Geologica et Palaeontologica	8	S. 1—14	4 Abb., 1 Taf.	Marburg, 15. 8. 1974

Late Precambrian microfossils from the basal sandstone unit of the Visingsö beds, South Sweden

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With 4 figures and 1 plate

VIDAL, Gonzalo: Late Precambrian microfossils from the basal sandstone unit of the Visingsö beds, South Sweden. — Geologica et Palaeontologica 8: 1–14, 4 figs., 1 pl., Marburg, 15. 8. 1974.

Microfossils found in quartz-sandstones at Karlsborg (boring) and Lemunda (quarry) resemble those earlier found in overlying units, indicating a relatively short time span of deposition. Overlying sediments are immature (glacially influenced?). 10 species of sphaeromorphic acritarchs were found, 7 of which are well known from the M.-U. Riphean and Vendian of the Russian and Siberian Platforms. 2 are also known from the Cambrian. A Late Riphean age (possibly 750–800 m.y.) is indicated for the basal Visingsö beds.

10 Arten von sphaeromorphen Acritarchen wurden in einer Bohrung (Karlsborg) und in einem Steinbruch (Lemunda, Östergötland) in Quarzsandsteinen der basalen Visingsö-Serie (nach den Befunden spätes Riphäikum 750–800 m. J.) gefunden. Davon waren 7 aus dem mittleren – oberen Riphäikum und dem Wendium der russischen und sibirischen Kratone bekannt, 2 auch aus dem Kambrium. Die Fundschichten werden durch unreife, wohl glazial beeinflußte Sedimente überlagert.

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Introduction

The results exposed in this paper are part of micropaleontological and biostratigraphical investigations of the Late Precambrian rocks of South Sweden. The present paper deals exclusively with the lowermost, sandy unit of the Visingsö beds (Visingsö sandstone). A paper dealing with the micropalaeontology and biostratigraphy of the middle and upper units of the Visingsö beds is in preparation. A separate publication of the results obtained from the lower, sandy unit is chosen because of the wider scope of this forthcoming paper. However, some kind of reference to the yet unpublished results is unavoidable.

The investigated unit is poorly exposed, the distribution of its rocks being known mainly through numerous borings. However, only 15 borings are described or documented in reports. Nine of these borings, drilled in the vicinity of the town of Huskvarna were described by BROTZEN (1941). Further, two of the borings drilled in the town of Jönköping were also reported by BROTZEN (1941). Unpublished data about borings in the Jönköping and Huskvarna areas, the neighbourhood of the lakes Landsjö, Stensjö and Tenhult, as well as in the Hjo and Karlsborg areas, was made available to the author by Dr. KAJ NILSSON and Eng. HELGE KARLSSON, of the consulting company VIAK AB.

Of the available boring material only one boring, drilled in the town of Karlsborg (designed here as K-IV), provided adequate and sufficiently large samples of rocks lithologically suitable for micropalaeontological investigations.

In addition to this material, all the outcrops of the rocks of the basal unit were visited. Totally, twelve sections were measured and sampled. A micropalaeontological evaluation of this material gave negative results. Appropriate lithologies were only found in a section at the Lemunda Quarry in Östergötland (Figs. 1, 2). The original material is deposited in the collections of the Institute of Palaeontology, University of Lund.

Geology

The unmetamorphic, sedimentary rocks of the Visingsö beds cover an area restricted to the vicinity of Lake Vättern in South Sweden (Fig. 1). The actual distribution of these rocks depends mainly on normal faulting. The main fault system runs in NNE-SSW direction, as easily observed in an area South of the town of Husqvarna to the area of Omberg (Fig. 1). The great normal fault along the eastern margin of Lake Vättern is the boundary between the rocks of the Visingsö beds and the highly deformed, much older, crystalline rocks East of the fault. The contact between the Visingsö beds and the older crystalline rocks at the western margin of Lake Vättern was considered to be a denudation boundary by COLLINI (1951). The restricted distribution of the Visingsö beds in the Lake Vättern Basin was interpreted by DE GEER (1910) and CLOOS (1939) as being due to a graben structure. This interpretation seems to be corroborated by gravimetric studies of the area (LIND 1967, 1972). Rocks undoubtedly belonging to the Visingsö beds occur in small, downfaulted areas outside the main Vättern fault-system. Two such areas occur some 40 and 70 km NW of the northernmost part of the area shown on the map in Fig. 1, on the eastern sides of the lakes Skagern and Möckeln.

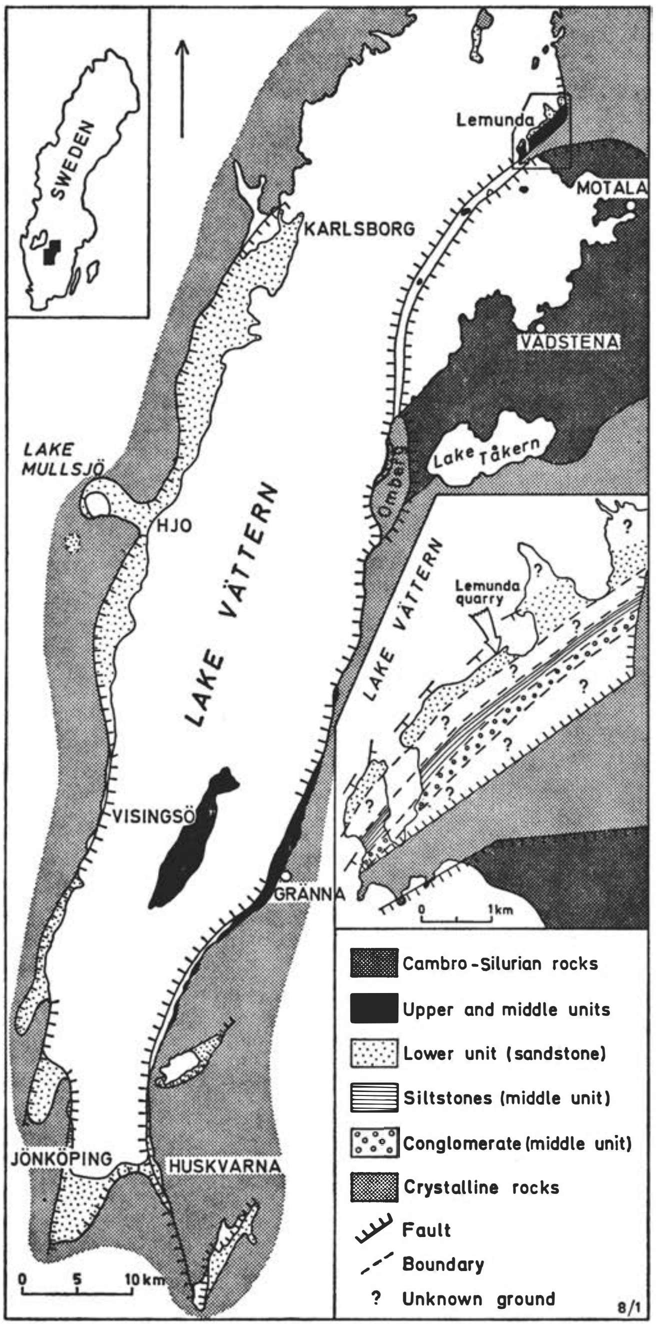

Fig. 1: Geological map of the Lake Vättern area, showing the approximative distribution of the Visingsö beds. The distribution of the Cambro-Silurian rocks after WESTERGÅRD (1944). The location of faults mainly after WESTERGÅRD (1944), LIND (1972) and maps of the Geological Survey of Sweden.
The insert map shows the supposed distribution of the rocks of the basal and middle units.

The Visingsö beds were divided by COLLINI (1951) into three lithological units. These are, in ascending order: (A) lowermost sandstone unit, (B) middle conglomerate, arkose, sandstone and siltstone unit, and (C) shale and carbonate unit. This paper deals with the lowermost unit (A). This unit consists mainly of white, yellow or red-coloured, medium to coarse-grained quartz sandstones. Conglomeratic, arkosic and silty layers occur sporadically in the sandstones. The thickness of this unit (Visingsö sandstone) has been estimated to over 145 m. (COLLINI 1951). According to the gravimetric results of LIND (1972), the thickness of the Visingsö beds at the southern margin of the Lake Vättern area (mainly sandstone) is about 400 m. Boring data from the southern and northern margin of the area (Husqvarna-Jönköping and Karlsborg areas, respectively) show a minimum thickness of 176 and 195 m., respectively.

At the eastern margin of Lake Vättern, the basal sandstone unit crops out NE of the town of Gränna (at the East side of the Gerabäcken Valley), the southernmost limit of the Omberg area and in the area of Lemunda (North of Motala) (Fig. 1). In the latter area, the sandstone unit is especially well exposed in extensive outcrops along the shore of Lake Vättern and in numerous quarries. Field data indicates a minimum thickness of 105 m. for the sandstone unit in this area.

The lower unit is also exposed in the southwestern limit of the Lake Vättern area in small outcrops on the shore of Lake Vättern. Here, the sandstone unit is also known through several well borings.

Sandstones, very likely belonging to the lower unit, have been met with in a number of well borings, drilled in the vicinity of the lakes Landsjö, Stensjö and Tenhult, in the southeastern corner of the area in Fig. 1. The sandstones crop out also in small areas, NE of the Lake Landsjö (Fig. 1) and at the southeastern margin of Lake Möckeln (outside the map, Fig. 1).

The boundary between the lower and middle units is exposed in the Gerabäcken Valley (North of Gränna). In this locality the quartz sandstone is overlain by a poorly consolidated, red-coloured, sandy pelite, probably passing upwards into sandstone, arkoses and conglomerates. In the Lemunda area (Fig. 1) the situation seems to be very similar to that in the Gerabäcken Valley. Here, conglomerate and arkose lithologically very similar to those above the basal sandstone in the Gerabäcken Valley, overly the basal Sandstone.

The correlation of outcrops and borings is rendered difficult by lithological monotony, poor exposure, tectonic disturbance and absence of marker layers.

Age

The age of the Visingsö beds has been discussed by many authors during the last century. On the basis of lithological similarities with the Triassic deposits of Scania (southernmost Sweden) a Late Triassic age was proposed by HOLM (1885) and by MUNTHE & GAVELIN (1907). The absence of macrofossils in these rocks was interpreted by NATHORST (1879 b) as suggestive of a Precambrian or Early Cambrian age. A Late Precambrian age was proposed by LINNARSSON (1880), NATHORST (1884, 1886), ROSÉN (1925), BROTZEN (1941), COLLINI (1951), and TIMOFEEV (1959, 1960, 1966, 1969). The Pre-Ordovician age of the Visingsö beds was proved by ROSÉN (1925) through the find of rock fragments from the Visingsö beds in a Lower Ordovician conglomerate in Östergötland. GAVELIN (1925), proposed that the Visingsö beds could represent a supramarine facies of the adjacent, marine, Cambrian in Östergötland. As pointed out by COLLINI (1951), this proposition is excluded by the fact that the Visingsö beds are several times thicker than the adjacent Cambrian deposits in Östergötland. Moreover, no Cambrian fossils have been encountered in the rocks of the Visingsö beds, although the lutitic rocks of the upper unit of the Visingsö beds seem to be very suitable for the preservation of fossils. Radiometric age determinations (K/Ar) of a shale in the Visingsö beds gave 985 and 1060 m.y. (MAGNUSSON 1960).

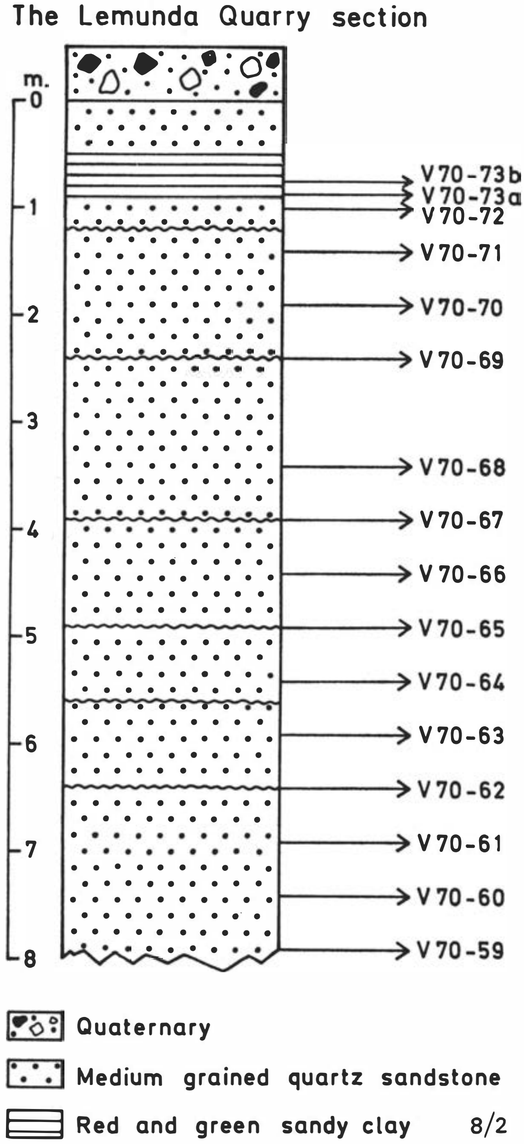

Fig. 2: Detailed lithological description of the section at the Lemunda Quarry. Marks on the right side of the section give the position of taken samples.

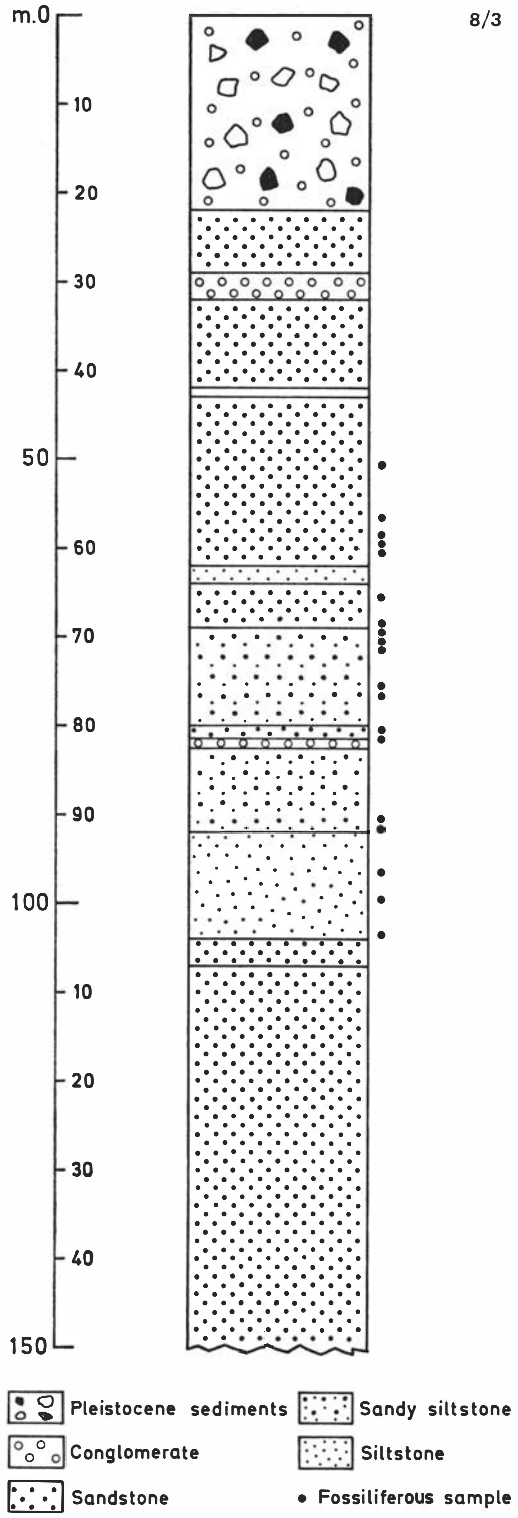

Fig. 3: Generalized lithological description of the K–IV borehole, at the Karlborg Peninsula. The log is based on cutting-samples taken at every meter. Black dots on the right side of the log indicate fossiliferous samples.

Material and methods

A total of 139 samples were treated in an attempt to obtain acid-resistant microfossils from the rocks of the lowermost unit of the Visingsö beds. Of these samples, 126 were well cuttings from a boring drilled in the town of Karlsborg (Figs. 1, 3). The location of the borehole is VE 725 884 (Topografisk karta över Sverige 1:50 000, map sheet 8 E Hjo NV). Of the 126 samples from this boring only 19 provided relatively abundant and well preserved acid-resistant microfossils. The fossiliferous samples are green-coloured, silty rock cuttings taken at 50–51, 56–57, 58–59, 60–61, 65–66, 68–69, 69–70, 70–71, 71–72, 75–76, 76–77, 80–81, 81–82, 90–91, 91–92, 96–97, 99–100 and 103–104 meters, respectively (Fig. 3).

From a section in the Lemunda Quarry (Figs. 1, 2), 18 samples were treated. The location of the quarry is VE 94 359 637 (Topografisk karta över Sverige 1:50 000, map sheet 8 E Hjo NO). All the sandstone samples from this section were devoid of organic material. Abundant, although poorly preserved microfossils were encountered in green-coloured clay layers occurring in a poorly consolidated, red-coloured clay bed with sandy intercalations (Fig. 2, Pl. 1, Fig. 19), at the top of the section. The rocks below this bed are yellowish, medium-grained, cross-bedded quartz sandstones. The bed containing the fossiliferous layers is overlain by a 0.5 meter thick sandstone bed, lithologically similar with that below.

From each sample 50 g. of rock were dissolved in hydrofluoric acid. The residue was then sifted through a sieve with a mesh distance of 20 microns. When necessary the residue was boiled in diluted hydrochloric acid in order to dissolve fluorides. After sifting in gently running distilled water the sample was treated a few minutes in warm 25 % nitric acid. After sifting and rinsing the residue was concentrated by centrifugation at 2500 r./min. for 10 minutes. Two slides were prepared of every sample using glycerole jelly as mounting medium. The slides were then sealed with Glyceel sealing medium.
The samples from the poorly consolidated clay layers of the Lemunda section were treated in a different way. Fifty grams of each sample were disintegrated in distilled water. Then, they were sifted through a system of sieves with mesh distance of 200, 95 and 20 microns. When examined in polarized and transmitted light under the microscope the residues were found to consist mainly of angular to sub-angular quartz grains, numerous biotite grains, and micro-fossils known to be acid-resistant. No pyrite or non-acid-resistant microfossils were encountered in the residues.
In order to facilitate the microscopic study the residues were then treated in hydrofluoric acid, in the above described way. These samples turned out to contain abundant, although poorly preserved acid-resistant microfossils. From the red-coloured part of the bed only a few fragmentary microfossils were obtained.

Organic remains

The occurrence of organic remains of uncertain affinity in the Visingsö beds is recorded in many papers. Papers by BROTZEN (1941), WIMAN (1894), HOLM (1885), LINNARSSON (1880) and NATHORST (1884, 1894) deal with the problematic fossil *Chuaria*. Worm trails ? have been reported by KAUDERN (1932) from rocks of the middle unit in the Island of Visingsö. Other kinds of fossils have been described by EWETZ (1932, 1933) and TIMOFEEV (1959, 1960, 1966, 1969). WIMAN (1915) and VIDAL (1972) described algal stromatolites from the uppermost unit of the Visingsö beds.
The microfossils encountered in samples from the K-IV bore-hole have been determined as: *Protosphaeridium laccatum* TIMOFEEV, *Kildinella hyperboreica* TIMOFEEV, *K. sinica* TIMOFEEV, *Trachysphaeridium laminaritum* TIMOFEEV, *T. levis* (LOPUKHIN) n. comb., *Trachysphaeridium* sp., and psilate sphaeromorphs of uncertain affinity.
In the samples from the Lemunda Quarry the following species were met with: *Protosphaeridium laccatum* TIMOFEEV, *Kildinella* cf. *vesljanica* TIMOFEEV, *K. sinica* TIMOFEEV, *Chuaria circularis* WALCOTT, *Trachysphaeridium* sp. A, and specimens of the above mentioned psilate sphaeromorphs of unknown affinity.
The identification of the material is based on comparative studies of TIMOFEEV's original preparations in Leningrad. The identified species are mainly known from Middle-Late Riphean and Vendian rocks of Eurasia. Their stratigraphic ranges can be seen in Fig. 4.
The sphaeromorphic acritarchs encountered in the treated material are considered to be marine phytoplankton. This assumption is sustained by their occurrence in sedimentary rocks indicating different marine environments and by their wide geographical distribution.
The author does not employ the classification suggested by DOWNIE, EVITT & SARJEANT (1963), nor that suggested by TIMOFEEV (1966, 1969). Evidently, these classifications, based on the external morphology and mode of occurrence of these microfossils, imply that acritarchs, showing features not included in some of the established groups or subgroups, cannot be adequately classified. So, the species met with of the genus *Kildinella*, *Trachysphaeridium*, *Chuaria* and *Protosphaeridium* are included by TIMOFEEV (1966, 1969) in the subgroup *Monosphaeritae* TIMOFEEV. However, all these microfossils were occasionally encountered in clusters of two or more cells, like the cluster of *Kidinella* specimens showed in Pl. 1, Fig. 2. If one follows the classification proposed by TIMOFEEV (1966, 1969) then all these taxa would be included in the subgroup *Polysphaerita* TIMOFEEV.

8/4 Stratigraphic distribution of microfossils	2000 – 1550 m.y.	1550 – 1350	1350 – 1100	1100 – 650	650 – 560	560 m.y.		
	Proterozoic					Cambrian		
		Upper						
		Riphean						
	Lower & Middle	Lower	Middle	Upper	Vendian	L	M	U
Protosphaeridium laccatum Tim.	●	●	●	●	●	●	●	●
Kildinella hyperboreica Tim.				●	●	●		
K. sinica Tim.		●	●	●	●			
K. cf. vesljanica Tim.				●	●			
Chuaria circularis Walcott				●	?			
Trachysphaeridium laminaritum Tim.				●	●			
T. levis (Lopukin) comb. nov.			●	●				
sphaeromorphs	●	●	●	●	●	●		

Fig. 4: Stratigraphic time scale of the Proterozoic and distribution of species met with.

On the other hand, the presence of an inner body in some well preserved specimens of *Kildinella* and *Trachysphaeridium* seems to be an inconvenience for their classification in the subgroup *Spaeromorphitae* DOWNIE, EVITT & SARJEANT, since, according to the description of this subgroup no such inner bodies are present. However, the other characters of these acritarchs seem to justify their classification in this subgroup. According to these arguments all the microfossils found are described in this paper as "spaeromorphic acritarchs". They are in this way left outside the provisional suprageneric nomenclatures proposed by TIMOFEEV (1966, 1969) and DOWNIE, EVITT & SARJEANT (1963).

Systematic Part

The specimens in the figures can be found in the slides with the help of an England Finder. Their position is given to the right of the colon.

Genus ***Protosphaeridium*** TIMOFEEV, 1966

1966 *Protosphaeridium* gen. n. – TIMOFEEV, p. 19.
1969 *Protosphaeridium* TIMOFEEV – TIMOFEEV, pp. 6–7.

Protosphaeridium laccatum TIMOFEEV, 1966
Pl. 1, Fig. 1

1933 Fossils IX & X – EWETZ, p. 515, Fig. 14, 15.
1967 *Spumosata minor* PICHOVA sp. n. – PICHOVA, p. 35, Pl. II, fig. 2.
1967 *Spumosata simplex* NAUMOVA – PICHOVA, Pl. II, figs. 3, 5, 6.
1969 *Protosphaeridium laccatum* TIM. – TIMOFEEV, p. 8, Pl. XIII, fig. 11, Pl. XV, fig. 2.
1969 *Protosphaeridium densum* TIM. – TIMOFEEV, p. 8, Pl. I, fig. 4, Pl. XXXVI, fig. 2.

Original Material: Slide V 70–73/2: V–22/2–4.

Description: The vesicle is thick, single walled, ovoidal, elliptical or circular in outline. The surface is psilate or velutinous. The colour is yellow to dark-brown. The distribution of the diameter ranges of this species is polymodal. Maximal frequencies are found in the interval 40–100 microns.

Remarks: The study and measuring of hundred specimens of this species, as well as the study of the original material of TIMOFEEV, support the conclusion that the species *Protosphaeridium densum* and *P. laccatum* are a single species. The differences in diameter ranges given by TIMOFEEV (1966, 1969) are, in my opinion, insufficient to distinguish two different species. Therefore a single species *P. laccatum* is proposed, *P. densum* and *P. laccatum* (sensu TIMOFEEV) being synonyms of the first species.

During the course of this investigation the author observed that *P. laccatum* has quite different diameter ranges in rocks of different lithologies. Very large specimens were observed to dominate in assemblages found in fine grained rocks as shales and phosphate nodules. There is an inverse relationship between the diameter range of the specimens and the grain size of the rock.

The fossils IX and X of EWETZ (1933) are undoubtedly identical with *P. laccatum* TIMOFEEV. These fossils were found by EWETZ in thin sections of a limestone boulder collected from the Pleistocene till on the shore of Lake Vättern near Gränna. From the description given by EWETZ (1933), it seems possible that the boulder came from the stromatolitic limestones of the upper unit, exposed at the shore of Lake Vättern, North of Gränna. EWETZ (1933) interpreted these microfossils as "Ostracodenschale?" and "Rest eines mit einem Winterei versehenen Ephippiums», respectively. They are considered here as marine phytoplancton of obscure biological affinity.

Occasionally, two specimens of *P. laccatum* TIMOFEEV were found joined. This circumstance was also reported by EWETZ (1933). Detailed examination of the contact areas revealed that these features are not mere coincidences. It is, on the other hand, difficult to understand the palaeobiological significance of this.

It deserves mentioning that extremely large specimens of *P. laccatum* TIMOFEEV turned out to be the only microfossil present in rocks indicating shallow water environment, that is, in algal stromatolites of the uppermost unit of the Visingsö beds (cf. VIDAL 1972, p. 363).

Occurrence: This species was found in the Lemunda section at 0.74 and 0.84 m. and in the K-IV borehole at 58–59, 59–60, 65–66, 69–70, 70–71, 71–72, 81–82 and 90–91 meters, respectively. The species has been reported from a glacial erratic from the area North of Gränna. According to TIMOFEEV (1966) the synonymous species *P. densum* has been encountered in the Bothnian area (Tampere, Finnland), Late Precambrian in Giperborey (River Anikeeva), Terskiy beds at the Kandalaksha Coast (White Sea), Barminskaya beds in Northern Timan Mountains, Upper Krivoy Rog Formation in Ukrania, Onguren, Goloustnaya and Kachergat beds in the area of Lake Baikal, Kandyk beds at the River Maya (Yakut), the Sinian of Northern China, Riphean and Vendian in boreholes in Lopydino, Sisole and Veslyane (SW Timan Mountains), Vendian at the Winter Coast (White Sea), Visingsö beds (South Sweden), Vendian in Kotushova, Sventok Mountains (Poland), the Lower Cambrian Ostrog beds in Volynia, Lomozov and Sokolets Horizons (Podolia), Sloboda Conglomerate (Carpathian Mountains), Late Precambrian in Priazovya (River Mokraya, Volnovakha, Ukrania), Lower Prizlbrusya beds in the basin of River Malka, Eocambrian in the Zheleznikh Mountains (Czechoslovakia), Adelaide System (South Australia), Precambrian in Eastern Antarctica, Upper Sinian in Northern China, Lower Cambrian "Blue Clay" at the River Tosna (Leningrad), Kunda beds in Estonia, Hecla Hoek Formation in Spitsbergen, the Vendian ?-Lower Cambrian Lower Shakovskaya beds in western Baical (River Khidusa), the Lower Cambrian Usol'ye beds (Irkutsk), Okhonoyskaya beds at the River Maya (Yakut), the Upper Cambrian Sukanskaya beds at the River Olenek (Yakut), the Middle Cambrian Upper Voronovskaya beds at the River Tunguska, Lower Cambrian in Northern China, and the Upper Riphean-Middle Cambrian in Graz (Austria).

P. laccatum (sensu TIMOFEEV 1966) has been reported from the Bothnian (Tampere) and Jotnian areas in Finland, Krivoy Rog Middle beds (Ukrania), the Riphean and Vendian Chapoma beds in the Winter Coast area, Chapoma River (White Sea), Malgin and Lakhanda beds at the River Maya (Yakut), the Lower Cambrian *Laminarites* beds (Leningrad), Sokolets beds and Ushitsa beds (Podolia), the metamorphic shists of the Rakhov Massif in the Sub-Carpathian area (Ukrania), the Vendian ? deposits in Sysola in the southwestern Pritiman area of the Winter Coast (White Sea), Starorechenskaya beds at the Olenek River (Yakut), Lausitzer Graywacke in Saxony, the Lower Cambrian Blue Clay in Estonia, the Lower Bituminous beds at the River Olenek (Yakut), metamorphic rocks in Karnische Alpen (Austria),

the Middle Cambrian in the Oslo Region (Norway), the Izhora beds at the River Izhora (Leningrad), the Upper Cambrian *Obulus* beds in Iru (Tallinn), and Chopkinskaya beds at the River Chopko (Krasnoyarsk).
The synonymous species *Spumosata minor* and *S. simplex* were reported by PICHOVA (1967) from the Vendian Middle Motsk complex in eastern Siberia. The stratigraphic range is Proterozoic and Cambrian (-Ordovician Kunda beds).

Genus **Kildinella** TIMOFEEV, 1966

1966 *Kildinella* TIMOFEEV, 1963 – TIMOFEEV, pp. 28–29.
1969 *Kildinella* TIMOFEEV, 1963 – TIMOFEEV, pp. 10–11.
1966 *Polyedrosphaeridium* gen. nov. – TIMOFEEV, pp. 43–44.
1969 *Polyedrosphaeridium* TIMOFEEV (1962) 1966 – TIMOFEEV, p. 26.

Kildinella cf. **vesljanica** TIMOFEEV, 1969
Pl. 1, Fig. 9

1969 *Kildinella vesljanica* sp. n. – TIMOFEEV, p. 11, Pl. II, fig. 5.
Original material: Slide V 70–73/1: X-22/2.
Description: The vesicle is single walled and circular to subcircular in outline. The surface is psilate or slightly granulated. The specimens found are commonly compressed, showing narrow and wide wrinkles. The colour is light brown. The average diameter ranges within the interval 38–48 microns.
Remarks: According to TIMOFEEV's diagnosis, *K. vesljanica* shows two kinds of folds or wrinkles, the first ones being large, narrow and bent, the second ones small, short, narrow and less numerous than the first ones. In my opinion the character of these wrinkles, as well as their number and position are accidental. The wrinkles are the result of the deformation of the vesicle by postsedimentary compaction. They only indicate that the form of the microfossils was sphaerical or subsphaerical before being deformed.
Occurrence: This species was found in the Lemunda section at 0.74 and 0.84 m. *K. vesljanica* is reported by TIMOFEEV (1969) from the Riphean of Vesljana and River Chapoma, in the area of the Winter Coast. This species is restricted to the Upper Riphean.

Kildinella hyperboreica TIMOFEEV, 1966
Pl. 1, Fig. 7

1969 *Kildinella hyperboreica* TIM. – TIMOFEEV, p. 11, Pl. XVII, fig. 8, Pl. XXXII, fig. 8.
1969 *Polyedrosphaeridium bullatum* TIM. – TIMOFEEV, p. 26, Pl. V, fig. 6, Pl. XXXII, fig. 5.
Original material: Slide K-IV/103–104/1: N-24.
Description: The vesicle is single walled and circular to subcircular in outline. The surface is psilate. In the specimens found the vesicle is commonly deformed, showing wide and narrow wrinkles. The colour is yellow or grey-yellow. The average diameter ranges within the interval 50–70 microns.
Remarks: The diameter range given by TIMOFEEV (1966, 1969) for this species is 5–80 microns. In the present material the specimens are too few for making an adequate comparison with the range given by TIMOFEEV.
As a result of comparative studies of TIMOFEEV's material the author found that the species *Polyedrosphaeridium bullatum* TIMOFEEV is a strongly deformed specimen of *Kildinella hyperboreica* TIMOFEEV and consequently synonymous with this species.
Occurrence: This species was found in the K-IV borehole at 58–59 and 103–104 meters. According to TIMOFEEV (1966) this species occurs in Riphean rocks of the Chapoma beds in southern Kola Peninsula, the Pachelma beds in the Morsovskaya borehole in the area of Pensa, the Lakhanda beds in the River Maya (Yakut), the Miroedikha beds at the River Maya (Turukhansk). This species is also reported from the Eocambrian "Sparagmite Series" in Finnmark (Norway), phyllites in Dobrudzhi (Izmail), metamorphic rocks in the central Timan Ridge, the Katav beds in southern Ural Mountains, Malgin and Kandyk beds at the River Maya (Yakut), Churochnaya beds in the Polyudova Mountains, the Sukhotungusinskoy and Burovoy beds at the River Inzha (Tunguska), Nemchaskoy beds at the River Isakovka, the Ingritskaya Series of the Infra-Cambrian in Sakary, the Lower Cambrian Blue Clay of Kunda (Estonia), and the Okhonoyskoy suite in River Maya (Yakut). The stratigraphic range of this species is, according to TIMOFEEV (1966) Riphean to Lower Cambrian.

Kildinella sinica TIMOFEEV, 1966
Pl. 1, Figs. 8, 10

1969 *Kildinella sinica* TIM. – TIMOFEEV, p. 11, Pl. X, fig. 10, Pl. XII, fig. 10, Pl. XIII, fig. 2.
Original material: Slides K-IV/56–57/2: M-45/3 and V 70–73/1: E-47/4.
Description: The vesicle is thick, single walled and circular to subcircular in outline. The surface is granulated. In the encountered specimens the vesicle is commonly compressed, showing narrow, concentric wrinkles. The colour is light to dark brown. The average diameter ranges within the interval 45–50 microns.
Remarks: *K. sinica* TIMOFEEV differs from the other species of the genus *Kildinella* met with in the present material by the granulation of the vesicle. The diameter range given by TIMOFEEV (1969) for this species in 5–70 microns.
Occurrence: This species was encountered in the K-IV borehole at 56–57 and 103–104 meters, respectively, and in the Lemunda section at 0.74 and 0.84 meters. TIMOFEEV (1966) gives the following Riphean occurrences: Kildin and Volokovoy beds in Murmansk, Chapoma beds, Tersky Coast (southern Kola Peninsula), Palchelma beds and Veslyana beds (SW Timan), Lakhanda beds (Yakut), Miroedikha beds (Turukhansk). This species is also reported by TIMOFEEV (1966) from the Late Precambrian and Vendian Tersky beds (Kandalaksha, SW Kola Peninsula), "Sparagmite Series" of Finnmark (Norway), Vendian of Kotushova, Sventok Mountains (Poland), Katav beds (southern Urals), Kandyk beds in River Maya (Yakut) Sterlnogoskoy, Il'yushkin, Sukhotungusinskoy and Burovoy beds in River Nizhnayaya, Tunguska, Turukhansk, Krasnoyarsk district. The stratigraphical distribution of this species is Riphean and Vendian.

Genus **Chuaria** WALCOTT, 1899

1899 *Chuaria circularis* nov. g. and sp. – WALCOTT, p. 234, Pl. 27, figs. 12–13.
Remarks: EISENACK (1966) suggested that *C. wimani* BROTZEN may be included into genus *Chuaria*, of which *C. circularis* WALCOTT is the type species. WALCOTT (1899) interpreted *C. circularis* as being a phosphatic brachiopod

allied to *Orbicula* or *Discina*. The phosphatic composition of *Chuaria* has been refuted by chemical analyses (EISENACK 1966) and by electron probe (FORD & BREED 1972 b). As pointed out by these authors, *Chuaria* is insoluble in KOH, HCl, HF, H_2SO_4 and HNO_3. Only boiling Schultze solution seems to destroy this fossil. FORD & BREED (1972 b) proposed a "predominantly carbonaceous" composition for this fossil. Fossils comparable to *Chuaria* have been reviewed by FORD & BREED (1972 b). These authors considered *Chuaria* as a "polygenetic assemblage of large acritarch-like plants, possibly cysts". They proposed *C. circularis* as a single name covering forms like *Fermoria minima, Protobolella jonesi* and *C. wimani.* An "arbitrary" lower limit is taken by these authors at 0.5 mm. in diameter, and they put forward the proposal that below this limit a variety of names may be used. In my opinion this "arbitrary" limit seems to be impossible to apply when studing material obtained by maceration. The large populations obtained by this method provided abundant *Chuaria* specimens ranging 90–200 microns in diameter, accompanied by specimens as large as 3000 microns. In the Visingsö beds, *Chuaria* seems to be restricted to shales, the very large specimens being only found in dark, pyrite rich shales (see below). As mentioned above, the species *Protosphaeridium laccatum* shows different diameter ranges in different lithologies. Specimens as large as 2000 microns were found in algal stromatolites of the upper unit. If one follows the practice proposed by FORD & BREED (1972 b) then, *P. laccatum* would also be included under the name *Chuaria,* although evidently, it has nothing in common with *Chuaria.* The present author does not propose any upper or lower limit for the diameter range of this fossils since it seems to be polymodal.

Chuaria circularis WALCOTT, 1899
Pl. 1, Figs. 3–6

1894 (unnamed) – WIMAN, pp. 109–113, Pl. V, figs. 1–5.
1899 *Chuaria circularis* WALCOTT nov. g. and sp. – WALCOTT, pp. 234–235, Pl. 27, figs. 12–13.
1941 *Chuaria wimani* n. nom. – BROTZEN, p. 258.
1966 *Chuaria wimani* BROTZEN – EISENACK, pp. 52–55, figs. 1–2.
1969 *Trachysphaeridium vetterni* sp. n. – TIMOFEEV, p. 21, Pl. VI, fig. 3.
1969 *Kildinella magna* sp. n. – TIMOFEEV, p. 14, Pl. VI, fig. 5.
1970 *Kildinella magna* TIMOFEEV – TIMOFEEV, p. 158, Pl. I, fig. D.
1972 b *Chuaria circularis* WALCOTT – FORD & BREED, p. 15–17, Pl. I, figs. 1–6, Pl. II, figs. 1–4.

Original material: Slide V 70–73/1: Z-42/2–4 and BV-3.95/1: G-42.

Description: The vesicle is very thick, single walled, circular to subcircular in outline. The surface is psilate or chagrinate, commonly compressed, showing wide, concentric wrinkles in the marginal areas and narrow, worm shaped wrinkles in the central parts. The colour is dark red-brown or black. The diameter range is polymodal. The complete specimens found in the present material range 98–200 microns in diameter. Fragments indicating diameter ranges up to 3000 microns were also encountered.

Remarks: Papers recording *C. wimani* have been listed elsewhere in this paper. Recently, FORD & BREED (1972 b) reviewed the literature dealing with the genus *Chuaria.*

Comparative studies of TIMOFEEV's material showed that the species *Kildinella magna* and *Trachysphaeridium vetterni* are synonymous with *C. circularis.* It seems also to be the opinion of FORD & BREED since they proposed to drop or re-define the group Megaspaeromorphida TIMOFEEV. The present author agrees also in considering *C. wimani* as synonym of *C. circularis.* However, the "polygenetic" groupation proposed by FORD & BREED (1972 b) does not agree with the results obtained from the study of hundreds of samples from the Visingsö beds. There is no evidence in this material which could support the loss of diagnostic features in the encountered acritarchs as they grow larger, suggested by FORD & BREED (1972 b, p. 16).

The study of specimens of *C. circularis* from the whole Visingsö beds showed that this fossil has a polymodal diameter range. Wall thickness and smoothness of the surface seem to be constant characters. It was also found that very large (up to 3 mm. in diameter), very thick walled specimens seem to be restricted to dark shales with high contents of detrital organic material, other kinds of microfossils and pyrite. No complete specimens as large as those of the above mentioned dark shales were found in the material from the Lemunda Quarry. However, easily identifiable, very large fragments are very common in these samples. The outline of some of these fragments suggests average diameters as large as 3000 microns. It was also observed that large, thick walled specimens showed imprints and perforations in their cell walls due to pyrite crystals. Structures similar to those observed on specimens of *C. circularis* habe been reported by NEVES & SULLIVAN (1964) in Late Palaezoic palynomorphs of Britain. The structures observed in the present material are simple polygonal cavities, favus or compound faviform cavities and compound cribate cavities (cf. NEVES & SULLIVAN 1964). Almost every specimen of *C. circularis* encountered in this material showed some of these kinds of relique pyrite imprints. Exceptionally, some large fragments of this fossil did not have these structures. In many cases, like that shown in Pl. 1, Figs. 3, 5, the vesicles were absolutely covered by perforations, showing in this way an apparent reticula. This resulted from the perforation of the very thick cell wall by compact aggregates of pyrite crystals growing inside the cell wall. Many aggregates seem to have grown inside a single vesicle, since numerous, more or less sphaerical, blister-shaped cavities can be observed inside the cell wall. These cavities are commonly 2–10 microns in diameter. In many instances, the smallest perforations (1 micron or less) in the surface of the vesicle are confluent. This was probably caused by the elimination of cell wall material between the perforations (cf. NEVES & SULLIVAN 1964). All these features are characteristic of compound cribate cavities originated by pyrite growing inside, very likely precipitated by bacterial activity (NEVES & SULLIVAN 1964).

Occurrence: This species was found in the Lemunda section at 0.74 and 0.84 meters.

C. circularis has been reported from the Galeros Formation (Tanner Member) and Kwagun Formation (Awatubi Member) of the Chuar Group, Grand Canyon (Arizona). The synonymous *Fermoria* has been reported from the Chapoghlu Shale (Iran) and the Vindhyan System (India). The also synonymous *C. wimani* was reported from the dark shales of the upper Visingsö beds (South Sweden). *C. circularis* has also been reported with the name *Kildinella magna* from the Miroedikha beds at the River Miroedikha (Turukhansk) and the upper Visingsö beds (South Sweden). Another synonymous species, *Trachysphaeridium vetterni* was reported from the upper Visingsö beds, the Miroedikha Beds and the Lakhanda Beds at the River Maya (Yakut).

This species seems to be restricted to the Upper Riphean.

Genus ***Trachysphaeridium*** TIMOFEEV (1966) 1969

1959 *Trachysphaeridium* gen. n. 1956 – TIMOFEEV, p. 28.
1966 *Trachysphaeridium* TIMOFEEV, 1959 – TIMOFEEV, p. 36.
1969 *Trachysphaeridium* TIMOFEEV (1956) 1959 – TIMOFEEV, pp. 19–20.
1971 *Menneria Lopukin* gen. nov. – LOPUKHIN, pp. 156–157.

Remarks: The date of the first diagnosis given for this genus is unclear. The type species *T. attenuatum* was described as a new species by TIMOFEEV (1959). In this paper from 1959 no diagnosis was given for the genus. However, in the same paper TIMOFEEV referred the first diagnosis given for the genus to a paper from 1956. On the other hand, in a paper from 1966 a diagnosis was given by the same author, although the first diagnosis is there referred to his paper from 1959. In a later paper (TIMOFEEV 1969) it seems as if the genus was originally described 1956 and later emended in 1959 (but see above). It may be pointed out that in his paper from 1969 TIMOFEEV gave no reference to a paper from 1956. Apparently, the valid diagnosis for this genus is that published in 1969.
According to LOPUKHIN (1971 a) the type species of the genus *Menneria* LOPUKHIN is *Menneria levis* LOPUKHIN. Since the type species is considered here to belong to the genus *Trachysphaeridium* TIMOFEEV, *Menneria* is synonym of *Trachysphaeridium*.

Trachysphaeridium laminaritum TIMOFEEV, 1966
Pl. 1, Fig. 17

1969 *Trachysphaeridium laminaritum* TIM. – TIMOFEEV, p. 20, Pl. IV, fig. 7.

Original material: Slide K-IV/103–104/2: X-20.
Description: The vesicle is sphaerical, thick and single walled, the surface roughly reticulated. An especially well developed reticula is observed in the largest found specimens. The vesicle is commonly found compressed, showing few narrow wrinkles in the marginal areas. The colour is yellow to brown. The equatorial diameter ranges within the interval 45–100 microns.
Remarks: The diameters given by TIMOFEEV (1966, 1969) range 70–250 microns, diameters between 120–200 microns being most common. These ranges can not be adequately compared with those of the present material, since this species occurs sparsely. In the present material most specimens have a diameter of 100 microns or more.
Occurrence: This species was found in the K-IV borehole at 75–76, 90–91, 91–92, 99–100 and 103–104 meters, respectively. This species has been reported from the Vendian of the *Laminarites* beds of Moldavia, the Syamalin Circle of the Pekin region, the Lower Cambrian "Blue Clay" at the Winter Coast (White Sea) and the Pestrotsvetnaya beds at the River Kenyada (Yakut). According to TIMOFEEV (1966) the stratigraphic range of this species is Vendian to Cambrian. The occurrence of the present species in the Visingsö beds indicate that the stratigraphic range is Upper Riphean to Lower Cambrian.

Trachysphaeridium levis (LOPUKHIN, 1971) comb. nov.
Pl. 1, Figs. 13, 14

1971 a *Menneria levis* LOPUKHIN sp. nov. – LOPUKHIN, p. 157, Figs. 1, 2.
1971 b *Menneria levis* LOPUKHIN – LOPUKHIN, p. 85, Pl. III, figs. 1–3, Pl. IV, figs. 1–3.

Original material: Slide K-IV/60–61: L-23 and K-IV/66–67/2: H-51/1.
Description: The vesicle is single walled, circular to subcircular in outline. The surface is granulated. No excystment structures were observed. The vesicle is commonly found compressed, showing narrow wrinkles in the marginal areas. Undeformed specimens from the upper unit of the Visingsö Beds turned out to be spherical or ovoidal. The colour is yellow, yellow-grey or grey. The equatorial diameter is 30–120 microns.
Remarks: The diagnosis of *Menneria levis* given by LOPUKHIN (1971 a) is remarkably coincident with that given by TIMOFEEV (1969, 1970) for the genus *Trachysphaeridium*. The microphotographs of *M. levis* published by LOPUKHIN show no diagnostic features which may justify the practice of establishing a new genus *Menneria*, of which *M. levis* is the type species. Undoubtedly, this species belongs to the genus *Trachysphaeridium*.
The species *T. levis* (LOPUKHIN 1971 a) comb. nov. occurs sparsely in the present material. On the other hand, this species is very well represented in samples from the middle and lower units, where thousands of very well preserved specimens occur. The average diameter of this species ranges between 30–120 microns. The diameter range given by LOPUKHIN for *M. levis* is 10–100 microns.
Occurrence: *T. levis* was encountered in the K-IV borehole at 50–51, 60–61 and 76–77 meters. The synonymous species *M. levis* has been reported from the Middle Riphean Kokdzhot beds in the Karatau Mountains, Bakairskaya beds in the Talas Mountains, Ashuturukskaya beds in the Terskey Alatau Mountains, and at the lower reaches of the Siberian River Lena. It is also reported from the Upper Riphean Chatkaragayskaya beds in Talas Mountains, Mureskaya Beds in Mongolia and the Pachelma beds in the Russian Platform. All these occurrences indicate a Middle to Upper Riphean stratigraphic range for *T. levis*.

Trachysphaeridium sp.
Pl. 1, Fig. 15

Original material: Slide K-IV/65–66/2: H-24.
Description: The vesicle is single walled and circular to subcircular in outline. The surface is roughly striate. No excystment structures were observed. All the specimens encountered were compressed, showing narrow wrinkles in the marginal areas. The colour is brown or rusty. The equatorial diameter ranges 175–200 microns.
Remarks: This species has an ornamentation dissimilar to all other species of the genus *Trachysphaeridium*. The species has not been found in rocks of the middle and upper units. The species is left under open nomenclature, since the ten specimens encountered are regarded as an insufficient basis for erecting a new species. The ten specimens have an average diameter of 170–200 microns.
Occurrence: This species was found in the K-IV borehole at 56–57, 65–66, 68–69, 71–72 and 90–91 meters.

Trachysphaeridium sp. A
Pl. 1, Figs. 16, 18

Original material: Slide V 70–73/2: E-41/2–4 and U-45/4.
Description: The vesicle is thick, single walled and ovoidal to sphaerical. The surface is finely granulated. No excystment structures were observed. The colour is grey-

yellow. The length axis ranges 55–140 microns, the broad axis 42–75 microns.
Remarks: Very small specimens of this species (30 microns or less), are commonly spherical. Specimens showing residual nuclear material, as well as groups of up to 4 cells found in clusters have been met with in samples from the middle and upper units of the Visingsö beds. The species is preliminarily described here, since it occurs sparsely in the present material. The formal description will be given in a forthcoming paper as numerous well preserved specimens are especially common in the middle upper units.
Occurrence: This species was encountered in the Lemunda section at 0.74 and 0.84 meters. Its distribution in the middle and upper units will be given in a future publication.

Sphaeromorphs of unknown affinity

Sphaeromorphic, psilate and apparently single walled acritarchs are very common in the investigated material. The average diameter of these sphaeromorphs ranges 20–50 microns. They commonly show impressions of pyrite crystals. In many instances the vesicles are completely perforated. The perforations show rims which at low magnifications are reminiscent of a reticulated sculpture (Pl. 1, Fig 11). These structures are only observed in uncompressed specimens. They are interpreted here as cribate pyrite structures, as described by NEVES & SULLIVAN (1964). Unperforated specimens (Pl. 1, Fig. 12) were also met with. These specimens are psilate sphaeroids with dark-yellow colour, ranging 20–35 microns. They occur often isolated, although, occasionally, two joined sphaeroids were encountered (Pl. 1, Fig. 12). Several sphaeromorphs similar to those described here have been observed by the author in acid resistant residues from low metamorphic Dalslandian, Jothnian and Svecofennian finegrained, sedimentary rocks. The sphaeromorphs are probably identical with the sphaeroids A and B described by VIDAL & RÖSHOFF (1971) from the Svecofennian Vetlanda series of southern Sweden. Very likely, they are also identical with *Polyporata nidia* PICHOVA (cf. PICHOVA 1967, Pl. III, figs. 6, 8) and *P. verrucosa* PICHOVA (cf. PICHOVA 1967, Pl. III, fig. 13), from the Lower Cambrian Bellskaja Formation in the Irkutsk area (eastern Siberia). Further, they seem to be similar with the sphaeromorphs type C and D of LA BERGE (1967), from the Proterozoic of western Australia, and to those described by HOFMANN & JACKSON (1969) as type 2, from the Precambrian (Aphebian) rocks in the Hudson Bay (Canada). Recently, HOFMANN (1972) classed the sphaeroids type 2 of HOFMANN & JACKSON (1969) as dubiofossils.
This kind of sphaeromorphs occurs sporadically throughout the whole Visingsö beds, especially in siltstones from the middle and upper units. Some samples from the lower part of the middle unit consist almost exclusively of these sphaeroids. One of these samples contains more than 234 sphaeromorphs per gram of rock.
Detailed examination of thousands of these sphaeromorphs from rocks ranging in age from more than 1740 m.y. to less than 985 m.y. has not revealed the presence of nuclear material. A coccoid myxophycean affinity can not be excluded. LICARI & CLOUD (1967) have suggested such an affinity for the microfossil *Huroniospora* BARGHOORN and related forms in the Precambrian (Animikian) Gunflint Formation in southern Canada.

Discussion

In the K-IV borehole in the Karlsborg Peninsula, acid-resistant microfossils are restricted to green-coloured siltstones. The filtered residues of the poorly consolidated, fossiliferous layers of the section of the Lemunda Quarry consist mainly of quartz and biotite grains. No pyrite was observed in these sediments, although *Chuaria circularis* and the enigmatic sphaeroids show clear pyrite imprints. These facts may imply that the sediments were originally deposited in a reducing environment. The crystallization of pyrite took place inside the cell walls of these acritarchs causing doming and perforation of the walls. The oxidation of the pyrite probably took place at a very early diagenetic stage of the sediment. This is suggested by the presence of highly compressed specimens of *C. circularis* showing compound cribate structures. The presence of cribate pyrite structures in the wall of the uncompressed enigmatic sphaeroids suggests that oxidation of the pyrite did not take place at a single diagenetic stage of the sediment since the sphaeroids without pyrite structures are found compressed. The red colour of the main part of the sediment could be due to an in situ formation of hematite, through oxidation of iron derived from interstitial alteration of detrital hornblende and/or biotite grains (detrital biotite was observed) (cf. WALKER 1967 a, b).
According to COLLINI (1951) the lithological differences between the basal sandstones and the feldspathic sandstones, arkoses, conglomerates and siltstones in the following units, are due to climatic factors So, according to the same author, the sediments of the middle unit indicate a period of mechanic weathering, probably in a dryer and colder climate than that at the time of deposition of the basal sandstones. Of special interest are the conglomeratic layers, apparently at the top of the sequence present in the Lemunda area (Fig. 1), since they contain large, apparently exotic blocks. It deserves mentioning that marks, "more or less parallel, consisting of shallow grooves, somewhat resembling glacial striation" were described by KAUDERN (1932) from a sandstone surface of the middle unit in the Island of Visingsö. Moreover, the recently published radiometric ages of sediments bellow the Lower Tillite Formation of the Tanafjord Group in Northern Norway (cf. PRINGLE 1973) seem to be in agreement with a glacial origin for the above mentioned rocks of the Visingsö beds.
The similarity of the microfossil assemblages encountered in the rocks of the basal unit with those in rocks of the following units indicates a short time span between the deposition of the basal unit and the following units.
According to TIMOFEEV (1966, 1969), PICHOVA (1967), LOPUKHIN (1971 a, b) and FORD & BREED (1972 a, b), the stratigraphic ranges of the encountered species are mainly Late Riphean and Vendian (Fig. 4). The species *Kildinella sinica* and *K. hyperboreica* are represented in the present material only by a few specimens (less than 10), however, *K. sinica* seems to be of little stratigraphic value. The occurrence in the present material of *Chuaria circularis* is also of interest, FORD & BREED (1972 a, b) found this fossil in rocks of the Galeros Formation (Tanner Member) and Kwagun Formation (Awatubi Member), of the Chuar Group, Grand Canyon (Arizona). In the opinion of these authors the occurrence in the Chuar Group of the algal stromatolites *Inzeria*, *Baicalia*, and *Boxonia* is suggestive of a Late Riphean age, consistent with radiometric age determinations (cf. FORD & BREED 1972 a).
The radiometric ages published by MAGNUSSON (1960) for a shale of the upper unit of the Visingsö beds are 985 and 1060 m.y. These ages are, as suggested by MAGNUSSON (1960)

too high. Yet unpublished micropalaeontological data from the uppermost part of the upper unit of the Visingsö beds suggests a very Late Riphean age (i.e. Early Vendian), expressed in figures, probably some 650 m.y. The problem of the upper age limit is outside the scope of this paper. However, it may be pointed out that this problem will be difficult to solve in southern Sweden. To the present, there is not any known point where the Visingsö beds are overlain by strata older than Pleistocene. Undoubtedly, there is a major hiatus between the time of deposition of the upper Visingsö beds and that of the Early Cambrian rocks. The lower boundary is not easy to draw either, since this boundary, whenever present, does not solve a crucial problem, i.e. the age relationship between the Visingsö beds and the adjacent Almesåkra beds. As far as known, the Visingsö beds do not overlie the Almesåkra beds at any place. Unfortunately, the lithologies of the Almesåkra beds do not seem to be suitable for micropalaeontological studies. A few shale and limestone samples analysed by the author gave no symptomatic microfossils (only smooth sphaeroids similar to those described above). Much more work needs to be done on this subject in the future.

Radiometric age determinations (K/Ar) of a slate of the Almesåkra beds gave 964 and 848–904 m.y. (cf. MAGNUSSON 1960). The incongruent character of these ages and those obtained for the Visingsö beds is illustrated by the fact that rock fragment of the Almesåkra beds have been encountered in a conglomerate of the Visingsö beds (cf. MUNTHE & GAVELIN 1907).

It seems difficult to draw precise conclusions about the absolute age of the rocks of the basal unit of the Visingsö beds from the data exposed above. However, the knowledge obtained from micropalaeontological investigations in sections through the middle and upper unit suggests a rather low figure. This assumption is also sustained by the similarity of the microfossil assemblages found in the lower and following units. This fact added to the lithological character of most of the basal and middle units, indicative of a rapid sedimentation, seems to be consistent with a very Late Riphean age, probably some 750–800 m.y.

Unfortunately for this kind of investigations, most of the papers dealing with this topic provide inadequate illustrations, which renders difficult the identification of the microfossils shown. Certainly, most of the species described in these papers seem to be synonymous with earlier described taxa. Regrettably, comparisons are rendered very difficult by the low quality of the illustrations provided. It is also regrettable that most of the authors do not give more precise stratigraphical information about the occurrences of the taxa encountered in the studied strata. All these facts render difficult any attempt at detailed biostratigraphy.

In this paper, the term "CBNTA" (sivita), most used by Russian authors, has been translated by beds. In Lexique Stratigraphique International (1956), vol. II, this term is translated by Série. It seems as if this term is used by Russian authors to denominate stratigraphic units of different categories.

Conclusions

From the data presented the following conclusions may be drawn:

(1) The occurrence of microfossils in rocks of the basal unit of the Visingsö beds is restricted to green-coloured silty and clayey layers.

(2) The occurrence of fossiliferous layers in red-coloured beds may indicate that the fossiliferous layers are unoxidated remnants of the original sediment. This assumption is sustained by the presence of pyrite structures in the microfossils encountered in these layers, indicative of deposition in an originally reducing environment. Uncompressed acritarchs showing pyrite structures, occurring in these sediments indicate oxidation at a very Late diagenetic stage.

(3) The similar character of the microfossils assemblages encountered in the basal and following units indicate that the time span between the deposition of the basal and following units was short. This is also suggested by the lithological character of the middle unit, indicative of a rapid deposition.

(4) The stratigraphic ranges of the microfossils met with in the lower unit seem to be in agreement with a very Late Riphean age, possibly some 750–800 m.y. This figure is also consistent with radiometric ages.

Acknowledgements

This investigation was carried out at the Department of Historical Geology and Palaeontology, University of Lund. Professor GERHARD REGNÉLL, Director of the Department made the facilities of the Department available to me. I am deeply grateful to Professor SVEN HJELMQVIST, Head of the Department of Mineralogy and Petrology at the same University for invaluable support. Dr. SVEN LAUFELD, Lund supported my work in every way. He kindly read the manuscript and suggested many improvements. I am obliged to Professor BORIS V. TIMOFEEV, Leningrad who kindly permitted the examination of his collections for comparative purpose. He, as well as Mrs. TAMARA NIKOLAYEVNA and Dr. MARINA B. GNILOVSKAYA helped me with idiomatical problems. Dr. KAJ NILSSON and Engineer HELGE KARLSSON of the consulting company VIAK, kindly provided me with samples of the Karlsborg borehole (K-IV) and gave me unpublished information on borings. Mrs. SIRI BERGSTRÖM has drawn the figures. To all mentioned I perform my sincere thanks.

My visit in the U.S.S.R. was granted by the Russian and Swedish Academies of Science. Financial support was obtained from *Statens Naturvetenskapliga Forskningsråd* (Dnr. 080-019/580 G).

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Plate 1

Fig. 1: *Protosphaeridium laccatum* TIMOFEEV. Oil immersion. Sample V70–73 a, Lemunda Quarry section, 0.84 m., Östergötland, Sweden. Slide V70–73/2:V–22/2–4.

Fig. 2: *Kildinella* sp. Small specimens forming a cluster. Oil immersion. Sample V70–73 a, Lemunda Quarry section, 0.84 m., Östergötland, Sweden. Slide V70–73/1:Z–25/1–2.

Fig. 3: *Chuaria circularis* WALCOTT. Specimen showing pseudoreticulated surface, caused by pyrite imprints. Sample V70–73 a, Lemunda Quarry section, 0.84 m., Östergötland, Sweden. Slide V70–73/1:Z–42/2–4.

Fig. 4: Specimen of *C. circularis* WALCOTT from a shale sample of the upper unit. Sample BV–3.95, Kumlaby borehole, at 3.95 m., Visingsö Island, Sweden. Slide BV–3.95/1: G–42.

Fig. 5: Surface detail of the specimen in Fig. 3 (oil immersion), showing blister-shaped cavity inside the cell wall caused by a pyrite aggregate.

Fig. 6: Surface detail of the specimen in Fig. 4, showing large pyrite perforations on the cell wall.

Fig. 7: *Kildinella hyperboreica* TIMOFEEV. Oil immersion. Sample K–IV/103–104, Karlsborg IV borehole, 103–104 m., Karlsborg, Sweden. Slide K–IV/103–104/1:N–24.

Fig. 8: *Kildinella sinica* TIMOFEEV. Oil immersion. Sample V70–73 a, Lemunda Quarry section, 0.84 m., Östergötland, Sweden. Slide V70–73/1: E-47/4.

Fig. 9: *Kildinella* cf. *vesljanica* TIMOFEEV. Oil immersion. Sample V70–73 a, Lemunda Quarry section, 0.84 m., Östergotland, Sweden. Slide V70–73/1:X–22/2.

Fig. 10: *Kildinella sinica* TIMOFEEV. Oil immersion. Sample K–IV/56–57, Karlsborg IV borehole, 56–57 m, Karlsborg, Sweden. Slide K–IV/56–57/2:M–45/3.

Fig. 11: Sphaeromorphic acritarch? showing pseudoreticulated surface, due to pyrite perforations with well developed rims. Oil immersion. Sample V70–73 a, Lemunda Quarry section, 0.84 m., Östergötland, Sweden. Slide V70–73/2:O–38/1.

Fig. 12: Two joined, psilate sphaeromorphic acritarchs?. Oil immersion. Slide V70–73 a, Lemunda Quarry section, Östergötland, Sweden. Slide V70–73/2:W–25/3.

Fig. 13: *Trachysphaeridium levis* (LOPUKIN) comb. nov. Sample K-IV/60–61, Karlsborg IV borehole, 60–61 m., Karlsborg, Sweden. Slide K–IV/60–61:L–23.

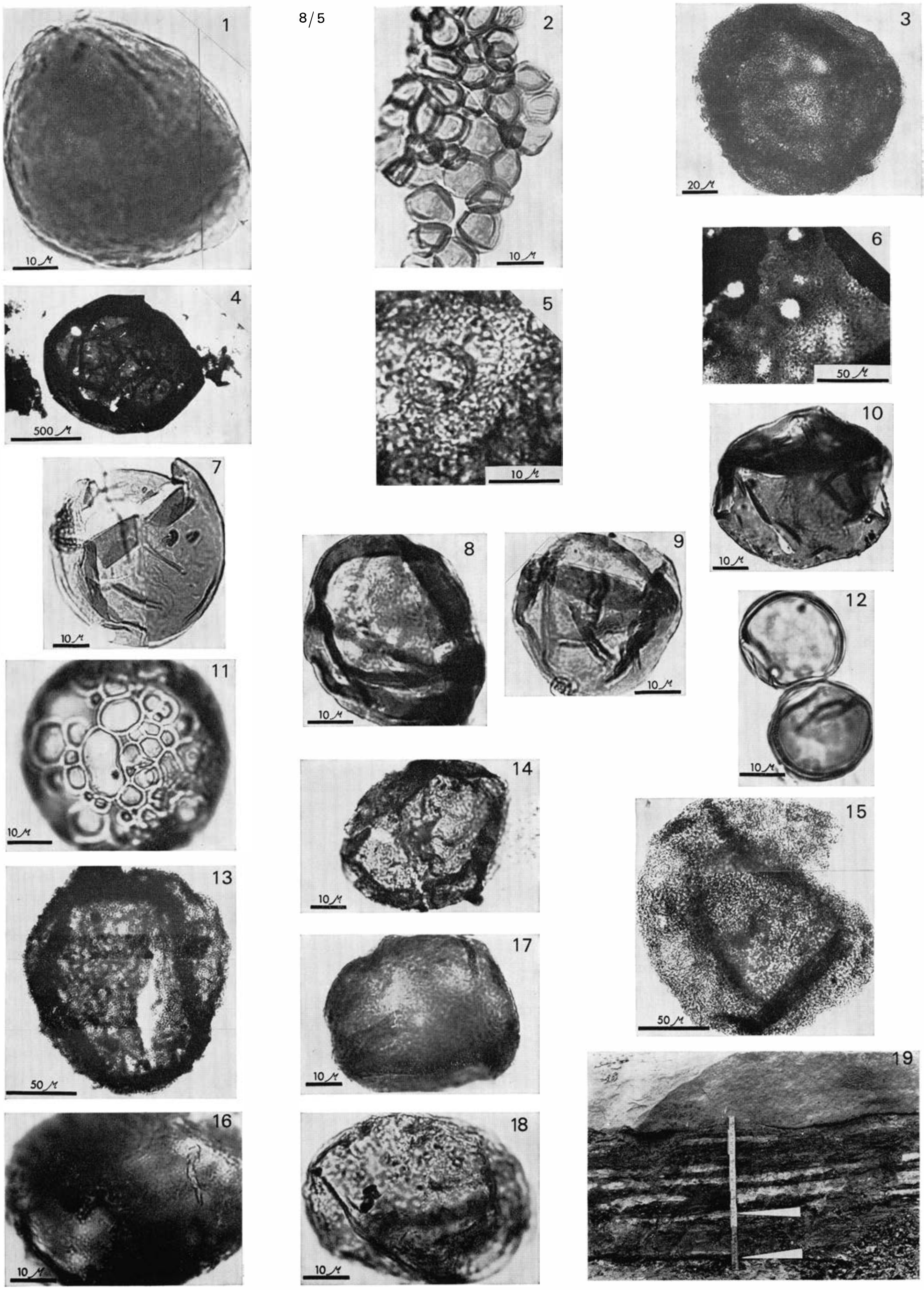
Fig. 14: *Trachysphaeridium levis* (LOPUKIN) comb. nov. Oil immersion. Sample K–IV/66–67, Karlsborg IV borehole, 66–67 m., Karlsborg, Sweden. Slide K–IV/66–67/2: H–51/1.

Fig. 15: *Trachysphaeridium* sp. Sample K–IV/65–66, Karlsborg IV borehole, 65–66 m., Karlsborg, Sweden. Slide K–IV/65–66/2:H–24.

Figs. 16, 18: *Trachysphaeridium* sp. A. Oil immersion. Sample V70–73 a, Lemunda Quarry section, 0.84 m, Östergötland, Sweden. Slide V70–73/E–41/2–4 and U–45/4.

Fig. 17: *Trachysphaeridium laminaritum* TIMOFEEV. Oil immersion. Sample K–IV/103–104, Karlsborg IV borehole, 103–104 m, Karlsborg, Sweden. Slide K–IV/103–104/2:X–20.

Fig. 19: Photograph of the uppermost part of the section at the Lemunda Quarry. Lithological description see text-fig. 2. The white arrows indicate fossiliferous layers.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