second set of species apparently originates from the Vormsi to Pirgu regional stages. Although this consigns nine species to the redeposited group, these cases amount to 3.0 % in frequency terms.

The species list also includes *Comasphaeridium varispinosum n. sp.* (<0.5 %).

In the view of the high amount of *Conochitina conulus* present, an eventual dating to older than the Keila, i.e. the Kukruse regional stage, was preferred. This dating must be regarded as inconclusive, however, on account of the occurrence of the species *Stelliferidium modesta* and *Leiofusa granulacutis f. quincunx n. f.*

Specimen no. 653: Kiukainen, Vaaniinkangas 2/ KH/83

No microfossils were found.

Specimen no. 654: Dragsfjärd, Vitfågelskär 8.7.80/KH
Fig. 17.

The species list is almost as heterogeneous as in the previous case. *Baltisphaeridium brevispinosum, Pheoclosterium sp. 2., Timofeevia sp. 1., T. sp. 2.,* and *Tranvikium polygonale,* together accounting for 1.5 % of the total, are all species of the lower part of the Middle Ordovician. *Veryhachium reductum* (<0.5 %) is known only from the Uhaku to the Keila regional stages and *V. geometricum,* which is generally found only in Silurian deposits, occurs in the Lasnamägi and Johvi regional stages at Rapla and is also present in the lower part of the Middle Ordovician on Gotland according to Gorka (1987). *Rhopaliophora foliatilis* (<0.5 %) is restricted to the Nabala regional stage at Rapla, and to the Upper Ordovician in U.S.A. (Tappan & Loeblich 1971). *Multiplicisphaeridium ramusculosum ramusculosum* (<0.5 %) is recorded only in the Lower Silurian deposits (Cramer & Diez 1972).

The species list also includes *Comasphaeridium varispinosum n. sp.* (0.5 %) and *Peteinosphaeridium parvispinosum n. sp.* (<0.5 %).

This species list comprises elements of two ages, the Aseri-Lasnamägi transition and the Nabala regional stage, the former interpretation being preferred here on account of the greater number of species with allow the sample to be traced to the lower part of the Middle Ordovician. Some uncertainty is nevertheless introduced by the presence of *Rhopaliophora foliatilis* and *Multiplicisphaeridium ramusculosum ramusculosum.*

Specimen no. 655: Dragsfjärd, Morgonlandet
Fig. 18.

This heterogeneous list of species includes *Pterospermopsis sp.* (0.5 %), which appears in the Kukruse regional stage and *Baltisphaeridium nanninum* (0.5 %), which disappears in the Oandu regional stage at Rapla, while among the 23 Chitinozoa, *Conochitina conulus* (1 ind.) existed in the Aseri to Keila regional stages.

Dictyotidium polygonium has not been found at

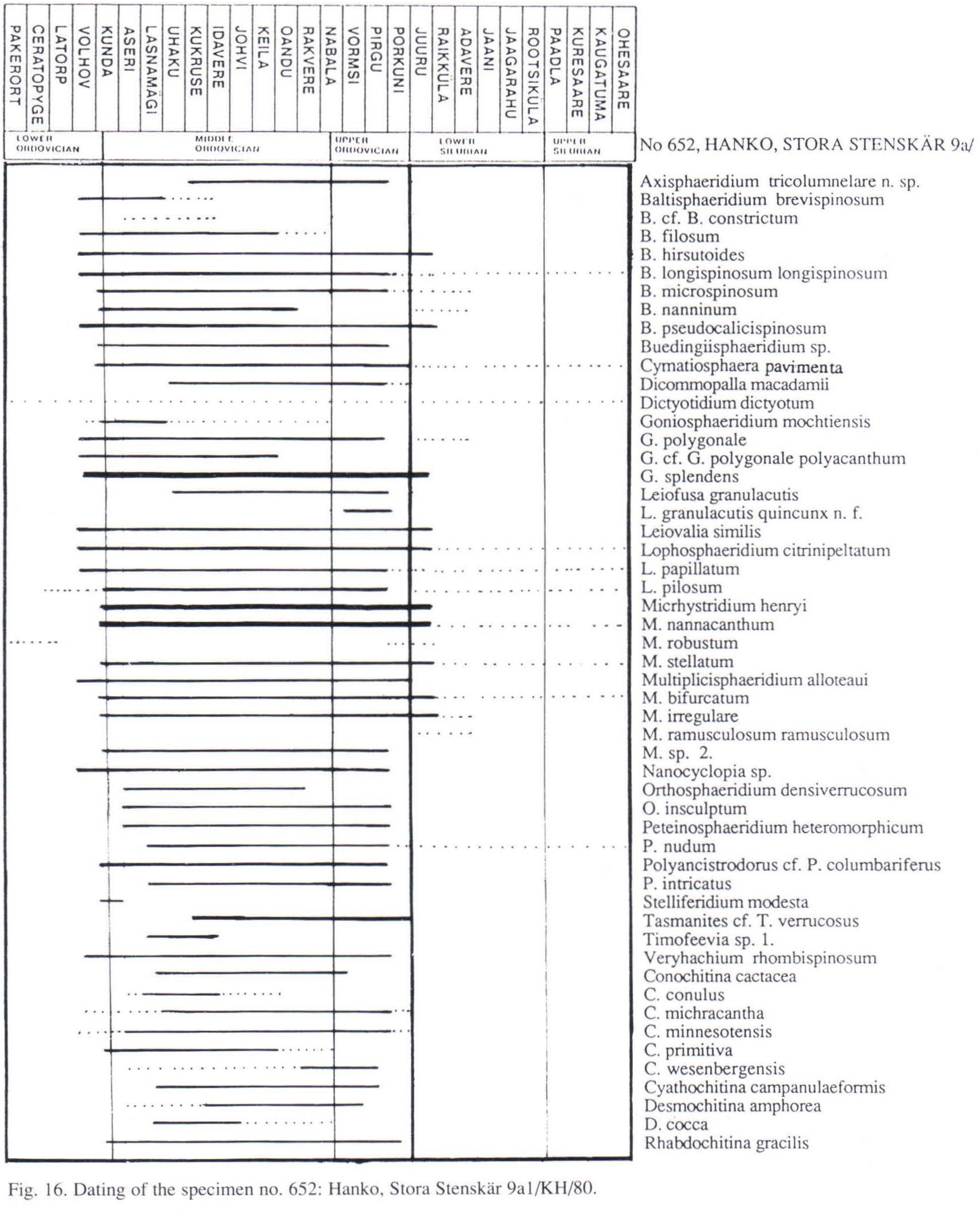


Fig. 16. Dating of the specimen no. 652: Hanko, Stora Stenskär 9a1/KH/80.

Rapla, but has recorded previously in Middle Silurian deposits. The species list also includes *Comasphaeridium varispinosum n. sp.* (<0.5 %).

The specimen was dated to the Middle Ordovician (Kukruse—Keila regional stages).

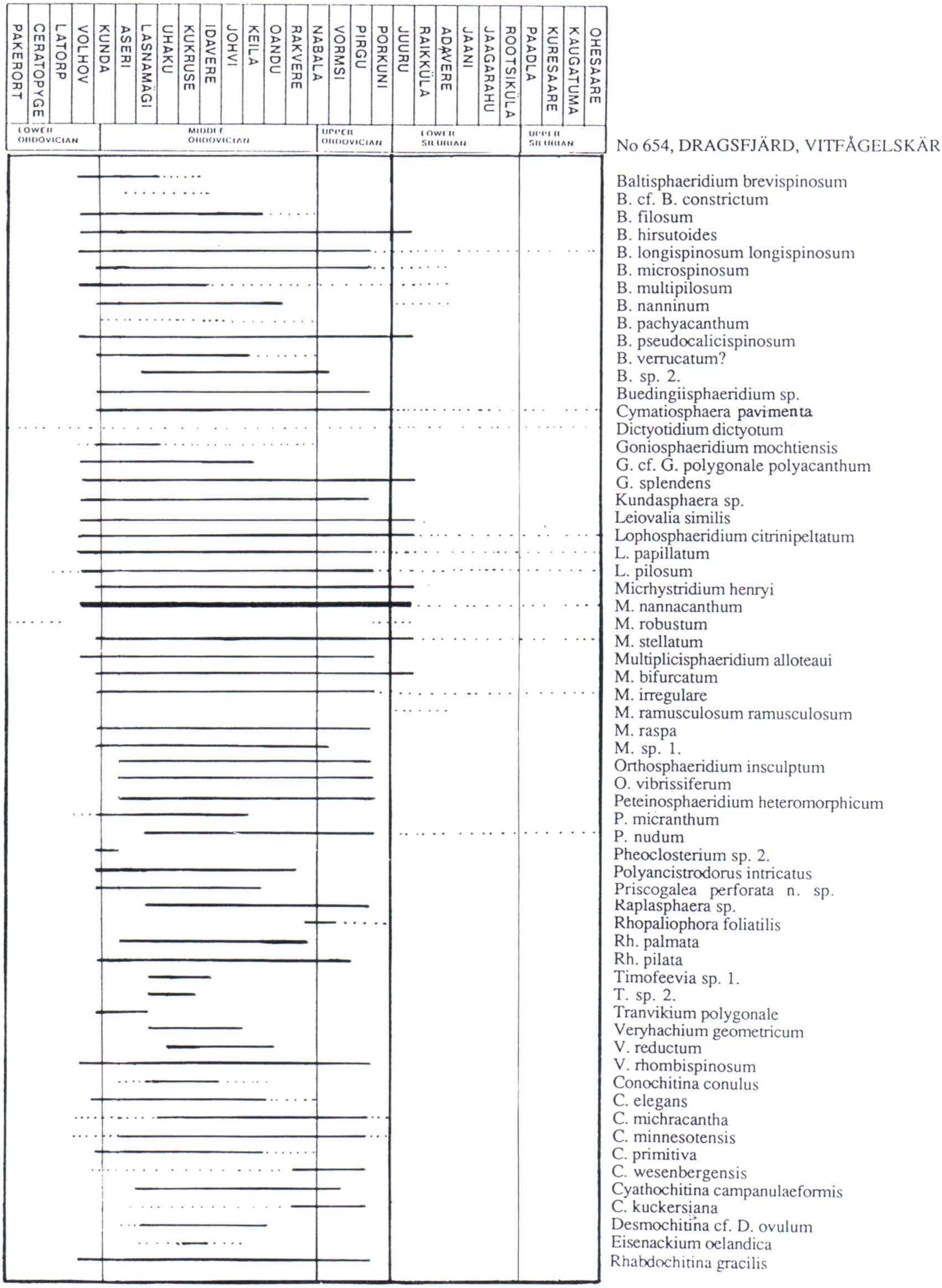


Fig. 17. Dating of the specimen no. 654: Dragsfjärd, Vitfågelskär 8.7.80/KH.

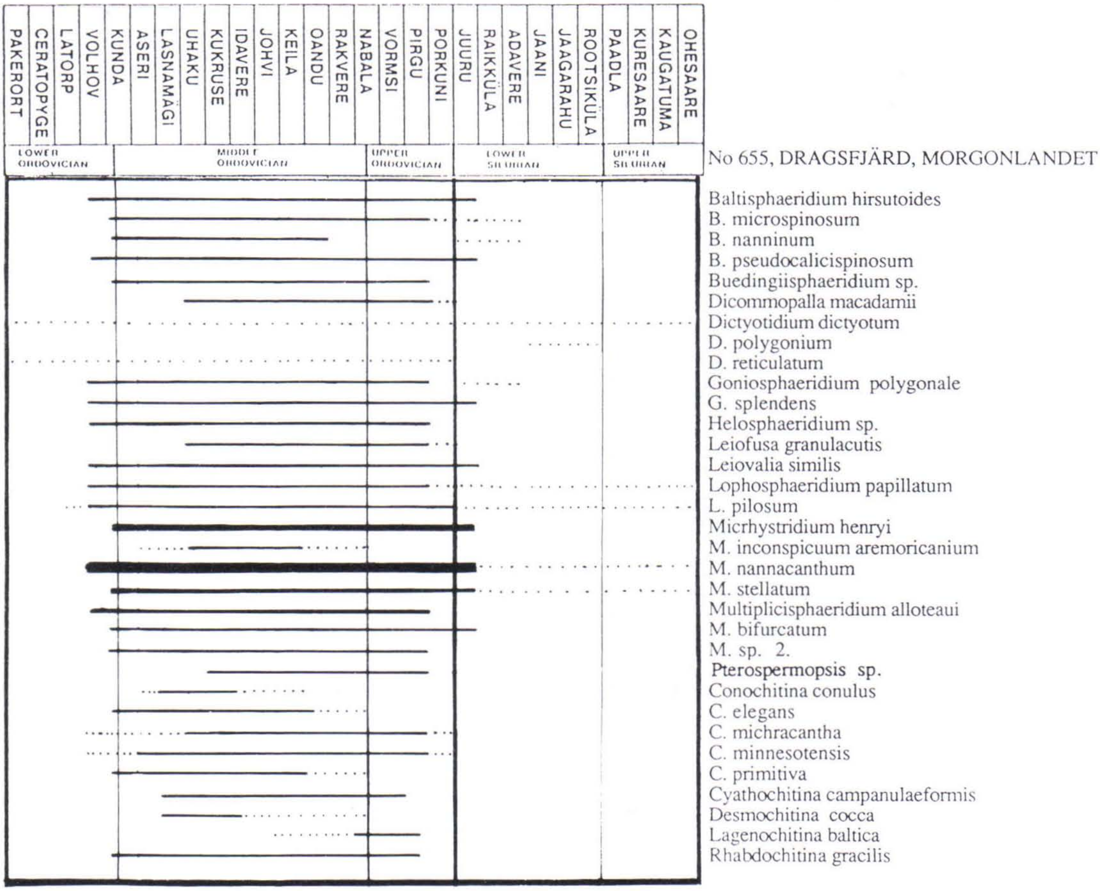


Fig. 18. Dating of the specimen no. 655: Dragsfjärd, Morgonlandet.

Specimen no. 656: Kustavi, Tjusgrund M.O. 81

No microfossils were found.

Specimen no. 657: Kustavi, P.J. 82a

No microfossils were found.

Specimen no. 658: Kustavi, P.J. 82b

No microfossils were found.

Specimen no. 660: Mynämäki, Lemi S.M.

No microfossils were found.

Specimen no. 661: Kustavi, Krokholmi 8/KH/81 Fig. 19.

The low total number of individuals, only 13, comprises largely ones of longer duration within the Ordovician and Silurian, the only one which is restricted to the lower Middle Ordovician being *Baltisphaeridium brevispinosum*. *Baltisphaeridium*

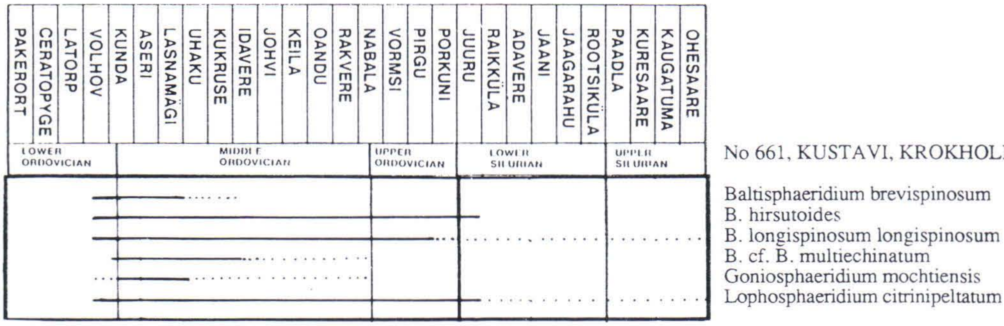


Fig. 19. Dating of the specimen no. 661: Kustavi, Krokholmi 8/KH/81.

cf. *B. multiechinatum* is found in the Kunda to Kukruse regional stages at Rapla, but it also present in the upper part of the Middle Ordovician elsewhere in the Baltic.

Reference to the Rapla material suggests that this specimen dates from the Kunda to the Lasnamägi regional stages, although in view of the data presented by Kjellström (1976) the date could be extended to cover the Kunda and Kukruse. Some uncertainty is introduced by the low number of species present.

Specimen no. 662: Kustavi, Nootholma 2/KH/81

No microfossils were found.

Specimen no. 663: Hanko, Lastankobben 10.7.80/KH
Fig. 20.

This predominantly long-term species list includes *Baltisphaeridium brevispinosum* (0.5 %), which is restricted to the Volhov to Kukruse regional stages, and *B. nanninum* (0.5 %), restricted to the Kunda to Oandu. *Dicommopalla macadamii* and *Leiofusa granulacutis* (both <0.5 %) make their appearance in the Uhaku regional stage, while *Multiplicisphaeridium inconspicuum aremoricanium* (<0.5 %) and *Pterospermopsis sp.* (0.5 %) from the Kukruse regional stage onwards.

Dictyotidium stenodictyotum is recorded earlier only in the Silurian deposits in Europe (Eisenack 1965a, Martin 1966a, 1967).

The species list also includes *Comasphaeridium varispinosum n. sp.* (0.5 %), but there are no chitinozoans.

The specimen was dated to the Kukruse regional stage.

Specimen no. 664: Kustavi, Nootholma 4/KH/81

No microfossils were found.

Specimen no. 681: Lappi Tl., Kariniemi V.L.

No microfossils were found.

Specimen no. 682: Hanko, Stora Stenskär 9b/KH/80

No microfossils were dound.

Specimens no. 683: Lappi Tl., Männistö V.L.

No microfossils were found.

Specimen no. 684: Eurajoki, Rannankulma
Fig. 21.

In addition to species of a broad temporal scope, one is found which is restricted to the lower Middle

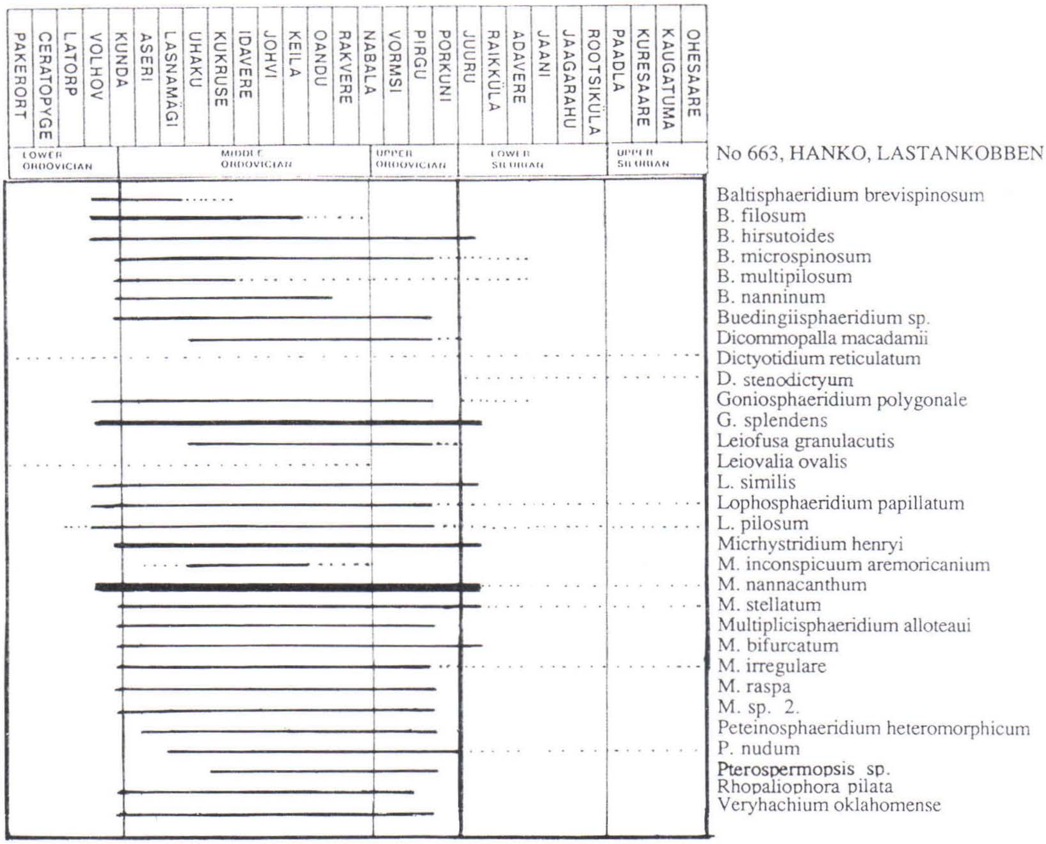


Fig. 20. Dating of the specimen no. 663: Hanko, Lastankobben 10.7.80/KH.

Ordovician, *Baltisphaeridium brevispinosum* (0.7 %). *Dicommopalla macadamii* (4.8 %) make its appearance in the Uhaku regional stage and *Pterospermopsis sp.* (1.5 %) in the Kukruse regional stage at Rapla.

The specimen may be dated to the Kukruse regional stage, Middle Ordovician.

Specimen no. 685: Hanko, Sälbådan 8/KH/80
Fig. 22.

The Middle and Upper Ordovician species list may be dated more precisely by reference to *Baltisphaeridium brevispinosum* (0.5 %), found in the Volhov to Kukruse regional stages and *Axisphaeridium tricolumnelare n. sp.* (0.5 %) in the Kukruse to Pirgu regional stages. The list also includes *Comasphaeridium varispinosum n. sp.* (0.5 %).

The Chitinozoa (13 ind.) are all species typical of the whole Ordovician, although *Conochitina primitiva* (2 ind.) disappears by the Nabala.

The specimen was dated to the Kukruse regional stage.

Specimen no. 689: Hanko, Hauensuoli 9.7.80/KH
Fig. 23.

The species present are all indifferent, occurring throughout the Ordovician.

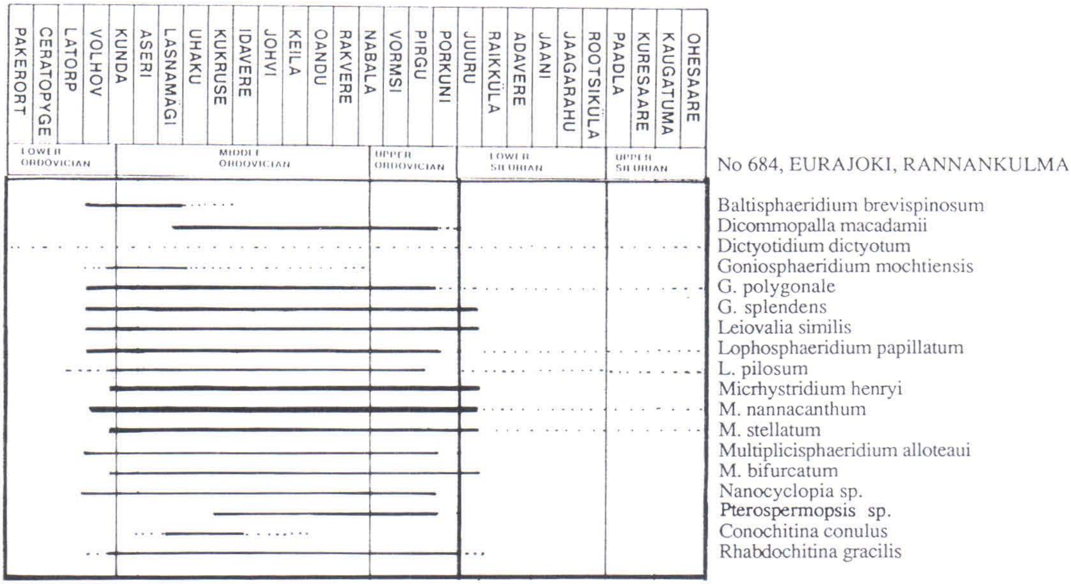


Fig. 21. Dating of the specimen no. 684: Eurajoki, Rannankulma.

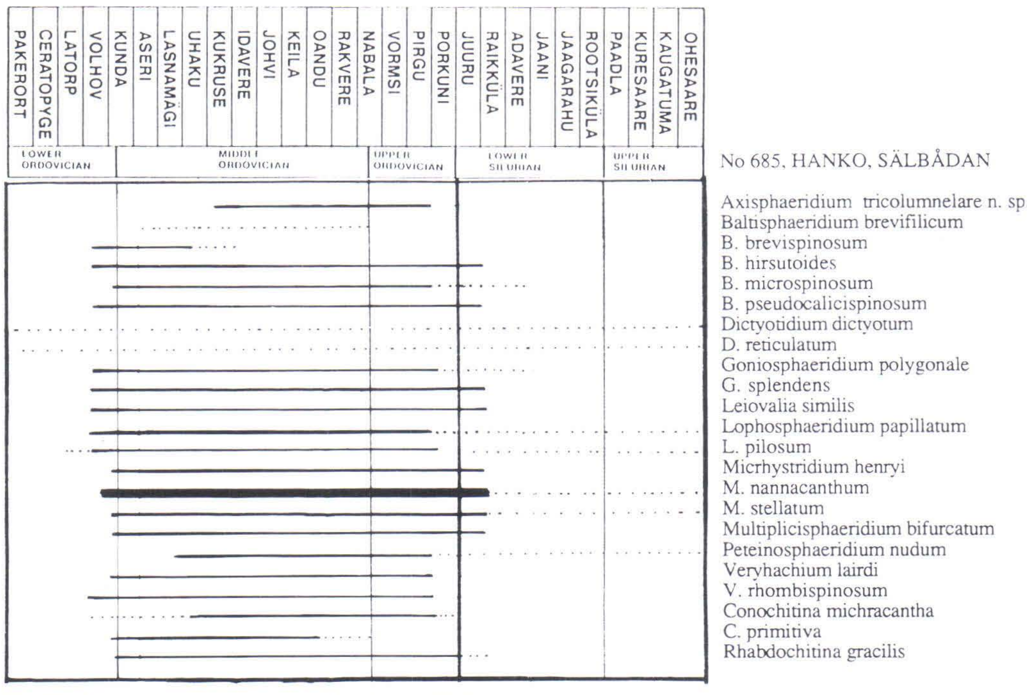


Fig. 22. Dating of the specimen no. 685: Hanko, Sälbådan 8/KH/80.

One unusual feature about this specimen is the absence of the genera *Baltisphaeridium* and *Peteinosphaeridium*, which are typical of the Baltic area. The same feature is recorded in the Rakvere regional stage at Rapla, where small acanthomorphs are predominant, as here.

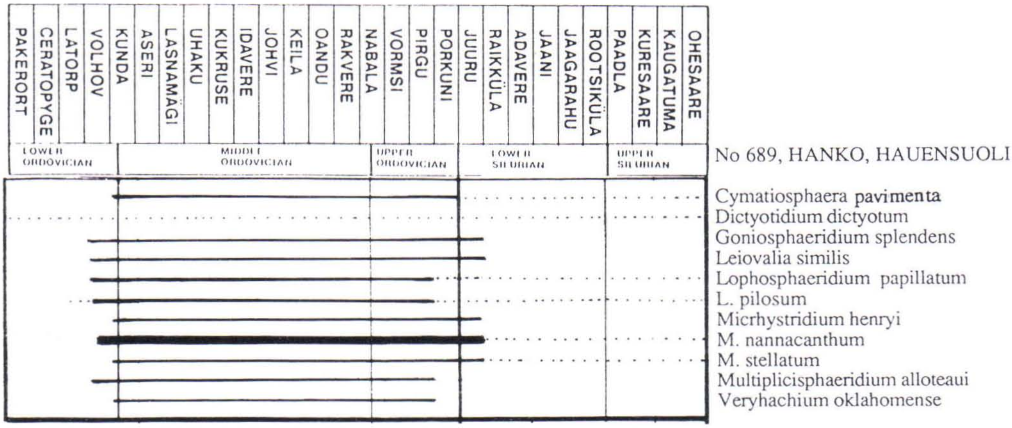


Fig. 23. Dating of the specimen no. 689: Hanko, Hauensuoli 9.7.80/KH.

The specimen was dated to the Kunda to Pirgu regional stages, probably the Rakvere regional stage.

Specimen no. 690: Turku H.S.1.

No microfossils were found.

Specimen no. 691.: Turku H.S.2.

No microfossils were found.

Specimen no. 692: Uusikaupunki, Valkiameri OTR-3

No microfossils were found.

Specimen no. 693: Taivassalo, M.J.

No microfossils were found.

Specimen no. 694: Uusikaupunki, Valkiameri OTR-1

No microfossils were found.

Specimen no. 695: Kalanti, OTR—14—83
Fig. 24.

Of the general Ordovician—Silurian species list, one species which restricts the specimen to the Lower and Middle Ordovician is *Peteinosphaeridium micranthum*, (1.0 %), which was present in Volkhov to Johvi regional stages. *Peteinosphaeridium heteromorphicum* (1.0 %) occurred for the first time in the Aseri regional stage, *Dicommopalla macadamii* (0.5 %) in the Uhaku regional stage and *Pterospermopsis sp.* (0.5 %) in the Kukruse regional stage.

Of the 40 Chitinozoans identified, the 6 individuals of *Conochitina conulus* represent a specifically Aseri and Keila species.

The specimen was dated to the Kukruse to Johvi regional stages.

Specimen no. 696: Hanko, Furuholm 2a/KH/80
Fig. 25.

All the acritarch species in this sample were in existence during the Lasnamägi regional stage with the exception of *Dicommopalla macadamii* (2.5 %), which is found in the Uhaku to Pirgu regional stages at Rapla. *Baltisphaeridium* aff. *B. constrictum* (0.5 %) is recorded in the Aseri to Kukruse regional stages in Sweden (Kjellström 1971a) .

The 13 chitinozoans found here include one *Lagenochitina baltica*, which was restricted to the Nabala and Pirgu regional stages at Rapla, although

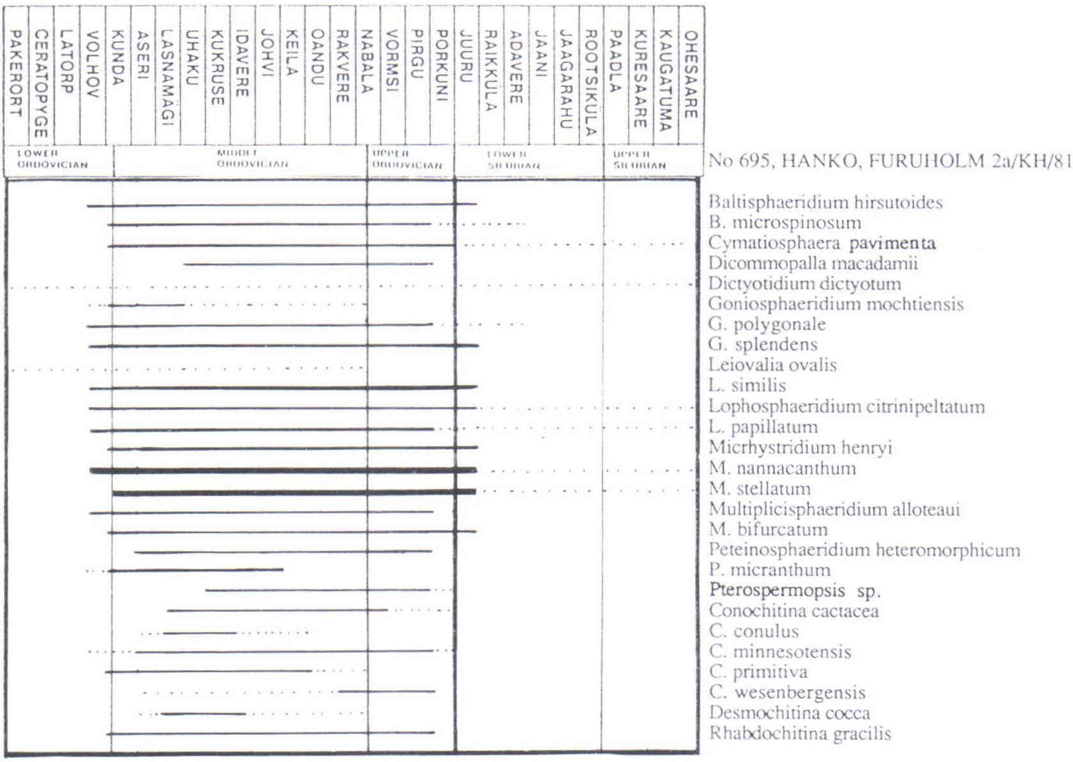


Fig. 24. Dating of the specimen no. 695: Kalanti, OTR—14—83.

it may also have existed in the upper part of the Middle Ordovician elsewhere in the Baltic.

The specimen was assigned to the Kukruse-Idavere transition.

Specimen 697: Hanko, Furuholm 2b/KH/80
Fig. 26.

The predominantly Ordovician—Silurian species list contains *Dicommopalla macadamii* (0.5 %) and *Leiofusa granulacutis* (0.5 %), which link it with the Uhaku and Pirgu regional stages. Of the three chitinozoans, *Conochitina conulus* (2 ind.) is from the Aseri to Keila and *C. primitiva* (1 ind.) from the Kunda to Nabala. The species list also includes *Axisphaeridium tricolumnelare n. sp.* (Kukruse to Pirgu regional stages, <0.5 %) and *Comasphaeridium varispinosum n.sp.* (0.5 %).

The sample is dated to the Kukruse—Keila regional stages.

Specimen no. 698: Uusikaupunki, Valkiameri OTR—83—L7

No microfossils were found.

Specimen no. 699: Kalanti OTR—20a—83
Fig. 27.

One species found here which is particular to the lower Middle Ordovician is *Baltisphaeridium brevispinosum* (4.0 %). The proportion of *Baltisphaeridium hirsutoides*, which occurs in large amounts at Rapla in the Volkhov—Kunda, Kukruse—Idavere and Keila regional stages, is exceptionally high (21.5 %). The others are long

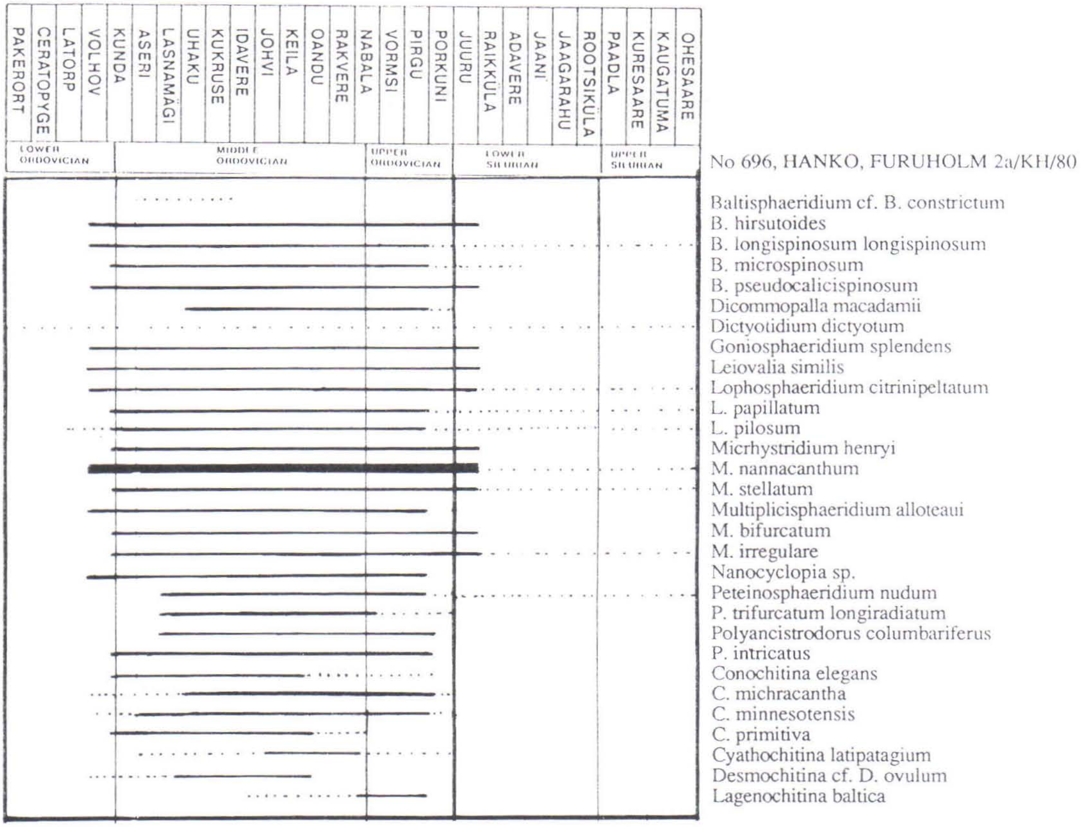


Fig. 25. Dating of the specimen no. 696: Hanko, Furuholm 2a/KH/80.

duration species which make their appearance at the beginning of the Volhov regional stage. The specimen would seem from the Rapla core evidence to originate from the Kunda to Lasnamägi regional stages, although the date should perhaps be extended to include the Kunda and Kukruse.

Specimen no. 700: Kalanti, Petis 68

No microfossils were found.

Specimen no. 701: Kalanti OTR—8—83
Fig. 28.

With the exception of one *Baltisphaeridium clavicinctum*, which is recorded in the Kunda in Estonia (Wetzel 1967), the acritarch species recovered all lived during the Uhaku—Kukruse regional stages.

Of the 34 Chitinozoa present, the 2 individuals of *Lagenochitina baltica*, represent a species which appears only in the Nabala at Rapla, but have existed earlier, in the Middle Caradocian, elsewhere in the Baltic (Grahn 1982a).

The species list contains large numbers of individuals of the genus *Veryhachium* (12.0 %) and *Baltisphaeridium hirsutoides* (9.0 %). *Comasphaeridium varispinosum, n. sp.* (1.0 %) is also present.

The specimen was dated to the Kukruse—Idavere transition, although the occurrence of *Baltisphaeridium clavicinctum* renders this results less reliable.

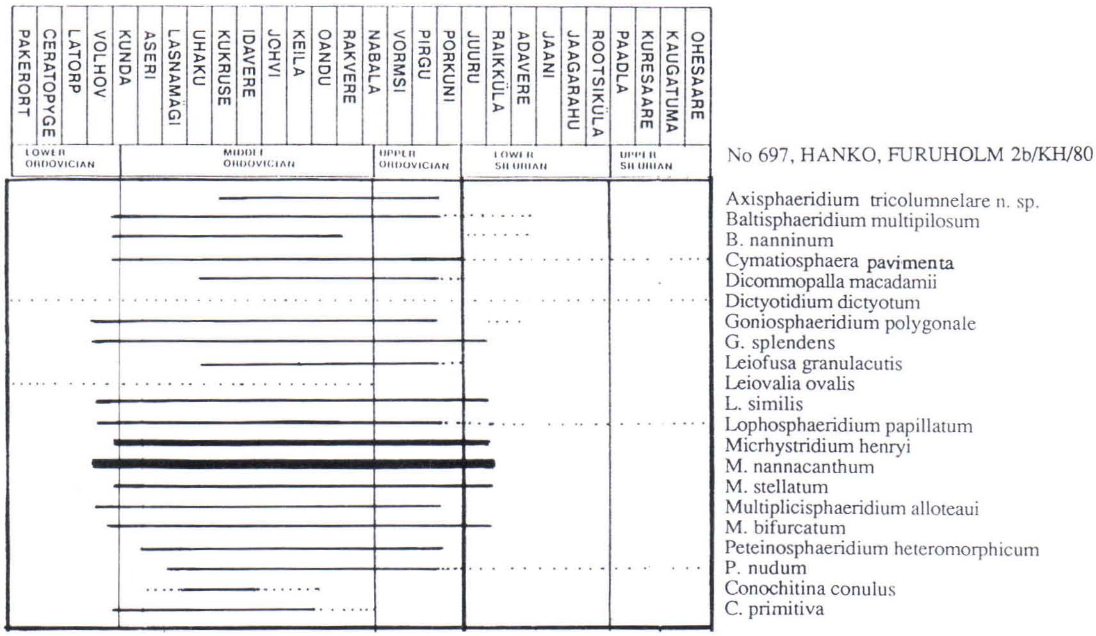


Fig. 26. Dating of the specimen no. 697: Hanko, Furuholm 2b/KH/80.

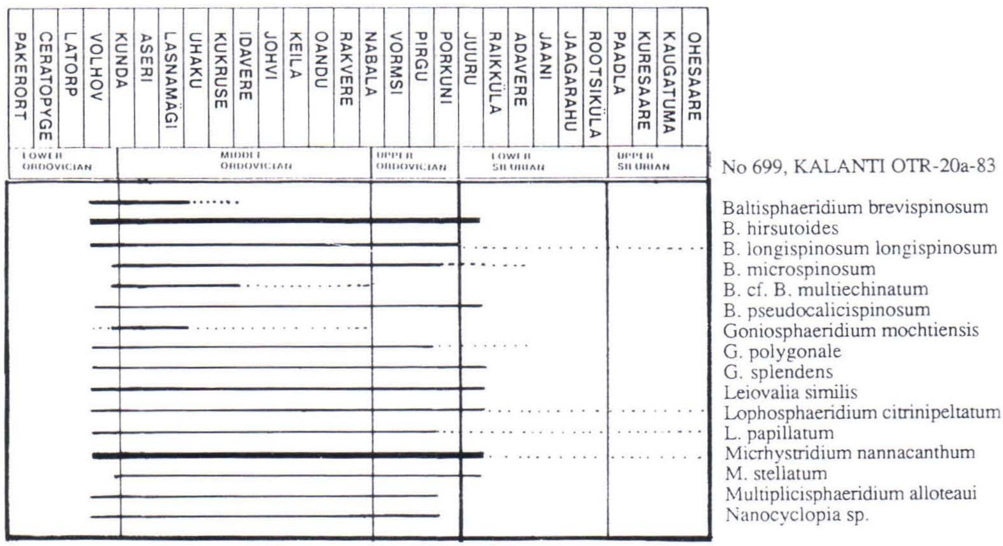


Fig. 27. Dating of the specimen no. 699: Kalanti, OTR—20a—83.

Specimen no. 703: Vehmaa 7/78
Fig. 29.

Among the Ordovician—Silurian species, *Dicommopalla macadamii* (0.5 %) is restricted to the Uhaku and Pirgu regional stages, and *Pterospermopsis sp.* (6.5 %) in the Kukruse to Pirgu regional stages. *Dictyotidium polygonium* has not previously been encountered in the Baltic region or elsewhere in Europe, and has been recovered only

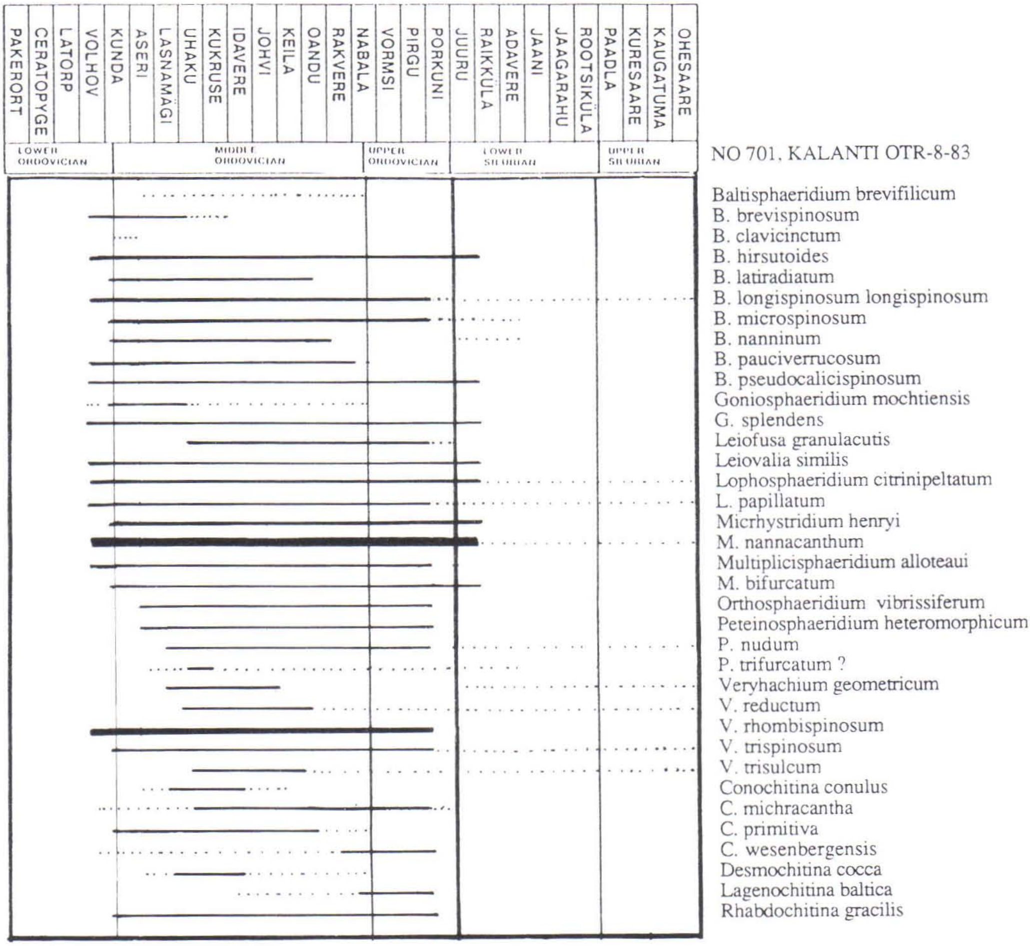


Fig. 28. Dating of the specimen no. 701: Kalanti, OTR—8—83.

from Silurian and Devonian sediments.

Of the Chitinozoa (9 ind.), *Conochitina conulus* (1 ind.) lived during the Aseri to Keila regional stages, and *C. primitiva* (1 ind.) during the Kunda to Nabala.

Comasphaeridium varispinosum n. sp. (1.5 %) also appears in the species list.

The sample was dated to the Kukruse to Keila regional stages.

Specimen no. 704: Kustavi NKK 1/83
Fig. 30.

One species limited to the lower Middle Ordovician is *Baltisphaeridium brevispinosum* (0.5 %). *Pterospermopsis sp.* (0.5 %) appears in the Kukruse regional stage, as well as *Axisphaeridium tricolumnelare n. sp.* (0.5 %). The proportion of *Baltisphaeridium hirsutoides* is exceptionally high (8.0 %).

The specimen was dated to the Kukruse regional stage.

Specimen no. 705: Säkylä, Pyhäjärvi, Sieravuori

No microfossils were found.

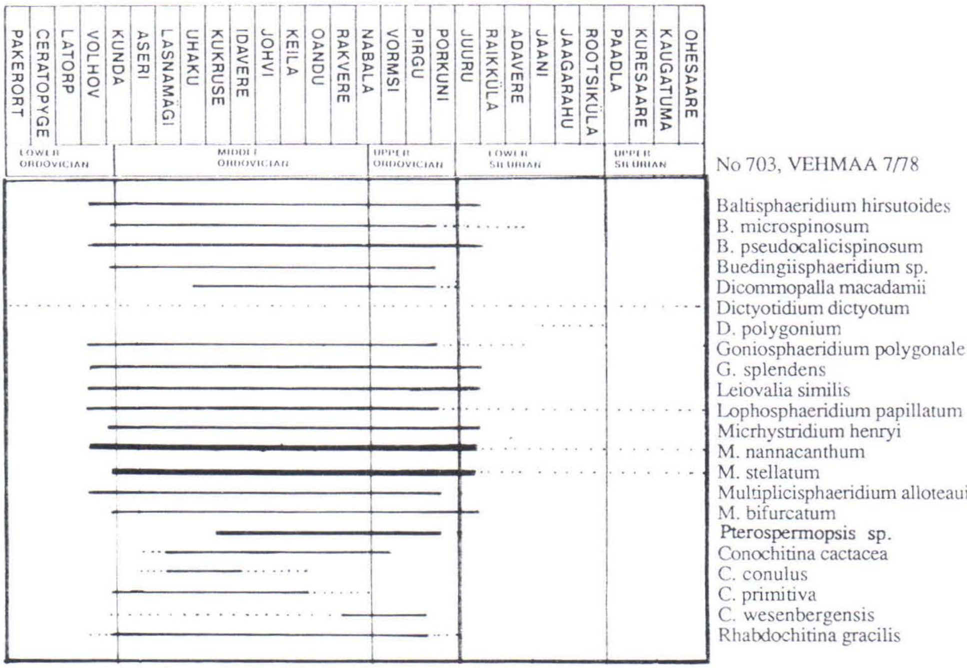


Fig. 29. Dating of the specimen no. 703: Vehmaa 7/78.

Specimen no. 706: Kalanti, Kiiski NKK—3—83 Fig. 31.

The predominantly long-term Ordovician species list includes *Veryhachium oligospinoides* (0.5 %), which lived at Rapla in the Keila to Pirgu regional stages, upper Middle Ordovician to Upper Ordovician. Of the Chitinozoa (23 ind.), *Conochitina primitiva* (3 ind.) existed in the Kunda and Nabala regional stages. *C. elegans* (1 ind.) and *C. wesenbergensis* (12 ind.) are cosmopolitan species of little dating value.

One unusual feature was the exceptionally high proportion of *Leiovalia similis* (8.5 %), as seen in the Uhaku regional stage at Rapla. The species identified also include *Comasphaeridium varispinosum n. sp.* (0.5 %).

The specimen was dated to the Keila to Nabala regional stages.

Specimen no. 707: Dragsfjärd, Trehållskäret 8.7.80

Fig. 32.

The total number of acritarch individuals, only 24, comprises ones of longer duration within the Ordovician. The occurrence of *Micrhystridium stellatum* (1 ind.) among acritarchs and *Conochitina elegans* (1 ind.) and *Desmochitina* cf. *D. ovulum* (1 ind.) among the Chitinozoa allow the specimen to be dated to the Kunda—Keila regional stages, although this must be tentative on account of uncertainty regarding the indentification of *D. ovulum*. An exceptionally high proportion of *Comasphaeridium varispinosum n. sp.* is present (6 ind.).

Specimen no. 709: Uusikaupunki 11/79

No microfossils were found.

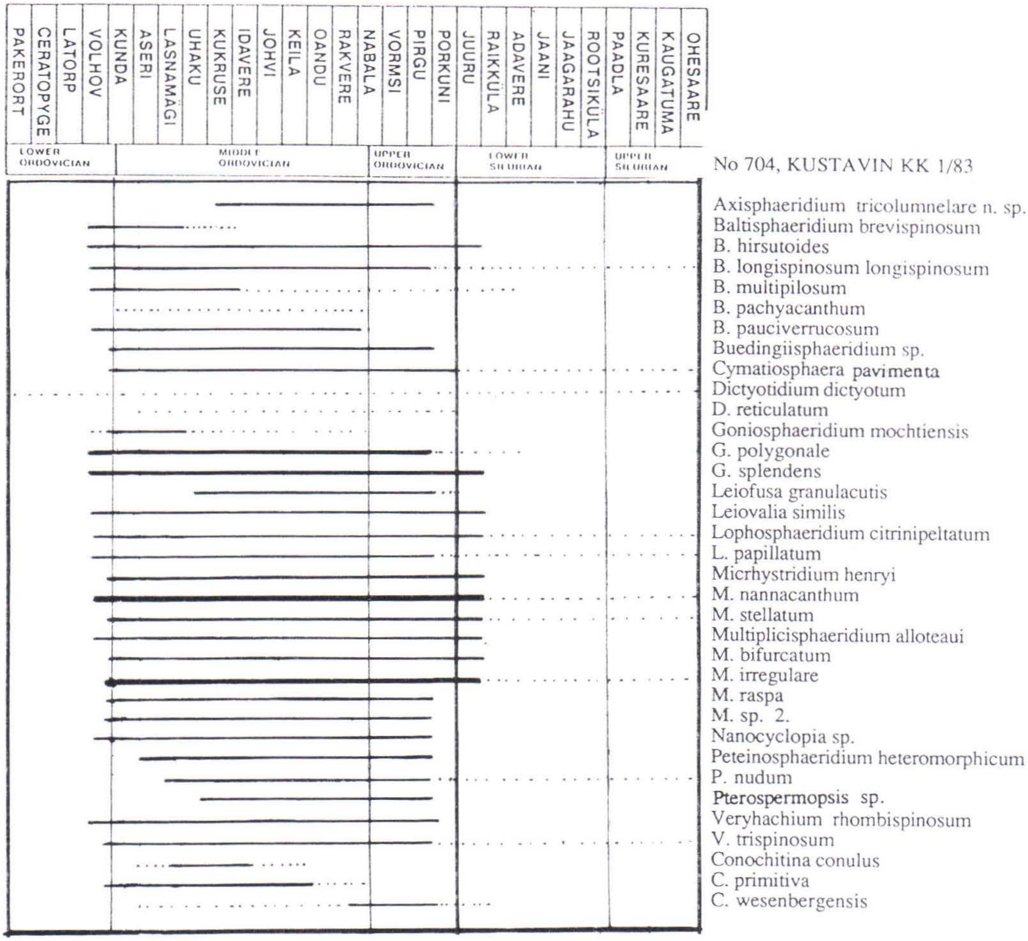


Fig. 30. Dating of the specimen no. 704: Kustavi NKK 1/83.

Specimen no. 710: Taivassalo 61E

No microfossils were found.

Specimen 711: Pyhämaa, Kammela NKK—L7—83
Fig. 33.

A typical Ordovician species list contain *Peteinosphaeridium nudum* (4.5 %), which appears in the Lasnamägi regional stage and *Baltisphaeridium nanninum* (1.1 %), which extincts in the Oandu regional stage. The proportion of *Baltisphaeridium hirsutoides* is exceptionally high (21.8 %). *Comasphaeridium varispinosum n. sp.* is also present (2.2 %).

The 6 Chitinozoa include 1 individual of *Conochitina cucumis*, which has been recorded only in the Volkhov and Kunda regional stages. *Conochitina conulus* (1 ind.) is restricted to the Lasnamägi and Kukruse regional stages at Rapla, but also the Aseri and Keila regional stages elsewhere in the Baltic area. The specimen was dated to the Aseri—Lasnamägi transition, although the occurrence of *Conochitina cucumis*.

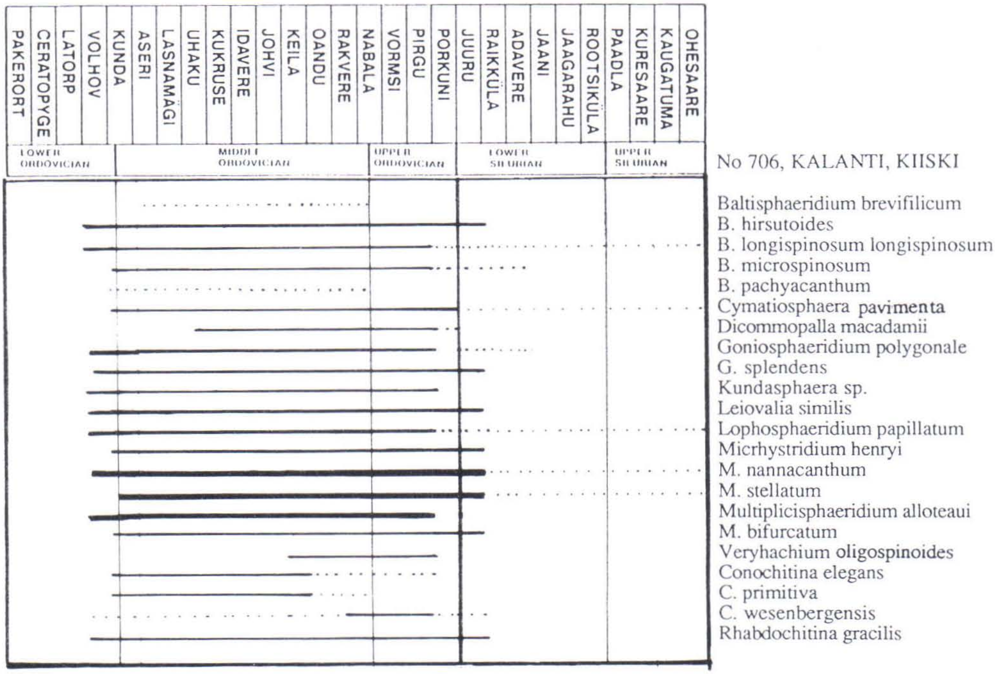


Fig. 31. Dating of the specimen no. 706: Kalanti, Kiiski NKK—3—83.

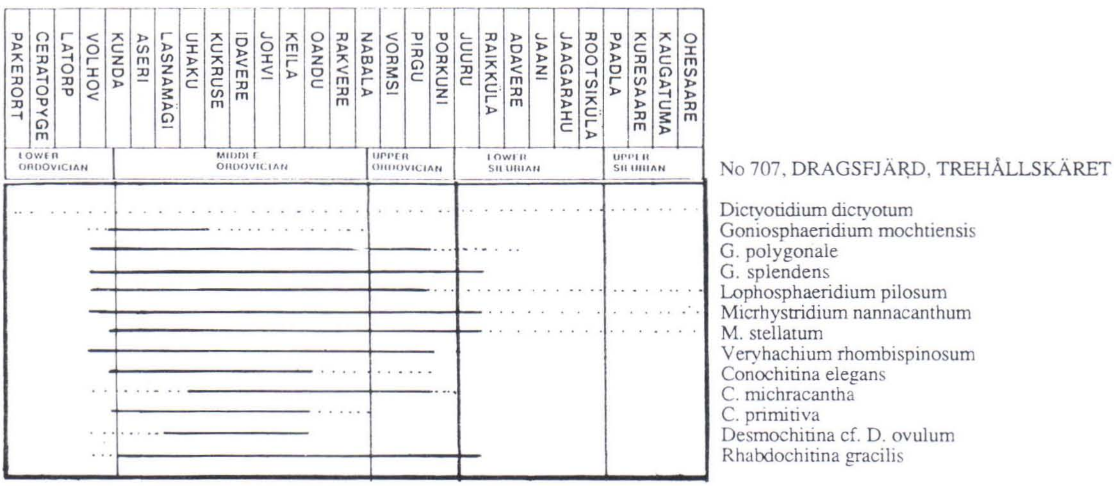


Fig. 32. Dating of the specimen no. 707: Dragsfjärd, Trehållskäret 8.7.80.

Specimen no. 712: Kalanti, OTR-20b-83
Fig. 34.

This generally long duration species list includes *Baltisphaeridium brevispinosum, B.* cf. *B. multiechinatum, B. sp. 1.* and *Goniosphaeridium mochtiensis* (accounting together for 45.1 % of the sample), which are markers of lower the Middle Ordovician at Rapla. *Baltisphaeridium podboroviscensis?* (<0.5 %) is known only from the

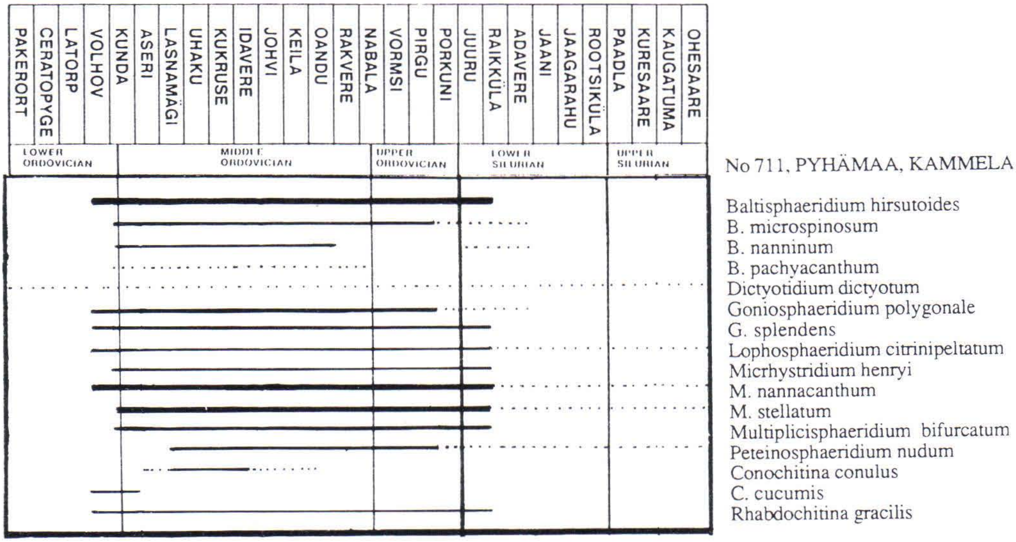


Fig. 33. Dating of the specimen no. 711: Pyhämaa, Kammela NKK—L7—83.

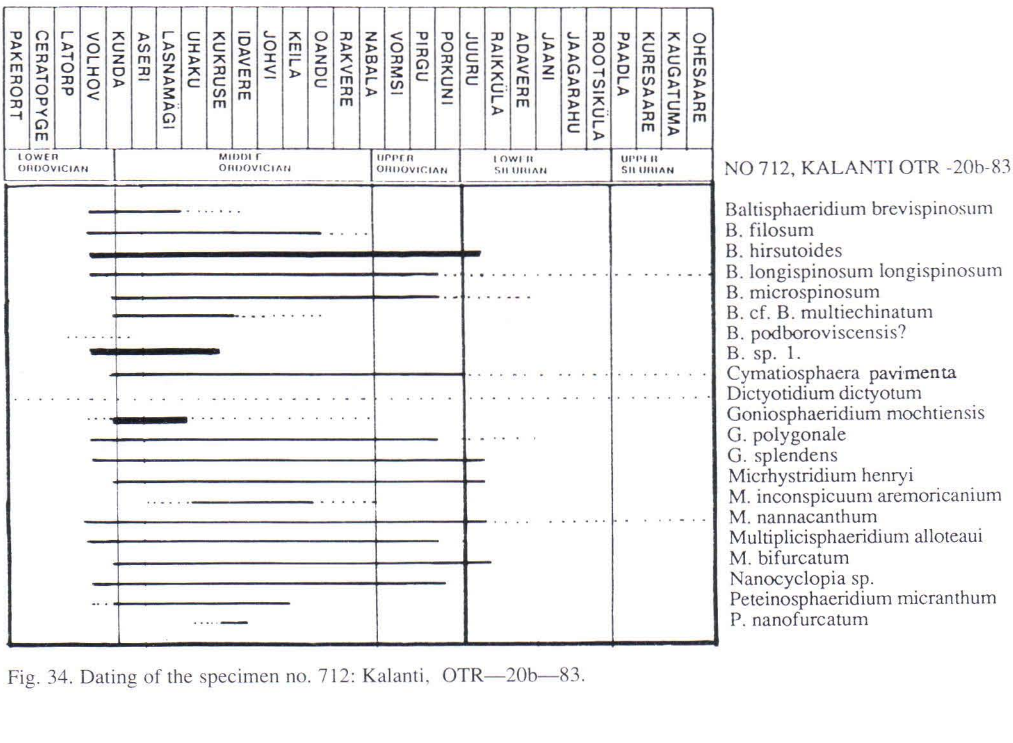


Fig. 34. Dating of the specimen no. 712: Kalanti, OTR—20b—83.

Arenigian deposits in Poland (Gorka 1969) and its identification is unsure in the present material because it is poorly preserved, so that it could also represent broken or eroded examples of *B. brevispinosum*. The species list also contains one *Peteinosphaeridium nanofurcatum*, which is found at Rapla only in the Kukruse regional stage, and is also recorded in the Uhaku (Kjellström 1971a,

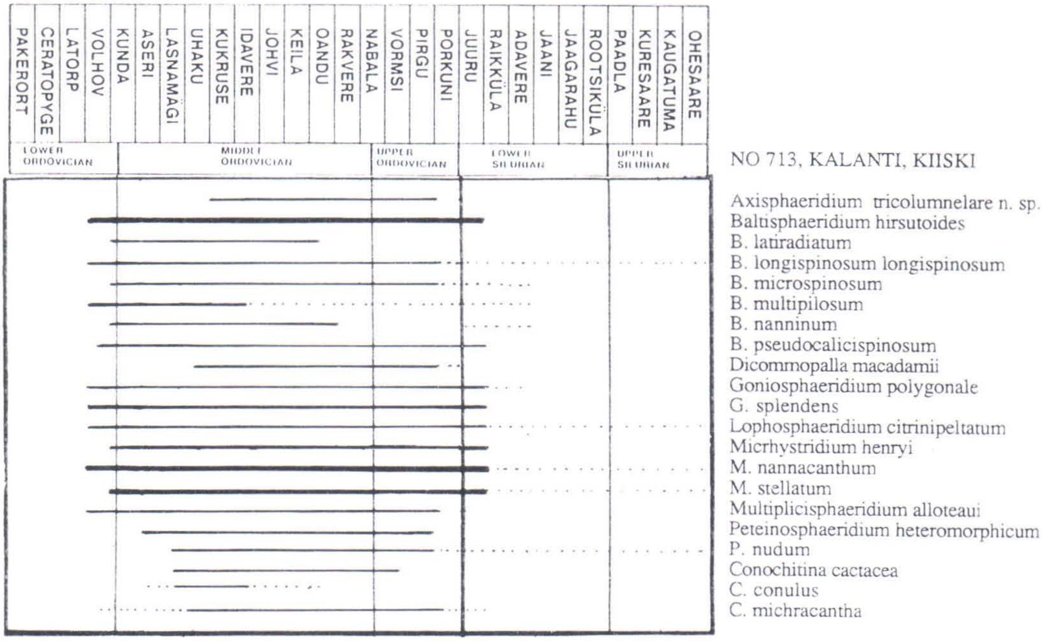


Fig. 35. Dating of the specimen no. 713: Kalanti, Kiiski, NKK—L8—83.

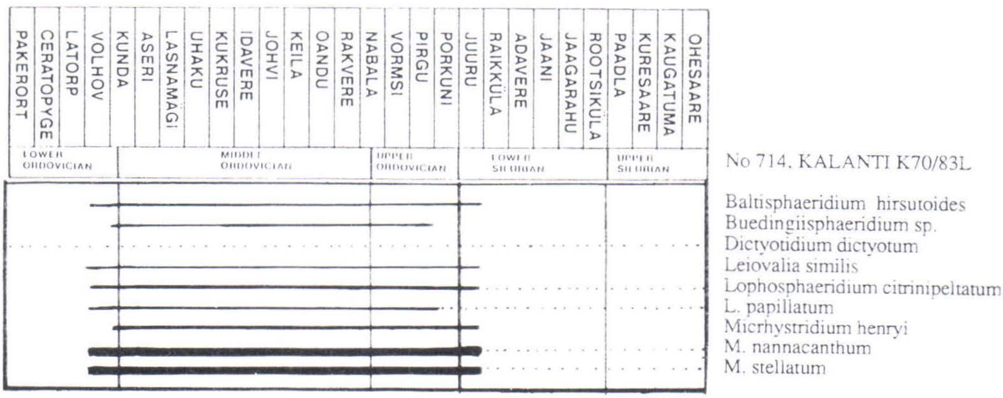


Fig. 36. Dating of the specimen no. 714: Kalanti K70/83L.

Bockelie & Kjellström 1979).

The specimen was dated to the Uhaku regional stage.

Specimen no. 713: Kalanti, Kiiski, NKK-L8-83 Fig. 35.

A typical long duration Ordovician species list includes the marker species *Baltisphaeridium latiradiatum* (1.0 %), which is restricted to the Kunda and Keila regional stages. The proportion of *B. hirsutoides* is exceptionally high (12.5 %). *Axisphaeridium tricolumnelare n. sp.* (1.0 %), which appears in the Kukruse at Rapla, is also present. 8 out of the 23 chitinizoans represent *Conochitina*

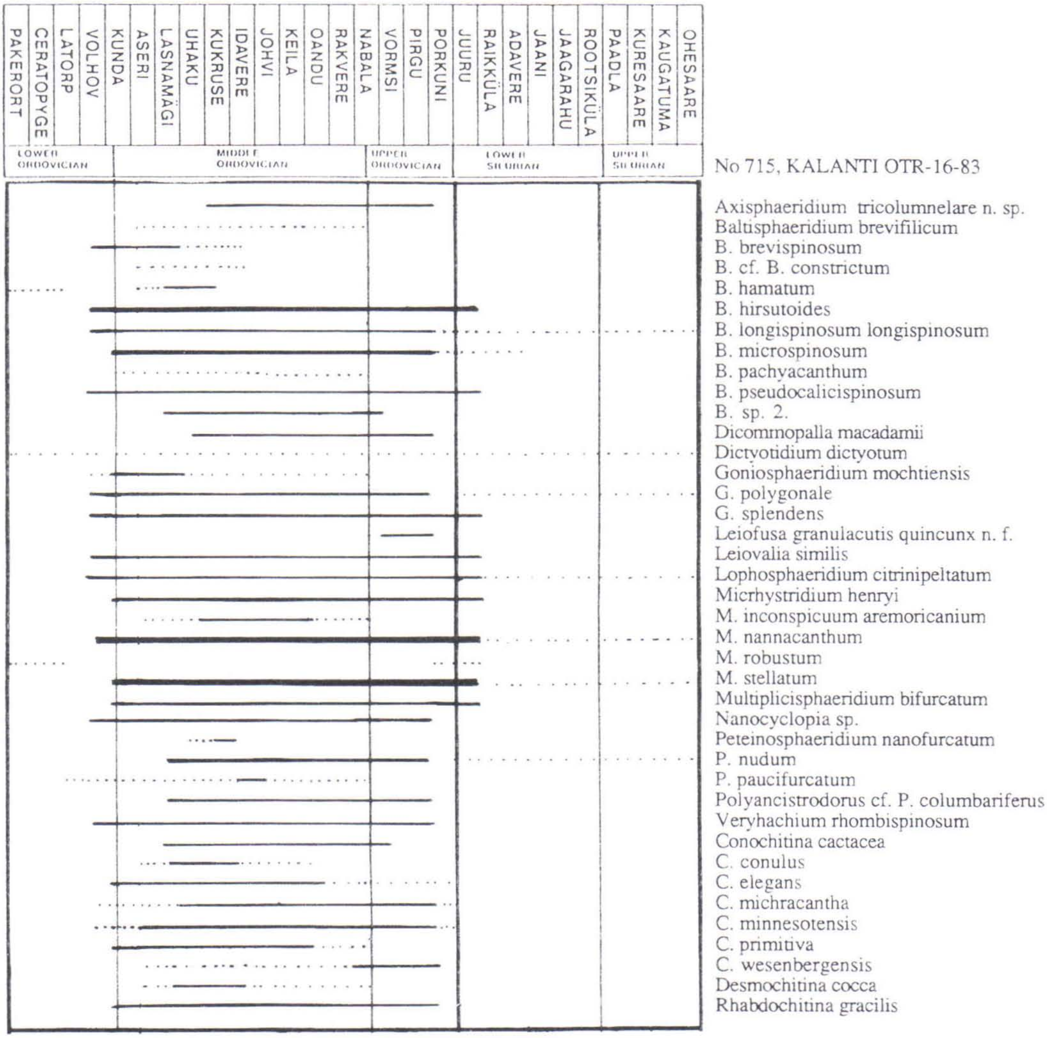


Fig. 37. Dating of the specimen no. 715: Kalanti, OTR—16—83.

conulus, which lived during the Aseri—Keila, and one *C. cactacea*, from the Lasnamägi and Nabala.

The specimen was dated to the Kukruse to Keila regional stages.

Specimen no. 714: Kalanti K70/83L
Fig. 36.

The number of species is low and the species present are all indifferent. There are no Chitinozoa at all.

No more precise date can be given than that the specimen is from some time in the Lower to Upper Ordovician.

Specimen no. 715: Kalanti, OTR-16-83
Fig. 37.

The species list here is highly heterogeneous as far as dating is concerned, and can be interpreted by

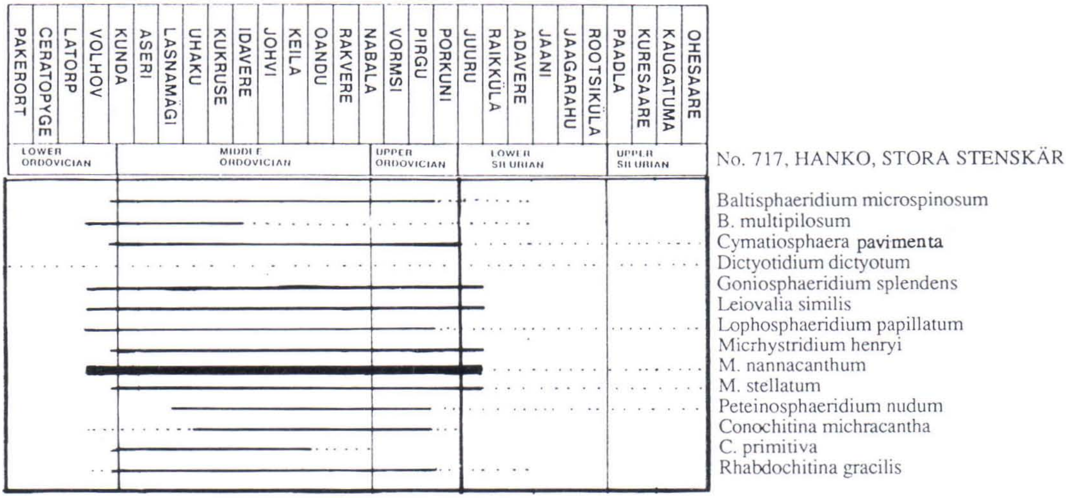


Fig. 38. Dating of the specimen no. 717: Hanko, Stora Stenskär 9a3/KH/80.

assuming either a high proportion of redeposited taxa or a high number of species with a longer life than previously recorded, or both. *Axisphaeridium tricolumnelare n. sp.*, *Baltisphaeridium brevispinosum*, *B. hamatum* and *Peteinosphaeridium nanofurcatum* (all <0.5 %) would date the specimen to the Uhaku—Kukruse transition.

Leiofusa granulacutis f. quincunx n. f. (<0.5 %) appears at Rapla in the Vormsi regional stage. Of the Chitinozoa (81 ind.), *Conochitina conulus* (31 ind.) points to the lower part of the Middle Ordovician.

The species list also includes *Comasphaeridium varispinosum n. sp.* (<0.5 %) and *Peteinosphaeridium parvispinosum n. sp.* (<0.5 %). The specimen was dated to the Uhaku—Kukruse transition, although the presence of *Leiofusa granulacutis f. quincunx n. f.* lends some uncertainty to the decision.

Specimen no. 716: Uusikaupunki OTR-17/83

No microfossils were found.

Specimen no. 717: Hanko, Stora Stenskär 9a3/KH/80
Fig. 38.

This generally indifferent Ordovician—Silurian material possesses certain exceptional features such as the absence of *Baltisphaeridium hirsutoides*. *Peteinosphaeridium nudum* (1.0 %) appears at Lasnamägi regional stage. Two out of the four Chitinozoa represent *Conochitina primitiva*, from the Kunda to Keila. The species list also includes *Comasphaeridium varispinosum n. sp.* (0.5 %). The sample is Middle Ordovician.

Specimen no. 718: Hanko, Kummelskär 10.7.80
Fig. 39.

The long duration sample includes *Baltisphaeridium nanninum* (1.8 %), which is particular to the Kunda and Oandu regional stages. *Peteinosphaeridium trifurcatum?* (2.7 %) is present at Rapla only during the Uhaku regional stage, but is recorded from the Middle Ordovician to the Lower Silurian elsewhere in the Baltic area.

This is the only specimen to contain *Multiplicisphaeridium radicosum* (6.3 %), which is

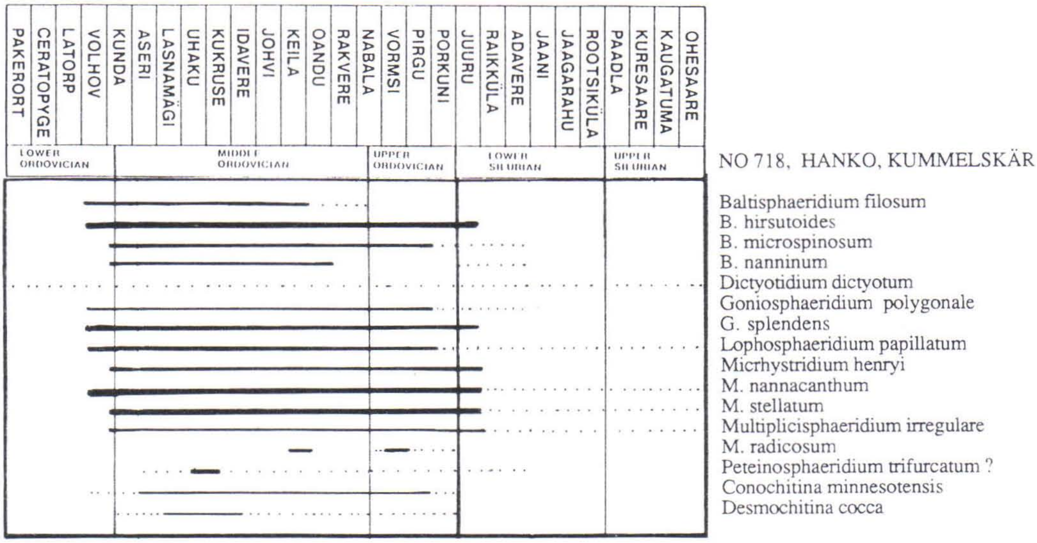


Fig. 39. Dating of the specimen no. 718: Hanko, Kummelskär 10.7.80.

found in the Vormsi regional stage of the Upper Ordovician at Rapla, and a smaller form also in the Keila. It occurs as an Upper Ordovician taxon only in the U.S.A. (Loeblich 1970b), but the Rapla evidence would suggest that a number of species occur in the Baltic region earlier than they do outside Europe.

The proportion of *Baltisphaeridium hirsutoides* is exceptionally high (16.2 %).

The specimen was dated to the Keila regional stage.

Specimen no. 719: Rymättylä, E.S. 80

No microfossils were found.

Specimen no. 720: Raisio, Ihala J.V.

No microfossils were found.

Specimen no. 721: Pyhäranta, Nro 2 H.P.

No microfossils were found.

Specimen no. 722: Uusikaupunki, Valkiameri OTR-4

No microfossils were found.

Specimen no. 723: Dragsfjärd, Morgonlandet — 80

Fig. 40.

Among species predominantly of long duration one finds *Baltisphaeridium filosum* (1.0 %), which is restricted to the Volhov to Nabala regional stages. The species list also features *Tasmanites* cf. *T. verrucosus* (0.5 %), which occurs from the Kukruse to the Porkuni. Most of the 50 Chitinozoa are cosmopolitan species of little stratigraphic value, only *Conochitina primitiva* and *Desmochitina cocca* being specifically Middle Ordovician species in the Baltic.

The specimen was dated to the Kukruse to Nabala regional stages.

Fig. 41. which shows the sedimentation dates of the specimens in which the microfossil evidence gave a positive result, indicates that 12 out of 26

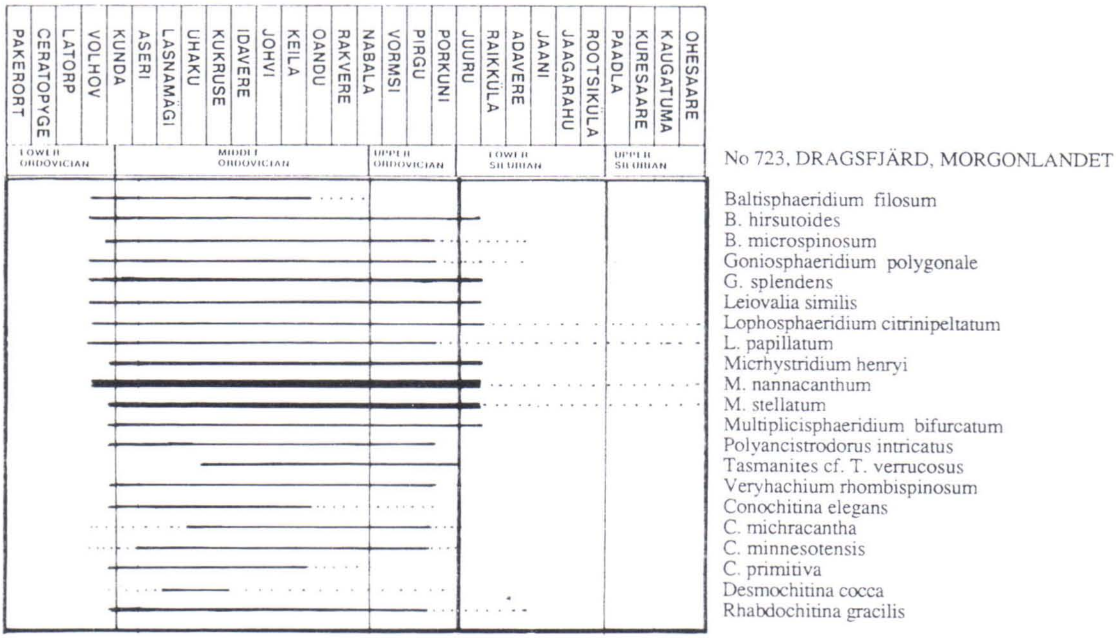


Fig. 40. Dating of the specimen no. 723: Dragsfjärd, Morgonlandet —80.

such specimens may be traced to the lower Middle Ordovician, two to the upper Middle Ordovician and nine to the transition of the lower and upper Middle Ordovician, while three could not be traced any more exactly than to the Middle or Upper Ordovician.

The greenish grey marl was dated to the Kunda to Kukruse regional stages of the Lower/Middle to Middle Ordovician, the grey marl to the Aseri—Lasnamägi transition to the Nabala regional stage of the Middle to Middle/Upper Ordovician and the yellowish grey calcilutite/calcarenitic calcilutite of the Baltic limestone to the Kunda to Pirgu regional stages of the Lower/Middle to Upper Ordovician.

There were nevertheless too few specimens giving a positive microfossil finding to enable any relationship to be posited between the numbers of specimens and the extents of the marine phases. The lithological compositions of the specimens do not allow them to be dated any more accurately than to the Ordovician.

In the case of many specimens, the critical species for dating purposes proved to be one that was rare in its occurrence, and was usually rare in the Rapla borehole as well.

Leiofusa granulacutis f. quincunx n. f. was found only in the Vormsi to Pirgu at Rapla, and being a small species with its typical quincucial structure visible only by electron microscopy, it may have given rise to errors of identification both in the Rapla core and in those of the present specimens for which scanning electron microscopy was not performed. *L. granulacutis f. quincunx n. f.* was observed only in specimens 652 and 715 in the present series, ones which were dated to the lower part of the Middle Ordovician by reference top the other species. *Leiofusa granulacutis*, which occurs from the Uhaku to the Pirgu at Rapla, occurred in specimens 652, 655, 633, 697, 701 and 704, of which only specimen 697 was not examined by electron microscopy.

Of the new species found here which were not

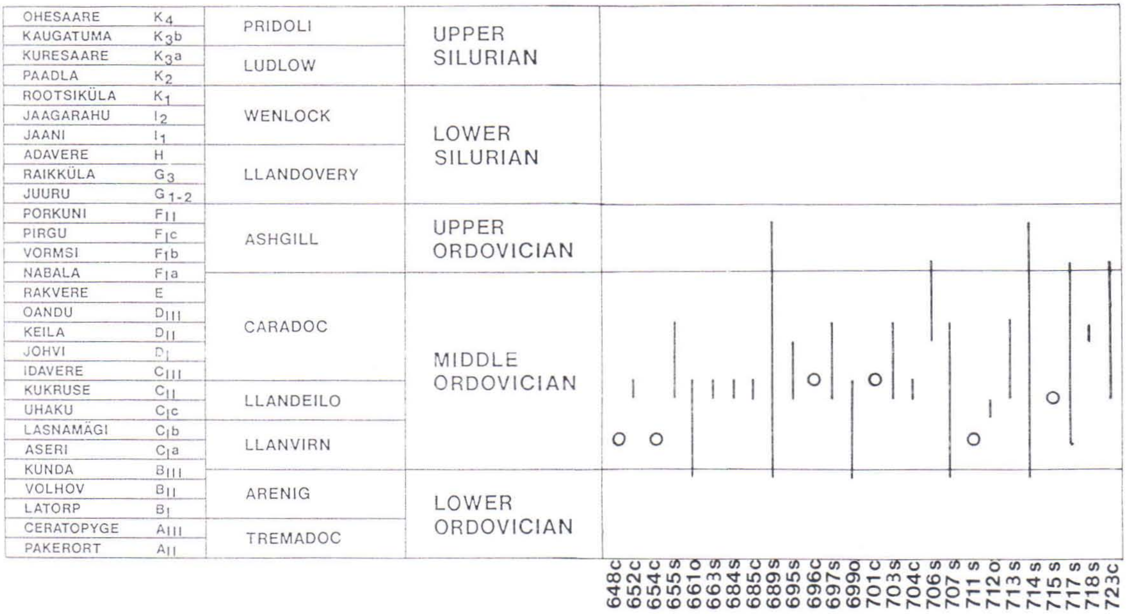


Fig. 41. Sedimentation dates of specimens based on the microfossil evidence. Legend: vo = reddish brown and greenish grey marl, c = grey marl and s = yellowish grey calcilutite/calcarenitic calcilutite of the Baltic limestone.

contained in the Rapla core, *Comasphaeridium varispinosum n. sp.* must have lived from the Aseri—Lasnamägi transition onwards. It in fact occurs over a relatively long period, comprising the lower part of the Middle Ordovician from the Lasnamägi up to the Nabala regional stage. It is usually rare in the specimens, with the exception of specimen 715, where it occupies 4.5 % of 200 items from the Uhaku—Kukruse transition.

Peteinosphaeridium parvispinosum n. sp. was found only in specimens 648 and 654 from the Aseri—Lasnamägi transition, and 715, from the Uhaku—Kukruse transition, so that its lifetime was probably restricted to the lower part of the Middle Ordovician. The same is also true of *Pirea sp.* in specimen 654 and *Pheoclosterium sp. 1.* in specimens 648 and 654.

Aremoricanium sp. and *Nodusosphaeridium rubus n. sp.* occurred only in specimen 712, which was dated to the Kukruse regional stage, where they were accompanied by the typical species of the Lower Ordovician and lower part of the Middle Ordovician *Baltisphaeridium brevispinosum, B. sp. 1.* and *Peteinosphaeridium nanofurcatum.*

Hapsidopalla sp. is confined to specimen 715, dated to the Uhaku—Kukruse transition by reference to *Baltisphaeridium hamatum* and *Peteinosphaeridium nanofurcatum.*

Multiplicisphaeridium sp. 1. (M. parvispinosum n. sp. at Rapla) was encounteredy in the Kunda to Nabala regional stages at Rapla.

Analysis of the Rapla core is still in progress, and it may well be that once that work has been completed the species discussed above will no longer pose problems as far as dating is concerned.

The cosmopolitan chitinozoan species are of little stratigraphical significance and their role is not discussed in connection with all the specimens.

DISCUSSION

History of the Baltic basin from the Cambrian to the Silurian

Many attempts have been made to identify the marine phases of the Palaeozoic in the Baltic area from cores and echo soundings, but the results as far as the Bothnian Sea is concerned are inconclusive, and are likely to remain so until cores can be obtained which tell us more about the sedimentary conditions prevailing during that time.

The Cambrian

The Baltic sedimentation basin during the Lower Cambrian bordered onto a bedrock which had been eroded down to a flat peneplain. The transgression at the end of the Lower Cambrian extended at its maximum as far as the Bothnian Bay, covering most of western and southern Finland (Fig. 42a). The Karstula sandstone in central Finland, the most easterly observation of its kind in the country, is taken by Simonen and Kouvo (1955) to represent the eastern margin of this Early Palaeozoic transgression.

During the regression that began in the Middle Cambrian the Baltic area was dry land as far south as the Gotland basin, and as the regression continued into the Lower Ordovician the dry land came to extend even as far as the Kattegat (Fig. 42b; Öpik 1956; Röömusoks 1960; Thorslund 1960; Martinsson 1974). In the opinion of Jaeger (1984), however, the sea reached Åland at the end of the Middle Cambrian (Fig. 42c). The brachiopod *Ceratreta tanneri* (Metzger 1922) found at Långbergsöda—Öjen, Åland, indicates Late Cambrian age (Martinsson 1968). The sediments of the Lumparn basin have a hiatus after the Lower Cambrian until the Lower Ordovician (Tynni 1982b), so that these cannot be used to reconcile the two views. The most recent research shows the deposits in the Söderfjärden basin to be of Middle Cambrian origin (Hagenfeldt 1988) rather than Lower Cambrian (Tynni 1978), so that the regression must have proceeded more slowly than had previously been thought.

The maximum thickness of the Lower Cambrian sediments in the Bothnian Bay is 90 m (Flodén *et al.* 1980), and that in the Bothnian Sea 165 m, on a line Hudiksvall—Pori, diminishing rapidly in an east-west direction to 40.95 m at Östra Banken and 33.29 m at Västra Banken. The decrease is less pronounced towards the north, however, for thicknesses of 100—105 m are still recorded at Härnösand (Axberg 1980).

By Åland only a thin Lower Cambrian stratum is left, at a depth of 65 m (Tynni 1982b), while in central Sweden its thickness varies in the range 2—18 m at Närke and 22—25 m in Östergötland (Fromm 1971b; Karis & Magnusson 1972, 1973).

The thickest Lower Cambrian sediments in the southern Baltic, 300 m, are to be found south of Gotland. Major variations in thickness occur in the area, however, with a thickness of 141 m recorded for Grötlingbo in central Gotland, 157 m at File Haidar to the north of the island, 105 m on Gotska Sandön and 72.5 m on Hamnudden. The corresponding stratum at Tallinn is 49 m thick, that on the Latvian coast 142 m and that at Vilnius 92 m (Korkutis 1981). A thickness of 78 m is reported for Böda Hamn on Öland (Hessland 1955), and 120 m in Skåne (Lindström & Staude 1971).

According to Hagenfeldt (1988), the Middle Cambrian sediments at Söderfjärden, south of Vaasa, are 68 m in thickness (Lauren *et al.* 1978). Their thickness at Närke, on the other hand, varies from 0.3 m to 20 m, and that at Östergötland from 19 m to 32 m (Fromm 1971b; Karis & Magnusson 1972, 1973). In western Estonia they are approx. 100 m thick, decreasing to 70 m towards the southeast (Kaljo 1984). As far as the southern Baltic is concerned, the corresponding thickness at Böda Hamn on Öland is approx. 62 m, that at Segerstad 105 m and that at Pavilosta in Latvia 106 m (Hessland 1955; Flodén 1980). Echo soundings indicate that there are no Middle or Upper Cambrian sediments beneath the Bothnian Sea (Winterhalter 1972; Axberg 1980).

Upper Cambrian sediments occupy some 12—15 m in the stratigraphy at Närke in central Sweden and 5—14 m in Östergötland. At När on Gotland they are only 2 m thick, but further south, at Ottenby on Öland, they again reach 13 m (Flodén 1980). The Upper Cambrian sediments of northern Estonia amount to 17 m and those of northeast Estonia to 12 m (Kaljo 1984).

Cambrian sedimentation in Estonia is said to have taken place in shallow, flowing water (Kaljo 1984), and the rate of deposition of the Upper Cambrian black schists in Sweden is similarly estimated at only 1 mm/1000 yrs (Lindström 1963).

During the Lower Cambrian, Scandinavia is thought to have been located between 60° and 40°S latitude, or perhaps even further south, and had a cold climate characterized by strong northwesternly winds. By the Middle Cambrian, however, its position had changed to 40°—25°S lat. and the winds had declined in strength, but the climate was still subject to the cooling effect of an ocean current which ran along the coast (Jeppson 1980). According to Korkutis *et al.* (1972) the climate in the Lower Cambrian was relatively mild. The Cambrian sediments consist of sandstones, siltstone, claystones and various schists. Recent datings suggest that the Cambrian lasted from 570 Ma to 500 Ma (van Eysinga 1975).

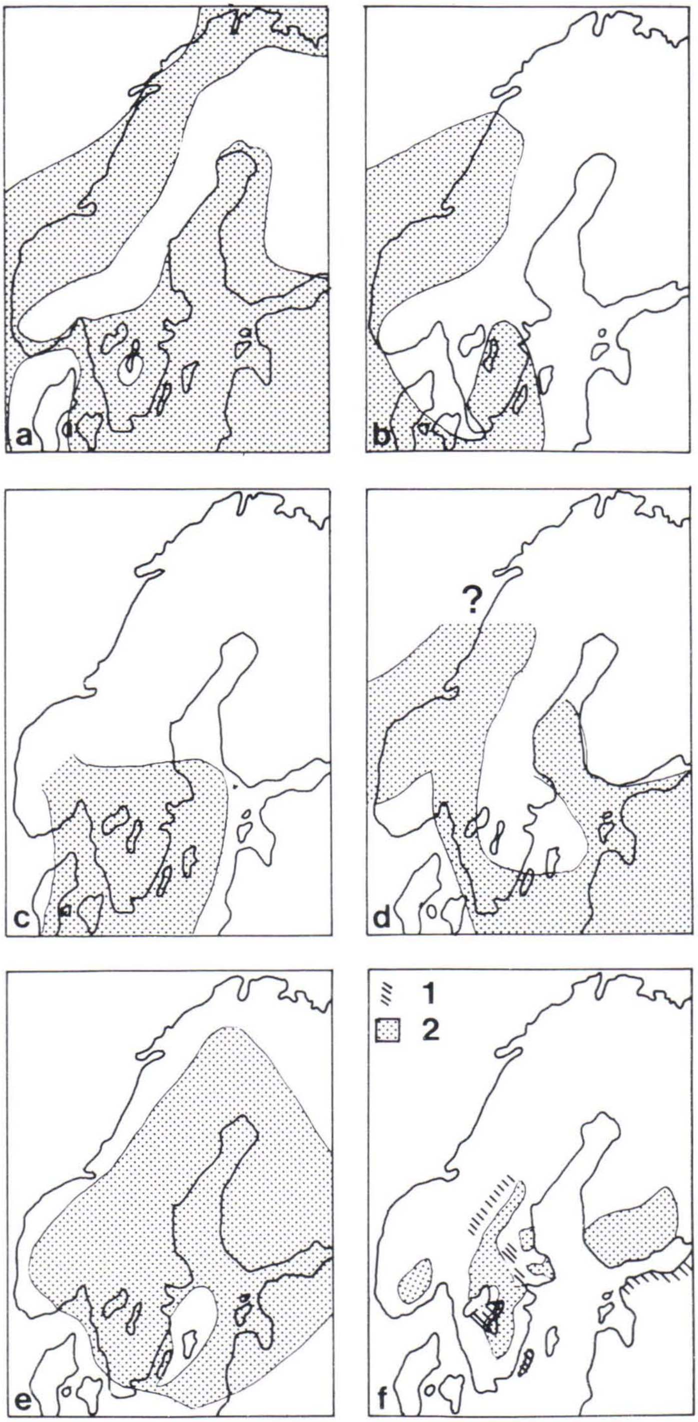


Fig. 42. Extents of (a) the Lower Cambrian marine phase, after Öpik (1956), Thorslund (1960) and Jaeger (1984), (b) the Middle Cambrian marine phase, after Thorslund (1960), (c) the Middle Cambrian marine phase, after Jaeger (1984), and (d) the Lower Ordovician Pakerort marine phase (Early Tremadocian), after Thorslund (1960) and Männil (1966), (e) the Latorp (Billingen) regional stage of the Lower Ordovician, after Thorslund (1960), (f) deposits preserved from the Arenigian stage of the Lower Ordovician (1) and possible carbonate production areas (2), after Lindström (1979).

The Ordovician

The sediments which were deposited in the Ordovician are well preserved and well known in the area south of the Gulf of Finland, i.e. in Estonia and the Leningrad region. Sediments of this age play a major part in the classic scheme for the division of the Lower Palaeozoic devised by Schmidt (1881), which served as the starting point for the present-day division into stages A-F with their various regional stages. The discussion below is based on selected pieces of recent research, the investigators' opinions on the extents of sea and dry land in the area being indicated in the accompanying palaeogeographical maps.

The transgression which began during the Pakerort regional stage of the Lower Ordovician (A_{II}, Tremadocian) extended from Estonia to Öland and the coast of southwestern Finland (Fig. 42d). The deposits dating from this stage are thin, since a new regression set in towards the end, lasting until the beginning of the Latorp regional stage (A_{II}/B_{I}, Arenigian). The transgression which ensued from that point onwards covered virtually the whole of Scandinavia with the exception of the northeastern corner of Finland (Fig. 42e, after Thorslund 1960).

According to Lindström (1979), it ought to be possible to find orthoceratite limestone laid down during the Arenigian in central and eastern Finland (Fig. 42f), but so far only one sample has been discovered, at Haukivuori, halfway between Mikkeli and Pieksämäki, although admittedly no particularly precise research has yet been carried out in the area (Hokkanen, pers. comm.).

Röömusoks (1960), Jaanusson (1963) and Männil (1966) propose narrower boundaries for the transgression, and suggest that a lobe of dry land may have extended from the coast of western Finland via Gotland to Hiiunmaa in Estonia (Fig. 43a). The transgression during the Volkov regional stage (B_{II}, Arenigian) must have extended from the coast of southeastern Finland via the northern part of Gotland to the Åland islands and the Bothnian Sea (Fig. 43b).

The Middle Ordovician transgression was the most extensive in the geological history of the world (Fairbridge 1964). It reached the archipelago of southwestern Finland in the first instance and spreading still further during the Aseri regional stage (C_{I}a, Llanvirnian) (Fig. 43c). During the Uhaku, Kukruse and Idavere regional stages (Llandeilian—Caradocian) the sea reached the Gulf of Finland and the Bothnian Sea coast (Fig. 43d), but this was followed in the Keila and Oandu regional stages (D_{II}, D_{III}, Caradocian) by a gentle regression, which allowed the lobe of dry land to extend from southwestern Finland via Åland to a point close to Gotland. Transgressive conditions were resumed during the Rakvere regional stage (E, Caradocian), and extended still further during the Nabala (F_{I}a), on the borderline between the Middle and Upper Ordovician, by which point the water covered a broad strip on the coast of southern Finland and the Bothnian Sea (Fig. 43e).

Marine conditions in the Vormsi regional stage of the Upper Ordovician (F_{I}b, Ashgillian) were again regressive, but they reverted to transgressive in the subsequent Pirgu (F_{I}c) so that the sea regained the extent it had occupied during the Nabala. At the end of the Upper Ordovician, during the Porkuni (F_{II}), a regression set in which continued into the Silurian. The area of Finland and the Bothnian Sea was dry land from this point onwards up to the Quaternary (Sources: Röömusoks 1960; Jaanusson 1963; Männil 1966).

The Lower Ordovician deposits in the Bothnian Sea area are 95—100 m in thickness (Axberg 1980), whereas figures reported in Närke, central Sweden, are in the range 0.4—28.3 m, that obtained in northern Estonia 9.5 m and that observed on Öland 16 m (Bruun & Dahlman 1980; Flodén 1980; Kaljo 1984). The combined thickness of the Lower and Middle Ordovician sediments on Åland varies between 32 m and 43 m (Tynni 1982b), while the Middle Ordovician stratum in the Bothnian Sea is 60—65 m thick (Axberg 1980), compared with a figure of 67.55 m in Östergötland, Central Sweden, 23 m on Öland and 29—31 m on Gotland (Bruun & Dahlman 1980; Flodén 1980), and 74.25 m in northern Estonia (Pölma 1972). The thickness of the Upper Ordovician sediments in the Bothnian Sea is 25—30 m (Axberg 1980), compared with 23.28 m in Östergötland (Bruun & Dahlman 1980) and 76.55 in northern Estonia (Pölma 1972).

The maximum recorded combined thickness of Ordovician sediments in the Bothnian Sea is 230 m, that for the Baltic Proper 130 m and that for northern Estonia 160 m (Pölma 1972; Axberg 1980; Flodén 1980). According to Jaanusson (1972), the mean rate of sedimentation during the Ordovician was 4—5 mm/1000 yrs. It would seem, in fact, that the rate was more of this order in the Bothnian Sea but less further south in the Baltic, or else erosion in that area was more pronounced.

Sedimentation conditions were evidently more favourable in the Bothnian Sea than in the Baltic Proper. Calcium carbonate is precipitated in greater amounts in shallow, warm water, where the epeiric sea is less than 30 m in depth (Blatt 1982). On the other hand, wave-influenced movement of water masses is capable of preventing sedimentation or even causing erosion down to depths of 50 metres (Winterhalter 1972). Calcarenite is an indicator of warmer conditions than calcilutite, while clayey marls are precipitated in colder, deeper water (Spjeldnaes 1960; Jaanusson 1972). Männil (1966) and Jaanusson (1976) divide the Baltic of the Middle Ordovician into confacies, with both the Bothnian Sea area and Rapla falling into the North Estonian Confacies, where lithologically the sediments are composed chiefly of calcarenites, while Gotland, Öland and Central Sweden belong to the Central Balto-Scandian confacies. Spjeldnaes (1960), for his part, divides Europe into zones by reference to the macrofauna, taking the

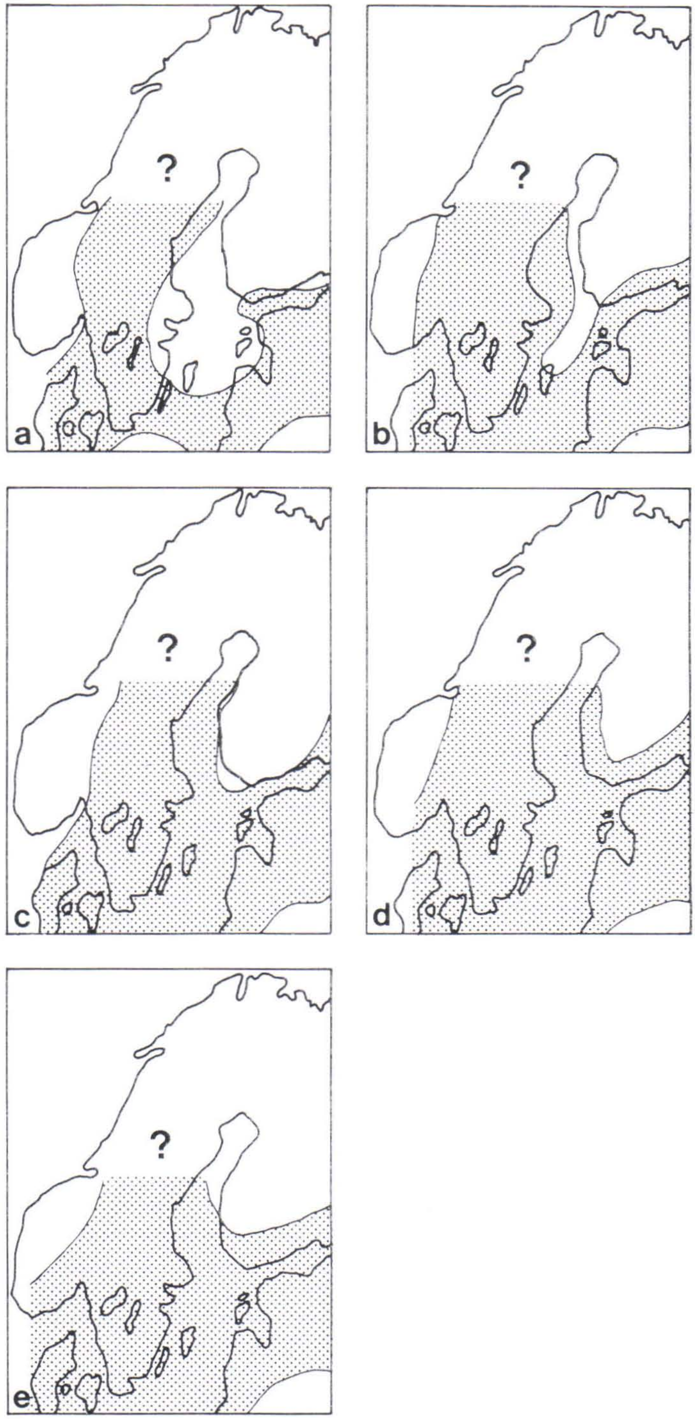


Fig. 43. Extents of (a) the Latorp regional stage of the Lower Ordovician, after Röömusoks (1960), Jaanusson (1963) and Männil (1966), (b) the Volkhov (Late Arenigian) regional stage, after Röömusoks (1960), Jaanusson (1963) and Männil (1966), (c) the Aseri regional stage of the Middle Ordovician (Early Llanvirnian), after Röömusoks (1960) and Männil (1966), (d) the Uhaku regional stage of the Middle Ordovician (Late Llanvirnian), and (e) the Nabala regional stage of the Upper Ordovician (Caradocian/Argillian transition), after Röömusoks (1960), Jaanusson (1963) and Männil (1966).

Balto-Scandian area to represent a shallow water limestone facies and to form part of the Anglo-Scandian zone together with Eire, Wales, England and Belgium.

Scandinavia was located between 35° and 25°S lat. at the beginning of the Ordovician and closer to the Equator, around 20°S, by the end. Rainfall and runoff were least around the Tropic and increased towards the Equator. An ocean current from the south served to reduce water temperatures below those of the air in the southern parts of the area, while towards the Equator temperatures were higher. There were strong southeasterly winds (Jeppson 1980).

Most of the sedimentary rocks that accumulated during the Ordovician, which lasted from 500 Ma to 435 Ma (van Eysinga 1975), were limestones.

The Silurian

The area covered by the Bothnian Sea and southwestern Finland was dry land from the Silurian up to the Quaternary, and was thus subject to erosional forces of all kinds. The Silurian deposits in Östergötland, central Sweden, are 10—65 m in thickness and those on Gotland 400 m at their maximum (Manten 1971; Bruun & Dahlman 1980; Flodén 1980). The same sediments reach a thickness of approx. 420 m on Saarenmaa in central Estonia (Kaljo 1984). Scandinavia was located around the Equator during the Silurian (Jeppson 1980).

The Silurian was again characterized by the deposition of calcareous sediments, and lasted from 435 Ma to 395 Ma (van Eysinga 1975).

Dating of the sedimentary rocks

In dating terms, the present material contains a typical range of Palaeozoic acritarch and Chitinozoa species, being principally of a long duration Ordovician—Silurian nature, and thus any more specific dating must rely on the small number of species with a shorter lifetime. Some of the species occur only within a very short span of time in the Rapla material, whereas they seem to be of longer duration in the present samples maybe because of a higher presentage of redeposition. Some degree of uncertainty arises from the fact that these species were evidently rare in the Baltic area, Estonia and Gotland, and also in the Bothnian Sea, but the reliability of their interpretation is enhanced by the availability of the Rapla core as a source of reference material (Uutela & Tynni, in preparation) and it is also dated from the occurrence of different fossils (Pölma 1972). Use of the Rapla material for reference was in fact absolutely essential, as in this way it became evident that the dating will be distorted if the lifetimes of the species are assessed on a global scale. The Chitinozoa and conodonts, which in themselves require to be studied in larger rock specimens, proved useful for the purpose of testing the dates obtained.

The set of samples dated here by reference to the microfossils was too small to enable any far-reaching conclusions to be drawn regarding the dates or extents of the marine phases, for the twelve from the 26 of them could be traced to the same lower portion of the Middle Ordovician, the Aseri to Kukruse regional stages (Fig. 41). Of these marine stages defined by Männil (1966), the Lasnamägi and Uhaku extended as far as the coast of Finland. Further research would be needed to determine whether the duration of sedimentation of the strata from which the specimens are derived is restricted only to these regional stages. The Early Palaeozoic sea covered only southwestern Finland during the Idavere regional stage. Similarly the Gulf of Finland coast was subaquatic during the Johvi, Keila and Oandu regional stages, one sample of that age has been recovered from Hanko. The coast of southeastern Finland is still entirely unexplored. During the Rakvere stage the sea extended well into western and southern Finland, and yet only one of the three longduration Ordovician specimen, possibly from the Rakvere regional stage, representing this period has come to light. Large amounts of reddish grey calcilutite have been found, however, which can be dated on conodont evidence to the Nabala regional stage (Merrill 1979), during which the sea extended over a large area of southern Finland. During the Nabala—Pirgu regional stages, the sea reached both the Bothnian Sea area and the Gulf of Finland coast, as also during the Pirgu, which is not represented by any sample in the present material.

More exact datings could be obtained from drillcores from the Bothnian Sea. After that the correlation between the marine phases and the specimens would be possible.

Depositional environment of the sedimentary rocks

The entire species list obtained here conforms to a shallow, turbulent depositional environment in the sense described by Wall (1965). The principal indicator of this is the high proportion accounted for by the genus *Micrhystridium*. The acritarch and Chitinozoa species lists for the grey marl and the yellowish grey calcilutite of the Baltic limestone are very similar, that for the former being slightly more homogeneous and containing slightly more acanthomorphs and polygonomorphs with thick processes. In the terms of Wall (1965), this would suggest calm water sedimentation conditions somewhat further away from the shore, although no categorical statement can be made on this from the present material, as the proportion of calm water species varies from 1/20 to 1/4.

The acritarch and Chitinozoa species lists for the yellowish grey calcilutite are highly heterogeneous, varying greatly from one specimen to another, and apparently representing a wider variety of sedimentation environments and times that in the case of the other rock types. Calm water types accounted for between 1/20 and 2/3 of the species recorded. Only the greenish grey marl stands out clearly from the other rock types in terms of the microfossil species recognized, but the number of samples is so small that no very far-reaching conclusions can be drawn.

The distributions of the material by species and genus vary just as much or as little between the samples within one type as they do between different types of sample. In other words, no generalizations can be made from the species lists for particular sample types. The differences may be random ones and attributable to flow or transport conditions, or else the sedimentation environments really were very much the same throughout.

Source areas for the sedimentary erratics

Glacial transport material

The frequency of a rock type moved by glacial transport decreases with increasing transport distance. Cambrian and Silurian sedimentary rocks break easily, and boulders of over 20 cm in diameter tend to remain close to their original site, as also does material of a grain size smaller than gravel. It is the material of stone size, 2—20 cm, that best follows the direction of glacial flow, spreading out to give the fan distributions commonly used to study ice movements (Gillberg 1965). According to Fromm (1972), orthoceratite limestone and alum schist occur in grain sizes of 2—20 cm only in local material, accompanied by as much as 50 % sandstone. Correspondingly, the Cambrian sandstone fractions of over 2.0 mm were better indicators in the material of Persson (1973) than were the finer fractions.

The laboratory experiments of Erdmann (1879) showed that a one kilogramme slab of argillaceous schist could be transported 30 km before it was completely crushed, a corresponding slab of orthoceratite limestone 60 km and the same-sized piece of granite 150 km. Cambrian sandstones survive transport best of all sedimentary rocks, followed by Silurian limestones and finally Ordovician limestones. When calcium carbonate disappears from these deposits they still retain 1—2 % sandstone (Gillberg 1965).

In the opinion of Gillberg (1965), basal till and drumlins are the most reliable indicators of local material, whereas surface till tends to contain some proportion of long-distance transport material. Salonen (1986) points out, however, that the material making up Rogen moraines and hummocky moraines can have been transported still shorter distance than that contained in drumlins. The till deposits in Lapland have been shown to contain large quantities of short-range local material (Hirvas *et al.* 1977).

Esker material is also usually of local origin (Gillberg 1968; Hellaakoski 1930; Königsson 1976), although Persson (1973) admittedly reports finding limestone fragments in such a formation about 20 km away from their source. In general, however, the CO_2 in the water dissolves limestone out of esker material, as is does out of sea bed material (Buch 1932; Gripenberg 1934).

Gillberg (1965, 1967) emphasizes the importance of the bedrock topography in determining the distance over which transport may take place, while Virkkala (1958) points out the influence of this same feature on the incidence of indicator boulders, rock types located in depressions being less well represented than those located on hills.

Persson (1973) claims that veins of Cambrian sandstone leave no indicators in Quaternary sediments, while Puranen (1988), having modelled veins of non-sedimentary rocks, maintains that indicators of these are to be found close to the distal contact of the vein, a broad vein being better represented than a narrow one.

The material of Veltheim (1962) from the Bothnian Sea supports the theory that Palaeozoic material accumulates close to its area of origin, the distances measured from present-day limestone deposits to the sites of erratics being 30—50 km (frequency 12.0—20.0 %), while only a few grains are to be found at a distance of approx. 60 km. He attributes the high incidence of such rocks at his site L 154, 66.0 %, to the location of the site directly on top of an *in situ* Palaeozoic sediment, while the numbers of 1.0—10.0 % obtained in an area northeast of Åland may be due to a source lying between the sites concerned and the above-mentioned site L 154.

The grab-sampler employed by Veltheim (1962) takes material only from the surface of the deposits, and certainly not from as far down as half a metre, as would be necessary to eliminate the solution of the CO^2 in the water. Thus distribution maps obtained using more modern equipment are likely to be somewhat different. On the other hand, many of the specimens studied here are also surface samples, from boulder fields on shores and from arable land, where the air and groundwater effect in dissolving calcareous solids would similarly be felt.

Hicock (1987), in his work on englacial transport of Palaeozoic sediments in Canada, explains that bottom friction in the glacier increases as it passes from an area of porous sedimentary rocks to a hard bedrock area, with the result that the sedimentary boulders are absorbed into the body of the glacier and can be transported for anything up to 150 kilometres. Examples of such long-distance glacial transport may be the dolomite from southwestern Finland found in Estonia (Öpik 1931) as well as crystalline erratics from Åland and southwestern Finland (Donner 1989) and the Åland rapakivi and porphyrite found in Latvia (Eskola 1933), Lithuania (Tarvydas 1960) and Holland (Overweel 1977; Zandstra 1983). Likewise Gaigalas (1970) reports on porphyrites discovered in Estonia which may originate from the Bothnian Sea. In all the above works the incidence figures are calculated as percentages of total transported material, excluding local material, so that it is impossible to form a true picture of the frequency of such long-distance transport.

The Palaeozoic erratics reported by Eisenack (1930, 1931, 1932, 1934, 1955a,b, 1965a) and Gorka (1969) are said to be derived from the Baltic. No more exact location is given, but it may be assumed that they mean the southern part of the Baltic Sea, the Baltic Proper.

The deposition of calcareous rocks from the Bothnian Sea onto the shore of southwestern Finland by a raft transport mechanism has also been touched upon by some authors (Hellaakoski 1930; Martinsson 1956b) and this theory undoubtedly holds good to some extent. De Geer (1919, 1932) had already proposed a similar mechanism in Sweden. One characteristic of material carried by ice rafts is that it is found in a transitional horizon between varved clay and homogeneous clay (de Geer 1932). A deep basin developed in the Baltic during the deglaciation, probably with considerable glacial oscillation (Martinsson 1956a), but the Coriolis effect would have meant that the ice rafts moved southwestwards rather than southeastwards.

Short-distance transport: effect of bedrock topography on transport distance

The effect of topography on transport distance has been studied by Gillberg (1965, 1967). As a body of ice moves from a low-lying substrate to a higher area the material contained in it tends to accumulate at the first topographical barrier. Deep, broad valleys, especially those broadening out in the direction of glacial flow, present very few such barriers, and the indicator boulders tend to travel further. The resistance of the various rock types to comminution during transport will also affect this accumulation, for small rock fragments will load the ice, causing plasticity, increasing the friction and reducing its mobility, with the result that deposition will increase. Fine material will be deposited first, followed by gravel and eventually stones.

The bedrock of the area studied here is broken up by innumerable fracture lines and zones, with the deeper fracture basins usually filled with thick water-laid sediments whereas the Quaternary deposits are otherwise fairly thin. There is little basal till in the area and few drumlins. The principal glaciofluvial formations are the eskers at Laitila and Säkylä, in addition to which there are some smaller, discontinuous eskers in places. The dominant orientation of the bedrock fractures is NW-SE, coinciding with the main direction of glacial movement, and these fractures, where they occur singly, tend to be steep-sided and 0.5—2.0 km in width. Their depth as such is about 10 m, but where fractures running in different directions form complexes the resulting formations tend to be both deeper and broader. The fractures running in a transverse direction with respect to the ice flow are narrower, 100—500 m, and would seem to be similar in depth to those running parallel to the direction of ice movement, although no generalizations can be made on this in the absence of accurate depth data.

The broadest basins are to be found on the coast, the Lapinjoki basin in the commune of Eurajoki and the Valkiameri basin in Kalanti. The Satakunta sandstone basin extends from Pori to Pyhäjärvi, but the bedrock depression in which it is situated continues as far as Loimaa. These depressions evidently guided the flow of ice to a considerable extent.

In Sweden Gillberg (1967) calculates for a till-covered terrain with a topography characterized by an alternation between low hills and depressions giving $x_{1/2}$ = 5.3 km. The transport distance in the archipelago will be somewhat greater, 9.4 km and that in depressions running in the direction of glacial flow greater still, 10.0 km, since there will be less barriers to the movement of the ice. Transport distances for till are usually less than 10 km,.and similar conclusions are reached by Perttunen (1977), Kinnunen (1979), Salonen (1986) and Puranen (1988).

The transport distance for glacial gravel in the Laitila esker is approx. 5 km (Hellaakoski 1930), while Gillberg (1968) quotes values of $x_{1/2}$ = 5.4 km for limestone and 7.5 km for Cambrian sandstone. Salonen (1986) estimates that 61.4 % of the material in the Laitila esker has been transported over a distance of less that 7 km, although he interprets one boulder of Cambrian sandstone as having travelled more than 150 km.

Such small percentages of Palaeozoic sedimentary limestone, as max. under 2.0 %, were found at the sites studied here that it is impossible to determine their source. The theory of short-range transport presupposes that they would have accumulated at the first topographical barrier that happened to be in their path. This would imply that the erratics originate from the fracture basins, close to which the majority of the examples are found (Fig. 44). Further research would be required to assess whether this is mere chance or whether the fracture basins in question actually contained, or possibly still do contain, Palaeozoic sediments. If they had, then the glacier could well have removed some of the rock and deposited it at the first topographical barrier. The fractures running parallel to the direction of glacial flow would have been eroded deeper and the material would have been transported further, while the material from the transverse fractures would have accumulated in the close vicinity of these. The present data do not allow any greater importance to be assigned to the depth of the

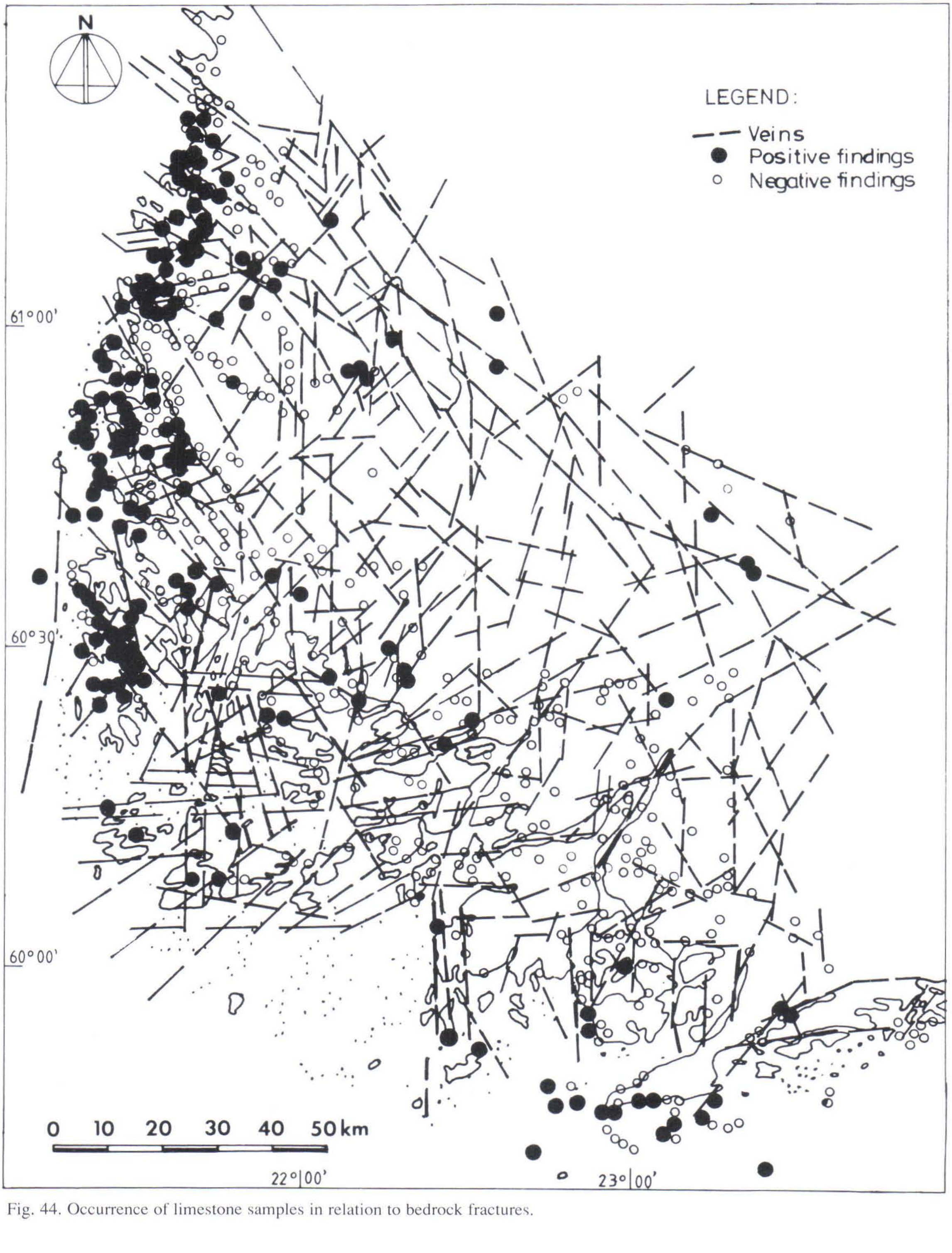


Fig. 44. Occurrence of limestone samples in relation to bedrock fractures.

fractures in this process than to their orientation, but the acquisition of more complete depth data may alter this picture.

The Exploration Department of the Geological Survey of Finland has carried out borings and echo soundings in the clay basin of Valkiameri in the districts of Uusikaupunki and Kalanti, a basin which is about 15 m deep and runs in the direction of ice flow, but has failed to find any evidence of *in situ* sedimentary rocks, even though this area is one of the richest in terms of erratics (Alviola 1988). If, according to Gillberg (1965), Palaeozoic sedimentary rocks are transported a maximum of 30 km and any finds further away from the source than this must be random or isolated ones, then the specimens obtained from this area must be interpreted as accidental or isolated cases, especially since 6.0 % from Vampula (Nenonen, pers. comm.). Calcareous sedimentary rocks are to be found in the stone counts only at Kuivalahti in Eurajoki, Lepäinen in Uusikaupunki and Padva in Bromarv. The consentration of 1.0—2.0 % of sedimentary rock specimens here by comparison with other parts of the area studied is nevertheless striking, and further research is called for to establish whether they can really be regarded as accidental or not.

Long-distance transport from the sedimentary basin to the Precambrian shield

The question of englacial transport of sedimentary rocks is discussed by Hicock (1987) in Hemlo area, Canada.

The uppermost rock type in the sedimentary deposits of the Bothnian Sea is the reddish grey calcilutite type of Baltic limestone, below which are the yellowish grey calcilutite type and the grey marl, evidently alternating, as at Rapla in Estonia. The lowermost of the Ordovician deposits consists of the greenish grey or reddish brown marl, beneath which lie the Cambrian and Jotnian sandstones. The Palaeozoic sediments of the Bothnian Sea are located in a depression and are broken up by various fracture lines and zones.

A simplified model of the border area may be proposed in which the glacier loosened first the reddish grey calcilutite type of Baltic limestone and so on, the last to be disturbed being the Cambrian and Jotnian sandstones. As the ice reached the bedrock area, at least some of these calcareous boulders will have been crushed into smaller pieces, the Cambrian and Jotnian sandstones, the last to be carried away, being affected the least. With the increased glacial bed friction due to the bedrock substrate, some of the material will have been deposited and some taken up into the body of the glacier. The sandstones, which were the last to be loosened from their site of origin, will then have become enriched in the base of the glacier and will have accumulated in the greatest numbers at the contact between the sedimentary rocks and the bedrock.

While numbers of 10.0—18.0 % and 2.0—3.0 % respectively are quoted for the proportions of Jotnian and Cambrian sandstones on the sea bed near the coast (Veltheim 1962), the present stone counts give 4.0—40.0 % Jotnian sandstone on the coast outside the area of the formation itself and 30.0—74.0 % on top of the formation, and 0—10.0 % Cambrian sandstone. The next most frequent should be the greenish grey or reddish brown marl and the least frequent the reddish grey calcilutite.

This is not in fact the case in the field, however (Figs. 5—9). The Bothnian Sea sedimentary deposits were evidently arranged in a more complex manner, the strata being of different thicknesses and differing in extent, some or all of them even being absent in places. These calcareous rocks also differ in their resistance to erosion during transport, the marls being less resilient than the lutites.

The Bothnian Sea Jotnian sandstone bed is located some 20—180 km from the coast of southwestern Finland, while the Satakunta sandstone area on the mainland forms a lobe stretching inland from Pori to Pyhäjärvi. Correspondingly, the Cambrian sandstone bed in the Bothnian Sea lies between 60 km and 220 km away from the area studied here, and the limestone deposit 80—250 km measured in the main direction of glacial movement. If we assume that the sedimentary erratics observed here were derived from the bed of the Bothnian Sea in accordance with the model of Hicock (1987), then certain questions remain to be answered:

— Why have only small numbers of erratics from the Lower Ordovician sediments reached the coast when large numbers from the Cambrian sandstone lying below it have done so (Figs. 5 and 6)?.

— Why is the yellowish grey calcilutite so frequent in the Hanko area but the reddish grey variety rare? It is possible that the reddish grey type was eroded from the sea bed earlier, or that Hanko belonged to the area covered by the North Estonian Confacies, in which the reddish grey type was absent.

— Why are Cambrian sandstone erratics distributed irregularly over the area, with large numbers between Uusikaupunki and Luvia, only occasional occurrences between Kustavi, Turku and Parainen, but more in Sauvo (4.0 %) and still more significant finds in Bromarv (4.0 % at one site and 1.0 % at four others)? The same is also true of the distribution of limestone erratics (Figs. 5—9).

— Is the occurrence of Palaeozoic sedimentary rocks close to bedrock fractures only a random feature, or did the glacial dynamics become predisposed towards deposition at such points?

The reason for the uneven distribution of sedimentary boulders may be that large boulders were broken up while being transported or deposited by glacial action. This is highly probable in cases where all the examples found in one place are of the same type. This fragmentation may take place in connection with either short or long distance transportation.

SUMMARY

The material studied here comprised 671 erratics representing Palaeozoic sedimentary calcareous rocks and 1573 of Cambrian sandstone from the coast of southwestern Finland. The Cambrian sandstone erratics were concentrated on the coast between Uusikaupunki and Luvia, with smaller accumulations in Sauvo and the eastern parts of Bromarv. There was little reddish brown or greenish grey marl, i.e. orthceratic limestone, in the area, only in Kustavi, Eurajoki and Luvia, while the largest amounts of grey marl, or Chasmops limestone, were found around Hanko, only isolated boulders being present elsewhere. The older type of the Baltic limestone, yellowish grey calcilutite or calcarenite, was found in the greatest amounts between Kustavi and Luvia and at Hanko. The reddish grey calcilutite of the Baltic limestone occurs in the same places as the yellowish grey type except that its proportion is extremely low around Hanko. The Palaeozoic sedimentary rocks are distributed very unevenly along the coast, erratics being fairly common between Luvia and Kustavi while the area between Kustavi and Kemiö is very poor in this type and it reappears in the Bromarv — Hanko area.

Stone counts were made at 31 sites, one per 40 km^2, in order to test whether Palaeozoic sedimentary rocks could be discovered by random sampling. Positive results were obtained for Cambrian sandstones in the area from Kustavi to Luvia and at Paimio and Bromarv, but sedimentary limestones were discovered less often, only around Eurajoki, Uusikaupunki and Bromarv, areas in which finds of such rocks tended to be concentrated in any case. No *in situ* deposits have been discovered to date.

The sedimentary rocks were dated by reference to the acritarchs and Chitinozoa contained in 26 out of the 62 specimens examined. The greenish grey marl, of which 3 specimens were investigated, was laid down during the Kunda to Kukruse regional stages of the Lower/Middle to Middle Ordovician, while the grey marl dates back to a period extending from the Aseri—Lasnamägi transition to the Nabala regional stage, Middle to Middle/Upper Ordovician five out of the 8 specimens being from the lower part of the Middle Ordovician and two from transition of lower and the upper part and one is longer duration, i.e. from the Kukruse to Nabala regional stages. The 15 specimens of yellowish grey calcilutitic type of the Baltic limestone were

more difficult to interpret in terms of age than the marls, 4 of the specimens being from the lower part of the Middle Ordovician, 6 from the middle part, 1 from the upper part and 4 specimens yielded only species of a longer duration, so that no more precise date could be given than the Ordovician as a whole. No microfossils were found in either the Cambrian sandstone or the reddish grey calcilutite.

The species of acritarchs and Chitinozoa identified were typical of the Palaeozoic in the Baltic basin, differing from previous material only in that the range of species was somewhat wider and the individuals smaller in size than in Gotland or Estonia. Comparative material was obtained from the stratigraphy of the Rapla core in Estonia, which has been dated accurately from its shelly fossils. The acritarchs and Chitinozoa of this core are now being examined by a joint Finnish and Estonian team of investigators.

The 98 species of acritarch belong to the genera *Aremoricanium, Axisphaeridium, Baltisphaeridium, Buedingiisphaeridium, Comasphaeridium, Cymatiosphaera, Dicommopalla, Dictyosphaeridium, Dictyotidium, Goniosphaeridium, Hapsidopalla, Helosphaeridium, Leiofusa, Leiosphaeridia, Leiovalia, Lophosphaeridium, Micrhystridium, Multiplicisphaeridium, Nanocyclopia, Orthosphaeridium, Peteinosphaeridium, Pheoclosterium, Pirea, Polyancirtrodorus, Priscogalea, Pterospermopsis, Rhopaliophora, Stelliferidium, Tasmanites, Timofeevia, Tranvikium* and *Veryhachium*. The 19 species of Chitinozoan belong to the genera *Conochitina, Cyathochitina, Desmochitina, Eisenachitina, Lagenochitina* and *Rhabdochitina*.

Three new genera are reported here, *Kundasphaera, Nodusosphaeridium* and *Raplasphaera* and six new species, *Axisphaeridium tricolumnelare, Comasphaeridium varispinosum, Kundasphaera lacunosa, Nodusosphaeridium rubus, Peteinosphaeridium parvispinosum* and *Priscogalea perforata*, and one new *forma, Leiofusa granulacutis f. cuincunx*. The species composition of the samples is indicative of sedimentation in shallow water under variable coastal conditions and in a generally turbulent environment. The differences between the various types were so slight that they could well represent no more than random variation. The grey marl did contain the genus *Orthosphaeridium*, however, which is an indicator of a calm depositional environment, and this finding is probably attributable to the conditions prevailing at the time.

The differences between the specimens, assessed in terms of the percentages of the acritarch genera, were only minor ones and were probably of a random nature with the exception of the genus *Orthosphaeridium* in the grey marl. Species differences calculated on the principle of the most common species, second most common, third most common, etc. failed to reveal any differences between the limestone types.

The specimens were also grouped according to their lithological composition and grain size, but no major differences in this respect emerged between the specimens of similar species composition among those that contained microfossils. The specimens of grey marl and yellow grey calcilutite cannot be dated any more exactly on lithological grounds than to the Ordovician.

The sources of the erratics are considered here in the light of theories of short-distance and long-distance glacial transport. Arguments in favour of short-distance transport include the existence of more fragile material which would not survive transport over long distances and the fact that most glacial transport in Finland, and particularly in this area, has been observed to take place over distances of less than 10 km. The erratics may be assumed to originate from the fracture basins, which were covered by the marine stages of the Palaeozoic, the greater proportion of the specimens being associated with fractures running transverse to the direction of glacial movement. The argument against short-distance transport is that no *in situ* deposits have been found, although soundings and borings have admittedly been carried out only in the Valkiameri basin in Kalanti.

The argument in favour of long-distance transport lies in the fact that this could have taken place englacially from known deposits on the bed of the Bothnian Sea, but this theory is unable to explain the uneven distribution of erratics on the coast, and particularly the distorted stratigraphy and relative thicknesses of the horizons, not to mention the location of the recovery sites in the vicinity of bedrock fractures.

ACKNOWLEDGEMENTS

This research was carried out at the Geological Survey of Finland in 1986—1987 under a project financed by the Academy of Finland.

I would like to express my warmest thanks to my supervisors, Dr. Risto Tynni of the Geological Survey of Finland and Prof. Joakim Donner of the University of Helsinki for the encouragement and support they have given me, and to the Director of the Geological Department of the Estonian Academy of Sciences, Prof. Dimitri Kaljo, for providing valuable comparative material and Mr. Jaak Nolvak, also of the Estonian Academy of Sciences, for information on the chitinozoa. Thanks are also due to Dr. Veli-Pekka Salonen of the Geological Survey of Finland and Stefan Hagenfeldt, Lic.Phil., of the University of Stockholm for their constructive comments on the manuscript.

I am very grateful to Professor Kalevi Kauranne for approving the study for publication in the Bulletin of the Geological Survey of Finland.

Much valuable material was received from the Exploration Department of the Geological Survey and from samples handed in by amateur samplers. I would also like to thank Mrs. Tarja Tuimala for drawing some of the diagrams for publication and Mr. Malcolm Hicks, M.A., for checking the English of the species descriptions and translating the remainder of the manuscript. Dos. Reijo Pitkäranta translating the names of new species into the Latin.

Finally, financial assistance from the Jenny and Antti Wihuri Foundation is gratefully acknowledged.

REFERENCES

Achab, A., 1977. Les chitinozoaires de la zone à Dicellograptus complanatus Formation de Vauréal, Ordovicien superieur. Ile d'Anticosti, Quebec. Can. J. Earth Sci. 14 (3), 413—425.

–, 1978. Sur quelques chitinozoaires de la formation de Vaureal et de la formation de Macasty de l'ile d'Anticosti, Quebec. Rev. Palaeobot. Palynol. 25, 295—314.

Alviola, R., 1988. Ordovikikalkkikivien etsintä Valkiameren altaasta kesällä 1984. Geologian tutkimuskeskus. Raportti M 19/1131/84. 10 s.

Axberg, S., 1980. Seismic stratigraphy and bedrock geology of the Bothnian Sea, Northern Baltic. Stockholm Contrib. Geol. 6 (3), 213 p.

Backlund, H.G., 1937. Die Umgrenzung der Svekofenniden. Bull. Geol. Inst. Univ. Upsala. 27, 219—269.

Benoit, A. & Tangourdeau, Ph., 1961. Sur quelques chitinozoaires de l'ordovicien du Sahara. Rev. Inst. Francais Petrol. XVI (12), 1403—1421.

Bergman, L., 1982. Clastic dykes in the Åland Islands, SW Finland and their origin. Geol. Surv. Finland, Bull. 317, 1—33.

Bergman, L. & Lindberg, B., 1979. Phanerozoic veins of galena in the Åland rapakivi area, southwestern Finland. Bull. Geol. Soc. Finland 51, 55—62.

Blatt, H., 1982. Sedimentary petrology. W.H. Freeman and Co., San Francisco. 564 p.

Bockelie, T.G. & Kjellström, G., 1979. Middle Ordovician acritarchs from the island of Odinsholm, Estonia. Geol. Fören. i Stockholm Förh. 101, 205—216.

Bruun, Å., 1985. Paleozoisk berggrund. Sveriges geologiska undersökning. Ser. Af, 134. Beskrivning till berggrundskartan Hjo SO, 91—130.

Bruun, Å. & Dahlman, B., 1980. Den paleozoiska berggrunden. Sveriges geologiska undersökning. Ser. Af, 119. Beskrivning till berggrundskartan Linköping NV, 68—103.

Buch, K., 1932. Untersuchen über gelöste Phosphate und Stickstoffverbindungen in den nordbaltischen Meeresgebieten. Merentutkimuslait. julk. 86, 30 p.

Cocchio, A.M., 1981. Donnés nouvelles sur les Acritarches du Tremadoc et de l'Arenig dans le Massif de Mouthoumet (Gorbieres, France). Rev. Micropaleontol. 25 (1), 26—39.

Colbath, K.G., 1979. Organic-Walled microphytoplancton from the Eden Shale (Upper Ordovician), Indiana, USA. Palaeontographica B. 171, 38 p.

Combaz, A. & Peniguel, G., 1972. Etude palynostratigraphique de l'Ordovicien dans quelques sondages du bassin de Canning (Australie Occidentale). Bull. Cent. Rech. Pau. SNPA. 6 (1), 121—167.

Cramer, F.H., 1964. Microplankton from three Palaeozoic formations in the Province of León (NW-Spain). Leidse Geol. Meded. 30, 253—361.

–, 1970. Distribution of selected Silurian acritarchs. An account of the palynostratigraphy and paleogeography of selected Silurian acritarchs. Rev. Espanola Micropaleont. Num. Extraodr. 1, 203 p.

Cramer, F.H. & Diez, M.d.C.R., 1972. North American Silurian Palynofacies and their Spatial Arrangement. Acritarchs. Paleontographica. B. 138, 107—180.

–, 1979. Lower Palaeozoic acritarchs. Palinologia 1, 17—160.

Dahlman, H., 1977. Sveriges Geologiska Undersökning. Berggrundskartan Linköping NV. Ser. Af. 119, 1: 50 000.

Deflandre, G., 1945. Microfossiles des calcaires siluriens de la Montagne Noire. Ann. Paléontologie 31 (1944—1945), 39—75.

Deunff, J., 1955. Un microplancton fossile dévonien à Hystrichosphères du continent Nord-Americain. Bull. Microsc. Appl. 5, 138—149.

—, 1958. Planctonic Microorganisms of the Breton Paleozoic. 1. The Ordovician of Veryhac'h (Crozon Peninsula). Bull. N.S. Soc. Geol. et Mineral. Bretagne 2, 1—41.

Donner, J., 1989. Transport distances of Finnish crystalline erratics during the Weichselian glaciation. Geol. Surv. Finland, Spec. Paper 7, 7—13

Doubinger, J., 1963. Chitinozoaires ordoviciens et siluriens des schistes de Steige dans les Vosges. Bull. Serv. Carte géol. d'Alsace et de Lorraine, 16 (3), 125—136.

Downie, C., 1958. An assemblage of microplankton from the Shineton Shales (Tremadocian). Proc. Yorkshire Geol. Soc., 31, 331—350.

–, 1963. "Hystrichospheres" (acritarchs) and spores of Wenlock Shales (Silurian) of Wenlock, England. Palaeontology 6. 625—652.

Downie, C. & Ford, T.D., 1966. Microfossils from the Manx Slate Series. Proc. Yorks. Geol. Soc., 31, 4 (12), 331—349.

Edelman, N., 1949. Structural history of the eastern part of the Gullkrona basin, SW-Finland. Bull. Comm. géol. Finlande 148. 48 p.

–, 1951. Glacial abrasion and Ice Movements in the Area of Rosala — Nötö, S.W. Finland. Bull. Comm. géol. Finlande 154, 157—169.

–, 1956. Kallioperäkartan selitys. — Explanation to the map of rocks. Suomen geologinen kartta — Geological map of Finland, 1:100 000. Lehti — Sheet 1033. Nötö. Geological Survey of Finland. 44 p.

–, 1960. The Gullkrona region, SW Finland. Bull. Comm. géol. Finland. 187. 87 p.

–, 1985. Nauvon (Nagu) kartta-alueen kallioperä. Summary: Pre-Quaternary rocks of the Nauvo (Nagu) map-sheet area. Kallioperäkarttojen selitykset — Explanation to the maps of pre-Quaternary rocks. Lehti — sheet 1034. Suomen geologinen kartta — Geological map of Finland, 1:100 000. Geological Survey of Finland. 47 p.

Eisenack, A., 1930. Neue Mikrofossilien des baltischen Silurs. (Vorläufige Mitteilung). Naturwissensch. 18 (42), 880—881.

–, 1931. Neue Mikrofossilien des baltischen Silurs I. Palaeont. Z. 13, 74—118.

–, 1932. Neue Mikrofossilien des baltischen Silurs II. Palaeont. Z. 14, 257—277.

–, 1934. Neue Mikrofossilien des baltischen Silurs III und neue Mikrofossilien des bömischen Silurs I. Palaeont. Z. 16, 52—76.

–, 1937. Neue Mikrofossilien des baltischen Silurs. IV. Palaeontol. Z. 19, 218—243.

–, 1938. Hystrichospheres and related Forms in the Baltic Silurian. Z. Geschiebeforschung und Flachlandsgeologie 14 (1), 1—30.

–, 1951. Uber Hystrichosphaerideen und andere Kleinformen aus baltischen Silur und Kambrium. Senckenbergiana, 32, 187—204.

–, 1955a. Chitinozoen, Hystrichosphären und andere Mikrofossilien aus dem Beyrichia-Kalk. Senck. Lethaea 36 (1/2), 157—188.

–, 1955b. Neue Chitinozoen aus dem Silur des Balticums und dem Devon der Eifel. Senck. leth. 36 (5/6), 311—319.

–, 1958. Microfossils of the Ordovician from the Baltic Area I. Senck. Lethaea 39 (5/6), 389—405.

–, 1959a. Neotypen baltischer Silur-Hystrichosphären und neue Arten. Palaeontographica Abt. A. 112 (5—6), 193—211.

–, 1959b. Neotypen baltischer Silur-Chitinozoen und neue Arten. N. Jb. Geol. Paläont. Abh. 108 (1), 1—20.

–, 1962a. Neotypen baltischer Silur-Chitinozoen und neue Arten. (Fortsetzung). N. Jb. Geol. Palaeontol. Abh. 114, 291—316

–, 1962b. Mikrofossilien aus dem Ordovizium des Baltikums. Senck. Lethaea 43 (5), 349—366.

–, 1963. Hystrichosphären. Biol. Rev. 38, 107—139.

–, 1965a. Die Mikrofauna der Ostseekalk. 1. Chitinozoen, Hystrichosphären. N. Jb. Geol. Paläont. Abh. 123 (2), 115—148.

–, 1965b. Mikrofossilien aus dem Silur Gothlands Hystrichosphären, Problematika. N. Jb. Geol. Paläont. Abh. 122, 257—274.

–, 1968. Mikrofossilien eines Geschiebes der Borkholmer Stufe, Baltischer Ordovizium, F_2. Mitt. Geol. Staatsinst. Hamburg, H. 37, 81—94.

–, 1969. Zur systematik einiger paläozoischer Hystrichospären (Acritarcha) des baltischen Gebiets. N. Jb. Geol. Paläont. Abh. 133 (3), 245—266.

–, 1976. Mikrofossilien aus dem Vaginatenkalk von Hälludden. Öland. Palaeontographica Abt. A 154 (4—6), 181—203.

Eisenack, A., Cramer, F.H. & Diez, M.d.C.R., 1973. Katalog der fossilen Dinoflagellaten, Hystrichospären und versandten Mikrofossilien. III. Acritarcha. 1 Teil. E. Schweitzerbart. Verlagsbuchhandlung, 1978. Stuttgart. 1104 p.

–, 1976. Katalog der fossilen Dinoflagellaten, Hystrichosphären und verwandten Mikrofossilien Band IV. Acritarcha. 2. Teil. E. Schweitzerbart Verlagsbuchhandlung, 1976. Stuttgart. 863 p.

–, 1979a. Katalog der fossilen Dinoflagellaten, Hystrichosphären und verwandten Mikrofossilien. Band. V. Acritarcha. 3. Teil. E. Schweitzerbart. Verlagsbuchhandlung, 1979. Stuttgart. 532 p.

–, 1979b. Katalog der fossilen Dinoflagellaten, Hystrichosphären und verwandten mikrofossilien. Band VI. Acritarcha. 3. Teil. E. Schweitzerbart. Verlagsbuchhandlung, 1979. Stuttgart. 533 p.

Eklund, O., 1934. Silurmoränen i skärgårdshavet. Terra 46 (4), 147—151.

–, 1946a. *Listera ovata* (L.), RBr. als Kalkindikator. Mem. Soc. Fauna et Flora Fennica 22 (1945—1946), 146—154.

–, 1946b. Uber die Kalkabhängigkeit der Kormophyten SW—Finnlands. Mem. Soc. Fauna et Flora Fennica 22 (1945—1946), 166—187.

–, 1948. Skärgårdsväxterna och kalken. Skärgårdboken. Nordenskjöld—Samfundet. 315—339.

Elaohad—Debbaj, Z., 1984. Acritarches et chitinozoaires de l'Arenig—Llanvirn de l'Anti-Atlas (Maroc). Rev. Paleobot. Palynol. 43, 67—88.

Erdmann, E., 1879. Bidrag till kännedom om rullstenarnas bildande. (Ett geologiskt experiment.) Geol. Fören. i Stockholm Förh. 4, 407—417.

Eskola, P., 1913. On phenomena of solution in Finnish limestones and on sandstone filling cavities. Bull. Comm. géol. Finlande 36, 50 p.

–, 1933. Tausend Geshiebe aus Lettland. Ann. Acad. Sci. Fennicae A. XXXIX. 5, 41 p.

van Eysinga, F.W.B. (Complier), 1975. Geological Time Table. 3 rd. ed. Elsevier. Amsterdam.

Fairbridge, R.W., 1964. Thoughts about an expanding globe. Advcing Frontiers in Geology and Geophysics. 59—88.

Flodén, T., 1980. Seismic stratigraphy and bedrock geology of the Central Baltic. Stockholm Contrib. Geol. 35, 1—240.

Flodén, T., Jacobsson, R., Kumpas, M.G., Wadstein, P. & Wannäs, Kj. 1980. Geophysical investigation of western Bothnian Bay. Geol. Fören. i Stockholm Förh. 101 (1979), 321—327.

Fromm, E., 1971a. Den kambro—ordoviciska berggrunden. Sveriges Geologiska Undersökningen. Ser. Af. 101. Beskrivning till berggrundskartbladet Örebro Sv., 26—69.

–, 1971b. Sveriges Geologiska Undersökningar. Ser Af. 101. Berggrundskartan Örebro SV. 1:50 000.

–, 1972. Sveriges Geologiska Undersökningar. Ser Ae 5. Beskrivning till geologiska katrbladen Örebro SV. Kvartära bildningar. 110 p.

Fromm, E. & Kjellström, G., 1976. Paleozoisk berggrund. SGU Ser. Af. 107. Beskrivning till berggrundskartan Linköping NO, 85—109.

Gaigalas, A., 1970. Spread areas of the effusive rock in the bottom of the Baltic Sea and their petrographic composition (on the basis of examination of the erratic boulders). Baltica 4, 259—272.

Gardemeister, R., 1973. Hienorakenteisten maalajien geologisia ja geoteknisiä tutkimustuloksia. VTT, Geotekniikan laboratorio. Tiedonanto 8, 113 p.

Geer, G. de, 1881. Några ord om bergarterna på Åland och flyttblocken derifrån. Geol. Fören. i Stockholm Förh. 5, 469—484.

–, 1919. Om moränmaterial i sekundärt läge. Geol. Fören. i Stockholm Förh. 41, 193—201.

–, 1932. Stockholmstraktens kvartärgeologi. Sveriges Geol. Unders. Ser. Ba 12, 89 p.

Geological Survey of Finland, Department of Quaternary Geology 1986. Uurteet, harjut ja reunamuodostumat — Striations, eskers and ice-marginal formations, 1:4 000 000.

Gillberg, G., 1965. Till distribution and ice movements on the northern slopes of the South Swedish Highlands. Geol. Fören. i Stockholm Förh. 86, 433—484.

–, 1967. Distribution of different limestone material in till. Geol. Fören. i Stockholm Förh. 89, 401—409.

–, 1968. Lithological distribution and homogenity of glaciofluvial material. Geol. Fören. i Stockholm Förh. 90 (2), 189—204.

Gorbatschev, R., 1976. Den tektoniska kartan. *In*: Sveriges Geologiska Undersökning. Beskrivning till berggrundskartan Linköping NO. Ser. AF. 107. 75—84.

Gorka, H., 1969. Microorganismes de l'Ordovicien de Pologne. Paleont. Polonica 22, 102 p.

–, 1979. Les Acritarches de l'Ordovicien moyen d'Olsztyn IG 2 (Pologne). Acta Palaeont. Polonica 24 (3), 351—376.

–, 1980. Le microplankton de l'Ordovicien moyen de Strabla (Pologne). Acta Palaeont. Polonica 25 (2), 261—277.

–, 1987. Acritarchs et Prasinophyceae de l'Ordovicien moyen (Viruen) du sondage de Smedsby Gård No 1. (Gotland, Suède). Rev. Palaeobot. Palynol., 52, 257—297.

Grahn, Y., 1978. Chitinozoan stratigraphy and palaeoecology at the Ordovician-Silurian boundary in Skåne, southernmost Sweden. Sveriges Geol. Unders. Ser C. 744, 16 p.

–, 1980. Early Ordovician Chinozoa from Öland. Sveriges Geol. Unders. Ser C, 775, 41 p.

–, 1981a. Middle Ordovician Chitinozoa from Öland. Sveriges Geol. Unders. Ser C, 784, 51 p.

–, 1981b. Ordovician Chitinozoa from the Stora Åsbotorp boring in Västergotland South-Central Sweden. Sveriges Geol. Unders. Ser C, 787, 40 p.

–, 1982a. Caradocian and Ashgillian Chitinozoa from the subsurface of Gotland. Sveriges Geol. Unders. Ser C, 788, 66 p.

–, 1982b. Chitinozoophoran palaeoecology in the Ordovician of Öland. Sveriges Geol. Unders. Ser C, 792, 17 p.

–, 1984. Ordovician Chitinozoa from Tallinn, Northern Estonia. Rev. Paleobot. Palynol. 43, 5—31.

Grahn, Y. & Bergström, S.M., 1984. Lower Middle Ordovician Chitinozoa from the Southern Appalachians, United States. Rev. Paleobot. Palynol. 43, 89—122.

Grahn, Y. & Miller, M.A., 1986. Chitinozoa from the Middle Ordovician Bromide Formation, Arbuckle Mountains, Oklahoma, USA. N. Jb. Geol. Palaont. Abh. 1972, 3., 381—403.

Gripenberg, S., 1934. Sediments of the North Baltic and adjoining Seas. Merentutkimuslaitoksen julk. 96, 231 p.

Gylling, Hj. 1891. Suomen geologinen tutkimus. Kertomus karttalehteen N:o 12. Uusikaupunki. 94 p.

Haavisto, M., Grönlund, T., Lahermo, P. & Stén, C-G., 1980. Someron kartta-alueen maaperä. Summary: Quaternary deposits in the Somero map-sheet area. Maaperäkarttojen selitykset — Explanation to the maps of Quaternary deposits. Lehti — sheet 2024. Suomen geologinen kartta — Geological map of Finland, 1:100 000. Geological Survey of Finland. 66 p.

Hagenfeldt, S., 1988. Acritarchs assemblages of Early and Middle Cambrian age in the Baltic Depression and South-Central Sweden. Geol. Survey of Finland, Spec. Pap. 6. 151—161.

Häkkinen, A., 1982. Ensimmäisen Salpausselän merenalainen jatke Hankoniemeltä lounaaseen. Summary: The Submarine continuation of the First Salpausselkä ice-marginal formation South-west of Hanko. Geologi 34 (3), 42—48.

Hämäläinen, A., 1985. Satakunnan jotunialueen geologisen karttakuvan historiallinen kehitys sekä uuteen tutkimusaineistoon perustuva kallioperäkarttaluonnos. Helsingin yliopisto. Helsinki University. Unpublished manuscript. 104 p.

–, 1986. Kartoitusyksikön kairaukset. Ala-Satakunta. Geologian tutkimuskeskus. Kallioperäosaston vuosikertomus 1985. 25—27.

Härme, M., 1958. Pre-Quaternary rocks — Kivilajikartta 1:400 000. Lehti — sheet Bl, Turku. Suomen geologinen yleiskartta — General geological map of Finland, Geological Survey of Finland.

–, 1960. Kivilajikartan selitys — Explanation to the map of pre-Quaternary rocks. Suomen geologinen yleiskartta — General geological map of Finland, 1:400000. Lehti — sheet Bl. Turku. Geological Survey of Finland. 78 p.

–, 1961. On the fault lines in Finland. Bull. Comm. géol. Finlande 196, 437—444.

Hausen, H., 1934. Uber ein neuentdecktes Kaolin-Sandstein-Vorkommen im kristallinen Kalkstein auf Pargas — Älgön, Gegend von Åbo-Turku. SW-Finland. Acta Acad. Aboensis. Ser. Math.—Phys., 8 (1), 1—59.

–, 1968. The history of geology and mineralogy in Finland 1828—1918. Soc. Sci. Fennica. 7a. 145 p.

Hellaakoski, A., 1930. On the Transportation of Materials in the Esker of Laitila. Fennia 52 (7), 42 p.

Henry, J.L., 1969. Microorganismes incertae sedis (acritarches et chitinozoaires) de l'Ordovicien de la Presqu'ile de Crozon (Finistère). Gisements de Mort-Anglaise et de Kerglintin. Bull. Soc. Géol. Miner. Bretagne, 1968, 59—100.

Hessland, I., 1955. Studies in the lithogenesis of the Cambrian and basal Ordovician of the Böda Hamn sequence of strata. Boring through the Cambrian and Ordovician strata at Böda Hamn, Öland II. Bull. Geol. Inst. Uppsala XXXV, 35—109.

Hicock, S.R., 1987. Genesis of carbonate till in the lee sides of Precambrian Shield uplands, Hemlo area, Ontario. Can. J. Earth Sci. 24, 2004—2015.

Hirvas, H., Alftan, A., Pulkkinen, E., Puranen, R. & Tynni, R., 1977. Raportti malminetsintää palvelevasta maaperätutkimuksesta Pohjois-Suomessa vuosina 1972—1976. Geol. Surv. Finland, Rep. Invest. 19, 54 p.

Ignatius, H., Kukkonen, E. & Winterhalter, B., 1980. Pohjanlahden kvartäärikerrostumat. Summary: The Quaternary deposits of the Gulf of Bothnia. Appendices: Marine geological maps of the Bothnian Sea and the Bothnian Bay, scale 1:1 000 000. Geol. Surv. Finland. Rep. Invest. 45, 50 p.

Jaanusson, V., 1963. Classification of the Harjuan (Upper Ordovician) rocks of the mainland of Sweden. Geol. Fören. i Stockholm Förh. 85, 110—144.

–, 1972. Constituent analysis of an Ordovician limestone from Sweden. Lethaia 5, 217—237.

–, 1976. Faunal dynamics in the Middle Ordovician (Viruan) of Balto-Scandia. *In*: Basset, M.G. (ed.), The Ordovician System. Proc. Palaeontological Association symposium 1974, Birmingham, Univ. Wales Press and National Museum of Wales, Cardiff. 301—326.

Jacobson, S.R., 1978. Acritarchs from the Upper Ordovician clays of the Ferry Formation, Kentucky, USA. Palinologia 1, 293—301.

Jaeger, H., 1984. Einige Aspekte der geologischen Entwicklung Südskandinaviens im Altpaläozoikum. Z. für angewandte Geologie, 30 (1), 17—32.

Järvimäki, P., 1968. Seisminen luotaus. Eurajoki 1968 (1969). Geologian tutkimuskeskus, Raportti Q 19/1132/68/1/23. 8 p.

Jenkins, W.A.M., 1967. Ordovician Chitinozoa from Shropshire. Palaeontology 10, 436—488.

–, 1969. Chitinozoa from the Ordovician Viola and Fernvale limestones of the Arbuckle Mountains, Oklahoma Special Papers in Palaeontology 5. 44 p.

–, 1970. Chitinozoa from the Ordovician Sylvan Shale of the Arbuckle Mountains, Oklahoma. Paleontology, 13 (2), 261—288.

Jenkins, W.A.M. & Legault, J.A. 1979. Stratigraphic ranges of selected Chitinozoa. Palynology 3, 235—264.

Jeppson, L. 1980. Skandinavien under 570 miljoner år. (Från pol till pol, Med Sverige igenim tiden). Avdelning för Historisk Geologi och Paleontologi. Lund. 34 p.

Kaljo, D. 1984. Stratigraphy and lithofacial characteristics. Int. Geol. congr. XXVII Session, ESSR. Guidebook. Excursions 027, 028. 8—21.

Kalvacheva, R. 1986. Acritarch stratigraphy of the Ordovician system in Bulgaria. IGCP Project No. 5: Correlation of Prevarisian and Varisian Events in the Alpine Mediterranean Belts. Final Meeting, Sardinia, May 25—31, 1986. Abstracts. 38—43.

Karis, L. & Magnusson, E., 1972. Paleozoisk berggrund. Sveriges Geologiska Undersökning. SEU Ser. Af. Nr 102. Beskrivning till berggrunds geologiska kartbladet Örebro NV. 156—186.

–, 1973. Paleogoisk berggriund Sveriges Geologiska Undersökning. SEU Ser. Af. 104. Örebro SO. 42—76.

Kärkkäinen, N. 1983. Selvitys nuorten kalkkikivien etsinnästä Lounais-Suomesta kesällä 1983. Geologinen tutkimuslaitos, malmiosasto. Raportti M19/10-11/1983/1/80, 11 p.

Kielosto, S. & Kukkonen, M. (in preparation). Hangon ja Perniön kartta-alueiden maaperä. Summary: Explanation to the maps of Hanko and Perniö map sheet areas. Lehdet — sheets 2011 and 2012. Maaperäkarttojen selitykset — Explanation to the maps of Quaternary deposits. Geological Survey of Finland.

Kinnunen, K. 1979. Ore mineral inclusions in detrital quartz conatined in basal till and the glacial transport from the Ylöjärvi copper-tungsten deposit, southwestern Finland. Geol. Surv. Finland, Bull. 298, 55 p.

Kinnunen, K., Tynni, R., Hokkanen, K. & Taavitsainen, J-P. 1985. Flint raw materials of prehistoric Finland: rock types, surface textures and microfossils. Geol. Surv. Finland, Bull. 334, 59 p.

Kjellström, G. 1971a. Ordovician microplankton (Baltisphaerids) from the Grötlingbo borehole No 1 in Gotland, Sweden. Sveriges Geol. Unders. Ser C, 655, 75 p.

–, 1971b. Middle Ordovician microplankton from the Grötlingbo borehole No 1 in Gotland, Sweden. Sveriges Geol. Unders. Ser C, 669, 35 p.

–, 1972. Lower Viruan microplankton from a boring in Öland, Sweden. N. Jb. Geol. Paläont. 72, 713—719.

–, 1976. Lower Viruan (Middle Ordovician) microplankton from the Ekön borehole No 1 in Östergötland, Sweden. Sveriges Geol. Unders. Ser C, 724, 44 p.

Königsson, L.-K., 1976. Palaeozoic limestone boulders in glaciofluvial material west of the Cambro-Ordovician area in south-eastern Sweden. Geol. Fören. i Stockholm Förh. 98 (3), 286—288.

Korkutis, V., 1981. Late Precambrian and Early Cambrian in the East European platform. Precambrian Res. 15. 75—94.

Korkutis, V.A., Lapinskas, P.P. & Lashkov, E.M., 1972. Lithologiva i fatsii neftenosnych otlozhenii nizhnego paleozoya Yuzhnoi Pribaltiki. Nedra, Moscow, 179 p.

Kukkonen, E., 1969. Merenalainen harjujakso Porin edustalla. Summary: On a submarine esker in the Bothnian Sea. Geologi 21 (5), 65—69.

Kulling, O., 1926. Nya data till Ålands geologi. Den nuupptäckta östersjökalken i Lumparnfjärden. Geol. Fören. i Stockholm Förh. 48, (4), 503—509.

Kunk, M.J. & Sutter, J.F., 1984. $^{40}Ar/^{39}Ar$ Age Spectrum Dating of Biotite from Middle Ordovician Bentonites, Eastern North America. *In*: Bruton, D.L. (ed.), Aspects of the Ordovician System. Palaeont. Contr. Univ. Oslo No 295, 11—22.

Laitakari, A., 1925. Uber das jotnische Gebiet von Satakunta. Bull. Comm. géol. Finlande, 73, 43 p.

Laufeld, S., 1967. Caradocian Chitinozoa from Dalarna, Sweden. Geol. Fören. i Stockholm Förh. 89 (3), 275—349.

–, 1971. Chitinozoa and correlation of the Moldova and Restevo Beds of Podolia, U.S.S.R. Mem. Bur. Geol. Mineral. 73, 291—300.

Laurén, L., Lehtovaara, J. & Boström, R., 1978. On the geology and the Cambrian sediments of the circular depression at Söderfjärden, western Finland. Geol. Surv. Finland, Bull. 297, 1—38.

Lehtovaara, J., 1982. Paleozoic sedimentary rocks in Finland. Ann. Acad. Sci. Fennicae. Ser. A. III Geologica-Geographica. 133. 35 p.

Leskelä, S. & Niemelä, J., 1972. Hiekkakivilohkareita III Salpausselällä Salon kaakkoispuolella. Geologi 24 (5—6), 58—60.

Lindroos, P., 1977. Havainto Satakunnan hiekkakivialueen moreenistratigrafiasta. Summary: Observation on the stratigraphy in the Jotnian sandstone area in Satakunta, SW-Finland. Geologi 29 (3), 29—36.

Lindroos, P., Hyyppä, J., Stén, C.G. & Turttila, H., 1983. Rauman—Kokemäen seudun maaperä. Summary: Quaternary deposits in the Rauma Kokemäki map-sheets areas. Maaperäkarttojen selitykset — Explanation to the maps of Quaternary deposits, lehdet — sheets 1132 and 1134. Suomen geologinen kartta — Geological map of Finland, 1:100 000. Geological Survey of Finland. 71 p.

Lindström, M., 1963. Sedimentary folds and development of limestone in an early Ordovician Sea. Sedimentology 2 (3), 243—275.

–, 1979. Diagenesis of Lower Ordovician hardgrounds in Sweden. Geol. Palaeont. 13, 9—30.

Lindström, M. & Staude, H. 1971. Beitrag zur Stratigraphie der unterkambrischen Sandsteine des südlichsten Skandinaviens. Geol. Paleont. 5, 1—7.

Lister, T.R., Cocks, L.R.M. & Rushton, A.W.A., 1969. The basement beds in the Bobbing Borehole, Kent. Geol. Magaz. 106, 601—603.

Loeblich, A.R., 1970a. Dicommopalla, a new acritarch genus from Dillsboro Formation (Upper Ordovician) of Indiana, U.S.A. Phycologia 9 (1), 39—43.

–, 1970b. Morphology, Ultrastructure and Distribution of Paleozoic Acritarchs. N. Am. Paleont. Convention 1969, 705—788.

Loeblich, A.R. & Tappan, H., 1969. Acritarch excystment and surface ultrastructure with descriptions of some Ordovician taxa. Rev. Espanola Micropaleont. 1, 45—57.

–, 1971. Two New *Orthosphaeridium* (Acritarcha) from the Middle and Upper Ordovician. Trans. Am. Microscopical. Soc. 90 (2), 182—188.

Loeblich, A.R. & Tappan, H., 1978. Some Middle and Late Ordovician microphytoplankton from Central North America. J. Paleontol. 52 (6), 1233—1287.

Lonka, A. & Papunen, H., 1968. Pyrite-bearing sandstone blocks, western Finland. Bull. Geol. Soc. Finland 40, 99—106.

Magnusson, N.H., 1972a. Sveriges Geologiska Undersökningar. Ser Ae 7. Beskrivning till geologiska kartbladet Örebro NO. Kvartära bildningar. 25—72.

–, 1972b. Sveriges Geologiska Undersökningar. Ser Af. Nr. 104. Berggrundskartan Örebro SO. 1:50 000.

Männil, R. 1966. Balti basseini areng ordoviitsiumis. (Evolution of the Baltic basin during the Ordovician). Eesti NSV Teaduste Akadeemia Geologia Instituut. Tallinn. 199 p.

–, 1971. Distribution of selected Ordovician Chitinozoan assemblages and species in northern Europe and their Stratigraphic evaluation. Mem. B.R.G.M. 73, 309—311.

Manten, A.A. 1971. Silurian Reefs of Gotland. Developments in sedimentology 13. Elsevier. Amsterdam. 537 p.

Marmo, V. & Laitakari, A. 1952. Lounais-Suomen rikkikiisukonkretioista. Summary: On the pyrite-concretions of South-West Finland. Geologinen tutkimuslaitos. Geoteknillisiä julkaisuja 53. 14 p.

Martin, F., 1966a. Les Acritarches de Sart-Bernard (Ordovicien belge). Bull. Soc. Belg. Géol. 74 (1965), 423—444.

–, 1966b. Les Acritarches du sondage de la brasserie Lust, à Kortrijk (Courtrai) (Silurien belge). Bull. Soc. Belge Géol. 74 (2 & 3) (1965). 354—402.

–, 1967. Les Acritarches de parc de Neuvillesous-Huy (Silurien belge). Bull. Soc. Belg. Géol. 75 (3), 306—335.

–, 1968. Les Acritarches de l'Ordovicien et du Silurien belges. Inst. Royal. Sci. Nat. Belg. Mém. 160, 1—175.

–, 1973. Ordovicien supérieur et Silurien inférieur a Deerlijk (Belgique). Palynofacies et microfacies. Inst. Royal Sci. Nat. Belgique, Mem. 174, 71.

–, 1975. Sur quelques Chitinozoaires Ordoviciens du Quebec et de l'Ontario, Canada. Can. J. Earth Sci. 12, 1006—1018.

–, 1980. Quelques Chitinozoaires et Achritarches Ordoviciens superieurs de la Formation de White Head en Gasperie, Quebec. Can. J. Earth Sci. 17 (1), 106—119.

–, 1983. Chitinozoaires et Acritarches Ordoviciens de la Plate—forme du Saint—Laurent (Quebec et Sud-est de l'Ontario). Geol. Surv. Canada, Bull. 310, 34 p.

Martinsson, A. 1955. Die ordovizischen Geschiebe im Schärengebiet von Hangö und Ekenäs im Südwestlichen Finnland. Bull. Geol. Inst. Univ. Uppsala XXXV 2, 175—189.

–, 1956a. Neue Funde kambrischer Gänge und ordovizischer Geschiebe im südwestlichen Finnland. Bull. Geol. Inst. Univ. Uppsala XXXVI, 79—105.

–, 1956b. Kambriska sandstengångar och ordoviciska fossilförande block i Nylands skärgård. Nordenskiöld-samfundets tidskrift XVI, 89—102.

–, 1968. Cambrian palaeontology of Fennoscandian basement fissures. Lethaia 1 (2), 137—155.

–, 1974. The Cambrian of Norden. *In*: Holland, C.H. (ed.), Lower Palaeozoic Rocks of the World 2. Cambrian of the British Isles, Norden, and Spitsbergen. 185—283.

Matisto, A., 1973. Satakunnan kallioperästä. Satakunnan geologia, Pori. Satakunnan Seutukaavaliitto. Sarja A (79), 1—5.

Merenkulkuhallituksen merikarttaosasto, 1981. Veneilykartta Hanko — Paraistenportti. Sarja C. 1:50 000.

–, 1986. Veneilykartta Paraistenportti — Utö — Uusikaupunki. Sarja D. 1:50000.

–, 1987. Veneilykartta Selkämeri. Uusikaupunki — Kaskinen. Sarja E. 1:50 000.

Merrill, G.K., 1979. Ordovician conodonts from the Åland Islands, Finland, Geol. Fören. i Stockholm Förh. 101, 329—341.

Metzger, A.A.T., 1922. Beiträge zur Paläontologie des nordbaltischen Silurs im Ålands-gebiet. Buli. Comm. géol. Finlande 56. 1—8.

Miller, M.A. & Eames, L.E., 1982. Palynomorphs from the Silurian Medina Group (Lower Llandovery) of the Niagara Gorge, Lewiston, New York, U.S.A. Palynology 6. 221—254.

Moreau-Benoit, A., 1967. Quelques Microplanctotes du Dévonien interieur de l'Anjou. Rev. Micropaléont. 10. 200—208.

–, 1974. Recherches de palynologie et de planctologie sur le Dévonien et quelques formations siluriennes dans le Sud-Est du Massif Amoricain. Thesis Univ. Paris 1, 1—226.

Niemelä, J., Ikonen, L. & Kinnunen, K., 1985. Kambri-ordovikikauden sedimenttikiviä Kattiluodon hiidenkirnussa. Summary: Pebbles of Cambro-Ordovician sedimentary rocks in potholes of Kattiluoto, SW-Finland. Geologi 37 (9—10), 169—175.

Niemelä, J. (ed), Sten, C.-G., Taka, M. & Winterhalter, B., 1987. Turun-Salon seudun maaperä. Summary: Quaternary deposits in the Turku-Salo map-sheet areas. Maaperäkarttojen selitykset — Explanation to the maps of Quaternary deposits. Suomen Geologinen kartta Geological map of Finland, 1:100 000. Lehdet — sheets 1043 and 2021. Geological Survey of Finland. 83 p.

Nolvak, J., 1980. Chitinozoans in biostratigraphy of the northern East Baltic Ashgillian. A preliminary report. Acta Palaeont. Polonica 25 (2), 253—260.

Nolvak, J., (in preparation). Ordovician — Silurian Chitinozoan from Rapla borehole, Estonian S.S.R. Geol. Surv. Finland Spec. Paper.

Öpik, A., 1931. Uber einige karbonatgesteine im glazialgeschiebe NW-Estlands. Tartu Ülikooli Geol. Inst. Toimetused. 25. 16 p.

–, 1956. Cambrian (Lower Cambrian) of Estonia. XX Congr. Geol. Int. México, Tomo I, Parte I, 97—126.

Orviku, K., 1929. Uhaku. Kirde-Eesti karstiala stratigraafiast ja geomorfoloogiast. Referat: Der Uhaku. Zur Stratigraphie und Geomorphologie des NO-estnischen Kartgebietes. Tartu Ülikooli Geoloogia-instituudi Toimetused. 14. 36 p.

Overweel, C.J., 1977. Distribution and transport of Fennoscandian indicators. Scripta Geologica 43, 117 p.

Paris, F., 1979. Les Chitinozoaires de la Formation de Lourdeo, Ordovicien superieur du synclinal de Bucaco (Portugal). Palaeontographica, A. 164. 24—51.

–, 1981. Les Chitinozoaires dans le paleozoique du sud-ouest de l'Europe. Mem. Soc. Geol. mineral. Bretagne. 26, 412.

Paris, F. & Deunff, J., 1970. Le paléoplancton llanvirnien de la Roche-au-Merle. Bull. Soc. Geol. Min. Bretagne, C. 2 (1), 25—43.

Persson, Ch., 1973. Förekomst av kambrisk sandsten, alanskiffer och ordovicisk kalksten i isälvsmaterial sydost om Hjälmaren. Sveriges Geol. Unders. Ser. C. 693, 17 p.

Perttunen, M., 1977. The litologic relation between till and bedrock in the region of Hämeenlinna, southern Finland. Geol. Surv. Finland, Bull. 291. 68 p.

Perttunen, M., Lappalainen, E., Taka, M. & Herola, E., 1984. Vehmaan, Mynämäen, Uudenkaupungin ja Yläneen kartta-alueiden maaperä. Summary: Quaternary deposits in the Vehmaa, Mynämäki, Uusikaupunki and Yläne mapsheets areas. Maaperäkarttojen selitykset. — Explanation to the maps of Quaternary deposits. Lehdet — sheets 1042, 1044, 1131 and 1133. Geological Survey of Finland. 51 p.

Playford, G. & Martin, F., 1984. Ordovician acritarchs from the Canning Basin, Western Australia. Alcheringa 8, 187—223.

Podhalanska, T., 1979. The correlative signifciance of the Chitinozoa-bearing horizon in the Caradocian profiles of the Leba region (NW Poland). Acta Geol. Pol. 29 (4), 443—448.

Pölma, L., 1972. Skeletal debris content and composition in the sediments of the northern facial belt of the east Baltic Ordovician (Rapla boring) (in Russian). Eesti NSV Teaduste Akadeemia Toimetised. 21. Köide Keemia Geoloogia 4, 326—332.

Puranen, R., 1988. Modelling of glacial transport of basal tills in Finland. Geological Survey of Finland. Rep. Invest. 81, 36 p.

Rauscher, R., 1973. Recherches micropaléontologiques et stratigraphiques dans l'Ordovicien et le Silurien en France. Etude des acritarches, des chitinozoaires et des spores. Sci. Géol. Mém. 38, 1—224.

Rauscher, R. & Doubinger, J., 1967. Les Chitinozoares des shistes à Calymène (Llanvirnien) de Normandie. 92e Congr. Natl. Soc. Savantes, Strasbourg et Colmar, 1967, 471—484.

Robardet, M., Henry, J.L., Nion, J., Paris, F. & Pillet, J., 1972. La Formation du Pont-de-Caen (Caradocien) dans les synclinaux de Domfront et de Sées (Normandie). Ann. Soc. Geol. Nord. XCII, 3, 117—137.

Röömusoks, A., 1960. Stratigraphy and paleogeography of the Ordovician in Estonia. Int. Geol. Congr. Rep. 21 Session, Norden 1960, Part VII, Proc. Sec. 7, Ordovician and Silurian Stratigraphy and correlations, 58—69.

Rudberg, S., 1954. Västerbottens berggrundmorfologi. Ett försök till rekonstruktion av preglaciala erosionsgenerationer i Sverige, Geographica 25, Uppsala universitet. 457 p.

Salonen, V-P., 1986. Glacial transport distance distributions of surface boulders in Finland. Geol. Surv. Finland, Bull. 338, 57 p.

Sarjeant, W.S.A., 1984. A Restudy of some Dinoflagellate Cyst Holotypes in the University of Kiel Collections. V. The Danian (Palaeocene) Holotypes of WALTER WETZEL (1952, 1955). Meyniana 36. 121—171.

Sauramo, M., 1916. Uber das Vorkommen von Sandstein in Karstula, Finnland. Fennia 39 (7), 13 p.

Schmidt, Fr., 1881. Revision der ostbaltischen silurischen Trilobiten nebst geogronostischer übersicht des ostbaltischen Silurgebietes. Mém. Acad. Impér. Sci. St.-Petersbourgh 7 (30) 1. 514—536.

Schulz, G., 1967. Mikrofossilien des oberen Llandovery von Dalarne (Schweden). Sonderveröff. Geol. Inst. Univ. Köln 13, 175—187.

Sederholm, J.J., 1903. Vuorilajikartta — Bergartskarta. Lehti — Sektionen B 2, Tampere. Geologisk ofversiktskarta öfver Finland, 1:4 000 000.

–, (1910). Les Roches Préquaternaires de la Fennoscandia. Bull. Comm. géol. Finlande 24, 39 p.

–, 1913. Weitere Mittelungen über Bruchspalten mit besonderer Beziehung zur Geomorphologie von Fennoscandia. Bull. Comm. géol. Finlande 37, 66 p.

Simonen, A., 1980. Suomen kallioperä 1:1000 000. Prequaternary rocks of Finland 1:1000 000. Geological Survey of Finland.

Simonen, A. & Kouvo, O., 1955. Sandstones in Finland. Bull. Comm. géol. Finlande 168, 57—87.

Spjeldnaes, N., 1960. Ordovician climatic zones. Norsk Geol. Tidskrift 41 (1), 45—77.

Staplin, F., 1961. Reef-controlled distribution of Devonian Microplankton in Alberta. Palaeontology 4 (3). 392—424.

Staplin, F.L., Janssonius, J. & Pockock, S.A.J., 1965. Evaluation of some Acritarhons Hystrichosphere Genera. N. Jb. Geol. Paläont. Abh. 123, 167—201.

Stockmans, F. & Willière, Y., 1963. Les hystrichosphères ou mieux les Acritarches du Silurien belge. Sondage de la Brasserie Lust à Courtrai (Kortrijk). Bull. Soc. belge Géol. 71, 450—481.

Tappan, H. & Loeblich, A.R., 1971. Surface sculpture of the wall in Lower Paleozoic acritarchs. Micropaleontology 17. 385—410.

Tarvydas, R., 1960. Kristallitseskie valuny poslednogo i predposlednego d olednenij na territorii Litovskoj SSR. Sb. statei dlja XXI sessii mezdunar. Geol. Kongr. Vilnjus 1960. 215—225.

Thorslund, P., 1960. The Cambro-Silurian. *In*: Hesslund, I. (ed.), Description to accompany the map of the pre-Quaternary rocks of Sweden, 69—110.

Thorslund, P. & Axberg, S., 1979. Geology of the Southern Bothnian Sea. Part 1. Bull. Geol. Inst. Univ. Uppsala. N.S. 8, 36—48.

Thusu, B., 1973. Acritarchs of the Middle Silurian Rochester Formation of Southern Ontario. Paleontology 16. 799—826.

Tikkanen, M., 1977. Etelä-Satakunnan kallioperästä. Bedrock of Southern Satakunta, Western Finland. Terra 89 (2), 80—89.

Tikkanen, M., 1981. Georelief, its origin and development in the coastal area between Pori and Uusikaupunki, southwestern Finland. Fennia 159 (2), 253—333.

Tjernvik, T.E. & Johansson, J.V., 1980. Description of the upper portion of the drill-core from Finngrundet in the South Bothnian Bay. Bull. Geol. Inst. Univ. Uppsala N.S. 8, 173—204.

Tuominen, H.V., Aarnisalo, J. & Söderholm, B., 1973. Tectonic patterns in the Central Baltic Shield. Bull. Geol. Soc. Finland. 45 (2), 205—217.

Turner, R.E., 1984. Acritarchs from the type area of the Ordovician Caradoc Series, Shropshire, England. Palaeontographica B. 190 (4—6), 87—157.

Tynni, R., 1975. Oreovician hystrichospheres and chitinozoans in limestone from the Bothnian Sea. Geol. Surv. Finland, Bull. 279, 59 p.

–, 1978. Lower Cambrian fossils and acritarchs in the sedimentary rocks on Söderfjärden, Western Finland. Geol. Surv. Finland, Bull. 297, 39—81.

–, 1981. Suomen sedimenttikivien fossiili- ja akritarktyypit. Helsingin yliopisto, Geologian laitos, Geologian ja paleontologian osasto. Moniste 4. 54 p.

–, 1982a. New results of studies on the fossils in the Lower Cambrian sediment deposits of Söderfjärden. Bull. Geol. Soc. Finland 54 (1—2), 57—68.

–, 1982b. Paleozoic microfossils on clastic dykes on the Åland Islands and in the core samples of Lumparn. Geol. Surv. Finland, Bull. 317, 35—132.

Tynni, R. & Hokkanen, K., 1982. Annelidien ryömimisjälkiä Lauhavuoren hiekkakivessä. Summary: Traces of crawling by annelids in Lauhavuori sandstone. Geologi 34 (7), 129—134.

Umnova, N.I., 1969. Distribution of Chitinozoa in the Ordovician of the Russian Platform. Paleont. Zhurnal 3 (3), 326—340.

–, 1975. Ordovician and Silurian acritarchs of the Moscow Basin and the Prebaltic. Izd. "Nedra". Moscow. 1—167.

Uutela, A. & Tynni, R. (in preparation). Ordovician — Silurian acritarchs from Rapla borehole, Estonian S.S.R. Geol. Surv. of Finland, Spec. Paper.

Vavrdova, M., 1972. Acritarchs from Klabava Shales (Arenig). Vestnik Ü.Ü.G. 47. 74—86.

Veltheim, V., 1962. On the pre—Quaternary geology of the bottom of the Bothnian Sea. Bull. Comm. géol. Finlande 200, 166 p.

Virkkala, K., 1958. Stone counts in the esker of Hämeenlinna, Southern Finland. Bull. Comm. géol. Finlande 180. 87—103.

Vuorela, P., 1982. Crustal fractures indicated by lineament density, Finland. The Photogrammetric Journal of Finland. 9 (1), 21—37.

Vuorinen, J.H.T., 1982. Piikivi ja Suomen kampakeraaminen piikauppa. Helsingin yliopiston arkeologian laitos. Moniste 30. 114 p.

Wall, D., 1965. Microplancton, pollen and spores from the Lower Jurassic in Britain. Micropaleontology 11, 151—190.

Wetzel, W., 1967. Characteristik des marinen Planktons im untersten Ordovizium (B3). Geschiebe-Sammler, 2. 35—50.

Wiik, F.J. (1878). Bidrag till Ålands geologi. Öfv. av finska vet. soc. förh. 20, 40—63.

Wiman, C., 1893. Ueber das Silurgebiet des Bottnischen Meeres I. Bull. Geol. Inst. Univ. Uppsala I (1), 65—75.

–, 1905. Studien über das Nordbaltische Silurgebiet I. Bull. Geol. Inst. Univ. Uppsala VI (1902—1903), 12—76.

–, 1908. Studien über das Nordbaltische Silurgebiet II. Bull. Geol. Inst. Univ. Uppsala VIII (1906—1907), 73—168.

Winterhalter, B., 1967. The Sylen and Solovjeva shoals as observed by a diving geologist. Geol. Fören. i Stockholm Förh. 89, 205—217.

–, 1972. On the geology of the Bothnian Sea, an apeiric sea that has undergone Pleistocene glaciation. Geol. Surv. Finland, Bull. 258, 66 p.

–, 1982. The bedrock Geology of Lumparn Bay, Åland. Geol. Surv. Finland, Bull. 317, 115—130.

Winterhalter, B., Flodén, T., Ignatius, H., Axberg, S. & Niemistö, L., 1981. Geology of the Baltic Sea. *In*:Voipio, A. (ed.), The Baltic Sea. Elsevier Oceanography Series 30, 1—121.

Zandstra, J.G., 1983. A new subdivision of crystalline Fennoscandian erratic pebble assemblages (Saalian) in the central Netherlands. Geol. Mijnbouw 62, 455—469.

Plate I

1. *Aremoricanium* sp., prep. 712, 2. *Axisphaeridium tricolumnelare* n. sp., prep. 715, 3. *Baltisphaeridium brevifilicum*, prep. 715, 4. *B. brevispinosum*, prep. 712, 5. *B. clavicinctum*, prep. 701, 6. *B.* cf. *B. constrictum*, prep. 715, 7. *B. filosum*, prep. 652, 8. *B. hamatum*, prep. 715. Bar is 10 μ.

Plate II

9. *B. hirsutoides*, prep. 648, 10. *B. latiradiatum*, prep. 701, 11. *B. longispinosum longispinosum*, prep. 701, 12. *B. microspinosum*, prep. 654, 13. *B.* cf. *B. multiechinatum*, prep. 712, 14. *B. multipilosum*, prep. 654, 15. *B. nanninum*, prep. 654, 16. *B. pachyacanthum*, prep. 706, 17. *B. pauciverrucosum*, prep. 704. Bar. is 10 μ.

Plate III

18. *B. podboroviscensis* ?, prep. 712, 19. *B. pseudocalicispinum*, prep. 654, 20. *B. verrucatum*?, prep. 654, 21. B. sp. 1., prep. 712, 22. *B.* sp. 2., prep. 715, 23. *Buedingiisphaeridium* sp., prep. 652, 24. *Comasphaeridium varispinosum* n. sp., prep. 715, 25. *Cymatiosphaera pavimenta*, prep. 652, 26. *C.* cf. *C. striata*, prep. 648. Bar is 10 μ.

Plate IV

27. *Dicommopalla macadamii*, prep. 697, 28. *Dictyosphaeridium sp.*, prep. 648, 29. *Dicyotidium dictyotum*, prep. 655, 30. *D. polygonium*, prep. 655, 31. *D. reticulatum*, prep. 663, 32. *D. stenodictyotum*, prep. 663, 33. *Goniosphaeridium mochtiensis*, prep. 648, 34. *G. polygonale*, prep. 663, 35. G. cf, *G. polygonale polyacanthum*, prep. 648. Bar is 10 μ.

Plate V

36. *G. splendens*, prep. 712, 37. *Hapsidopalla* sp., prep. 715, 38. *Helosphaeridium* sp., prep. 655, 39. *Kundasphaera* sp., prep. 654, 40. *Leiofusa granulacutis*, prep. 652, 41. *L. granulacutis* f. *quincunx*, n. f., prep. 715, 42. *Leiosphaeridia* sp., prep. 663, 43. *Leiosphaeridia* ssp., prep. 704, 44. *Leiovalia ovalis*, prep. 697. Bar is 10 μ.

Plate VI

45. *L. similis*, prep. 697, 46. *Lophosphaeridium citrinipeltatum*, prep. 648, 47. *L. papillatum*, prep. 654, 48. *L. pilosum*, prep. 685, 49. *Micrhystridium henryi*, prep. 715, 50. *M. inconspicuum aremoricanium*, prep. 655, 51. *M. nannacanthum*, prep. 648, 52. *M. robustum*, prep. 715, 53. *M. stellatum*, prep. 648. Bar is 10 μ.

Plate VII

54. *Multiplicisphaeridium alloteaui*, prep. 648, 55. *M. bifurcatum*, prep. 704, 56. *M. irregulare*, prep. 654, 57. *M. radicosum*, prep. 718, 58. *M. ramusculosum ramusculosum*, prep. 652, 59. *M. raspa*, prep. 704, 60. *M.* sp. 1., prep. 652, 61. *M.* sp. 2., prep. 655, 62. *Nanocyclopia* sp., prep. 652. Bar is 10 μ.

Plate VIII

63. *Nodusosphaeridium rubus* n. sp., prep. 712, 64. *Orthosphaeridium densiverrucosum*, prep. 648, 65. *O. insculptum*, prep. 654, 66. *O. vibrissiferum*, prep. 648, 67. *Peteinosphaeridium heteromorphicum*, prep. 713, 68. *P. micranthum*, prep. 712, 69. *P. nanofurcatum*, prep. 712, 70. *P. nudum*, prep. 715, 71. *P. parvispinosum* n. sp., prep. 648. Bar is 10 μ.

Plate IX

72. *P. paucifurcatum*, prep. 715, 73. *P. trifurcatum*?, prep. 701, 74. *P. trifurcatum longiradiatum*, prep. 696, 75. *Pheoclosterium* sp. 1., prep. 654, 76. *P.* sp. 2., prep. 654, 77. *Pirea* sp., prep. 654, 78. *Polyancistrodorus* cf. *P. columbariferus*, prep. 715, 79. *P. intricatus*, prep. 654, 80. *Priscogalea perforata* n. sp., prep. 654. Bar is 10 μ.

Plate X

81. *Pterospermopsis* sp., prep. 703, 82. *Raplasphaera* sp., prep. 654, 83. *Rhopaliophora foliatilis*, prep. 654, 84. *R. palmata*, prep. 654, 85. *R. pilata*, prep. 654, 86. *Stelliferidium modesta*, prep. 652, 87. *Tasmanites* cf. *T. verrucosus*, prep. 652, 88. *Timofeevia* sp. 1., prep. 652, 89. *T.* sp. 2., prep. 654. Bar is 10 μ.

Plate XI

90. *Tranvikium polygonale*, prep. 648, 91. *Veryhachium geometricum*, prep. 654, 92. *V. irroratum*, prep. 648, 93. *V. lairdi*, prep. 685, 94. *V. oklahomense*, prep. 663, 95. *V. oligospinosum*, prep. 706, 96. *V. reductum*, prep. 654, 97. *V. rhombispinosum*, prep. 654, 98. *V. trispinosum*, prep. 701, 99. *V. trisulcum*, prep. 701. Bar is 10 μ.

Plate XII

100. *Conochitina cactacea*, prep. 703, 101. *C. conulus*, prep. 648, 102. *C. cucumis*, prep. 711, 103. *C. elegans*, prep. 696, 104. *C. micracantha*, prep. 648, 105. *C. minnesotensis*, prep. 652, 106. *C. primitiva*, prep. 652, 107. *C. wesenbergensis*, prep. 652, 108. *Cyathochitina campanulaeformis*, prep. 654, 109. *C. kuckersiana*, prep. 654. Bar is 10 μ. Doublebar is 100 μ.

Plate XIII

110. *C. latipatagium*, prep. 696, 111. *Desmochitina amphorea*, prep. 652, 112. *D. cocca*, prep. 715, 113. *D. minor*, prep. 648, 114. *D.* cf. *D. ovulum*, prep. 648, 115. *D. papilla*?, prep. 648, 116. *Eisenachitina oelandica*, prep. 654, 117. *Lagenochitina baltica*, prep. 701, 118. *Rhabdochitina gracilis*, prep. 652. Bar is 10 μ. Doublebar is 10 μ.

Plate I

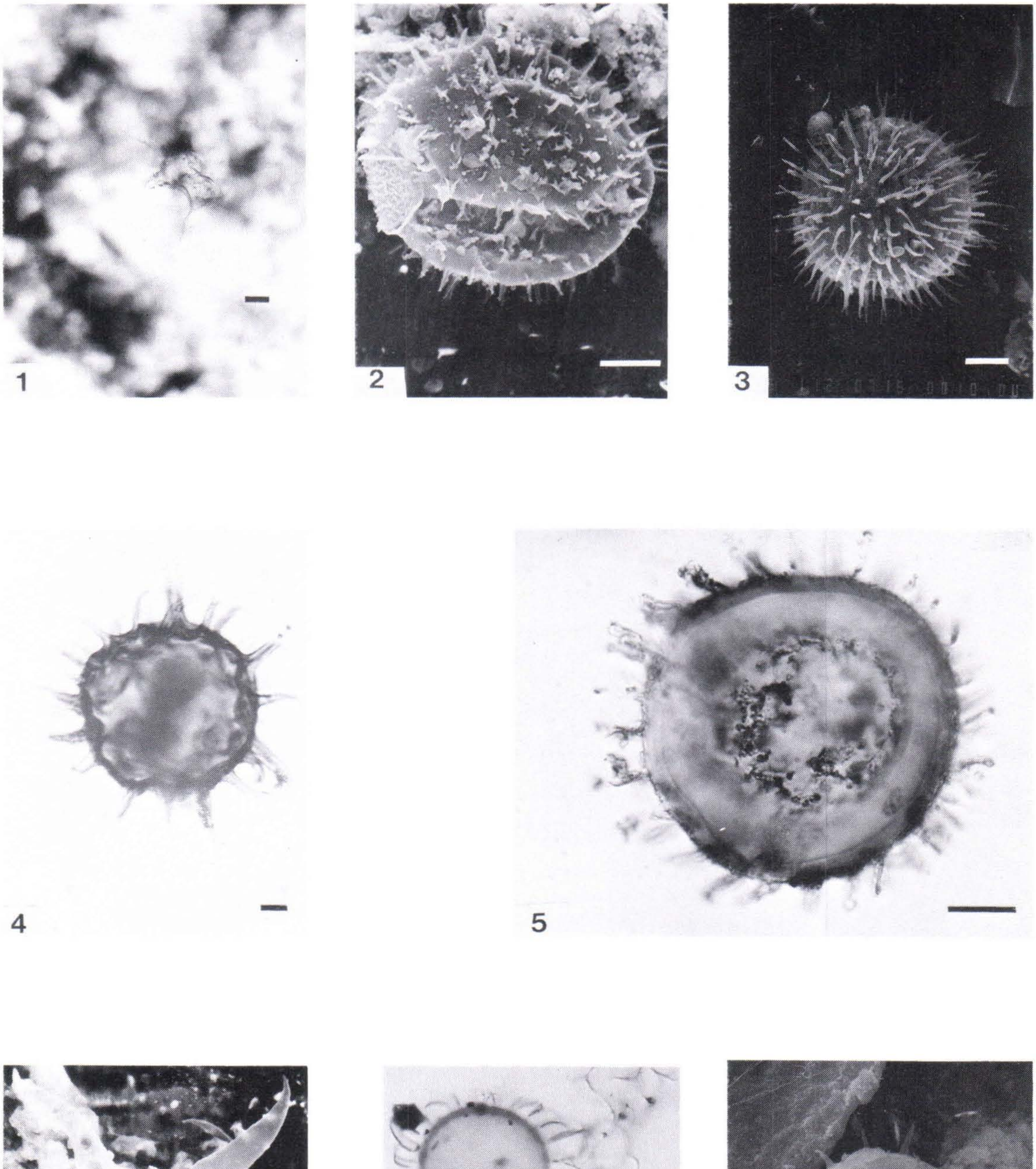


Plate II

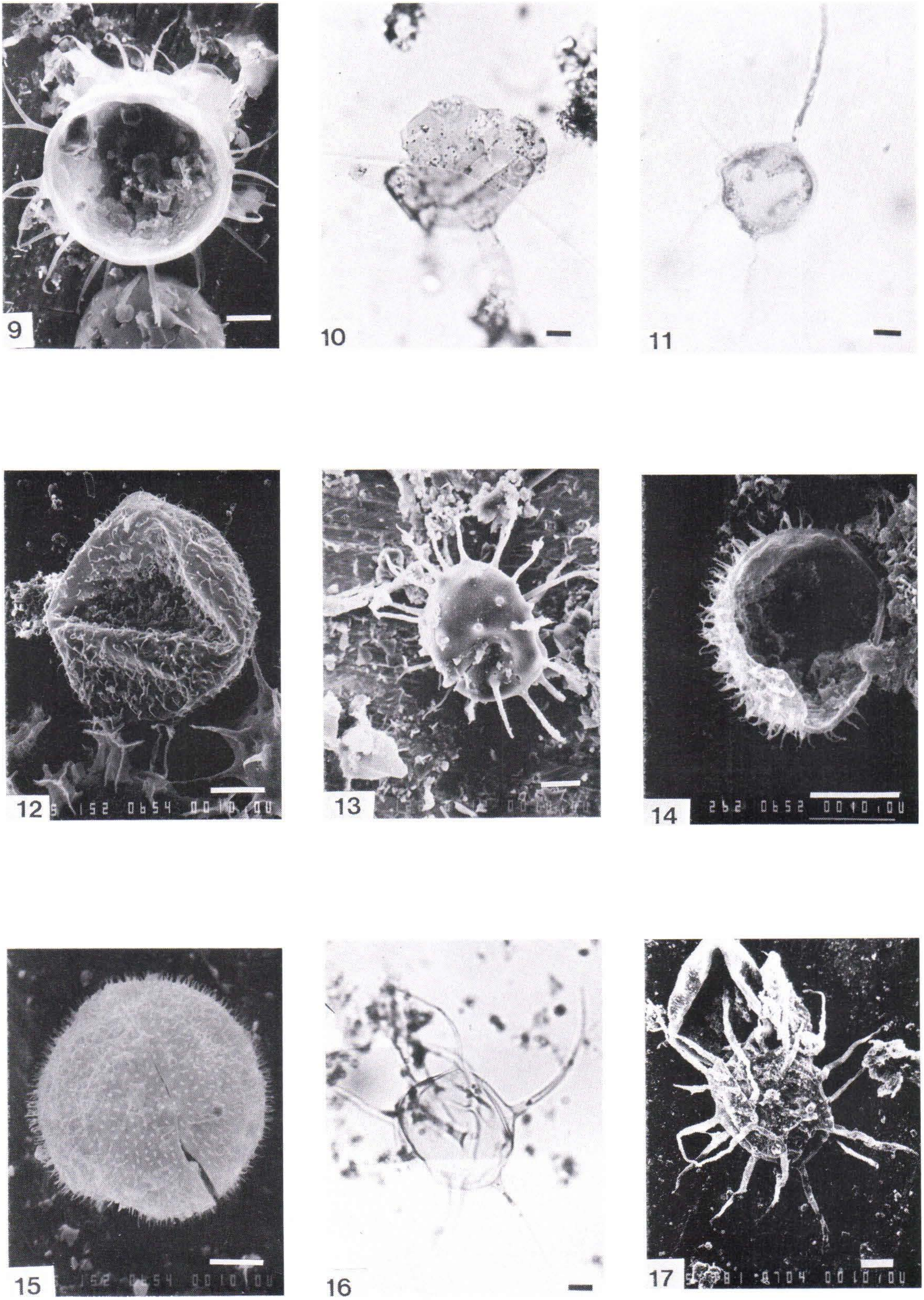


Plate III

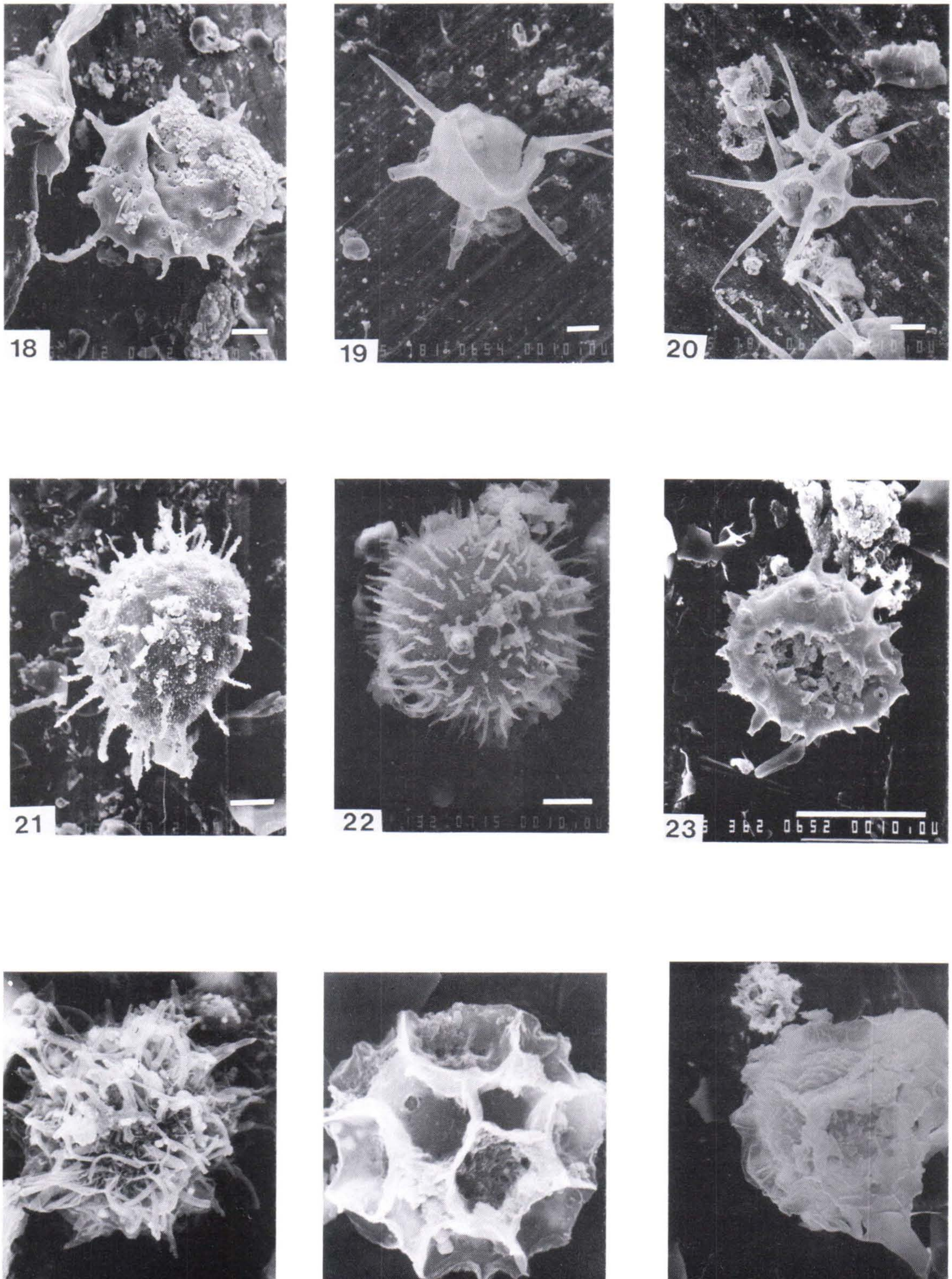


Plate IV

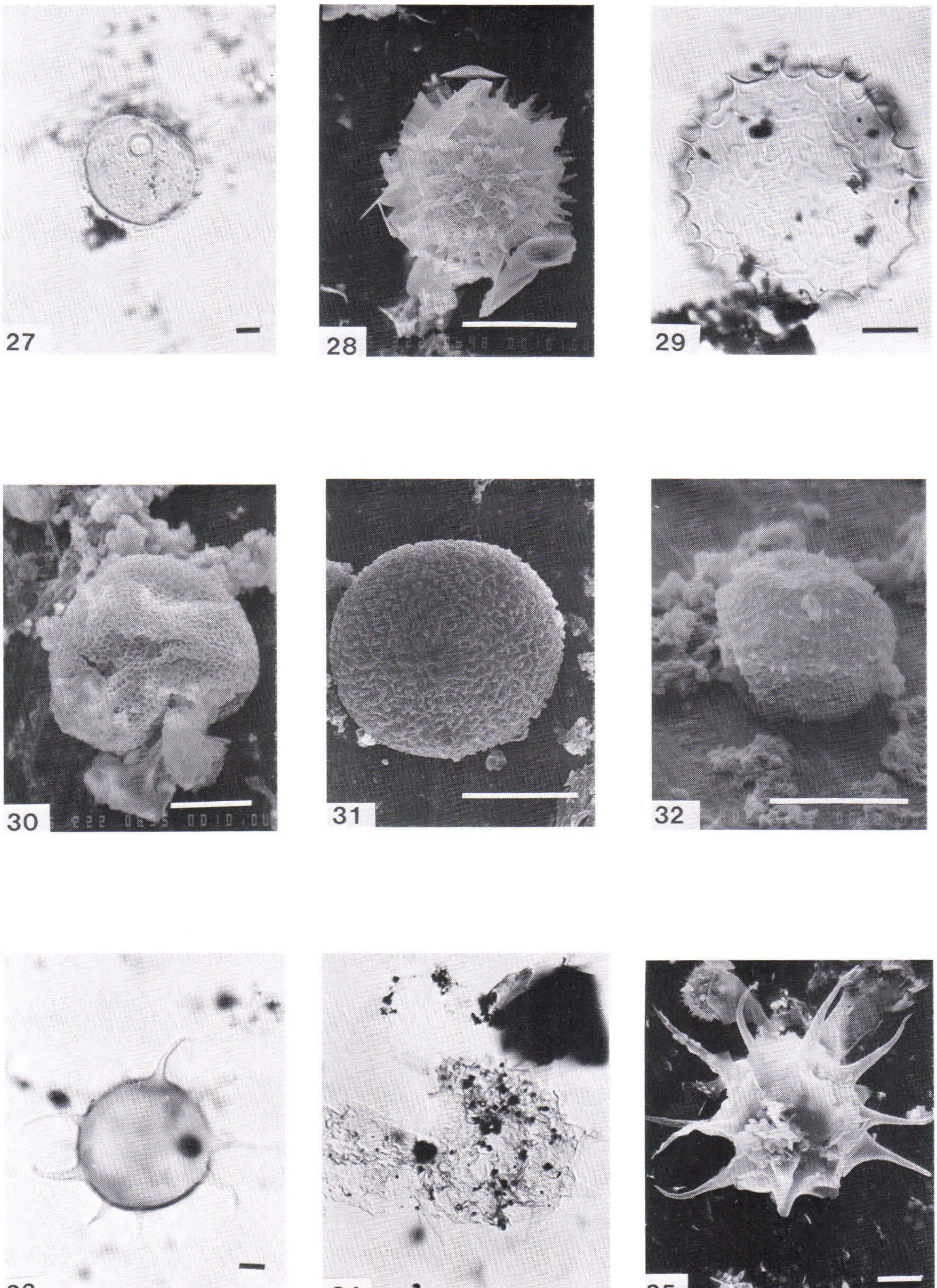


Plate V

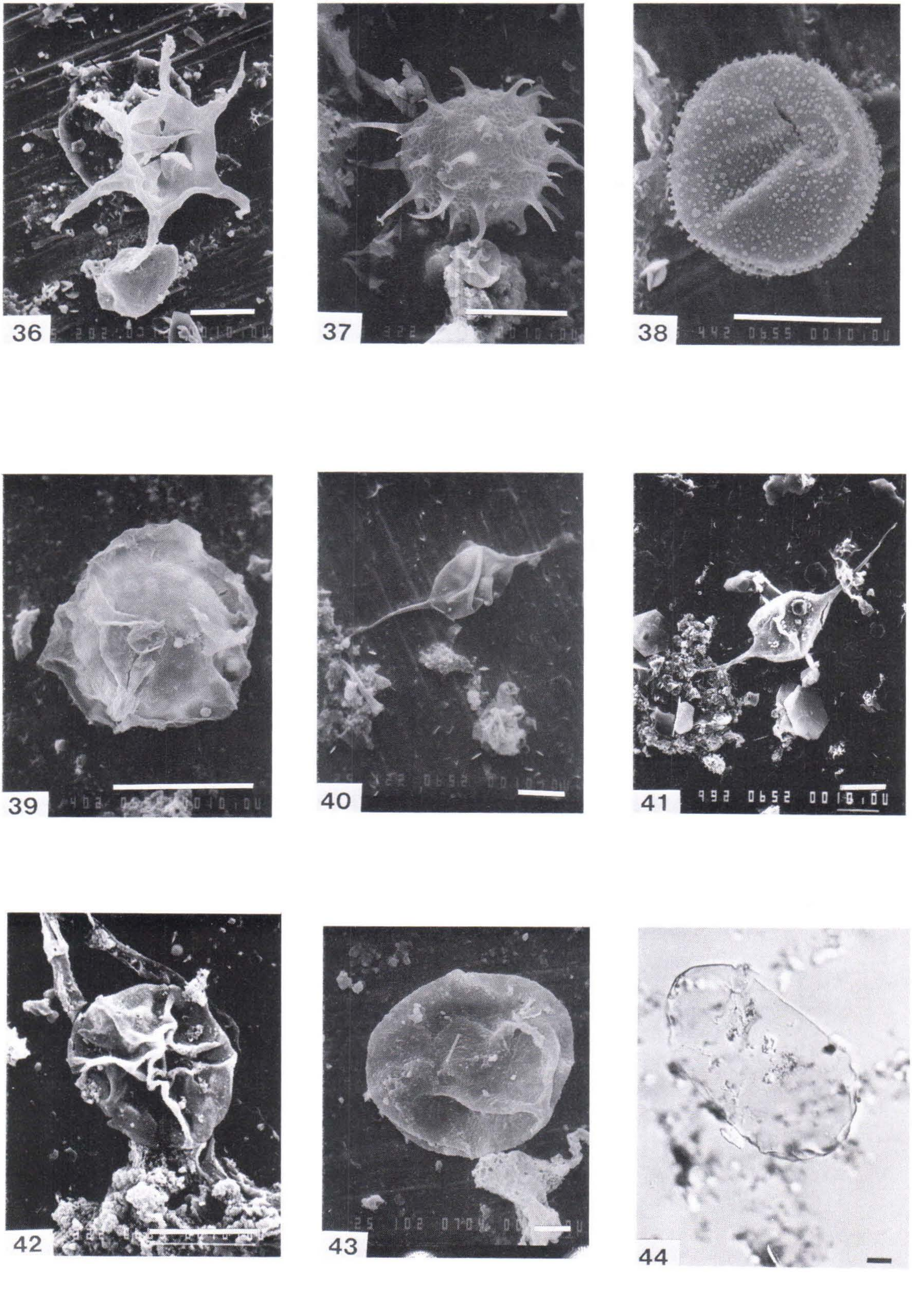


Plate VI

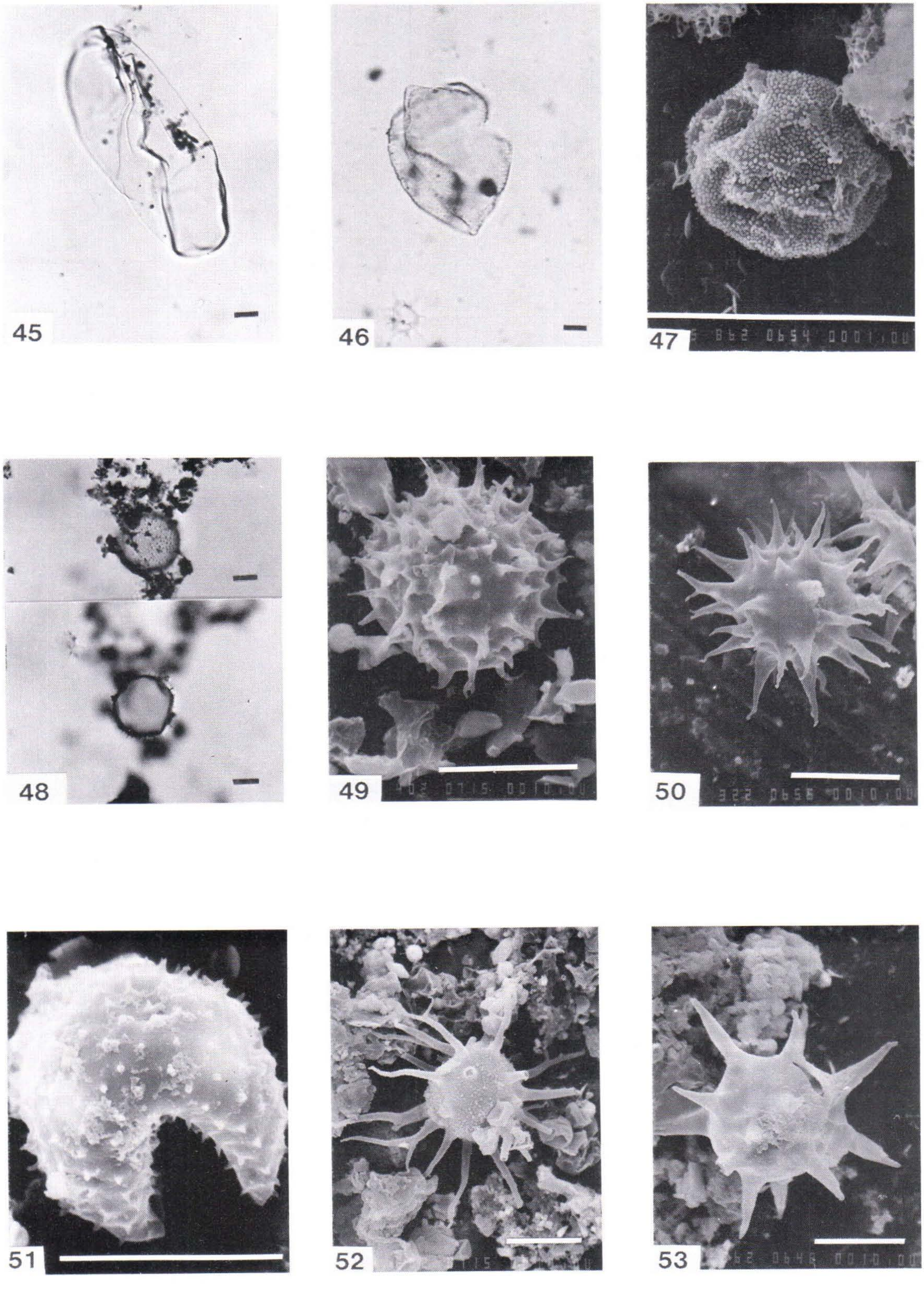
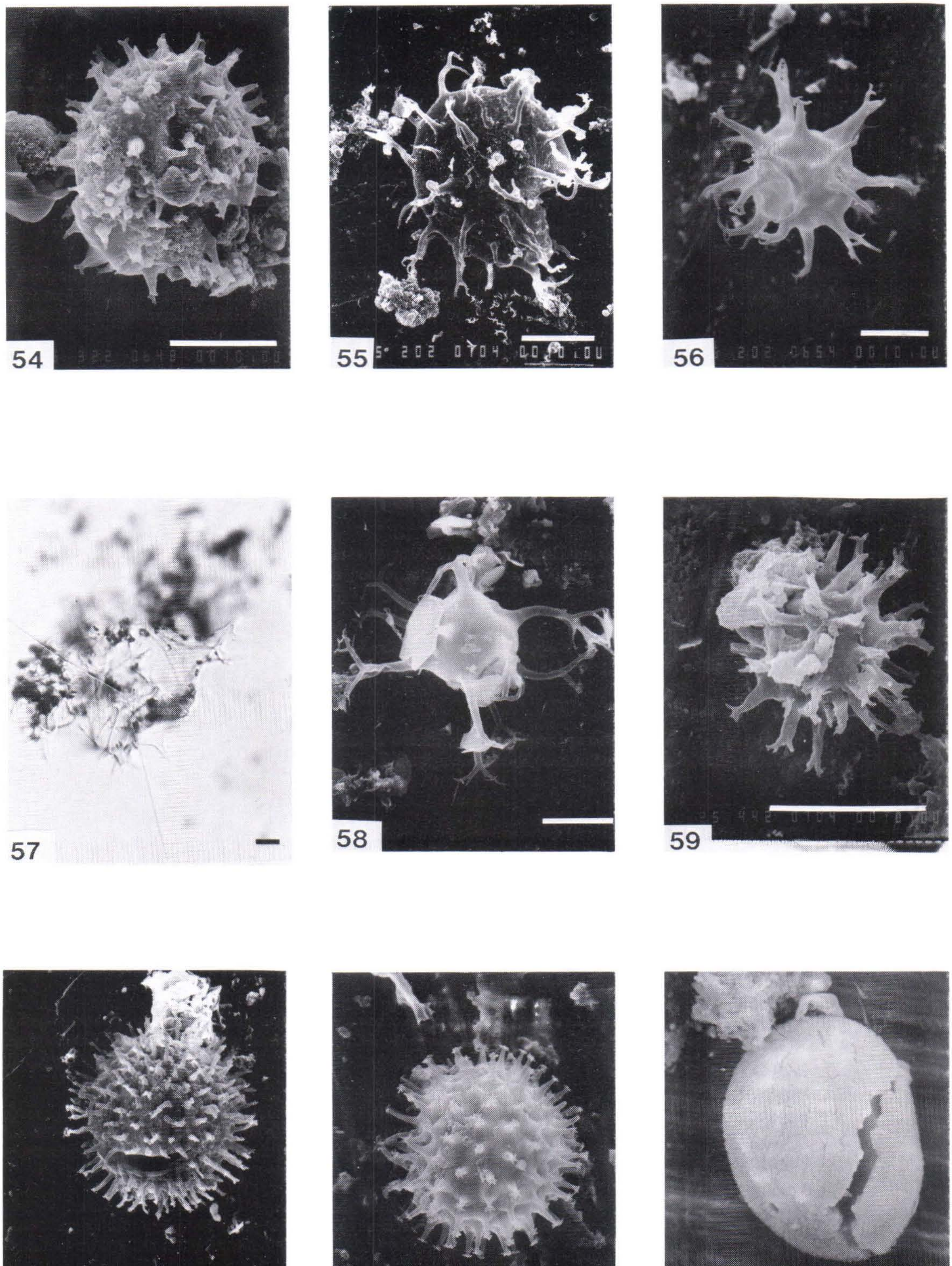


Plate VII



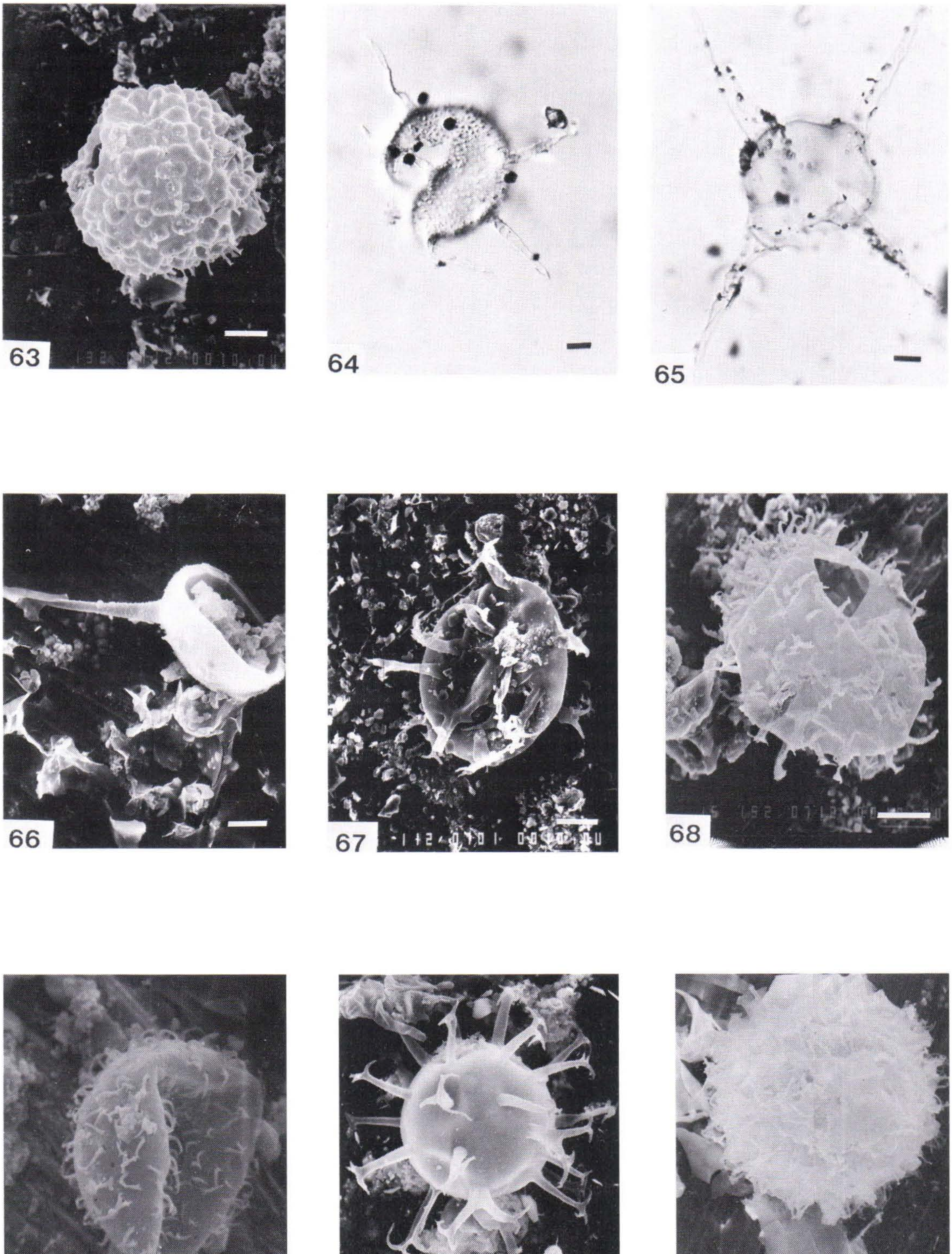

63
64
65
66
67
68
69
70
71

Plate IX

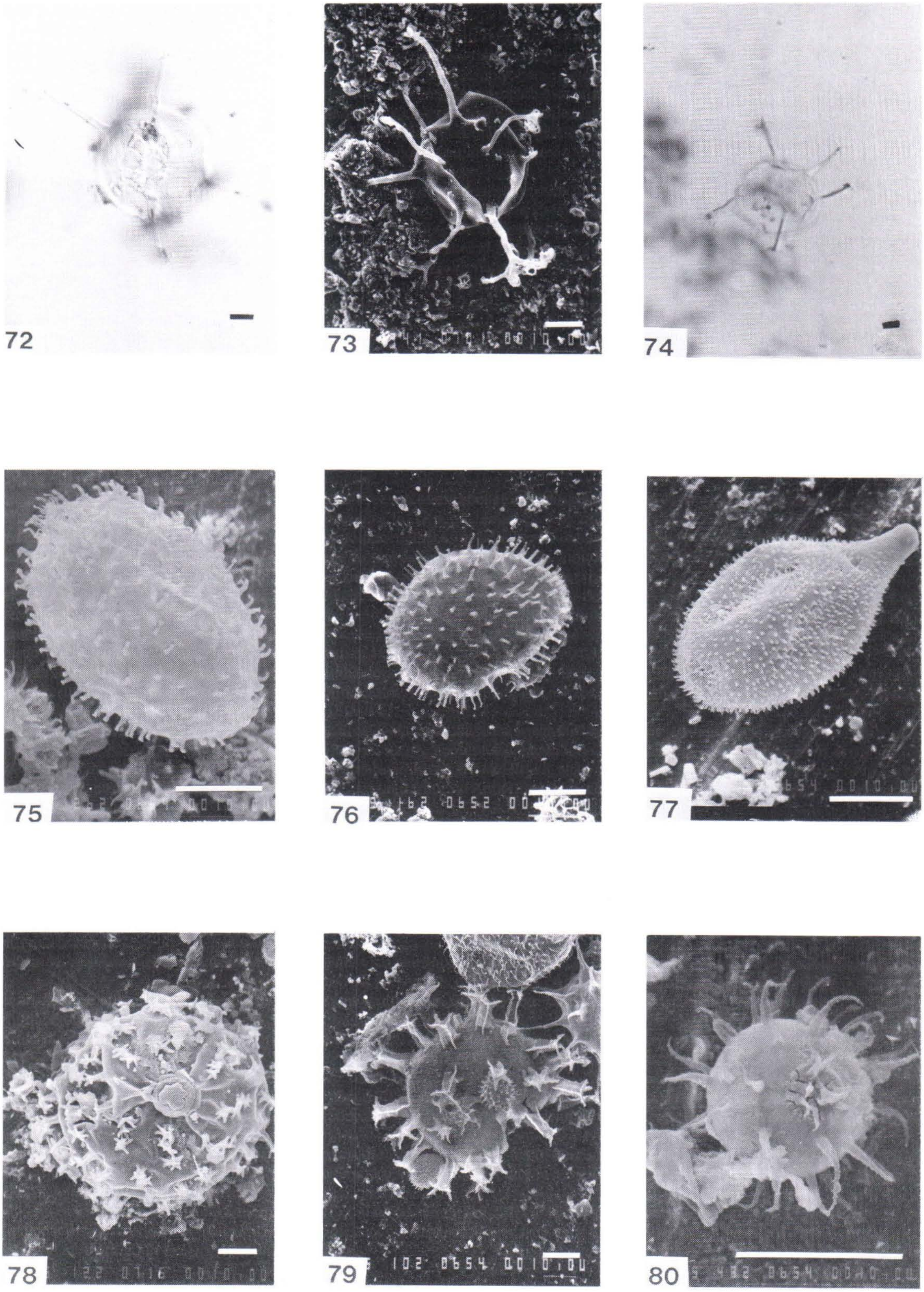


Plate X

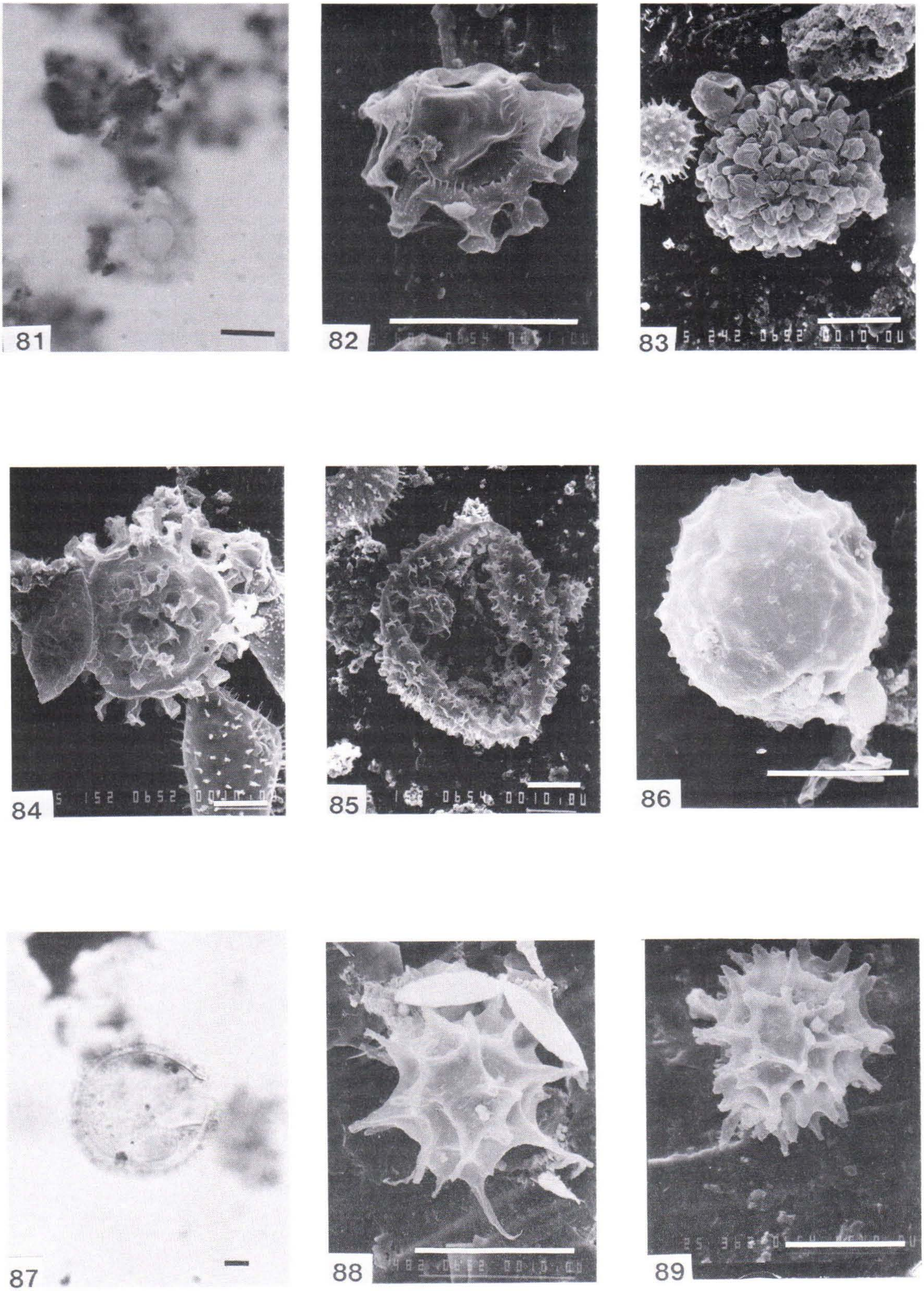
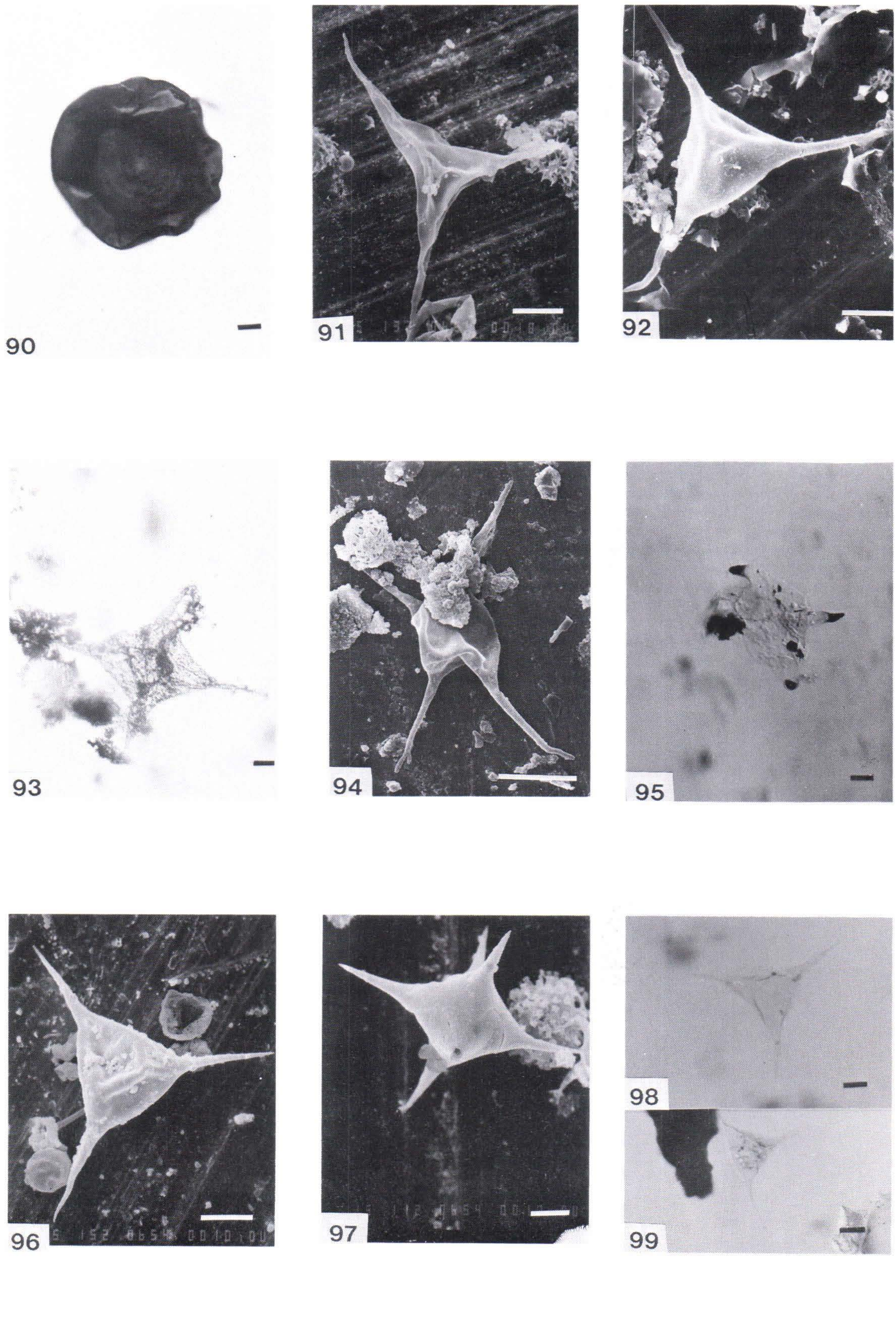


Plate XI



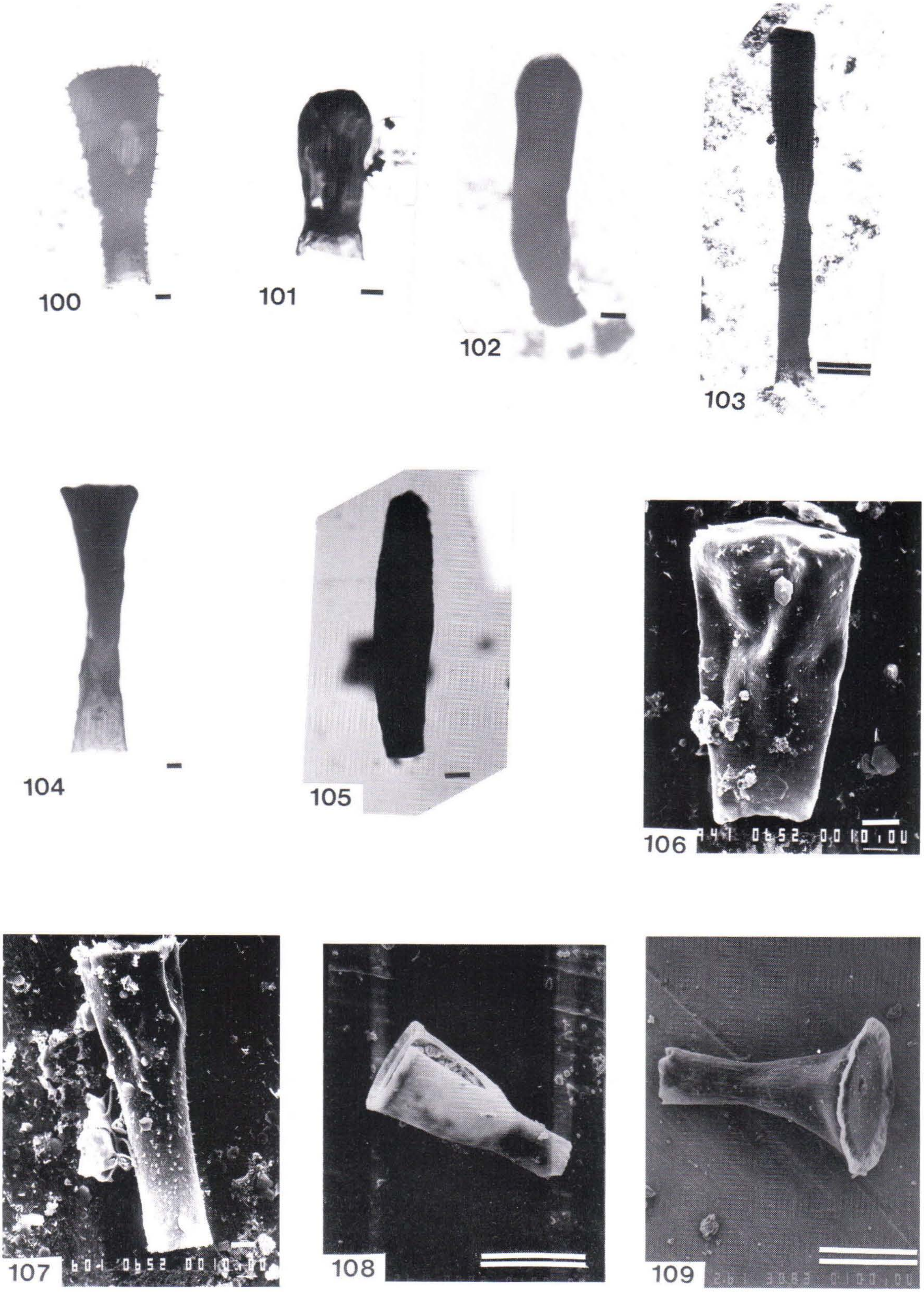
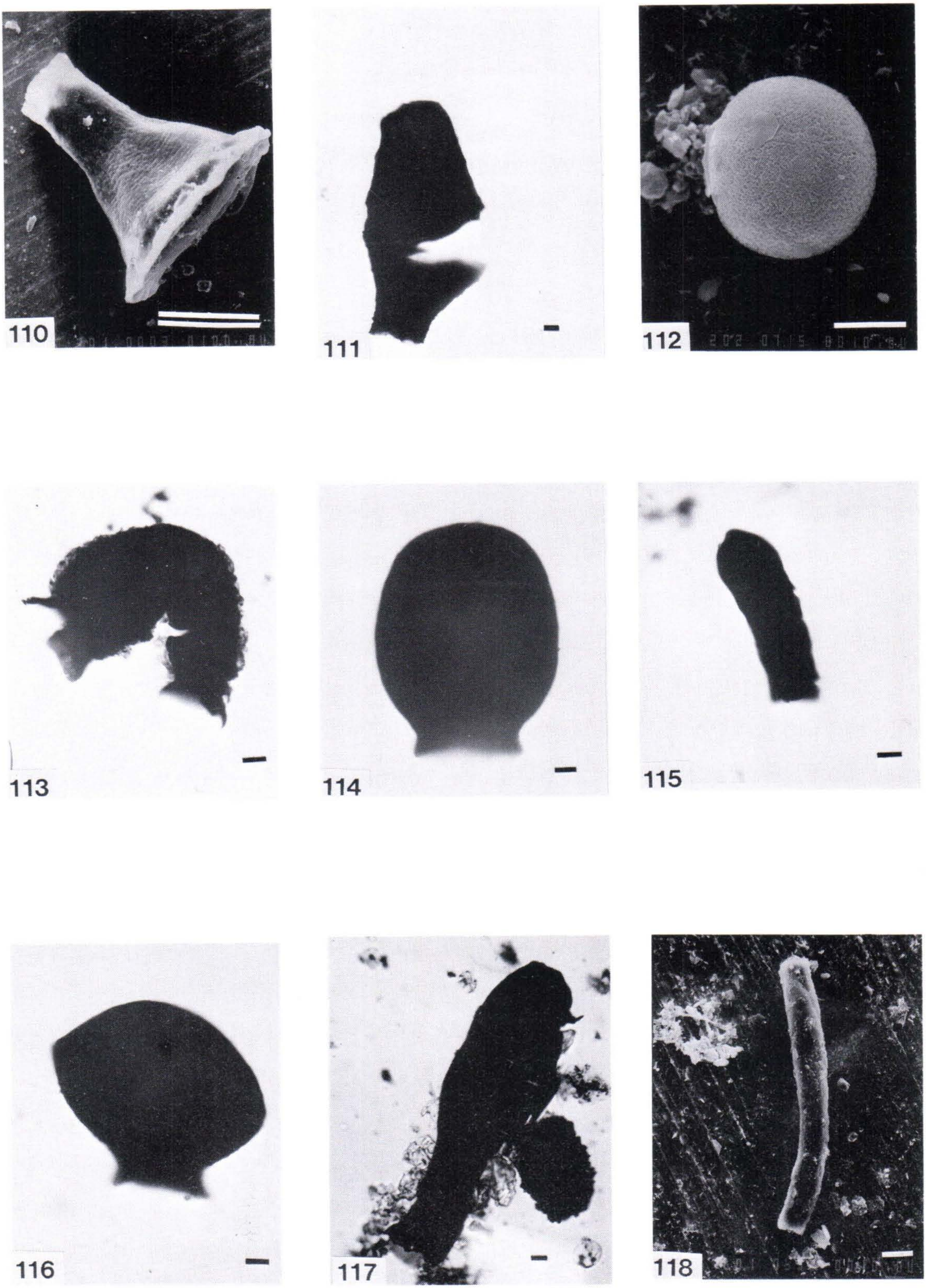

100
101
102
103
104
105
106
107
108
109

Plate XIII



Appendix 1. Finds of calcareous erratics by locality.

1	Alastaro, Virttaankangas	2111	03	6764050/2424270/97	1S,1L
2	Bromarv, Padva 15/AU/84	2012	04	6655200/2436000/0	1L
2	Bromarv, Padva 16/AU/84	2012	04	6653950/2434000/0	1C
2	Bromarv, Vitsand 19/AU/85	2011	06	6647900/2436600/0	1L
3	Dragsfjärd, Hiittinen HV	2011	03	6644000/2390200/0	1S
3	Dragsfjärd, Kasnäs 10/AU/84	1033	12	6646300/1579100/0	2S
3	Dragsfjärd, Morgonlandet KH	2011	01	6628200/2427300/1	2C,3S,1L
3	Dragsfjärd, Trehållskäret KH	2011	05	6639600/2431100/1	1S
3	Dragsfjärd, Vitfågelskär KH	2011	02	6638700/2422800/1	1C
3	Dragsfjärd, Överölmos 13/AU/85	1034	11	6665400/1577500/0	1L
3	Dragsfjärd, Äspskär PO	1033	09	6648970/1566970/1	1L
4	Eura, Honkilahti 56/83	1133	09	6762500/1567000/41	1L
4	Eura, Honkilahti, Sieravuori	1133	09	6765500/1566700/50	1L
5	Eurajoki, Hankkila 9/AU/85	1132	11	6788140/1531500/5	1PO
5	Eurajoki, Kaarlenkari 47/AU/85	1141	07	6800520/1528100/0	1L
5	Eurajoki, Kaarlenpää 48/AU/85	1141	07	6800520/1528420/0	1S
5	Eurajoki, Korvenkulma 44/AU/85	1132	12	6795180/1538000/39	1S
5	Eurajoki, Lapijoki 38/AU/85	1132	11	6783420/1539100/20	1PO,1S,1L
5	Eurajoki, Marjakari 46/AU/85	1141	07	6800520/1528650/0	1VO,1S,1L
5	Eurajoki, Pujonnokka 42/AU/85	1132	09	6797180/1526420/0	2S
5	Eurajoki, Vähä-Frouvi 43/AU/85	1132	09	6795440/1526700/0	1PO,1C,13S,8L
5	Eurajoki, Männistö VL	1134	02	6784400/1543800/20	1PO
5	Eurajoki, Rannankulma VL	1131	12	6793500/1531000/5	1S
5	Eurajoki, Rannankulma 19/AU/85	1132	12	6797980/1530260/1	1S
5	Eurajoki, Ritavuori 34/AU/85	1132	11	6785480/1538940/26	3S,3L
5	Eurajoki, Verkkokari 18/AU/85	1132	12	6791920/1531940/1	2S
6	Halikko, Märynummi AS	2021	09	6704400/2447800/105	1L
7	Hanko, Furuholm 2/KH/80	2011	11	6635800/2459200/1	1C,1S
7	Hanko, Granskär HH	2011	08	6634200/2445750/1	2S
7	Hanko, Gråskär HH	2011	08	6633900/2444500/0	20S,1L
7	Hanko, Hauensuoli KH-80	2011	05	6633100/2438800/1	1C,3S
7	Hanko, Kummelskär KH-80	2011	05	6639570/2435200/1	1L
7	Hanko, Lastankobben KH-80	2011	08	6634700/2450000/1	1S
7	Hanko, Långören HH	2011	08	6634500/2446500/0	4C,10S
7	Hanko, Segelskär KH-79	20		6624600/2462600/0	5S
7	Hanko, Spikarna 7/KH/80	2011	11	6633480/2455500/1	2C, 1S
7	Hanko, Stora Stenskär 9/KH/80	2011	08	6631300/2449800/1	2C,9S
7	Hanko, Sälbådan 8/KH/80	2011	08	6631300/2449500/1	1C
7	Hanko, Tulliniemi HH-86	2011	05	6634500/2439500/0	6S
8	Houtskär, Lektarskär 9/PK	1041	04	6682400/1510600/0	1L
8	Houtskär, Västra saverkeit 8/PK	1032	09	6678500/1523500/5	1L
9	Iniö, Nygrynn 77/AU/85	1041	09	6706400/1520440/0	4S,3L
9	Iniö, Nölestholm 78/AU/85	1041	09	6705860/1520900/0	13S
10	Kaarina, Tuorla 29/AU/84	1043	12	6701380/1579260/20	1PO
11	Kalanti, Elkkyinen 37/AU/85	1131	08	6751640/1522550/3	1S
11	Kalanti, Kiiski NKK-L2-83	1131	06	6747540/1529670/10	1L
11	Kalanti, Kiiski NKK-3-83	1131	07	6747750/1529750/10	1C
11	Kalanti, Kiiski NKK-L8-83	1131	07	6749750/1529750/10	1S
11	Kalanti, Lahti OTR-12-13-83	1042	09	6739370/1528960/10	2L
11	Kalanti, Lahti OTR-L14-83	1042	09	6739400/1529400/10	1L
11	Kalanti, Lahti OTR-15-83	1042	09	6739270/1529230/10	1S
11	Kalanti, Lahti OTR-16-83	1042	12	6739350/1530100/10	1S
11	Kalanti, Lahti OTR-17-83	1042	12	6739520/1530340/10	1S
11	Kalanti, Lahti OTR-18-19-83	1042	12	6739400/1530460/10	1C,1S
11	Kalanti, Orivo MK-86	1131	07	6744300/1527320/11	1L
11	Kalanti, Petes 68/83	1131	07	6740300/1527280/10	12L
11	Kalanti, Petes 63/AU/85	1131	07	6740950/1527260/2	2L
11	Kalanti, Suurikkala OTR-20ab-83	1131	08	6751980/1526270/10	2VO
11	Kalanti, Valkiameri OTR-1-2-83	1042	09	6739290/1527530/10	2L
11	Kalanti, Valkiameri OTR-3-83	1042	09	6738500/1529880/10	1L
11	Kalanti, Valkiameri OTR-4-5-83	1042	12	6739200/1530450/10	2L

App.1 cont.

11	Kalanti, Valkiameri OTR-6-8-83	1042	09	6739770/1528300/10	1C,1S,1L
11	Kalanti, Valkiameri OTR-9-83	1042	09	6739580/1528000/10	1S
11	Kalanti, Valkiameri OTR-10-11-83	1042	09	6793650/1528630/10	2L
11	Kalanti, Vellua PP-86	1042	12	6739200/1532850/3	2L
11	Kalanti 70/83	1131	08	6750560/1525200/17	1S,2L
11	Kalanti 12/KH/83	1131	07	6740210/1526380/2	1L
12	Kiukainen, Vaaniinkangas 2/KH/81	1134	05	6787340/1554400/40	1L
13	Korppoo, Markomby 12/PK	1032	11	6669300/1533500/5	1L
14	Kustavi, NKK 1/83	1042	07	6716150/1521400/10	1S
14	Kustavi, Isoluoto 76/AU/85	1041	09	6709920/1522780/0	9S,1L
14	Kustavi, Iso-Rahi 61/AU/85	1042	07	6717900/1522650/3	1PO
14	Kustavi, Järvikari 73/AU/85	1042	05	6722510/1512070/0	3L
14	Kustavi, Kaaskeri 71/AU/85	1042	05	6720000/1514320/0	3S,7L
14	Kustavi, Kooskerinkari 79/AU/85	1041	06	6706310/1516680/1	1VO,15S,4L
14	Kustavi, Kraakut 40/AU/85	1041	09	6707750/1520320/0	1C,5S,14L
14	Kustavi, Krokholmi 8/KH/81	1042	04	6716980/1513450/1	1VO
14	Kustavi, Kuulivuori 62/AU/85	1042	07	6717800/1522880/0	2S
14	Kustavi, Langstet PK/AU	1042	07	6711100/1520120/2	2S,13L
14	Kustavi, L. Munakari 42/AU/85	1042	09	6708100/1521800/0	2S,2L
14	Kustavi, Nootholma 2/KH/81	1042	04	6719060/1516000/1	1PO
14	Kustavi, Penakluppi 80/AU/85	1041	06	6707770/1517750/0	39S,17L
14	Kustavi, P. Munakari 41/AU/84	1041	09	6708240/1522100/0	1S
14	Kustavi, Pohjakari 72/AU/85	1042	05	6722200/1512300/0	3L
14	Kustavi, Poostanluodot 70/AU/85	1042	04	6717730/1515660/0	1S
14	Kustavi, Salmenperä 1/AU/85	1042	04	6715850/1516900/0	2C,1S,3L
14	Kustavi, Santasaari 81/AU/85	1041	06	6707420/1518500/0	12S,3L
14	Kustavi, Sikaluoto 43/AU/85	1042	04	6711800/1519150/1	1C,8L
14	Kustavi, Tiuskrunni MO	1042	02	6723500/1506000/1	1L
14	Kustavi, Varakluppi 82/AU/85	1041	06	6707400/1519600/0	16S,7L
14	Kustavi, Varstala 2/AU/85	1042	04	6712900/1516800/7	3L
14	Kustavi, Vuosnainen 3/AU/85	1042	04	6710800/1513850/0	3S,2L
15	Kuusisto PK 10	1043	11	6697200/1576000/30	1L
16	Laitila, Metsänpää 5/AU/85	1131	11	6757700/1533000/35	1VO
17	Lappi Tl., Kariniemi VL	1134	01	6779000/1541000/14	1S,1OL
17	Lappi Tl., Kullanperä RM-86	1132	10	6778800/1539500/15	1S,1L
18	Lemu, ML	1044	05	6717500/1550500/0	1L
19	Lokalahti, Hakula ES	1042	09	6730200/1520200/10	1S
19	Lokalahti, Humalkari 67/AU/85	1042	06	6733240/1519160/0	3L
19	Lokalahti, Pitkäluoto 28/AU/85	1042	09	6735400/1522280/20	1L
19	Lokalahti, Ruskiavuorenaukko	1042	09	6735100/1524470/0	1S
19	Lokalahti, Tirkkala 68/AU/85	1042	08	6728720/1520940/0	1S
20	Luvia, Engsholma 69/AU/85	1141	07	6806370/1528780/0	1VO
20	Luvia, Laitakari 50/AU/85	1141	10	6804130/1530310/0	1L
20	Luvia, Pärkööri 1 51/AU/85	1141	07	6805260/1528580/0	1S
20	Luvia, Pärkööri 2 52/AU/85	1141	07	6805220/1529060/2	1L
20	Luvia, Siikkari 49/AU/85	1141	07	6801280/1529540/0	1L
20	Luvia, Tröömi 53/AU/85	1141	10	6804620/1530540/0	1L
21	Mietoinen, Aarlahti 60/AU/85	1044	02	6724420/1544540/0	1S
22	Naantali, Taimo 36/AU/85	1043	06	6708600/1556700/0	1S
23	Nauvo, Kattiluoto JN	1043	01	6685900/1544700/1	3S,2L
23	Nauvo, Persnäs 45/AU/85	1032	12	6672440/1539380/0	3S,3L
24	Pyhämaa NKK-5 ja 7-83	1131	05	6751160/1512500/1	1S
24	Pyhämaa, Heinänen 3/AU/85	1131	05	6755460/1519850/3	2L
24	Pyhämaa, Heinästenlahti 4/AU/85	1131	08	6754850/1520600/5	1S
24	Pyhämaa, Kulju 2/AU/85	1131	05	6757530/1518900/3	1S
24	Pyhämaa, Liesluoto 17/AU/85	1131	05	6753750/1511350/1	5S,2L
24	Pyhämaa, Lintuluoto 1 58/AU/85	1131	05	6759340/1516800/0	1L
24	Pyhämaa, Lintuluoto 2 59/AU/85	1131	05	6759340/1516920/0	1S,1L
24	Pyhämaa, Lyökki S-osa 14/AU/85	1131	01	6749960/1509880/1	8S,5L
24	Pyhämaa, Lyökki N-osa 13/AU/85	1131	02	6750020/1509960/1	1S
24	Pyhämaa, Otavanpää 15/AU/85	1131	04	6748180/1512380/1	3S,9L
24	Pyhämaa, Portinlauhanaukko 16/AU/85	1131	05	6750740/1511780/2	1L
24	Pyhämaa, Salomaa 12/AU/85	1131	05	6756520/1516600/7	1L

App. 1 cont.

24	Pyhämaa, Letonmaa 57/AU/85	1131	06	6763660/1513680/0	1S,1L
25	Pyhäranta, Kauhianpää Nro 2	1131	08	6758800/1524500/5	1L
25	Pyhäranta, Kaukka 40/AU/85	1131	08	6755460/1524900/1	1VO
25	Pyhäranta, Rihtniemi 26/AU/85	1132	07	6772950/1520700/1	1S
25	Pyhäranta, Rihtniemi 56/AU/85	1132	04	6775230/1517700/0	1S
25	Pyhäranta, Rihtniemi 55/AU/85	1132	04	6775040/1517740/0	1S
25	Pyhäranta, Rihtniemi 54/AU/85	1132	04	6771520/1518500/0	1PO
26	Raisio, Hahdenniemi 29/AU/85	1043	09	6706140/1561680/0	1S
26	Raisio, Ihala	1043	09	6706500/1563800/5	1L
27	Rauma, Kaaro 8/AU/85	1132	08	6784170/1529050/23	1S
27	Rauma, Kinno 7/AU/85	1132	08	6782200/1528680/13	1S,1L
27	Rauma, Kortelanlahti 21/AU/85	1132	07	6775050/1525320/1	3S,3L
27	Rauma, Maanpää 20/AU/85	1132	07	6778080/1524380/1	2L
27	Rauma, Noidanlahti 6/AU/85	1132	08	6781740/1527000/5	1S
27	Rauma, Poroalho 10/AU/85	1132	07	6778540/1527750/8	1VO,4S,6L
27	Rauma, Petäs 41/AU/85	1132	08	6780680/1523960/1	2S,1L
27	Rauma, Pyynpää 11/AU/85	1132	08	6781000/1527700/4	1S
27	Rauma, Rokinnokka 30/AU/85	1132	08	6784230/1528500/0	3S,1L
27	Rauma, uimaranta 1/AU/85	1132	08	6780850/1525500/0	3S,2L
28	Rauman mlk, Anttila ES	1132	07	6772500/1526000/10	1L
28	Rauman mlk, Hanhinen 24/AU/85	1132	07	6775340/1520720/1	1L
28	Rauman mlk, Hanhinen 22/AU/85	1132	07	6775850/1520700/1	6S,1L
28	Rauman mlk, Hanhinen 23/AU/85	1132	07	6775520/1520240/1	2S
28	Rauman mlk, Otanmaa 31/AU/85	1132	08	6785350/1524270/0	1S
28	Rauman mlk, Puulu 33/AU/85	1132	08	6788800/1527500/0	3S,1L
28	Rauman mlk, Taipalmaa 32/AU/85	1132	08	6787300/1525600/0	1PO
28	Rauman mlk, Unajanlahti 39/AU/85	1132	07	6774100/1526880/0	4L
28	Rauman mlk, Vasarainen SKL	1132	10	6774800/1533220/10	1L
28	Rauman mlk, Voiluoto 25/AU/85	1132	07	6771980/1524480/15	3S
29	Rusko, Haapa-alho PK 11	1044	07	6710800/1568800/45	1L
29	Rusko, Runosmäki PK 4	1043	09	6708500/1568800/45	1L
30	Rymättylä, Poikko 12/77	1043	03	6700900/1549500/3	2L
30	Rymättylä, Poikko ES-80	1043	02	6699300/1545850/10	1L
31	Somero, Kankaannummi	2024	03	6733500/2461000/120	1L
31	Somero, Kuusjoki 47/AU/84	2022	12	6738120/2456970/105	1S
31	Somero, Pitkäjärvi 46/AU/84, AS	2024	02	6729300/2461640/95	3S,7L
32	Särkisalo, Pettu 26/AU/84	2012	07	6658550/2443100/0	1L
33	Taivassalo, Isolahti PJ	1042	11	6721950/1537100/13	1L
33	Taivassalo, Kolkanaukko OV	1042	10	6719500/1532000/0	1L
33	Taivassalo EK	1042	10	6718250/1533500/2	1S,2L
33	Taivassalo 79	1042	10	6719880/1534780/2	1L
34	Tammisaari, Ramsholmen 23/AU/84	2014	01	6650600/2467960/0	2S
34	Tammisaari, uimaranta 24/AU/84	2014	01	6650420/2469320/0	1S
35	Uusikaupunki, Iso-Haidus 10/KH/81	1131	04	6742300/1525150/0	3L
35	Uusikaupunki, Iso-Hylkimys 12/KH/81	1042	06	6735600/1514900/1	3S,1L
35	Uusikaupunki, Kouklainen 66/AU/85	1131	04	6743140/1519720/0	3S
35	Uusikaupunki, leirintäalue 35/AU/85	1131	07	6744400/1521650/0	1S
35	Uusikaupunki, Lepäinen 36/AU/85	1131	04	6743850/1513500/0	3S,2L
35	Uusikaupunki, Morseinkari 65/AU/85	1131	07	6743360/1520000/0	10S,11L
35	Uusikaupunki, P. Viisastenkari 11/KH/81	1131	04	6742000/1513700/1	1S
35	Uusikaupunki, Seiskarit 13/KH/81	1042	06	6736000/1512500/1	2L
35	Uusikaupunki, Vasikkamaa 11/79	1042	06	6738600/1518100/1	1L
36	Vampula, kalkkikaivos PK	2112	01	6772250/2426400/76	L (6 %)
37	Vehmaa 78	1042	11	6721200/1539600/1	1S
38	Velkua, Teerisalo 37/AU/85	1041	12	6706480/1538440/0	1C,1S,10L

Tätä julkaisua myy

GEOLOGIAN
TUTKIMUSKESKUS (GTK)
Julkaisumyynti
02150 Espoo
☏ 90-46931
Teleksi: 123 185 geolo sf
Telekopio: 90-462 205

GTK, Väli-Suomen
aluetoimisto
Kirjasto
PL 1237
70701 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

Denna publikation säljes av

GEOLOGISKA
FORSKNINGSCENTRALEN (GFC)
Publikationsförsäljning
02150 Esbo
☏ 90-46931
Telex: 123 185 geolo sf
Telefax: 90-462 205

GFC, Mellersta Finlands
distriktsbyrå
Biblioteket
PB 1237
70701 Kuopio
☏ 971-205 111
Telefax: 971-205 215

GFC, Norra Finlands
distriktsbyrå
Biblioteket
PB 77
96101 Rovaniemi
☏ 960-297 219
Telex: 37 295 geolo SF
Telefax: 960-297 289

This publication can be obtained
from

GEOLOGICAL SURVEY
OF FINLAND (GSF)
Publication sales
SF-02150 Espoo, Finland
☏ 90-46931
Telex: 123 185 geolo sf
Telefax: 90-462 205

GSF, Regional office of
Mid-Finland
Library
P.O. Box 1237
SF-70701 Kuopio, Finland
☏ 971-205 111
Telefax: 971-205 215

GSF, Regional office of
Northern Finland
Library
P.O. Box 77
SF-96101 Rovaniemi, Finland
☏ 960-297 219
Telex: 37 295 geolo SF
Telefax: 960-297 289

ISBN 951-690-359-2
ISSN 0367-522-X