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EARLY SILURIAN CHITINOZOANS OF ESTONIA AND NORTH LATVIA

ESTONIAN ACADEMY OF SCIENCES

EARLY SILURIAN CHITINOZOANS OF ESTONIA AND NORTH LATVIA

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Silurian chitinozoans from 31 core sections and 10 outcrops of the Llandoverian and Wenlockian strata of Estonia and North Latvia are discussed. The results of the study of about 2000 samples are assembled, 111 species from 22 genera are described, among these two new genera and fifteen new species. Stratigraphical ranges of all chitinozoan taxa are presented in the lithological logs, 22 local chitinozoan biozones are defined and the East Baltic Llandoverian and Wenlockian sequence is correlated with those of Sweden, Belgium, Canada and other areas. The problems of the palaeoecology of chitinozoans are discussed in relation to the main facies belts of the East Baltic Silurian Palaeobasin and selective facies dependence of taxa.

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Contents

Introduction

Geological background

The location of Estonia in the north-western part of the East European Platform (Fig.1) predetermines its general geological characteristics, among which more important are 1) horizontal bedding of early Palaeozoic rocks; 2) almost complete sequence of Silurian rocks, very rich and diverse in fossils; 3) excellent preservation of the palaeontological material.

The gulf-like Silurian Baltic Basin was characterized by a rather great lateral differentiation of sediments from shallow-water lagoonal dolomites at the margins of the basin, including middle Estonia, up to graptolitic argillites in its axial part, embracing western Latvia and western Lithuania (see H. Nestor 1990).

In middle Estonia (including central Estonia, the western part of Estonian mainland and West Estonian islands, except Sôrve Peninsula) a large variety of limestones, dolomites, marlstones and domerites were formed during the Silurian. At the regressive phases of the basin development (middle Llandovery, late Wenlock), various rocks of shallow-water genesis were widespread, including primary dolomites, skeletal and pelletal grainstones with organic build-ups. These nearshore facies are almost barren of chitinozoans, while the deeper-water bioclastic carbonate rocks (wackestones, packstones) and marlstones, which occurred widely at the phases of relative stability of the basin development, contain chitinozoans in moderate to high frequency.

In Latvia, in the deepest-water axial part of the basin, graptolite-bearing grey, monotonous or dark-brown kerogenous argillites predominate, only in the lower Llandovery there occurred almost barren calcareous mudstones and aphanitic limestones. The occurrence of chitinozoans in these types of rocks is moderate to sparse.

In the transitional zone between these two main confacies belts, in southernmost Estonia and northern Latvia, there dominate different marlstones and mudstones interbedded with micritic (aphanitic) limestones in the lower and middle Llandovery. This was the optimum site for the habitat of chitinozoans. During the transgressive phases of the basin development (late Llandovery and the beginning of the Wenlock), deeper-water facies of the transitional zone migrated farther to the north and spread over the whole middle Estonia.

In the axial part of the basin, Silurian sedimentation took place without any notable hiatuses and the corresponding rather thick sequence is there one of the completest in the world. In the much thinner carbonate sequence of the Middle Estonian Confacies Belt some stratigraphic gaps have been established (Nestor 1976, 1984; Nestor and Nestor 1991).

Fig. 1. Location of the studied boreholes.

The facies-sedimentological model of the Silurian Palaeobaltic Basin, worked out by H. Nestor and Einasto (1977), describing general regularities of the facies zonation, has served as a framework for characterizing the spatial distribution of fossils (Klaamann *et al.* 1980; Kaljo *et al.* 1983). It is also used in the present work to interpret environmental settings of chitinozoan distribution.

As a stratigraphical frame the unified regional correlation chart of the Silurian of the East European Platform (Resheniya ... 1987) is used (Fig. 3). Recently some amendments have been made in the chart (Kaljo 1990; H. Nestor 1993), concerning mainly a more detailed division of the most shallow-water sections of the Raikküla and Jaagarahu stages. As the initial material for this book was studied before these supplements were made, the author could not take them into account, moreover, the changes concern the parts of the sequence containing very little chitinozoans.

Study history

The study of the relatively well exposed Palaeozoic rocks of Estonia began already in the 18th century. However, more outstanding results have been achieved since the second half of the 19th century with the publication of palaeontological monographs on the Ordovician and Silurian fossils of Estonia: trilobites (Nieczkowski 1957; Schmidt 1881–1907), corals (Dybowski 1873–1874), stromatoporoids (Rosen 1867), etc.

The first stratigraphic division of the Estonian Palaeozoic was elaborated by Schmidt (1858–1881). Later essential contributions to the stratigraphy have been made by Twenhofel (1916), Bekker (1922, 1925) and Luha (1930).

In the years after World War II, intensive geological mapping along with subsurface drilling was started on the territories of Estonia and Latvia. At the Institute of Geology of the Estonian Academy of Sciences, a group of palaeontologists was formed for the study of this rich material. Results of the study have appeared in numerous stratigraphical and palaeontological publications, including "The Silurian of Estonia" (1970), "Facies and fauna of the Baltic Silurian" (1977), "Communities and biozones in the Baltic Silurian" (1982), "Ecostratigraphy of the East Baltic Silurian" (1982). Also the regional stratigraphic correlation charts of the East Baltic and East European Platform have been compiled (Resheniya ... 1976, 1987), and as the last most notable work "An Excursion Guidebook. Field Meeting Estonia, 1990" (1990) was published.

The above-mentioned publications serve as a good review on the Silurian geology of Estonia.

The investigation of Lower Palaeozoic chitinozoans in Estonia, as well as in the whole Baltic region, was initiated by Eisenack (1931–1976). He concentrated mainly on the study of Ordovician and Silurian erratic boulders, but dealt also with some rock samples from the outcrops of Gotland and Estonia. Eisenack's work in the Baltic region was continued by Laufeld (1967, 1974, etc.) and Ralf Männil (1970, 1971, 1972, etc.). The latter noted great biostratigraphical

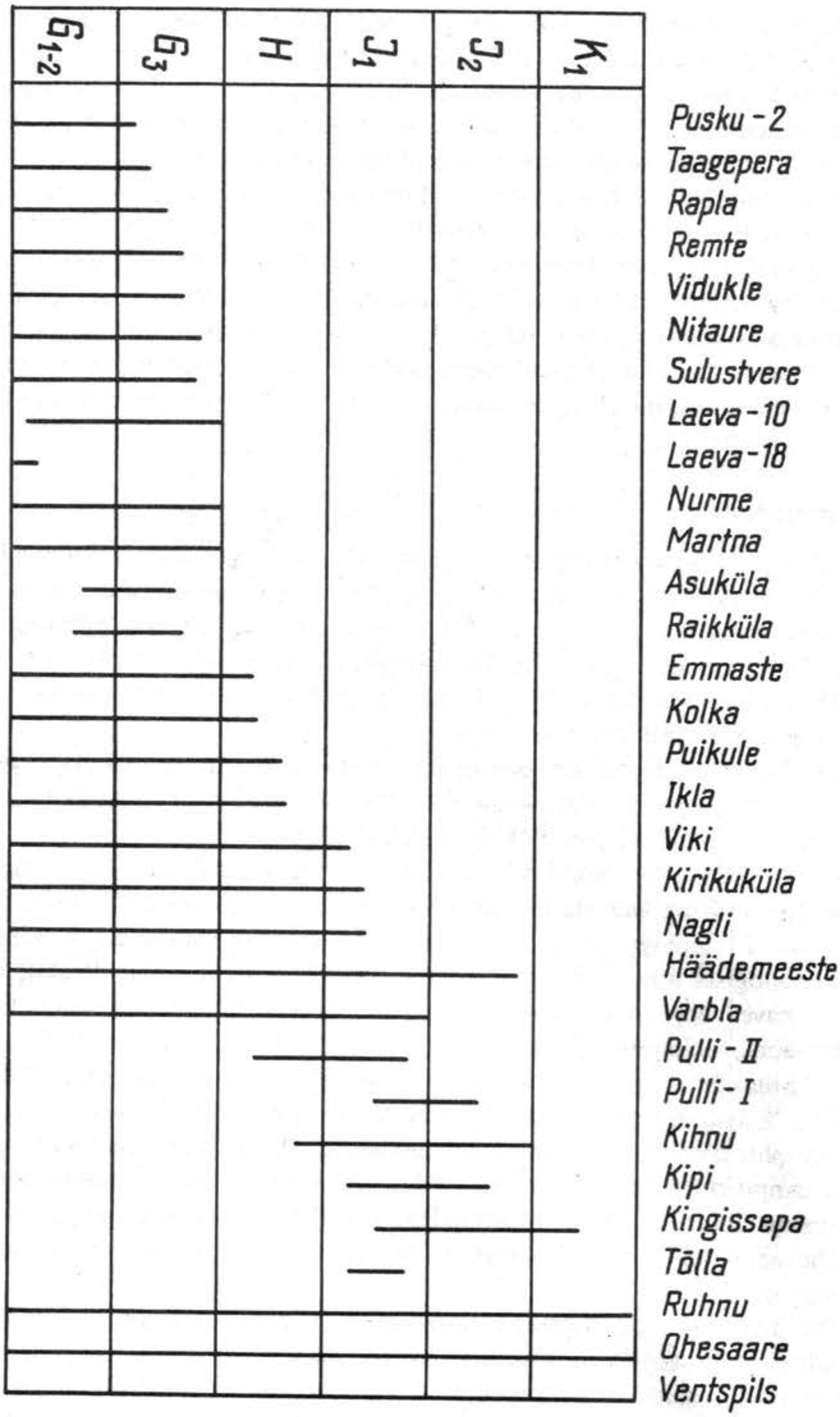

Fig. 2. Stratigraphic position of the studied core sections.

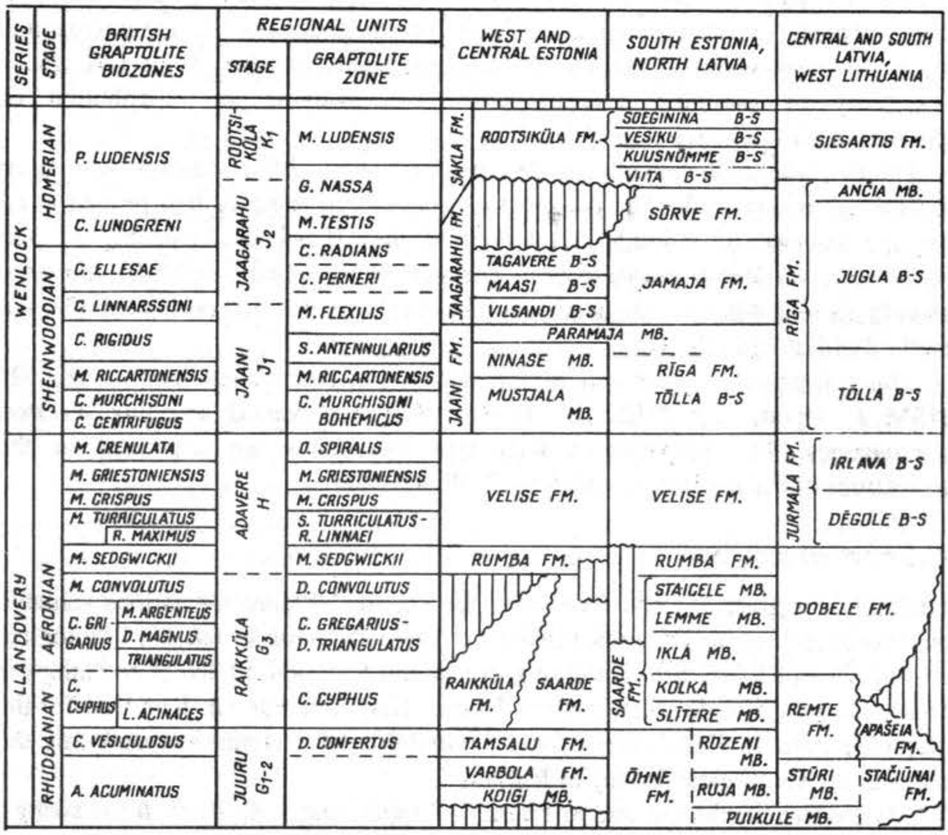

Fig. 3. Stratigraphic chart of the early Silurian of northen East Baltic.

significance of chitinozoans, using them widely for detailed division and correlation of Ordovician sections. The study of Silurian chitinozoans in the East Baltic has been carried on by the present author (Nestor 1976–1993). The main standpoints expressed in the current work were presented already in 1987 as a candidate's thesis in Russian with a short published summary (Nestor 1987).

Material and methods of study

Most of the study material has been collected by the author during field works in the years 1973–1985 from 31 core sections and 10 outcrops. The material comes mainly from the Estonian territory, seven core sections, however, are located in Latvia. Thanks to Rita Ulst and other Latvian colleagues, who showed interest in a more extensive study of the Latvian Silurian sequence, the author had also a possibility of sampling several sections to examine the distribution of chitinozoans in that area (see Figs 1, 2).

On the whole, the results of the study of about 2000 samples have been assembled in this work. The core sections have been sampled bed by bed at an average interval of 1.5–2.5 m, sometimes also 0.5–1 m depending on the lithological variability of the section. The samples weighed 0.3–0.5 kg and were usually dissolved in 15–20% acetic acid, insoluble residue was processed after the method of Laufeld (1974).

The microphotos presented in the book have been taken using "AKASI" MSM–2 (Japan) and "TESLA" BS–300 (Czechoslovakia) scanning electron microscopes. The preparations with type specimens are deposited in the collections of the Institute of Geology, Tallinn, Estonia.

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The author is grateful to her late colleague Dr. Ralf Männil for various valuable recommendations, to Dr. Rein Einasto for the permission to use his lithological descriptions of lower Silurian core sections and for good advice concerning the facies analysis of sediments, to Prof. Dimitri Kaljo and late Dr. Rita Ulst for the graptolite data, to Helle Perens for the possibility of studying and sampling the cores of the Geological Survey of Estonia.

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Systematic palaeontology

General notes

In the present work descriptions of the chitinozoan genera and species are arranged using mainly Paris's (1981) classification, which comprises 14 subfamilies, established by external morphological characters (ornamentation of the vesicle wall, occurrence of appendices, carina, copula, etc.), regarded as evolutionary features. In some cases this has caused the assignment of several similar, sometimes hardly distinguishable genera into different subfamilies, e.g. Conochitina and Belonechitina (see Eisenack 1968, p. 184) or Linochitina and Cingulochitina (see Schweineberg 1987, pp. 31–32).

Nevertheless, among the taxonomic classifications of chitinozoans, this is the most complete and biologically well-grounded one.

Altogether 22 genera and 111 species have been described without using formas and subspecies, as the intraspecific variability of chitinozoan species is still poorly studied. The morphology of chitinozoan vesicles is extremely simple and the number of permanent features is too small to require very detailed classification. Two new genera and 15 new species have been described in this chapter. Some of them occur rarely and are represented by only few specimens, but they have distinctive characters. Rather many taxa were described with open nomenclature as the aim of this work was to show the multitude of different forms of chitinozoans in the East Baltic lower Silurian as fully as possible. These taxa do not fit in the variability of the existing species, but the grounds for their designation as a new species seem insufficient. The open nomenclature was also used in the case of scarcity of the material and its unsatisfactory preservation (see Bengtson 1988). Sometimes additional study is needed.

The descriptions of the taxa are presented as briefly as possible and full synonymy is given only in case of need. Sometimes references have been made to the work containing the most complete synonymy acceptable to the present author.

The measuring of the specimens was carried out as in Laufeld 1974 (p. 6). As the measurements of the vesicles – length (L), width (D), etc. commonly vary greatly even within one sample, it is better not to define species solely on these grounds. In the case of new species there are given the size intervals obtained through the measuring on average of 10 specimens. As for the species described earlier, the dimensions of the studied specimens have been mentioned only when they did not coincide with those of the type material.

The descriptions, which have been published earlier in Russian (Nestor 1980a, b; 1982a, b), are presented here in English in the full scope.

The stratigraphical distribution of the described species is mainly given according to their occurrence in the East Baltic sections. In this work no references are made to the global distribution of species, as data from more distant regions should be treated with caution due to complications by the identification without direct comparison of collections. Therefore only references to the distribution of chitinozoans on Gotland (Laufeld 1974) have been added to the East Baltic data.

As the samples were comparatively large (about 300 g in weight), they were studied without counting every specimen. Therefore only an approximate evaluation of the abundance of the species is given. For example, if the occurrence of a species is marked as "abundant", the collection contains more than a thousand specimens. If no special comment has been made, the estimated number is a few hundreds. The "scarce" occurrence of specimens refers to their number less than a hundred. Ten or less specimens are designated as "rare" ones.

The associated species are not named in the text, but their co-occurrences are shown in all logs (Figs 4–22).

In the descriptions of certain species similar forms (aff., cf.) are sometimes discussed briefly and photos are presented separately.

Description of taxa

Order Operculatifera Eisenack, 1972
Family Desmochitinidae Eisenack, 1931 emend. Paris, 1981
Subfamily Desmochitininae Paris, 1981

Genus *Calpichitina* Wilson et Hedlund, 1964.
Type species: *Calpichitina scabiosa* Wilson et Hedlund, 1964

Diagnosis. Lenticular or subspherical vesicle, width exceeding length; aperture wide, usually without collar; base lacking callus, mucron or other external structures; vesicle wall smooth, spongiose or granulate; chain formation not observed.

Calpichitina acollaris (Eisenack, 1959)
Plate 24, figs 1–2

Synonymy: *Desmochitina acollaris* Eisenack – Laufeld 1974, pp. 75–76. fig. 38 (see synonymy).

Description. The vesicle is small, discoid, without a collar. Its surface is smooth or with characteristic ornamentation (see Laufeld 1974, p. 75). The vesicle wall is thin.

Remarks. In the Ruhnu core section at a depth of 333 m rare specimens were found, similar to *Calpichitina acollaris*, but having a somewhat longer vesicle and wider aperture, here identified as *C.* cf. *acollaris*.

Occurrence. In Estonian sections *C. acollaris* occurs in small numbers in the uppermost part of the Jaani and in the lowermost part of the Jaagarahu stages. Varbla core, depth 93.3–98.4 m; Ruhnu core, 394–417.5 m; Ohesaare core, 303.4–308.3 m; Kipi core, 97–101.1 m and Paramaja cliff.

On Gotland *D. acollaris* ranges from the uppermost part of the Högklint Beds up to the top of the Slite Beds (Laufeld 1974, p. 76).

Genus *Densichitina* Paris, 1981

Type species: *Desmochitina densa* Eisenack, 1962

Diagnosis. Lenticular or subspherical vesicle, width exceeding length; aperture provided with collar; base usually with callus, fixed to operculum of next vesicle; vesicle wall smooth, spongiose or granulate; occurs in chains.

Densichitina densa (Eisenack, 1962)

Plate 24, figs 3–5

Synonymy: *Desmochitina densa* Eisenack – Laufeld 1974, p. 77; fig. 39 (see synonymy).

Description. The vesicle is subspherical or discoid, with a short cylindrical collar and a short callus. The vesicle surface is smooth. Usually occurs in firm chains.

Occurrence. Commonly present in abundance in the Velise Formation of the Adavere Stage and sporadically in the lowermost part of the Jaani Stage. Pulli 2 core, depth 19.2–43.5 m; Ohesaare core, 321(?)–349.5 m; Ruhnu core, 436(?)–481.4 m; Viki core, 149.4–153 m; Varbla core, 144.9–148.6 m; Kirikuküla core, 18.8–27.7 m; Häädemeeste core, 205 m; Tõlla core, 123.5 m; Kipi core, 132.8 m; Ventspils core, 817.5 m; Suuriku cliff.

On Gotland *D. densa* occurs in the Lower and Upper Visby Beds and in the lower and middle parts of the Högklint Beds (Laufeld 1974, p. 77).

Densichitina opaca (Laufeld, 1974)

Plate 24, figs 7–8

Synonymy: *Desmochitina opaca* – Laufeld 1974, p. 79, fig. 42; Verniers and Rickards 1978, pl. 2, fig. 8; Verniers 1982, p. 42, pl. 2, fig. 32.

Description. The vesicle is small, discoid, with a short subcylindrical collar. The vesicle surface is covered with a thick spongy ornamentation. Separate vesicles and short weakly connected chains are common. Cocoons have also been recorded.

Occurrence. Occurs in small numbers in the lowermost part of the Jaani Stage. Ohesaare core, depth 338.2–342.2 m; Ruhnu core, 441.4–454 m; Pulli 2 core, 14.2 m; Ventspils core, 778–782 m.

On Gotland *D. opaca* was encountered in the Upper Visby Beds and in the uppermost part of the south-western, marly facies of the Högklint Beds (Laufeld 1974, p. 80).

Subfamily Margachitininae Paris, 1981

Genus *Margachitina* Eisenack, 1968

Type species: *Desmochitina margaritana* Eisenack, 1937.

Diagnosis. Small discoid, ovoid or subspherical vesicle with convex base; long copula widening downwards and welding tightly to operculum of the next vesicle; occurs in firm chains.

Margachitina margaritana Eisenack, 1937

Plate 31, figs 2–3

Synonymy: *Desmochitina margaritana* sp. n. – Eisenack 1937, p. 221, pl. 15, figs 9–11; *Margachitina margaritana* (Eisenack) – Laufeld 1974, pp. 102–104, fig. 62 (see synonymy)

Description. The vesicle is subspherical or discoid, provided with a copula of variable length, firmly connecting the vesicles with each other. The vesicle wall is smooth or with a characteristic radial sculpture, best developed in the aboral part of the vesicle.

Occurrence. In the East Baltic sections *M. margaritana* occurs abundantly in lower Wenlock beds. Rare finds have been recorded from the topmost Llandovery of some deeper-water mudstone sections (Ohesaare, Ventspils). In the upper part of the Wenlock, particularly in shallower-water carbonate sections (Kipi, Varbla, Kihnu, etc.), this species is scattered, disappearing completely in the upper part of the Sôrve Formation of the Jaagarahu Stage, as well as in the Jugla Beds of Latvia. Varbla core, depth 93-137.5 m; Kirikuküla core, 3.4 m; Häädemeeste core, 196.4–213 m; Kuressaare (Kingissepa) core, 136.8 m; Viki core, 144.5–6 m; Kihnu core, 131.8–196.6 m; Ohesaare core, 167.8–344.5 m; Ruhnu core, 309–459.5? m; Ventspils core, 697–815 m.

According to Laufeld (1974, p. 102), *M. margaritana* ranges through the lower part of the section of Gotland up to the top of the Slite Beds, not occurring in the Slite Siltstone.

Genus *Linochitina* Eisenack, 1968

Type species: *Desmochitina erratica* Eisenack, 1931.

Diagnosis. Small elongate cylindro-ovoid to club-shaped vesicle; operculum attached by medium-sized copula; occurs in chains.

Remarks. The forms, earlier identified in the East Baltic as *Linochitina erratica* (Nestor 1982d, etc.), have usually a very small but visible in the SEM photographs edging, therefore they cannot be considered a constituent part of the genus *Linochitina*.

The problems connected with two genera – *Lino*- and *Cingulochitina* will be discussed below (see genus *Cingulochitina*).

Linochitina odiosa Laufeld, 1974

Plate 30, fig. 3

Synonymy: *Linochitina odiosa* sp. n.. – Laufeld 1974, pp. 100–101, fig. 61.

Description. The vesicle is elongated and club-shaped, the flexure is inconspicuous, the shoulder is missing. The oral part of the vesicle is widened towards the aperture. The copula is well developed, the base highly convex, without the basal edging. The vesicle wall is smooth. Occurs in short chains.

Remarks. In comparison with the type material from Gotland (Laufeld 1974), our specimens are slightly more slender.

Occurrence. Up to now *L. odiosa* has been recorded from the Ventspils core at a depth of 767 m, corresponding to the uppermost part of the Tõlla Beds of the Riga Formation.

On Gotland *L. odiosa* ranges from the Slite "f" unit through the Slite Siltstone (Laufeld 1974, p. 101), i.e. in stratigraphically higher beds than in the Ventspils core.

Genus *Nanochitina* gen. n.

Type species: *Nanochitina nana* sp. n.

Derivation of name: Latinized Greek nanos – small, dwarfish, tiny, referring to the small size of the vesicles of the type species. Named also after my father Villem Nano.

Diagnosis. Small wide subcylindrical or subconical vesicle with flat or concave base provided with copula; basal edge rounded but indistinct; flexure, shoulder and collar poorly or not developed; operculum provided with short thin membrane; vesicle wall smooth; forms fragile chains.

Remarks. The overall shape of the new genus is similar to *Eisenackitina*, but the latter is ornamented and lacks the copula. In the way the vesicles are connected in the chain, the new genus resembles *Linochitina*, but differs completely in the vesicle shape which in *Linochitina* is elongated, tubular or club-shaped.

Nanochitina nana sp. n.
Plate 25, figs 7–9

Derivation of name: Latinized Greek nannos, nanos – dwarf, refers to smallness of the vesicles of this species.

Holotype: Ch 387/1962, Ohesaare core, depth 343.75 m, Jaani Stage.

Diagnosis. Very small subcylindrical vesicles with flat or concave base, provided with thin short copula; vesicle wall smooth or roughened; occurs singly or in short chains.

Description. The vesicle flanks are straight or slightly convex, gently narrowing toward the aperture which is wide and smooth, usually without a collar. The flexure and shoulder are lacking or inconspicuous. The basal edge is broadly rounded, the base is flat or concave, provided with the copula. The fine stem of the copula is fragile and breaks easily, but short chains are common. The greatest width is between the basal edge and the middle of the vesicle. The length/width ratio is approximately equal to one. The vesicle wall is smooth or roughened.

Dimensions (in µm): length 60–90 (holotype 70), maximum width 60–95 (holotype 65).

Discussion. The overall shape of this species is similar to *Eisenackitina* sp. 1, but the latter lacks the copula and chains are not observed.

Occurrence. *Nanochitina nana* occurs in the upper part of the Adavere Stage, in the topmost Velise Formation and in the Irlava Beds of the Jurmala Formation. In deeper-water sections it is also recorded in the lowermost part of the Tõlla Beds of the Jaani Stage. Ohesaare core, depth 336.8–348 m; Ruhnu core, 448.5–459.2 m; Häädemeeste core, 210 m; Ventspils core, 791–812 m; Nagli core, 609.1–617 m.

Material. In the collection about 150 specimens.

Subfamily Eisenackitininae Paris, 1981

Genus *Eisenackitina* Jansonius, 1964

Type species: *Eisenackitina castor* Jansonius, 1964.

Diagnosis. Small subcylindrical, ovoid or slightly conical vesicle with flat or convex base, neck reduced to narrow collar; aperture wide, operculum simple; vesicle wall ornamented with spines or tubercles; chain formation rare.

Remarks. Some forms in our material may have a slightly concave base.

Eisenackitina dolioliformis Umnova, 1976
Plate 25, figs 1–4

Synonymy: *Conochitina oelandica silurica* Taugourdeau – Cramer 1967, p. 91, pl. 2, figs 37, 38, 42, 44; Cramer 1973, pl. 2, figs 17, 23; *Conochitina* n. sp. 1 – Laufeld 1971, p. 295, pl. 1, fig. D; *Eisenackitina dolioliformis* Umnova 1976, p. 31, pl. 2, figs 20, 21; *Eisenackitina* sp. A – Verniers 1982, p. 43, pl. 5, figs 89–92; *Eisenackitina* sp. C – Verniers 1982, p. 44, pl. 5, figs 103–105, 117–118, pl. 6, figs 120–121; *Eurychitina latiuscula* n. sp. – Tsegelnyuk 1982, p. 41, pl. 3, figs 9–11; *Eisenackitina* aff. *E. dolioliformis* – Asselin, Achab and Bourque 1989, pl. 4, figs 3, 4.

Description. The vesicle is wide, subcylindrical, with slightly convex flanks. The neck is reduced, flexure and shoulder somewhat convex, the base is flat or slightly convex, common is a wide short mucron. The basal edge is broadly rounded, the aperture is wide. The vesicle surface is granulate or tuberculate, but also almost smooth vesicles are encountered.

Dimensions (in µm): length 120–260; greatest width 90–170.

Occurrence. *E. dolioliformis* is abundant in all studied upper Llandovery and lower Wenlock sections.

It should be noted that Umnova (1976) has described this species from the Virtsu core (depth 38.6–41 m) of western Estonia.

Kirikuküla core, depth 1.3–49.3 m; Varbla core, 125–157.5 m; Häädemeeste core, 210.5–230.8 m; Viki core, 142.2–190.4 m; Pulli 2 core, 27.5–60 m; Kihnu core, 187.3–201 m; Ruhnu core, 441.5–489.2 m; Ohesaare core, 332.5–372.2 m; Ikla core, 305.6–313.8 m; Kipi core, 138 m; Tôlla core, 122–127 m; Kolka core, 601.8–602 m; Nagli core, 609.1–645.5 m; Ventspils core, 784.5–852 m.

Eisenackitina lagena (Eisenack, 1968)
Plate 14, figs 9–11; Plate 15, figs 1–2

Synonymy: *Conochitina lagena* – Eisenack 1968, p. 285; pl. 26, figs 2–5; pl. 29, figs 21–22, text-fig. 9; *Conochitina brevis brevis*? Taugourdeau and Jekhowsky 1964 – Verniers 1982, p. 31, pl. 3, figs 46–50.

Description. The vesicle is wide, conical or subconical, with more or less convex flanks and base. The neck is short or missing. The greatest width is usually noticed somewhat oralward of the broadly rounded and indistinct basal edge. The vesicle constricts sharply towards the smooth and straight, usually slightly widened aperture. The mucron is short, wide, callus-like or missing. The vesicle wall is covered with spongy ornamentation which, depending on the degree of degradation, may be fine reticulate, rugate, granulate or nearly smooth.

Remarks. Like Eisenack (1968, p. 285, pl. 26, figs 2–5), we treat this species sensu lato – it has more or less convex flanks and the base carrying a short mucron or lacking it. It should be noted that one specimen from the original population of

E. lagena, figured by Eisenack in pl. 26 (fig. 2), resembles the holotype of *Conochitina gutta* (Laufeld 1974, Fig. 25B). Our material is mostly represented by vesicles, in shape resembling the holotype of *E. lagena*. Vesicles identical to *C. gutta* have not been found, but there still occur similar forms. Compared to *E. lagena*, *C. gutta* is somewhat more elongate, having a short neck. Both species occur in the sections of Estonia and Gotland in the same stratigraphic interval.

In the Ventspils core section, on the level of the *nilssoni* Zone, there are encountered the forms, so far identified as *C.* cf. *lagena* (see Nestor 1982, pp. 92–93). However, the well-preserved material is too scanty to state their identity with *C. lagena*.

Occurrence. *E. lagena* occurs in the middle of the Jamaja Formation and Jugla Beds of the Jaagarahu Stage. In the Ohesaare core we can establish a distinct zone of this species. In other sections it occurs more sporadically and the most marginal finds are sometimes taxonomically problematic. Ohesaare core, depth 250–270 m; Ruhnu core, 347–365 m and 383.5(?) m; Häädemeeste core, 150 m; Ventspils core, 699–738 m.

Eisenackitina sp. 1
Plate 25, figs 5–6

Synonymy: *Eisenackitina* sp. B – Verniers 1982, p. 43, pl. 5, figs 98–100.

Description. The vesicle is small, subcylindrical or slightly conical, with a flat, weakly convex or concave base. The basal edge is rounded. The aperture is wide, sometimes a narrow collar is distinguished. The length of the vesicle is 90–100 µm, the length/width ratio approximately 1:1. The vesicle wall is usually granulate or micro-verrucate.

Remarks. *Eisenackitina daozhensis* Geng, 1986 from the lowermost Telychian of China is longer (123–157 µm) and its maximum diameter is at the basal margin. *E. bayuensis* Geng is more conical and its vesicle wall is smooth. *E. dolioliformis* Umnova is longer (141–255 µm), having a length/width ratio 2:1 and a short mucron at the base.

Occurrence. *E.* sp. 1 is abundant in the uppermost part of the Adavere Stage, in the Velise and Jurmala formations, also in the lowermost part of the Tôlla Member of the Jaani Stage predominating in deeper-water sediments. Ventspils core, depth 791–840.5 m; Ohesaare core, 332.6–360.8 m; Ruhnu core, 448.7–471 m; Pulli 2 core, 25.5–40.6 m; Nagli core, 609.1–625 m; Viki core, 141.3–173.6 m; Kirikuküla core, 19.3–27.6 m.

Eisenackitina? sp. 2
Plate 24, figs 1–3

Description. The vesicle is small and conical, usually the width (80-130 μm) exceeds the length (80-110 μm). The vesicle base is concave and the basal edge is broadly rounded. The vesicle walls are strongly constricted oralward, but the collar is not developed. The vesicle wall is covered with a thick spongy ornamentation, from which in the result of abrasion only some irregularly placed spinose fragments may have remained.

Occurrence. *E.*? sp. 2 occurs only as scarce specimens in the Velise and Jurmala formations of the Adavere Stage. Ventspils core, depth 830 m; Nagli core, 609-625 m; Pulli 2 core, 47.7 m.

Eisenackitina? sp. 3
Plate 26, fig. 4

Description. The vesicle is subcylindrical, with a convex base and wide aperture. The length of the vesicle is 140-180 μm, the length/width ratio is about 1.5:1. The vesicle surface is smooth.

Remarks. By its smooth vesicle wall this species fits better to the genus *Bursachitina*, but the lack of the mucron and chain formation contradicts to it.

Occurrence. *E.*? sp. 3 occurs only as rare specimens in the middle Llandovery of the Raikküla Stage, in the Ikla and Lemme members. Ruhnu core, depth 530.4-533 m and 502.9 m; Ikla core, 386 m; Häädemeeste core, 311.4 m; Puikule core, 401.4 m.

Eisenackitina? sp. 4
Plate 26, fig. 5

Description. The vesicle is small (60-80 μm), subconical, with weakly convex flanks and a concave base. The length/width ratio is about 1:1. The vesicle surface is smooth.

Remarks. The same as in *Eisenackitina*? sp. 3.

Occurrence. *E.*? sp. 4 occurs in small numbers in the uppermost part of the Jaagarahu Stage in the Sôrve Formation and in the uppermost beds of the Siesartis Formation. Ohesaare core, depth 169.5-171.6 m; Ventspils core, 662-667 m.

Subfamily Pterochitininae Paris, 1981

Genus *Pterochitina* Eisenack, 1955

Type species: *Bion perivelatum* Eisenack, 1937.

Diagnosis. Lenticular or hemispherical vesicle with membraneous carina surrounding chamber at about shoulder; neck, collar, collarette and basal structures (mucron, callus, scar) not developed.

Pterochitina macroptera Eisenack, 1959

Plate 31, figs 5–6

Synonymy: *Pterochitina macroptera* sp. n. – Eisenack 1959, p. 17, pl. 2, figs 10, 11; Eisenack 1964, p. 327, pl. 30, fig. 12.

Description. The vesicle is hemispherical, with a convex base and wide membraneous carina on the oral half of the vesicle near the shoulder. The aperture is smaller than the vesicle diameter. Chains are not observed. The vesicle wall is smooth.

Occurrence. Scarce specimens of *P. macroptera* have been recorded from the lower half of the Jaani Stage. Kipi core, depth 130.1 m; Pulli 1 core, 17.6-29.5 m; Pulli 2 core, 10.5 m; Suuriku and Ninase outcrops. The species occurs also in the Varbla core, depth 156 m (uppermost Rumba Formation of the Adavere Stage).

Genus *Cingulochitina* Paris, 1981

Type species: *Desmochitina cingulata* Eisenack, 1937.

Diagnosis. Short ovoid to conical vesicles with flat or convex base, provided with short copula; basal edge marked by short edging or membraneous carina; occurs in chains.

Remarks. *Cingulochitina* was separated from the genus *Linochitina* (Eisenack 1968) and extensively used after its erection by Paris in 1981, as the taxon is widely distributed in the Silurian and Devonian sediments all over the world. Nevertheless, some problems remain open to discussion. Firstly, it is still not definitely proved whether the type species of *Linochitina* – *L. erratica* (Eisenack 1931, p. 92,pl. 3, fig. 6 – holotype; Eisenack 1962, p. 307, pl. 17, fig. 11 – neotype) lacks the short edging or not, as Eisenack has photographed only silhouettes of the vesicles using low magnification. Secondly, there occur a number of transitional forms between the ones with the aboral edging and those without it. Eisenack (1968, p. 171) and Schweineberg (1987, p. 41) have pointed out the difficulties connected with the identification of such forms. It seems hardly reasonable to ascribe them to different families. Abundant material, studied on the genus *Cingulochitina* in the East Baltic Wenlock sections, has revealed high variability of the vesicle shape, basal edging and carina, but the forms without any kind of edging seem to be extremely rare.

Cingulochitina cingulata (Eisenack, 1937)
Plate 29, figs 1–4

Synonymy: *Desmochitina cingulata* sp. n. – Eisenack 1937, p. 220, pl. 15, figs 6–7; *Linochitina cingulata* (Eisenack) – Laufeld 1974, p. 97, fig. 57 (see synonymy); *Cingulochitina cingulata* (Eisenack) – Verniers 1982, pl. 6, fig. 122; pl. 7, figs 148, 157–169.

Description. The vesicle is small, subcylindrical or conical, with more or less convex flanks and flat or slightly convex base. The neck is widened towards the aperture. The basal edge is provided with a membraneous cingulum of variable width. The vesicles form firm chains by means of a short copula.

Occurrence. *C. cingulata* occurs abundantly only in deeper-water sections in the Jamaja Formation and Jugla Beds, but also sporadically in the lower part of the Sôrve Formation of the Jaagarahu Stage. Ohesaare core, depth 241–299.8 m and 183–198 m; Ruhnu core, 329.3–413.3 m; Ventspils core, 708–754 m.

On Gotland *C. cingulata* makes its appearance in Slite "f" unit and in the north-western part of the Slite Marl, ranging to the top of the Mulde Beds (Laufeld 1974, p. 97).

Cingulochitina baltica sp. n.
Plate 30, figs 1–2

Synonymy: *Linochitina erratica* (Eisenack, 1931) – Laufeld 1974, p. 93, fig. 59; Nestor 1982c, pl. 17, fig. 3.

Derivation of name: After the Baltic region.

Holotype. Ch 152/1959 (the lowermost vesicle of the chain), Ohesaare core, depth 245.6 m, Jaagarahu Stage.

Diagnosis. Small subconical vesicle with gently curved flanks and convex base, which carries fragile tube-like copula; basal edge provided with short and narrow, but distinct edging.

Description. The chamber is not distinguished from the neck, which widens towards the aperture. The flexure is generally inconspicuous and the shoulder is lacking. The broadly or bluntly rounded basal edge bears short and narrow, sometimes hardly distinguishable edging. The vesicle wall is thin and smooth, usually covered with faint concentric striation. Chains as well as separate vesicles are common.

Dimensions (in µm): total length 100–130 (holotype 115), maximum width 40–60 (holotype 50).

Remarks. Because of the thin vesicle wall the specimens of *C. baltica* are usually flattened, therefore it is sometimes rather difficult to distinguish them from *C. cingulata*. Generally, the vesicle of *C. baltica* is more slender (L/D=2–2.5), the small aboral edging is not membraneous and is shorter than in *C. cingulata*. Earlier (Nestor 1982c) we supported the view of Laufeld (1974, pp. 99–100), identifying this species as *Linochitina erratica* (Eisenack).

From *C. wronai* (Paris and Kříž 1984, p. 167) our species differs in a more rounded basal edge and vesicle flanks, also in the vesicle shape, which in *C. wronai* is subcylindrical and generally more slender (L/D=3.23).

Occurrence. *C. baltica* is abundant in deep-water sections of the middle-upper part of the Jamaja and Sôrve formations and in the Jugla Beds of the Jaagarahu Stage. Scattered specimens have been encountered in the Siesartis Formation of the Rootsiküla Stage. Ohesaare core, depth 179–253 m; Ruhnu core, 262.8–286.5 m; Ventspils core, 663–736 m.

On Gotland this species was recorded from the Wenlock part in the lowermost Halla and Mulde beds (Laufeld 1974, p. 100).

Material. In the collection more than 1000 specimens.

Cingulochitina crassa sp. n.
Plate 29, figs 5–9

Derivation of name: Latin "crassus" – stout, corpulent, plump, referring to the wide chamber of this species.

Holotype: Ch 407/9458 (the uppermost vesicle in the chain), Ventspils core, depth 708 m, Jaagarahu Stage.

Diagnosis. Small subconical vesicle with highly convex flanks and base and gently curved flexure; shoulder is absent; neck widens abruptly towards aperture; basal edge provided with very short inconspicuous edging; vesicle wall smooth or carries very fine rugose ornamentation.

Description. The vesicle is wide (L/D=1.3–1.6:1) with convex flanks and a broadly rounded basal edge. The base is convex, provided with a short copula and encircled by a very short edging, almost invisible under the ordinary binocular microscope. The aperture is wide, the oral margin wave-like expanded. The fine rugose ornamentation is better developed on the aboral part of the vesicle. Twins and chains are common.

Dimensions (in μm): total length 75–160 (holotype 80), maximum width 45–90 (holotype 50).

Remarks. *C. crassa* is similar to *C. convexa* (Laufeld 1974), which occurs in the Hemse Beds on Gotland, but differs from the latter in a more stout vesicle shape (in *C. convexa* L/D>2), chain formation and fine rugose ornamentation, which are lacking in *C. convexa*.

Occurrence. *C. crassa* is abundant in the upper part of the Jamaja and the lower part of the Sõrve formations, also in the upper part of the Jugla Beds of the Jaagarahu Stage. Sporadic finds come from the Siesartis Formation of the Rootsiküla Stage. Occurs in deeper-water sections. Ohesaare core, depth 206.8-229.3 m; Ruhnu core, 326.6-346.4 m; Ventspils core, 663-718 m.

Material. Over 1000 specimens.

Order Prosomatifera Eisenack, 1972
Family Conochitinidae Eisenack, 1931
Subfamily Conochitininae Paris, 1981

Genus *Conochitina* Eisenack, 1931

Type species: *Conochitina claviformis* Eisenack, 1931.

Diagnosis. Elongated-conical or subcylindrical vesicle with rounded basal edge; flexure and shoulder weakly developed or lacking; in the middle of flat or convex base there are mucron, callus and scar or one of these elements; vesicle wall smooth, roughened, spongy, granulate or microverrucate.

Remarks. Verrucate, granulate and spongy types of ornamentation of the vesicles are all quite common in the East Baltic Silurian. They show a large scale of variations, including smooth forms, which may be observed in the limits of one species. The main cause of this phenomenon can be related to degradation and maceration processes of chitinozoan vesicles (Urban 1972).

Conochitina acuminata Eisenack, 1959

Plate 10, figs 1–2

Synonymy: *Conochitina acuminata* Eisenack – Verniers 1982, p. 28, pl. 4, figs 74–82 (see synonymy).

Description. The vesicle is small, conical, with a convex base and rounded cone-like mucron in the centre. The flexure is missing or poorly developed. The oral part of the vesicle widens slightly. The aperture is wide. The vesicle walls are sometimes a bit constricted immediately above the basal edge. The vesicle surface is covered with lanate ornamentation which is seen only at great magnifications.

Remarks. Scarce specimens, resembling *C. acuminata*, coming from the Adavere Stage from the Irlava Beds, Ventspils core, depth 798.6 m and Nagli core, depth 615.3 m, are named here *C.* aff. *acuminata*. Their poor preservation does not allow to state their identity with *C. acuminata*.

Occurrence. Occurs rarely in the Llandovery-Wenlock boundary beds in the uppermost part of the Velise Formation and in the lowermost part of the Tõlla Beds and Mustjala Member of the Jaani Stage. Ruhnu core, depth 465.4 m; Viki core, 140.2 m; Ohesaare core, 342–352 m. In the sequence of Gotland *C. acuminata* is found in the Lower and Upper Visby beds (Laufeld 1974, p. 59).

Conochitina argillophila Laufeld, 1974
Plate 10, figs 5–6

Synonymy: *Conochitina argillophila* sp. n. – Laufeld 1974, p. 59, fig. 22; Nestor 1982a, pl. 17, fig. 6; pl. 20, fig. 2.

Description. The vesicle is conical, with a convex base having a low callus and basal scar. The vesicle walls are more or less constricted immediately above the rounded basal edge. The aperture is wide. The surface is smooth or lanate (felt-like).

Remarks. Compared to type material, the length of the vesicle is more variable in our specimens. Apart from short specimens (150–170 μm), in Estonian sections there occur also longer ones (250–270 μm).

More slender specimens found from the uppermost part of the Jaagarahu Stage were identified as *C.* cf. *argillophila* (see Pl. 10, figs 7–8).

Occurrence. *C. argillophila* occurs in the Jamaja Formation and in the middle of the Jugla Beds of the Jaagarahu Stage. Ohesaare core, depth 250–262 m; Ruhnu core, 359 m; Kihnu core, 131–142 m; Ventspils core, 726–728 m.

C. cf. *argillophila* has been found in small numbers in the uppermost part of the Jaagarahu Stage in the Sôrve Formation and partly in the Jaagarahu Formation, also in the Siesartis Formation of the Rootsiküla Stage. Ohesaare core, depth 160–174 m; Ruhnu core, 288–294 m; Ventspils core, 679 m.

In the sequence of Gotland (Laufeld 1974, p. 59), *C. argillophila* is recorded from the upper half of the Slite Beds.

Conochitina claviformis Eisenack, 1931
Plate 11, figs 1–12

Synonymy: *Conochitina claviformis* – Eisenack 1934, p. 84, pl. 1, fig. 17; Eisenack 1968, p. 159, pl. 25, figs 5–8, text-fig. 2; *Conochitina proboscifera* – Taugourdeau and Jekhowsky 1964, pl. 3, fig. 24; *Conochitina* cf. *armillata* – Taugourdeau and Jekhowsky, 1964, pl. 4, figs 33, 34; *Conochitina* aff. *proboscifera* – Laufeld 1974, p. 72, fig. 35A; ? *Conochitina pachycephala* – Laufeld 1974, figs 31D, E; ? Schweineberg 1987, p. 44, pl. 3, figs 12–15; ? *Conochitina leptosoma* – Laufeld 1974, fig. 29-B; ? Paris 1981, p. 182, pl. 19, figs 15–17.

Description. The vesicle is elongated-conical or subcylindrical, without or with a very weakly developed flexure. The base is usually flat, sometimes slightly convex or concave, the basal edge is bluntly rounded. In the centre of the base there is a short mucron which may be hidden in the specimens with a concave base, sometimes it may be missing. Short callus is rarely present. The vesicle flanks are straight, the surface is smooth.

Remarks. *C. claviformis* is the most similar to *C. tuba* and *C. pachycephala*. *C. tuba* is shorter and the length/width ratio of the vesicle is smaller (3:1 to 4:1 – 8:1). *C. pachycephala* has a convex base, broadly rounded basal edge, wide mucron and flanks, constricted above the basal edge. It differs from *C. proboscifera* in the shape of the vesicle but mostly in a thinner vesicle wall (see also Eisenack 1968, p. 145, figs 2, 3).

C. claviformis was described by Eisenack (1931, 1968) from the erratic boulders (Graptolithen-Gestein) containing graptolites (mostly *Retiolites* sp. – Eisenack 1931, p. 76), which does not allow to establish their exact level in the graptolite scale. Neotype of *C. claviformis* occurs together with the species *E. lagena* (Eisenack 1968, pp. 159, 165, 189). In East Baltic sections these species are concurrent in the lower half of the upper Wenlock (mostly in the *C. perneri* Zone) and in the lowermost Ludlow, in the *N. nilssoni* Zone (together with *E.* cf. *lagena*, see Nestor 1982d). Due to such a wide stratigraphic range, the species is greatly variable, but there are scarcely sufficient criteria for its subdivision. In this work *C. claviformis* is treated in conformity with Eisenack's presentation (Eisenack 1968, p. 159).

It should be noted that *C. claviformis* is a dominant species. Only in the uppermost part of the Jamaja Formation and the lowermost part of the Sõrve Formation, in the Ohesaare and Ruhnu core sections, and in the middle of the Jugla Beds in the Ventspils core section (see Fig. 21), there are intervals where *C. claviformis* is practically missing or is represented by rare uncharacteristic specimens (see also Nestor 1982c, 1982d).

Occurrence. *C. claviformis* occurs in all studied sections from the uppermost part of the Mustjala Member and Tõlla Beds or the lowermost beds of the Ninase Member of the Jaani Stage up to the lowermost part of the Rootsiküla Stage in the sections of southern Estonia. In deeper-water sections (Ventspils core), this species occurs in the lowermost part of the Paadla Stage. Ohesaare core, depth 142–331 m; Ruhnu core, 283–438 m; Ventspils core, 663 (540)–778 m; Häädemeeste core, 131–201 m; Varbla core, 90–125 m; Kuressaare (Kingissepa) core, 107–141 m; Kihnu core, 127–191 m; Pulli 2 core, 5–18 m; Kipi core, 87–25 m; Tõlla core, 117–125 m; Paramaja cliff, Ninase cliff, Suuriku cliff.

It is most likely that *C. claviformis* occurs also in the Wenlock sequence (see synonymy) of Gotland, beginning with the upper part of the Högklint Beds.

Conochitina cribrosa Nestor, 1982

Plate 12, figs 1–4

Synonymy: *Conochitina cribrosa* sp. n. – Nestor 1982a, pl. 1, figs 4–5, pl. 2, figs 1–3.

Description. The vesicle is conical to subconical, with straight flanks and a rounded basal edge. The shape of the vesicle is variable, the base may be concave, flat or slightly convex, usually without a mucron, having a basal scar in the centre. Sometimes the base bears a mucron of variable shape and dimensions. The vesicle walls are usually straight, widening at the aperture, but there occur also specimens with slightly convex flanks. The flexure is not developed. The aperture is straight and smooth. The ornamentation of the vesicle is finely reticulate. The net is coarser at the basal margin and finer at the aperture. The central part of the base lacks ornamentation.

Dimensions (in μm): vesicle length 160–280, maximum width 70–100, smallest width 50–70. L/D=2:1 to 3:1. Diameter of separate loops of the reticulate ornamentation is 1–3 μm.

Remarks. *Conochitina cribrosa* occurs together with *C. tuba* resembling it in shape. Typical forms of *C. tuba* have a mucron, but *C. cribrosa* has usually a concave base. Preservation of ornamentation is different in *C. cribrosa*. Sometimes a part of the reticulum is broken or worn out and only irregular fine spines occur on the surface. Describing *C. tuba*, Eisenack (1962, p. 295) assigned to this species also specimens with up to 2 μm high fine spines. They might have been specimens of *C. cribrosa* with partly preserved ornamentation. Like Laufeld (1974, p. 73), we include in *C. tuba* only the specimens with a smooth vesicle wall.

Occurrence. Occurs abundantly in the upper half of the Sôrve Formation of the Jaagarahu Stage. Ohesaare core, depth 161–192 m; Ruhnu core, 288–325 m; Ikla core, 183–205 m; Kolka core, 425–466 m, and in the upper part of the Jugla Beds in the Ventspils core, 689–693 m.

Conochitina edjelensis Taugourdeau, 1963 s. l.
Plate 12, figs 5–9

Remarks. *Conochitina edjelensis* and its subspecies *C. e. elongata* (later treated as different species) were first described by Taugourdeau (1963) from the middle and upper Llandovery beds of Sahara occurring there frequently or very frequently. Cramer (1967) described another subspecies (later species) *C. e. alargada* from the Llandovery beds of northern Spain. He treated all these forms as one complex taxon as they occur together in the same stratigraphic interval and are hard to distinguish due to variability.

A similar complex of forms has been recorded from the middle Llandovery beds of the East Baltic, mostly differing from the previous one in greater dimensions (Nestor 1980b, p. 140). The Estonian specimens are also highly variable and different (sub)species occur simultaneously in one section. All these (sub)species have a chamber, slightly widening to the side of the base, and a wide aperture. The outer surface of the vesicle is smooth. It should be noted that comparing Silurian chitinozoans of Sahara and Gotland Island, Taugourdeau and Jekhowsky (1964) pointed out higher frequency and greater dimensions of *Conochitina* in the Baltic area.

We cannot agree with Zaslavskaya (1983, pp. 63–64) who has included *C. e. alargada* (Nestor 1980, Pl. 3, fig. 1) within the species *C. siberica* Obut, 1973. *C. e. alargada* is characterized by slight convexity of the chamber and base, the flanks are somewhat constricted above the basal edge. In the centre of the base it has a low mucron or the basal scar. These features are missing in *C. siberica*. It must be noted that in spite of special searching, the representatives of *C. siberica* were not found in East Baltic sections.

Occurrence. *C. edjelensis* s.l. occurs abundantly in the middle and lowermost upper Llandovery of the East Baltic – in the Kolka, Ikla, Lemme, Staicele and Kullamaa members and in the Dobele Formation of the Raikküla Stage, also in the lowermost part of the Rumba Formation of the Adavere Stage. Ikla core, depth 318–471 m; Ruhnu core, 490–556 m; Ohesaare core, 373–381 m; Varbla core, 163–192 m; Häädemeeste core, 232–235 m; Viki core, 191.3–197.4 m; Nurme core, 48–54 m; Kirikuküla core, 49.5–50 m; Sulustvere core, 38–40 m; Laeva 10 core, 59.5 m; Puikule core, 331–420 m; Remte core, 942.6 m; Kolka core, 603.5–623.8 m; Ventspils core, 856–862.2 m; Vidukle core, 1445.2 m; Nitaure core, 668–673 m.

Conochitina electa Nestor, 1980
Plate 12, figs 10–13

Synonymy: *Conochitina* sp. n. – Nestor 1976, pp. 320–321; *Conochitina electa* – Nestor 1980a, pp. 102–103, pl. 6, fig. 3; *Conochitina* sp. 1 – Achab 1981, pl. 2, figs 1, 5, 7, 14; *Conochitina* sp. – Achab 1981, pl. 2, figs 15–17; ? *Conochitina* cf. *electa* – Achab 1981, pl. 2, fig. 9; ? *Conochitina* sp. 2 – Asselin, Achab and Bourque 1989, pl. 2, figs 1–5, pl. 3, figs 1–3, 7, 11.

Description. The vesicle is subconical or subcylindrical, with an indistinct or slight flexure. The chamber is hardly differentiated from the neck and comprises 1/2–2/3 of the total vesicle length. The chamber has a more or less developed funnel-shaped widening in its basal part. The basal edge is bluntly rounded, the base is flat or concave, the basal scar is inconspicuous. The apertural margin is slightly widened, the aperture is straight and smooth. The vesicle surface is smooth or granulate. The largest granules are seen at the basal margin, which usually bears irregularly arranged very fine cone-like spines. The spines have a wide base, more or less pointed, usually curved to the centre of the base. The spinose specimens occur together with those lacking spines, the latters are always dominating.

Dimensions (in μm): vesicle length 220–510, greatest width 65–105, width of aperture 35–75, maximum height of ornamentation (spines) 3.

Remarks. The described species differs from *C. elegans* Eisenack in the ornamentation on the basal margin of the vesicle and frequent occurrence of a slight flexure. The Wenlock species *Conochitina* cf. (aff.) *elegans* (see Eisenack, 1964, p. 315; Laufeld, 1974, p. 59) differs from the described one in a completely smooth basal edge and in usually having a sunken mucron.

Occurrence. *C. electa* occurs in abundance in all studied sections of the Raikküla Stage (mostly in the Pusku, Slitere and Kolka members), but appears in scarce numbers already in the uppermost part of the Juuru Stage in the uppermost part of the Õhne and Varbola formations, Karinu and Hilliste members, partly in the Tammiku Member in the Viki and Kirikuküla core sections, in the uppermost part of the Apaščia Formation in the Nagli core section. Ohesaare core, depth 386–408 m; Laeva core, 49.2–105.9 m; Sulustvere core, 38.4–77.1 m; Ikla core, 499–514.6 m; Ruhnu core, 567.5–587.6 m; Häädemeeste core, 350.7–400 m; Varbla core, 187–224 m; Kirikuküla core, 65.7–91.8 m; Rapla core, 7.6–14.6 m; Asuküla core, 6–18.2 m; Pusku 2 core, 5.4–9.4 m; Emmaste core, 39.2–58.3 m; Martna core, 7.5–22.5 m; Puikule core, 422–438 m; Nagli core, 649.2 m; Viki core, 98–222 m; Ventspils core, 865–867 m; Taagepera core, 364–384 m; Nurme core, 75.8–76 m; Kolka core, 628–643.3 m; Raikküla core, 32–39 m.

Conochitina emmastensis Nestor, 1982
Plate 13, figs 1–4

Synonymy: *Conochitina emmastensis* sp. n. – Nestor 1982a, p. 105, pl. 1, figs 1–3, text-fig. 1; *C.* aff. *emmastensis* – Asselin, Achab and Bourque 1989, pl. 4, fig. 17.

Description. The vesicle is subconical to subcylindrical, with a wide chamber hardly distinguished from the short neck. The basal edge is broadly rounded, the base is slightly concave or convex, usually provided with a wide mucron which may be sunken and invisible (Nestor 1982a, text-fig. 1). The vesicle flanks are straight, with the greatest width at the basal margin, but sometimes also vesicles with slightly convex flanks are observed. The flexure is inconspicuous or missing. The vesicle wall is smooth. The apertural margin is usually widened, the aperture is straight and smooth.

Dimensions (in µm): vesicle length 240–380, maximum width 85–130, smallest width of the neck 55–85.

Remarks. This species somewhat resembles *Conochitina tuba* Eisenack. Yet, in *C. emmastensis* the vesicle is longer, the chamber is wider, the neck is narrower and usually widens towards the aperture.

Compared to *C. proboscifera* Eisenack, the vesicle of *C. emmastensis* is shorter, the chamber and mucron are wider and the vesicle wall is considerably thinner.

Occurrence. *C. emmastensis* occurs usually abundantly in the Rumba Formation, sporadically in the Velise Formation and as rare specimens in the lowermost part of the Jaani Stage. In Latvian core sections this species is mainly encountered in the uppermost part of the Dobele Formation and in the Jurmala Formation of the Adavere Stage. Varbla core, depth 132–160 m; Kirikuküla core, 1–49 m; Emmaste core, 33–44 m; Ikla core, 305–312 m; Ruhnu core, 454–489 m; Pulli 2 core, 27–59 m; Tôlla core, 125–127 m; Häädemeeste core, 210.4(?)–231 m; Viki core, 140–191 m; Ohesaare core, 343--367 m; Kolka core, 600–602 m; Puikule core, 335.1 m; Ventspils core, 790?–852.5 m; Nagli core, 609–645.5 m.

Conochitina aff. *emmastensis* Nestor, 1982

Plate 13, figs 5–6

Synonymy: *Conochitina* aff. *emmastensis* – Nestor 1984, pl. 2, figs 5, 6.

Description. The vesicle is conical or subcylindrical, with a flat or slightly convex base, usually provided with a mucron. The basal edge is rounded. The neck is short, hardly differentiated from the chamber. The average length of the vesicle is 250–350 μm. The vesicle surface is granulate.

Remarks. In the overall shape of the vesicle this species is similar to *C. emmastensis*, differing from it mostly in the ornamentation of the vesicle wall. The surface of *C. emmastensis* is usually completely smooth.

Occurrence. *C.* aff. *emmastensis* occurs sporadically in the Adavere Stage. Varbla core, depth 152–156 m; Kirikuküla core, 37–46 m; Viki core, 147–191 m; Pulli 2 core, 50–60 m; Ruhnu core, 488.6 m; Puikule core, 331–335.1 m; Nagli core, 545.5–633 m; Kolka core, 600–602 m; Ventspils core, 840–845 m.

Conochitina cf. *flamma* Laufeld, 1974

Plate 13, figs 7–8

Description. The vesicle is subconical or subcylindrical, with a convex base and coarse conical mucron. The basal edge is bluntly rounded. The vesicle wall is lanate.

Remarks. The described forms differ from the typical representatives of *C. flamma* (see Laufeld 1974, p. 61, fig. 23) in the lack of the sharp basal edge and constriction of flanks of the chamber above the base. From *C. acuminata* our forms differ in a more subcylindrical and longer vesicle.

Occurrence. *C.* cf. *flamma* is encountered in abundance in the lowermost part of the Jaani Stage – in the lower half of the Tôlla and Mustjala members. Kirikuküla core, depth 3.6–7 m; Viki core, 140.3 m; Pulli 2 core, 23 m; Häädemeeste core, 210.4 m; Ruhnu core, 441.5 m; Ohesaare core, 332–342 m.

Conochitina fortis Nestor, 1982
Plate 14, figs 5–6

Synonymy: *Conochitina fortis* sp. n. – Nestor 1982a, p. 107, pl. 3, figs 1–4.

Description. The vesicle is subcylindrical, with straight or slightly convex flanks of the stout chamber, which has a broadly rounded basal edge and a large mucron in the middle of the weakly convex base. The flexure and shoulder are slightly or not developed. The neck is wide, usually hardly distinguished from the chamber. In some specimens the flanks are slightly compressed in the lower third of the chamber. The wide conical mucron bears characteristic concentric striation. The aperture is straight, the vesicle wall is smooth.

Dimensions (in µm): vesicle length 200–380, maximum width 85–110, smallest width 55–75.

Remarks. *Conochitina fortis* occurs together with *C. pachycephala* and *C. tuba*. *C. fortis* has a subcylindrical vesicle with more or less parallel flanks of the chamber (in flattened specimens the flanks may be convex), in *C. tuba* and *C. pachycephala* the vesicles are conical or subconical, besides, *C. tuba* may sometimes lack the mucron (see Eisenack 1962, fig. 2).

In overall shape *C. fortis* somewhat resembles *C. proboscifera* f. *truncata* (see Laufeld 1974, fig. 34D). The latter, however, has a smaller mucron, the L/D ratio is greater (3–5:1, in *C. fortis* 2–3:1) and the vesicle wall is considerably thicker (see Laufeld 1974, p. 70).

Occurrence. *C. fortis* occurs in the middle Wenlock, in the upper part of the Jamaja Formation and in the lower part of the Sôrve Formation. Ohesaare core, depth 191–246 m; Ruhnu core, 325–356 m; Ikla core, 206–245 m; Kolka core, 452–485 m; Ventspils core, 710–726 m; Kihnu core, 127.2–130 m; Häädemeeste core, 141–145 m.

Conochitina aff. *fortis* Nestor, 1982
Plate 14, fig. 7

Description. The vesicle is short and wide, with straight or slightly convex flanks. The neck is not developed. The basal edge is broadly rounded, the base is slightly convex, provided with a large conical mucron. The oral margin is widened. The vesicle wall is smooth.

Remarks. This form differs from the typical representatives of *C. fortis* in a more thickset figure. The L/D ratio of the vesicle is in *C. fortis* 2–3:1, in *C.* aff. *fortis* 1.5:1.

Occurrence. Scarce specimens of *C.* aff. *fortis* have been recorded only from the Ohesaare core section (depth 202–208.2 m) at the boundary of the Jamaja and Sôrve formations of the Jaagarahu Stage.

Conochitina iklaensis Nestor, 1980
Plate 14, figs 1–4

Synonymy: *Conochitina iklaensis* sp. n. – Nestor 1980b, p. 139, pl. 3, figs 3–5; *C.* cf. *iklaensis* – Achab 1981, pl. 3, figs 5, 14; non:Verniers 1982, pl. 3, figs 58–60; ? *Conochitina* sp. 1 – Asselin, Achab and Bourque 1989, pl. 1, fig. 12, pl. 2, fig. 18.

Description. The vesicle is subcylindrical, with a broadly rounded basal edge. The base is flat or slightly concave, with a basal scar in the centre. The vesicle flanks are usually straight, almost parallel, sometimes weakly convex. The flexure is missing. The vesicle walls may be slightly constricted somewhat higher the basal edge. The L/D ratio is 4:1 – 6:1. The vesicle wall is smooth.

Dimensions (in µm): vesicle length 220–580, greatest width 45–70, width of the aperture 40–60.

Remarks. Specific characters of *C. iklaensis* are inexpressive and have often disappeared due to the flattening of the material.

C. edjelensis elongata and *C. e. alargada* are more conical, their maximum diameter is on the basal margin or near it, they are shorter than *C. iklaensis*. The average length of *C. iklaensis* is greater (400 µm) than the maximum length of the type material of *C. e. elongata* (275 µm, see Taugourdeau 1963, p. 138) and *C. e. alargada* (360 µm, see Cramer 1967, p. 88).

Occurrence. The species occurs abundantly, particularly in the Raikküla Stage, but usually appears already in the uppermost part of the Juuru Stage (of the Õhne Formation and in the Karinu Member of the Tamsalu Formation). Ikla core, depth 311–504 m; Ohesaare core, 373–409 m; Ruhnu core, 484–588 m; Varbla core, 160–219 m; Häädemeeste core, 222–389 m; Laeva core, 54–93 m; Kirikuküla core, 83–87 m; Asuküla core, 13–18 m; Sulustvere core, 71–77 m; Taagepera core, 364–387 m; Nagli core, 643–649.2 m; Puikule core, 331.3 m; Kolka core, 603–643.2 m; Remte core, 942–947 m; Ventspils core, 852–868 m; Vidukle core, 1446–1450 m; Emmaste core, 33.5–33.55 m; Nurme core, 48–54 m; Viki core, 191–221.4 m; Nitaure core, 667–680 m.

Conochitina leptosoma Laufeld, 1974
Plate 15, figs 3–4

Synonymy: *Conochitina leptosoma* sp. n. – Laufeld 1974, p. 67, Fig. 29A, C (non B); *C.* cf. *leptosoma* – Nestor 1982c, pl. 14, figs 7–8.

Description. The vesicle is extremely slender, subcylindrical, with a convex base and wide, short mucron. The basal edge is broadly rounded, sometimes inconspicuous. The vesicle wall is thin, usually slightly deformed. The surface is smooth.

Remarks. In our specimens constriction of the flanks oralward of the basal edge (see Laufeld 1974, p. 67) is expressed very weakly or inconspicuous.

In the present work clearly conical specimens with a bluntly rounded basal edge (Laufeld 1974, fig. 29B) have been excluded from this species. They are defined as *C. claviformis*.

Occurrence. *C. leptosoma* occurs sporadically from the Velise Formation of the Adavere Stage up to the Paramaja Member of the Jaani Stage inclusive. Kirikuküla core, depth 1–28 m; Varbla core, 114–146 m; Häädemeeste core, 196–215.5 m; Viki core, 144–174 m; Kihnu core, 194 m; Pulli 2 core, 8–41 m; Ruhnu core, 434–482 m; Ohesaare core, 305–350 m; Nagli core, 644(?) m and 617–628 m; Ventspils core, 771–821 m.

On Gotland *C. leptosoma* is restricted to the Högklint Beds and ranges beginning from the upper part of unit "a" (Laufeld 1974, p. 68).

Conochitina cf. *leptosoma* Laufeld, 1974

Plate 15, figs 5–6

Remarks. The vesicle is extremely slender, subcylindrical, resembling *C. leptosoma*, but the vesicle wall is thicker, the base is highly convex and the mucron has a more variable shape. *C.* cf. *leptosoma* occurs stratigraphically higher than *C. leptosoma*.

Occurrence. The species occurs sporadically in the Jamaja Formation and in the lowermost part of the Sôrve Formation,also in the Jugla Beds of the Jaagarahu Stage. Häädemeeste core, depth 150 m; Kihnu core, 132–144 m; Ohesaare core, 177–279 m; Ruhnu core, 329–408 m; Ventspils core, 693–758 m.

Conochitina linearistriata Nestor, 1982

Plate 16, figs 1–3

Synonymy: *Conochitina linearistriata* sp. n. – Nestor 1982a, p. 108, pl. 3, figs 5–8.

Description. The vesicle is subconical, with a concave base and broadly rounded basal edge. The flanks are usually slightly constricted immediately above the base which has a scar in the centre. The differentiated neck and flexure are missing. The width of the vesicle is smallest immediately below the aperture. The oral margin widens sharply resembling a frill.

The vesicle surface is usually vertically finely striated. The ornamentation is the most distinct at the basal margin, it is very fine and hardly observable, especially in flattened material.

Dimensions (in µm): vesicle length 150–270, greatest width 80–100, smallest width 55–70.

Remarks. *Conochitina linearistriata* co-occurs with *C. tuba*, *C. pachycephala* and *C. subcyatha*, differing from them in characteristic ornamentation and some other features. *C. tuba* and *C. subcyatha* have a mucron and straight unconstricted flanks. *C. pachycephala* is longer and has a flat or concave base carrying a mucron.

Occurrence. *C. linearistriata* occurs sporadically in the upper part of the Jamaja Formation and in the lower part of the Sôrve Formation of the Jaagarahu Stage. Ohesaare core, depth 192–248 m; Ruhnu core, 331–355 m; Ikla core, 202–245 m; Kolka core, 440–475 m.

Conochitina cf. *mamilla* Laufeld, 1974
Plate 15, figs 7–10

Description. The vesicle is elongated-conical or subcylindrical, with a broadly rounded basal edge. The flat or convex base bears a wide callus-like mucron with a basal scar in the centre. Between the broadly rounded basal edge and mucron there is usually a weakly developed furrow-like deepening. Vesicle flanks are slightly constricted above the basal margin. The vesicle surface is smooth.

Remarks. The species described from the East Baltic sections is not exactly identical to *C. mamilla* from Gotland Island. In the latter (Laufeld 1974, p. 68, fig. 30) the base of the vesicle is wider, flanks are more constricted and the deepening around the mucron is more conspicuous.

C. claviformis differs in the lack of a broadly rounded basal edge and distinct oralward constriction, also in the presence of a short and narrow mucron.

Occurrence. Rare specimens of *C.* cf. *mamilla* occur sporadically mostly in the Ninase Member and in the uppermost part of the Tõlla Member, but in places also in the lowermost part of the Paramaja Member of the Jaani Stage. Kingissepa core, depth 140.6 m; Kipi core, 114–120 m; Pulli 2 core, 10–12 m; Kihnu core, 170–180 m; Varbla core, 116–125 m; Häädemeeste core, 196–199 m; Ruhnu core, 437.6 m; Ohesaare core, 313–329 m; Ventspils core, 744–769 m; Ninase outcrop.

C. cf. *mamilla* is probably contemporaneous with *C. mamilla* from Gotland Island, occurring there only in units "b" and "c" of the Högklint Beds (Laufeld 1974, p. 69).

Conochitina pachycephala Eisenack, 1964
Plate 16, figs 4–6

Synonymy: *Conochitina pachycephala* sp. n – Eisenack 1964, p. 315, pl. 26, figs 4–8; Laufeld 1974, p. 69, fig. 31A–C; Eisenack 1977, p. 30, fig. 7; *C.* cf. *pachycephala* – Nestor 1982b, pl. 18, fig. 1.

Description. The vesicle is conical having a more or less convex base provided with a wide short mucron. The flanks are straight or slightly convex, constricted oralward of the broadly rounded basal edge. The vesicle surface is smooth.

Remarks. Not all specimens of *C. pachycephala*, recorded from our core sections, are completely identical with the holotype of *C. pachycephala* (Eisenack

1964, p. 315, pl. 26, fig. 6). Their vesicles are usually wider: the mean length/width ratio of the vesicle is 3.5–4:1 (in the holotype 4.5:1). However, the study of chitinozoans from the type locality – Mulde outcrop – has shown that our forms may remain within the variability of this species.

C. pachycephala is probably related to *C. claviformis*. This was already noted by Eisenack (1968 p. 159) and Paris (1981, p. 183). More considerable differences between these species are as follows:

(1) In *C. pachycephala* vesicles are always conical, the greatest width is at the basal margin; vesicles of *C. claviformis* may be also subcylindrical (see Eisenack 1964, p.315 and Eisenack 1969, p. 159).

(2) In *C. pachycepahala* the base is more or less convex; in *C. claviformis* the base is flat or slightly concave.

(3) In *C. pachycephala* the basal edge is broadly rounded, in *C. claviformis* bluntly rounded.

(4) In *C. pachycephala* the flanks are distinctly constricted near the basal margin, in *C. claviformis* constriction is missing.

(5) In *C. pachycephala* the mucron is wide, callus-like, in *C. claviformis* usually small and conical.

C. pachycephala resembles also *C.* cf. *mamilla*, but lacks a characteristic furrow between the basal edge and the mucron.

From *C. proboscifera* *C. pachycephala* differs in a thinner vesicle wall. Besides, *C. proboscifera* has a subcylindrical vesicle lacking constriction of flanks above the basal edge.

Vesicles of *C. tuba* are shorter than those of *C. pachycephala*; in *C. tuba* the length/width ratio of the vesicle is 2–3:1, the base is flat, constriction of flanks above the basal edge is lacking.

Occurrence. In East Baltic sections *C. pachycephala* occurs in the uppermost part of the Jamaja Formation and in the lowermost part of the Sôrve Formation of the Jaagarahu Stage, also in the middle of the Jugla Beds of Latvia. Ohesaare core, depth 190-248 m; Ruhnu core, 321–366 m; Häädemeeste core, 136–145 m; Kihnu core, 127.2–130 m; Ventspils core, 714–728 m.

On Gotland *C. pachycephala* ranges from the uppermost part of the Slite Beds through the Mulde and Klinteberg beds into the lowermost part of the Hemse Marl (Laufeld 1974, p. 70).

Conochitina aff. *pachycephala* Eisenack, 1964
Plate 16, fig. 7

Description and remarks. The vesicle is conical, with a convex base and flanks. The basal edge is broadly rounded, the base is provided with a short mucron or lacks it. The vesicle wall is smooth. This species has a constriction of flanks somewhat more oralward of the basal edge than *C. pachycephala* and *C.* cf. *mamilla*, also the base is more convex.

Occurrence. *C.* aff. *pachycephala* is encountered in small numbers in the lowermost part of the Jamaja Formation of the Jaagarahu Stage. Ohesaare core, depth 294 m; Ruhnu core, 388–399 m.

Conochitina praeproboscifera sp. n.
Plate 18, figs 4–8

Synonymy: *Conochitina proboscifera* f. *truncata* – Paris 1981, p. 184, fig. 83b, pl. 19, figs 4, 7; *C.* cf. *proboscifera* – Verniers 1982, p. 35; *C.* aff. *proboscifera* – Nestor 1984, pl. 1, figs 4, 9–12.

Derivation of name. The prefix "prae" (=before) particularly refers to earlier appearance of this species compared to *C. proboscifera*.

Holotype: Ch 224/276, Varbla core, depth 160.15 m, Adavere Stage.

Diagnosis. Vesicle elongated-conical, with flat, slightly concave or convex base provided with mucron; basal edge broadly rounded, aperture smooth; flanks straight; vesicle surface smooth.

Description. The vesicle is usually elongated-conical, sometimes subcylindrical with a mucron, variable in shape. It may be small button-like, conical or coarse and callus-like, having a basal scar in the centre. On the concave base the mucron may be invisible, sometimes it is sunken. The greatest width of the vesicle is usually at the basal margin, above which the flanks may sometimes be slightly constricted. The vesicle wall is thin, particularly at the aperture. The surface is smooth.

Dimensions (in µm): vesicle length 360–510 (in holotype 420), width 80–120 (in holotype 100).

Remarks. In East Baltic sections *C. praeproboscifera* is probably related to *C. iklaensis* Nestor, 1980 and *C. proboscifera* Eisenack, 1937, occurring simultaneously with them in a short interval.

In the Rumba Formation of the uppermost middle Llandovery *C. praeproboscifera* sometimes co-occurs with *C. iklaensis*, which has a more cylindrical vesicle and lacks the mucron.

In the upper part of its occurrence interval, *C. praeproboscifera* may be found together with *C. proboscifera*, but the latter has a considerably thicker vesicle wall and shiny surface.

C. emmastensis Nestor, 1982 has a shorter and wider vesicle than *C. praeproboscifera*. The average length/width ratio of the vesicle is 2.5–3:1 in *C. emmastensis* and 4–4.5:1 in *C. praeproboscifera*.

Occurrence. *C. praeproboscifera* occurs in the uppermost Llandovery in the Rumba, Velise and Jurmala formations of the Adavere Stage. In the Puikule core it has also been recorded from the Dobele Formation in the uppermost part of the Raikküla Stage. Emmaste core, depth 33.5–36.7 m; Kirikuküla core, 29?–43 m; Varbla core, 145–169.8 m; Häädemeeste core, 222–232.5 m; Ikla core, 316–320.2 m; Viki core, 158–190 m; Pulli 2 core, 38–51 m; Ohesaare core, 360–369 m; Ruhnu core, 471–489.3 m; Kolka core, 600–602 m; Puikule core, 331–373 m; Nagli core, 637–644 m.

Material. Over 1000 specimens.

Conochitina proboscifera Eisenack, 1937
Plate 18, figs 1–3

Synonymy: *Conochitina proboscifera* Eisenack - Laufeld 1974, p. 70, figs 32-33 (see synonymy).

Description. The vesicle is large, subcylindrical, with thick, slightly convex flanks. The flat or weakly convex base is provided with a small conical mucron, sometimes with a low callus. The shape of the vesicle may be variable (see Eisenack 1968, p. 19, fig. 3; Laufeld 1974, pp. 70–72), but commonly the most significant features, a thick wall and smooth shiny vesicle surface, are seen.

Occurrence. *C. proboscifera* is the dominant species in the uppermost Llandovery and lowermost Wenlock, being less numerous in deep-water sections (Ventspils, Nagli). It ranges from the upper half of the Velise Formation of the Adavere Stage up to the uppermost parts of the Tôlla and Mustjala members of the Jaani Stage. Only rare specimens may occur in the lower half of the Ninase Member. Kipi core, depth 120–139 m; Viki core, 140–159 m; Pulli 2 core, 15–39 m; Kirikuküla core, 1–24 m; Varbla core, 119–142 m; Häädemeeste core, 205–214 m; Tôlla core, 122–127 m; Kihnu core, 181–201 m; Ohesaare core, 331–359 m; Ruhnu core, 436–474 m; Ventspils core, 807–815 m; Nagli core, 609–618 m.

On Gotland *C. proboscifera* ranges from the Lower Visby Beds to the lower-middle part and south-western facies of the Högklint Beds. Scattered uncharacteristic specimens occur also in unit "b" of the Slite Beds and in the north-westernmost part of the Slite Marl (Laufeld 1974, p. 71).

Conochitina aff. *proboscifera* Eisenack, 1937
Plate 18, figs 9–11

Description and remarks. The vesicle is large, conical or subcylindrical with a more or less convex base and a mucron in the centre. Flanks are usually straight, sometimes slightly convex. The vesicle surface is smooth. In the overall shape and the average length (350–500 µm) *C.* aff. *proboscifera* resembles *C. proboscifera*, differing from it mostly in a considerably thinner vesicle wall.

C. aff. *proboscifera* seems to be related to *C. pachycephala*. It has a convex base and broadly rounded basal edge, but lacks diagnostic of *C. pachycephala* constriction of flanks above the base.

Occurrence. *C.* aff. *proboscifera* occurs in the uppermost part of the Jamaja Formation and in the lowermost part of the Sôrve Formation, in the Ventspils core also in the uppermost part of the Jugla Beds. Häädemeeste core, depth 136–141 m; Ohesaare core, 177–253 m; Ruhnu core, 309–356 m; Ventspils core, 691–710 m.

Conochitina cf. *protracta* (Zaslavskaja, 1980)
Plate 17, figs 8–10

Synonymy: *Conochitina* cf. *protracta* – Nestor 1990, p. 81, pl. 14, fig. 12.

Description. The vesicle is subcylindrical, with weakly convex flanks and base. In the centre of the base there is a basal scar. The basal edge is broadly rounded. The aperture is wide. The vesicle surface is smooth.

Remarks. The material available is mostly flattened, the vesicle length is 170–230 μm (in type material 150–180 μm). In some specimens the middle of the base is concave.

Occurrence. *C.* cf. *protracta* occurs in small numbers in the upper half of the Raikküla Stage in the Lemme Member. Scarce specimens have been found in the uppermost part of the Ikla Member and in the lowermost part of the Rumba Formation of the Adavere Stage. Kolka core, depth 603.6 m; Puikule core, 345–391(?) m; Ruhnu core, 490.5–512 m; Häädemeeste core, 232–255 m; Ikla core, 370–423(?) m.

Conochitina rara sp. n.
Plate 10, figs 3–4

Derivation of name. Latin rarus – rare, refers to its rare occurrence. The species has been recorded only from the uppermost part of the Raikküla Stage in the Ruhnu core.

Holotype. Ch 264/1820, Ruhnu core, depth 496.9 m, Raikküla Stage.

Diagnosis. Subcylindrical vesicle with highly convex base, wide callus and short mucron in the centre; vesicle surface smooth.

Description. The basal edge is broadly rounded, indistinct. The neck is not distinguished from the chamber, the flexure is lacking. The wide callus comprises most of the base. The mucron is small, sometimes may be absent. The aperture is wide, the oral margin is straight and smooth.

Dimensions (in μm): vesicle length 260–340 (in holotype 305), greatest width 55–85 (in holotype 70).

Remarks. *C. rara* is similar to *C.* cf. *protracta* (Zaslavskaja 1980), but in the latter the vesicle is shorter (170–230 μm) and the mucron and callus are lacking in the centre of the base.

In *C. iklaensis* Nestor, 1980 the base is flat or concave, the callus and the mucron are not developed, the average length of the specimens (400 μm) exceeds considerably that of *C. rara* (300 μm).

In *C. tuba* the base is flat and the basal edge is better developed.

The elongated-conical vesicles of *C. praeproboscifera* sp. n. are longer (360–510 μm) and wider (80–120 μm), the base is less convex (usually flat) and the mucron is better developed than in *C. rara*.

Occurrence. *C. rara* occurs in small numbers in the upper half of the Raikküla Stage in the Lemme Member. Ruhnu core, depth 490–500 m.

Material. About 20 specimens.

Conochitina subcyatha Nestor, 1982
Plate 16, figs 8–11

Synonymy: *Conochitina subcyatha* sp. n. – Nestor 1982a, p. 109, pl. 4, figs 1–5, text-fig. 2; Nestor 1990, p. 81, pl. 15, fig. 2.

Description. The vesicle is subconical to subcylindrical, with a flat or slightly concave base. The chamber and neck are distinguished, the neck forming 1/2 or 2/3 of the total vesicle length. The flexure and shoulder are more or less developed, but the shoulder may be missing. The chamber flanks are straight or slightly convex. The basal edge is usually well developed, more or less rounded. The base is mostly flat, with a small mucron in the centre. In some cases the vesicles may have a sunken mucron or completely lack it, sometimes a wide and low callus may occur.

The neck widens towards the smooth aperture. The vesicle wall is smooth.

Dimensions (in μm): vesicle length 155–300, greatest width of the chamber 65–120, smallest width of the neck 35–55.

Remarks. This species occurs simultaneously with *Conochitina tuba*, resembling it in size. However, in *C. tuba* the flexure and shoulder are not developed.

From *C. claviformis* this species differs in a shorter vesicle and a developed flexure (see Eisenack 1968, p. 159). *C. armillata* (see Taugourdeau and Jekhowsky 1960) has a convex base and flanks.

Occurrence. *C. subcyatha* occurs abundantly in the upper Wenlock in the upper part of the Jamaja Formation, in the lower part of the Sõrve Formation of the Jaagarahu Stage and in the middle of the Jugla Beds of the Riga Formation. Ohesaare core, depth 198–226 m; Ruhnu core, 329–357 m; Ikla core, 219–230 m; Ventspils core, 714–722 m; Kolka core, 452–471 m; Kihnu core, 127 m; Häädemeeste core, 143 m.

Conochitina tuba Eisenack, 1932

Plate 19, figs 1–4

Synonymy: *Conochitina tuba* Eisenack - Laufeld 1974, p. 72, fig. 36 (see synonymy).

Description. The vesicle is conical or subcylindrical, usually with a bluntly rounded basal edge. The vesicle flanks are straight, the base is flat, provided with a wide short mucron and a callus with a scar in the centre. Sometimes the mucron is sunken. The vesicle surface is smooth.

Remarks. From *C. claviformis C. tuba* differs in a shorter and wider vesicle (the average length/width ratio is 3:1, in *C. claviformis* 4–5:1).

Occurrence. *C. tuba* is encountered in all upper Wenlock sections, often occurring sporadically. It is frequent only sometimes in the uppermost part of the Jamaja Formation and in the lowermost part of the Sõrve Formation of the Jaagarahu Stage. Generally it ranges from the uppermost part of the Ninase Member of the Jaani Stage up to the top of the Sõrve Formation. Ohesaare core, depth 160–316 m; Ruhnu core, 287–430 m; Häädemeeste core, 131–194 m; Varbla core, 91–114 m; Viki core, 105–108 m; Kingissepa core, 83.5(?) m; Kihnu core, 129– 142 m; Ventspils core, 666–760 m.

In the section of Gotland *C. tuba* ranges from the Slite Beds (from subunit "c") to the base of the Hemse Beds.

Conochitina aff. *tuba* Eisenack, 1932

Plate 19, figs 5–7

Description. The vesicle is subcylindrical, with straight flanks and a wide aperture. The vesicle base is flat or slightly convex, provided with a wide mucron, sometimes with a callus. The basal edge is rounded. The vesicle surface is smooth.

Remarks. The described species is similar to *C. tuba*, differing from it in a more subcylindrical vesicle and a wider aperture. It is represented by few specimens and is genetically probably related to the species group of *C. edjelensis*.

Occurrence. *C.* aff. *tuba* is encountered sporadically in the sections of the Lemme and Staicele members of the Raikküla Stage. Ruhnu core, depth 498–512 m; Ikla core, 326–380 m; Puikule core, 347–374 m.

Conochitina visbyensis Laufeld, 1974

Plate 19, figs 8–9

Description. The vesicle is small, subcylindrical, with a broadly rounded basal edge, flat or slightly concave base, commonly provided with a short and wide mucron. The flexure and shoulder are weakly developed or missing. The vesicle wall has a fine rugose ornamentation, which is better developed on the aboral part of the chamber.

Remarks. From typical *C. visbyensis* (see Laufeld 1974, p. 74) our specimens sometimes differ in a greater size (length of the type material is 96–125 µm, in our material 110–180 µm).

Occurrence. *C. visbyensis* occurs in small numbers in the uppermost part of the Velise Formation and in the lowermost parts of the Tôlla and Mustjala members, in places (Pulli 2 core) it is present in the Ninase Member and in the lowermost part of the Paramaja Member. Viki core, depth 140–145 m; Kirikuküla core, 10–17 m; Varbla core, 137–139 m; Häädemeeste core, 210–214 m; Pulli 2 core, 10–33 m; Ohesaare core, 332–350 m; Ruhnu core, 450–470 m; Nagli core, 612–625 m, in the uppermost part of the Degole and Irlava beds of the Jurmala Formation.

On Gotland *C. visbyensis* occurs in the Upper Visby Beds, as well as in subunits "a" and "b" of the Högklint Beds.

Conochitina? sp. 1

Plate 20, fig. 1

Synonymy: *Conochitina*? sp. 1 – Nestor 1984, pl. 3, fig. 13.

Description. The subcylindrical vesicle is short and narrow (L=145–155 µm, D≐40–45 µm), with a sharp basal edge. The base is flat or slightly convex, having a basal scar in the centre. The flanks of the chamber are more or less parallel, the chamber wall is differentiated from the cylindrical neck, the flexure and shoulder are conspicuous. The vesicle wall is smooth.

Remarks. The overall shape of the vesicle, the well differentiated cylindrical neck and sharp basal edge contradict to the assignment of this species to the genus *Conochitina*. The presence of the well differentiated neck and the lack of basal structures (copula) do not allow to assign it to *Linochitina*. The absence of the translucent tegument of the vesicle does not permit to assign it to the genus *Vitreachitina*. Evidently, more well-preserved material is needed to determine the generic assignment of this particular taxon.

Occurrence. Rare specimens of *Conochitina*? sp.1 occur in the Rumba Formation of the Adavere Stage. Kirikuküla core, depth 46(?)–49 m; Varbla core, 154–157 m.

Conochitina sp. 2

Plate 20, figs 2–3

Description. The vesicle is subcylindrical (L=230–280 µm, L/D=2–2.5:1), having a bluntly rounded basal edge and a flat base, the aperture is wide. The base carries a wide callus-like mucron with a wide basal scar in the centre. The vesicle wall is smooth.

Remarks. This species is similar to *C. emmastensis*, but the latter has a broadly rounded basal edge and a convex or concave base.

Occurrence. *C.* sp. 2 occurs in scarce numbers in the Rumba Formation of the Adavere Stage. Kirikuküla core, depth 48–49.2? m; Pulli 2 core, 158.7–160 m; Varbla core, 154–157 m.

Conochitina? sp. 3
Plate 20, figs 4–5

Synonymy: *Conochitina*? sp. 3 – Nestor 1984, pl. 2, fig. 11

Description. The vesicle is conical, with a more or less concave base and bluntly rounded basal edge. In the middle of the base there is a basal scar. The flanks of the vesicle are slightly convex, somewhat constricted oralward of the basal edge. The neck is short, hardly distinguished from the chamber (L=180–210 µm, L/D=1.5–2:1). The vesicle surface is smooth, sometimes bearing fine ornamentation composed of longitudinal striation.

Remarks. The peculiar strongly conical shape of the vesicle of *C.*? sp. 3 is not very characteristic of the genus *Conochitina* and due to insufficiency of well-preserved material this taxon is here described under the open nomenclature.

Occurrence. *C.*? sp. 3 occurs in scarce numbers in the uppermost part of the Rumba Formation and in the lowermost part of the Velise Formation of the Adavere Stage. Varbla core, depth 149–153 m; Kirikuküla core, 23–36 m; Pulli 2 core, 42.5–6(?) m; Häädemeeste core, 220.9–221 m; Ventspils core, 842.8–844 m.

Conochitina sp. 4
Plate 20, figs 6–7

Synonymy: *Conochitina* sp. 4 – Nestor 1984, pl. 1, figs 3, 14.

Description. The vesicle is conical and elongated-conical, with a flat, concave or slightly convex base. The flanks are usually weakly constricted oralward of the basal edge. The length of the vesicle is variable (L=200–420 µm) like the length/width ratio (3–5:1). The basal edge is sharp or bluntly rounded, the surface is smooth.

Remarks. In overall shape the vesicle of *C.* sp. 4 is greatly variable. In some cases it may resemble *Conochitina electa*, but the vesicle surface and basal edge of *C.* sp. 4 are always smooth. The elongated vesicles of *C.* sp. 4 are similar to those of *C. elegans* of middle Ordovician age (Eisenack 1968, p. 161). The recorded specimens of *C.* sp. 4 are almost all flattened. In the future, when acquiring some new material, evidently at least two independent taxa (species or subspecies) can be distinguished.

Occurrence. *C.* sp. 4 occurs sporadically in the Adavere Stage of the East Baltic, in places being also numerous. Varbla core, depth 141(?)–152 m; Kirikuküla core, 27–49 m; Ikla core, 320.2–325 m; Pulli 2 core, 42–60 m; Viki core, 163–191 m; Emmaste core, 37–39 m; Kolka core, 600 m; Puikule core, 336 m; Nagli core, 629–646(?) m; Ventspils core, 826.5 m.

Conochitina sp. 5

Plate 20, figs 8–10

Synonymy: *Conochitina* sp. 5 – Nestor 1984, pl. 2, fig. 12.

Description. The vesicle is small (L=100–180 µm, L/D=2–2.5:1), conical, usually has slightly convex flanks and a weakly concave or convex base. The middle of the base carries a very short button-like mucron with a basal scar. The basal edge is broadly rounded, the aperture slightly widened. The vesicle surface is smooth.

Remarks. Our specimens of *C.* sp. 5 resemble those in Verniers 1982 (40, pl. 2, figs 30–45), described there as *Conochitina* sp. D. However, our material is of Llandovery age, whereas the age of Vernier's material from the Mehaigne area (Belgium) is middle and late Wenlock.

Occurrence. *C.* sp. 5 occurs usually in scarce numbers in the Rumba Formation and in the lowermost part of the Velise Formation of the Adavere Stage, also in the uppermost part of the Dobele Formation and Degole Beds of the Jurmala Formation in Latvia. Kirikuküla core, depth 25–43.4 m; Häädemeeste core, 220–221 m; Ikla core, 306–307.5 m; Viki core, 163–190 m; Ohesaare core, 368–372 m; Kolka core, 600–602 m; Ventspils core, 827–842.8 m; Nagli core, 622–646 m; Vängla outcrop.

Conochitina sp. 6

Plate 21, figs 1–2

Description. The vesicle is subcylindrical, 220–250 µm (L/D=2.5:1) long, has a broadly rounded basal edge and a slightly concave narrow base. The neck is not distinguished from the chamber. The vesicle surface is covered with dense fine granulation.

Remarks. Only flattened specimens are available in the present collection. From *C.* aff. *emmastensis* this species differs in a shorter vesicle with a narrower base and also in a denser and finer ornamentation.

Occurrence. *C.* sp. 6 occurs abundantly in the uppermost part of the Velise Formation and in the Jurmala Formation of the Adavere Stage. Ohesaare core, depth 356.2 m; Viki core, 148–172 m; Ventspils core, 798(?)–842.8 m; Nagli core, 612–642 m.

Conochitina sp. 7
Plate 21, figs 3–4

Synonymy: *Conochitina* sp. a – Nestor 1982c, pp. 92–93.

Description. The vesicle is small (length 130–170 µm, L/D=1–1.5:1), subconical, with straight flanks and a flat or weakly convex base. The basal edge is rounded, in the centre of the base there is a basal scar. The vesicle surface is smooth or lanate.

Remarks. Specimens with a subcylindrical vesicle, having a more or less convex base and flanks, are treated here as *C.* aff. sp. 7 (Pl. 21, fig. 5).

Occurrence. *C.* sp. a occurs sporadically or as rare specimens in the upper half of the Jamaja Formation and in the Sõrve Formation, also in the middle part of the Jugla Beds of the Jaagarahu Stage. Ohesaare core, depth 160(?)–251 m; Ruhnu core, 332–357 m; Ventspils core, 718 m.

Conochitina sp. 8
Plate 21, fig. 7

Synonymy: *Conochitina* sp. d – Nestor 1982c, p. 93, pl. 20, fig. 1.

Description. The vesicle is elongated-conical (L=530–570 µm), with a convex base and a wide callus-like mucron. The flanks are straight. The basal edge is broadly rounded. The vesicle surface is smooth.

Occurrence. Scarce specimens of *C.* sp. 8 are encountered in the Ohesaare core, at a depth of 161 m in the uppermost part of the Sõrve Formation of the Jaagarahu Stage.

Genus *Rhabdochitina* Eisenack, 1931
Type species: *Rhabdochitina magna* Eisenack, 1931

Diagnosis. Vesicle long, cylindrical, with smooth surface.

Remarks. In the Wenlockian samples, containing abundantly long *Conochitina* species (especially *C. leptosoma* and *C. claviformis*), there occur sometimes rare more slender, almost cylindrical specimens resembling the representatives of the genus *Rhabdochitina*. They are considered extreme members of the variability of these *Conochitina* species, having no affinity with *Rhabdochitina*. Besides, the example described below, comes from the topmost Wenlock.

Rhabdochitina? sp. 1

Plate 31, fig. 4

Description. The vesicle is long (600–700 μm), almost cylindrical, with a concave base (L/D=7–8:1). The vesicle flanks are nearly parallel. The base is more or less concave, with a basal scar in the centre. The vesicle surface is smooth.

Remarks. It should be noted that the vesicle wall is very thin, therefore up to now only flattened specimens have been recorded.

Occurrence. *R.*? sp. 1 occurs in small numbers in the Ventspils core, depth 663–667 m, in the uppermost part of the Siesartis Formation of the Rootsiküla Stage, but ranges also into the lowermost upper Silurian (see Nestor 1982d).

Subfamily Belonechitininae Paris, 1981

Genus *Belonechitina* Jansonius, 1964

Type species *Conochitina micracantha robusta* Eisenack, 1959.

Diagnosis. Elongated-conical vesicle with flat or concave base and rounded basal edge; flexure and shoulder poorly developed; vesicle wall completely ornamented with randomly or evenly spaced spines or cones.

Remarks. The genus *Belonechitina* was erected for the *Conochitina* vesicles "completely ornamented with spines" (Jansonius 1964, p. 906). This type of ornamentation is widespread and characteristic of the Ordovician chitinozoans. Paris (1981) included to *Belonechitina* also elongated vesicles with "pointed tubercles".

The very spiny ornamentation of the vesicles is quite rare in the East Baltic Silurian chitinozoans. For instance, from the population of *Belonechitina postrobusta* in the lowermost Llandovery Juuru Stage only a few real spiny specimens were found (Nestor 1980, pl. 4, figs 2–3), whereas most specimens of this species have usually more or less degraded (due to maceration ?) verrucate ornamentation.

Belonechitina aspera (Nestor, 1980)

Plate 10, fig. 9

Synonymy: *Conochitina aspera* sp. n. – Nestor 1980a, p. 101, pl. 3, figs 2–3.

Description. The vesicle is oval, with a strongly convex base. The basal edge is indistinct. The flexure and shoulder are lacking or weakly developed. In the centre of the vesicle base there is usually a sunken area. The basal scar is inconspicuous, the callus and mucron are not developed. The flanks are more or less convex. The oral margin is finely fringed. The surface is lanate or verrucate, the triangular verrucae are usually arranged parallel to the longitudinal axis of the vesicle.

Dimensions (in µm): vesicle length 140–230, greatest width 70–100, width of the aperture 40–60.

Remarks. In the overall shape this species resembles *C. brevis conica* Taugourdeau and Jekhowsky (1964) from the Wenlock of Gotland, differing from it mostly in the ornamented surface of the vesicle. *B. aspera* is also similar to *B. postrobusta*, differing from it mainly in smaller dimensions and convex flanks and base.

Occurrence. *B. aspera* occurs in small numbers in the lowermost and uppermost parts of the Juuru Stage, mostly in the Puikule, Ruja and Sturi members and in the uppermost part of the Õhne Formation. Quite rare finds come from the Karinu Member of the Tamsalu Formation. Single specimens were recorded from the lowermost part of the Slitere and Pusku members of the Raikküla Stage. Ohesaare core, depth 440.2– 447.6 m and 415.5 m; Häädemeeste core, 423–425 m and 387.8–398.2 m; Sulustvere core, 71.7 m; Emmaste core, 61.05 m; Laeva 10 core, 90.4 m; Varbla core, 251.7 m; Martna core, 18.6 m; Viki core, 224–237 m; Taagepera core 373–410.6 m; Ikla core, 499–528 m; Ruhnu core, 584–588 m; Raikküla core, 32.4 m; Asuküla core, 13.6 m; Kolka core, 660.6 m; Remte core, 960.7 m; Nagli core, 665.3 m.

Belonechitina postrobusta (Nestor, 1980)
Plate 17, figs 1–7

Synonymy: *Conochitina postrobusta* sp. n. – Nestor 1980a, pl. 4, figs 1–4, pl. 5, figs 2–3, Fig. 3; *Conochitina robusta* Eisenack, 1959 – Grahn 1978, Fig. 4; ? *Belonechitina postrobusta* (Nestor) – Hill, Paris and Richardson 1985, pl. 12, fig. 4a, b; ? *Conochitina* sp. 2 – Grahn 1985, pl. 2, figs2, 3, 6; ? *Belonechitina aspera* (Nestor) – Geng, Liang-yu and Cai, Xi-rao 1988, pl. 1, fig. 11; *Belonechitina*? sp. – Asselin, Achab and Bourque 1989, pl. 1, fig. 4.

Description. The vesicle is subcylindrical. The flanks are straight to convex. The chamber is sometimes slightly constricted above the basal broadly rounded edge. The base is flat or weakly concave, with a basal scar in the centre. The vesicle surface is covered with irregularly arranged verrucae or short spines. The ornamentation is best developed at the basal edge and on the aboral half of the vesicle, but there occur also almost smooth specimens. The central part of the base is smooth. Spines are usually short, irregular and blunt with short roots often coalescent on the vesicle surface (λ-spines).

Dimensions (in µm): vesicle length 180–385, greatest width 75–100, width of the aperture 45–75, maximum height of ornamentation 3–4.

Remarks. The species described is similar to *Belonechitina robusta*, which has a different overall shape of the vesicle (*B. robusta* is more conical) and ornamentation. In *B. robusta* the spines are more slender, with high roots. The spines are arranged regularly, often in rows.

From *C. baculata* (occurring in the uppermost Ordovician of Anticosti Island, Achab 1977) *B. postrobusta* differs in a more developed ornamentation. In *C. baculata* the surface is smooth or slightly granulate.

Chitinozoans identified by Grahn as *C. robusta* (Grahn 1978, Fig. 4, p. 11) from the Ordovician/Silurian boundary beds of southern Sweden, evidently belong also to the species discussed.

It is noteworthy that specimens of *B. postrobusta*, occurring in the basalmost part of the Juuru Stage, have generally a more weakly developed (degraded ?) verrucate ornamentation than those occurring on stratigraphically higher levels.

Occurrence. *B. postrobusta* occurs in the Juuru Stage of the East Baltic in two intervals – in the lowermost (Puikule Member of the Õhne Formation) and uppermost (upper part of the Õhne or Varbola formations, or sometimes in the Karinu or Tammiku members) parts of the stage. Ikla core, depth 449–515.7 m and 528 m; Ohesaare core, 411–417.5 m and 447.6 m; Ruhnu core, 600.8 m; Laeva 10 core, 89–111.2 m and 131.4 m; Häädemeeste core, 387.8–403.3 m and 425.5 m; Varbla core, 216.8–224 m; Emmaste core, 58.3–61.1 m; Sulustvere core, 73.5–78.5 m; Tartu core, 188.7 m; Viki core, 221.3–229 m; Taagepera core, 410.7–411 m and 373–401.5 m; Laeva 18 core, 176.6–177.2 m; Kolka core, 660.5–661 m; Remte core, 960 m; Nagli core, 649.2? m; Puikule core, 459.8–460 m and 436–443 m; Rapla core, 40(?) m.

Belonechitina? sp. 1

Plate 21, fig. 6

Synonymy: *Conochitina* sp. b – Nestor 1982c, p. 92, pl. 18, fig. 9.

Description. The vesicle is small (on average L=170 μm, L/D=2:1), conical, with a bluntly rounded basal edge and straight flanks. The base is flat or slightly concave having a basal scar in the centre. The vesicle surface is verrucate.

Occurrence. *B.* sp. 1 occurs in small numbers in the lower half of the Sôrve Formation of the Jaagarahu Stage. Ohesaare core, depth 193–203 m; Ruhnu core, 331–339 m.

Subfamily Spinachitininae Paris, 1981

Genus *Spinachitina* Schallreuter, 1963.

Type species: *Conochitina cervicornis* Eisenack, 1931

Diagnosis. Vesicle conical or subcylindrical, with sharp or bluntly rounded basal edge provided with crown of simple or branching spines.

Remarks. The above diagnosis coincides with the previous diagnosis of the genus *Coronochitina* Eisenack, 1965, now regarded as a junior synonym of *Spinachitina*. Laufeld (1967) emended the original diagnosis of Schallreuter, including in *Spinachitina* also smooth forms, which have spines only on the basal edge. Recently the genus was restricted to forms without a conspicuous flexure and instead of the lost holotype of Eisenack 1931, a neotype for *Spinachitina*, *S. cervicornis* (Eisenack, 1931) was suggested (Paris *et al.*, in preparation) from the Rapla borehole of Estonia (Nôlvak and Grahn 1993, pl. 3, fig. A).

Spinachitina fragilis (Nestor, 1980)
Plate 22, figs 1–2

Synonymy: ? *Conochitina* aff. *bulmani* Jansonius, 1964 – Achab 1977, p. 418, pl. 2, figs 1–6; pl. 3, figs 1–3, 5–6; *Coronochitina fragilis* sp. n. – Nestor 1980a, 104, pl. 5, fig. 1.

Description. The vesicle is conical, with a relatively sharp basal edge provided with a crown of fine and short spines. The neck progrades fluently into a chamber and is usually not distinguished. The greatest width of the vesicle occurs at the basal margin. The base is flat or concave. The spines are subcylindrical, simple, with blunt distal ends. They are short and fragile, about 20 in number (usually most of them are broken). The vesicle wall is thin, sometimes semi-transparent. The aperture is finely fringed. The vesicle surface is smooth.

Dimensions (in µm): vesicle length 140–280, greatest width 70–85, width of the aperture 50–70, greatest length of spines 10. (The collection contains only flattened specimens, but the dimensions are given without the coefficient of correction 0.7).

Remarks. From *Spinachitina coronata* this species differs in the absence of the funnel-shaped widening and smaller dimensions of the vesicle and spines. Besides, *S. fragilis* is lacking spines at the oral margin.

S. maennili is more subcylindrical, has better developed spines at the basal edge and a granulate vesicle wall.

Occurrence. *S. fragilis* is rather common in the Juuru Stage in the Puikule, Ruja and Sturi members, in places in the lowermost part of the Õhne Formation. Ohesaare core, depth 440.8–450 m; Ruhnu core, 600.8 m; Häädemeeste core, 425.5 m; Laeva 18 core, 172–175 m; Taagepera core, 408–410.8 m; Kolka core, 660.6–661 m; Remte core, 952.0 m (cf.); Ventspils core, 872.5 m; Puikule core, 495.8 m; Nagli core, 679–680.2 m.

Spinachitina maennili (Nestor, 1980)
Plate 22, figs 3–4

Synonymy: *Coronochitina* sp. n. – Nestor 1976, pp. 321–322; *Coronochitina maennili* sp. n. – Nestor 1980b, p. 138, pl. 2, figs 1–2; pl. 3, fig. 1.

Description. The vesicle is subconical to subcylindrical, the neck is poorly differentiated from the chamber, the base is concave or flat. The maximum width of the vesicle is at the basal edge. Length of the neck is variable forming about 1/3–1/2 of the whole vesicle length. The neck widens slightly immediately below the finely fringed aperture. The chamber sometimes widens slightly in the basal part. The basal edge is bluntly rounded, provided with a crown of irregular, fine and comparatively long spines, arranged parallel to the longitudinal axis or being slightly curved towards the middle of the base. The widened proximal part of the spines is often two- to many-rooted, some of the distal ends may branch once. The number of spines ranges from 8 to 20, but usually it is 10–15. In the flattened material most or all of the spines are broken.

The vesicle surface is finely granulate, granules are coarser at the basal edge.

Dimensions (in µm): vesicle length (incl. spines) 160–450, maximum width 45–110, minimum width 30–80, maximum length of spines 15.

Remarks. From the Ordovician species *Spinachitina coronata* (Eisenack, 1931) *S. maennili* differs in the lack of wide funnel-shaped swelling in the basal part of the chamber and in the granulate vesicle surface. Besides, the oral margin of *S. maennili* bears no spines and the structure of the basal spines is different: in *S. coronata* the spines are coarse and simple. *S. fragilis* (Nestor 1980a) differs in simple, shorter and more fragile spines, more conical shape and smooth vesicle surface.

Occurrence. *S. maennili* occurs abundantly in the Saarde Formation of the Raikküla Stage in south-western Estonia, in the Kolka and Ikla members and in the lower half of the Lemme Member. Ikla core, depth 386–475 m; Ruhnu core, 494–574 m; Ohesaare core, 373–397 m; Häädemeeste core, 274–367 m; Puikule core, 340–422 m; Kolka core, 607–633 m; Remte core, 942–947 m; Vidukle core, 1445–1450 m; Nitaure core, 672–675 m.

Spinachitina cf. *maennili* (Nestor, 1980)
Plate 22, fig. 5

Synonymy: *Coronochitina* cf. *fragilis* Nestor, 1984, pl. 1, fig. 2.

Remarks. In the lowermost or middle parts of the Rumba Formation of the Adavere Stage, in some sections there were found rare poorly preserved specimens of *Spinachitina*. Considering the vesicle length, these specimens are similar to *S. maennili*, the structure of spines, however, reminds of that of *S. fragilis*.

Occurrence. *S.* cf. *maennili* is found only as scarce specimens in the Ikla core, depth 319.2 m; Ruhnu core, 489–490 m; Kirikuküla core, 48.5–49.6 m; Varbla core, 159.6 m.

Family Lagenochitinidae Eisenack, 1931
Subfamily Lagenochitininae Paris, 1981

Genus *Lagenochitina* Eisenack, 1931
Type species: *Lagenochitina baltica* Eisenack, 1931.

Diagnosis. Flask-shaped vesicle with greatest width in middle of chamber; vesicle base convex or flat, basal edge broadly rounded; flexure and shoulder more or less developed; vesicle surface smooth, lanate or granulate.

Remarks. Typical lagenochitinids occur in the Ordovician. Umnova (1976) has identified them from the Wenlock of the northern part of the Russian platform, but later they have not been recorded there (Umnova 1981). The form described in this paper is also atypical of *Lagenochitina*.

Lagenochitina? sp.
Plate 31, fig. 1

Description. The vesicle is cylindro-ovoid, with the length of 250–300 µm, the greatest width is in the middle part of the chamber. The base is flat, the basal edge is rounded. The flexure is weak, the shoulder is not developed. The neck comprises about 1/4 of the total vesicle length widening slightly oralward. The vesicle surface is granulate, the neck is smooth, in the flexure area there are noticed low longitudinal ribs.

Remarks. The weakly developed flexure and the lack of the shoulder contradict to the assignment of this form to *Lagenochitina*, although other features speak in favour of this. In overall shape our specimens somewhat resemble the lower and middle Ordovician species *Conochitina pirum* and *Lagenochitina* sp. A (see Achab 1983, 1984) from Canada, but differ from them mostly in the ornamentation of the vesicle.

Occurrence. *L.*? sp. is represented by scarce specimens (about 10 specimens recorded) in the lowermost Silurian, in the Stačiunai and Apaščia formations of the Juuru Stage. Nagli core, depth 657–676 m.

Genus *Vitreachitina* gen. n.

Type species: *Sphaerochitina vitrea* Taugourdeau, 1962.

Diagnosis. Cylindro-subconical vesicle usually with more or less developed flexure and shoulder; base almost flat lacking callus, mucron or other external structures; aperture wide, without collar; vesicle wall thin, transparent or semitransparent.

Remarks. The type species of this genus has earlier been affiliated to different genera: *Sphaerochitina* (Taugourdeau 1962, 1963; Cramer 1964), *Lagenochitina* (Taugourdeau 1966; Cramer 1967), *Linochitina* (Cramer 1978), *Conochitina* (Paris 1988; Dufka 1992), which means that actually this taxon did not fit to any of them. *Sphaerochitina* differs in having a spherical chamber and ornamented vesicle. *Lagenochitina* has a subspherical or oval chamber, often with basal structures and a granulate vesicle wall. *Conochitina* has a conical or subcylindrical vesicle with basal structures. *Linochitina* resembles *Vitreachitina* in the vesicle shape but is also provided with basal structures (copula).

According to Taugourdeau (1963), transparency of the vesicle wall is an essential character in *V. vitrea,* which is proper to specimens from several palaeocontinents.

Due to the very thin tegument, all specimens of our collection are completely flattened but general transparency of the vesicles makes them easily recognizable among other taxa.

Vitreachitina sp. 1

Plate 30, fig. 4

Description. The vesicle is small (L=130–140 μm), conical or subconical. The neck is short, sometimes inconspicuous. The flexure and shoulder are lacking or very poorly developed. The base is flat or slightly concave, the basal edge is rounded. The vesicle surface is smooth, the wall is thin, semi-transparent. Chain formation not observed.

Occurrence. Scarce specimens of *V.* sp. 1 were recorded from the Dobele Formation, Adavere Stage. Nagli core, 643.4–645.5 m.

Vitreachitina sp. 2

Plate 30, figs 5–6

Description. The vesicle is small (L=110–150 μm), cylindro-subconical, with convex flanks. The neck is conspicuous, comprising almost half of the total vesicle length. The flexure and shoulder are more or less developed. The base is slightly convex or concave. The vesicle surface is smooth, walls are thin, semi-transparent. Chain formation not observed.

Remarks. *V.* sp. 2 is similar to *V.* sp. 1, differing from it in a well-developed neck and convex flanks.

Occurrence. Rare specimens of *V.* sp. 2 occur in the Dobele, Jurmala and Velise formations of the Adavere Stage. Viki core, depth 171.5 m; Nagli core, 625–645.5 m.

Vitreachitina sp. 3
Plate 30, figs 7–8

Description. The vesicle is elongated (length about 200 µm), cylindro-conical. The flexure and shoulder are poorly developed. The base is flat or slightly concave, the walls are thin, semi-transparent, the surface is smooth.

Remarks. Compared to *V.* sp. 1 and *V.* sp. 2, the described form has a longer and more slender vesicle. In *V.* sp. 3 the length and shape of the vesicle remind those of *V. vitrea*. We cannot, however, prove their identity, as our material is insufficient and the specimens are completely flattened.

Occurrence. Scarce specimens of *V.* sp. 3 have been encountered in the lowermost part of the Degole Beds of the Adavere Stage. Nagli core, depth 632.9–633.1 m; Ventspils core, 842.8–844.5 m.

Subfamily Angochitininae Paris, 1981

Genus *Angochitina* Eisenack, 1931

Type species: *Angochitina echinata* Eisenack, 1931.

Diagnosis. Vesicle with elongated-rounded or oval chamber and cylindrical neck; flexure developed, shoulder and basal edge indistinct, base rounded; vesicle with spinose ornamentation, spines usually simple, relatively short and fine.

Angochitina longicollis Eisenack, 1959
Plate 7, figs 1–4

Synonymy: *Angochitina longicollis* Eisenack – Laufeld 1974, p. 56, fig. 19 (see synonymy); Aldridge *et al.*, 1979, p. 434; Dorning 1981, p. 206; Mabillard 1981, pl. 6, figs 8, 9; Verniers 1982, p. 17. pl. 9, figs 230–237; Grahn 1985, p. 158, pl. 1, figs 5–6; ? *Angochitina* sp. A – Verniers 1982, p. 19, pl. 9, figs 243–245; ? *Angochitina* sp. B – Verniers 1982, p. 19, pl. 9, figs 238–240.

Description. The vesicle has an oval chamber which gradually goes over into a subcylindrical neck. The neck usually widens towards the aperture. The spinose ornamentation is regular, but the length and density of spines are variable. The spines are simple, sometimes split in proximal or distal parts.

Remarks. *A. longicollis* occurs sometimes together with almost smooth specimens (see Nestor *et al.* 1978, p. 13). In these forms the spinose ornamentation seems to be worn off, therefore they are not treated as a separate taxon.

Occurrence. *A. longicollis* occurs abundantly in the Velise Formation, but also in the uppermost part of the Degole and Irlava beds of the Adavere Stage and in the lowermost part of the Mustjala and Tôlla members of the Jaani Stage. Ohesaare core, depth 339–372 m; Ruhnu core, 454.2–486 m; Kihnu core, 199–201 m; Pulli 2 core, 20–51 m; Viki core, 142–178? m; Varbla core, 132–146 m; Häädemeeste core, 210–217 m; Kirikuküla core, 1–28 m; Tôlla core, 126 m; Ventspils core, 784–828 m; Nagli core, 615–620 m.

By data of Laufeld (1974 p. 56), on Gotland Island *A. longicollis* appears in the upper Llandovery above the red marl (Arachnophyllum Marl), occurring abundantly in the Lower Visby Beds and in the lowermost part of the Upper Visby Beds. Higher in the section this species decreases in number up to its total disappearance a few metres below the boundary of the Högklint Beds. Laufeld has reported the presence of *A. longicollis* already in the middle Llandovery beds of the Dalarna section of Central Sweden, corresponding to the lower part of the *M. gregarius* Zone. However, it is not excluded that the specimens recorded may be representatives of some other taxon (see *Angochitina*? sp. 1).

Angochitina? sp. 1

Plate 7, fig. 5

Remarks. This taxon is represented by rare poorly preserved smooth specimens with the vesicle shape reminding of *Angochitina*, occurring in the Remte core at a depth of 946–947 m in the Remte Formation, the Raikküla Stage.

Angochitina? sp. 2

Plate 7, fig. 6

Remarks. In the Nitaure core, at a depth of 672–677 m, the lowermost beds of the Dobele Formation of the Raikküla Stage have yielded specimens of *A.*? sp. 2 with cylindro-spherical vesicles having a regular tuberculate ornamentation. Due to a small number of specimens, this taxon is kept here in open nomenclature.

Genus *Gotlandochitina* Laufeld, 1974

Type species: *Gotlandochitina martinssoni* Laufeld, 1974.

Diagnosis. Vesicle with subconical or spherical chamber and subcylindrical neck; flexure distinct, shoulder poorly developed or missing; vesicle surface covered with spines arranged in longitudinal rows.

Remarks. In the overall shape of the vesicles this genus is similar to *Sphaero-* or *Ancyrochitina* differing from them in a characteristic ornamentation.

Some problems arose with the taxa having long spines or appendices arranged in short rows just at the basal edge, visually forming one appendix. In this work these forms are described among the species of *Ancyrochitina.*

Gotlandochitina angusta Nestor, 1982
Plate 26, fig. 6

Synonymy: *Gotlandochitina*? *angusta* sp. n. – Nestor 1982b, p. 147, pl. 1, fig. 3.

Description. The vesicle is cylindro-subspherical without a clear basal margin. The spines of different shape and dimensions are arranged in irregular rows. The elongated chamber forms about half of the whole vesicle length. The flexure is weak and the shoulder is missing. Rows of spines are often hardly conspicuous and sparse. The spines are of different shape, often sail-like, converging along the longitudinal axis of the vesicle. The aperture is smooth. The vesicle surface is irregularly granulate.

Dimensions of the holotype (in µm): vesicle length 290; greatest width 115, width of the neck 45, greatest length of spines 30–35.

Remarks. In the vesicle shape this species resembles *Angochitina longicollis* (Eisenack, 1959), but differs from it in the type of ornamentation, shape and length of spines.

Occurrence. Rare specimens have been recorded from the lowermost part of the Jaani Stage. Ruhnu core, depth 454 m; Viki core, 142.2 m; Häädemeeste core, 212.3–213 m; Nagli core, 637–642 m. In the uppermost part of the Dobele Formation there occur specimens identified as *G.* cf. *angusta* (see pl. 26, fig. 7).

Gotlandochitina costata (Umnova, 1981)
Plate 26, figs 8–9

Synonymy: *Angochitina costata* sp. n., Umnova 1981, p. 26, pl. 2, figs 1–3.

Description. The vesicle has an oval or rounded chamber and a subcylindrical neck. The chamber comprises half of the total vesicle length. The vesicle surface is covered with spines fused at their proximal ends and forming long flat rows – ribs, running parallel to each other longitudinally to the vesicle axis. The spines are thin, simple or branching, with sharp ends. The ribs are comparatively regular, sometimes interrupted, 8–12 in number, reaching the oral margin of the vesicle. The aperture is finely fringed.

Transitional forms between *C. costata* and *G. martinssoni* have also been recorded. In the proximal parts of the spines the ribs are more interrupted and do not reach the aperture. The oral part of the neck carries irregularly arranged simple short spines.

Remarks. Umnova (1981, p. 26) has included this species within the genus *Angochitina*. The arrangement of spines in rows and great similarity of this species with *G. martinssoni*, however, caused its affiliation to the genus *Gotlandochitina*.

Occurrence. *G. costata* occurs in small numbers together with *G. martinssoni* in the lower half of the Jamaja Formation of the Jaagarahu Stage. Ohesaare core, depth 291.3 m; Ruhnu core, 379 m.

According to Umnova (1981), *G. costata* is present in the Wenlock of the Virtsu core of west Estonia, depth 38.6–41 m.

Gotlandochitina magnifica Nestor, 1982
Plate 27, figs 1–2

Synonymy: *Gotlandochitina magnifica* sp. n. – Nestor 1982b, pp. 147–148, pl. 1, fig. 4, pl. 2, fig. 1.

Description. The vesicle is cylindro-spherical, provided with long branching spines. The average chamber/neck ratio is 1:1. The flexure and the shoulder are broadly rounded. The chamber is spherical, without the basal edge. The spines are arranged in 7–8 rows on the aboral part of the chamber and on the oral half of the neck. They are placed more or less regularly, on average three spines forming a row. Spines are lacking in the middle of the base and on the oral half of the chamber. Usually spines have a long unbranched proximal part and a distal end branching 2–5 times. The neck carries fine irregularly branching spines. Their length decreases towards the finely fringed aperture.

Dimensions (in µm): vesicle length (excl.) 140–225, greatest width 65–85, width of the neck 25–40, greatest length of spines 55.

Remarks. *G. magnifica* resembles *G. villosa* (Laufeld 1974), but differs from it in a larger vesicle and long strongly branching pointed spines.

Occurrence. *G. magnifica* occurs in small numbers in the lowermost part of the Jaani Stage. Ruhnu core, depth 454–456 m; Ohesaare core, 342–346 m; Häädemeeste core, 210 m; Nagli core, 612 m; Viki core, 134.8–135 m; Jaagarahu core, 53.3 m.

Gotlandochitina martinssoni Laufeld, 1974
Plate 27, fig. 3

Synonymy: *Gotlandochitina martinssoni* sp. n. – Laufeld 1974, pp. 86–89, fig. 49; Nestor 1982c, pl. 16, fig. 5.

Description. The vesicle has a subconical or spherical chamber and a subcylindrical neck somewhat widening towards the aperture. The basal edge is missing. The vesicle surface is covered with densely spaced curved spines arranged in 10–12 longitudinal rows, where the neighbouring spines are sometimes coalescent in their proximal parts. The spines are simple, sometimes branching, with sharp tips. At the base the spines are longer (maximum length 30 µm). Towards the aperture their length decreases gradually. The aperture is finely fringed.

Occurrence. *G. martinssoni* occurs in the lower and middle parts of the Jamaja Formation of the Jaagarahu Stage. Ohesaare core, depth 247–292 m; Ruhnu core (sporadic finds), 357–394 m.

On Gotland *G. martinssoni* is restricted to the middle-upper part of the Slite Beds (Laufeld 1974, p. 89).

Gotlandochitina ruhnuensis Nestor, 1982

Plate 27, figs 4–6

Synonymy: *Gotlandochitina ruhnuensis* sp. n. – Nestor 1982b, p. 148, pl. 2, figs 2–3; ? *Fungochitina*? sp. 1 – Asselin, Achab and Bourque 1989, pl. 6, fig. 25.

Description. The vesicle is cylindro-conical, with a flat or slightly convex base. The ornamentation consists of fine spines arranged in indistinct rows on the chamber and on the neck. The neck usually comprises about half of the whole vesicle length. The flexure is more or less developed, the shoulder is missing. The spines cover the whole vesicle surface, but they are longer and denser on the aboral half of the chamber. On the base and on the oral part of the neck the spines are less numerous and shorter. The spines are fine, of variable shape, sometimes branching in the distal ends, sometimes coalescent near the base along the longitudinal axis of the vesicle. The aperture is finely fringed. The vesicle surface is finely granulate.

Dimensions (in µm): vesicle length 135–195, greatest width 55–75, maximum length of spines 20.

Remarks. *G. ruhnuensis* differs from *G. corniculata* (Laufeld 1974) in a finer and denser ornamentation, also in the form of spines. Besides, the base of *G. corniculata* lacks spines. *G. martinssoni* (Laufeld 1974) and *G. militaris* (Laufeld 1974) have a spherical chamber, the spines are arranged in regular rows and differ in shape.

Occurrence. *G. ruhnuensis* occurs in the lowermost beds of the Jaani Stage (Mustjala and Tôlla members), in some sections sporadically also in the uppermost part of the Velise and Jurmala formations of the Adavere Stage. Ruhnu core, depth 454–463 m; Varbla core, 132.5–137.35 m; Kirikuküla core, 6.30 m; Pulli 2 core, 25.3–28.3 m; Tôlla core, 126.10 m; Häädemeeste core, 212–213 m; Jaagarahu core, 42.6–59.7 m; Viki core, 142–149 m; Nagli core, 612–614 m; Ventspils core, 808 m.

Gotlandochitina spinosa (Eisenack, 1932)
Plate 27, figs 7–9

Synonymy: *Conochitina spinosa* sp. n. – Eisenack 1932, pp. 271–272, pl. 12, figs 11–13; *Angochitina spinosa* – Eisenack 1959, pp. 13–14, fig. 2 c, pl. 2, figs 1–2; Eisenack 1964, p. 325, pl. 28, figs 10–11; *Gotlandochitina spinosa* – Laufeld 1974, p. 91, fig. 52.

Description. The vesicle has a subconical chamber and a subcylindrical neck. The neck comprises about half of the total vesicle length and is slightly widened towards the finely fringed aperture. The base is flat, somewhat convex or concave, the basal edge is usually broadly rounded. The spines are long, simple – curved or branching once or twice in the proximal or distal ends. Sparse spines cover the whole vesicle, their length decreases at the base of the vesicle and in the oral part of the neck. The spines are arranged in 6–8 indistinct rows. The vesicle surface between the spines is smooth or finely granulate.

Occurrence. *G. spinosa* occurs in small numbers in the lower part and in the middle of the Jamaja Formation, also as single finds in the middle of the Sôrve Formation of the Jaagarahu Stage. Ohesaare core, depth 179?–292 m; Ruhnu core, 347?–396 m.

On Gotland *G. spinosa* is restricted to the middle-upper part of the Slite Beds (Laufeld 1974, p. 91).

Gotlandochitina tabernaculifera Laufeld, 1974
Plate 28, figs 1–2

Synonymy: *Gotlandochitina tabernaculifera* sp. n. – Laufeld 1974, pp. 92–93, fig. 53; Nestor 1982c, pl. 20, fig. 5.

Description. The vesicle is cylindro-conical, with a convex or flat base. In the oral part the neck widens, the aperture is finely fringed. The ornamentation is composed of sparsely set short spines with coalescent proximal ends arranged in more or less conspicuous rows. The vesicle surface is finely to coarsely granulate.

Occurrence. Rare finds of *G. tabernaculifera* are usually encountered in the uppermost part of the Sôrve Formation of the Jaagarahu Stage and in the lowermost part of the Rootsiküla Stage. Ohesaare core, depth 144–168 m; Ruhnu core, 269–298 m.

On Gotland *G. tabernaculifera* was restricted only to the Klinteberg Beds.

Gotlandochitina uncinata Laufeld, 1974
Plate 28, figs 4–5

Synonymy: *Gotlandochitina uncinata* sp. n. – Laufeld 1974, p. 94, fig. 54.

Description. The vesicle is cylindro-spherical, with a more or less developed shoulder. The neck widens towards the finely fringed aperture. The ornamentation is composed of 6–11 longitudinal rows of spines, which distally branch 2–3 times, occurring in the aboral part of the chamber and in the oral part of the neck. The oral part of the chamber, the flexure area and the vesicle base lack spines.

Occurrence. *G. uncinata* has been found sporadically, sometimes as rare specimens in the middle and upper parts of the Jamaja Formation and in the middle part of the Jugla Beds of the Jaagarahu Stage. Ohesaare core, depth 206?–261 m; Ruhnu core, 347–394 m; Ventspils core, 703–728 m.

On Gotland *G. uncinata* occurs in the upper part of the Slite Beds and in the Halla Beds.

Gotlandochitina cf. *valbyttiensis* Laufeld, 1974
Plate 28, figs 6–7

Description. The vesicle is cylindro-subspherical, with an indistinct shoulder. In the basal part of the chamber the ornamentation is composed of thick short spines arranged in longitudinal rows or being scattered. The spines are open in their distal ends resembling a palisade. Their bases are usually longitudinally elongated and have an irregular outline. In the aboral part of the neck and in the flexure area the spines are commonly simple, sometimes there occur λ-spines. The vesicle surface is sparsely granulate.

Remarks. The Estonian material does not correspond completely to the description of Laufeld as some of the specimens have a well developed spinose ornamentation, arranged in longitudinal rows in the flexure area and in the aboral part of the neck. The bases of the basal spines have sometimes a rounded outline.

It should be noted that the basal spines of this species are fragile and badly preserved in the holotype (see Laufeld 1974, fig. 55) as well as in our material.

Occurrence. Only a few specimens of *C.* cf. *valbyttiensis* have been encountered in the lower half of the Jamaja Formation of the Jaagarahu Stage. Ohesaare core, depth 282 m; Ruhnu core, 370–372 m.

On Gotland *G. valbyttiensis* ranges from unit "d" of the Slite Beds to the upper part of the Mulde Beds.

Gotlandochitina sp.
Plate 28, fig. 3

Remarks. In this work the name *Gotlandochitina* sp. marks rare badly preserved specimens or those with insufficiently expressed specific features. Such forms occur mostly in the upper part of the Jamaja Formation and in the Maasi Beds of the Jaagarahu Stage – Häädemeeste core, depth 131–150 m; Kipi core, 132–141 m; Kuressaare (Kingissepa) core, 99.4 m; also in the lowermost and middle parts of the Velise Formation of the Adavere Stage – Ruhnu core, depth 473 m; Viki core, 171.5 m; and in the boundary beds of the Tôlla and Paramaja members of the Jaani Stage – Ruhnu core, depth 434–441 m.

Genus *Sphaerochitina* Eisenack, 1955

Type species: *Lagenochitina sphaerocephala* Eisenack, 1932.

Diagnosis. Vesicle with spherical or subcylindrical chamber and cylindrical neck; base convex, flat or slightly concave; flexure and shoulder are developed or shoulder is missing; vesicle surface granulate or covered with random or dense cones or short spines.

Sphaerochitina indecora Nestor, 1982

Plate 32, figs 1–3

Synonymy: *Sphaerochitina indecora* sp. n. – Nestor 1982b, p. 149, pl. 2, figs 4–5.

Description. The vesicle is cylindro-subspherical to conical, with a rounded or inconspicuous basal edge and more or less convex flanks. The flexure and shoulder are developed. The ornamentation of short spines covers randomly the whole vesicle surface, it is finer at the base and on the oral part of the neck. The spines are usually simple, conical, sometimes more massive with a blunt end.

Dimensions (in µm): vesicle length 100–160, greatest width of the chamber 50–70, width of the neck 25–30, maximum length of spines 5–6.

Remarks. *Sphaerochitina indecora* is similar to *S. concava* (Laufeld 1974), but in *S. indecora* the vesicle flanks are straighter, less convex, spines are coarser, arranged more sparsely and randomly.

From *S. impia* (Laufeld 1974) this species differs mostly in longer sparse spines.

Most of the specimens are poorly preserved being partly broken and flattened.

Occurrence. *S. indecora* is scattered in small numbers in the upper part of the Sôrve Formation of the Jaagarahu Stage and in the lowermost part of the Rootsiküla Stage. Ohesaare core, depth 145–172 m; Ruhnu core, 269–312 ? m; Ikla core, 185–188 m; Kolka core, 409–430 m.

Sphaerochitina sp. 1

Plate 32, fig. 4

Description. The vesicle is cylindro-conical, carrying an irregular ornamentation of sparse simple short spines which are longer in the area of the basal edge.

Occurrence. Only rare flattened specimens were recorded from the Lemme Member of the Raikküla Stage. Ikla core, depth 370.8 m.

Sphaerochitina? sp. 2

Plate 32, fig. 5

Description. The vesicle is cylindro-subconical, with a slightly convex or concave base. The vesicle surface is granulate with random short spines.

Remarks. The vesicle wall of *S.*? sp. 2 is very thin, the vesicles are fragile and flattened. *S.*? sp. 2 is occurring together with *S. indecora* and may be related to this species.

Occurrence. Rare specimens of this species occur in the uppermost part of the Sôrve Formation and in the Jaagarahu Formation of the Jaagarahu Stage, also in the lowermost part of the Rootsiküla Stage. Ohesaare core, depth 150?–170 m; Ruhnu core, 284–309 m.

Sphaerochitina? sp. 3

Plate 32, fig. 6

Description. The vesicle has a spherical chamber and a subcylindrical neck. The middle part of the base is flat. The flexure is inconspicuous, the neck is wide. The vesicle wall carries a regular ornamentation with short simple, densely arranged spines. The middle of the base lacks spines, they are less numerous also on the oral part of the neck.

Remarks. The overall shape of this species is not characteristic of *Sphaerochitina* because of its too wide neck. Atypical is also the lack of the ornamentation in the middle part of the base.

Occurrence. Rare specimens were recorded from the uppermost part of the Õhne Formation of the Juuru Stage. Ruhnu core, depth 589.1 m; Puikule core, 436.0 m.

Subfamily Ancyrochitininae Paris, 1981

Genus *Ancyrochitina* Eisenack, 1955

Type species *Conochitina ancyrea* Eisenack, 1931.

Diagnosis. Cylindro-conical or cylindro-spherical vesicle with flat, convex or concave base; broadly or bluntly rounded basal edge provided with appendices or coarse simple or complicated spines; neck well differentiated, with or without ornamentation; flexure usually broad, shoulder inconspicuous.

Remarks. Some species of the genus *Ancyrochitina* have common characters also with other genera, e.g appendices of *A. plurispinosa* occur in longitudinally oriented very close pairs or triplets like in *Gotlandochitina*, but as these elements are always strictly converging upon the basal edge only, this species is here ascribed to the genus *Ancyrochitina*.

The species with the spongy texture of appendices are described under the genus *Plectochitina*.

Ancyrochitina ancyrea (Eisenack, 1931)
Plate 1, figs 1–3

Synonymy: *Ancyrochitina ancyrea* (Eisenack) – Laufeld 1974, p. 38, figs 4–5 (see synonymy); ? Grahn 1978, p. 10, fig. 5, A–B; ? Grahn 1985, p. 156, pl. 1, figs 1, 2; *Ancyrochitina primitiva* Eisenack – Grahn 1985, p. 158, pl. 1, figs 3–4.

Description. The vesicle is cylindro-conical, with 4–10 relatively long appendices branching 1–2 times in the distal part. The vesicle neck may have a short spinose ornamentation. The number, length and width of appendices are variable. The aperture is straight or fringed. The chamber surface is smooth.

Remarks. Fragile splitting ends of the appendices are often broken due to which this species is sometimes difficult to distinguish from *A. primitiva*. Transitional forms may also occur, having simple as well as branching appendices. Actually the appendices of *A. ancyrea* are slightly thinner than those of *A. primitiva* (see Eisenack 1964, p. 323).

Occurrence. *A. ancyrea* ranges from the Ordovician up to the upper Silurian. It is abundant almost throughout the Silurian section of the East Baltic but rarely serves as the dominant species. No reference concerning the sections and occurrence depths of *A. ancyrea* has been made here because of the too long list (see Figs 4–21).

Ancyrochitina aff. *ancyrea* (Eisenack, 1931)
Plate 1, figs 4–5

Remarks. The cylindro-conical vesicle has a flat or slightly convex base. Compared to *A. ancyrea*, the appendices are thicker and shorter, the branching of distal ends is more complicated. The neck is provided with short simple spines, which sometimes have longitudinally elongated bases.

Occurrence. Rare specimens of *A.* aff. *ancyrea* occur in the upper part of the Velise Formation and in the middle of the Irlava Beds of the Adavere Stage. Viki core, depth 148–152 m; Jaagarahu core, 57.3–60.2 m; Ruhnu core, 473 m; Ventspils core, 794(?) m and 815 m.

Ancyrochitina ansarviensis Laufeld, 1974

Plate 1, figs 6–7

Synonymy: *Ancyrochitina ansarviensis* sp. n. – Laufeld 1974, p. 39, fig. 5.

Description. The vesicle is cylindro-conical, with a wide, more or less flat base. The bluntly rounded basal edge is provided with 18–25 short spine-like appendices. The appendices are hollow, simple, often curved, sometimes splitting in their distal ends. The neck is widened towards the finely fringed aperture. The vesicle surface is slightly granulate.

Occurrence. Scarce specimens of *A. ansarviensis* are usually found in two intervals of the sections: in the Llandovery-Wenlock boundary beds (Velise Formation, Tõlla and Mustjala members) and in the middle Wenlock (the uppermost part of the Ninase Member and Paramaja Member). Ohesaare core, depth 310.5 m; Ruhnu core, 455–458 m; Viki core, 144–149 m; Pulli 2 core, 34–36 m; Kingissepa core, 127.5 m; Kihnu core, 179.7 m; Kirikuküla core, 14–17 m; Jaagarahu core, 45.5–59.7 m.

On Gotland the distribution of *A. ansarviensis* is restricted to the uppermost part of the Högklint Beds (upper part of unit "c") and to the south-western, marly facies (Laufeld 1974, p. 41).

Ancyrochitina bifurcaspina sp. n.

Plate 3, figs 3–5

Synonymy: *Ancyrochitina* sp. c – Nestor 1990, p. 81, pl. 14, fig. 5; *A.* sp. aff. *laevaensis* Nestor – Nestor, in press.

Derivation of name. Latin bifurca – two-forked refers to the character of ramification of the appendices.

Holotype. Ch 541/1919, Ohesaare core, depth 391.35 m, Raikküla Stage.

Diagnosis. Vesicle cylindro-conical, with convex base; broadly rounded basal edge carries 8–12 short appendices twice branching regularly; vesicle wall has granulate ornamentation.

Description. The chamber comprises about half of the total length and has a broadly rounded flexure. The shoulder is lacking. The broadly rounded or inconspicuous basal edge is provided with short weakly curved appendices, which have a short, sometimes coalescent proximal part and a distal part regularly branching twice. The neck is slightly widened towards the usually unfringed aperture and may carry some short triangular spines elongated in longitudinal direction. The vesicle wall has a delicate granulate ornamentation.

Dimensions (in µm): vesicle length 110–150 (holotype 130), maximum width 65–75 (excl., holotype 70), length of appendices 15–25 (holotype 18).

Discussion. *A. bifurcata* sp. n. differs from *A. ancyrea* in a characteristic regular way of branching, as well as in granulate ornamentation of the vesicle wall. *A. laevaensis* has short curved appendices branching 3–4 times.

Occurrence. *A. bifurcata* occurs in the uppermost part of the Õhne Formation of the Juuru Stage and in the Slitere Member of the Raikküla Stage. Ruhnu core, depth 573–577 m; Ohesaare core, 391–411? m; Ikla core, 484–506 m; Kolka core, 632–643.3 m; Viki core, 200–221.4 m; Häädemeeste core, 379–389 m; Sulustvere core, 71.6 m; Taagepera core, 366–397? m; Raikküla core, 32–34 m; Asuküla core, 11–18 m; Pusku 2 core, 5–12.2 m; Martna core, 18–20.2 m.

Material about 300 specimens.

Ancyrochitina cf. *clathrospinosa* Eisenack, 1968
Plate 2, figs 1–2

Synonymy: see Eisenack, 1968, p. 173.

Description. The vesicle is cylindro-conical, with 5–7 relatively long proximally branching appendices. The distal ends of the appendices are simple or bifurcating. The neck lacks ornamentation. The vesicle wall is smooth.

Remarks. *A.* cf. *clathrospinosa* has affinities with *A. primitiva* and *A. ancyrea*, being connected with these species by means of transitional forms (see Eisenack 1968, p. 174). In our samples scarce specimens of *A.* cf. *clathrospinosa* occur only together with abundant *A. primitiva* or *A. ancyrea*, but never constitute a separate population. Thus, it is difficult to agree with Eisenack's and Laufeld's supposition that *A. clathrospinosa* should be classified as a new genus (Laufeld 1974, p. 46).

Occurrence. Sporadic finds of *A.* cf. *clathrospinosa* have been recorded from two stratigraphic intervals: in the Rumba Formation of the Adavere Stage and in the uppermost part of the Jaani Stage – in the Ninase and Paramaja members. Ruhnu core, depth 489.6 m and 415–425 m; Ohesaare core, 308.4 m; Ikla core, 309.1 m; Varbla core, 104.0 m; Pulli 1 core, 13–15 m; Kingissepa core, 127.5 m; Häädemeeste core, 198.4 m; Kirikuküla core, 48.6–49 m; Puikule core, 335.0 m; Nagli core, 612 m; Kipi core, 100–111 m.

Ancyrochitina convexa Nestor, 1980
Plate 2, figs 3–5

Synonymy: *Ancyrochitina* cf. *tomentosa* Taugourdeau and Jekhowsky – Nestor 1976, p. 321; *Angochitina* sp. – Nestor 1976, p. 321; *Ancyrochitina convexa* sp. n. – Nestor 1980b, p. 137, pl. 1, figs 1–2.

Description. The vesicle has a cylindrical neck and more or less spherical chamber. The neck usually comprises more than half of the total vesicle length. The base is often strongly convex, therefore the chamber is almost spherical, without a distinct basal edge. The cylindrical neck widens slightly towards the finely fringed aperture. Most of the specimens have a conspicuous flexure and broadly rounded shoulder. Short curved appendices are usually arranged in 6–8 irregular groups along the basal edge, each containing 2–5 appendices. The appendices are simple or branching 3–4 times. The proximal unbranched part is less than half of the total length of the appendix. The length of appendices equals to 1/3 of the chamber diameter. Branching is complicated, sometimes fan-like, but occasionally appendices are connected by cross-bars. The appendices are irregular, of uneven thickness. The flexure and the lower part of the neck bear strongly curved fine spines. They are very fragile and therefore usually broken. The vesicle surface is finely granulate.

Dimensions (in µm): vesicle length 150–215, width (appendices incl.) 105–145, maximum length of appendices 30.

Remarks. *A. convexa* differs from *A. tomentosa* (Taugourdeau and Jekhowsky 1960) in the spherical chamber and ornamentation of the vesicle surface. From *A. laevaensis* (Nestor, 1980) it differs in a more convex base, shape of appendices and the presence of spines on the neck and flexure.

Appendices of *A. convexa* are fragile and break easily. Specimens in which appendices are not preserved can be erroneously assigned to the genus *Angochitina*, particularly in case of flattened material (see *Angochitina* sp. in Nestor 1976 = *Ancyrochitina convexa*).

Occurrence. *A. convexa* occurs in the lowermost part of the Ikla Member and in the lower part of the Dobele Formation, in places as rare specimens also in the uppermost beds of the Kolka Member of the Raikküla Stage. Ohesaare core, depth 373–384 m; Ruhnu core, 535–560 m; Ikla core, 441–467 m; Varbla core, 182–185 m; Häädemeeste core, 274–314 m; Viki core, 193 m; Nitaure core, 672–675 m; Puikule core, 383–413 m; Ventspils core, 856 m (cf.); Kolka core, 613–622 m; Remte core, 942.5 m; Vidukle core, 1445.2 m.

Ancyrochitina aff. *convexa* Nestor, 1980

Plate 2, fig. 6

Description. The vesicle is cylindro-conical, with a weakly convex base. The basal edge carries short branching spinose appendices with a longitudinally elongated and wide proximal part. The neck lacks ornamentation, the aperture is fringed. The vesicle surface is tuberculate.

Occurrence. Scarce specimens of *A.* aff. *convexa* occur in the Rumba Formation of the Adavere Stage. Varbla core, depth 154.5 m; Ikla core, 307–309.5 m; Häädemeeste core, 230.8 m; Pulli 2 core, 59.7 m; Viki core, 186–190 m.

Ancyrochitina gutnica Laufeld, 1974

Plate 2, figs 7–8

Synonymy: *Ancyrochitina gutnica* sp. n. – Laufeld 1974, p. 45, fig. 49; Dorning 1981, p. 206.

Description. The vesicle is cylindro-conical, with long appendices branching 2–4 times, which have a long, rather wide unbranched proximal part. The neck carries long, usually branching spines decreasing in size towards the fringed aperture. The vesicle surface is smooth or slightly verrucate.

Occurrence. *A. gutnica* occurs generally sporadically but sometimes abundantly in the Jamaja Formation and in the lower part of the Sôrve Formation, it is also present in the lowermost part of the Jugla Beds of the Jaagarahu Stage. Ruhnu core, depth 309–397 m; Ohesaare core, 181?–297 m; Häädemeeste core, 139–180 m; Kihnu core, 133–142 m; Ventspils core, 744–748 m.

By data of Laufeld (1974, p. 45), on Gotland *A. gutnica* ranges from the lowermost Slite Beds (unit "c") up to the middle of the Klinteberg Beds.

Ancyrochitina laevaensis Nestor, 1980

Plate 3, figs 1–2

Synonymy: *Ancyrochitina laevaensis* sp. n. – Nestor 1980a, p. 9, pl. 1, figs 1–3; Hill, Paris and Richardson 1985, pl. 12, fig. 8.

Description. The vesicle is cylindro-conical, with a convex base and more or less developed flexure. The shoulder is usually lacking. The neck is about half of the total vesicle length, widening towards the fringed aperture. The broadly rounded basal edge carries 7–10 slightly curved appendices branching 3–4 times. Their proximal part is short, wide, usually constricted at sides. The neck is without spines. The vesicle surface is regularly finely granulate.

Dimensions (in µm): vesicle length 140–170, greatest width 55–80, length of appendices 15–30.

Remarks. *Ancyrochitina laevaensis* occurs together with *A. ancyrea* differing from the latter mostly in the shape of appendices, which in *A. laevaensis* are shorter and more branching. The vesicle wall of *A. laevaensis* is granulate.

Occurrence. *A. laevaensis* is encountered in the Juuru Stage in the Puikule and Ruja members, in the lowermost part of the Sturi Member and in the lowermost part of the Õhne and (more rarely) Varbola formations. Ohesaare core, depth 441–446.9 m; Häädemeeste core, 425 m; Laeva 10 core, 122.5–143 m; Laeva 18 core, 166–176.5 m; Viki core, 232–240 m; Varbla core, 251.7 m (cf.); Taagepera core, 408.8 m; Nagli core, 659.2 ?–680.2 m; Kolka core, 659.5 m.

Ancyrochitina magna Nestor, 1982

Plate 4, figs 1–3

Synonymy: *Ancyrochitina magna* sp. n. – Nestor 1982b, pp. 146–147, pl. 1, figs 1–2.

Description. The vesicle is cylindro-conical, with a convex base. The neck usually constitutes more than half of the total vesicle length. The flexure is developed, the shoulder is missing. The base of the vesicle is strongly convex. The broadly rounded basal edge carries 5–6 thick, distally tapering appendices. The appendices are triangular, flat, with a wide base and pointed, sometimes splitting tips, usually curved aborally.

Short triangular spines (commonly 2–4) occurring on the neck are oriented towards the longitudinal axis of the vesicle. The oral margin is finely fringed. The vesicle surface is smooth to sparsely tuberculate.

Dimensions (in μm): vesicle length 160–210, maximum width of the chamber 70–100, smallest width of the neck 25–40, length of appendices 15–50, greatest width of appendices 15–35.

Remarks. *Ancyrochitina magna* occurs together with *A. primitiva* (Eisenack 1964), differing from it in the size (*A. magna* is longer) and the form of appendices (in *A. magna* they are triangular), but also in the strongly convex base of the vesicle.

Occurrence. Rare specimens of *A. magna* occur in the lowermost beds of the Jaani Stage. Ruhnu core, depth 441.5(?)–454 m; Varbla core, 135.1 m; Viki core, 144.5 m; Jaagarahu core, 43.6–56.2 m; Nagli core, 612.0 m; Ventspils core, 792 m.

Ancyrochitina paulaspina sp. n.
Plate 6, fig. 5

Synonymy: *Ancyrochitina* sp. b – Nestor 1982c, pl. 15, fig. 4; *Ancyrochitina* cf. *tomentosa* Taugourdeau and Jekhowsky – Nestor 1984, fig. 2.

Derivation of name. Latin "paulus" – small, little, referring to short appendices, the characteristic feature of the species.

Holotype. Ch 119/1828, Ruhnu core, depth 417.5 m, Jaagarahu Stage.

Diagnosis. Small cylindro-conical vesicle with flat or slightly convex base; basal edge provided with 4–10 short appendices branching 2–3 times; chamber flanks and neck lack ornamentation or neck carries a few short simple spines.

Description. The chamber comprises half of the total vesicle length. The shoulder is not developed. The bluntly rounded basal edge is bearing short appendices with a wide and short proximal part and distal ends branching 2–3 times parallel to the longitudinal axis of the vesicle. The neck lacks ornamentation, sometimes a few simple short spines may be present. The chamber wall is smooth.

Dimensions (in μm): vesicle length 110–150 (holotype 120), maximum width (excl.) 60–75 (holotype 62), length of appendices 10–20 (holotype 15), maximum length of spines on the neck 6.

Remarks. *A. laevaensis* Nestor, 1980 from the lower Llandovery of Estonia has a granulate vesicle wall and the ramification of the appendices is better developed than in *A. paulaspina*.

A. gutnica Laufeld (1974) from the Wenlock of Gotland has well developed long and curved spines on the neck and its long appendices have also a long and unbranched proximal part.

A. (*Gotlandochitina*?) *tomentosa* Taugourdeau and Jekhowsky, 1960 from the Silurian of Sahara has solid bending short spines on the chamber wall, which are completely missing in *A. paulaspina*.

The Devonian species *A. libeyensis* Jaglin (1986) and *A. morzadeci* Paris (1981) have a quite dense spinose ornamentation on the neck and flexure. The overall shape of these species differs greatly from that of *A. paulaspina*.

In some sections of the uppermost Wenlock (Sôrve Formation) there occur specimens not quite identical with *A. paulaspina*. Their appendices are shorter and the unbranched proximal part is almost lacking, while the spines on the neck are longer than those of *A. paulaspina*. In this paper these forms are classified as *A.* cf. *paulaspina*.

Occurrence. *A. paulaspina* occurs in the uppermost part of the Tôlla Member and in the Paramaja Member of the Jaani Stage, also in the Jamaja Formation and in the Jugla Beds of the Jaagarahu Stage. Ruhnu core, depth 344–420 m and 314–330 m (cf.), Ohesaare core, 244–311 m and 181–193 m (cf.), Ventspils core, 732–765 m and 687–706 m (cf.), Häädemeeste core, 131–176 m; Kingissepa core, 127.5 m; Kihnu core, 133.0 m; Varbla core, 114.5 m.

Material. Over 200 specimens.

Ancyrochitina plurispinosa sp. n.

Plate 6, figs 3, 7

Synonymy: *Ancyrochitina* sp. c – Nestor 1982b, pl. 17, fig. 2.

Derivation of name. Latin plures – more numerous, refers to the number of appendices.

Holotype. Ch 476/10915, Ohesaare core, depth 200.8, Jaagarahu Stage.

Diagnosis. Cylindro-conical vesicle with flat or concave base; basal edge carries 6–8 groups of short branched appendices arranged close to each other and forming short rows oriented along longitudinal axis of vesicle; chamber wall lacks ornamentation; neck bears simple, sometimes curved or slightly branching short spines.

Description. The chamber has straight flanks and comprises about half of the whole vesicle length. Rarely there occur specimens with a weakly convex base. The appendices are grouped by 2–3 and are attached to the basal edge close to each other, parallel to the longitudinal axis of the vesicle. The appendices are short, branching 2–4 times, curved aborally or orally. The neck is cylindrical. The oral part of the neck is provided with simple or branching, often curved spines, which are longer in the middle of the neck and shortern towards the aperture. In some specimens the whole neck is covered with spines. The chamber surface is usually smooth, sometimes weakly granulate. The aperture is fringed.

Dimensions (in µm): vesicle length 110–160 (holotype 115), greatest width (excl.) 45–75 (holotype 45), length of appendices 10–20 (holotype 15), greatest length of spines on the neck 8.

Remarks. Although the bases of branched appendices are arranged in short rows (characteristic feature of *Gotlandochitina*), they still remain in the area of the basal edge, visually forming one appendix. Due to this, these specimens are here affiliated to the genus *Ançyrochitina.*

A. plurispinosa resembles *A. valladolitana* Schweineberg, 1987 (Pl. 13, figs 4, 6–10), but this species has a convex base and convex chamber walls, basal appendices are arranged in 12 or more groups, the appendices are coalescent in the proximal part or scattered, not occurring in regular rows like in *A. plurispinosa.*

Occurrence. *A. plurispinosa* occurs sporadically, but rather numerously in the uppermost part of the Jamaja Formation, in the Ruhnu core also in the Sôrve Formation of the Jaagarahu Stage. In the Ventspils core this species occurs in the Ančia Member (depth 687.1 m). Ruhnu core, depth 314–399 m; Ohesaare core, 244–282 m.

Material. Over 200 specimens.

Ancyrochitina porrectaspina sp. n.

Plate 3, figs 6–8

Synonymy: *Ancyrochitina* sp. E – Nestor 1990, p. 81, pl. 14, fig. 21.

Derivation of name. Latin porrecta – prolonged refers to great length of appendices.

Holotype. Ch 273/1064, Viki core, depth 147.6 m, Adavere Stage.

Diagnosis. Cylindro-conical vesicle with 5–8 long, 2–4 times branching appendices; neck bears rare minute spines.

Description. The chamber comprises about half of the total vesicle length. The base is flat, slightly convex or concave. The flexure is conspicuous, the shoulder is absent. The bluntly rounded basal edge carries 5–8 long branching appendices, which usually have a long and thick unbranched proximal part and thin distal ends. The neck carries occasionally small simple spines. The vesicle wall is smooth.

Dimensions (in µm): vesicle length (excl.) 100–220 (holotype 105), maximum width (excl.) 65–105 (holotype 65), maximum length of appendices 45–85 (holotype 65).

Remarks. Achab (1978, II, pl. 2, figs 8–11) has described *A. longispina* from the upper Ordovician (Vaureal and Ellis Bay formations) of Anticosti Island resembling *A. porrectaspina* from Estonian upper Llandovery, but there are also noted some differences: 1) length of our forms varies in wider limits – specimens with a length of over 160 μm have not been recorded from Anticosti; 2) in *A. longispina* the neck lacks spines, only slight granulation is noted. In *A. porrectaspina* short simple spines are attached to the neck; 3) in Anticosti material the branching of appendices takes place crosswise to the longitudinal axis, contrary to *A. porrectaspina,* where branching is parallel with the longitudinal axis of the vesicle.

Occurrence. *A. porrectaspina* occurs sporadically, but in places rather abundantly, especialy in the upper half of the Velise Formation and Irlava Beds of the Adavere Stage. Only in the Viki core the range of this species is wider – from the uppermost part of the Rumba Formation of the Adavere Stage to the lowermost part of the Jaani Stage, at a depth of 141–171.6 m; Ohesaare core, 346–359 m; Ruhnu core, 463–471 m; Nagli core, 613–617 m.

Material. About 700 specimens.

Ancyrochitina primitiva Eisenack, 1964

Plate 5, figs 1–2

Synonymy: *Ancyrochitina primitiva* Eisenack – Laufeld 1974, p. 47, figs 12–13 (see synonymy); non Grahn, 1985, p. 158, pl. 1, figs 3–4.

Description. The vesicle is cylindro-conical, usually with a flat or slightly convex base. The basal edge carries 4–8 simple, unbranched, relatively wide appendices. The length of the appendices is variable. The neck usually lacks ornamentation. The vesicle surface is smooth.

Remarks. In many sections the lower and middle Llandovery parts have yielded specimens of *Ancyrochitina* resembling *A. primitiva.* They have thin, simple appendices, usually with broken tips. We have identified these specimens as *A. ancyrea* due to the sometimes splitting distal parts of their appendices, which are especially thin, fragile and therefore usually broken.

Occurrence. In all studied sections *A. primitiva* ranges from the upper Llandovery to the upper Silurian, inclusive. It appears usually abundantly in the middle of the Rumba Formation of the Adavere Stage. Only in the graptolitic section of the Ventspils core it is rare. No reference concerning the sections and the depths of occurrence of *A. primitiva* has been made here because of a too long list (see figs 4–21).

On Gotland *A. primitiva* ranges from the Lower Visby Beds up to the top of the Hemse Beds.

Ancyrochitina ramosaspina sp. n.
Plate 4, figs 5–7

Synonymy: ? *Ancyrochitina* sp. 1 – Achab 1981, pl. 3, figs 6, 11, 12; *Ancyrochitina* sp. D – Nestor 1990, p. 81, pl. 14, fig. 9; *Ancyrochitina* sp., aff. *nodifera* – Nestor, in press.

Derivation of name. From the Latin word "ramosus" (=branchy), referring to the appendices which resemble rigid branches.

Holotype. Ch 474/1456, Ikla core, depth 472.6 m, Raikküla Stage.

Diagnosis. Cylindro-conical vesicle with convex base carries 4–9 straight, rigid, 3–4 times branching appendices; neck provided with sparse simple or triangular minute spines; aperture fringed or with short spines.

Description. The chamber comprises about half of the total length of the vesicle. The basal edge is broadly to bluntly rounded. The flexure is conspicuous, but the shoulder is absent. The appendices are straight and wide in their proximal parts and mostly irregularly branching in their distal ends. The branching is developed more or less parallel to the longitudinal axis of the vesicle. The subcylindrical neck and the flexure area of the chamber carry occasionally short triangular spines. The aperture is fringed or provided with short indented spines.

Dimensions (in μm): vesicle length 115–170 (holotype 140), maximum width 50–65 (holotype 65), length of appendices 25–45 (holotype 40).

Remarks. *A. ramosaspina* differs from all previously described species of *Ancyrochitina* in its peculiar straight and rigid branch-like appendices with quite complicated ramification. *A. ramosaspina* is very similar to and, maybe identical with *A.* sp. 1 from the Gun River Formation in the Anticosti section (Achab 1981, pl. 3, figs 6, 11, 12), though the ornamentation of small spines on the neck is denser.

Occurrence. *A. ramosaspina* sp. n. occurs mostly in the Kolka Member, but sometimes in the upper part of the Slitere Member and in the lowermost part of the Ikla Member of the Raikküla Stage. Ohesaare core, depth 384–392 m; Ruhnu core 559–574 m; Ikla core, 465–481 m; Häädemeeste core, 329–334 m; Varbla core, 192–195 m; Viki core, 193–199 m; Puikule core, 407–419.3 m.

Material. About 50 specimens.

Ancyrochitina rumbaensis sp. n.
Plate 5, figs 7–10

Synonymy: *Ancyrochitina* sp. A – Nestor 1984, pl. 2, fig. 1; Nestor 1990, p. 81, pl. 14, fig. 15.

Derivation of name. Rumba Formation of the Adavere Stage where the species was recorded.

Holotype. Ch 226/1135, Ikla core, depth 309.3 m, Adavere Stage.

Diagnosis. Large cylindro-conical vesicle; chamber elongated, with highly convex base carrying 5–6 coarse appendices branching 2–4 times; neck almost smooth, sometimes provided with rare minute spines.

Description. The chamber usually comprises half or more of the total length of the vesicle. It is elongated, with a weak flexure. The shoulder is not developed, the basal edge is broadly rounded. The appendices are usually wide and long, branched in the distal, sometimes also in the proximal part. The neck has sometimes rare simple or triangular very fine spines. The aperture is fringed.

Dimensions (in µm): vesicle length 180–240 (holotype 240), maximum width 65–75 (holotype 75), length of appendices 35–55 (holotype 50).

Remarks. *A. rumbaensis* occurs together with *A. ancyrea*, but differs from it in a considerably coarser vesicle and more complex branching of appendices.

In some core sections and in the Vängla outcrop there are present single specimens identified as *A.* cf. *rumbaensis*, with a length of 150–160 µm, having 6–7 wide and relatively short (25–30 µm) appendices (Pl. 5, fig. II). The other features are the same as in *A. rumbaensis*.

Occurrence. *A. rumbaensis* occurs in the Rumba Formation of the Adavere Stage within a short interval. Viki core, depth 189.4 m; Häädemeeste core, 226.1 m (cf.); Ikla core, 308–309.5 m and 308.4 m (cf.); Varbla core, 159–161 m; Kirikuküla core, 41.6–43 m and 42–49 m (cf.); Kolka core, 601.8–602 m; Nagli core, 637–642 m (the uppermost Dobele Formation).

Material. About 120 specimens.

Ancyrochitina vikiensis sp. n.

Plate 1, fig. 8

Derivation of name. From the Viki village and borehole in the north-western part of Saaremaa Island.

Holotype. Ch 245/10464, Viki core, depth 147.6 m, Adavere Stage.

Diagnosis. Vesicle cylindro-conical; base flat or concave, provided with 10–18 short 2–4 times branching curved appendices with fine distal ends.

Description. A short and wide conical chamber comprises less than half of the total length. The flexure is conspicuous, but the shoulder is absent. The bluntly rounded basal edge is provided with numerous curved appendices with wide proximal parts and fine distal tips. The neck carries sparse simple short spines with tapering pointed ends. The chamber wall is smooth.

Dimensions (in µm): vesicle length 110–160 (holotype 140), maximum width (excl.) 60–100 (holotype 80), length of appendices 10–15 (holotype 12).

Discussion. *A. vikiensis* is similar to *A. libyensis* Jaglin, 1986 from the Pridoli of Libya, but the latter has a convex base, sometimes granules on the chamber wall, ornamentation on the neck consists of more densely arranged minute spines.

Occurrence. *A. vikiensis* occurs in the boundary beds of the Adavere and Jaani stages in the Viki core, depth 144–149 m.

Material. In the collection approximately 30 specimens.

Ancyrochitina sp. 1
Plate 6, fig. X 4

Synonymy: *Ancyrochitina* sp. a. – Nestor 1982b, pl. 13, fig. 3.

Description. The vesicle is cylindro-conical with a length of 140–155 μm, the base is concave or slightly convex. The body comprises more than half of the total length of the vesicle and usually has a broadly rounded shoulder. The bluntly rounded basal edge carries 6–8 short, branched appendices with a wide base and the proximal part, sometimes bulging in a bowl-like manner. The distal ends of appendices branch 1–3 times. The neck of the vesicle is wide and relatively short, provided with rare fine simple spines. The aperture is fringed. The vesicle surface is weakly granulate.

Occurrence. Scarce specimens of *A.* sp. 1 occur in the lowermost part of the Jaani Stage. Ruhnu core, depth 454.65 m; Viki core, 144.5 m; Jaagarahu core, 54.1 m.

Genus *Clathrochitina* Eisenack, 1959
Type species: *Clathrochitina clathrata* Eisenack, 1959.

Diagnosis. Cylindro-conical vesicle with well-developed flexure but without shoulder; base slightly convex or concave; basal edge provided with appendices coalescent at distal ends, sometimes forming a circular net around the base; appendices may be partly or completely covered with transparent membrane.

Remarks. This genus is closely related to *Ancyrochitina* (see Eisenack 1968, p. 174; Jansonius 1970, p. 795; Laufeld 1974, p. 57), but not to *Cyathochitina* as regarded by Cramer (1967). The genus *Clathrochitina* comprises the forms with a membrane between the appendices and those without it (see Paris 1981), since sometimes there are found specimens with a partial membraneous cover.

Clathrochitina clathrata Eisenack, 1959
Plate 9, figs 1–3

Synonymy: *Clathrochitina clathrata* Eisenack – Laufeld 1974, p. 57, fig. 20 (see synonymy).

Description. The vesicle is cylindro-conical, with 8–12 appendices covered with a thin transparent membrane. The neck is usually provided with short simple spines, decreasing in size towards the aperture. The vesicle surface is lanate.

Occurrence. *C. clathrata* is encountered in the lower part of the Jamaja Formation of the Jaagarahu Stage. Ohesaare core, depth 275–298 m; Ruhnu core, 373–413.3(?) m; Häädemeeste core, 180 m.

In the section of Gotland Island (Laufeld 1974, p. 57) *C. clathrata* occurs in the middle part of the Slite Beds (units "e", "f", "g") and in the beds with *Pentamerus gothlandicus*.

Clathrochitina aff. *clathrata* Eisenack, 1959

Plate 9, figs 4–5

Description. The vesicle is cylindro-conical, with a concave base. The proximal ends of the appendices are branching, the membrane is usually missing. The neck carries irregular very short spines. Solitary spines are attached to the chamber. The vesicle surface is smooth or lanate.

Occurrence. Scarce specimens of *C.* aff. *clathrata* occur in the uppermost part of the Adavere Stage (top of the Velise Formation and Irlava Beds) and in the lowermost part of the Jaani Stage. Pulli 2 core, depth 23–37 m; Nagli core, 612–614 m; Jaagarahu core, 59.6 m.

In some sections within the same stratigraphical interval, there were also recorded representatives of this genus, which in the figures of the distribution of species are named *Clathrochitina* sp., but evidently are identical with the described species. Usually these forms are poorly preserved. Häädemeeste core, depth 217 m; Varbla core, 139–142 m; Viki core, 144–149 m; Kirikuküla core, 11–22 m; Ventspils core, 805 m.

Clathrochitina sp.

Plate 9, figs 6–18

Synonymy: *Clathrochitina* sp. 1 – Achab 1981, pl. 3, figs 9, 10.

Description. The vesicle is cylindro-conical, with distally coalescent and proximally 2–4 times branching appendices. The membrane is missing. Sometimes the neck bears rare short spines, but usually they are absent. The vesicle surface is smooth.

Remarks. Separately should be considered the specimens of this genus occurring in scarce numbers in the uppermost part of the Sôrve Formation of the Jaagarahu Stage in the Ohesaare core, depth 161–163 m. In these specimens the flanks of the vesicle chamber are concave and the appendices may be provided with a membrane.

Occurrence. *C.* sp. occurs in small numbers in the uppermost part of the Juuru Stage, in the uppermost beds of the Õhne and Stačiunai formations, also in the Raikküla Stage (mostly in the Kolka Member or in the lowermost part of the Ikla Member). Ikla core, depth 470.3–473 m; Ohesaare core, 375.0 m; Varbla core, 194.2 m; Ruhnu core, 576.1 m; Taagepera core, 379.8–380 m; Nagli core, 667.0 m; Sulustvere core, 40.8–43 m.

Genus *Plectochitina* Cramer, 1964

Type species: *Plectochitina carminae* Cramer, 1964.

Diagnosis: Cylindro-conical vesicle with simple, bifurcate, ramified or anastomosing appendices, having spongy texture.

Remarks. The main discriminating character of this genus, considered by Paris (1981) is the tendency of appendices to anastomose. According to Cramer (1964), the most important feature is the spongy texture of the appendices. On the ground of his opinion the species with simple appendices cannot be omitted from the genus *Plectochitina*. Several species (*P. spongiosa, P. nodifera, P. pachyderma*) have usually simple appendices, but occasionally some of them may be weakly anastomosing in their proximal parts (e.g. Achab 1977, pl. I, figs 1–12).

To avoid the inclusion of the species with strongly anastomosing and simpler appendices into the same genus, it would probably be useful to differentiate the latter forms as a separate, new genus.

Plectochitina nodifera Nestor, 1982

Plate 4, fig. 4

Synonymy: *Ancyrochitina nodifera* sp. n. – Nestor 1980a, p. 100, pl. 2, figs 1–3; pl. 3, fig. 1.

Description. The vesicle is cylindro-conical, with a flat or slightly convex base provided with 6–8 branching spongy appendices. The cylindrical neck comprises half or a bit more of the total length of the vesicle. The neck widens towards the aperture and may end with a collar. The basal edge is rounded. In the proximal parts the appendices have irregular nodular thickenings, which were formed in the result of the separation and the following joining of appendices. Sometimes the appendices have a many-rooted base. Due to spongy nodular thickenings the appendices are slightly curved. Their irregularly branching distal ends are usually short and blunt. The oral margin carries numerous short spines which are rarely preserved.

Dimensions (in µm): length 110–165, greatest width 55–75, length of appendices 30–50.

Remarks. In the spinose aperture and irregular appendices *P. nodifera* resembles *Ancyrochitina alaticornis* (Jenkins 1967), differing from it in the structure and form of appendices. From *Ancyrochitina clathrospinosa* (Eisenack 1968) this species differs in the presence of spongy nodular thickenings and branching of the ends of appendices.

Occurrence. *P. nodifera* occurs usually in small numbers in the lowermost part of the Juuru Stage, mostly in the lowermost beds of the Õhne and Stačiunai formations – the lower half of the Ruja and Sturi members. Ohesaare core, depth 439.3–441.6 m; Laeva core, 124.6–141.0 m; Sulustvere core, 108 m; Viki core, 213 m; Häädemeeste core, 423–424 m; Taagepera core, 401(?)–408.9 m; Laeva 18 core, 171.3 m; Nagli core, 659.2(?)–677 m; Kolka core, 659.5 m; Remte core, 955.8–959 m.

Plectochitina obuti sp. n.
Plate 6, figs 2, 8

Synonymy: *Ancyrochitina* sp. d – Nestor 1982b, pl. 18, fig. 5.

Derivation of name: In honour of Prof. A.M. Obut, well-known Russian palaeontologist.

Holotype. Ch 475/977, Ohesaare core, depth 218.05 m, Jaagarahu Stage.

Diagnosis. Cylindro-conical vesicle with flat or slightly convex base and 4–8 hollow spongy, aborally curved appendices; bases of appendices elongated along longitudinal axis of vesicle; distal ends of appendices may split; vesicle surface granulate.

Description. The chamber comprises about half of the total vesicle length, its length exceeding the width. The basal edge is broadly rounded, sometimes inconspicuous. The shoulder is not developed. Spongy appendices are curved, horn-shaped, having fully or partly open walls. Distal ends of appendices are tapering, often curved and sometimes split. The neck lacks ornamentation, but occasionally may carry scarce simple spines. The aperture is fringed. The vesicle surface is slightly granulate.

Dimensions (in µm): vesicle length 100–160 (in holotype 120), greatest width 50–70 (in holotype 53), length of appendices 15–35 (in holotype 22), greatest length of spines on the neck 10.

Remarks. In *P. spongiosa* (Achab 1977) the width of the chamber is greater than length, the spines are longer (40–70 µm). The aperture is widening, provided with the collar.

In *P. pachyderma* (Laufeld 1974) the appendices are fenestrated and triangular, "flattened" in the oral-aboral direction, the neck lacks the spines and the chamber is more finely granulate.

Occurrence. *P. obuti* sp. n. occurs sporadically in small numbers in the uppermost part of the Jamaja Formation and in the Sôrve Formation, it is also present in the uppermost part of the Jugla Beds of the Jaagarahu Stage. Ohesaare core, depth 162?–233 m; Ruhnu core, 329–348 m; Häädemeeste core, 131.0 m; Kihnu core, 127.0 m; Ventspils core, 724.0 m.

Material. About 50 specimens.

Plectochitina cf. *pachyderma* Laufeld, 1974
Plate 4, figs 8–10

Description. The vesicle is cylindro-conical, with a flat or slightly convex base. The basal edge has 4–7 flat triangular appendices with a wide base. The appendices are hollow, composed of a spongy tissue, provided with a wide base and sharp distal ends. The vesicle surface is granulate.

Remarks. These forms resemble *P. pachyderma* from Gotland Island (see Laufeld 1974, p. 45, fig. 10), but our specimens have only rarely appendices with a fenestrated base and their stratigraphic range is longer.

Occurrence. *P.* cf. *pachyderma* occurs rarely, but in places rather abundantly in the Jaani Stage, especially in the lowermost parts of the Mustjala and Tôlla members, but also in the Paramaja Member. Fairly scarce finds come from the lower half of the Jamaja Formation of the Jaagarahu Stage. Ohesaare core, depth 248–342 m; Ruhnu core, 354?–454 m; Häädemeeste core, 150–185 m; Varbla core, 91.3–122 m; Kingissepa core, 87–91 m (Tagavere Beds of the Jaagarahu Stage); Pulli 1 core, 8–15 m; Pulli 2 core, 1–26 m; Viki core, 141–145 m; Nagli core, 612.0 m.

In the section of Gotland *P. pachyderma* occurs in the Lower Visby marls and south-western facies of the Högklint Beds (Laufeld 1974, p. 47).

Plectochitina ralphi sp. n.
Plate 5, figs 3–6

Synonymy: *Ancyrochitina* sp. B – Nestor 1984, pl. 2, figs 8–10.

Derivation of name: The species was named in honour of Dr. Ralf Männil, initiator of the study of chitinozoans in the former Soviet Union, who gave for the study most of the material of this species collected by him from the Vängla ditch.

Holotype. Ch 238/1940, Vängla ditch, Adavere Stage.

Diagnosis. Vesicle cylindro-conical, with flat or slightly convex base, provided with 6–8 irregular, spongy, blunt, aborally curved appendices.

Description. The chamber is conical, with a broadly rounded basal edge, comprising less than half of the total length of the vesicle. The appendices are simple, unbranched, irregularly nodular, always curved aborally. The chamber gradually turns into the neck, the shoulder is missing. The neck widens towards the finely fringed aperture. The vesicle surface is smooth or weakly granulate.

Dimensions (in µm): vesicle length 120–175 (holotype 145), maximum width 55–70 (holotype 70), length of appendices 35–65 (holotype 45).

Remarks. *P. ralphi* somewhat resembles *P.* cf. *spongiosa*, but the latter has more straight uncurved appendices, less in number.

Occurrence. *P. ralphi* is encountered rarely as solitary specimens in the Rumba Formation of the Adavere Stage. Rather abundantly it occurs (over 130 specimens) in the sample from the Vängla ditch. Viki core, depth 184.8–185 m;

Ikla core, 308.4 m; Varbla core, 160.2 m; Emmaste core, 36.7 m; Kirikuküla core, 42.9–43 m.

Plectochitina cf. *spongiosa* Achab, 1977
Plate 6, fig. 1

Description. The vesicle is cylindro-conical, usually with a flat or slightly convex base. The length of the neck is equal to or exceeds a little that of the chamber. The basal edge carries 4–6 straight spongy appendices varying in length and width. The appendices are rounded, conical or almost cylindrical, with blunt, sometimes splitting distal ends. The aperture is fringed. The vesicle surface is slightly granulate.

Remarks. *P.* cf. *spongiosa* differs from the type material (Achab 1977, 2195, pl. I, figs 1–9, 12; Achab 1978, 299, pl. I, figs 1–3) from the upper Ordovician of Anticosti Island, only in having a longer neck compared to the chamber (in Canadian material the length of the neck is equal to or less than that of the chamber). Besides, in our specimens the proximal parts of the appendices are not connected with each other like in the type material.

Occurrence. *P.* cf. *spongiosa* occurs in scarce numbers in the Juuru Stage (in the Ruja and Sturi members, sometimes in the Varbola and Õhne formations and in the Karinu Member) and also in the Raikküla Stage (in the lowermost part of the Slitere Member). Viki core, depth 213–239 m; Ohesaare core, 440.2 m; Emmaste core, 70.8–75 m; Ikla core, 499(?)–515 m; Pusku 2 core, 5(?)–23 m; Asuküla core, 11.2 m; Raikküla core, 40.6 m; Rapla core, 31–40 m; Nurme core, 85(?)–111.5 m; Laeva 18 core, 171(?)–175.5 m; Taagepera core, 367–408.9 m; Nagli core, 661– 673 m; Remte core, 954–959 m; Kolka core, 643.8(?)–659.8 m.

In the Puikule core at a depth of 331–402 m, *P.* aff. *spongiosa* having a low spinose ornamentation on the neck of the vesicle, has been identified in the lowermost part of the Adavere Stage.

Plectochitina sp. 1
Plate 6, fig. 9

Synonymy: *Ancyrochitina* sp. 2 – Nestor 1982b, pl. 19, fig. 6.

Description. The vesicle is short (120–130 μm), cylindro-conical, with a flat or slightly concave base. The basal edge is provided with 8–10 spongy appendices. The appendices have an obscure, complicated outline with the bulging proximal part along with the rounded base and indistinctly branching distal ends. The neck and the flexure area carry rare fine, sometimes two- or three-rooted spines. The vesicle wall is granulate.

Occurrence. Scarce specimens of *P.* sp. 1 occur in the Ohesaare core in the uppermost part of the Sôrve Formation of the Jaagarahu Stage at a depth of 174.6 m.

Subfamily Cyathochitininae Paris, 1981

Genus *Anthochitina* Eisenack, 1971

Type species: *Anthochitina superba* Eisenack, 1971.

Diagnosis. Cylindro-conical vesicle; basal edge provided with wide, spongy membraneous carina widening aborally; carina edge plane, wavy, dentate or indented.

Remarks. Up to the present time this genus was known only from the uppermost Silurian. The type species comes from the ostracode-bearing limestone ("Beyrichienkalk") of Pridoli age, but has also been recorded from the lowermost Devonian. Our material, collected from the Llandovery-Wenlock boundary beds, is extremely similar to the type material, in spite of great differences in age.

Anthochitina primula sp. n.

Plate 8, figs 1–6

Synonymy: ? *Clathrochitina* sp. 2 – Achab 1981, pl. 5, figs 1–5.

Derivation of name: Latin primulus (=first) refers to the earlier time of the appearance of this genus already in the East Baltic Llandovery, compared to other *Anthochitina* species known from the uppermost Silurian and Devonian.

Holotype. Ch 335/10471, Viki core, depth 140.1 m, Adavere Stage.

Diagnosis. Cylindro-conical vesicle with slightly convex or concave base; basal edge provided with wide spongy membraneous carina.

Description. The chamber usually comprises about half of the total vesicle length. The flexure is present, but the shoulder is not developed. The spongy membraneous carina is sometimes pierced by holes of various sizes. The teeth occurring at the edge of the carina may be of different length and form, sometimes also splitting. The neck is cylindrical, smooth, bearing scarce simple short spines. The chamber surface is smooth. The aperture is finely fringed.

Dimensions (in μm): vesicle length 140–200 (in holotype 140), greatest width 55–80 (in holotype 65), width of the carina 15–40.

Remarks. *A. primula* resembles *A. superba* (Eisenack 1971, p. 452, Abb 1–15), but differs from it in the cylindrical neck. In *A. superba* the neck widens considerably towards the aperture. In *A. primula* the neck may carry fine spines, whereas in *A. superba* the neck lacks ornamentation. The membraneous carina of

A. superba is very thin and reticulate, in *A. primula* the carina is more homogeneous and thick.

Occurrence. By now *A. primula* has been recorded from three sections: Viki core, depth 140.1 m, Jaagarahu core, depth 59.6 m and Ruhnu core, depth 463.2 m (the last occurrence is from a supplementary sample and is not shown in Fig. 19/2). It is encountered within a short interval in the uppermost part of the Velise Formation of the Adavere Stage. The stratigraphic distribution of this species seems to be rather restricted.

Material. In the collection about 90 specimens.

Genus *Cyathochitina* Eisenack, 1955

Type species: *Conochitina campanulaeformis* Eisenack, 1931.

Diagnosis. Vesicle with subconical chamber and cylindrical neck; flexure more or less developed, shoulder indistinct or missing; basal edge sharp, with or without carina; vesicle surface smooth to granulate.

Remarks. Representatives of the genus *Cyathochitina,* occurring in East Baltic sections, have vesicles of three different types (calix, campanulaeformis, kuckersiana), known already from the lower or middle Ordovician (Eisenack 1931, 1934, 1962, etc.). In the morphology of Silurian forms there may be some differences, but they are insufficient for establishing new taxa. This conclusion was reached by Cramer (Cramer and Diez 1978) during the study of *Cyathochitina campanulaeformis* from the upper Llandovery of Spain.

In the East Baltic Llandovery all three species of the genus *Cyathochitina* may give a number of transitional forms which cannot be treated as independent taxa.

Cyathochitina calix (Eisenack, 1931)

Plate 23, figs 1–3

Synonymy: *Cyathochitina calix* (Eisenack) – Schallreuter 1981, p. 125, pl. 16–17 (see synonymy).

Description. The vesicle has an elongated-subconical chamber and cylindrical neck. The width is greatest at the basal edge which has a narrow carina, commonly parallel to the longitudinal axis of the vesicle. L/D=2.2–2.5:1. The base is flat, with a concentric sculpture and a basal scar in the centre. The vesicle surface is granulate, carrying faint radial ribbing on the flanks and the longitudinal one on the neck and flexure area.

Remarks. *C. calix* is not a homogeneous species. There occur more elongated, subcylindrical forms with notable constriction of flanks immediately oralward of the basal edge (Eisenack 1962, pl. 14, fig. 3; Eisenack 1965, pl. 2, figs 1–2; Grahn 1980, fig. 14A, etc.). However, the holotype (Eisenack 1931, pl. 2, fig. 3) and especially the neotype (Eisenack 1962, pl. 14, fig. 4) are more conical, with a wider chamber and base.

The neotype of *C. calix* was used by Schallreuter for erecting a new subspecies *C. calix jagovalensis* (Schallreuter 1981, pp. 127–128). However, its features were not sufficiently characterized to affiliate our specimens with this taxon, though in the shape the Llandoverian representatives of *C. calix* are rather close to *C. c. jagovalensis*.

Recently Nôlvak and Grahn (1993) described *C. angusta* from the upper Ordovician of Estonia and Sweden, but in this taxon L/D=1.5–2:1 and the vesicle wall is smooth, in our specimens L/D=2.2-2.5:1 and the vesicle surface is granulate, usually with radial ribbing on the chamber flanks.

Occurrence. *C. calix* occurs sporadically but abundantly at definite stratigraphic intervals of the East Baltic Llandovery. In the Juuru Stage it has been identified in the upper half of the Õhne Formation, in the uppermost part of the Varbola Formation and in the Karinu Member of the Tamsalu Formation. In the Raikküla Stage this species was recorded from the Slitere Member and from the lowermost part of the Kolka Member in the sections of southern Estonia and Latvia. Ikla core, depth 478–516? m; Ohesaare core, 389–423 m; Ruhnu core, 567.8–593.6 m; Kolka core, 628–643 m; Remte core, 946–947 m; Puikule core, 423–430 m; Ventspils core, 867–867.5 m; Taagepera core, 379–395 m; Nagli core, 657–660 m; Laeva 10 core, 70–128 m; Häädemeeste core, 350–409 m; Varbla core, 201–231 m; Viki core, 222–229 m; Emmaste core, 60–64 m; Nurme core, 84.3 m; Martna core, 46.5 m.

Cyathochitina campanulaeformis (Eisenack, 1931)
Plate 23, figs 4–6

Synonymy: *Cyathochitina campanulaeformis* (Eisenack) – Eisenack 1976, p. 187, pl. 2, fig. 4 (see synonymy).

Description. The vesicle is cylindro-conical, with a flat or weakly convex base having a scar in the centre. The basal edge is sharp forming a narrow carina. The length/width ratio is always smaller than 2:1. The vesicle surface is granulate. Ribbing is concentric on the base, on the flanks it is developed longitudinally or crosswise, on the neck longitudinally to the vesicle axis. The sculpture is usually weakly expressed, sometimes inconspicuous.

Occurrence. *C. campanulaeformis* occurs abundantly in the lowermost Llandovery, rarely in the middle and upper parts of the series. Ohesaare core, depth 389?–447.7 m; Ikla core, 473?–513 m and 320.7–322 m; Ruhnu core, 516?–600.8 m; Puikule core, 412–459.5 m; Kolka core, 618–661 m; Remte core, 945–961 m; Ventspils core, 862–872 m; Vidukle core, 1446–1470 m; Nagli core, 645–679.2 m; Nitaure core, 674.7–709 m; Taagepera core, 364–409 m; Laeva 10 core, 74–143 m; Laeva 18 core, 166–176 m; Sulustvere core, 54–109 m; Varbla core

194–225 m and 157.5? m; Viki core, 198–242 m; Pulli 2 core, 57.8 m; Häädemeeste core, 274–425 m; Emmaste core, 33–73.4 m; Kirikuküla core, 87 m; Raikküla core, 34–39 m; Rapla core, 17–40 m; Pusku 2 core, 9.7m; Martna core, 25 m; Nurme core, 85.4 m.

Cyathochitina kuckersiana (Eisenack, 1934)
Plate 23, figs 7–8

Synonymy: *Cyathochitina kuckersiana* (Eisenack) – Schallreuter 1981, pp. 122–124, pl. 15, fig. 3 (see synonymy).

Description. The vesicle is cylindro-conical, with a wide transparent carina on the basal edge. The base is flat carrying a weak concentric sculpture and a scar in the centre. The flanks are concave, straight or slightly convex. The aboral part of the neck is provided with longitudinal rib-like thickenings. The vesicle surface is weakly granulate, sometimes there are noted radial thickenings.

Remarks. The length/width ratio of the vesicles usually varies from 1.5:1 to 1:1. The width of the carina is also variable. In the same samples there occur "normal" specimens and short ("brevis") forms (see Eisenack 1962, p. 298), although short forms are prevailing.

Questionable seem also the subspecies *latipatagium* and *patagiata* distinguished by Jenkins (1969) for the shorter and longer forms of *Cyathochitina kuckersiana*, as shorter and longer vesicles with the carina of variable width occur together in almost all studied samples.

Occurrence. In the Silurian of Estonia *C. kuckersiana* occurs only in some intervals of the section, sometimes in large numbers. It is encountered in the uppermost beds of the Juuru Stage (the uppermost parts of the Õhne, Varbola and Tamsalu formations) and in the lowermost part of the Raikküla Stage (the lowermost parts of the "Pusku", sometimes of the Slitere members). This species is numerous almost everywhere in the Kolka Member of the Raikküla Stage. Only sporadic finds have been recorded from the Rumba Formation of the Adavere Stage. Ohesaare core, depth 413–416 m; Ruhnu core, 564.5 m; Ikla core, 471–504 m and 316–320.4 m; Kolka core, 623.5 m; Remte core, 945?–961? m; Puikule core, 421.7–434? m; Nitaure core, 674.4–678 m; Nagli core, 649.1 m; Taagepera core, 365–380 m; Laeva 10 core, 89–101 m; Sulustvere core, 72.2–75 m; Häädemeeste core, 388–399 m and 337 m; Varbla core, 218–223 m and 189.8 m; Viki core, 198.6–223 m; Emmaste core, 33–56 m; Kirikuküla core, 33.5–87 m; Nurme core, 73–80 m; Pusku 2 core, 6–9 m; Asuküla core, 17.9 m; Raikküla core, 32–35 m; Rapla core, 7–17 m; Martna core, 25 m.

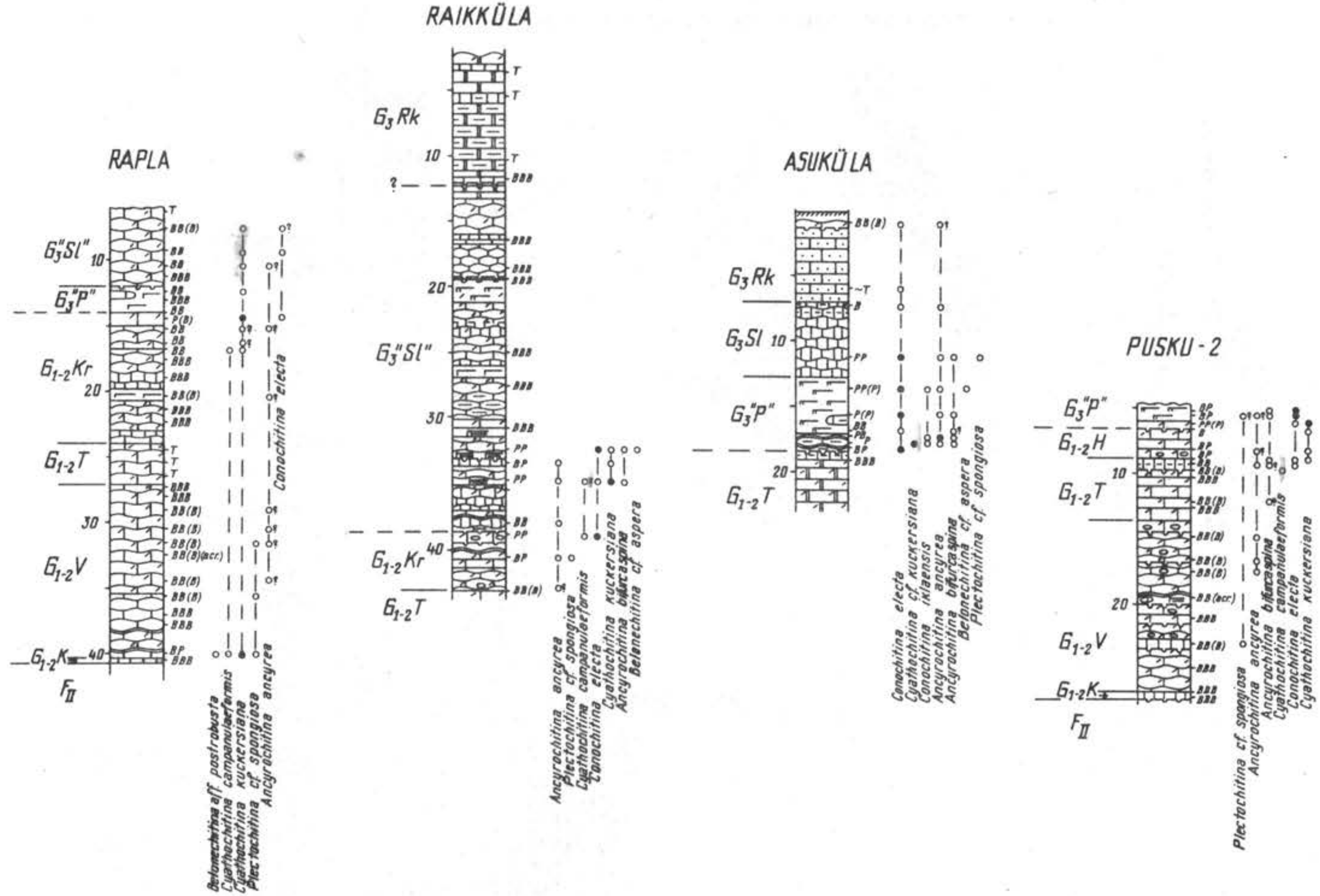

Fig. 4. Distribution of chitinozoans in the Rapla, Raikküla, Asuküla and Pusku 2 core sections. For the lithological legend see Fig. 22.

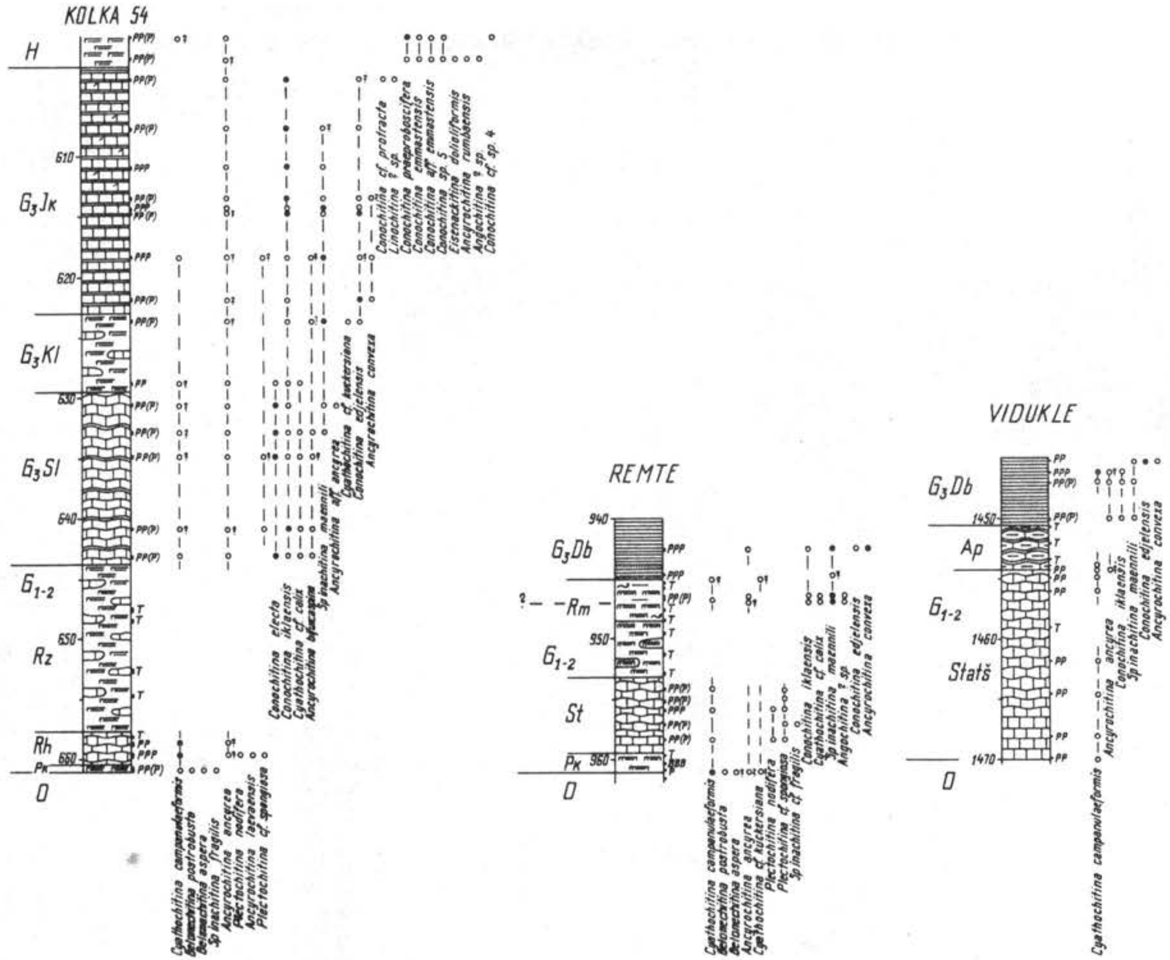

Fig. 5. Distribution of chitinozoans in the Kolka, Remte and Vidukle sections.

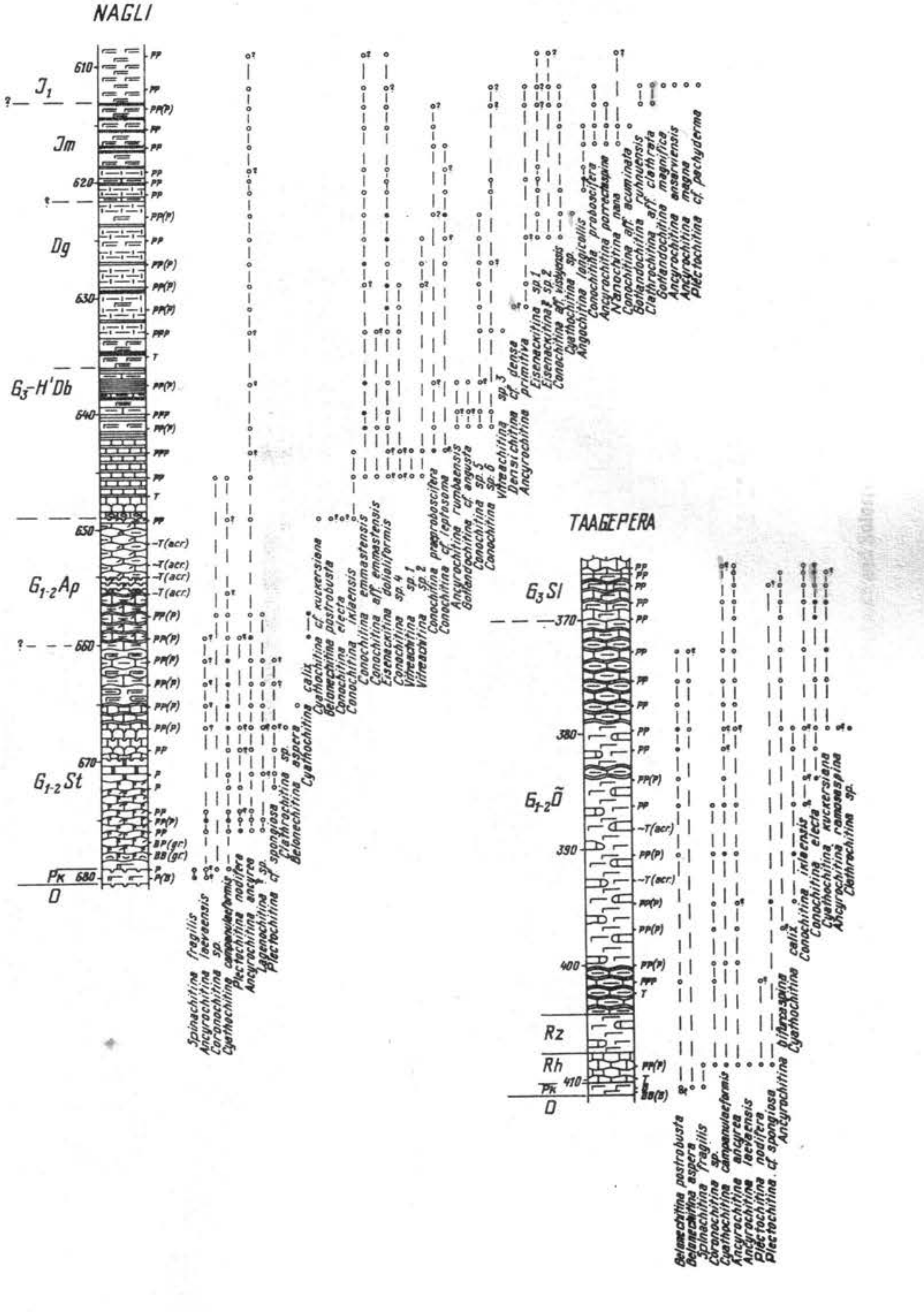

Fig. 6. Distribution of chitinozoans in the Nagli and Taagepera sections.

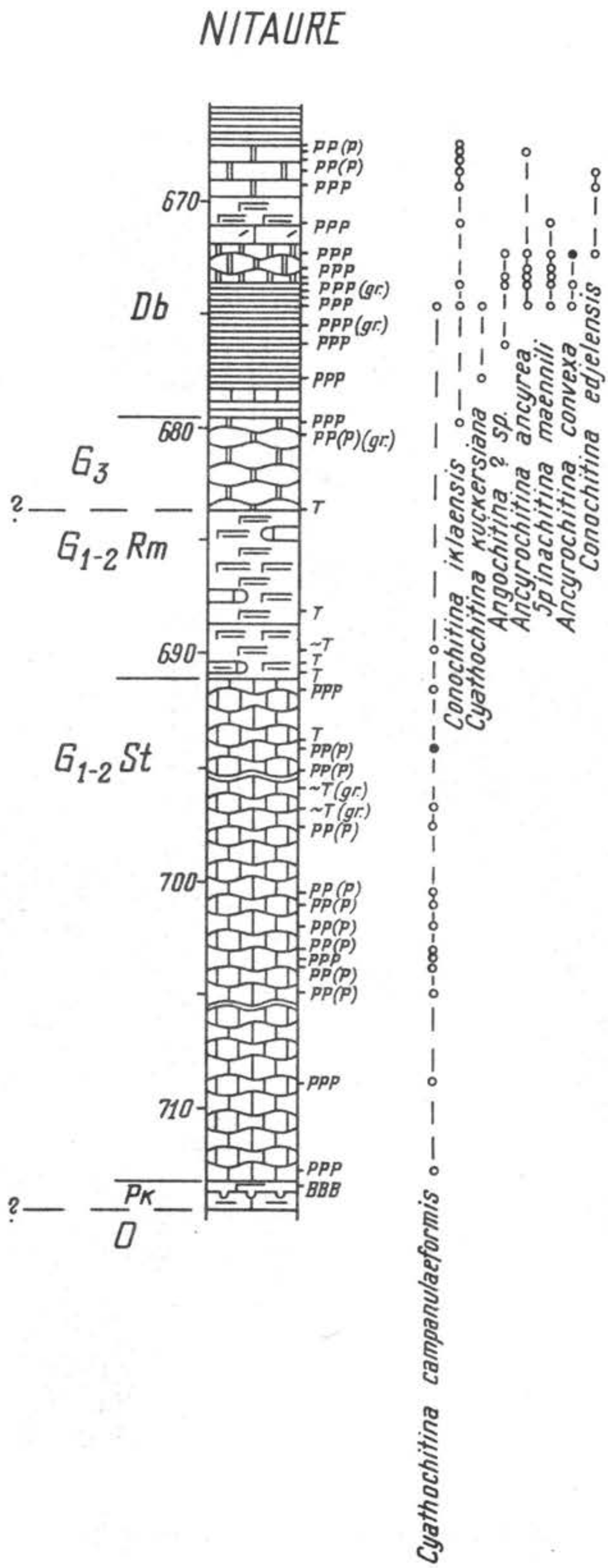

Fig. 7. Distribution of chitinozoans in the Nitaure section.

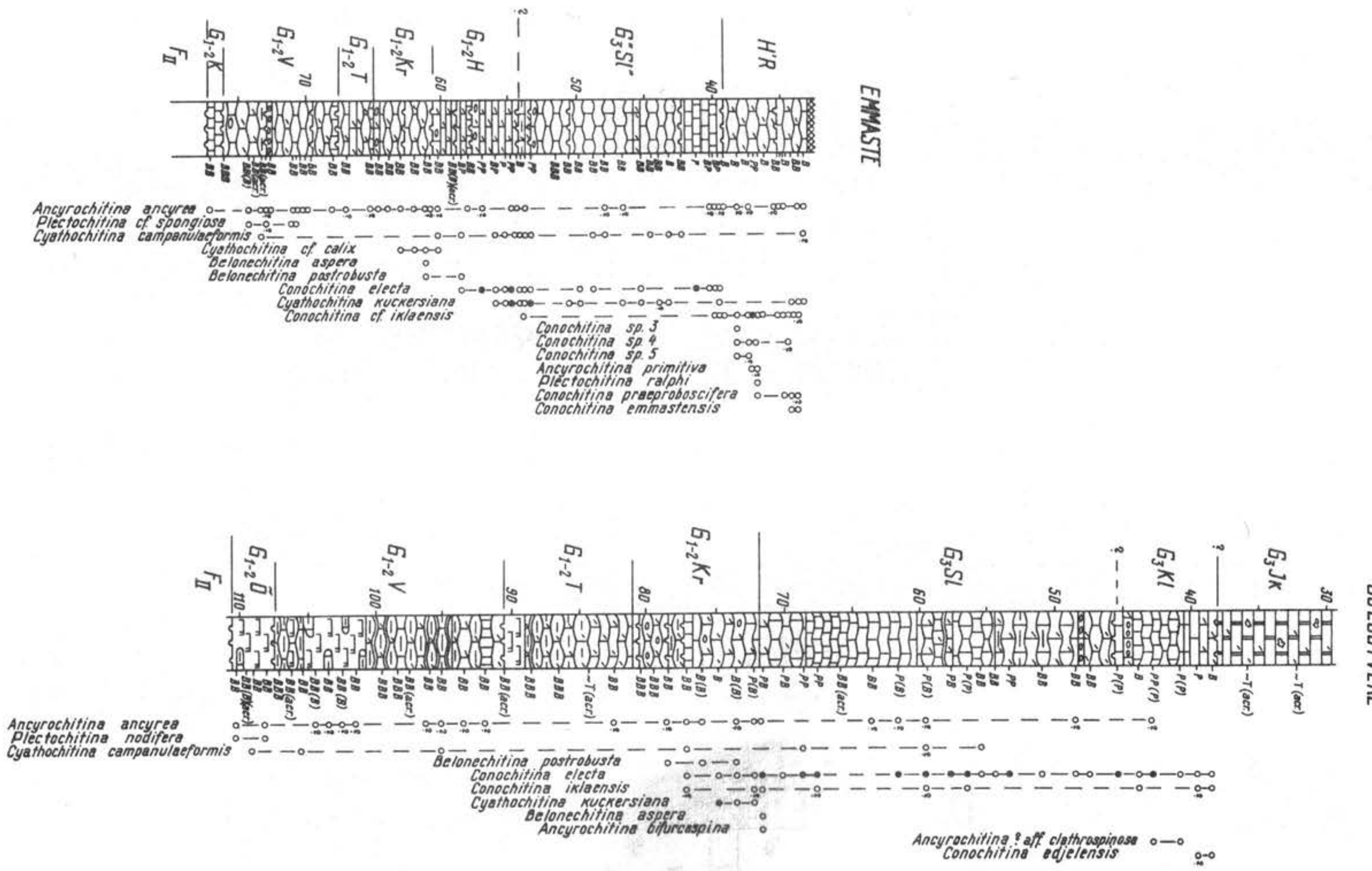

Fig. 8. Distribution of chitinozoans in the Emmaste and Sulustvere sections.

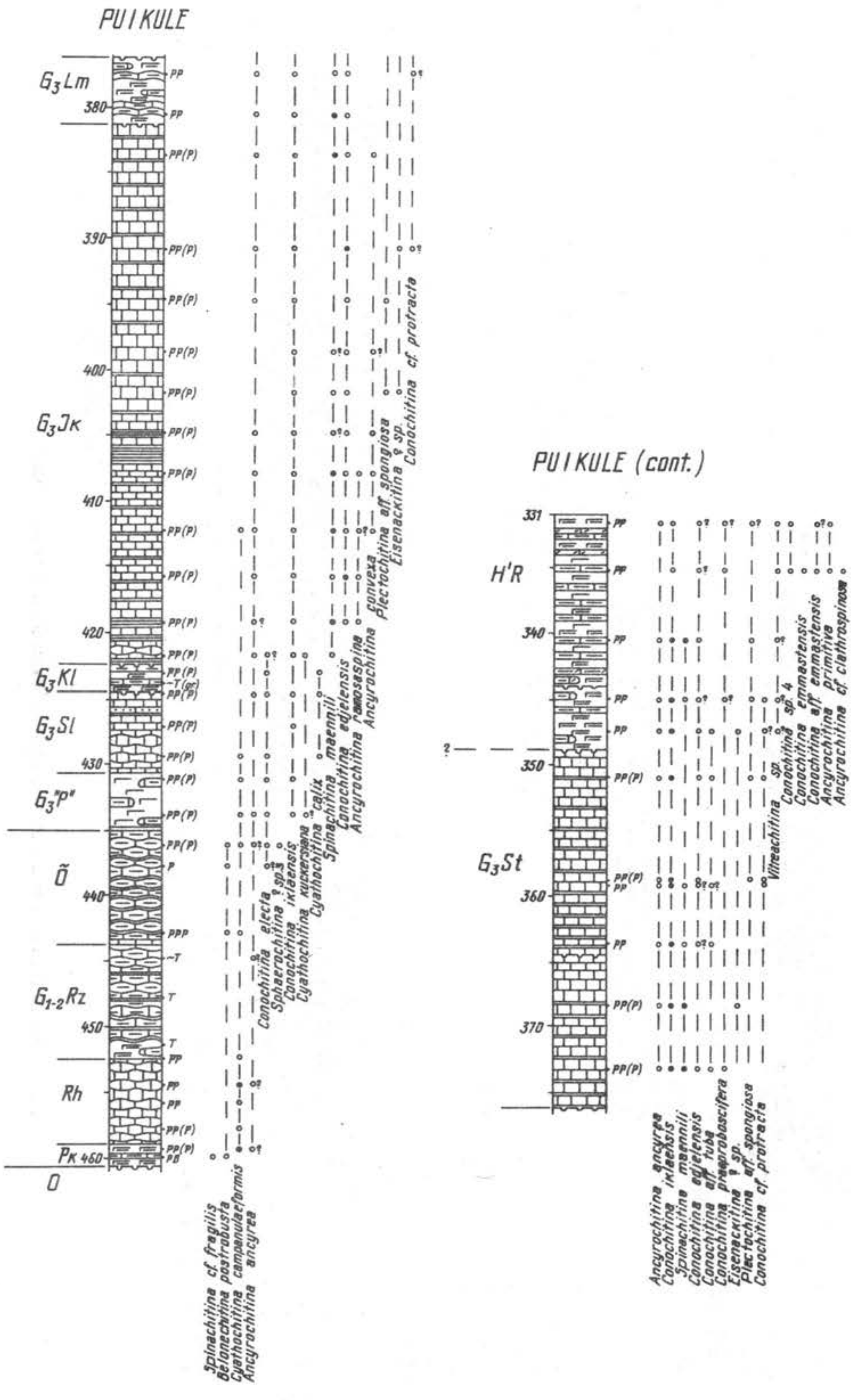

Fig. 9. Distribution of chitinozoans in the Puikule section.

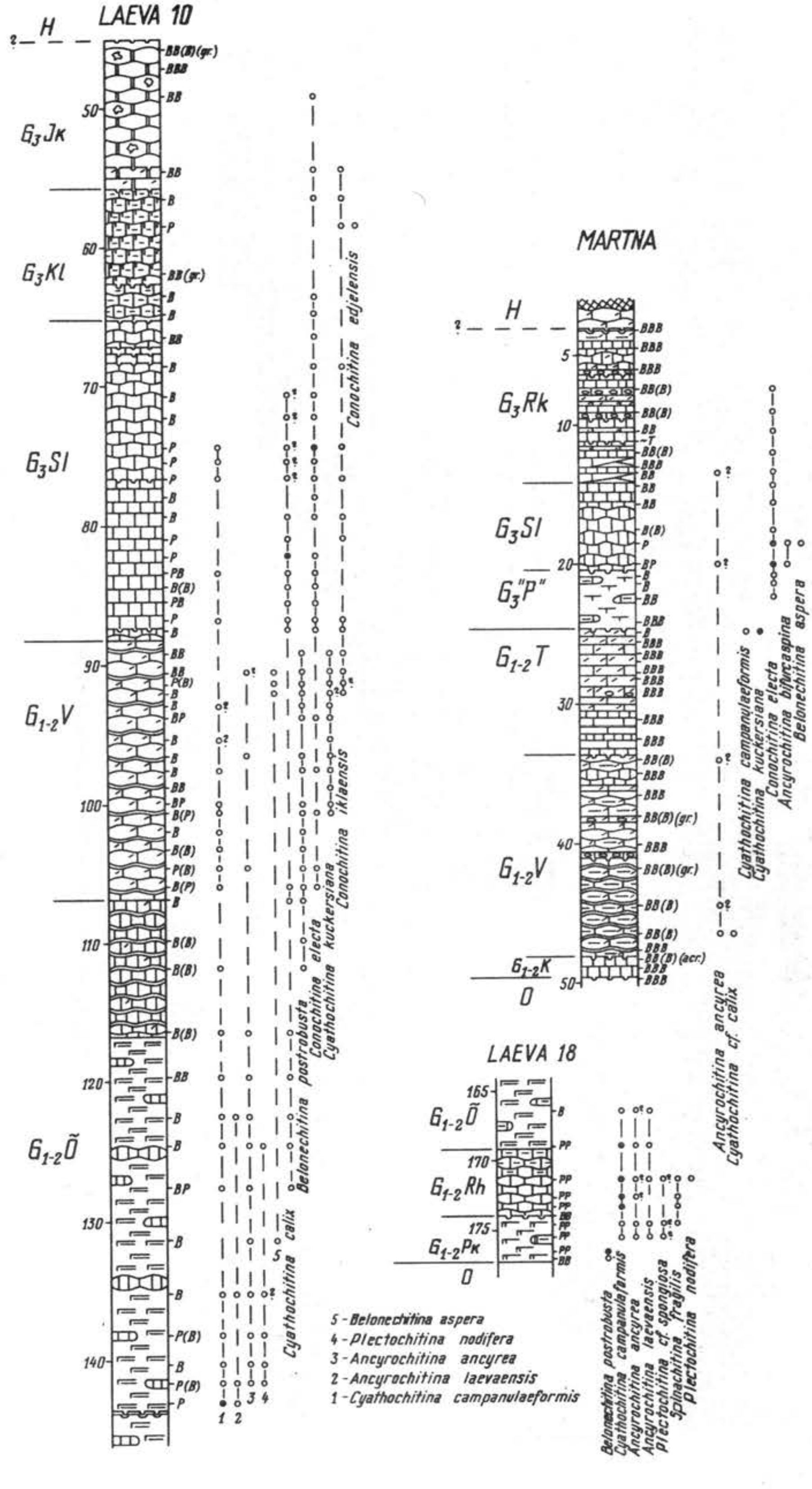

Fig. 10. Distribution of chitinozoans in the Laeva 10, Laeva 18 and Martna sections.

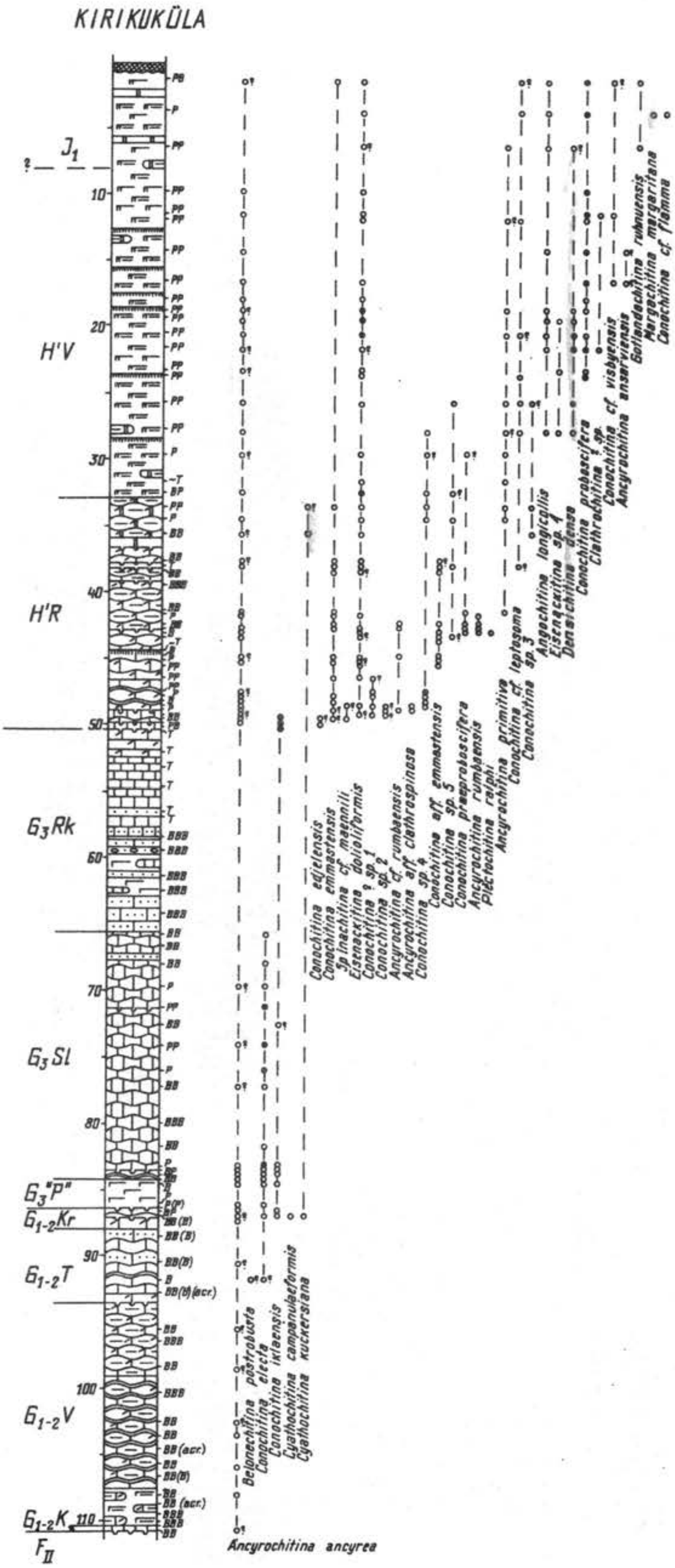

Fig. 11. Distribution of chitinozoans in the Kirikukula section.

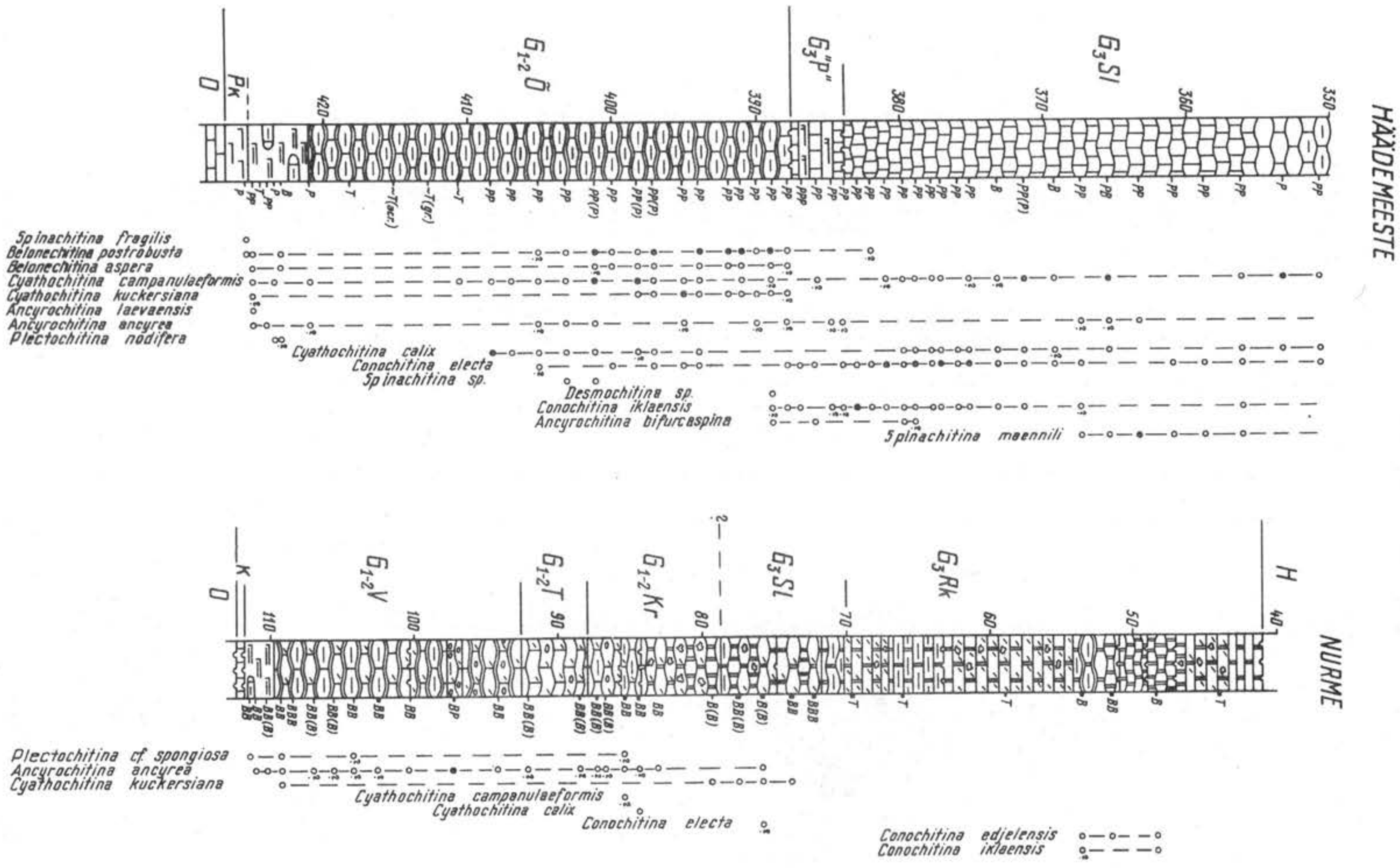

Fig. 12/1. Distribution of chitinozoans in the Häädemeeste and Nurme sections.

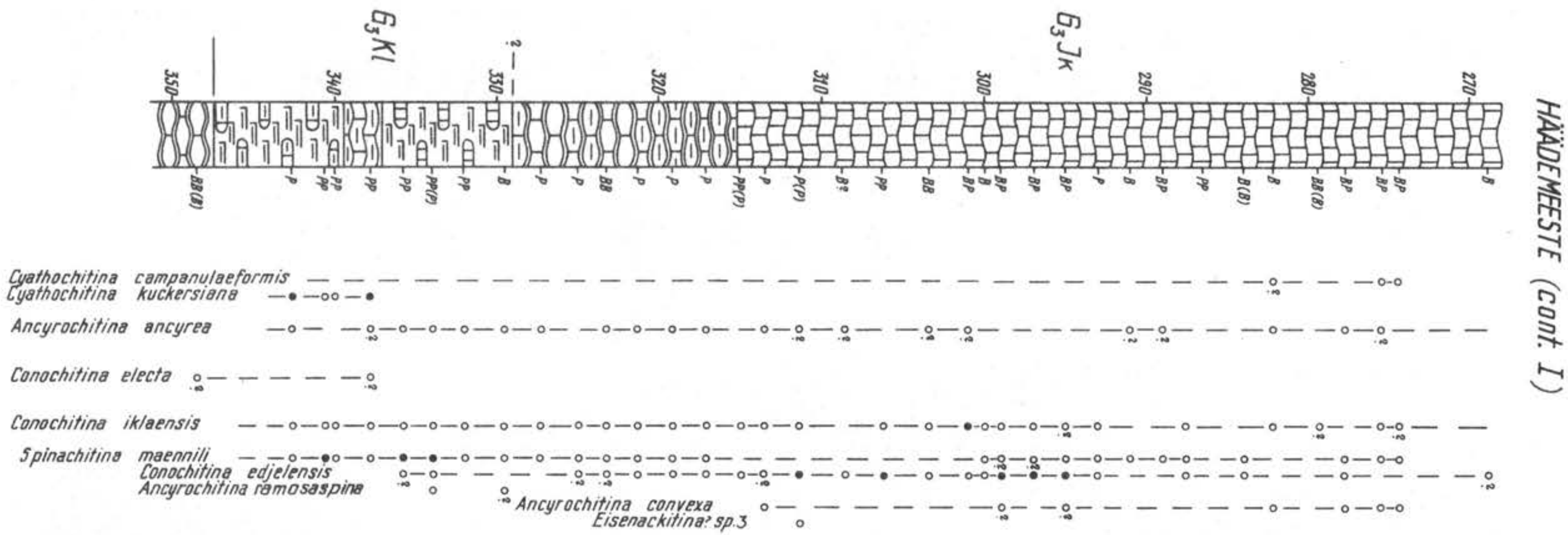

Fig. 12/2. Distribution of chitinozoans in the Häädemeeste section (cont. I).

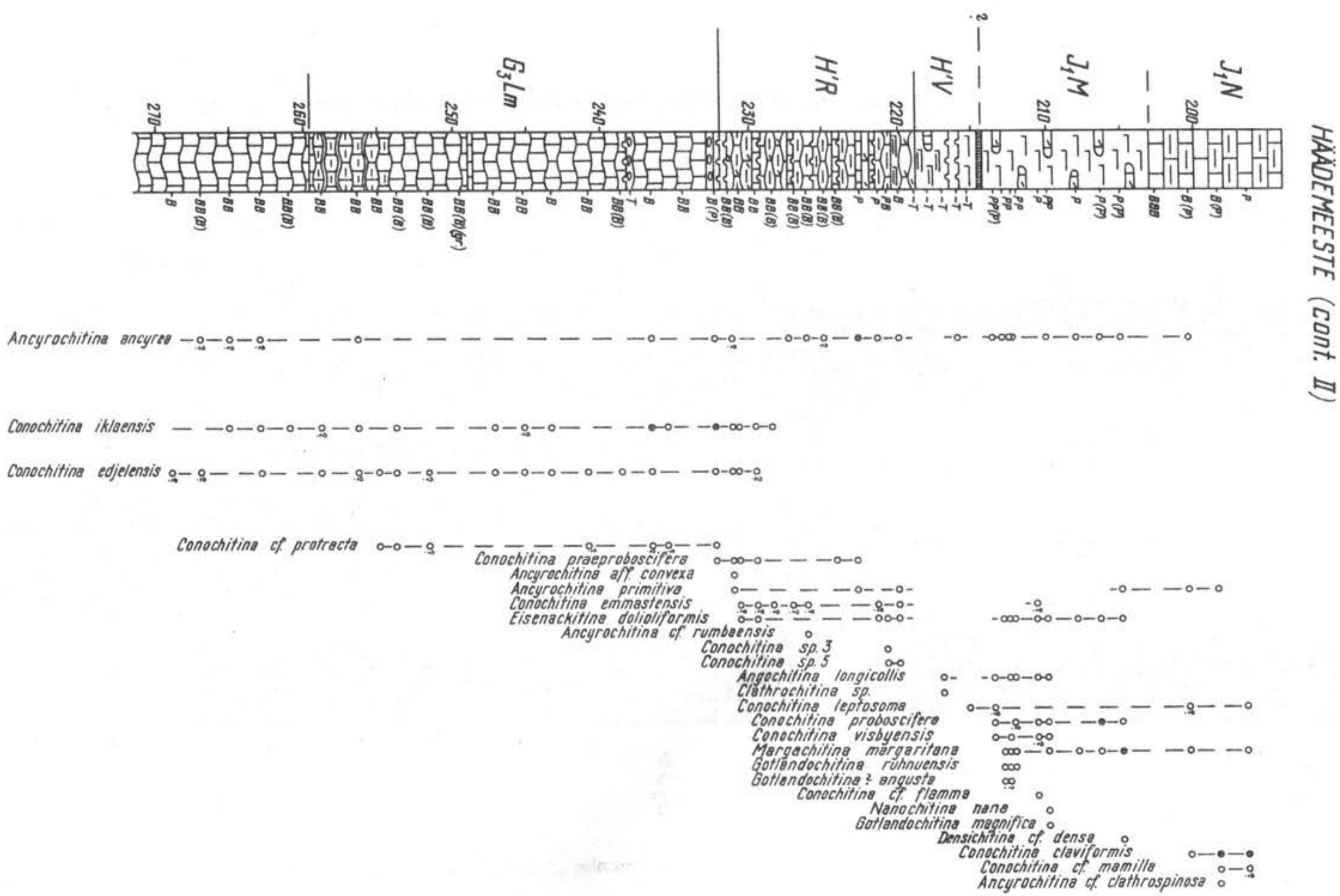

Fig. 12/3. Distribution of chitinozoans in the Häädemeeste section (cont. II).

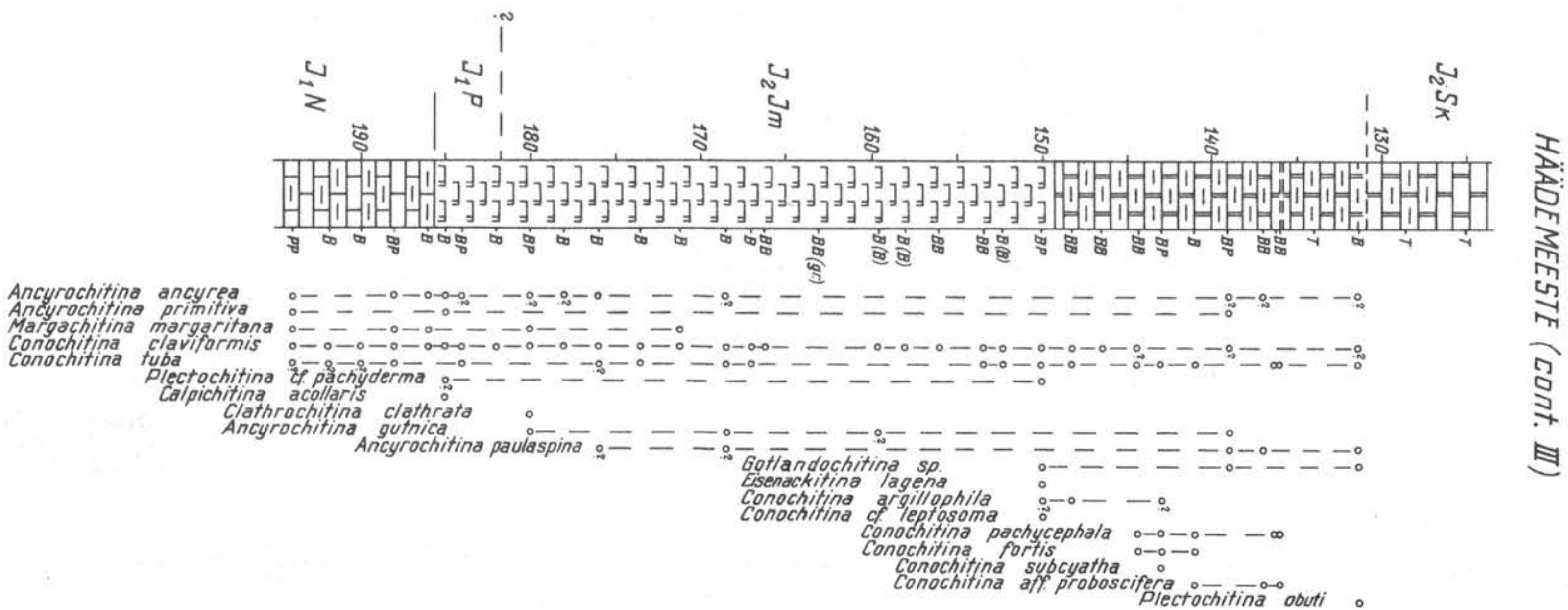

Fig. 12/4. Distribution of chitinozoans in the Häädemeeste section (cont. III).

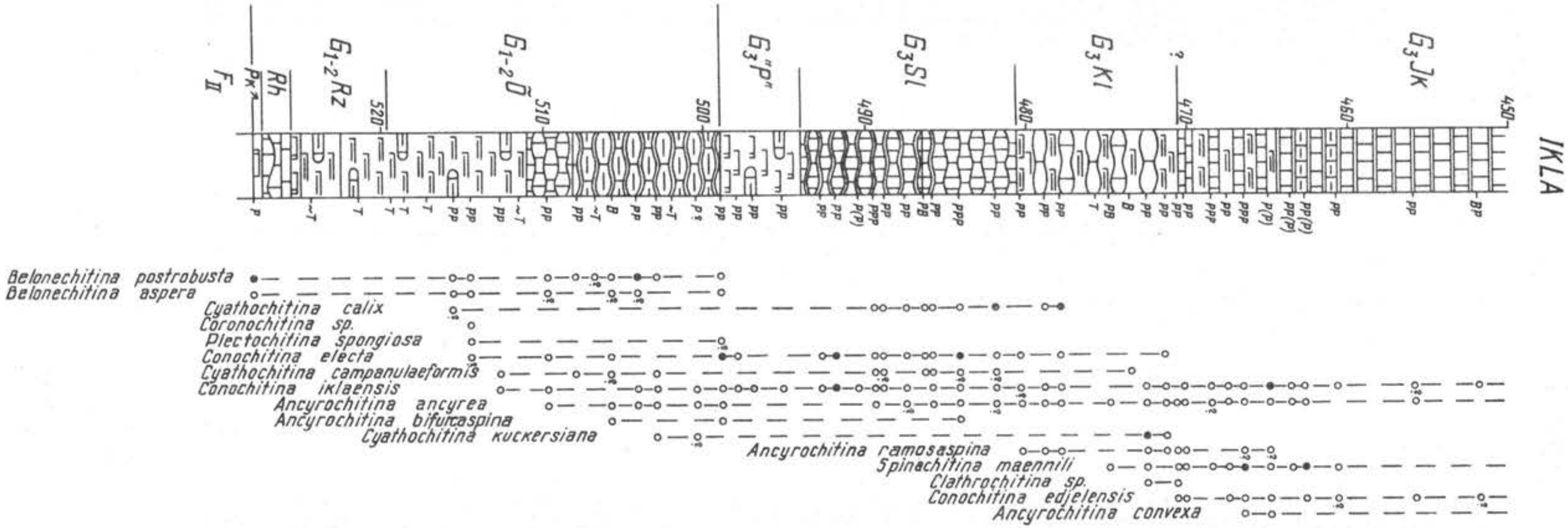

Fig. 13/1. Distribution of chitinozoans in the Ikla section.

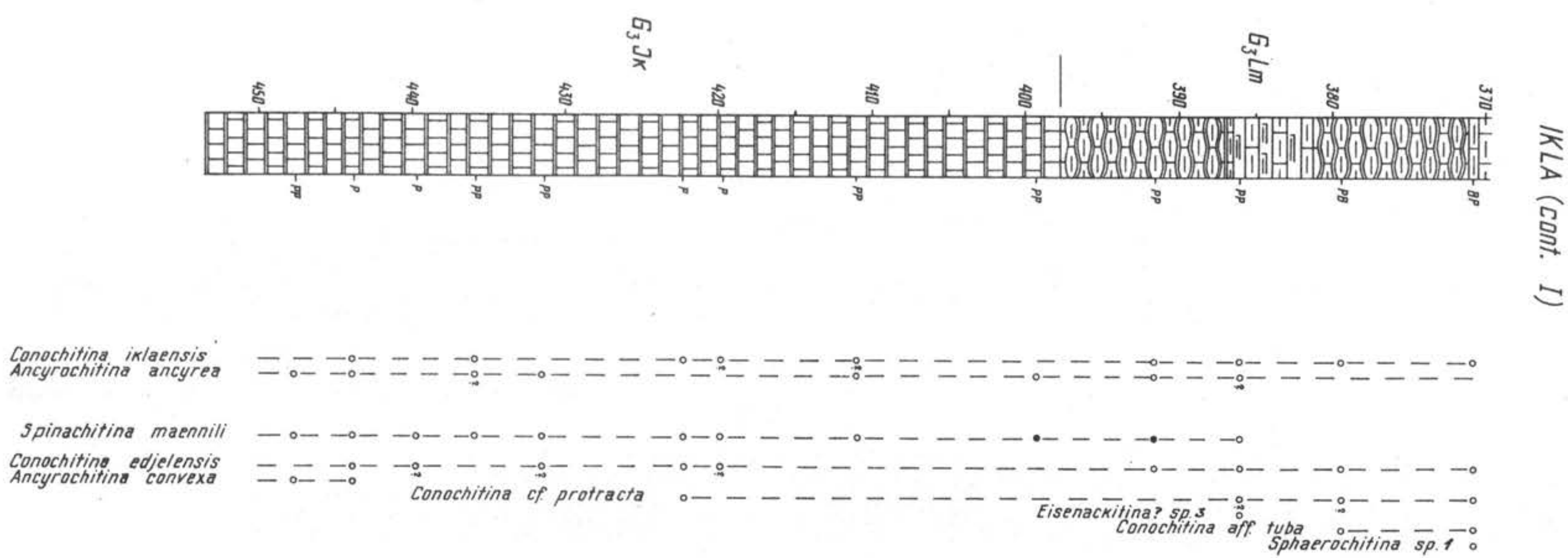

Fig. 13/2. Distribution of chitinozoans in the Ikla section (cont. I).

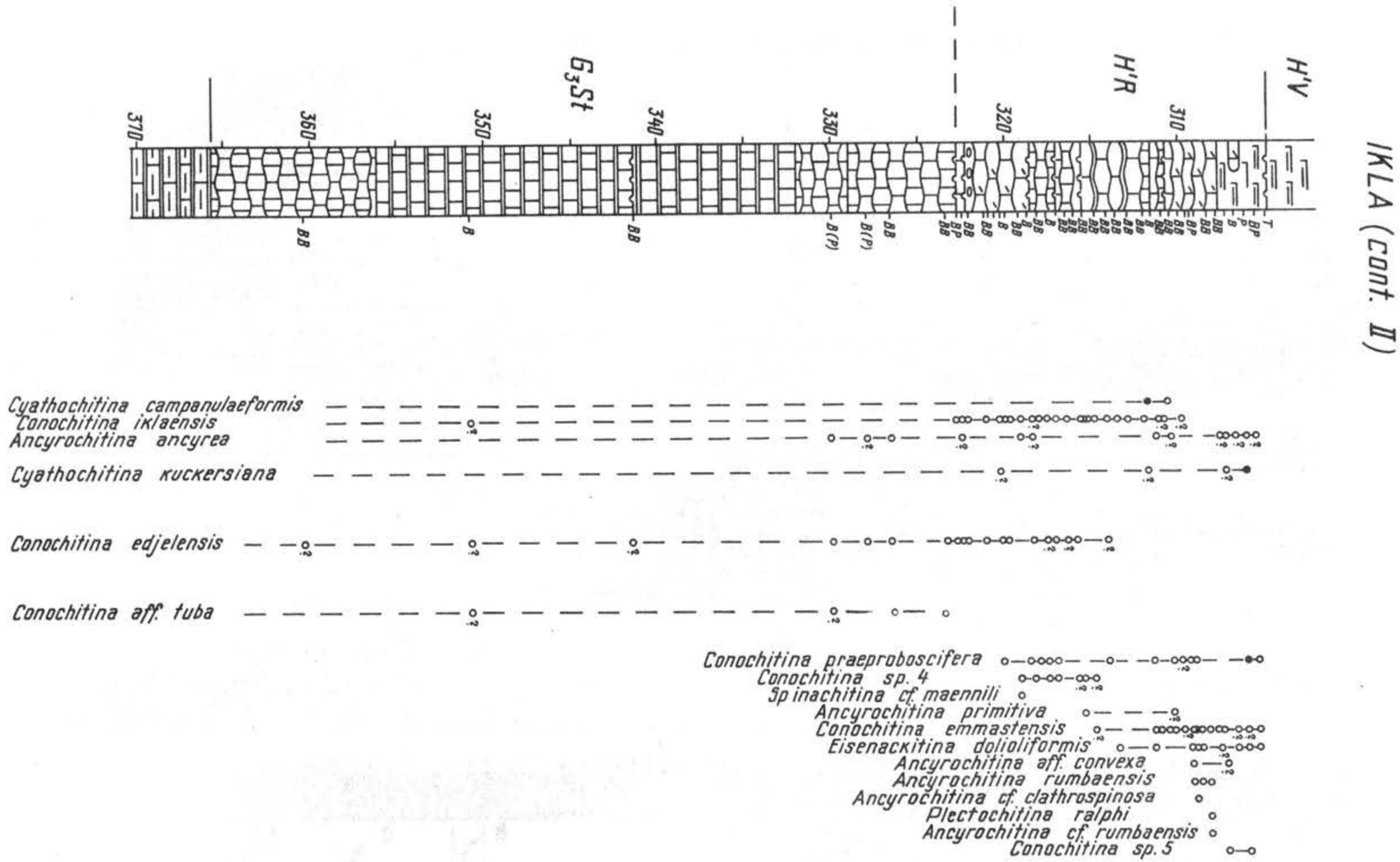

Fig. 13/3. Distribution of chitinozoans in the Ikla section (cont. II).

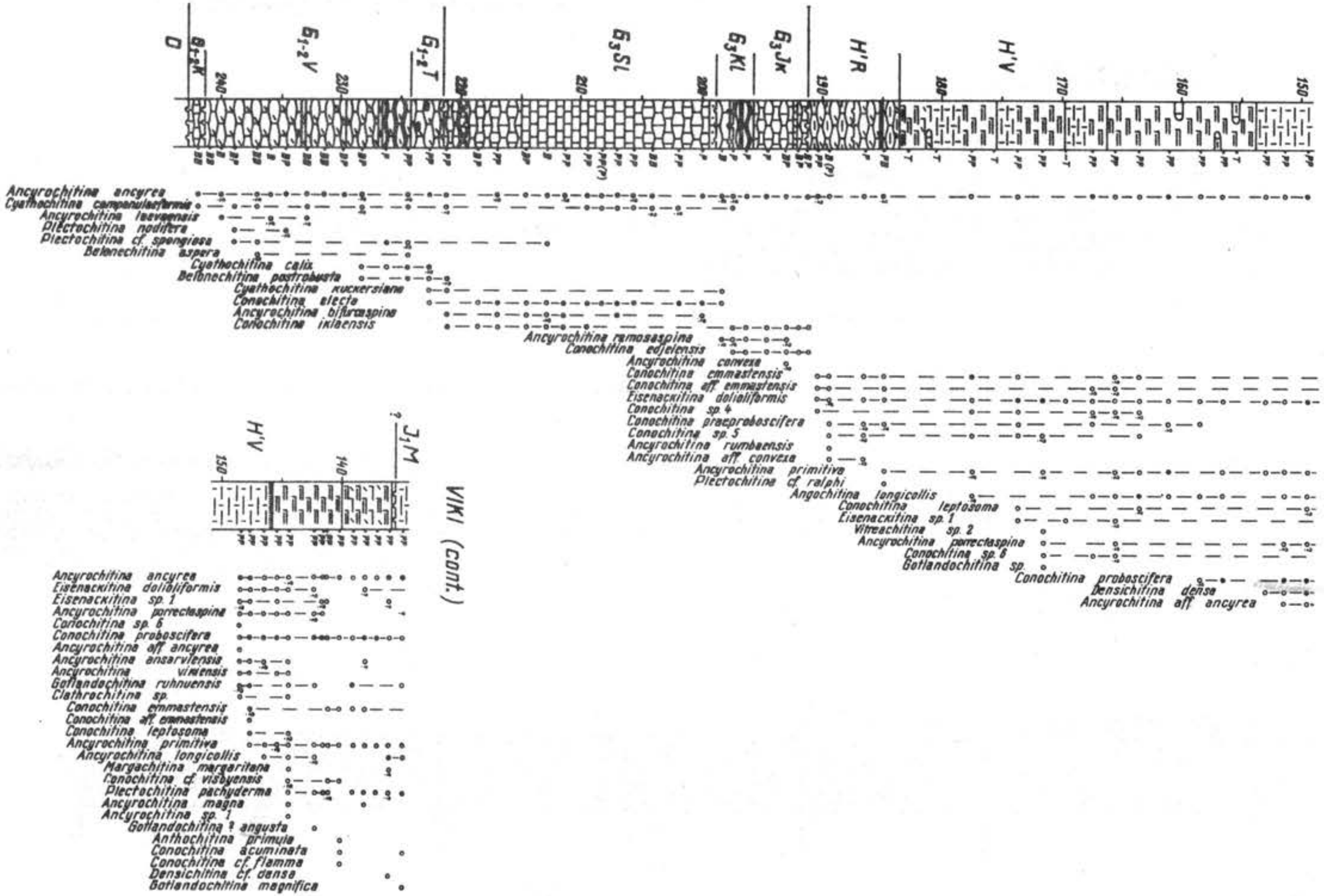

Fig. 14. Distribution of chitinozoans in the Viki section.

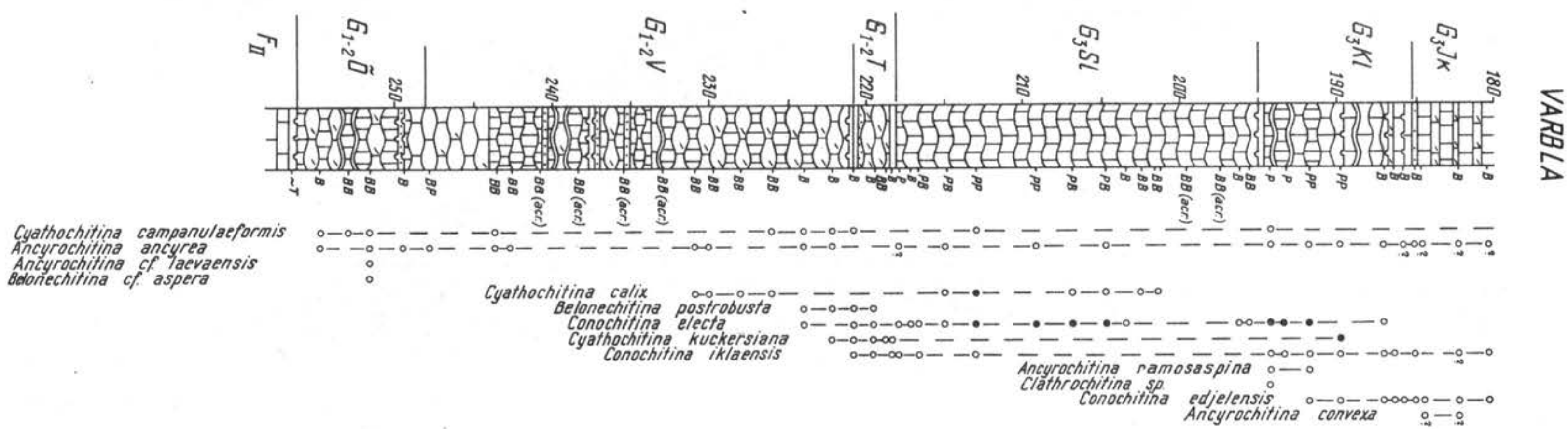

Fig. 15/1. Distribution of chitinozoans in the Varbla section.

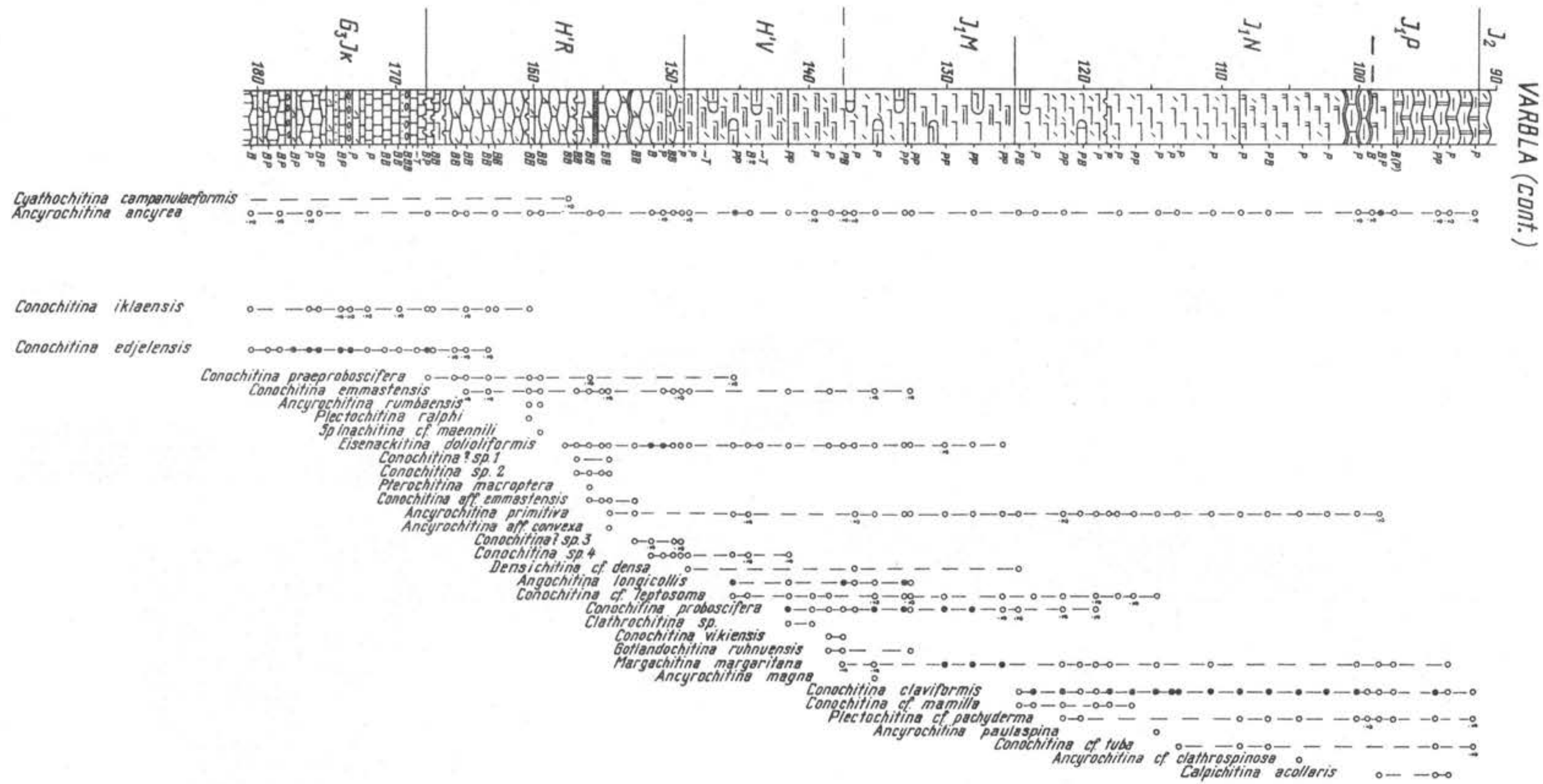

Fig. 15/2. Distribution of chitinozoans in the Varbla section (cont.).

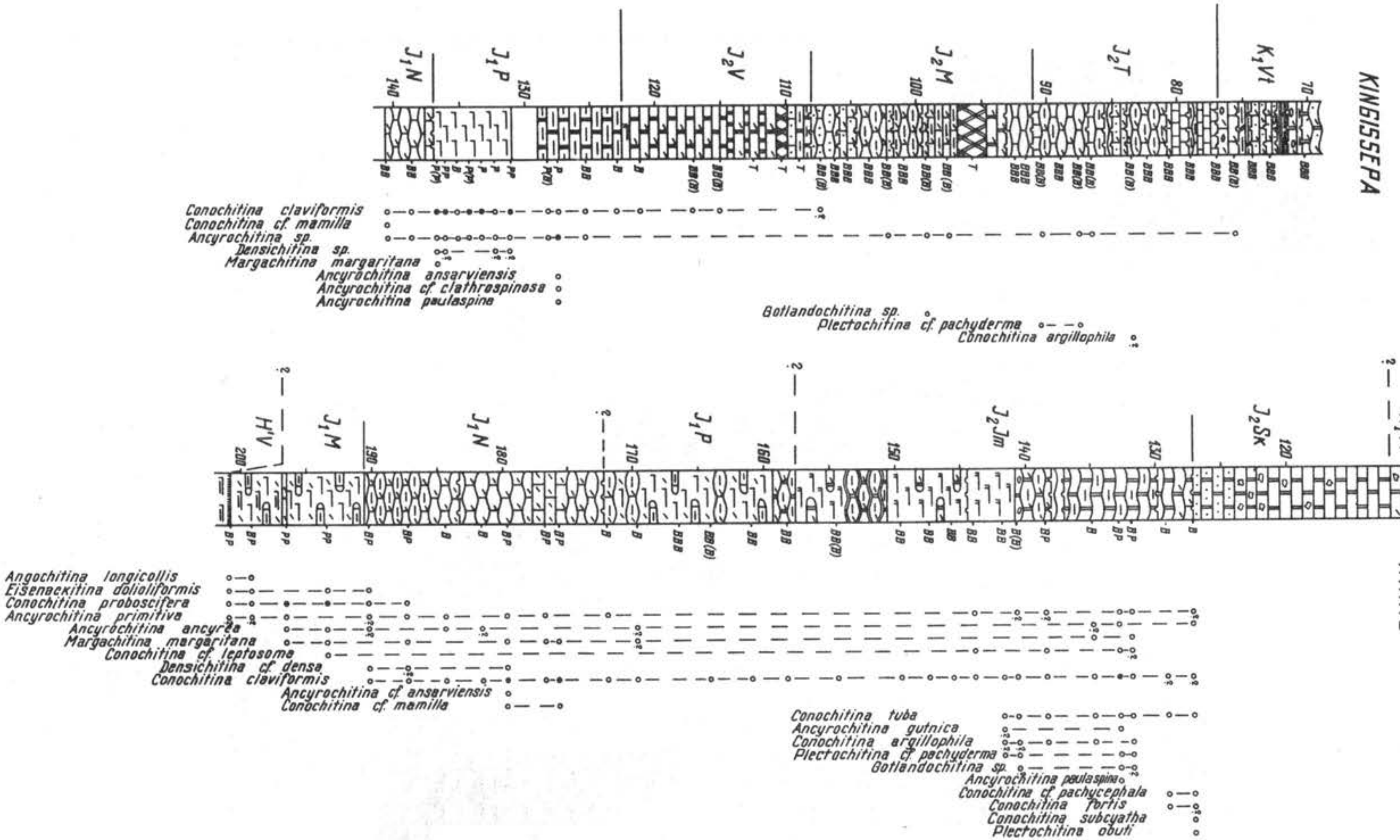

Fig. 16. Distribution of chitinozoans in the Kuressaare (Kingissepa) and Kihnu sections.

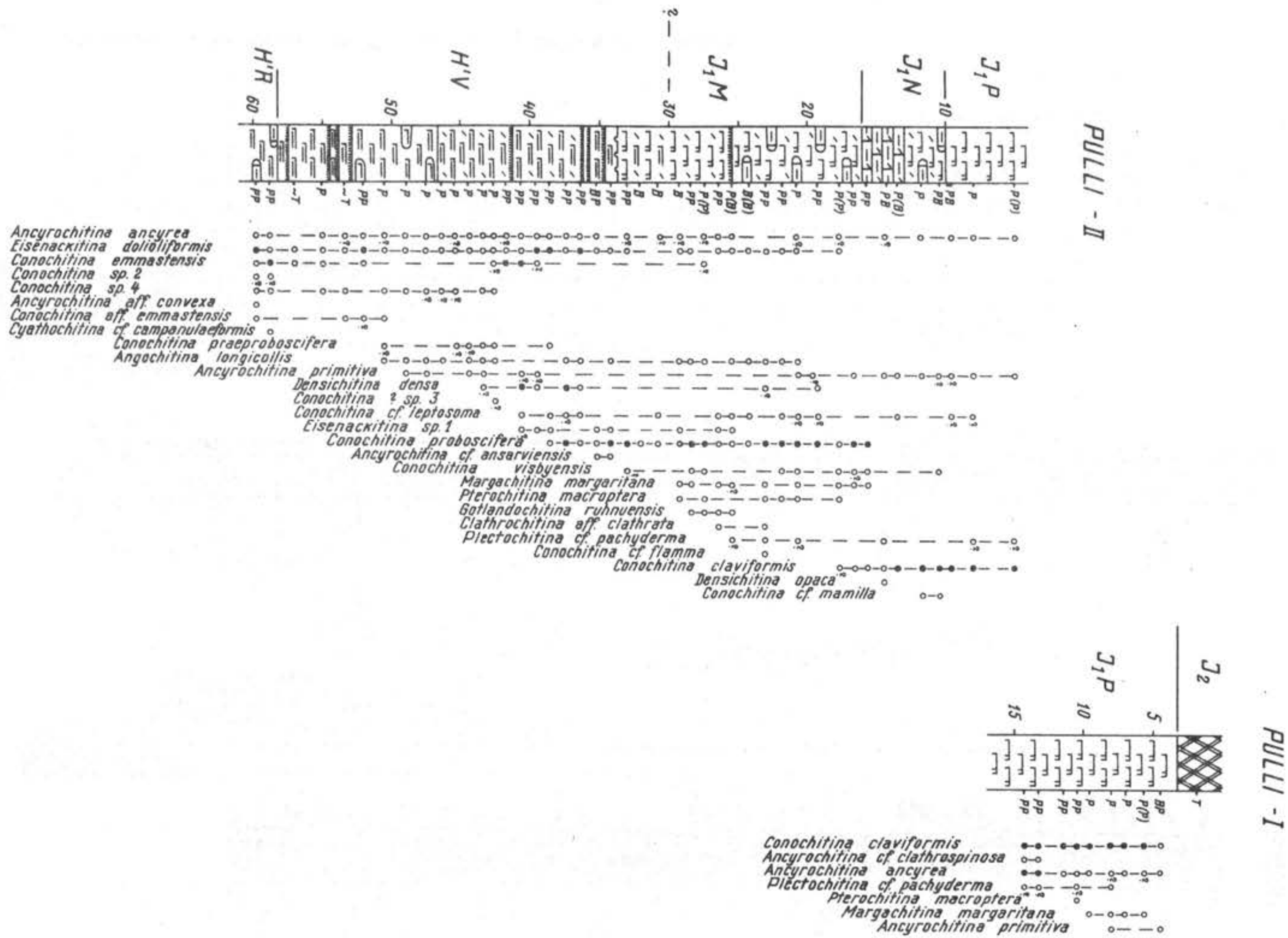

Fig. 17. Distribution of chitinozoans in the Pulli 1 and Pulli 2 sections.

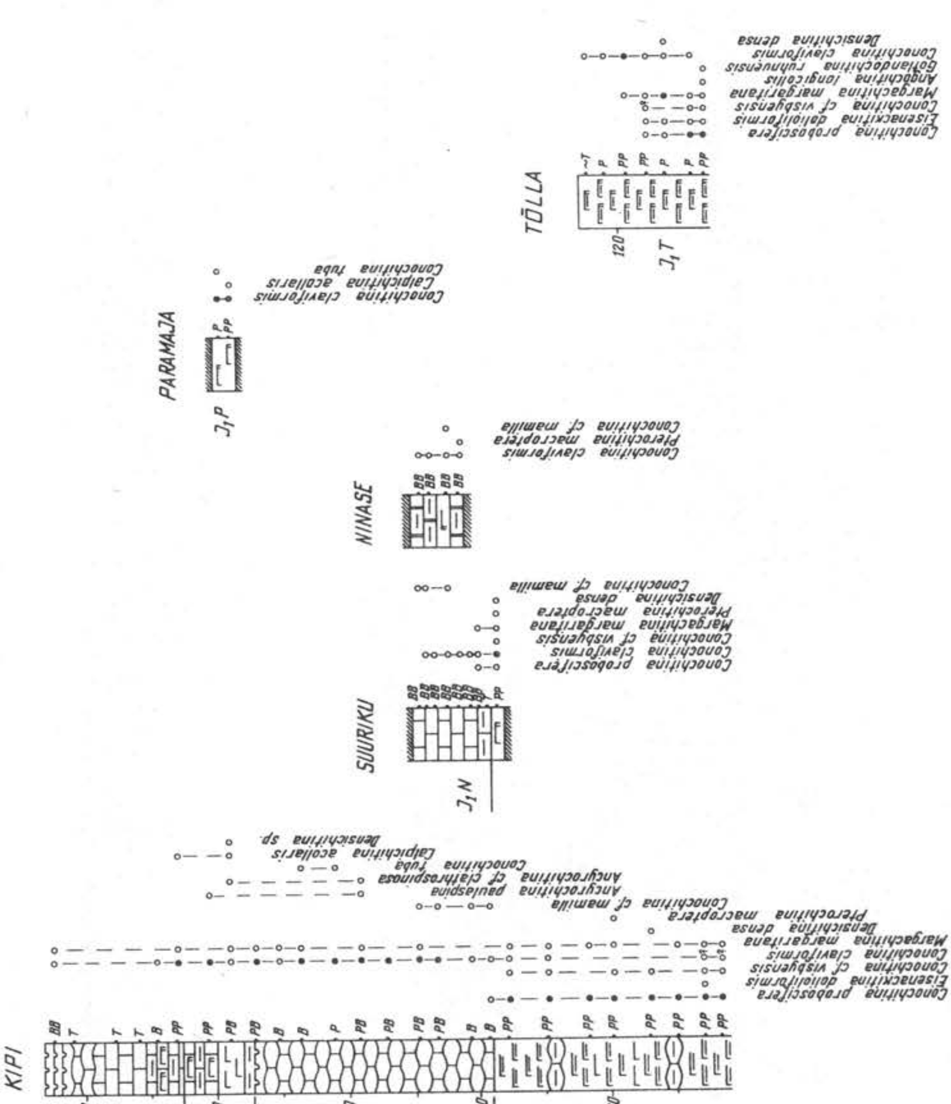

Fig. 18. Distribution of chitinozoans in the Kipi and Tõlla core sections and Suuriku, Ninase and Paramaja outcrops.

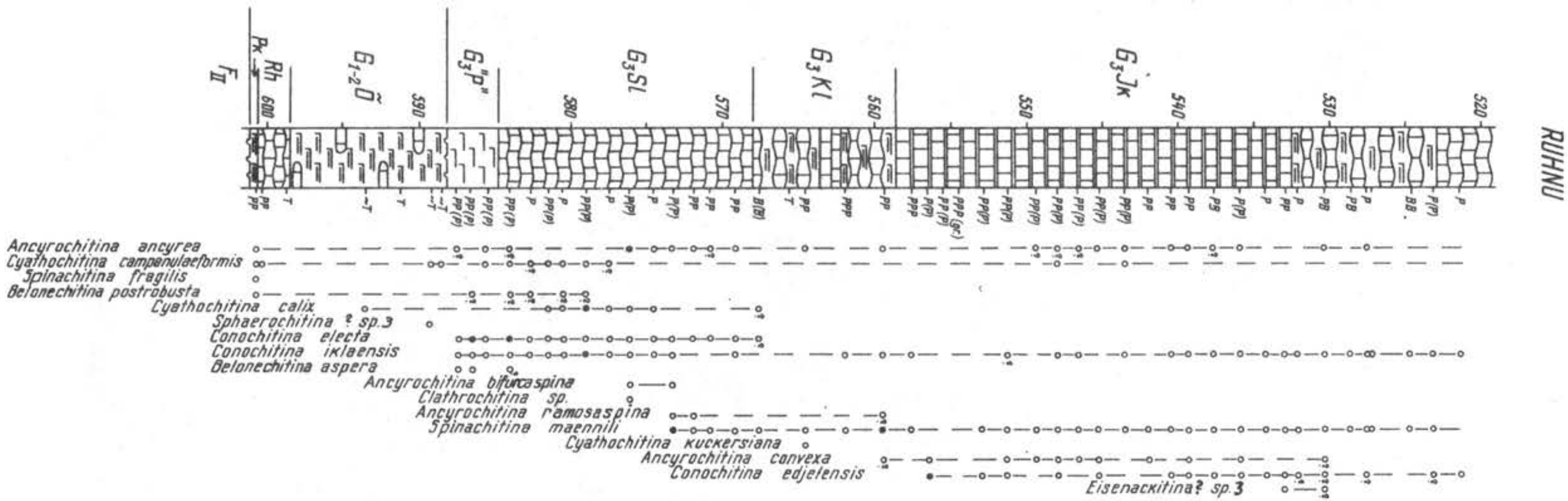

Fig. 19/1. Distribution of chitinozoans in the Ruhnu section.

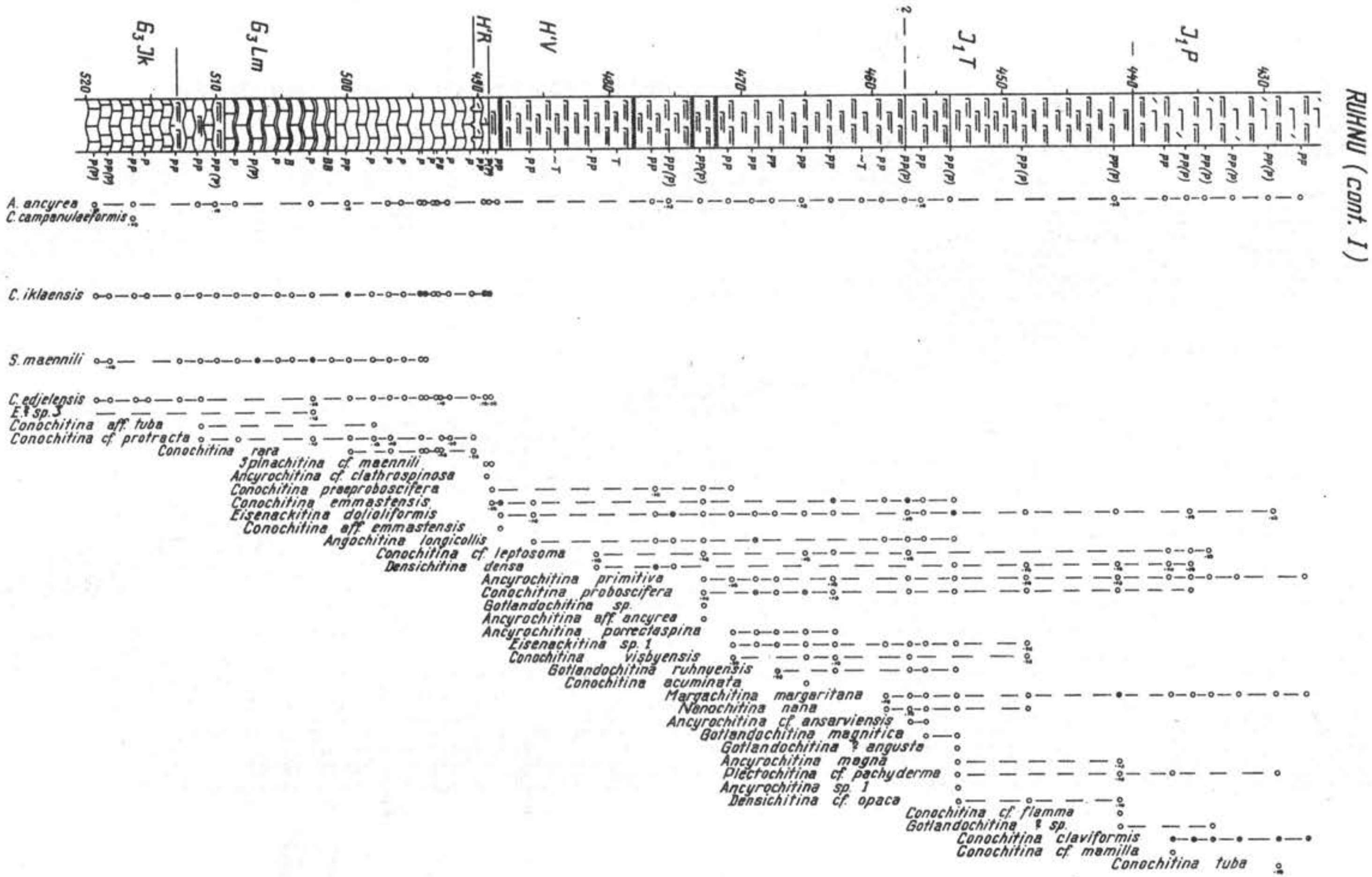

Fig. 19/2. Distribution of chitinozoans in the Ruhnu section (cont. I).

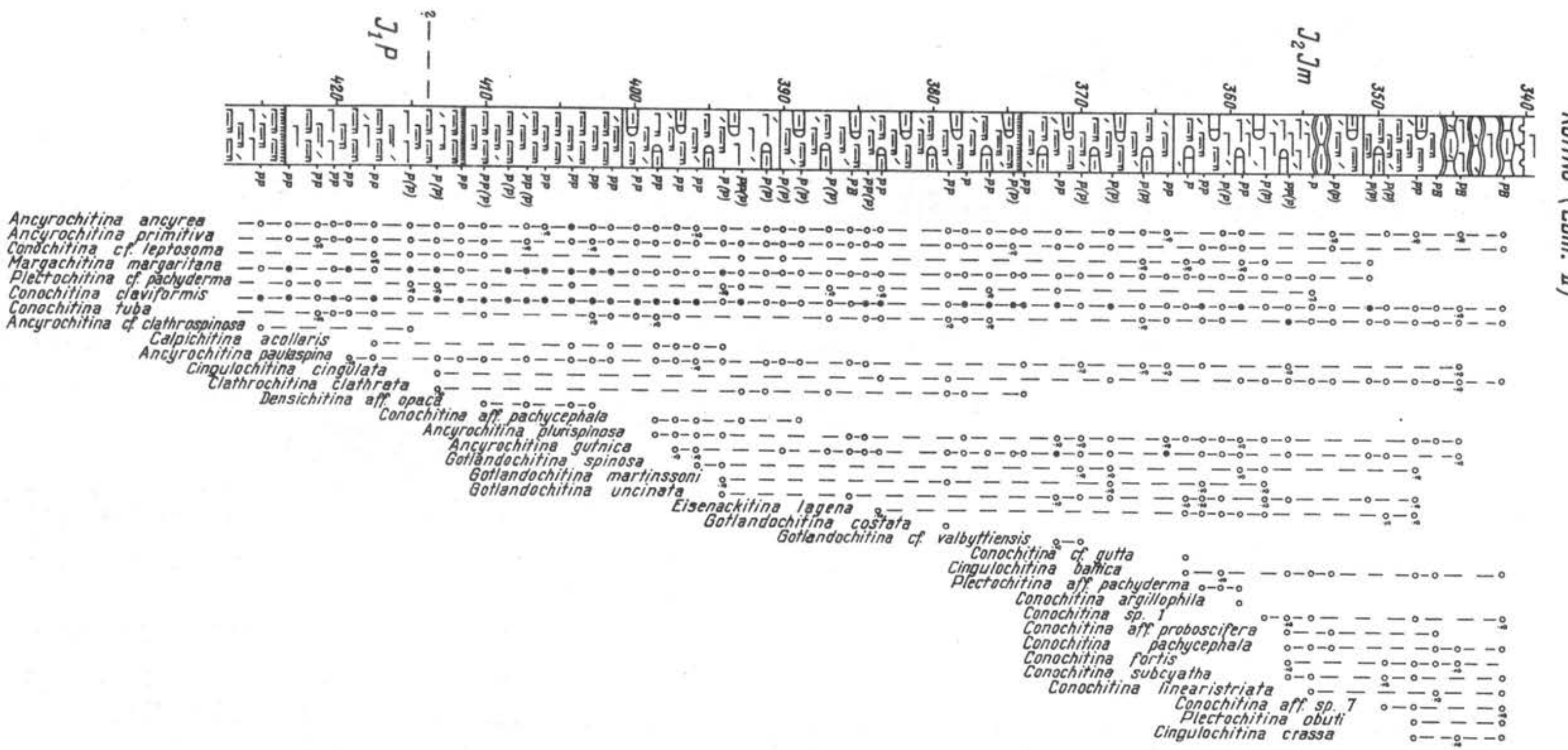

Fig. 19/3. Distribution of chitinozoans in the Ruhnu section (cont. II).

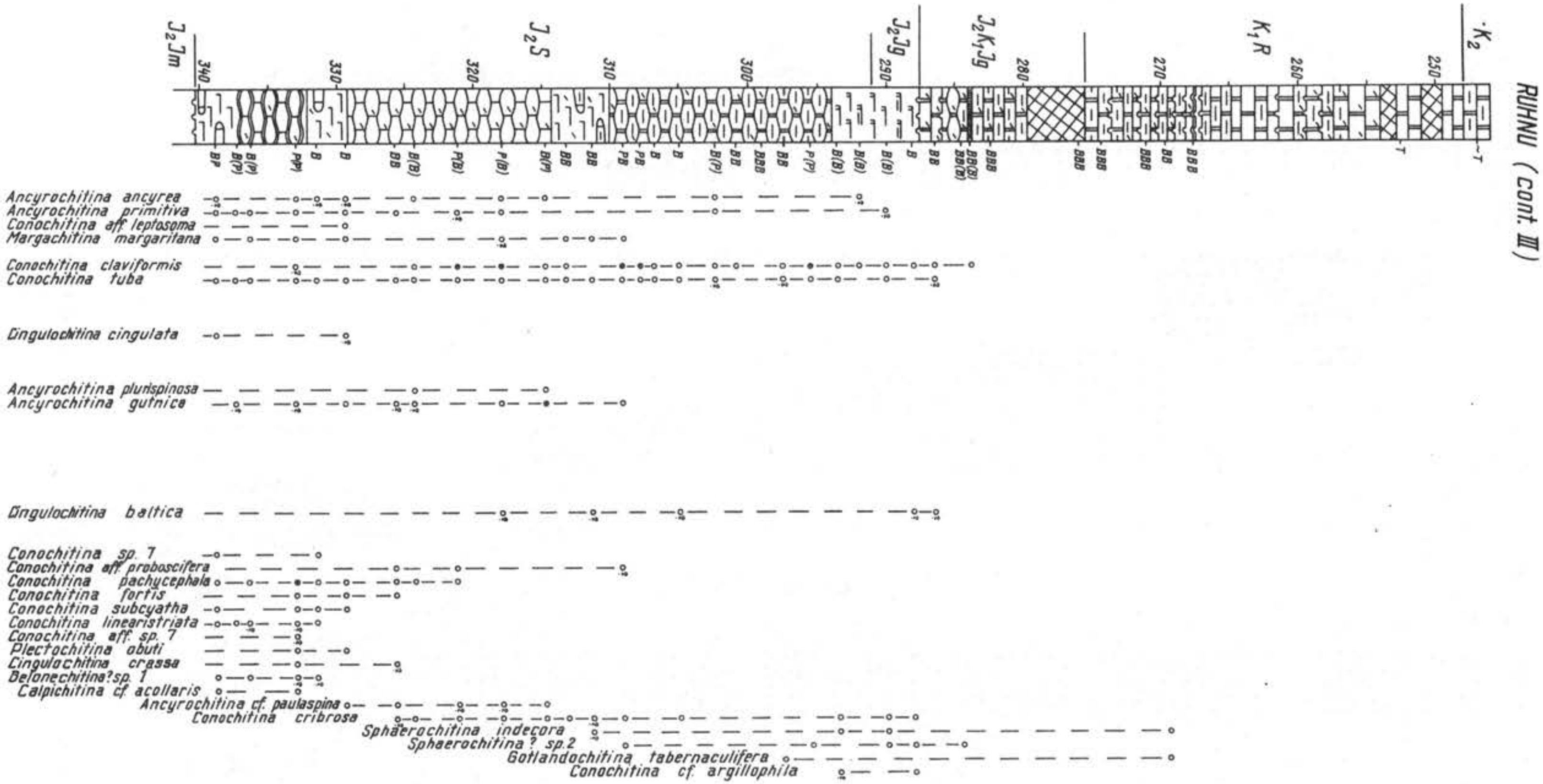

Fig. 19/4. Distribution of chitinozoans in the Ruhnu section (cont. III).

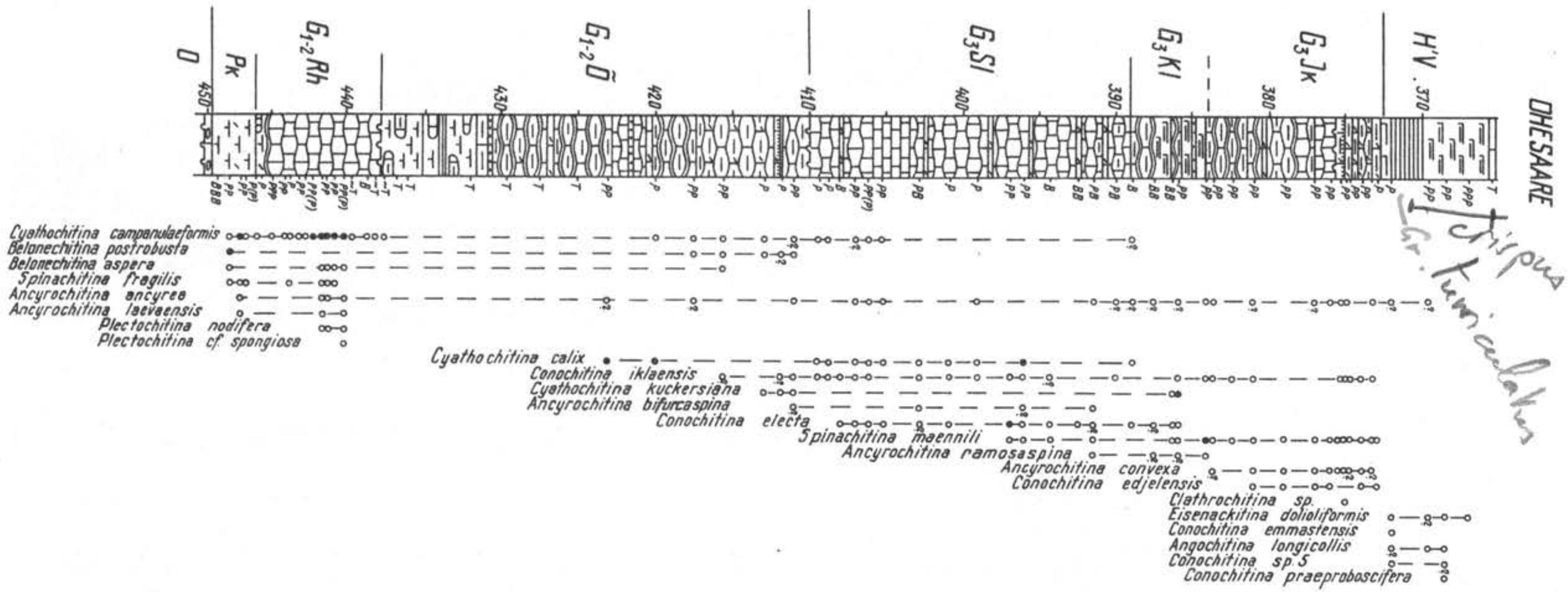

Fig. 20/1. Distribution of chitinozoans in the Ohesaare section.

OHESAARE (cont. I)

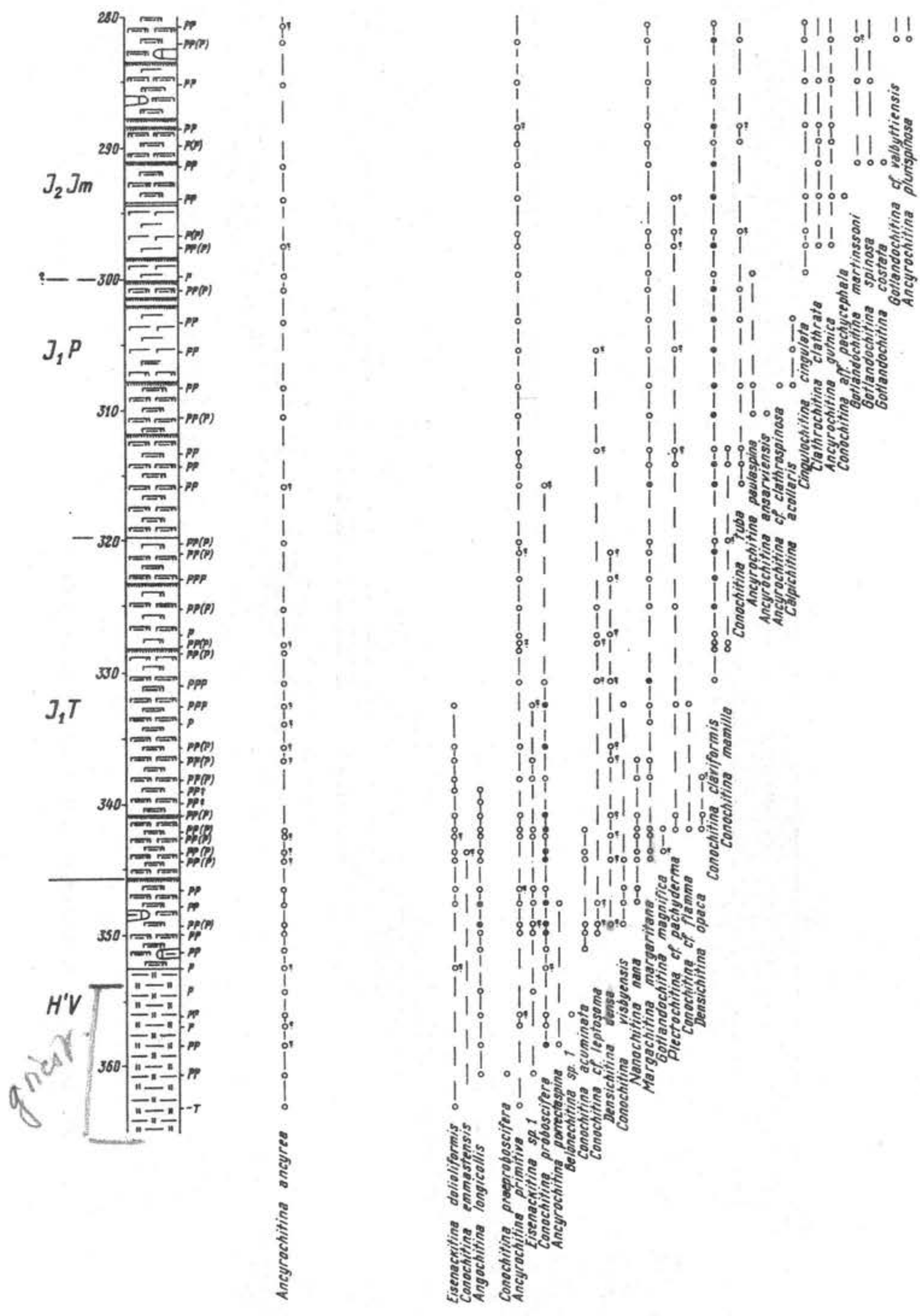

Fig. 20/2. Distribution of chitinozoans in the Ohesaare section (cont. I).

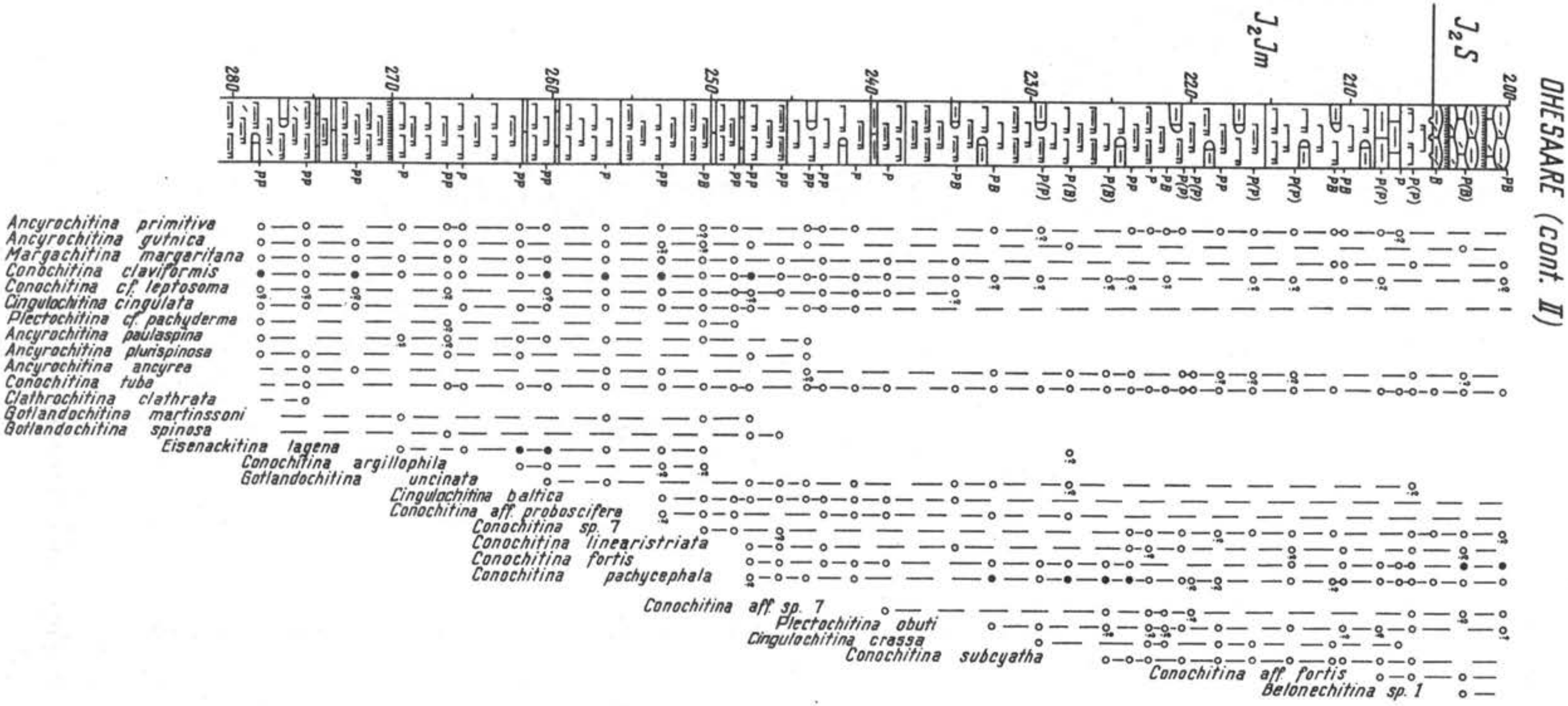

Fig. 20/3. Distribution of chitinozoans in the Ohesaare section (cont. II).

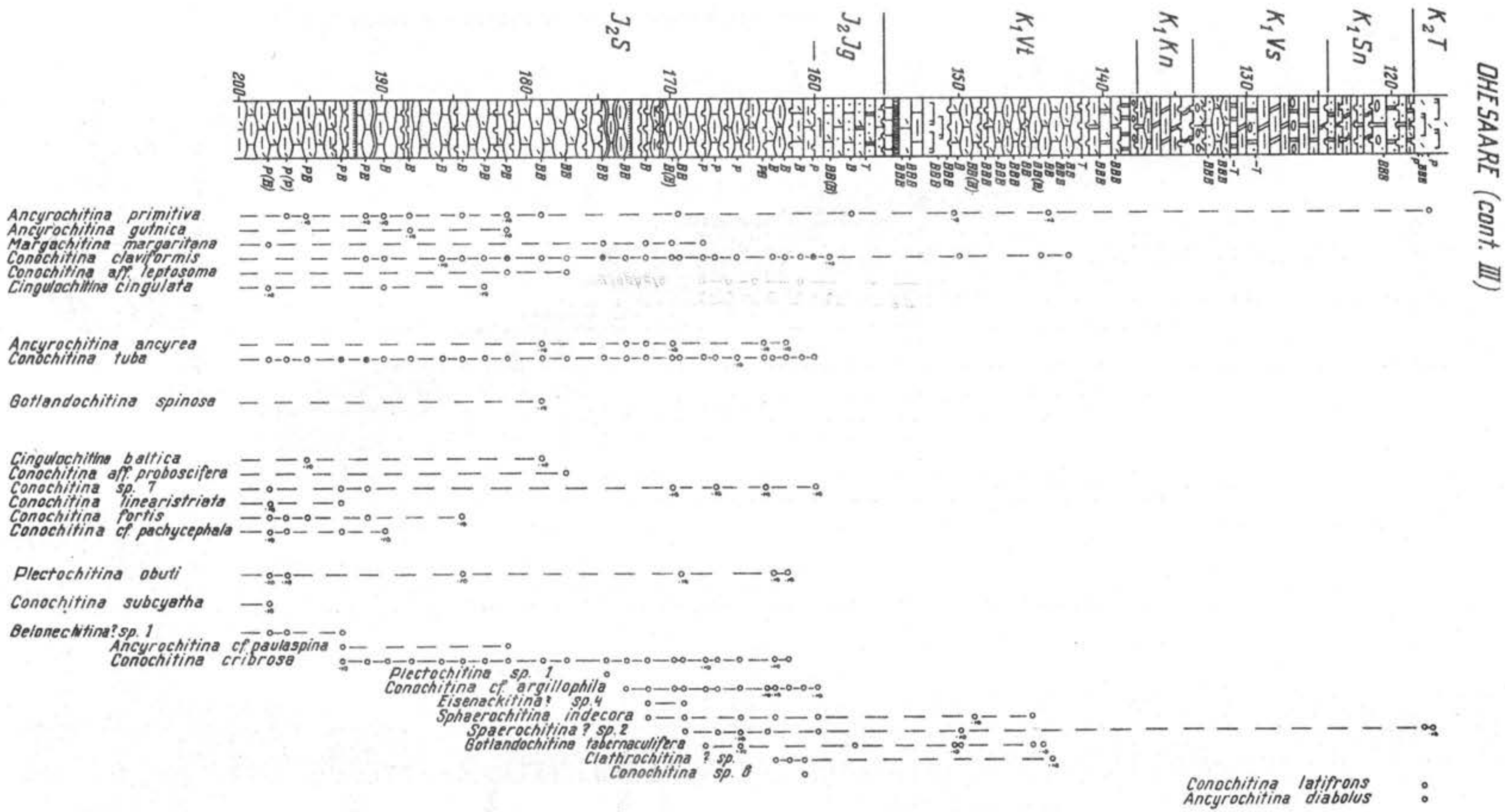

Fig. 20/4. Distribution of chitinozoans in the Ohesaare section (cont. III).

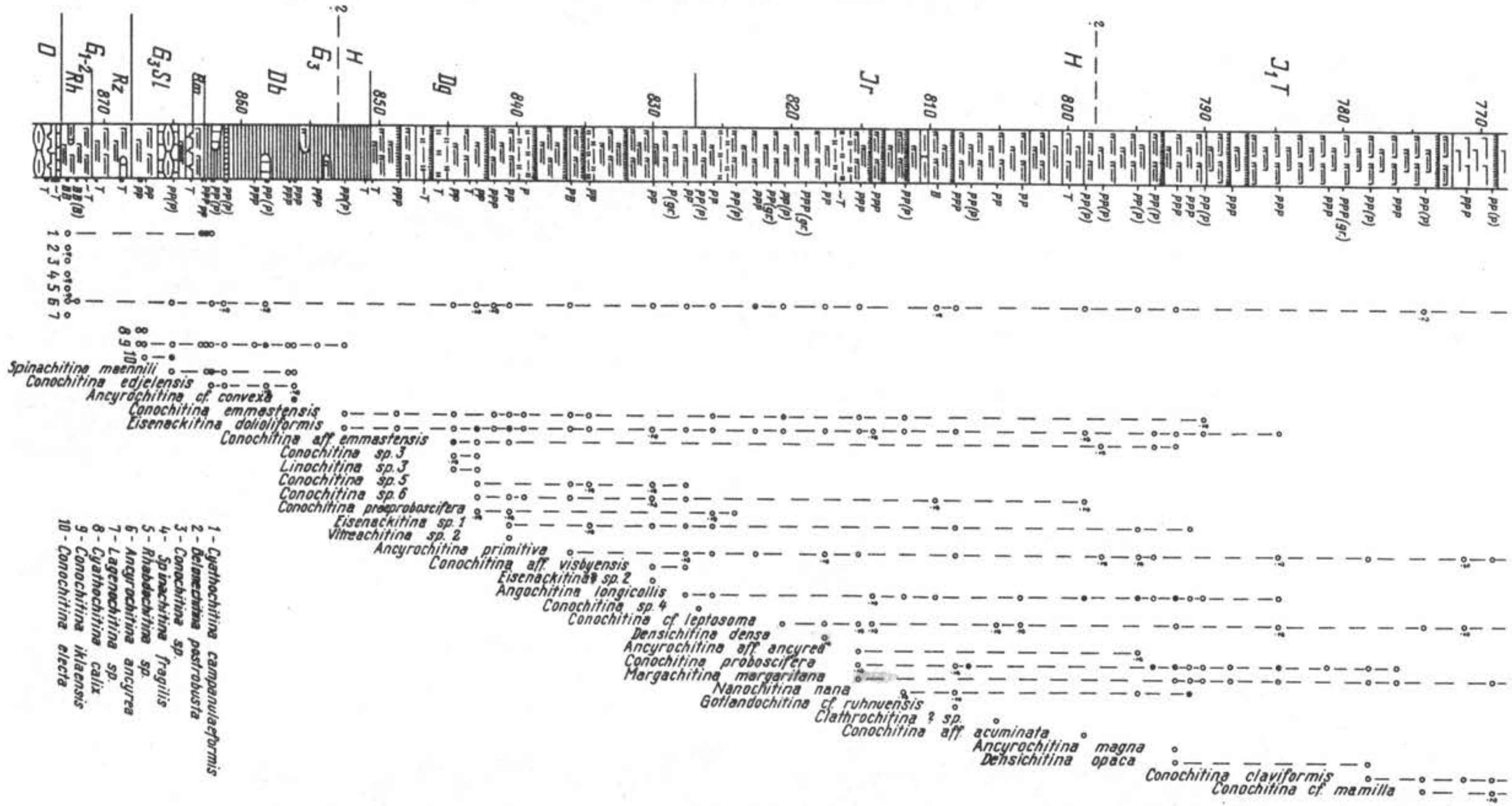

Fig. 21/1. Distribution of chitinozoans in the Ventspils section.

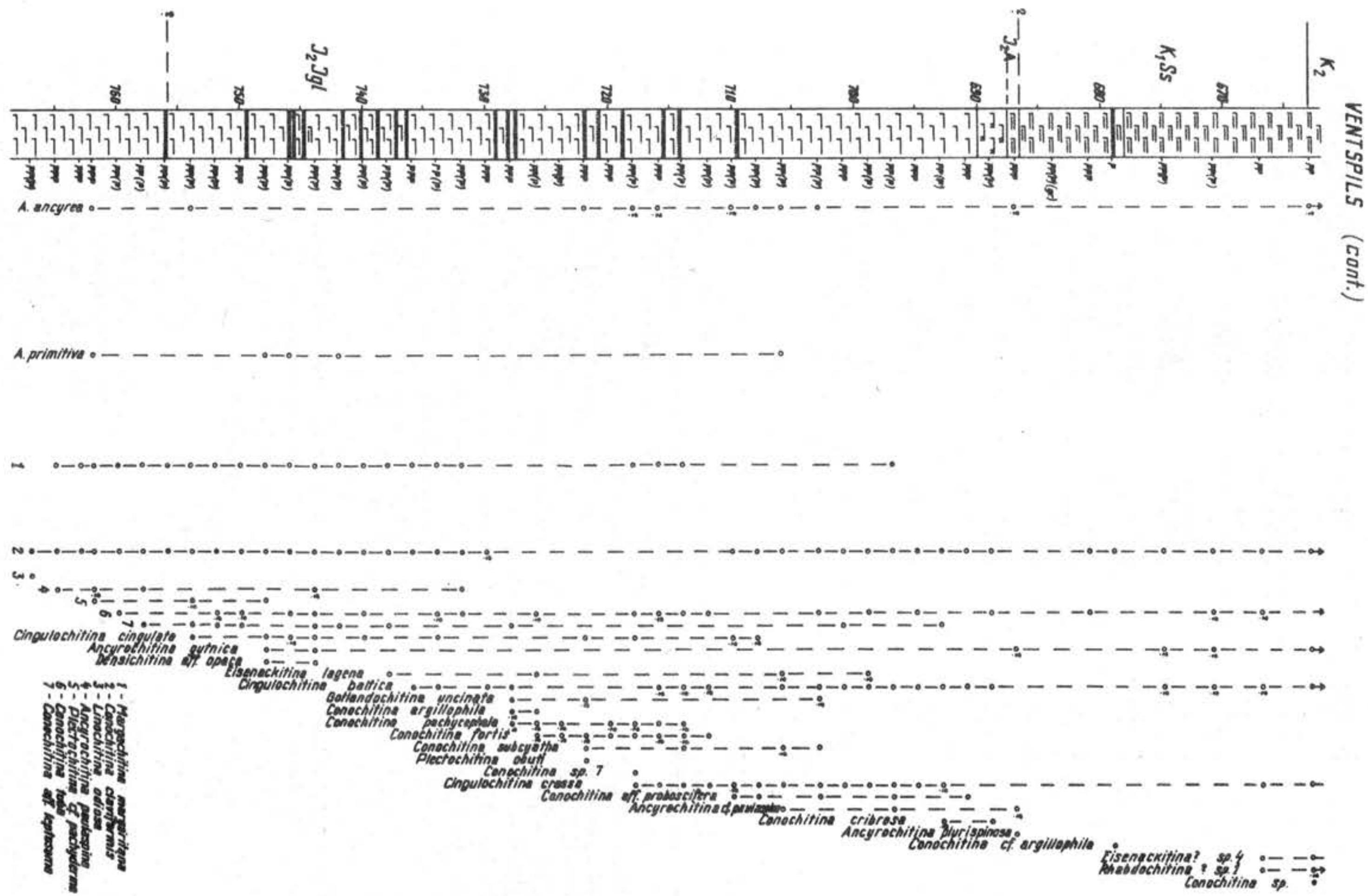

Fig. 21/2. Distribution of chitinozoans in the Ventspils section (cont. I).

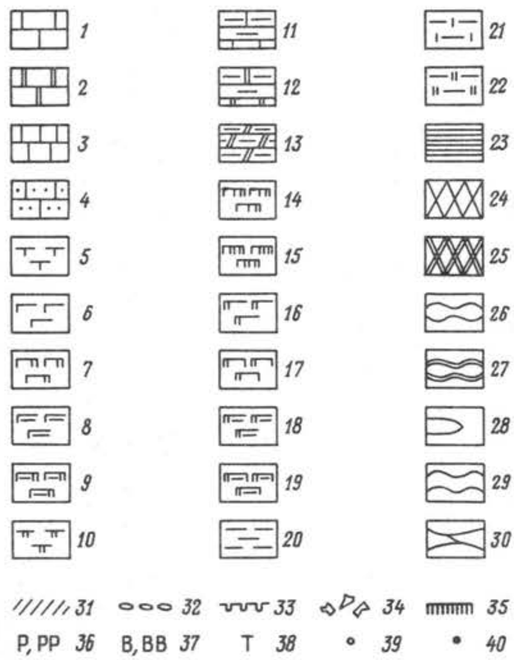

Fig. 22. Legend to the logs of the core sections.

Lithological legend: 1 – limestones (in general); 2 – dolomites (in general); 3 – micritic (aphanitic) limestone; 4 – bioclastic and pelletal grainstones; 5 – marlstones (in general); 6 – calcareous marlstone; 7 – dolomitic marlstone; 8 – argillaceous marlstone; 9 – dolomitic argillaceous marlstone; 10 – domerites (dolomitic marls); 11 – argillaceous limestone; 12 – argillaceous dolomite; 13 – *Eurypterus*-dolomite; 14 – dolomitic calcareous marlstone; 15 – calcareous domerite; 16 – dolomitic domerite; 17 – calcitic dolomitic domerite; 18 – argillaceous domerites; 19 – calcitic argillaceous domerite; 20 – dolomitic mudstone; 23 – argillite; 24 – reef limestone; 25 – reef dolomite; 26 – nodular structure; 27 – nodular limestone with clayey intercalations; 28 – marlstone with limestone nodules; 29 – wavy bedding; 30 – cross-bedding; 31 – skeletal detritus; 32 – conglomerate; 33 – hardground; 34 – pores and caverns; 35 – metabentonite layer; 36 – planktonic elements (mainly chitinozoans) prevailing in the organic-walled microfossil association (the number of letters indicates the stage of prevalence); 37 – benthic elements prevailing; 38 – samples not containing organic-walled microfossils; 39 – occurrence of species; 40 – abundant occurrence of species.

Stratigraphic indices: Ordovician System (O), Porkuni Stage (F_2). Juuru Stage (G_{1-2}): V – Varbola Formation, K – Koigi Member, T – Tamsalu Formation, Kr – Karinu Member, H – Hilliste Member, Õ – Õhne Formation, Pk – Puikule Member, Rh – Ruja Member, Rz – Rozèni Member, Rm – Remte Formation, Statš – Stačiunai Formation, St – Sturi Member, Ap – Apaščia Formation. Raikküla Stage (G_3): "P" – "Pusku" Member, Sl – Slitere Member, Kl – Kolka Member, Ik – Ikla Member, Lm – Lemme Member, St – Staicele Member, Rk – Raikküla Formation, Db – Dobele Formation. Adavere Stage (H): R – Rumba Formation, V – Velise Formation, Dg – Degole Beds, Ir – Irlava Beds. Jaani Stage (J_1): M – Mustjala Member, N – Ninase Member, P – Paramaja Member, T – Tôlla Member (Beds). Jaagarahu Stage (J_2): Sk – Sakla Formation, Jg – Jaagarahu Formation, V – Vilsandi Beds, M – Maasi Beds, T – Tagavere Beds, Jm – Jamaja Formation, S – Sôrve Formation, Jgl – Jugla Beds, A – Ančia Member. Rootsiküla Stage (K_1): R – Rootsiküla Formation, Vt – Viita Beds, Kn – Kuusnômme Beds, Vs – Vesiku Beds, Sn – Soeginina Beds, Ss – Siesartis Formation. Paadla Stage (K_2): T – Torgu Formation.

Stratigraphical distribution of chitinozoans

Occurrence in the local stratigraphic units

The distribution of chitinozoans, mainly their occurrence frequency and taxonomic diversity, is well controlled by the facies pattern of the sedimentary basin. In the study area of the East Baltic Silurian three confacies belts are distinguished (see Kaljo 1977): 1) Middle Estonian, 2) South Estonian – North Latvian, 3) West and South Latvian. Each of them has a system of specific local stratigraphic units (Fig. 3). The first region is characterized by shallow-water, predominantly carbonate sections, the second one by transitional sections, represented by marls and calcareous mudstones, the third one by comparatively deep-water sections with graptolitic mudstones and clays. Below follows a brief account on the distribution of lower Silurian chitinozoans by regional stages, as well as by confacies belts.

In middle Estonia chitinozoans are rare in the lowermost Llandovery Juuru Stage. The skeletal argillaceous packstones of the Varbola Formation, with the aphanitic limestones of the Koigi Member occurring in the lower part of the stage, contain chitinozoans only sporadically (Rapla, Pusku, Sulustvere cores). In the upper part of the stage brachiopod limestones of the Tamsalu Formation (Tammiku Member) and pelletal limestones of the lowermost part of the Karinu Member are devoid of chitinozoans (Rapla, Sulustvere cores). The most abundantly chitinozoans occur in the argillaceous limestone interbeds of the uppermost Karinu and Hilliste members (Rapla, Sulustvere, Pusku cores). In southern Estonia and northern Latvia the abundance and diversity of chitinozoans increase. Marls and dolomitic mudstones of the Õhne Formation, including red-coloured marls of the Rozeni Member, show barren intervals (Ohesaare, Ikla, Kolka cores). The lowermost part of the Juuru Stage – marls and dolomitic mudstones of the Puikule Member and micritic limestones of the Ruja Member, also the upper half of the Õhne Formation, are characterized by a rich chitinozoan assemblage. In more southern sections of Latvia (Remte, Nagli cores), micritic limestones of the Sturi Member (Nitaure core) and of the Stačiunai Member (Vidukle core in Lithuania), as well as marls of the Remte Formation (Remte core) and argillaceous nodular limestones of the Apaščia Formation (Vidukle and Nagli cores), have yielded only scarce chitinozoans.

In central Estonia the Raikküla Stage, which is mostly represented by extremely shallow-water skeletal grainstones, coral limestones and dolomites of the Raikküla Formation, is barren or contains very rare chtinozoans (Rapla, Nurme, Raikküla cores). To the west and south the lowermost beds of the Raikküla Stage are represented by marls or dolomitic mudstones of the so-called "Pusku" Member, overlain by micritic (aphanitic) limestones of the Slitere Member (both belonging to the Saarde Formation). These rocks are comparatively rich in chitinozoans (Asuküla, Kirikuküla cores). In the upper part of the stage, represented by the Raikküla Formation, chitinozoans are lacking (Kirikuküla core) or rare (Nurme, Martna cores). In southern Estonian and northern Latvian sections chitinozoans occur abundantly throughout the sequence of the aphanitic limestones and mudstones of the Saarde Formation, though upwards in the section the number of chitinozoans decreases gradually (Häädemeeste, Ikla cores). Graptolitic shale of the Latvian Dobele Formation has sometimes yielded abundantly chitinozoans (Ventspils core), but usually the assemblage is rather poor (Remte, Nitaure cores).

In Estonia the lower part of the Adavere Stage is represented by the rocks of the Rumba Formation, distributed in middle, as well as in southern Estonia and comprising nodular skeletal packstones and marls. In the sections of the Rumba Formation, the number of chitinozoans is relatively low, whereas their taxonomic diversity is rather high (Nestor 1984). The upper part of the Adavere Stage is represented in middle and southern Estonia by marls, clays and dolomitic mudstones of the Velise Formation, usually containing chitinozoans in large numbers. Only the lowermost, partly red-coloured beds of the formation, are barren of chitinozoans. In graptolitic mudstones, carbonate clays and marls of the upper Llandovery of Latvia, in the Dobele and Jurmala formations (Ventspils, Nagli cores), the abundance and diversity of chitinozoans are also relatively low.

In the lowermost beds of the Jaani Stage, in dolomitic mudstones and marls of the Mustjala Member (middle Estonia) and in the Tôlla Member of the Riga Formation (southern Estonia) chitinozoans occur in high frequency. In the contemporaneous graptolitic mudstones and clays of the Tôlla Beds of Latvia (Ventspils core) the abundance and diversity of chitinozoans decrease. Nodular skeletal packstones of the Ninase Member in the Middle Estonian Confacies Belt have yielded scarce chitinozoans and their number is decreasing gradually northwards. In the uppermost beds of the Jaani Stage, in marls of the Paramaja Member, chitinozoans abound again in all sections.

The Jaagarahu Stage of the Middle Estonian Confacies Belt, represented by cyclically alternating shallow-water skeletal packstones, grainstones and dolomites of the Vilsandi, Maasi and Tagavere beds, is poor in chitinozoans (Kingissepa core). Only scarce specimens have been recorded, whereas several intervals are barren. In southern Estonia (Ohesaare, Ruhnu cores) rocks of the Jaagarahu Stage – marls of the Jamaja Formation and argillaceous nodular limestones of the Sôrve Formation, are characterized by an abundant and highly diverse chitinozoan assemblage. The uppermost beds of the stage, skeletal packstones and grainstones, have yielded rare chitinozoans. The chitinozoan assemblage of graptolitic carbonate clays and argillaceous limestones of the Jugla Beds of the Latvian Riga Formation (Ventspils core) is somewhat impoverished, compared to southern Estonian sections. Thin-bedded limestones and marls of the Ančia Member contain a specific assemblage of chitinozoans, comprising only representatives of Ancyrochitina.

In Estonia extremely shallow-water limestones and dolomites of the Rootsiküla Stage practically lack chitinozoans. Only some intervals of the Viita Beds of southern Estonian sections (Ohesaare core) have yielded a small number of chitinozoans. The diversity of chitinozoans is rather low also in argillaceous limestones and mudstones of the Siesartis Formation in Latvia.

Main stages in the development of chitinozoan assemblages

In the stratigraphic distribution of chitinozoans in the lower Silurian sequence of the North East Baltic area several stages can be distinguished, characterized by the presence of taxa with specific morphological features typical of a definite stratigraphic interval. The stages are established on the basis of considerable innovation of the taxonomic composition of chitinozoan assemblages. At the end of each stage extensive disappearance of species took place; at the beginning of the next stage, however, there appeared abundantly new elements.

The first stage comprises the early and middle Llandovery and is characterized by a particular homogeneous assemblage of chitinozoans represented by numerous species and genera (Fig. 23). Characteristic is the presence of some typical Ordovician genera (*Cyathochitina, Spinachitina*) with specific morphological features, but also absence of forms with the mucron.

At the beginning of the late Llandovery (Adavere time), complete turnover of the chitinozoan assemblage took place: the middle Llandovery species disappeared and the new ones appeared, characterizing the second, late Llandovery – early Wenlock stage in the evolution of chitinozoans. The chitinozoan assemblages of the Adavere Stage and lowermost Jaani Stage are closely related containing specific forms, mainly *Eisenackitina* in large numbers. Here chainlet forms (*Densichitina, Margachitina*) made their appearance. Widely distributed became forms with the mucron, also those in which the spines are arranged in rows on the vesicle surface (*Gotlandochitina*). At the end of this stage, corresponding to the top of the Mustjala and Tôlla members of the Jaani Stage, many species, which had abounded since the beginning or middle of the Adavere time, vanished gradually. On the whole, the late Llandovery and early Wenlock evolutionary stage of chitinozoans is characterized in the East Baltic region by a diverse and rich assemblage of chitinozoans.

The third stage in the evolution of chitinozoans comprises the middle and late Wenlock. The chitinozoan assemblage is mostly characterized by the abundance of *Cingulochitina* species and by high diversity of *Conochitina* species. There occur also species with a characteristic spongy and fine-reticulate ornamentation of the vesicle.

At the end of the Jaagarahu time most of the species, which had appeared in the middle Wenlock, disappeared gradually. The succeeding Rootsiküla time, however, is characterized by an exceptionally poor assemblage of chitinozoans,

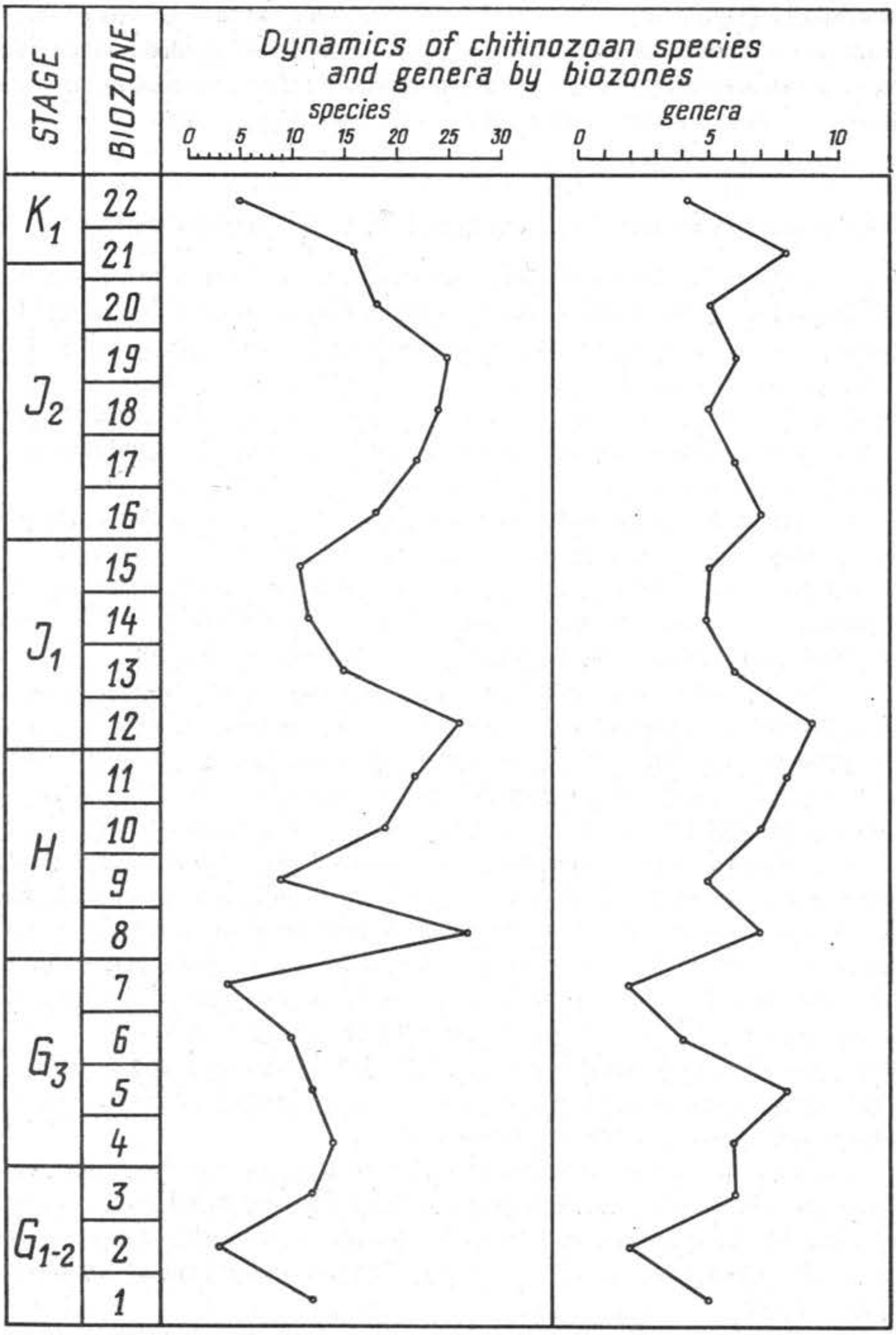

Fig. 23. Chitinozoan diversity dynamics in the East Baltic early Silurian sequence.

denoting the end of the third stage in the development of chitinozoan assemblages in the early Silurian of the East Baltic.

Different chitinozoan biotic events in the East Baltic Silurian, along with the diversity, innovation and extinction dynamics, linked to the regional graptolite scale, were discussed earlier in Nestor 1992.

Chitinozoan biozonation

Although the frequency and taxonomic variability of chitinozoans are greatly varying in different rock types and facies belts of the East Baltic, it was possible to distinguish regional biozones by certain chitinozoan assemblages and trace them throughout the East Baltic area.

In the whole Silurian sequence 31 biozonal units have been established (Nestor 1990), five of which are treated as interzones, badly characterized by chitinozoans. Chitinozoan zones are correlated with the graptolite biozones (data by Ulst and Kaljo), basing on their co-occurrence in some sections of southern Estonia and Latvia (Ohesaare, Ikla, Ventspils cores).

22 biozones of chitinozoans from the Llandovery and Wenlock sequences are briefly described and discussed in this work.

The biozones under consideration are mostly interval zones: their bases were defined by the first occurrence of the index species and tops by the first occurrence of the index species of the next, overlying biozone (biozones 8, 10, 11, 14, 15, 16, 17, 18, 20).

Some biozones were defined as total-range biozones of the index-species (biozones 1, 5, 6, 19, 21).

In some cases partial-range biozones of index species were defined, if rare specimens of the index species appeared already in the underlying biozone but abundance was gained in the nominal zone (biozones 3, 4, 12).

In order to avoid the gaps in the zonal succession, interzones were distinguished to point out the intervals containing only scarce chitinozoans without specific forms (biozones 2, 7, 9, 13, 22).

Besides the definition of the zone, also its type stratum and locality, associated chitinozoans, main occurrences outside the Baltic region, age assignment and remarks are pointed out in this chapter.

At the present time a working group (J. Verniers, F. Paris, P. Dufka, S. Sutherland, G. van Grootel, V. Nestor) is elaborating the global zonal standard of chitinozoans for the Silurian. For this biozonation some new index species have been selected using the species, which are better preserved and defined or more widely distributed in other regions. These species are also mentioned below in the definitions of biozones.

Different data concerning the described biozones are presented in several tables and figures. The Llandovery and Wenlock biozonal sequence of chitinozoans of Estonia and North Latvia, tied to graptolite biozones and regional stratigraphic units, is given in Fig. 24. The distribution of all chitinozoan taxa in the lower Silurian biozones is shown in Tables 1, 3. The levels of the boundaries of chitinozoan biozones in all studied sections are given in Tables 2, 4, 5. The correlation of chitinozoan biozones and the corresponding local stratigraphic units with the graptolite biozonal sequence in the Ohesaare, Ikla and Ventspils sections is shown in Figs 25, 26.

1. *Ancyrochitina laevaensis* Biozone

Definition. This chitinozoan biozone corresponds to the total-range biozone of *Ancyrochitina laevaensis* Nestor 1980 and *Spinachitina fragilis* (Nestor 1980) in the lowermost Llandovery.

Type stratum and locality. The lower part of the Õhne Formation, Puikule and Ruja members of the Juuru Stage. Ohesaare core, in the interval 438–448.75 m.

Associated chitinozoans. The zonal assemblage includes besides *Ancyrochitina laevaensis* and *Spinachitina fragilis* also *Plectochitina nodifera, Belonechitina aspera* and *B.* cf. *postrobusta* (the latter occurs in the basal part of the biozone). The most abundant species is *Cyathochitina campanulaeformis.*

Other occurrences. *A. laevaensis* has been recorded from the lowermost Llandovery, from the *acuminatus* graptolite Zone of Libya (Hill, Paris and Richardson 1985; Paris 1988). *Belonechitina aspera* has been identified from the lower Llandovery of China (Geng *et al.* 1988), *C. robusta* (= *B.* cf. *postrobusta*) on the *acuminatus* Zone level from Skåne, Sweden (Grahn 1978) and from the Deerlijk section, Belgium (Martin 1973). The biozone is also recognized in Saudi Arabia and Tunisia (Verniers *et al.* in prep.).

Age assignment. In the East Baltic the *A. laevaensis* Zone corresponds evidently to the lower part of the *acuminatus* graptolite Zone (see Resheniya... 1987).

Remarks. In the more carbonate middle Estonian sections the *A. laevaensis* Zone is usually lacking, corresponding partly to a gap in sedimentation (see Resheniya... 1987).

The species composition of the uppermost part of the biozone is impoverished also in most of the southern Estonian and Latvian (Stašiunai Formation) sections.

2. Interzone I

Definition. Interzone I corresponds to the beds, barren of or poor in chitinozoans, from the disappearance of the index species of the preceding biozone up to the first occurrence of the zonal species of the succeeding biozone.

Type stratum and locality. The Rozeni Member of the Õhne Formation of the Juuru Stage. Ohesaare core, in the interval 424–438 m.

SERIES	STAGE	REGIONAL STAGE	NESTOR, 1976 NESTOR, 1982	NESTOR 1984	NESTOR, 1990 THIS BOOK	GRAPTOLITE BIOZONES BY KALJO 1969, 1970; ULST 1987, PERS. COMM.
WENLOCK	HOMERIAN	ROOTSI-KÜLA	Interregnum	– – –	22. Interzone (V)	nassa
			S. indecora	– – –	21. S. indecora	
		JAAGARAHU	C. cf. pachycephala c		20. C. cribrosa	testis
			b		19. C. subcyatha	
	SHEINWOODIAN		a	– – –	18. C. pachycephala	radians
			C. lagena	– – –	17. E. lagena	perneri
			L. cingulata		16. C. cingulata	flexilis
		JAANI	C. claviformis	Beds J_1^{IV}	15. C. tuba	antennularius
				Beds J_1^{III}	14. C. cf. mamilla	riccartonensis
			C. proboscifera	Beds J_1^{II}	13. Interzone (IV)	
				Beds J_1^{I}	12. M. margaritana	murchisoni bohemicus
LLANDOVERY	TELYCHIAN	ADAVERE			11. C. proboscifera	spiralis griestoniensis
					10. A. longicollis	crispus
					9. Interzone (III)	turriculatus
	AERONIAN			– – –	8. C. emmastensis	sedgwicki
		RAIKKÜLA	Beds G_3^{III}		7. Interzone (II)	convolutus
			Beds G_3^{II} b	– – –	6. C. cf. protracta	gregarius triangulatus
			a	– – –	5. A. convexa	
	RHUDDANIAN		Beds G_3^{I} c/b/a	– – –	4. C. electa	cyphus
		JUURU			3. B. postrobusta	confertus
					2. Interzone (I)	
					1. A. laevaensis	

Fig. 24. East Baltic early Silurian chitinozoan biozones (published in Nestor 1976, 1982, 1984, 1990) correlated with regional graptolite succession.

Chitinozoans. Interzone I contains only rare specimens of the transitional species *Ancyrochitina ancyrea* and *Cyathochitina campanulaeformis*. In southern Estonian and Latvian sections chitinozoans are completely missing in this interval.

Age assignment. Interzone I is tentatively assigned to the upper part of the *acuminatus* Zone (see Resheniya... 1987).

Remarks. Ecological reasons of the scantiness of chitinozoans in the Varbola Formation, containing abundantly macrofossils, are unknown.

3. *Belonechitina postrobusta* Biozone

Definition. This biozone corresponds to the partial-range biozone of *Belonechitina postrobusta* (Nestor 1980) from its appearance above Interzone I up to the last occurrence of the zonal species and abundant appearance of *Conochitina electa*, which is the index species of the succeeding biozone.

Type stratum and locality. The upper part of the Õhne Formation of the Juuru Stage. Ohesaare core, in the interval 410.1–424 m.

Associated chitinozoans. Besides the index species, the lower part of the zone shows abundant occurrence of *Cyathochitina calix*. In the upper part of the zone it is replaced by *C. kuckersiana*. In this zone there appears for the first time *Ancyrochitina bifurcaspina*, also a few specimens of *Conochitina iklaensis* and *C. electa* come in. *B. aspera* is also present in this zone.

Other occurrences. On the same stratigraphic level *Belonechitina postrobusta* has been recorded from the Deerlijk section of Belgium (Martin 1973) and from the Skåne section of Sweden (Grahn 1978). The biozone is recognized in Bohemia (Dufka 1992), Saudi Arabia, south-western Algeria and Tunisia (Paris *et al.* in press), Quebec, Canada (Asselin *et al.* 1989, with *Belonechitina* sp. 1) and southern China (Geng and Cai 1988).

Age assignment. According to the graptolite zonal scale of the East Baltic (Kaljo, Paškevičius and Ulst 1984), the *B. postrobusta* Zone roughly correlates with the *D. confertus (=vesiculosus)* Zone.

Remarks. This zone is sometimes traceable also in shallower-water rocks of the Tamsalu and Varbola (uppermost part) formations.

4. *Conochitina electa* Biozone

Definition. This biozone corresponds to the partial-range and abundance biozone of *Conochitina electa* Nestor 1980. Its base is defined by the disappearance of *Belonechitina postrobusta* and abundant appearance of *C. electa*. The top is fixed by the first appearance of *Ancyrochitina convexa* and *Conochitina edjelensis*.

Table 1

Distribution pattern of chitinozoans in the Llandovery biozones

Rhudd.| Aeronian Telychian

Chitinozoan taxa	Juuru Stage			Raikküla Stage				Adavere Stage			
	Chitinozoan biozones										
	1	2	3	4	5	6	7	8	9	10	11
Ancyrochitina laevaensis Nestor	x										
A. ancyrea Eisenack	x	x	x	x	x	x	x	x	x	x	x
A. bifurcaspina sp. n			x	x							
A. ramosaspina sp. n.				x	x						
A. cf. *clathrospinosa* Eisenack				.				.			
A. porrectaspina sp. n.				?							x
A. convexa Nestor					x						
A. rumbaensis sp. n.								x			
A. aff. *convexa* Nestor								x			
A. primitiva Eisenack								x	.	x	x
A. aff. *ancyrea* (Eisenack)											x
A. ansarviensis Laufeld											x
A. vikiensis sp. n.											x
Belonechitina aspera Nestor	x		.								
B. postrobusta Nestor	.		x								
Spinachitina fragilis Nestor	x										
S. cf. *fragilis* Nestor	.										
S. maennili Nestor				x	x	x					
S. cf. *maennili* Nestor								.			
Cyathochitina campanulaeformis Eis.	x	.	x	x	x			.		?	
C. kuckersiana Eisenack	x		x	x				.			
C. calix Eisenack			x	x							
Lagenochitina? sp.	.										
Plectochitina nodifera Nestor	x										
P. cf. *spongiosa* Achab	x	.		x		?					
P. ralphi sp. n.								x			
Clathrochitina sp.			.	.	.						
C. aff. *clathrata* Eisenack											
Conochitina electa Nestor			.	x							
C. iklaensis Nestor			.	x	x	x	.	.			
C. edjelensis Taugourdeau					x	x	x	.			
C. cf. *protracta* (Zaslavskaja)					.	x					
C. rara sp. n.						x					?
C. aff. *tuba* Eisenack						x	.				

Chitinozoan taxa	Juuru Stage			Raikküla Stage				Adavere Stage			
	Chitinozoan biozones										
	1	2	3	4	5	6	7	8	9	10	11
C. praeproboscifera sp. n						?		x	.	x	.
C. emmastensis Nestor							x	x	x	x	
C. aff. *emmastensis* Nestor							x		x	x	
C. leptosoma Laufeld							.		x	x	
Conochitina? sp. 1							.				
Conochitina sp. 2							.				
C.? sp. 3							.		.		
C. sp. 4							x	.	x		
C. sp. 5							x	.	x		
C. sp. 6							.		x	x	
C. visbyensis Laufeld										x	
C. proboscifera Eisenack										x	
C. acuminata Eisenack										x	
Sphaerochitina? sp. 3	.										
S. sp. 1			.								
Angochitina sp.		.	.								
A. longicollis Eisenack								.	x	x	
Eisenackitina? sp. 3			.	.							
E. dolioliformis Umnova							x	x	x	x	
E. sp. 1									x	x	
E.? sp. 2									x		
Nanochitina nana									x		
Vitreachitina sp. 1							x				
V. sp. 2							x		x		
V. sp. 3									x		
Densichitina densa (Eisenack)								.	x	.	
Gotlandochitina sp							.				
G. cf. *angusta* Nestor							.				
G. ruhnuensis Nestor										x	
Anthochitina primula sp. n.									x		
Margachitina margaritana (Eisenack)											

x – occurrence of species
. – sporadic finds

Type stratum and locality. The Slitere and Kolka members of the Saarde Formation of the Raikküla Stage. Ohesaare core, in the interval 384.1–410.1 m.

Associated chitinozoans. The zonal assemblage includes *Conochitina iklaensis, Cyathochitina* sp. sp. and *Ancyrochitina* sp. sp. In the upper part of the zone there appears for the first time *Ancyrochitina ramosaspina* and in deeper-water sections *Spinachitina maennili* comes in. The distribution of these species serves as a basis for the distinction of several biofacies at this level (Nestor, in press).

Other occurrences. Grahn (1985) has identified *C.* cf. *electa* in the Lick Fork section of the Brassfield Formation (U.S.A., southern Ohio). Like in the East Baltic sections, its range is there higher overlapping with the range of *Spinachitina maennili.*

In the Anticosti section (Canada) Achab has established *C.* cf. *electa, Conochitina* sp. 1 and *C.* sp. in the Becscie and Gun River formations. Part of the specimens are evidently identical with *C. electa* (see Achab 1981, pl. 2, figs 1, 7–8, 14–17). The biozone is also recognized in the Llandovery sequence at Chaleurs Bay (Quebec, Canada), containing *Conochitina* sp. 2 (=*C. electa*) (Asselin *et al.* 1989).

Age assignment. The *C. electa* Zone correlates with the *C. cyphus* Zone in the graptolite standard of the East Baltic (Kaljo *et al.* 1984).

Remarks. The *C. electa* Zone is well established in all studied sections, as the index species seems to be more independent of the facies than the other species occurring on this level (Nestor, in press).

5. *Ancyrochitina convexa* Biozone

Definition. This biozone corresponds to the total-range biozone of *Ancyrochitina convexa* Nestor 1980.

Type stratum and locality. The Ikla Member of the middle part of the Saarde Formation of the Raikküla Stage. Ohesaare core, in the interval 372.6–384.1 m.

Associated chitinozoans. Besides the index species, the most common taxa in the *A. convexa* Biozone are *Conochitina iklaensis, Spinachitina maennili* and *Conochitina edjelensis*, the latter appearing for the first time in this zone. Several *Ancyrochitina* species are transitional from the preceding biozone.

Other occurrences. There is no information about the occurrence of the index species outside the Baltic area, but *Spinachitina maennili* was reported from the Lick Fork section of southern Ohio, U.S.A. by Grahn (1985) and from Saudi Arabia by Paris (Paris *et al.* in prep.). *Conochitina iklaensis* and *C. edjelensis* occur on the same level in Bohemia, the Prague Basin (Dufka 1992).

Age assignment. Numerous finds of *C. gregarius* and associated graptolite species from the Latvian sections (Ulst 1973; Gailite *et al.* 1987), but also from the Ohesaare and Ikla cores (Kaljo 1967; Kaljo and Vingissaar 1969), allow to correlate the *A. convexa* Zone with the lower part of the *C. gregarius* Zone.

Table 2

Lower boundary levels of chitinozoan biozones in the sections of the Juuru and Raikküla stages

Borehole	Chitinozoan biozones							
	1.	2.	3.	4.	5.	6.	7.	8.
Ikla	528	525.6	516	499	471	423	365.7	320
Häädemeeste	426.8	422	410	387.5	337	260?	232	-
Ruhnu	601	599	-	588.1	560	513	491	-
Ohesaare	448.7	438	424	410.1	384.1	372.6	-	-
Viki	243.7	232?	229	221.5	195.7	191.2	-	-
Varbla	256.2	250	232	218	185.2	167.8	-	-
Laeva 10		135?	128?	88.3	56?	-	-	-
Laeva 18	177.6	165						
Taagepera	411.1	408	402	370.2				
Sulustvere	110.6	108?	79	71.7	38			
Kirikuküla	110.6	-	92	86.4	-	-	-	-
Emmaste	77.3	-	63.5	57.7	32.3	-	-	-
Raikküla			42	39?	-	-	-	-
Nurme	112.2	-	85.5	79?	54.2	-	-	-
Asuküla				18.4	-	-	-	-
Martna	49.6	-	-	24.6	-	-	-	-
Rapla	40.1	39	17	14	-	-	-	-
Pusku 2	27.3	-	9.7	6.6	-	-	-	-
Kolka	661	658	-	645.8	623	606?	-	-
Puikule	460.5	452	443	435	420?	481.3	344?	-
Nagli	680.5	-	660?	649	-	-	-	-
Ventspils	873?	-	-	868	862.5	856?	-	-
Remte	961	953	-	945				
Nitaure	713.7	691?	-	683?	674			
Vidukle	1470	-	-	-	1446			

Remarks. In most of the studied western and middle-Estonian sections the *A. convexa* Biozone is lacking, as on this level a stratigraphic break has been established (Nestor 1976). In the Latvian sequence (Ventspils core) this biozone corresponds to the lowermost part of the Dobele Formation.

6. *Conochitina* cf. *protracta* Biozone

Definition. This biozone corresponds to the total-range biozone of *Conochitina* cf. *protracta* (Zaslavskaya 1980).

Type stratum and locality. The uppermost part of the Ikla Member and the Lemme Member of the Saarde Formation of the Raikküla Stage. Ikla core, in the interval 365.7–423 m.

Associated chitinozoans. *Conochitina iklaensis* and *Spinachitina maennili* of wider stratigraphic range are the most numerous taxa in this biozone. Sporadically there occur also *Conochitina edjelensis, C.* aff. *tuba* and *C. rara.*

Other occurrences. *Conochitina protracta* is reported from the Siberian Platform in the Gorbiatshin River section, but its range is estimated to be there from the lower to upper Llandovery (Zaslavskaya 1980).

Age assignment. According to Kaljo (Kaljo and Vingissaar 1969), the Lemme Member (earlier "marly" member) corresponds to the upper part of the *C. gregarius* graptolite Zone.

Remarks. In some sections scarce specimens of the index species have been found in the lowermost part of the Rumba Formation of the Adavere Stage. In most of the studied sections this biozone is lacking due to the stratigraphic break.

7. Interzone II

Definition. Interzone II corresponds to the beds poor in chitinozoans, beginning from the disappearance of the index species of the underlying biozone up to the first occurrence of *Eisenackitina dolioliformis* or *Conochitina emmastensis.*

Type stratum and locality. The Staicele Member of the Saarde Formation of the Raikküla Stage. Ikla core, in the interval 320(?)–365.7 m.

Chitinozoans. Interzone II is characterized by only a few transitional species *Conochitina iklaensis, C. edjelensis* and *C.* aff. *tuba*, occurring sporadically in small numbers.

Age assignment. According to Kaljo *et al.* (1984), the upper part of the Saarde Formation corresponds to the *D. convolutus* Zone in the graptolite zonal scale.

Remarks. From the studied sections this biozone was established only in the Ikla core. In more northern sections there occurs a distinct stratigraphic hiatus, corresponding to this biozone and growing north-westwards.

8. *Conochitina emmastensis* Biozone

Definition. This biozone corresponds to the interval biozone of *Conochitina emmastensis* Nestor 1982 and the range of *Eisenackitina dolioliformis* Umnova 1976 from their appearance up to the appearance of *Angochitina longicollis*, the index species of the succeeding biozone.

Type stratum and locality. The Rumba Formation of the Adavere Stage. Kirikuküla core in the interval 33–50 m.

Associated chitinozoans. The appearance of the zonal species is usually accompanied by *Conochitina praeproboscifera*, but also *C.* aff. *emmastensis*, *C.*? sp. 1, *C.* sp. 2 and *C.* sp. 4 occur in the lower part of the biozone. In deeper-water sections *Vitreachitina* sp. 1, *V.* sp. 2 and *V.* sp. 3 are present. In the middle part of the biozone, *Ancyrochitina rumbaensis*, *A. primitiva*, *Plectochitina ralphi*, *Conochitina*? sp. 3, *C.* sp. 5 make their appearance. In the lower or middle part of the biozone typical lower and middle Llandovery species (*Conochitina iklaensis*, *C. edjelensis*, *Cyathochitina campanulaeformis*) disappear from the sections.

The *C. emmastensis* Biozone is characterized by one of the chitinozoan diversity high stands in the whole Silurian (Nestor 1992, Fig. 2).

Other occurrences. *Eisenackitina dolioliformis* was recorded from the Prague Basin as *E. brabantium* (Dufka 1992). Van Grootel regarded it as a junior synonym of *E. dolioliformis*. *Eisenackitina* sp. A (= *E. dolioliformis*) was identified from the Brabant Massif, Belgium by Verniers (1982). The biozone is also recognized from Libya, Tunisia, Saudi Arabia (Hill *et al.* 1985; Paris 1988; Verniers *et al.* in prep.). It occurs possibly also in Quebec, Canada (Asselin *et al.* 1989) and southern China, Jiangsu (possible equivalent of the biozone – Geng *et al.* 1987, Geng and Cai 1988).

Age assignment. According to H. Nestor (1972) and others, the section of the Rumba Formation in Estonia and the uppermost part of the Dobele Formation in the Ventspils core (Ulst 1973, etc.) correspond to the *M. sedgwickii* graptolite Zone.

Remarks. The extent of the *C. emmastensis* Biozone is variable, ranging from a few metres (Ruhnu, Ventspils cores) to 19 m (Varbla core). In some sections this biozone is lacking due to a local stratigraphic break (Ohesaare core).

9/10 *Angochitina longicollis* Biozone

Definition. This biozone corresponds to the interval biozone of *Angochitina longicollis* Eisenack 1931 from its first appearance up to the first occurrence of *Conochitina proboscifera*, the index species of the succeeding biozone.

Type stratum and locality. The lower part of the Velise Formation of the Adavere Stage. Ohesaare core, in the interval 359–372 m.

Associated chitinozoans. Approximately at the same level with the index species there appear *Conochitina* cf. *leptosoma* (Ventspils, Ruhnu, Pulli, Varbla, Viki, Häädemeeste cores) and *Densichitina densa* (Ventspils, Ruhnu, Pulli, Kirikuküla cores), but also *Eisenackitina* sp. 1 (Ohesaare, Kirikuküla, Viki, Pulli). In this biozone *Conochitina* sp. 3, *C.* sp. 4 and *C.* sp. 5 disappear. In more southern sections of Latvia (Nagli and Ventspils cores), *Angochitina longicollis* is not recorded from the lowermost part of the biozone, but besides *Densichitina densa*, there occur *Vitreachitina* sp. 2, *V.* sp. 3 and *Eisenackitina* sp. 2, which are very rare in Estonian sections.

Other occurrences. *Angochitina longicollis* is widely distributed all over the world. It is identified from the Welsh Basin (Dorning 1981), Brabant Massif, Mehaigne area(Verniers 1982), Quebec, Canada (Asselin *et al.* 1989), southern Ohio (Grahn 1985), southern China, Jiangsu (Geng *et al.* 1987).

Age assignment. Graptolite finds (Kaljo 1970) in the Ohesaare core at a depth of 372–372.6 m have enabled to establish there the *S. turriculatus* Zone. The *M. crispus* Zone was distinguished at a depth of 366–372 m and the *M. griestoniensis* Zone at 353–366 m. In the Ventspils core section, where the *A. longicollis* Zone embraces the interval 816–845 m, the *S. turriculatus, M. crispus* and *M. griestoniensis* zones have been established by Ulst in the interval 825.1–851.5 m without distinct boundaries between them. The interval 798–825.1 m represents the *O. spiralis* Zone (Gailite *et al.* 1987). Thus, the *Angochitina longicollis* Zone corresponds mostly to the *turriculatus, crispus* and partly to the *griestoniensis* graptolite zones, but in the Ventspils core section also to the lowermost part of the *O. spiralis* Zone.

Remarks. In earlier publications (Nestor 1990, 1992) the lowermost beds of the Velise Formation were distinguished as 3. Interzone, as this part of the sections contains chitinozoans sporadically or they are completely lacking. However, rare specimens of the index species, as well as of *Densichitina densa,* appear in some sections (Ohesaare, Ruhnu, Varbla) already in the lowermost part of this interval below or in between the barren beds. For that reason it seems more correct to abandon this interzone. Still, to point out the scantiness of chitinozoans and other fossils in the lowermost part of the Velise Formation, this interregnum is shown in the figures as Interzone III separately from the *A. longicollis*Zone.

In Latvian sections the *A. longicollis* Zone coincides with the Degole Beds and the lowermost part of the Irlava Beds of the Jurmala Formation.

11. *Conochitina proboscifera* Biozone

Definition. This biozone corresponds to the interval biozone of *Conochitina proboscifera* Eisenack 1937 from its first appearance up to abundant appearance of *Margachitina margaritana.*

Type stratum and locality. The upper part of the Velise Formation of the Adavere Stage. Ohesaare core, in the interval 345.8–359 m.

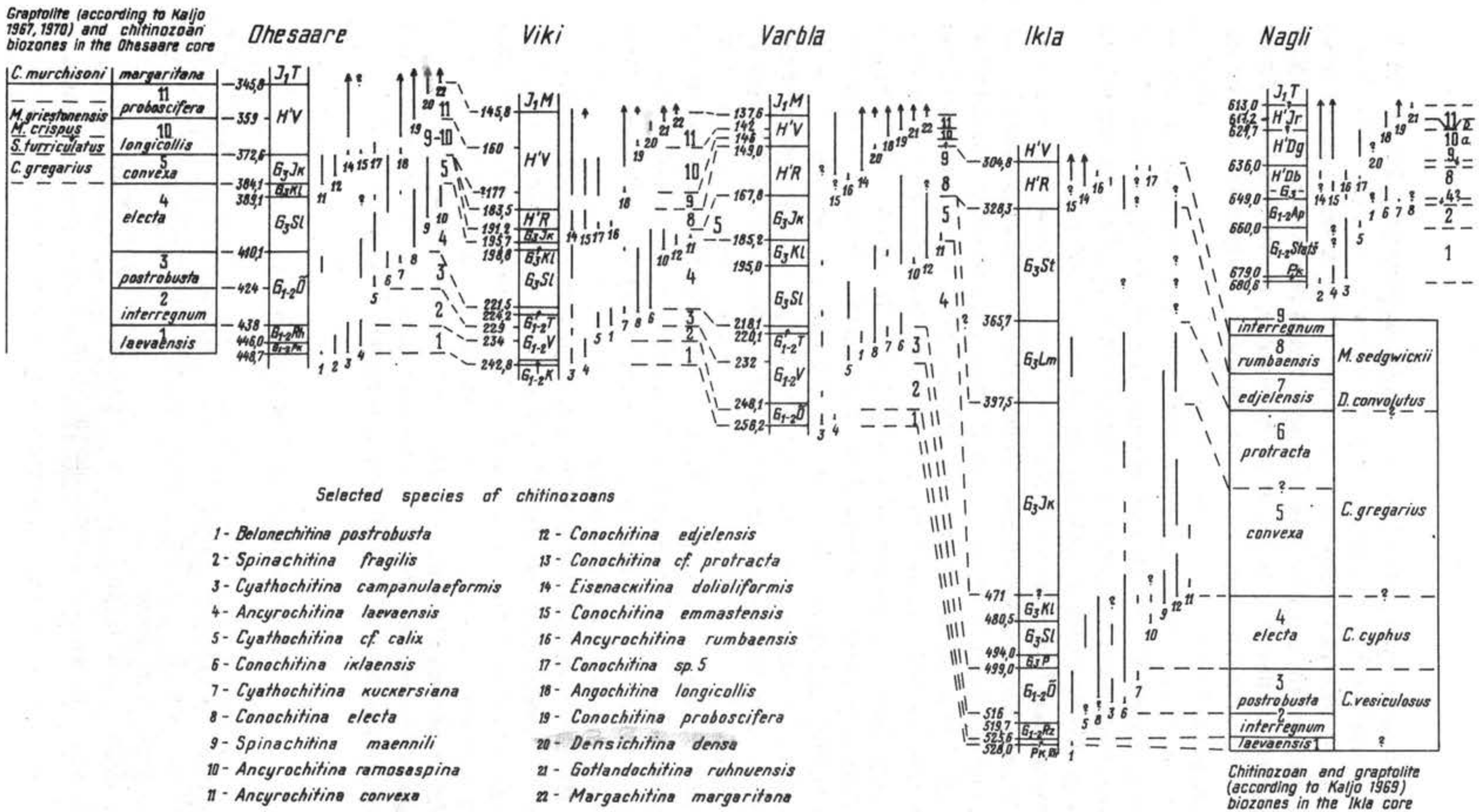

Fig. 25. Ranges of index species and chitinozoan biozones in some Llandoverian sections, correlated with graptolite succession in the Ohesaare and Ikla cores (by data in Kaljo 1967, 1969, 1970).

Associated chitinozoans. The zonal assemblage includes *Conochitina proboscifera* (as the dominant species), *Ancyrochitina porrectaspina, A. ansarviensis, A.* aff. *ancyrea, Conochitina acuminata, C. visbyensis, Gotlandochitina ruhnuensis, Nanochitina nana, Anthochitina primula*, which all appear for the first time in this biozone and are well represented in most sections. On the other hand, *Conochitina praeproboscifera* and *C.* sp. 6 disappear here. *Ancyrochitina porrectaspina, A.* aff. *ancyrea* and *Anthochitina primula* are restricted to this biozone only.

Other occurrences. *Conochitina proboscifera* is recorded from the uppermost Llandovery in many regions of the world, e.g. from the Brabant Massif of Belgium (Verniers 1982) Jacksonville section, Ohio, U.S.A. (Grahn 1985), the Welsh Basin (Dorning 1981; Mabillard and Aldridge 1985), the lower unit of the Pitinga Formation in the Amazonas Basin, Brazil (Grahn and Paris 1992).

Age assignment. According to the occurrence of graptolites in the Ohesaare core (Kaljo 1970), the *C. proboscifera* Biozone corresponds to the upper half of the *M. griestoniensis* Zone (353–359 m) and possibly to the *O. spiralis* Zone (above 353 m graptolites have not been recorded). By the data of the Ventspils core (Ulst in Gailite *et al.* 1987), this zone (interval 798–816 m) corresponds to the middle and upper parts of the *O. spiralis* Zone.

Remarks. In Latvian sections this biozone correlates with the upper part of the Irlava Beds of the Jurmala Formation. In the Ventspils core section, a sample taken at a depth of 815 m has already yielded *Margachitina margaritana*, the index species of the next biozone.

12. *Margachitina margaritana* Biozone

Definition. This biozone corresponds to the partial-range biozone of *Margachitina margaritana* (Eisenack 1937) from its abundant appearance up to the disappearance of *Angochitina longicollis* from the sections.

Type stratum and locality. The Tôlla Beds of the Riga Formation of the Jaani Stage. Ohesaare core, in the interval 338–345.8 m.

Associated chitinozoans. This biozone is characterized by a highly diverse assemblage of chitinozoan species (Nestor 1992, fig. 2). *Gotlandochitina magnifica, G. angusta, Ancyrochitina magna* and *A.* sp. 1 are typical of this zone only. It includes also many species ranging from the uppermost Llandovery – *Conochitina proboscifera, C. visbyensis, C. acuminata, C. emmastensis, Eisenackitina dolioliformis, E.* sp. 1, *Densichitina densa, Gotlandochitina ruhnuensis*. Some sections have yielded also *Pterochitina macroptera, Conochitina* cf. *leptosoma, Densichitina opaca, Ancyrochitina ansarviensis, Plectochitina pachyderma, Clathrochitina* aff. *clathrata*, etc.

Other occurrences. In the lowermost Wenlock *M. margaritana* is recorded from the Welsh Basin (Dorning 1981; Mabillard and Aldridge 1985), the Brabant Massif, Belgium (Verniers 1982), Canada, Nova Scotia (Cramer 1970), Bohemia,

Table 3

Distribution pattern of chitinozoans in the Wenlock biozones

Chitinozoan taxa	Jaani Stage				Jaagarahu Stage					K_1	
	Chitinozoan biozones										
	12	13	14	15	16	17	18	19	20	21	22
Angochitina longicollis Eisen.	x										
Densichitina densa (Eisenack)	x	x	x								
D. opaca (Laufeld)	x	x									
Calpichitina acollaris (Eis.)				x	.			?			
Eisenackitina sp. 1	x	x									
E. dolioliformis Umnova	x	x	.								
E. lagena (Eisenack)					x	.	.				
E.? sp. 4										.	
E.? sp.											.
Gotlandochitina angusta Nest.	x										
G. ruhnuensis Nestor	x										
G. magnifica Nestor	x										
G. martinssoni Laufeld					x	x					
G. costata (Umnova)					x	x					
G. cf. *valbyttiensis* Laufeld					x	x					
G. uncinata Laufeld					x	x	x	.			
G. spinosa (Eisenack)					x	x.		.			
G. tabernaculifera Laufeld										x	
Ancyrochitina magna Nestor	x										
*A.*sp. 1	x										
A. ansarviensis Laufeld	x										
A. ancyrea (Eisenack)	x	x	x	x	x	x	x	x	x	x	.
A. primitiva Eisenack	x	x	x	x	x	x	x	x	x	x	
A. cf. *clathrospinosa* Eisen.				x							
A. paulaspina sp. n.				x	x	x	.	.			
A. gutnica Laufeld					x	x	.	.	x		
A. plurispinosa sp. n.					x	x	x	x	x		
A. cf. *paulaspina* sp. n.								.	x		
Conochitina acuminata Eisen.	x										
C. emmastensis Nestor	x										
C. aff. *emmastensis* Nestor	.										
C. proboscifera Eisenack	x	x	.								
C. visbyensis Laufeld	x	.	.								
C. leptosoma Laufeld	x	.	x	.							

Chitinozoan taxa	Jaani Stage				Jaagarahu Stage					K_1	
	Chitinozoan biozones										
	12	13	14	15	16	17	18	19	20	21	22
C. cf. *flamma* Laufeld	x	.	.								
C. claviformis Eisenack		.	x	x	x	x	.	.	x	x	x
C. cf. *mamilla* laufeld			x	.							
C. tuba Eisenack				x	x	x	x	x	x	x	.
C. aff. *pachycephala* Eisen.					x						
C. argillophila Laufeld						x	.	.			
C. aff. *proboscifera* Eisen.						.	x	x	.		
C. pachycephala Eisenack							x	x	.		
C. fortis Nestor							x	x	.		
C. linearistriata Nestor							.	.			
C. sp. 7							.	x			
C. aff. sp. 7						.	.	x	.	.	
C. cribrosa Nestor							.	.			
C. cf. *argillophila* Laufeld									x	x	
C. sp. 8										x	
Margachitina margaritana (Eis.)	x	x	x	x	x	x	x	x	.	.	
Nanochitina nana sp. n.	x	x									
Plectochitina pachyderma (Lauf.)	x	x	x	x	x	x	.				
P. obuti sp. n.							.	x	.	.	
P. sp. 1									.		
Pterochitina macroptera Eisen.	.	.	.		.						
Cingulochitina cingulata (Eis.)					x	x	x	x	.		
C. baltica sp. n.						x	x	x	.	.	
C. crassa sp. n.							.	x			
Clathrochitina clathrata Eis.					x	x					
Clathrochitina? sp.										.	
Belonechitina sp. 1								.			
Sphaerochitina indecora Nestor										x	
S.? sp. 2										.	
Rhabdochitina? sp. 1											x

x - occurrence of species

. - sporadic finds

Prague Basin (Dufka 1992), Brazil, Amazonas Basin (Grahn and Paris 1992). The biozone is also recognized in Libya (Paris 1988) and Algeria (Taugourdeau and Jekhowsky 1960).

Age assignment. The *M. margaritana* Zone is well corresponding to the *C. murchisoni* graptolite Zone according to the data from the Ohesaare core section (Kaljo 1970), as well as from the Ventspils section (Ulst in Gailite *et al.* 1987).

Remarks. The extent of the biozone is usually 5–8 m. In central and western Estonia it corresponds to the lowermost part of the Mustjala Member of the Jaani Stage.

13. Interzone IV

Definition. Interzone IV corresponds to the beds with very low diversity of chitinozoans from the disappearance of *Angochitina longicollis* up to abundant appearance of *Conochitina claviformis* and the disappearance of *Conochitina proboscifera.*

Type stratum and locality. The uppermost part of the Mustjala Member and the middle part of the Tõlla Beds of the Jaani Stage. Ohesaare core, in the interval 440–451 m.

Chitinozoans. Within this interzone gradual disappearance of chitinozoan species takes place. New chitinozoan taxa have not been recorded, except in the topmost part of this zone, where the first representatives of *Conochitina claviformis* appear in some sections. Only *Conochitina proboscifera* is occurring numerously throughout this interzone, disappearing also at the top of the zone.

Age assignment. In the Ohesaare core by graptolite finds (Kaljo 1970) this interzone corresponds approximately to the *M. riccartonensis* Zone, in the Ventspils core only to the lower half of the *M. riccartonensis* Zone, which Ulst established in the interval 768–783 m (Gailite *et al.* 1987).

Remarks. This interzone is connected with a major extinction event of chitinozoans in the East Baltic Silurian (Nestor 1992, fig. 4).

14. *Conochitina* cf. *mamilla* Biozone

Definition. This biozone corresponds to the interval biozone of *Conochitina* cf. *mamilla* Laufeld 1974, ranging from the first appearance of the index species and abundant appearance of *Conochitina claviformis* up to the appearance of *Conochitina tuba* or *Ancyrochitina paulaspina.*

Type stratum and locality. The upper part of the Tõlla Beds of the Riga Formation of the Jaani Stage. Ohesaare core, in the interval 312–330 m.

Table 4

Lower boundary levels of chitinozoan biozones in the sections of the Adavere and Jaani stages

Borehole	Chitinozoan biozones							
	8.	9.	10.	1.1	12.	13.	14.	15.
Emmaste	39.6							
Kolka	602.6							
Puikule	344?							
Ikla	322.8	304.8						
Kirikuküla	50	33	28	24	8?			
Viki	191.2	183.5	177?	160	145.8			
Nagli	649	636	634	617.2	613			
Tôlla					127	126	122	
Pulli II		58.2	51?	39	30	20	15?	
Pulli I								15?
Kipi							121	112
Kingissepa								140?
Varbla	167.8	149	146	142	137.6	131	135	125
Kihnu					200.8	198	190.6	175?
Häädemeeste	232	218.7	-	-	214.4	209	203	195
Ruhnu	491	489	477	474	459	451	440	425
Ohesaare	-	-	372.6	359	354.8	338	330	316
Ventspils	853	851.5	845	816	793	783?	776	768?

Associated chitinozoans. In this biozone the dominant species is *Conochitina claviformis*. Other species, including the index species, are less numerous. There occur also *Densichitina densa, D. opaca, Conochitina leptosoma, C. visbyensis, Pterochitina macroptera, Margachitina margaritana.*

Other occurrences. The index species has been described from the Högklint Beds of Gotland, but it is not yet identified from other sections outside the Baltic region.

Age assignment. In the interval 327–331 m of the Ohesaare core section there occurs *Pristiograptus sardous* (Kaljo 1970). In the Ventspils section the *C.* cf. *mamilla* Zone comprises the interval 768–776 m, corresponding to the upper half of the *M. riccartonensis* Zone (Ulst in Gailite *et al.* 1987).

Remarks. In middle Estonian sections this biozone corresponds to the lower half of the Ninase Member of the Jaani Formation. The extent of this zone in the studied sections ranges from 8 to 18 m.

15. *Conochitina tuba* Biozone

Definition. This biozone corresponds to the interval biozone of *Conochitina tuba* Eisenack 1932 from the final appearance of the index species and *Ancyrochitina paulaspina* up to the appearance of *Cingulochitina cingulata* and *Clathrochitina clathrata.*

Type stratum and locality. The Paramaja Member of the Jaani Stage (by Resheniya... 1987). Ohesaare core, in theinterval 300–312 m.

Associated chitinozoans. The most numerous species in this biozone is *Conochitina claviformis*. The other species, including the index species, occur sporadically. *Calpichitina acollaris, Ancyrochitina paulaspina, A.* cf. *clathrospinosa* and *Margachitina margaritana* have been recorded in this biozone.

Other occurrences. *Conochitina tuba* was identified by Laufeld (1974) from Slite unit "c" on Gotland and by Tsegelnyuk (1982) from the Vrublevtsy Subformation in Podolia. *C. tuba* has also been recorded from other regions, but being a long-ranging species, it occurs usually on higher levels of the Wenlock (Dorning 1981; Schweineberg 1987; Dufka 1992).

Age assignment. According to Kaljo (1970), the zonal graptolite species *M. flexilis* is identified from the Ohesaare core (at 311.7 and 311.8 m). In the Ventspils core section the *C. tuba* Zone has been distinguished in the interval 756–768 m, corresponding to the *S. antennularius* graptolite Zone, established in the interval 761–768 m, and to the lowermost part of the *M. flexilis* Zone (Ulst in Gailite *et al.* 1987).

Remarks. In the studied sections the thickness of the biozone ranges from 11–17 m. In middle Estonian sections it corresponds besides the Paramaja Member also to the upper part of the Ninase Member, in the Ventspils core, however, to the uppermost part of the Tôlla Beds of the Jaani Stage.

16. *Cingulochitina cingulata* Biozone

Definition. This biozone corresponds to the interval biozone of *Cingulochitina cingulata* (Eisenack 1937) from the first appearance of the index species and *Clathrochitina clathrata* up to the appearance of *Eisenackitina lagena*, the index species of the next biozone.

Type stratum and locality. The lower part of the Jamaja Formation of the Jaagarahu Stage. Ohesaare core, in the interval 270–300 m.

Associated chitinozoans. The zonal assemblage contains many representatives of the genus *Gotlandochitina*: *G. martinssoni, G. costata, G. spinosa, G.* cf. *valbyttiensis*, all appearing for the first time in this zone. Highly variable is the genus *Ancyrochitina*, different species of which are often connected by transitional forms (*A. ancyrea* and *A. gutnica*, *A. paulaspina* and *A. plurispinosa*). The most abundant species in this biozone are *Conochitina claviformis* and *Margachitina margaritana.*

Other occurrences. *Clathrochitina clathrata* was identified from Slite unit "d", the index species from Slite unit "e" (Laufeld 1974) of Gotland. The same species were recorded from the Vrublevtsy Subformation of Podolia (Tsegelnyuk 1982). *Cingulochitina cingulata* occurs in the middle Wenlock strata of the Brabant Massif (Verniers 1982) and in the Coalbrookdale Formation of the Welsh Basin (Dorning 1981).

Age assignment. By Kaljo (1970) in the Ohesaare core this interval has yielded *Monograptus* cf. *flemingii primus* (295.5 m and 288 m) and *M.* cf. *jaekeli* (283.9 m). Besides, from the samples dissolved on chitinozoans, Kaljo has identified *Plectograptus bouček*i, *Monoclimacis* ex. gr. *flumindosae, Pristiograptus* ex. gr. *dubius*. In the Ventspilscore section the *C. cingulata* Biozone corresponds to the uppermost part of the *M. flexilis* Zone (Ulst in Gailite *et al.* 1987).

Remarks. In the Ventspils section this biozone corresponds to the lowermost part of the Jugla Beds of the Jaagarahu Stage. In middle Estonian cores (Kuressaare–Kingissepa, Kihnu) this biozone has not been established or only a few scattered specimens of the zonal species have been found from some sections (Häädemeeste, Nässumaa, see Nestor and Nestor 1991, Fig. 4).

17. *Eisenackitina lagena* Biozone

Definition. This biozone corresponds to the interval biozone of *Eisenackitina lagena* (Eisenack 1968) from its first appearance up to the first occurrence of *Conochitina pachycephala* and associated *Conochitina* species, which are characteristic of the succeeding biozone.

Type stratum and locality. The middle part of the Jamaja Formation of the Jaagarahu Stage. Ohesaare core, in the interval 218–270 m.

Associated chitinozoans. Besides the index species, *Conochitina argillophila* and *Cingulochitina baltica* make their appearance in this biozone, but also *Conochitina* aff. *proboscifera* and *C.* sp. 7 come in in the upper part of the zone. *Conochitina tuba* is more numerous than in the lowerlying zone, but *C. claviformis* is still the dominant species. Species of *Ancyrochitina* and *Gotlandochitina* occur in a remarkable variety, including *Ancyrochitina ancyrea, A.primitiva, A. gutnica, A. paulaspina, A. plurispinosa*, also *Gotlandochitina martinssoni, G. spinosa, G. uncinata* and *G.* cf. *valbyttiensis*.

Other occurrences. The index species was described by Eisenack (1968) from the upper Wenlock or lower Ludlow graptolite-bearing erratics of South Baltic. Later no references have been made to this taxon in the publications on chitinozoans. However, in East Baltic sections together with *E. lagena* there occur specimens resembling *Conochitina gutta*. *C. gutta* is recorded from the Brabant Massif, Belgium (Verniers 1982) and Welsh Basin (Dorning 1981). On Gotland it occurs in Slite unit "f" (Laufeld 1974).

Age assignment. In the Ventspils section Ulst (Gailite *et al.* 1987) has distinguished an interzone (727–750 m) between the *M. flexilis* and *C. radians* zones, corresponding roughly to the *C. perneri* Zone. The *C. lagena* Biozone is identified there in the interval 729–739 m.

Remarks. In middle Estonian sections the index species has not been found, but in some cores (Kuressaare–Kingissepa, Kihnu) *Conochitina argillophila* is present in the Tagavere Beds of the Jaagarahu Stage. In the Ventspils core section the *C. lagena* Biozone corresponds to the middle part of the Jugla Beds of the same stage.

18. *Conochitina pachycephala* Biozone

Definition. This biozone corresponds to the interval biozone of *Conochitina pachycephala* Eisenack 1964 from its first appearance up to the first occurrence of *Conochitina subcyatha,* the index species of the succeeding biozone.

Type stratum and locality. The middle and upper parts of the Jamaja Formation of the Jaagarahu Stage. Ohesaare core, in the interval 226–248 m.

Associated chitinozans. This biozone is characterized by almost simultaneous appearance of several species of *Conochitina*: *C. fortis, C. linearistriata, C.* aff. *proboscifera, C. pachycephala.* The zone contains abundantly *C. tuba*, in the basal part of the biozone there occur also *C. claviformis, C. argillophila* and different species of the genus *Ancyrochitina.*

Other occurrences. On Gotland the index species ranges from the uppermost part of the Slite Beds up to the Hemse Marl (Laufeld 1974). It was also recorded from the Wenlock of the Welsh Basin (Eisenack 1968; Dorning 1981), from the Amazonas Basin (Grahn and Paris 1992) in Brazil and from the uppermost part of the Vrublevtsy Subformation of Podolia (Tsegelnyuk 1982 and V. Nestor, unpublished).

Age assignment. In the Ventspils core this biozone embraces the interval 723–729 m, which according to Ulst (Gailite *et al.* 1987) corresponds roughly to the lower half of the *C. radians* graptolite Zone established in the interval 718–727.3 m.

Remarks. A part (?) of this zone has been distinguished also in some transitional sections from southern to middle Estonia (Häädemeeste, Kihnu), corresponding there to the upper part of the Jamaja Formation. In the Ventspils core it corresponds to the middle part of the Jugla Beds of the Jaagarahu Stage.

19. *Conochitina subcyatha* Biozone

Definition. This biozone corresponds to the total-range biozone of *Conochitina subcyatha* Nestor 1982 from its first appearance up to the first occurrence of *Conochitina cribrosa*, the index species of the succeeding biozone.

Type stratum and locality. The uppermost part of the Jamaja Formation and the lowermost part of the Sõrve Formation of the Jaagarahu Stage. Ohesaare core, in the interval 193.2–226 m.

Associated chitinozoans. Several *Conochitina* species (*C. tuba, C. pachycephala, C. fortis*) are more numerous in this biozone. In the upper half of the zone there occurs *Belonechitina* sp. 1. *Conochitina claviformis* is rare in this biozone, being mostly represented by atypical specimens.

Other occurrences. The index species and most of the associated chitinozoans are not reported from the other regions including Gotland.

Age assignment. In the Ohesaare core section Kaljo (1970) has identified *Monograptus* f. *flemingii* at a depth of 194.5 m and *Pristiograptus* ex. gr. *dubius* at a depth of 200 m within the range of the *S. subcyatha* Biozone. In the Ventspils core section this biozone, distinguished in the interval 694–723 m, corresponds to the upper half of the *C. radians* graptolite Zone and to the lower half of the *M. testis* Zone. The latter zone was determined by Ulst in the interval 687–718 m (Gailite *et al.* 1987).

Remarks. Some traces of this biozone were also established from two transitional sections (Kihnu, Häädemeeste), where they occur in the uppermost part of the Jamaja Formation of the Jaagarahu Stage. In the Ventspils core the biozone corresponds to the middle and upper parts of the Jugla Beds of the Riga Formation.

Table 5

Lower boundary levels of chitinozoan biozones in the sections of the Jaagarahu and Rootsiküla stages

Borehole	Chitinozoan biozones							
	16.	17.	18.	19.	20.	21.	22.	
Pulli I	3.3?							
Kipi	96?							
Kingissepa	122.5?							
Varbla	91?							
Kihnu	172?	144?	129.9					
Häädemeeste	181?	155?	145	143	131?			
Ruhnu	414	384	357	348?	327	312	269	248
Ohesaare	300	270	248	226	193.2	174	141.6	118.4
Ventspils	756	739	729?	723	694?	684?	677?	663

20. *Conochitina cribrosa* Biozone

Definition. This biozone corresponds to the interval biozone of *Conochitina cribrosa* Nestor 1982 from its first appearance up to the first occurrence of *Sphaerochitina indecora*, the index species of the succeeding biozone.

Type stratum and locality. The middle part of the Sôrve Formation of the Jaagarahu Stage. Ohesaare core, in the interval 174–193.2 m.

Associated chitinozoans. Besides the index species, the basal part of the biozone is characterized by the appearance of *Ancyrochitina* cf. *paulaspina* and recurrence of numerous *Conochitina claviformis*. At the lower boundary and within the limits of this biozone most of *Conochitina* and *Ancyrochitina* species disappear (*C. pachycephala, C. fortis, C.* cf. *leptosoma, C.* aff. *proboscifera, Ancyrochitina plurispinosa, A.* cf. *paulaspina* and *A. gutnica*). In the Ventspils section *A. gutnica* and *C. pachycephala* range up to the Ludlow strata.

Other occurrences. The index species and most of the associated chitinozoans are not reported outside the East Baltic.

Age assignment. From the *C. cribrosa* Biozone, *Monograptus* cf. *flemingii flemingii* was identified in the Ohesaare core and *Gothograptus nassa* has been recorded from the Ruhnu core (321.05 m) (Kaljo pers. comm.). According to Ulst (Gailite *et al.* 1987), in the Ventspils section at a depth of 677–687 m the *G. nassa* graptolite Zone has been distinguished. Thus, the *C. cribrosa* Biozone, in the same section determined in the interval 684–694 m, corresponds to the upper part of the *M. testis* Zone and to the basal part of the *G. nassa* Zone.

Remarks. In the studied sections this biozone has been established only in the Ohesaare, Ruhnu and Ventspils cores, corresponding in the last section to the uppermost part of the Jugla Beds and probably to the Ančia Member of the Riga Formation.

21. *Sphaerochitina indecora* Biozone

Definition. This biozone corresponds to the total-range biozone of *Sphaerochitina indecora* Nestor 1982.

Type stratum and locality. The upper part of the Sôrve Formation of the Jaagarahu Stage and the lower part of the Viita Beds of the Rootsiküla Stage. Ohesaare core, in the interval 141.6–174 m.

Associated chitinozoans. The most numerous species in this biozone is again *Conochitina claviformis*. The species assemblage of the lower part of the zone is more diverse, including *Conochitina* cf. *argillophila, Eisenackitina* sp., *Margachitina margaritana* and some other species, which occur for the last time in the Silurian sequence of the East Baltic. *Gotlandochitina tabernaculifera* and *Conochitina* cf. *argillophila* are the most essential species among the associated chitinozoans of the *Sphaerochitina indecora* Biozone.

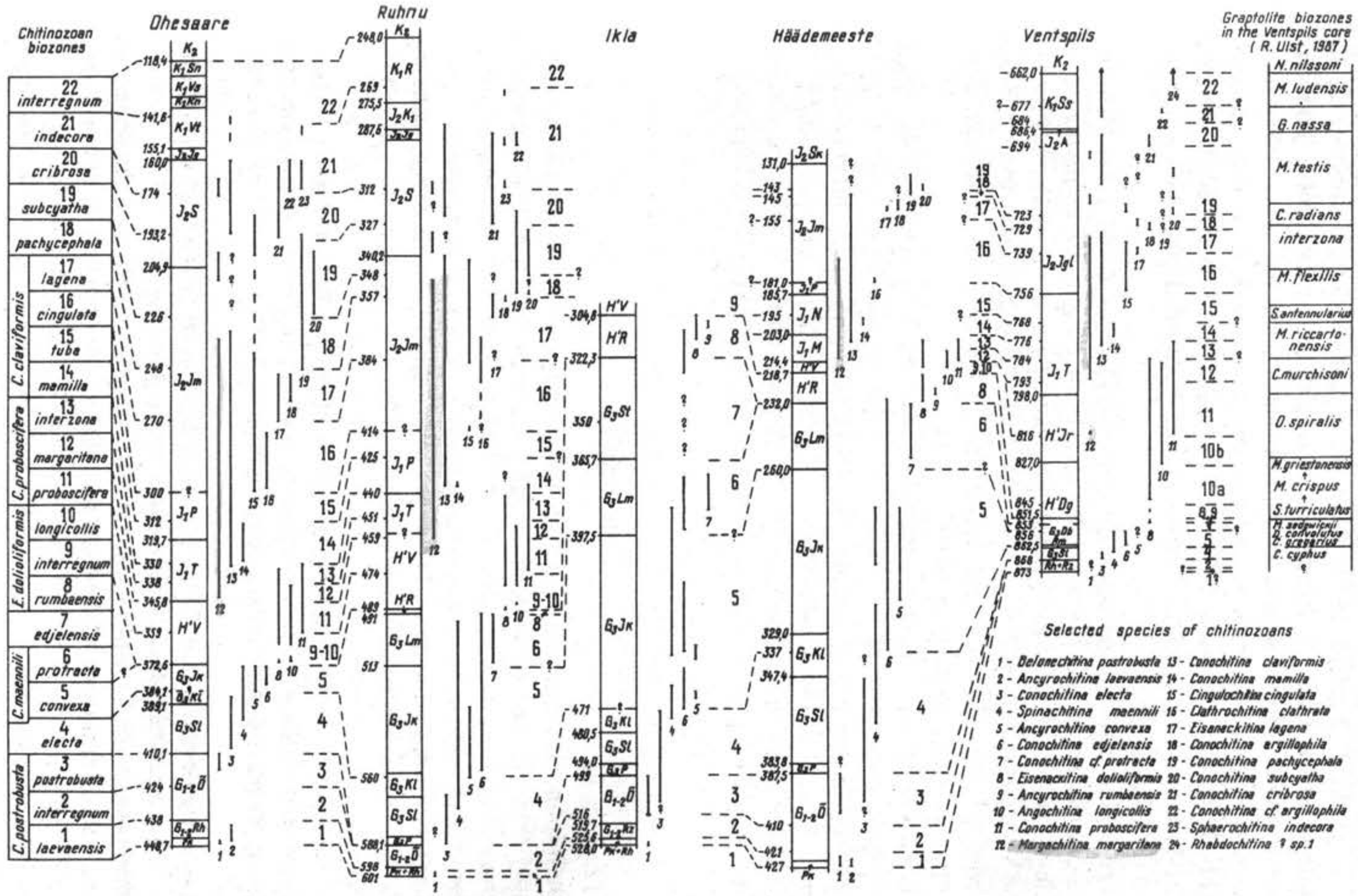

Fig. 26. Ranges of index species and chitinozoan biozones insome early Silurian sections, correlated with graptolite succession in the Ventspils core (by data in Ulst 1987 and pers. comm.).

Other occurrences. *S. indecora* has not been identified outside the East Baltic, but on Gotland (Laufeld 1974) there occur *Sphaerochitina concava* in the uppermost Halla Beds, *S. lycoperdoides* in the uppermost Mulde Beds and *Gotlandochitina tabernaculifera* in the lowermost Klinteberg Beds. Very likely the first appearance of *Sphaerochitina* species in the both areas may coincide roughly. From the uppermost Wenlock *S. lycoperdoides* was recorded also from the Brabant Massif, Belgium (Verniers 1982), Portugal (Paris 1981) and Welsh Basin (Rombouts 1982).

Age assignment. In the Ohesaare core Kaljo (pers. comm.) has identified *Gothograptus nassa* and *Plectograptus* sp. (166.4 m) and *Monograptus* ex. gr. *flemingii* (162.15 m) from the interval corresponding to the *S. indecora* Biozone. In the Ventspils core section the *S. indecora* Zone, distinguished at about 677–684 m, evidently corresponds to the upper half of the *G. nassa* graptolite Zone, determined by Ulst in the interval 677–687 m.

Remarks. In the Ventspils section *S. indecora* is absent and the whole chitinozoan assemblage of this biozone is impoverished. Only *Conochitina* cf. *argillophila* occurs in one sample. The lower boundary of the biozone can be defined there by the disappearance of *Ancyrochitina* cf. *paulaspina*, *A. plurispinosa* and *Conochitina cribrosa*. In this section the *S. indecora* Biozone corresponds to the lower part of the Siesartis Formation of the Rootsiküla Stage.

22. Interzone V

Definition. This interzone corresponds to the beds barren of chitinozoans, ranging from the last occurrence of *Sphaerochitina indecora*, *Gotlandochitina tabernaculifera* and *Conochitina* cf. *argillophila* up to the first appearance of *Belonechitina latifrons*, *Ancyrochitina diabolus* or other Ludlow species.

Type stratum and locality. The upper part of the Rootsiküla Stage, including the Kuusnômme, Vesiku and Soeginina beds. Ohesaare core, in the interval 118–141.6 m.

Chitinozoans. Some long-ranging species (*Conochitina claviformis*, *C. tuba*, *Cingulochitina baltica*, *C. crassa*) occur in this interzone in the Ventspils section. In the upper part of this unit scarce specimens of *Rhabdochitina*? sp. have been found.

Age assignment. In the Ventspils core in the interval 662–677 m Ulst (Gailite *et al.* 1987) has established the *M. ludensis* graptolite Zone.

Remarks. In the Ventspils section this interzone corresponds to the upper part of the Siesartis Formation of the Rootsiküla Stage.

Correlation of the East Baltic sequence with other areas

Although at present only scarce data are available on the distribution of lower Silurian chitinozoans in other regions of the world, there have been noted the occurrence of identical forms and general similarity of the succession of taxonomic associations. Below the distribution of chitinozoan species in the lower Silurian sections of Gotland Island, Podolia, Great Britain, Belgium, Anticosti, etc. will be analysed. For the correlation numerous identical or similar species were selected. In several cases the taxonomic identification of a species has been revised and the presumable new name is given in brackets after the originally used name.

Gotland. The correlation of the East Baltic sections with the key sequence of Gotland has been treated by the author already earlier (Nestor 1982c, 1982d, 1984a) basing on the data published in the papers of Eisenack (1964), Taugourdeau and Jekhowsky (1964) and Laufeld (1974, 1979).

The stratigraphic ranges of the selected chitinozoan species in the sequence of Gotland and in the Ohesaare core section are given in Fig. 27, the correlation of the regional stratigraphic units in Fig. 28..

The Lower Visby Beds of Gotland have usually been correlated with the top of the Adavere Stage, the Upper Visby Beds with the base of the Jaani Stage of Estonia (Kaljo 1970, etc.). According to Laufeld (1974), the distinction of the Lower and Upper Visby beds is impossible by chitinozoans, as all studied Lower Visby species (*Conochitina proboscifera, Angochitina longicollis, Margachitina margaritana*, etc.) pass over into the Upper Visby Beds. Therefore chitinozoans do not offer additional criteria for the correlation of the Lower Visby Beds, but do not contradict to the existing correlation either, as *Margachitina margaritana*, formerly considered a strictly Wenlock species (Nestor 1982c, etc.), occurs in the Ventspils core section also in the uppermost Llandovery.

The Upper Visby Beds, except for the topmost part, have yielded *Angochitina longicollis*, a characteristic species of the uppermost beds of the Adavere Stage and lowermost beds of the Jaani Stage. On this basis we may suppose that the Upper Visby Beds approximately correspond to the *Margachitina margaritana* Zone.

In the lowermost Högklint Beds (unit "a" by Laufeld 1974), also *Conochitina proboscifera* and its subspecies have been recorded connecting this part of the sequence with the lower-lying beds. In Estonia unit "a" corresponds roughly to Interzone IV in the chitinozoan zonal succession.

Distinct alteration of the chitinozoan assemblage, in Estonia observed at the boundary of Interzone IV and the *Conochitina mamilla* Zone, can also be traced in the sequence of Gotland, probably occurring there at the boundary of units "a" and "b" of the Högklint Beds.

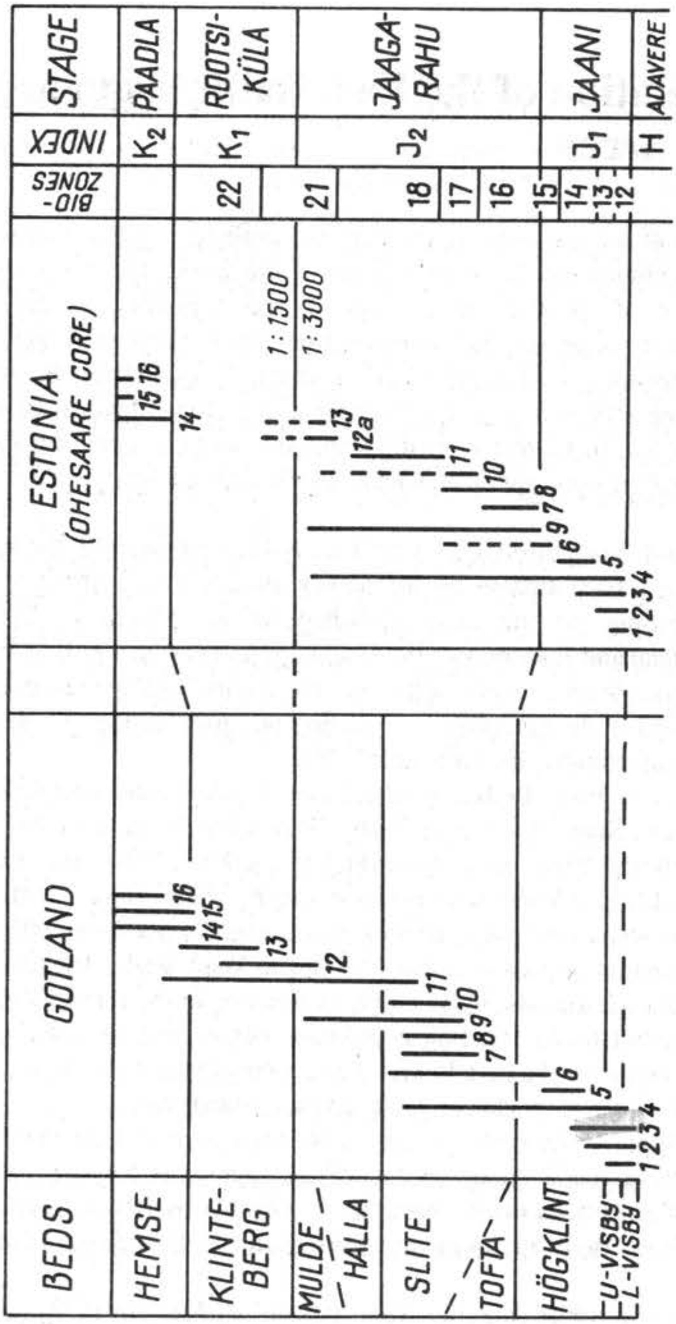

Fig. 27. Stratigraphical ranges of selected chitinozoan species in the early Silurian of Gotland (Laufeld 1974), compared with those in the Ohesaare core of Estonia.
Chitinozoan species: 1 – *Angochitina longicollis*; 2 – *Conochitina proboscifera*; 3 – *Densichitina densa*; 4 – *Margachitina margaritana*; 5 – *Conochitina mamilla*; 6– *Calpichitina acollaris*; 7 – *Clathrochitina clathrata*; 8 – *Gotlandochitina martinssoni*; 9 – *Cingulochitina cingulata*; 10 – *Conochitina argillophila*; 11 – *Conochitina pachycephala*; 12 – *Sphaerochitina concava*; 12a – *Sphaerochitina indecora*; 13 – *Gotlandochitina tabernaculifera*; 14 – *Conochitina latifrons*; 15 – *Angochitina elongata*; 16 – *Conochitina lauensis*.

The Högklint units "b" and "c" are characterized by the following species: *Densichitina densa, Conochitina mamilla* (unit "b"), *C. flamma, C. leptosoma* ("b" + "c") and *Calpichitina acollaris* ("c") (see Laufeld 1974, 1979). This enables to correlate these units with the *C. mamilla* and *C. tuba* zones in the Jaani Stage, respectively.

The species *Clathrochitina clathrata, Gotlandochitina martinssoni* and *Cingulochitina cingulata* appear one after another in consecutive units of the Slite Beds and in the lowermost part of the Jaagarahu Stage in the Ohesaare core section. This permits to correlate roughly these parts of the sequence in both regions. The successive appearance of the species *Conochitina argillophila* and *C. pachycephala* in the upper Wenlock offers a similar possibility for the correlation of the topmost parts of the Jamaja Formation and Slite Beds.

In the topmost part of the Jaagarahu Stage in the Ohesaare section, the earliest representatives of the genus *Sphaerochitina* make their appearance. The species composition is different from that of the same genus in the Mulde Beds, but it probably still refers to the more or less same age of these beds.

In the uppermost Klinteberg Beds there appear *Conochitina latifrons* and *Angochitina elongata*, which in the Ohesaare core come in at the base of the Paadla Stage.

Skåne. Grahn (1978) has studied chitinozoans of the Ordovician-Silurian boundary beds in two sections of Skåne (Sweden), in one of which (Lindegard 27 borehole) Nilsson (1979) has also established graptolite zones. In his paper Grahn has mostly described the quantitative relations of two species: *Belonechitina robusta (= B. postrobusta)* and *Ancyrochitina ancyrea*. In this borehole section the ranges of these species have been established within the limits of the *persculptus, acuminatus* and *extenuatus* graptolite zones with a total thickness of about 15 m. By Grahn, in the Ordovician- Silurian boundary strata, *Belonechitina robusta* is recorded on three levels: at the base of the *persculptus* Zone, at the base or in the middle of the *acuminatus* Zone and at the top of the *extenuatus* Zone. The *confertus* graptolite Zone (analogue of the *extenuatus* Zone) has been established by Kaljo in the uppermost Juuru Stage in the Ikla core (Kaljo and Vingissaar 1969). On this level and lower, an interval of about 16 m of the Ikla core section has yielded abundantly *Belonechitina postrobusta*, which is also found in the lowermost Silurian, in the Puikule Member. Thus, recurrence of *B. postrobusta* is characteristic of both sections, but more detailed correlation is yet impossible due to insufficient data on the associated species. It should be noted that *Rhabdochitina gracilis*, occurring in the *Dalmanitina* Beds of the Skåne section, as well as in the East Baltic, does not pass over the Ordovician- Silurian boundary.

Podolia. The distribution of chitinozoans in the Silurian sequence of Podolia has been discussed by Laufeld (1971) and Tsegelnyuk (1982, 1983), where the first author has studied only the basal part of the Silurian sequence. Besides, the present author has examined the section of the Kitaigorod stratotype outcrop

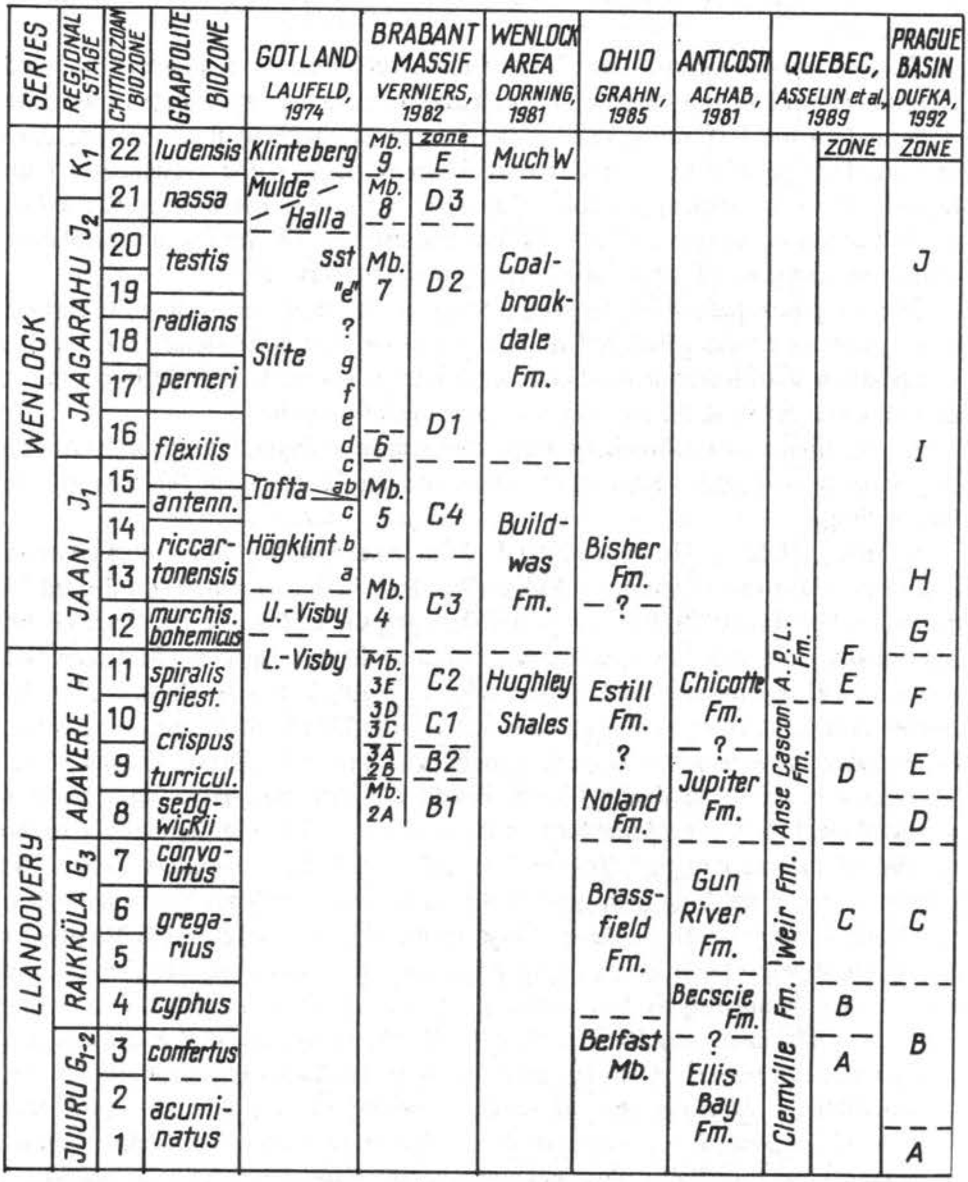

Fig. 28. Correlation of the early Silurian chitinozoan biozonation of Estonia and North Latvia with successions of Gotland (Laufeld 1974), Brabant Massif (Verniers 1982), Prague Basin (Dufka 1992), Wenlock area (Dorning 1981), Ohio (Grahn 1985), Anticosti (Achab 1981) and Quebec (Asselin *et al.* 1989).

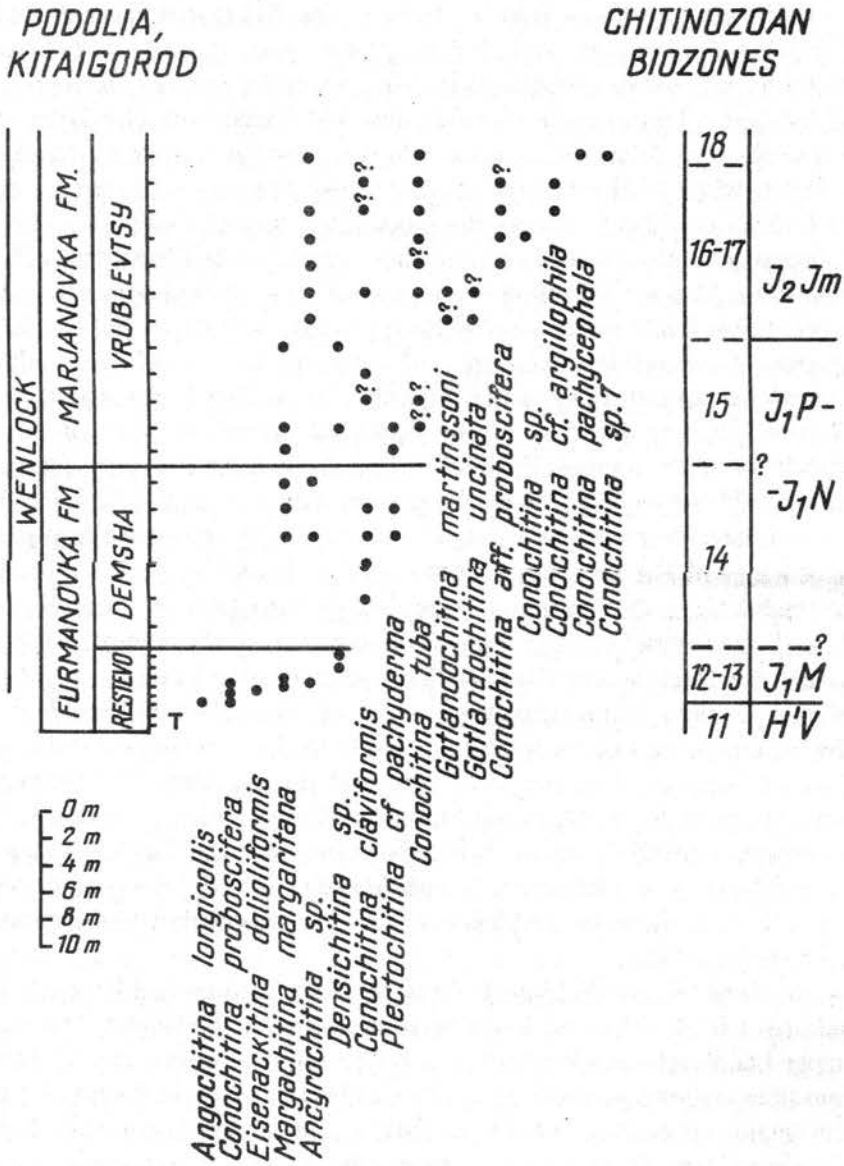

Fig. 29. Correlation of the chitinozoan biozones of Estonia and North Latvia with the Wenlockian succession of the Kitaigorod outcrop, Podolia.

(Fig. 29) using the boundaries of formations and subformations as defined by Tsegelnyuk (1983).

From the lowermost Restevo Beds of the Kitaigorod outcrop Laufeld has identified the species *Conochitina proboscifera*, *C.* sp. 1 (=*Eisenackitina dolioliformis*) and *Angochitina longicollis*, which are typical of the uppermost part of the Velise Formation in Estonia (zone 11). Tsegelnyuk (1982) has described numerous new chitinozoan species, which for various reasons are very difficult to correlate with earlier established taxa. They allow to draw only some conclusions. In Podolia the Llandovery-Wenlock boundary evidently coincides also with the appearance of *Margachitina margaritana* (see Fig. 1 in Tsegelnyuk 1982). At the base of the Demsha Subformation, *Conochitina claviformis* comes in, marking the level of East Baltic biozone 14. At the base of the Vrublevtsy Subformation, there appears *Clathrochitina clathrata* and in the middle of this subformation *Cingulochitina cingulata* comes in, which in the East Baltic marks the base of biozone 16, i.e. the base of the Jaagarahu Stage. Reliable criteria for the correlation of the topmost Wenlock of Podolia with the Estonian sections are still lacking. The data obtained by the present author from the Kitaigorod outcrop section, have permitted to distinguish the following correlative levels: 1) by the appearance of *Margachitina margaritana* the Llandovery-Wenlock boundary can be established in the lower part of the Restevo Subformation; 2) the appearance of *Conochitina claviformis* in the lowermost part of the Demsha Subformation makes this level correlatable with the base of biozone 14 or with the base of the Ninase Member of the Jaani Stage; 3) by the appearance of *Conochitina tuba* in the lowermost part of the Vrublevtsy Subformation, this level correlates with the base of biozone 15 of the Jaani Stage; 4) the appearance of *Gotlandochitina martinssoni* in the middle of the Vrublevtsy Subformation coincides with biozone 16 or approximately with the boundary of the Jaani and Jaagarahu stages; 5) the appearance of *Conochitina pachycephala* and *C.* sp. 7 at the top of the Vrublevtsy Subformation allows to establish biozone 18, corresponding to the middle part of the Jaagarahu Stage.

Brabant Massif (Belgium). Verniers (1982; Verniers and Rickards 1978) has studied a thick (2100 m) lower Silurian section at Mehaigne. The middle and upper Llandovery and Wenlock flysch-type sediments have been divided by him into nine assemblage zones and subzones (see Fig. 28). In the upper Llandovery the mass appearance of *Eisenackitina* and atypical thin-walled forms of *Conochitina proboscifera (= C. praeproboscifera)* may serve as a correlative level, characterizing the upper half of zone B2 in Belgium and the lowermost beds of the Rumba Formation (biozone 8 in the present work) in Estonia. Another correlative event is the appearance of *Angochitina longicollis, Conochitina acuminata* and *C. proboscifera* (typical form) in zone C1 and in the Velise Formation (biozones 10–11), respectively.

Co-occurrence of *Conochitina proboscifera, C. acuminata, C. flamma, Margachitina margaritana, Densichitina opaca, Eisenackitina* sp. (=*E.*

dolioliformis) and *Angochitina longicollis* in zone C3 allows to correlate it with the lowermost beds of the Jaani Stage in the East Baltic area (with biozone 12). Gradual disappearance of these species in the upper half of zone C3 evidently permits to correlate this part of the sequence with chitinozoan biozone 13 of the East Baltic. In the middle and upper Wenlock the number of correlatable levels is smaller. We should point out only the appearance of *Cingulochitina cingulata* in the lowermost part of zone D1, corresponding to the base of the Jaagarahu Stage of Estonia (biozone 16), but also the appearance of *Conochitina gutta* at the top of zone D1 and the entrance of its possible analogue *Eisenackitina lagena* at the base of biozone 17. In the upper Wenlock zone D3 of Belgium, there appears *Sphaerochitina lyckoperdoides*, to which in Estonian sections probably corresponds the appearance of sphaerochitinids in biozone 21.

In Belgium the Ordovician-Silurian boundary has been studied by Martin (1973) in the Deerlijk sequence (Brabant Massif). In two succeeding sections, mostly corresponding to the *acuminatus* and *vesiculosus* graptolite zones, beside certain other species also *Belonechitina robusta (= ? B. postrobusta), Cyathochitina campanulaeformis* and *C. kuckersiana* have been identified, which in the Baltic sections occur simultaneously in the Juuru Stage.

British Isles. Silurian chitinozoans of British Isles have been studied only together with acritarchs and other microfossils (Lister 1970; Eisenack 1977, 1978; Dorning 1983, etc.) The distribution of chitinozoans in Wales and Welsh Borderland has been briefly dealt with by Dorning (1979, 1981). The present author could only use some unpublished data on the distribution of chitinozoans in two outcrops of Wales (Mabillard 1981, partly published in Mabillard and Aldridge 1985). Of these outcrops No 25 ("Leasows") is considered as a type section for the base of the Wenlock Stage. The correlation of these sections with the East Baltic ones has revealed a similar successive appearance of a number of species. According to Dorning (1981), the Llandovery-Wenlock boundary is rather well defined by microfossils. By Mabillard (1981; Mabillard and Aldridge 1985), *Margachitina margaritana* has not been found below the Wenlock boundary. According to Dorning (1981, see Fig. 28), at the base of the Buildwas Formation the counterpart of chitinozoan biozone 12 can be distinguished considering the disappearance of *Angochitina longicollis* and *Conochitina acuminata.* Higher in the section there is an undivided interval (zones 13–15) characterized by the disappearance of *Conochitina visbyensis* and the appearance of *Calpichitina acollaris* and *Conochitina argillophila (= ? C. tuba).* The lower boundary of the Coalbrookdale Formation coincides with the appearance of *Cingulochitina cingulata, Gotlandochitina martinssoni,* etc. testifying to the correspondence of this boundary to the base of biozone 16 in the Jaagarahu Stage of the East Baltic. By the appearance of *Conochitina gutta* (= ? *E. lagena*), it may be possible to identify biozone 17 and by the disappearance of *Gotlandochitina martinssoni* biozone 18. Higher in the section only the disappearance of some species has been registered, which does not allow more exact correlations.

U.S.A. Grahn (1985; Grahn and Bergström 1985) has studied chitinozoans from the Ordovician-Silurian boundary beds, as well as from the Llandovery-Wenlock boundary level in the southern part of the State of Ohio and northern part of the State of Kentucky. The taxonomic composition and successive appearance of chitinozoan species in two studied sections (Lick Fork, Jacksonville 2) enable to correlate certain stratigraphic levels with those of the Estonian sequence (see Fig. 28).

Noteworthy is the alteration of the species *Conochitina electa* and *Spinachitina maennili* in the first section (Lick Fork), which takes place analogically also on the boundary of biozones 4 and 5 in the sections of the Raikküla Stage of Estonia. In the other section (Jacksonville 2) the simultaneous appearance of *Conochitina* aff. *visbyensis, C.* aff. *acuminata* and *Densichitina densa* obviously marks the level of zone 11. As *Margachitina margaritana* is lacking in this section, chitinozoans do not indicate here the exact Llandovery-Wenlock boundary level (see Grahn 1985). The disappearance of *Angochitina longicollis* allows to define only the level corresponding to the boundary between biozones 12 and 13 within the lower part of the Jaani Stage.

Canada. From the section of Anticosti Island chitinozoans have been studied by Achab (1981). In the lowermost Silurian (top of the Ellis Bay Formation, see Fig. 28) she has identified *Cyathochitina kuckersiana* and *Plectochitina spongiosa*, occurring also in the East Baltic Juuru Stage. Higher in the section (Becscie Formation) she has distinguished the beds with *Conochitina* sp. 1 (= *C. electa*), which can probably be correlated with the lowermost part of the Raikküla Stage. Still higher (Gun River Formation), on Anticosti, there occur *Conochitina* sp. 2 (= *C.* cf. *edjelensis*), *C. iklaensis, Ancyrochitina* sp. 1 (= *A. ramosaspina*) and *Clathrochitina* sp., which have also been recorded from the upper (middle Llandovery) part of the Raikküla Stage. In the Jupiter Formation there occur already the species characteristic of the Adavere Stage. Apart from *Cyathochitina* species, this part of the Anticosti sequence has revealed *Conochitina* cf. *proboscifera, C.* sp. (= *Eisenackitina dolioliformis*), ? *Clathrochitina* sp. 2 (= ? *Anthochitina primula*) and others, which are still too scarce for more detailed correlations.

In the Llandovery and lower Wenlock sequence at Chaleurs Bay (Quebec), Asselin *et al.* (1989) described six chitinozoan assemblages, which could be roughly correlated with the East Baltic biozones (Fig. 28). The presence of *Belonechitina* species (partly identical to *B. postrobusta*) in assemblage A indicates the correspondence of this unit to the *B. postrobusta* Biozone (3). In assemblage B *Conochitina* sp. 2 (= *C. electa*) was identified, which permits to correlate this part of the sequence with the *C. electa* Biozone (4). The middle Llandovery assemblage C with uncharacteristic *Conochitina* species corresponds roughly to biozones 5–7 in the East Baltic biozonal succession. The appearance of *Conochitina* aff. *emmastensis* and *Eisenackitina* aff. *dolioliformis* in assemblage D allows to correlate it with the *C. emmastensis* Biozone (8). The appearance of

Conochitina cf. *proboscifera* and *C.* cf. *visbyensis* in assemblage E enables to correlate this unit with the *C. proboscifera* Biozone (11). The occurrence of *Angochitina* aff. *longicollis, Conochitina acuminata* and *Fungochitina*? sp. 1 (= *Gotlandochitina ruhnuensis*) in assemblage F does not allow exact correlation, as these species are present in the uppermost Llandovery, as well as in the lowermost Wenlock of the East Baltic sections (biozones 11 and 12).

Prague Basin (Barrandian). Chitinozoans from the lower Silurian were identified and 10 assemblage zones (the stratigraphic positions of which are known on the basis of graptolites) were considered by Dufka (1992) (Fig. 28). There are a few succeeding species, which we can use for the correlation with East Baltic biozones. *Belonechitina postrobusta* is represented in biozones B and 3 respectively, *Conochitina iklaensis* occurs in biozone C and zones 5–7 of the East Baltic. From biozone D *Conochitina emmastensis* was identified and *Margachitina margaritana* was recorded from biozone G, which appear correspondingly in biozones 8 and 12 of the East Baltic. The Wenlock part of the sequence shows the occurrence of also *Conochitina proboscifera, C. tuba, Ancyrochitina* cf. *primitiva* and some other species, not enabling precise correlation.

Other regions. In the subsurface of north-eastern Libya, Paris (1988) has recorded four early Silurian chitinozoan assemblages, containing beside exotic forms also *Ancyrochitina laevaensis, Densichitina densa* and *Margachitina margaritana.* Their occurrence in the succeeding biozones shows some affinity with the East Baltic chitinozoan seccession (biozones 1, 10, 12).

In north-western France (Armoricain Massif, Lande-Mureé Formation) Paris (1981) has established several chitinozoan zones, only one of which (No 19 by Paris) contains lower Silurian chitinozoans. The presence of *Cyathochitina* (sp. B) and an atypical form of *Conochitina proboscifera (= C. praeproboscifera)* allows to roughly correlate this level with the Rumba Formation (zone 8) of the Adavere Stage of Estonia.

Certain elements of the East Baltic chitinozoan succession are common to other regions of the world as well, e.g. Spain (Cramer 1964, 1967, 1978), North Africa (Taugourdeau 1960, 1963, etc.), Siberian Platform (Zaslavskaja 1982, 1983), Florida (Cramer 1973), China (Hou Jinpeng and Wang Xiaofeng 1983; Geng Liang-yu 1986), etc., but the Silurian of these areas is as well characterized by the species and genera not having close analogues in the Llandovery and Wenlock of the East Baltic. Exact identification is sometimes impossible also because of bad preservation of the material in these regions.

The above review of the distribution of certain characteristic chitinozoan species in rather distant regions shows that many chitinozoan zones established in the East Baltic, can be recognized in other regions too, particularly in the North-European palaeobiogeographical province, and may be used for interregional correlation.

Palaeoecology of chitinozoans

Main problems

Palaeoecology of chitinozoans has repeatedly been a subject of discussions. Most authors support the view that chitinozoans were pelagic or epipelagic organisms (Jenkins 1970; Obut 1973; Paris 1981, etc.). Widespread is also the opinion that chitinozoans had different modes of life: part of them were of planktonic (vesicles with appendices and coarse ornamentation), another part of benthic habitation (longer thick-walled vesicles) (Collinson and Schwalb 1955; Laufeld 1974; Rombouts 1982). The wide geographical and environmental distribution of chitinozoans and their low dependence on the type of the bottom (Wright 1978; Paris 1981, etc.), but also the presence of the large *Conochitina* species in the deeper-water depression sediments (e.g. Ventspils core in western Latvia), which are very poor in or devoid of benthic organisms, speak in favour of the first opinion.

There is a wide spectrum of environmental parameters, which have affected the ecology and distribution of chitinozoans. Very little is known about the physico-chemical character of sea water and its hydrodynamics, especially about the currents action during the sedimentation.

More is known about the dependence of chitinozoans on the relative depth of water and the sediment type. According to Grahn (1982b), chitinozoans were the most abundant in relatively shallow sea associating with a diverse fauna of macrobenthos (see also Obut 1973). On the contrary, according to Paris (1981), high abundance of spores, which are regarded as indicators of the nearshore environment, is generally conversely correlated with the chitinozoan abundance. This means that the quiet-water nearshore environment, having a water energy moderate enough for the sedimentation of such small organic particles as spores, was not favourable for chitinozoan proliferation.

Most authors support the view that the assemblage of chitinozoans was the most abundant and diverse in the deep-water part of the shelf seas, whereas in the onshore direction their number decreased abruptly (Laufeld 1974; Wright 1978; Miller 1982; Verniers 1982, etc.). This is also confirmed by the studies of the present author (Kaljo *et al.* 1983, 1986).

Different opinions have been expressed as to the reasons of the concentration of chitinozoans in deep-water argillaceous sediments. According to some authors (Urban 1972; Urban and Newport 1973), chitinozoans were transported to the site of deposition together with fine terrigenous particles, forming siltstones and shales.

Paris (1981) explains the concentration degree of chitinozoans in rocks by sedimentation rate and also by post-sedimentation compaction of deposits, due to which during lithification the volume of argillaceous rocks decreases three to four times more than that of limestones. Besides, also rapid accumulation of sediments may account for the relatively high concentration of aberrant forms of chitinozoans (Nestor 1991).

The above-said shows that although high abundance of chitinozoans in the argillaceous rocks was to some extent related to the sedimentation process, the main reason of it was that the deepest parts of the open shelf and slope were also the most favourable dwelling sites for these organisms (Laufeld 1974, 1977, etc.).

Facies control

The distribution of chitinozoans should be studied considering the evolution of the ancient sedimentary basin. As is supposed, the Silurian Palaeobaltic basin constituted a pericontinental sea in the western part of the East European Platform, connected with the Middle European geosynclinal (oceanic) basin (see H. Nestor, Einasto 1977; Kaljo *et al.* 1983). For characterizing general environmental settings, a facies-sedimentary model has been worked out by distinguishing five main facies belts with the corresponding types of sediments (see H. Nestor, Einasto 1977, etc.). On its basis an ecological model for the Silurian basin of the East Baltic has been compiled (Klaamann *et al.* 1980; Kaljo *et al.* 1982). The distribution of chitinozoans in different facies belts, their relations with other groups of micro- and macrofossils have been treated repeatedly (Kaljo *et al.* 1982; Kaljo *et al.* 1986, etc.).

Below a short review of the distribution of chitinozoans in sediments of the main facies belts of the early Silurian Palaeobasin in the East Baltic will be given, proceeding from the facies interpretation of local lithostratigraphic units worked out by H. Nestor and Einasto (1977).

1) Sediments of the first ("lagoonal") facies belt are mostly represented by lagoonal dolomites and domerites, which in the lower Silurian sections of the East Baltic are distributed in the Raikküla Formation of the same stage (e.g. Raikküla core, interval 4–12 m; Kirikuküla core, interval 51–65 m, etc.), and in the Kuusnômme, Vesiku and Soeginina beds of the Rootsiküla Stage (Ohesaare core, interval 125–138 m, etc.). As separate interbeds and bands these rock types occur also in the Jaagarahu Stage (Häädemeeste core, interval 125–131 m, etc.).

Rocks of this facies belt are usually devoid of chitinozoans, although by way of exception there may occur rare specimens. In this case the species composition is homogeneous consisting of 1–2 species.

Special attention should be paid to relative abundance of chitinozoans in the deposits of the so-called "restricted shelf" environment differing from a typical lagoonal facies in more diverse biota. Thus, for instance, a rather numerous low-diversity association of chitinozoans has been established in argillaceous dolomitic rocks containing peculiar mud mounds and occurring in the lowermost Vilsandi Beds of the Jaagarahu Stage in the Koguva quarry of Muhu Island (see H. Nestor 1990, p. 157).

2) Sediments of the second ("shoal") facies belt are mostly represented by pure skeletal and pelletal grainstones, sometimes associated with small reef bodies (bioherms) or beds of coral-stromatoporoid limestones, which accumulated in high- energy conditions. They are characterized by a very low content of terrigenous material. In the Silurian sequence of Estonia such deposits occur in most of the Tamsalu Formation of the Juuru Stage (e.g. Rapla core, interval 24–27 m; Martna core, interval 25–33 m), in a part of the Raikküla Formation of the same stage (Asuküla core, interval 2–7 m), in north- westernmost sections of the Ninase Member of the Jaani Formation (Suuriku), but also in some intervals of the Jaagarahu and Rootsiküla stages, especially in the Middle Estonian Confacies Belt. Less frequently they occur also in southern Estonia (e.g. Ohesaare core, intervals 155–160 m and 119–125 m; Ruhnu core, intervals 275–280 m and 248–256 m). In the sediments of this facies belt chitinozoans have low diversity and occurrence frequency or they may be completely missing (see also Kaljo *et al.* 1986). Most certainly this could be explained by transportation of light vesicles from this high-energy, agitated-water belt into quieter-water parts of the basin.

3) Sediments of the third ("open shelf") facies belt are represented by argillaceous nodular skeletal pack- and wackestones, which are widely distributed in the lower Silurian of the East Baltic. They occur, for example, in the Varbola Formation of the Juuru Stage, in most part of the Rumba Formation of the Adavere Stage and Ninase Member of the Jaani Stage, also in the Sôrve Formation of the Jaagarahu Stage. In the rocks of this facies belt chitinozoans are distributed differently. On some levels (e.g. in the Varbola Formation) chitinozoans occur only sporadically and in rather small numbers, but usually (e.g. in the Rumba and Sôrve formations) the assemblage of chitinozoans is rich and diverse (see also Kaljo *et al.* 1986).

4) The fourth ("slope" or "transitional") facies belt is mainly represented by marl- or mudstones and micritic argillaceous limestones, which are the most widely distributed in southern Estonia and northern Latvia. This belt comprises the sediments of the Õhne Formation of the Juuru Stage, Saarde Formation of the Raikküla Stage, Velise Formation of the Adavere Stage, Mustjala and Paramaja members of the Jaani Stage and Jamaja Formation of the Jaagarahu Stage. In this belt chitinozoans occur usually very abundantly and in maximum diversity (see also Kaljo *et al.* 1986). Exceptional is only the lower half (or middle part) of the Õhne Formation of the Juuru Stage, which is devoid of chitinozoans. The lack of chitinozoans and other microfossils testifies to specific conditions of accumulation of these sediments. Possibly the marl- and mudstones and micritic limestones of the Õhne Formation have formed in the semiisolated depression of the Baltic basin during the initial phase of the Silurian transgression (H. Nestor pers. comm.). Later, when the connection with the oceanic sea in Central Europe became better, microorganisms started to develop more intensively (judging from the uppermost part of the Õhne Formation). Chitinozoans are also lacking in red-coloured mudstones of this belt, in the Õhne, Remte and Velise formations.

5) Sediments of the fifth ("depression") belt are mainly represented by graptolitic argillites and mudstones. In south-western Estonia this facies belt comprises graptolitic interbeds of the Saarde Formation (Raikküla Stage) and the dark-grey argillaceous marlstones of the Tôlla Member of the Jaani Stage, in western Latvia (Ventspils core) – graptolitic mudstones and argillites of the Dobele, Jurmala and Riga formations, stratigraphically ranging from the middle Llandovery to the uppermost Wenlock. The rocks of this facies belt contain considerably rare chitinozoans with low species diversity. In places chitinozoans are totally lacking (some intervals of the Ventspils core section).

Sometimes the above facies belts are subdivided into subbelts (Kaljo *et al* 1983, etc.). In this case chitinozoans are more numerous in the rocks of the offshore part of the open shelf and in the fourth, transitional facies belt (Kaljo *et al.* 1986).

Selective dependence of taxa

Facies control is expressed not only in a variable total number and diversity of chitinozoans, but also in characteristic distribution of some taxa. Dependence on facies is expressed differently by different chitinozoan taxa. The representatives of the genera *Spinachitina, Cingulochitina*, possibly also *Margachitina*, and those of *Ancyro-, Ango-* and *Gotlandochitina*, having a coarser and more complicated ornamentation of the vesicle, are mostly distributed in the transitional facies belt (see also Laufeld 1977; Wrona 1980; Miller 1982). In shallower-water shelf sediments they occur sporadically or are completely lacking (e.g. *Gotlandochitina martinssoni, G. spinosa, G. magnifica*, etc.) in the Jaagarahu Stage in the Kihnu and Kuressaare (Kingissepa) cores. Smooth and weakly ornamented simple forms (e.g. representatives of the genera *Conochitina, Eisenackitina*, also *Ancyrochitina ancyrea* and *A. primitiva*) are more widespread in different facies, sometimes occurring also in the rocks of the shoal facies belt. The large *Conochitina* species (*C. proboscifera, C. claviformis*) occur abundantly in the rocks of the open-shelf, as well as of the transitional facies belts. Only in the central part of the basin, in depression sediments the frequency of these large forms (which probably floated close to the bottom) decreases considerably. It should be noted that the extreme numbers of the facies spectrum (i.e. semilagoonal on one and depression facies on the other side) were mostly populated by the species, which on that particular stratigraphic level were the most numerous (e.g. *Conochitina claviformis* in the Jaagarahu Stage in the Kihnu section).

The investigations have shown that extremely rarely chitinozoans preferred shallow-water facies. As an example may serve the distribution of some taxa having the vesicle with a broad carina: *Cyathochitina kuckersiana* from the Llandovery and *Pterochitina macroptera* from the Wenlock beds, occurring only in the sections of the Middle Estonian Confacies Belt and lacking in southern

Estonian sections. According to Laufeld (1974), *Sphaerochitina acanthifera* is widely represented in shallow-water deposits of the Burgsvik Beds on Gotland.

Thus, the environmental control on numerous chitinozoan taxa is evident, but we have not yet distinguished clear lateral biofacies (communities), except for one case on the stratigraphic level of the lowermost beds of the Raikküla Stage (Nestor, in press). 20 sections of the Slitere Member of the Saarde Formation have been studied, the age of which is well dated by the species assemblage of the lower part of the *Conochitina electa* Zone. In this stratigraphic interval the selective environmental control is observed in the distribution pattern of several species. In shallower-water northern and north-western sections there occurs *Cyathochitina kuckersiana* (Emmaste, Rapla, Nurme, Raikküla cores), or the representatives of this genus are lacking at all (Asuküla, Martna, Kirikuküla cores). In coeval but deeper-water sections of southern and south-western Estonia and Latvia, *Cyathochitina calix* has been identified (Ohesaare, Ruhnu, Kolka cores, etc.). Most probably in this case lateral replacement of different *Cyathochitina* species takes place, whereas *Cyathochitina campanulaeformis* has here an intermediate position, occurring together with *C. calix* and *C. kuckersiana*. The environmental control seems to concern also the distribution of *Conochitina iklaensis*, which has not been recorded from the northernmost shallow-water sections, and *Spinachitina maennili*, which is found only in the south-western, i.e. deeper-water sections of Estonia and Latvia.

Associations of organic-walled microfossils

The sedimentation in the East Baltic palaeobasin was characterized by certain cyclicity, caused mainly by cyclic sea-level fluctuations or sometimes, perhaps, by climatic changes. These processes have been affected by the intensiveness of the influx of the terrigenous material and by the relations of epeirogenetic movements and rate of sedimentation (Kaljo *et al.* 1983; Einasto 1986, etc.). These cyclic processes have greatly influenced also the distribution of all groups of macro- and microfossils. In sections this is revealed by rhythmic changes in the ratio of chitinozoans and some other groups of acid-resistant microfossils (Nestor 1976; Klaamann *et al.* 1976; Kaljo *et al.* 1986).

During the study of samples on chitinozoans, visually the ratio of remains of planktonic and benthic groups of microfossils was estimated. These data are presented in logs of all studied sections right of the lithological column, next to the depths of sampling using the combinations of the letters P (plankton) and B (benthos) (see Fig. 22).

The planktonic association consists mainly of chitinozoans, acritarchs (by the processing of our samples only large forms with D>100 μm were separated), siculae and rhabdosome fragments of graptolites. In this association usually chitinozoans are predominating, except for graptolitic argillites, where graptolite fragments are prevailing. In the benthic association scolecodonts are commonly predominating, occurring there together with fragments of melanosclerites, hydroids, foraminifers, etc.

The facies changes in the sections are well reflected in the relations of planktonic and benthic elements, the trends of facies changes, however, in their dynamics. More distinct alternation of planktonic and benthic associations is especially characteristic of the sections and stratigraphic levels undergoing the most distinct facies changes (e.g. in the Raikküla and Jaagarahu stages in middle and southern Estonian sections).

Sometimes the changes in the associations of organic - walled microfossils may serve as auxiliary criteria for the correlation of sections. Of particular interest are rhythmic changes in the ratio of planktonic and benthic elements in externally relatively uniform sections, for instance in micritic (aphanitic) limestones of the Slitere Member of the Raikküla Stage (Nestor 1976). Presumably in that case the above changes may be the result of certain rhythmic changes of facies conditions, weakly reflected in the character of sediments. It should be noted that such rhythmic changes – alternation of intervals with abundant plankton and increased content of microbenthos – can be observed even in the sections of adjacent facies belts. Yet, in deeper-water sections such minor facies changes are usually indistinct (Nestor 1976).

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PLATES
I – XXXII

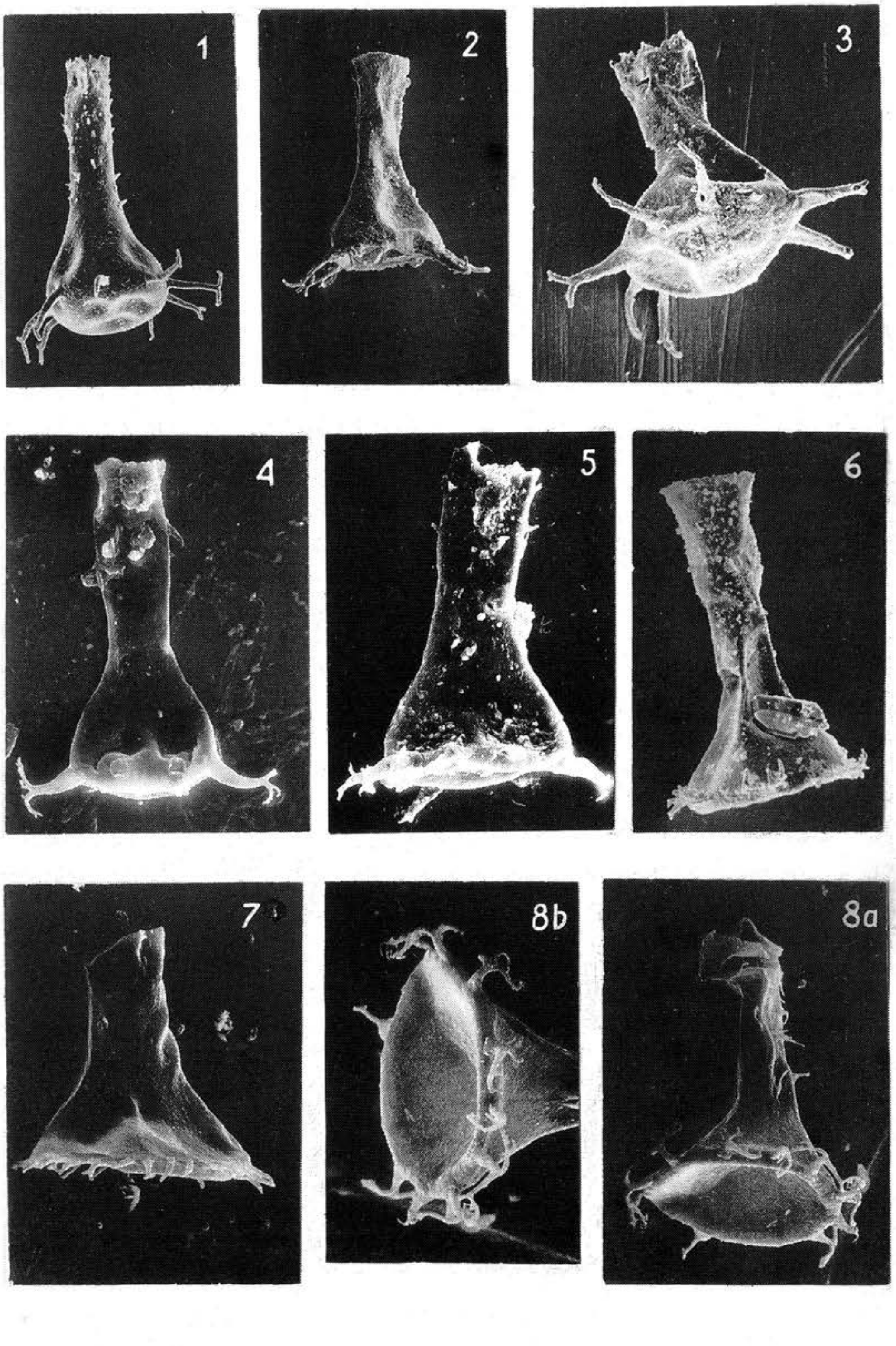
Plate I

Figs 1–3. *Ancyrochitina ancyrea* (Eisenack). 1 – Ch 241/1919, Ohesaare core, depth 391.35 m; Raikküla Stage; x 250. 2 – Ch 240/1760, Ruhnu core, depth 371.5 m; Jaagarahu Stage; x 245. 3 – Ch 118/9218, Paramaja cliff; Jaani Stage; x 365.

Figs 4–5. *Ancyrochitina* aff. *ancyrea* (Eisenack). 4 – Ch 242/1726, Ruhnu core, depth 437.2 m; Adavere Stage; x 305. 5 – Ch 243/10462, Viki core, depth 149.4 m; Adavere Stage; x 390.

Figs 6–7. *Ancyrochitina ansarviensis* Laufeld. 6 – Ch 114/1734, Ruhnu core, depth 457.45 m; Jaani Stage; x 350. 7 – 284/10463, Viki core, depth 148.4 m; Adavere Stage; x 510.

Fig. 8. *Ancyrochitina vikiensis* sp. n. Ch 245/10464 (HT), Viki core, depth 147.6 m; Adavere Stage; 8a – x 440, 8b – x 540.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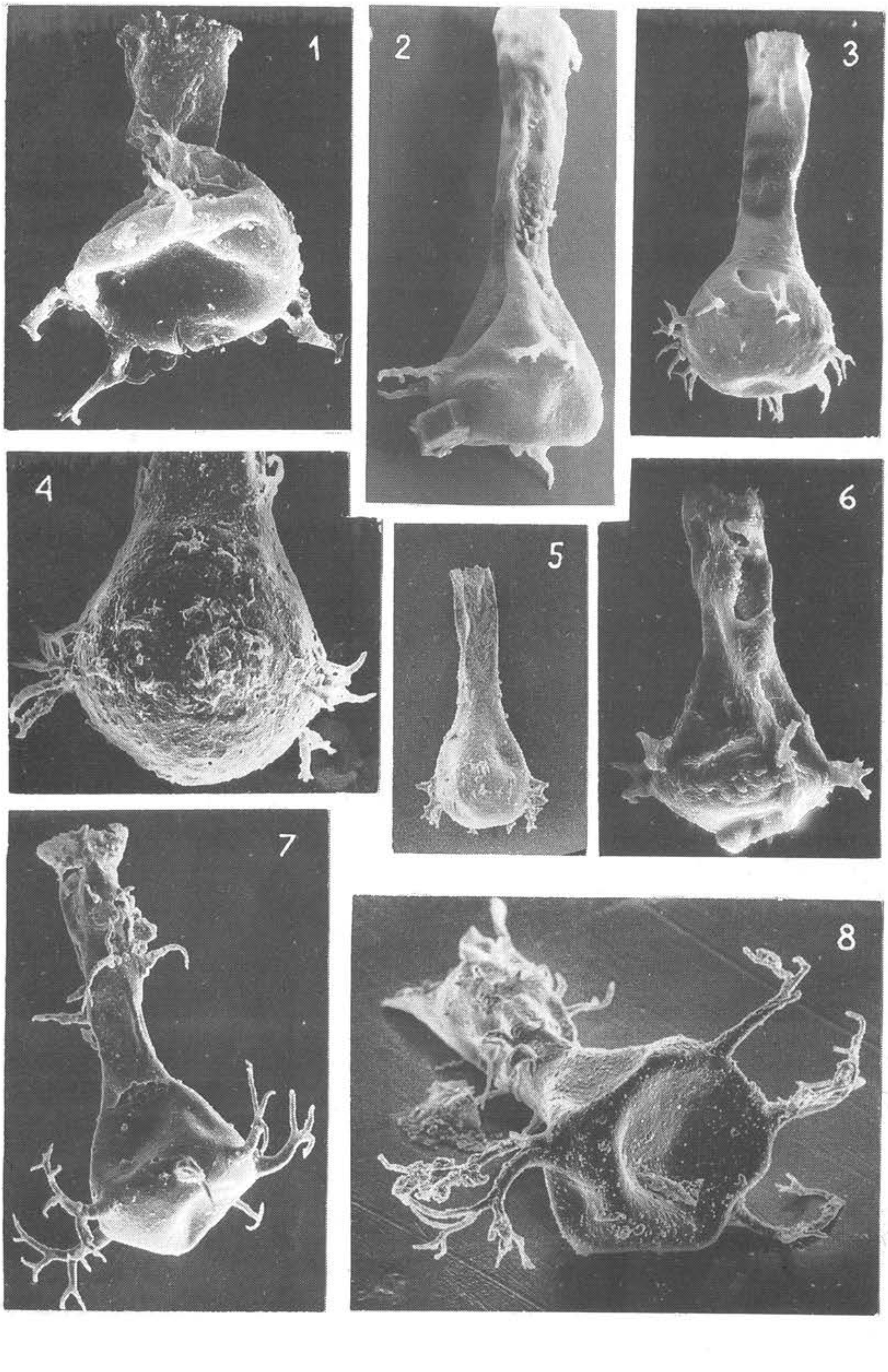
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Plate II

Figs 1–2. *Ancyrochitina* cf. *clathrospinosa* Eisenack. 1 – Ch 246/9280, Pulli 1. core, depth 13.2 m; Jaani Stage; x 455. 2 – Ch 247/1939, Vängla outcrop, Adavere Stage; x 440.

Figs 3–5. *Ancyrochitina convexa* Nestor. 3 – Ch 248/9795, Kolka core, depth 621.7 m; Raikküla Stage; x 420. 4 – Ch 14/1810, (HT), Ruhnu core, depth 536 m; Raikküla Stage; x 530. 5 – Ch 15/1810, Ruhnu core, depth 536 m; Raikküla Stage; x 200.

Fig. 6. *Ancyrochitina* aff. *convexa* Nestor. Ch 249/10447, Viki core, depth 189.45 m; Adavere Stage; x 480.

Figs 7–8. *Ancyrochitina gutnica* Laufeld. 7 – Ch 250/1778, Ruhnu core, depth 314.75 m; Jaagarahu Stage; x 365. 8 – Ch 251/1760, Ruhnu core, depth 371.5 m; Jaagarahu Stage; x 365.

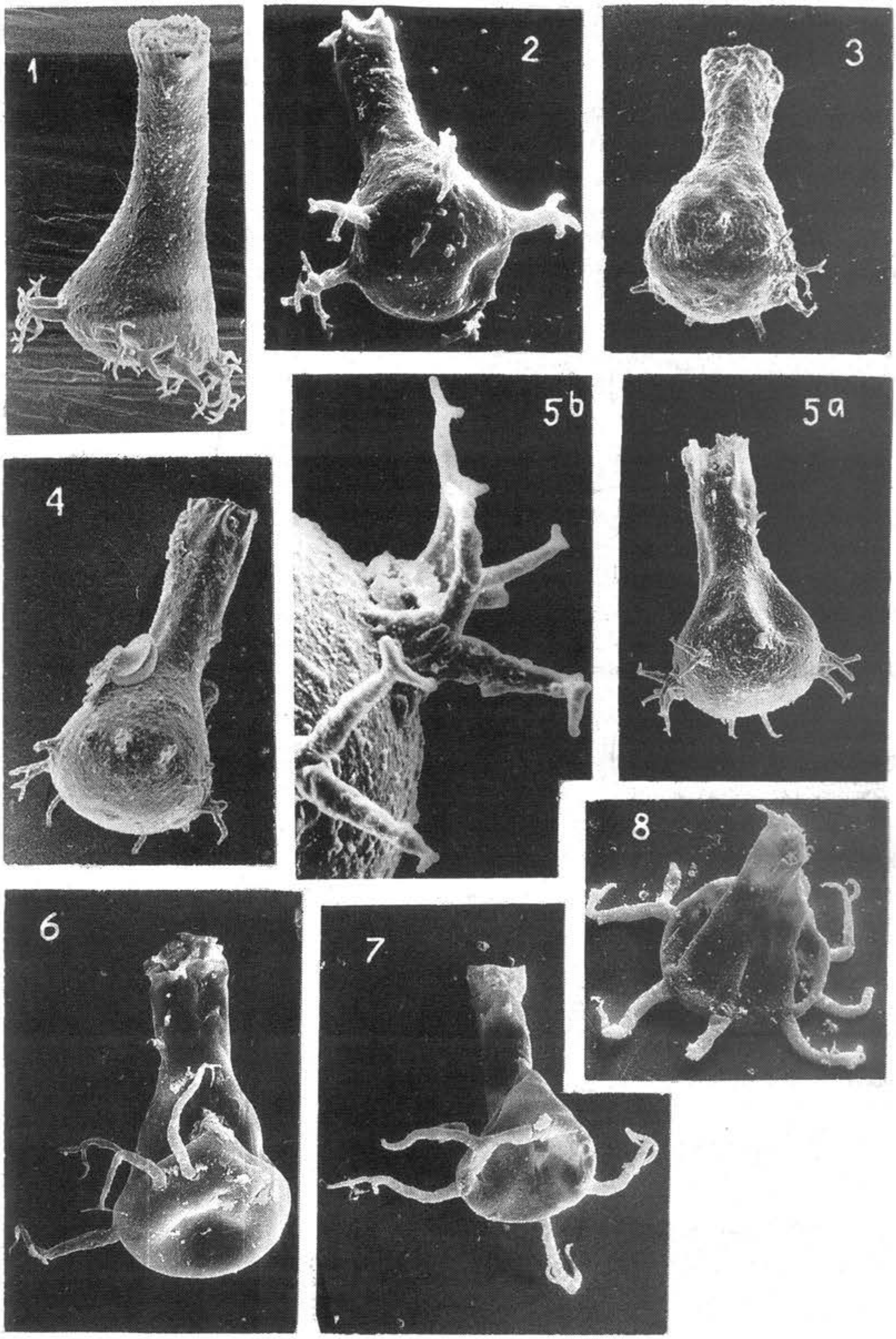
Plate III

Figs 1–2. *Ancyrochitina laevaensis* Nestor. Juuru Stage. 1 – Ch 10/8009 (HT), Laeva 10 core, depth 122.5 m; x 365. 2 – Ch 271/10395, Nagli core, depth 676 m; x 425.

Figs 3–5. *Ancyrochitina bifurcaspina* sp. n. 3 – Ch 253/1437, Ikla core, depth 505.7 m; Juuru Stage; x 365. 4 – Ch 254/1685, Ruhnu core, depth 576.2 m; Raikküla Stage; x 365. 5 – Ch 541/1919 (HT), Ohesaare core, depth 391.35 m; Raikküla Stage; 5a – 525, 5b – x 1630.

Figs 6–8. *Ancyrochitina porrectaspina* sp. n. 6 – Ch 426/1730, Ruhnu core, depth 464.4 m; Adavere Stage; x 345. 7 – Ch 273/1064 (HT), Viki core, depth 147.6 m; Adavere Stage; x 310. 8 – Ch 274/1730, Ruhnu core, depth 465.4 m; Adavere Stage; x 340.

III



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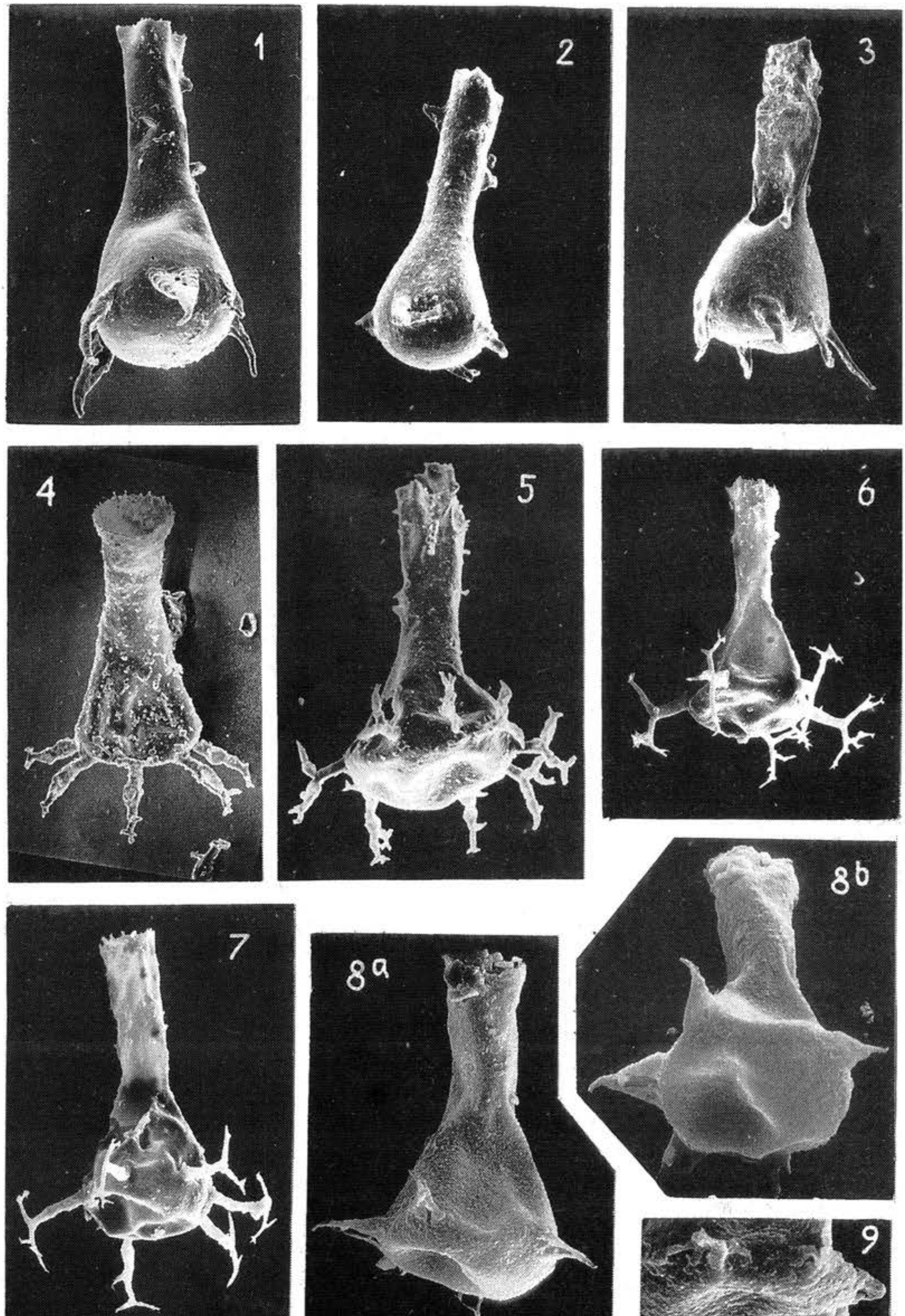


Plate IV

Figs 1–3. *Ancyrochitina magna* Nestor. Varbla core, depth 135.1 m; Juuru Stage; x 245. 1 – Ch 115/1398 (HT); 2 – Ch 185/1398; 3 – Ch 433/1398.

Fig. 4. *Plectochitina nodifera* (Nestor). Ch 16/898,Ohesaare core. depth 441.6 m; Juuru Stage; x 350.

Figs 5–7. *Ancyrochitina ramosaspina* sp. n. Raikküla Stage. 5 – Ch 252/1452. Ikla core, depth 480.4 m; x 325. 6 – Ch 474/1456 (HT), Ikla core, depth 472.6 m; x 320. 7 – Ch 427/1919, Ikla core, depth 480.4 m; x 280.

Figs 8–9. *Plectochitina* cf. *pachyderma* (Laufeld). Ruhnu core, depth 359.25 m; Jaagarahu Stage; 8 – Ch 255/1764; 8a – x 420, 8b – x 465. 9 – Ch 434/ 1764; x 640.

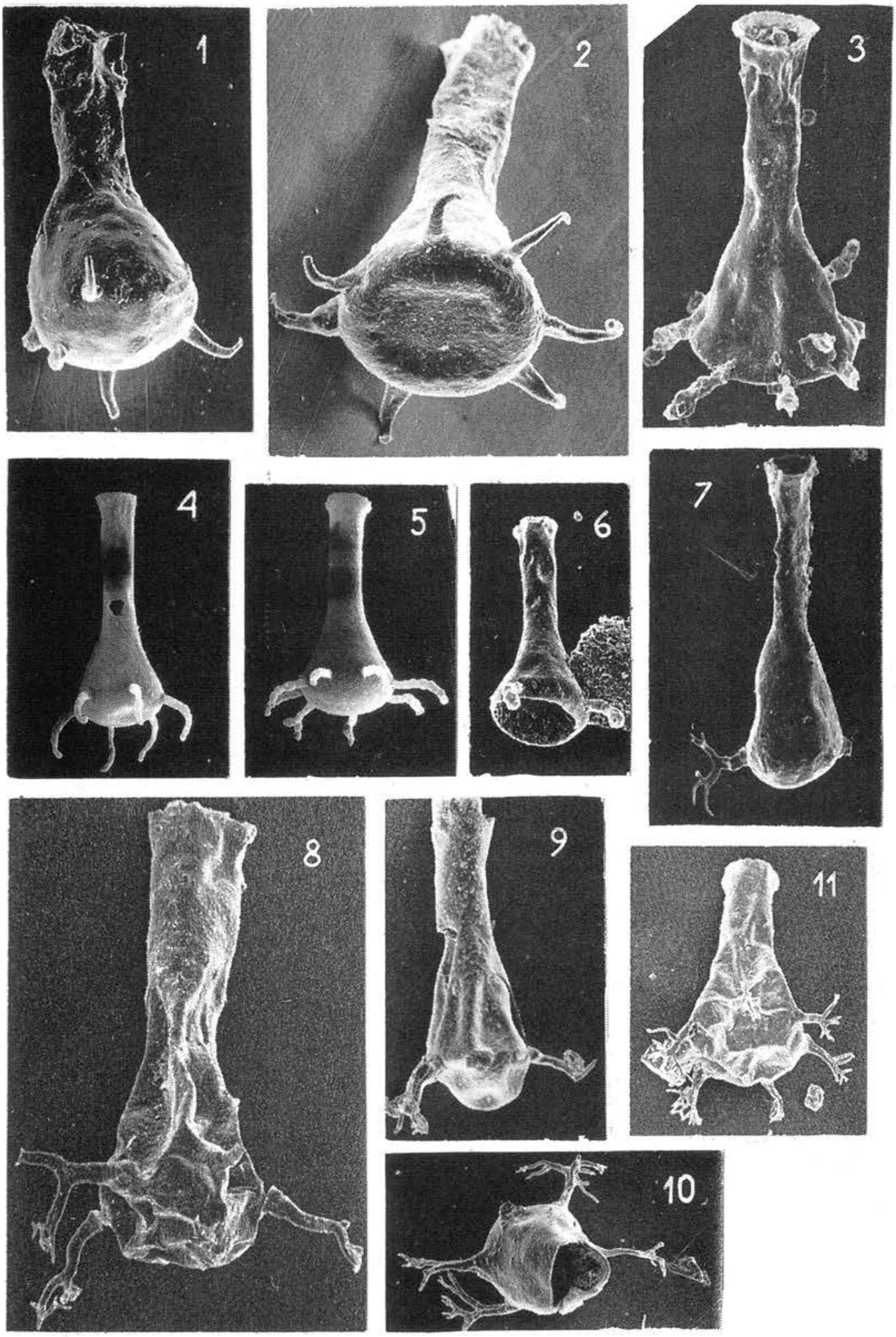
Plate V

Figs 1–2. *Ancyrochitina primitiva* Eisenack; Jaani Stage. 1 – Ch 275/1970, Varbla core, depth 124.7 m; x 365. 2 – Ch 117/9279, Pulli 1 core, depth 14.2 m; x 365.

Figs 3–6. *Plectochitina ralphi* sp. n.; Vängla outcrop; Adavere Stage. 3 – Ch 238/1940 (HT); x 365. 4 – Ch 436/1940; x 250. 5 – Ch 237/1940; x 225. 6 – Ch 239/1940; x 200.

Figs 7–10. *Ancyrochitina rumbaensis* sp. n. Adavere Stage. 7 – Ch 226/1135 (HT), Ikla core, depth 309.2 m; x 200. 8 – Ch 435/1136, Ikla core, depth 308.4 m; x 365. 9 – Ch 277/1385, Varbla core, depth 159.66 m; x 200. 10 – Ch 255/1385, Varbla core, depth 159.55 m; x 245.

Fig. 11. *Ancyrochitina* cf. *rumbaensis* sp. n., Ch 235/1940, Vängla outcrop; Adavere Stage; x 200.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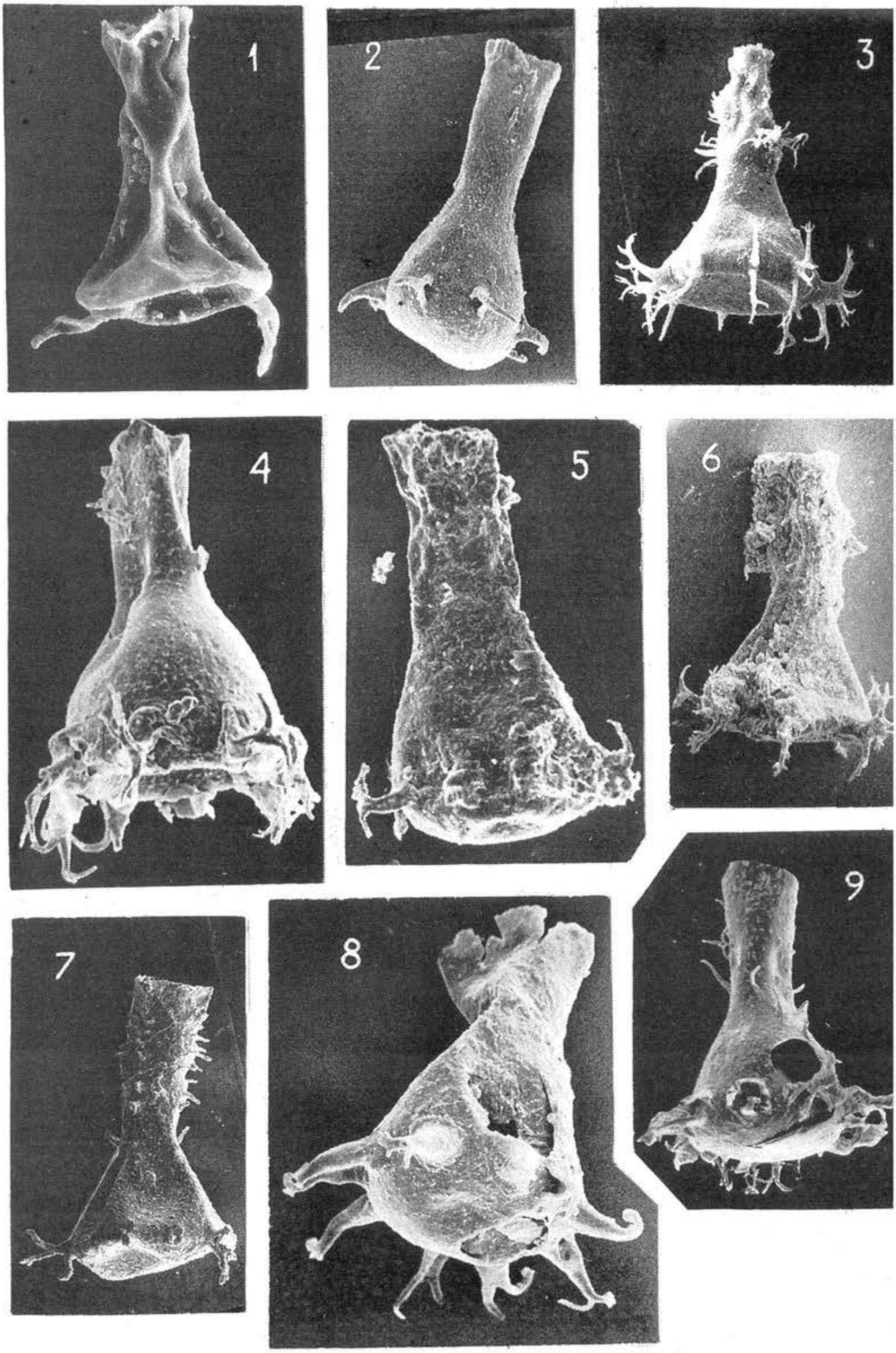


Plate VI

Fig. 1. *Plectochitina* cf. *spongiosa* (Achab); Ch 267/10420, Viki core, depth 226.4 m; Juuru Stage; x 420.

Figs 2,8. *Plectochitina obuti* sp. n. Jaagarahu Stage. 2 – Ch 475/977 (HT), Ohesaare core, depth 218.05 m; x 350. 8 – Ch 121/1587, Ohesaare core, depth 213.5 m; x 525.

Figs 3,7. *Ancyrochitina plurispinosa* sp. n. Jaagarahu Stage; x 350. 3 – Ch 476/10915 (HT), Ohesaare core, depth 200.8 m. 7 – Ch 120/1768, Ruhnu core, depth 347.4 m.

Fig. 4. *Ancyrochitina* sp. 1; Ch 113/1736, Ruhnu core, depth 545.05 m; Jaani Stage; x 365.

Fig. 5. *Ancyrochitina paulaspina* sp. n. Ch 119/1828 (HT), Ruhnu core, depth 417.5 m; Jaagarahu Stage; x 525.

Fig. 6. *Ancyrochitina* cf. *paulaspina* sp. n. Ch 266/1601, Ohesaare core, depth 181.45 m; Jaagarahu Stage; x 380.

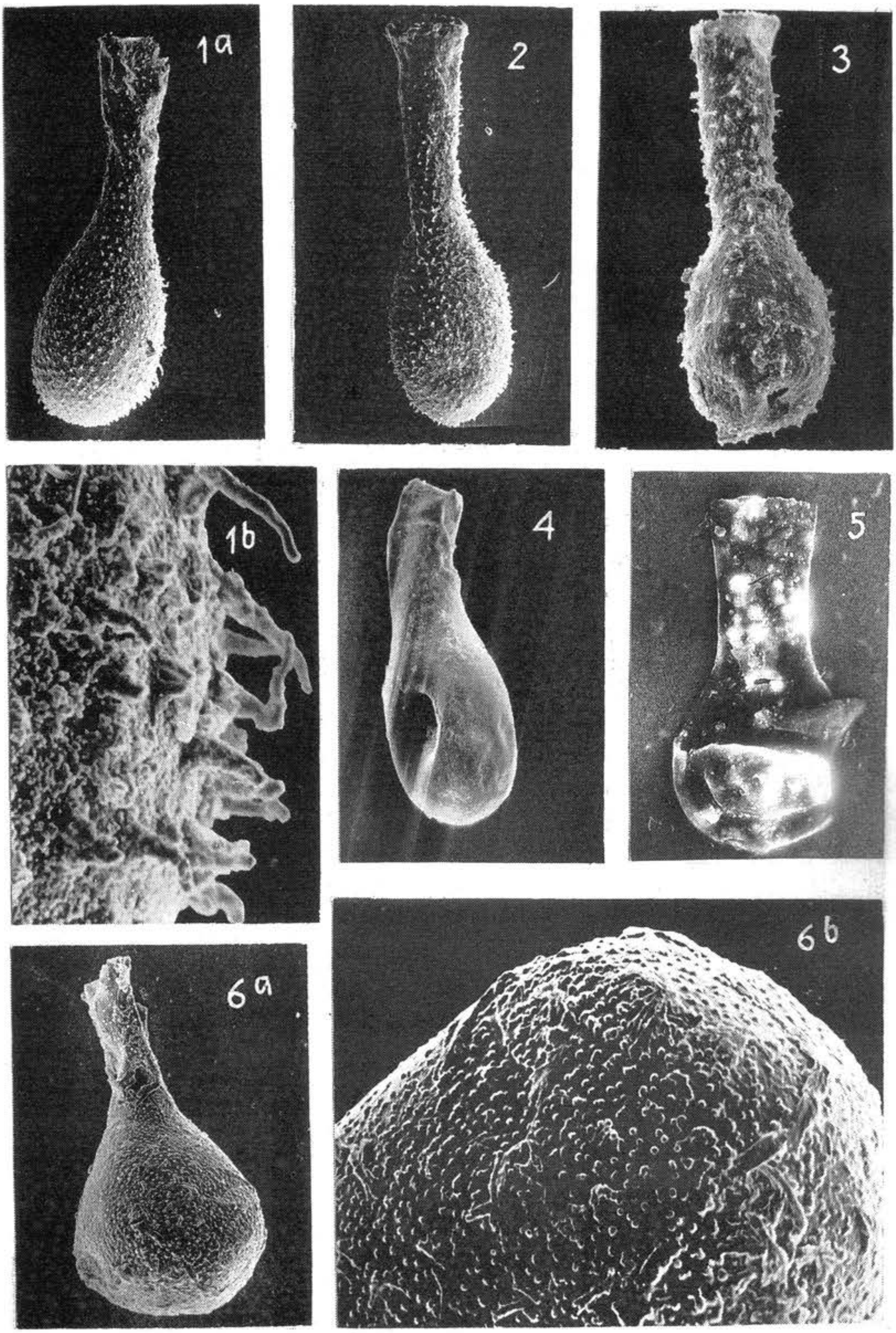
Fig. 9. *Plectochitina* sp. 1. Ch 122/1604, Ohesaare core, depth 174.6 m; Jaagarahu Stage; x 350.

Plate VII

Figs 1–4. *Angochitina longicollis* Eisenack; Jaani Stage. 1–2. Pulli 2. core, depth 20.7 m; 1 – Ch 105/9267; 1a – x 365, 1b – x 2800. 3–4. Varbla core, depth 135.1 m; x 365. 3 – Ch 291/1398, 4 – Ch 292/1398.

Figs 5–6. *Angochitina* ? sp. Raikküla Stage. 5 – Ch 282/10390, Remte core, depth 946.4 m; x 390. 6 – Ch 281/9600, Nitaure core, depth 673.4 m; 6a – x 350, 6b – 1630.

VII



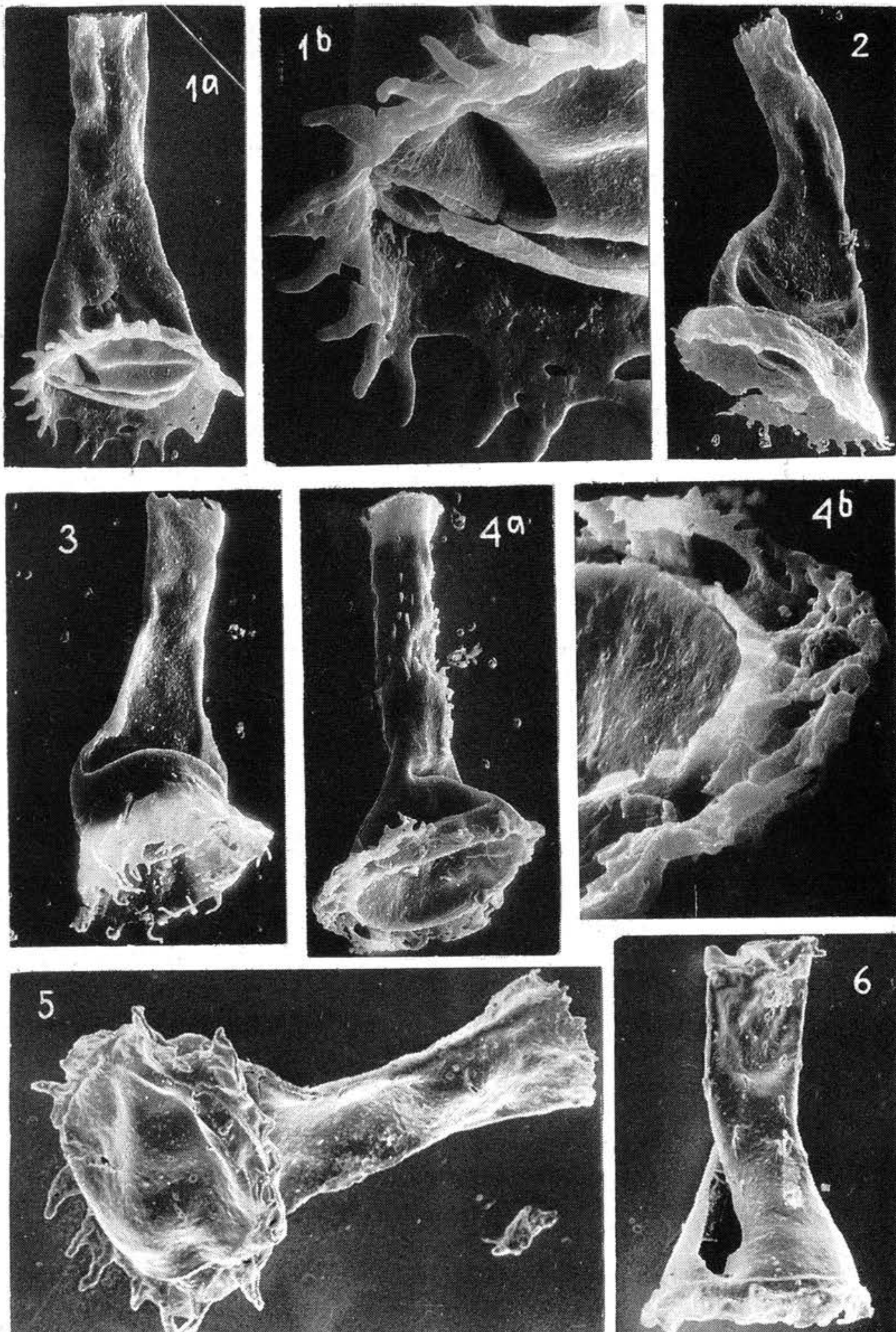

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Plate YIII

Figs 1–6. *Anthochitina primula* sp. n. 1–4. Viki core, depth 140.1 m; 1 – Ch 332/10471; 1a – x 320, 1b – x 1160. 2 – Ch 333/10471; x 335. 3 – Ch 334/10471; x 340. 4 – Ch 335/10471 (HT); 4a – x 425, 4b – x 1400. 5–6. Jaagarahu core, depth 59.6 m; 5 – Ch 283/9199; x 525. 6 – Ch 295/9199; x 365.

Plate IX

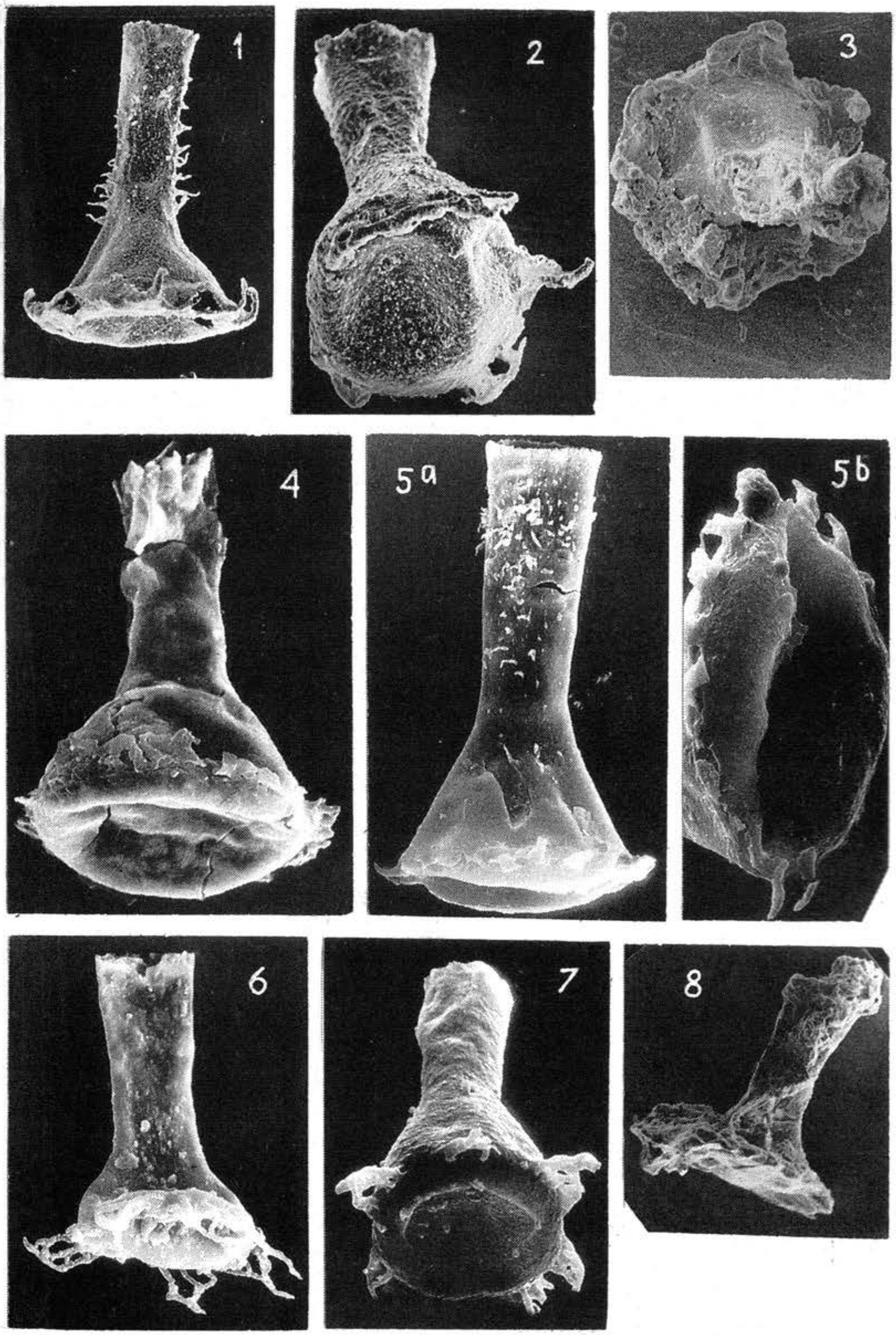
Figs 1–3. *Clathrochitina clathrata* Eisenack; Jaani Stage. 1 – Ch 153/1572, Ohesaare core, depth 291.4 m; x 365. 1 – Ch155/1954, Ohesaare core, depth 275.4 m; x 525. 3 – Ch 154/175?, Ruhnu core, depth 379 m; x 525.

Figs 4–5. *Clathrochitina* aff. *clathrata* Eisenack; Adavere Stage. 4 – Ch 270/1093, Kirikuküla core, depth 11.5 m; x 615. 5 – Ch 278/10371, Nagli core, depth 613.5 m; 5a – x 340, 5b – x 575.

Figs 6–7. *Clathrochitina* sp.; Juuru Stage. 6 – Ch 279/10437, Taagepera core, depth 379.7 m; x 380. 7 – Ch 280/10341, Nagli core, depth 667.2 m; x 520.

Fig. 8. *Clathrochitina* ? sp. Ch 262/657, Ohesaare core, depth 163.6 m; Jaagarahu Stage; x 640.

IX



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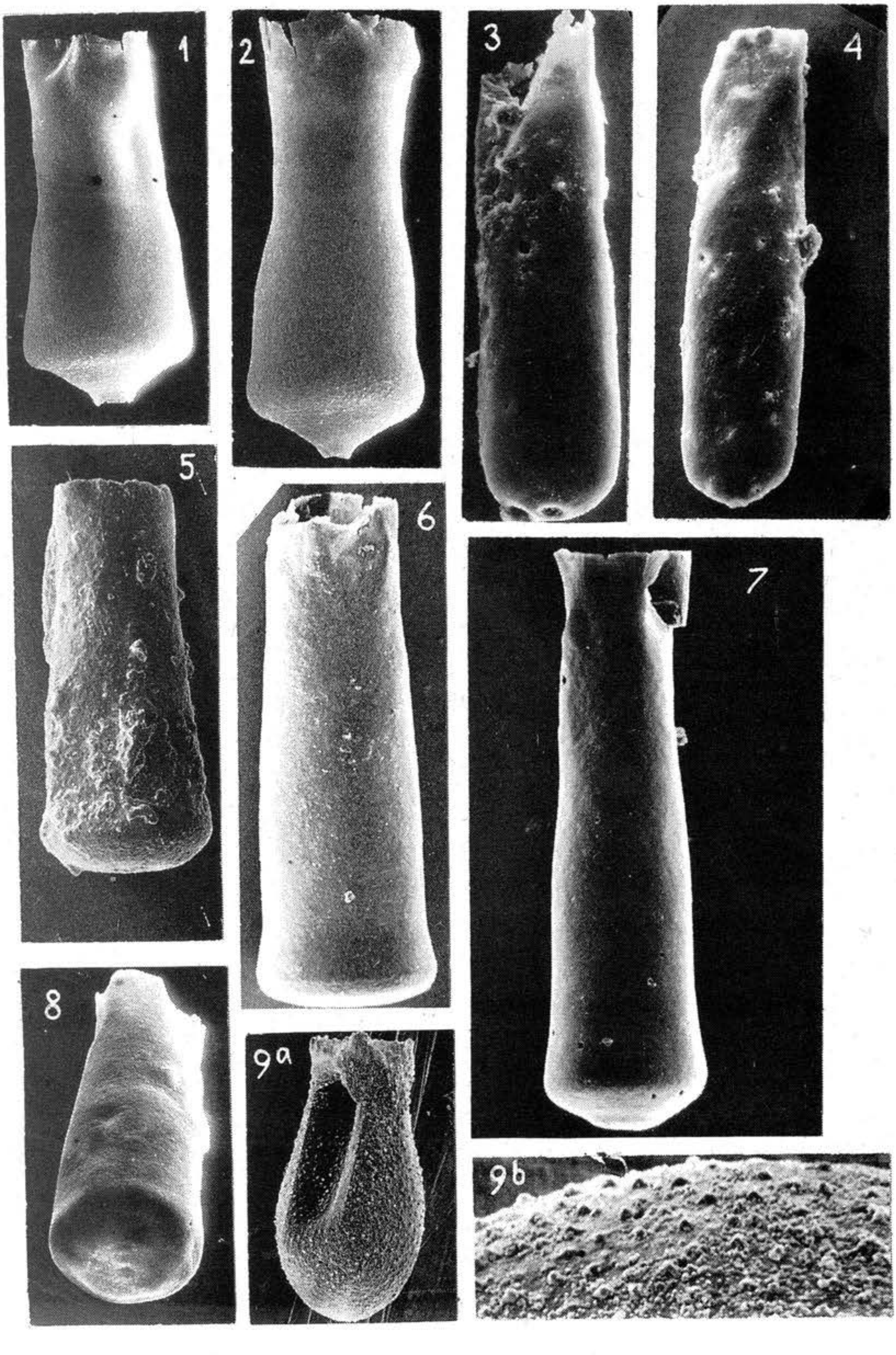


Plate X

Figs 1–2. *Conochitina acuminata* Eisenack, Ohesaare core, depth 349.4 m; Adavere Stage. 1 – Ch 269/1996; x 480. 2 – Ch 437/1996; x 465.

Figs 3–4. *Conochitina rara* sp. n.; Raikküla Stage. 3 – Ch 263/1821, Ruhnu core, depth 494.45 m; x 350. 4 – Ch 264/1820 (HT), Ruhnu core, depth 496.9 m; x 250.

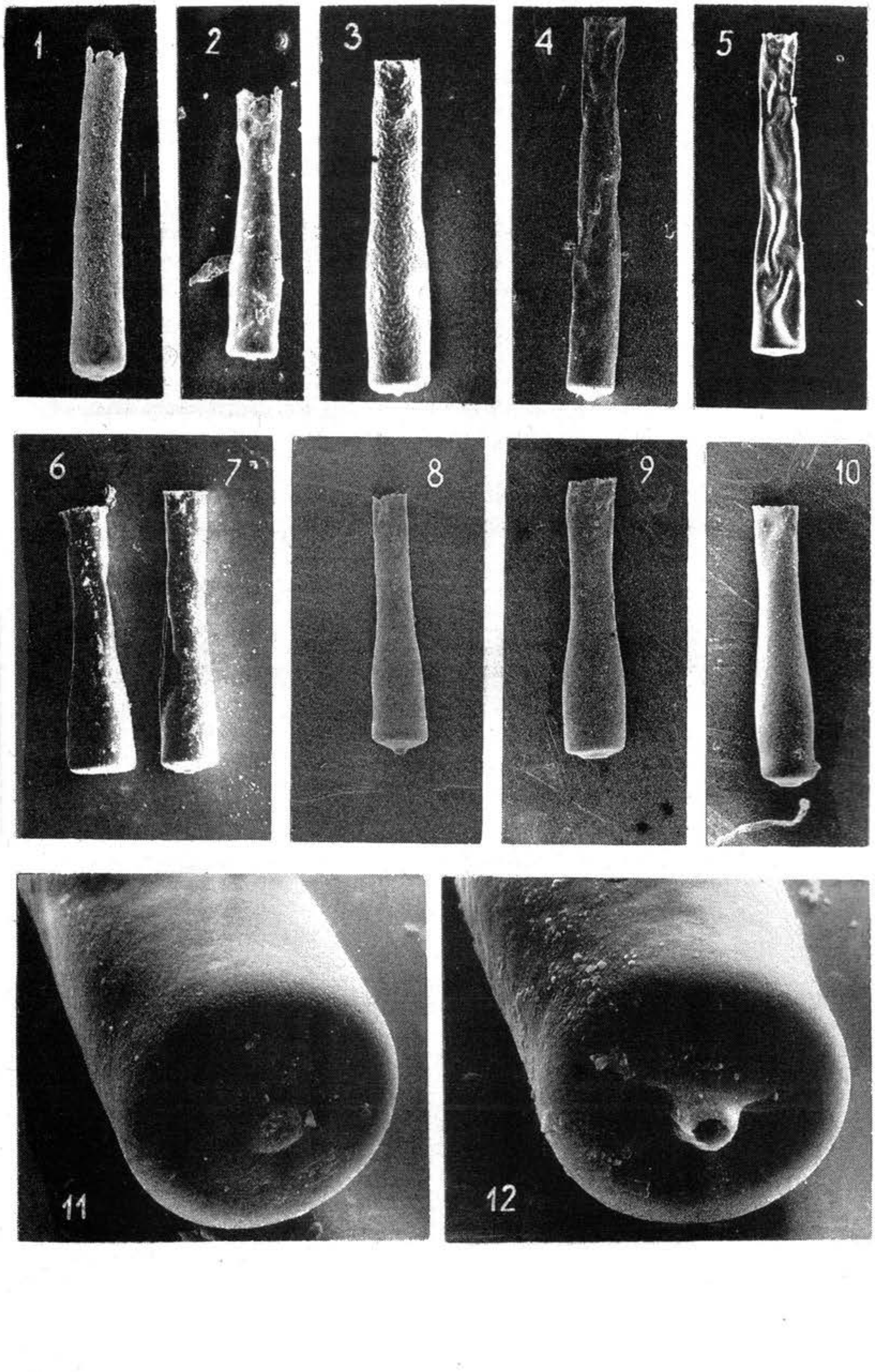
Figs 5–6. *Conochitina argillophila* Laufeld, Ohesaare core, depth 260.3m; Jaagarahu Stage; x 365. 5 – Ch 293/1578; 6 – Ch 132/1578.

Figs 7–8. *Conochitina* cf. *argillophila* Laufeld; Ohesaare core, depth 169.5 m; Jaagarahu Stage. 7 – Ch 265/650; x 365. 8 – Ch 294/650; x 350.

Fig. 9. *Belonechitina aspera* (Nestor). Ch 21/1431, (HT), Ikla core, depth 514.6 m; Juuru Stage. 9a – x 350, 9b – x 1630.

Plate XI

Figs 1–12. *Conochitina claviformis* Eisenack. 1 – Ch 256/1947, Ohesaare core, depth 308.25 m; Jaani Stage; x 105. 2 – Ch 260/1417, Varbla core, depth 97.2 m; Jaani Stage; x 105. 3 – Ch 257/1595, Ohesaare core, depth 192.9 m; Jaagarahu Stage; x 105. 4 – Ch 258/1601, Ohesaare core, depth 181.45 m; Jaagarahu Stage; x 105. 5 – Ch 259/1604, Ohesaare core, depth 174.4 m; Jaagarahu Stage; x 105. 6–12 – Ruhnu core, depth 392.8 m; Jaagarahu Stage. 6 – Ch 261/1753; x 105. 7 – Ch 285/1753; x 105. 8 – Ch 286/1753; x 105. 9 – Ch 287/1753; x 105. 10 – Ch 288/1753; x 105. 11 – Ch 289/1753; x 640 (vesicle base). 12 – Ch 290/1753; x 680 (vesicle base).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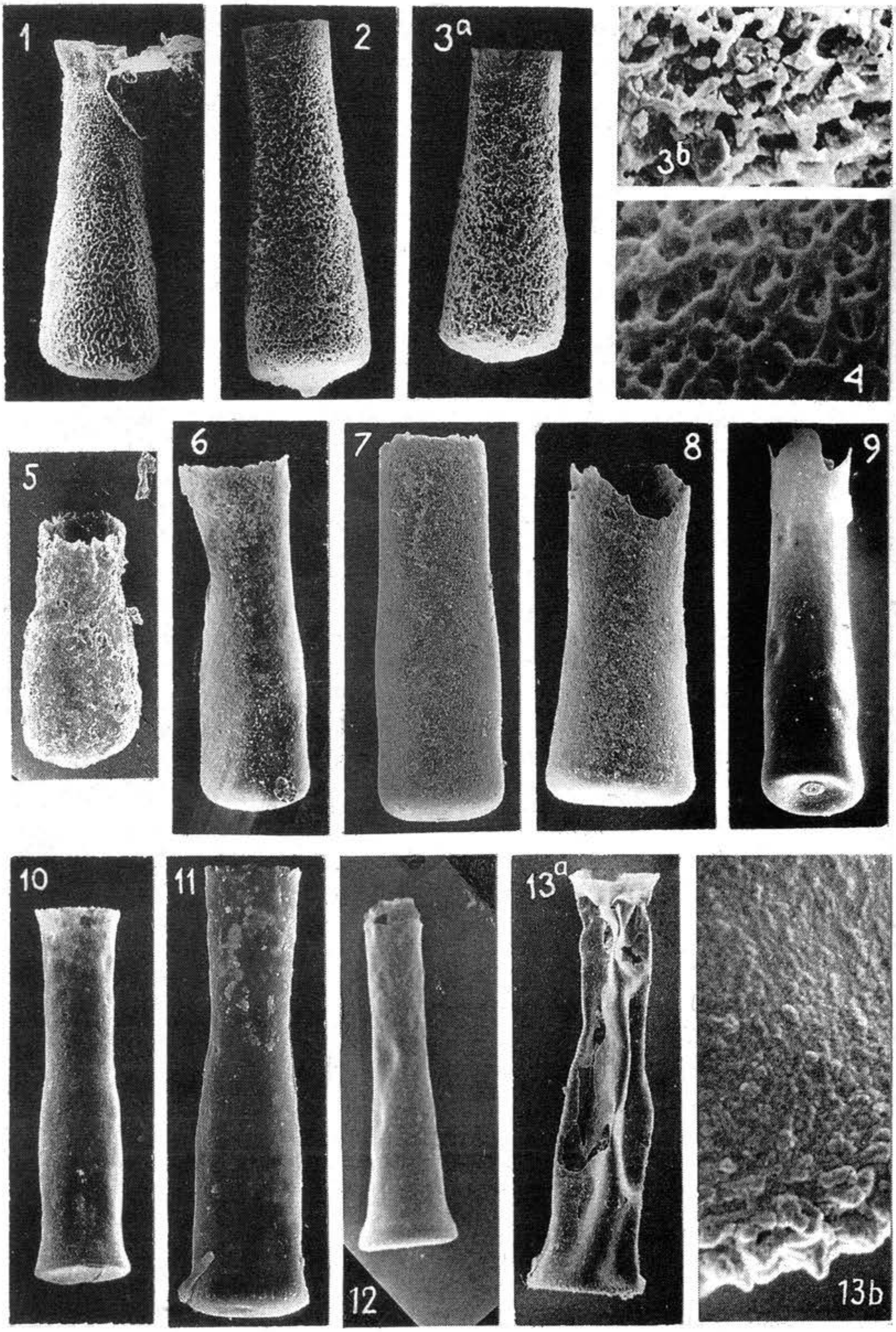
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Plate XII

Figs 1–4. *Conochitina cribrosa* Nestor. 1–3. Ohesaare core, depth 188.2 m; Jaagarahu Stage. 1 – Ch 177/1598; x 245. 2 – Ch 336/1598; x 245. 3 – Ch 178/1598; 3a – x 245, 3b – x 1640. 4 – Ch 146/1539, Ikla core, depth 185.5 m; x 3920 (detail).

Figs 5–9. *Conochitina edjelensis* Taugourdeau; Raikküla Stage. 5 – Ch 32/1926, Varbla core, depth 176.05 m, x 245. 6–8 – Varbla core, depth 173.4 m.6 – Ch 338/1378; x 200. 7 – Ch 34/1378; x 245. 8 – Ch 33/1378; x 245. 9 – Ch 337/9046, Häädemeeste core, depth 247.2–3 m; x 245.

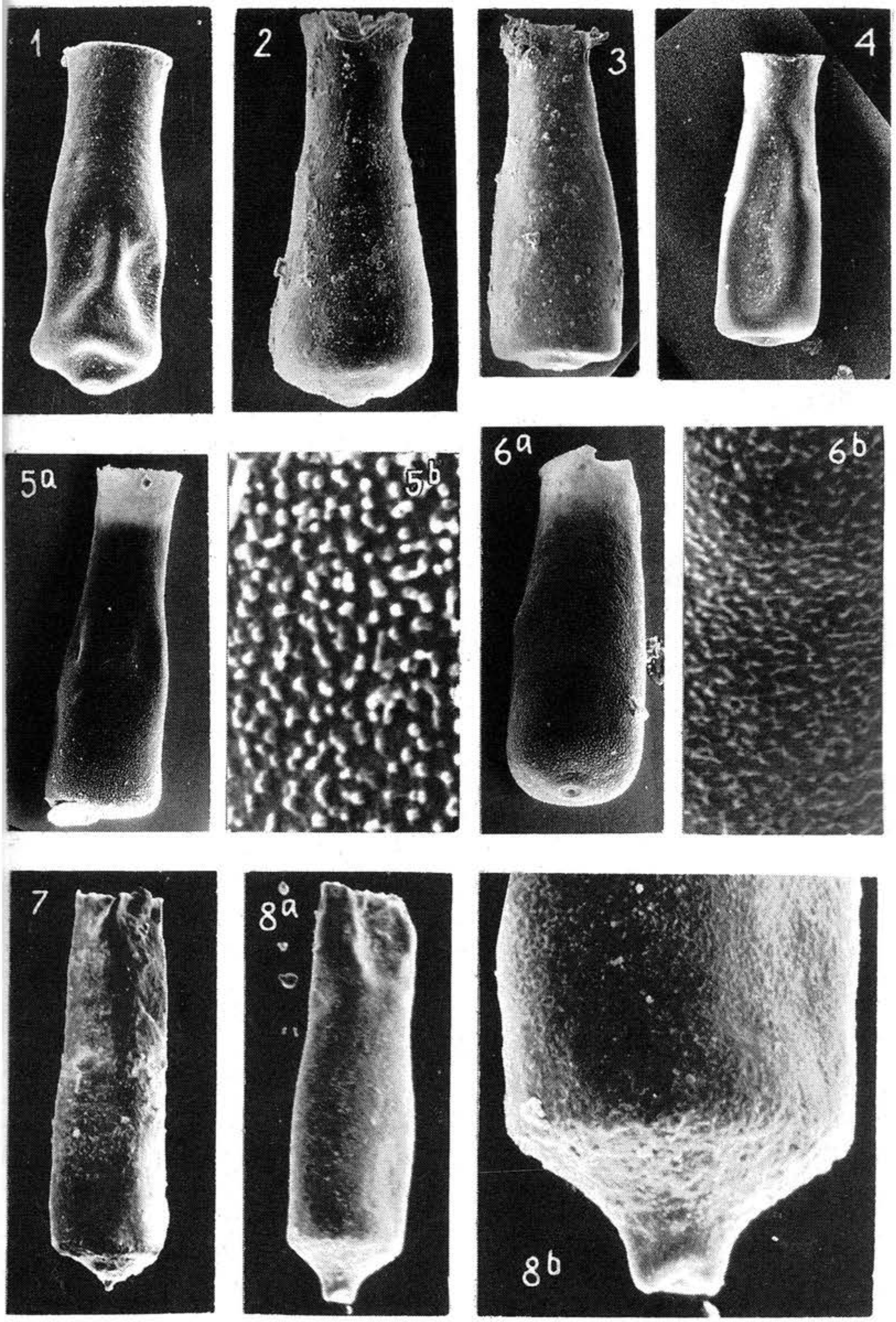
Figs 10–13. *Conochitina electa* Nestor; Raikküla Stage. 10 – Ch 28/1220, Emmaste core, depth 41.2 m; x 200. 11 – Ch 339/10428; Viki core, depth 211.25 m; x 240. 12 – Ch 27/1680 (HT), Ruhnu core, depth 576.2 m; x 135. 13 – Ch 341/9388, Ventspils core, depth 867 m; 13a – x 200, 13b – x 1630.

Plate XIII

Figs 1–4. *Conochitina emmastensis* Nestor. 1 – Ch 180/1204 (HT), Emmaste core, depth 33.8 m; Adavere Stage; x 200. 2 – Ch 104/1734, Ruhnu core, depth 457.45 m; Jaani Stage; x 200. 3 – Ch 345/9233, Pulli II core, depth 59.8 m; Adavere Stage; x 245. 4 – Ch 181/1385, Varbla core, depth 159.55 m; Adavere Stage, x 135.

Figs 5–6. *Conochitina* aff. *emmastensis* Nestor, Varbla core, depth 155 m; Adavere Stage. 5 – Ch 223/1273; 5a – x 260, 5b – x 2160. 6 – Ch 343/1273; 6a – x 280, 6b – x 1240.

Figs 7–8. *Conochitina* cf. *flamma* Laufeld, Ohesaare core, depth 342.2 m; Jaani Stage. 7 – Ch 344/764; x 365. 8 – Ch 335/764; 8a – x 365, 8b – x 1085.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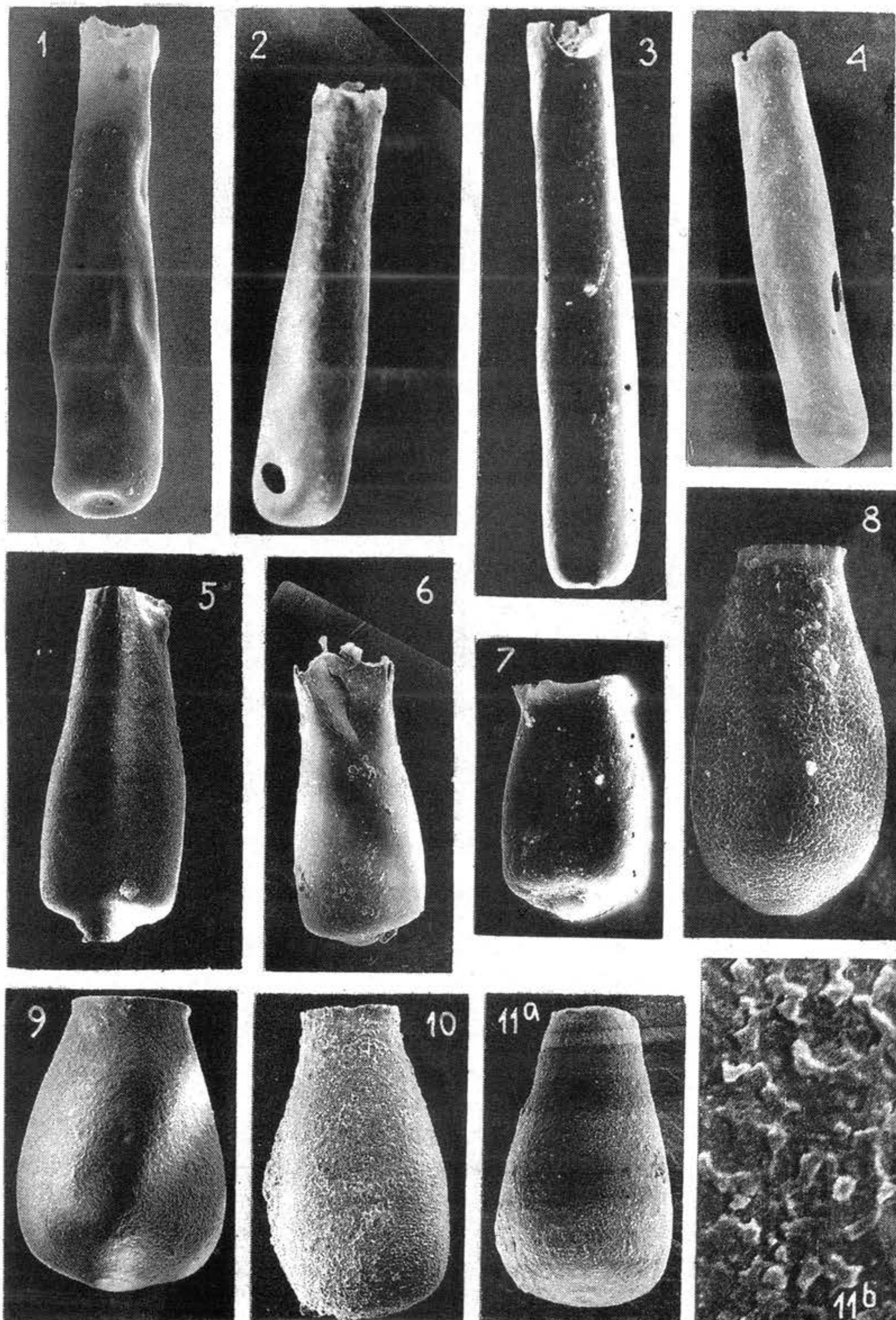
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Plate XIV

Figs 1–4. *Conochitina iklaensis* Nestor. 1 – Ch 346/1914, Ohesaare core, depth 411 m; Juuru Stage; x 240. 2 – Ch 38/1445 (HT), Ikla core, depth 492 m; Juuru Stage; x 200. 3 – Ch 349/9053, Häädemeeste core, depth 232.4 m; Raikküla Stage; x 200. 4 – Ch 348/1682, Ruhnu core, depth 584 m; Raikküla Stage; x 200.

Figs 5–6. *Conochitina fortis* Nestor; Jaagarahu Stage. 5 – Ch 170/1592 (HT), Ohesaare core, depth 200 m; x 200. 6 – Ch 171/1773, Ruhnu core, depth 333 m; x 245.

Fig. 7. *Conochitina* aff. *fortis* Nestor. Ch 352/1588, Ohesaare core, depth 208.1 m; Jaagarahu Stage; x 255.

Fig. 8. *Conochitina* cf. *gutta* Laufeld. Ch 349/1844, Ruhnu core, depth 362.85 m; Jaagarahu Stage; x 305.

Figs 9–11. *Eisenackitina lagena* (Eisenack), Ruhnu core, depth 361.9 m; Jaagarahu Stage. 9 – Ch 352/1763; x 245. 10 – Ch 353/1763; x 200. 11 – Ch 130/1763; 11a – x 200, 11b – x 2800.

Plate XV

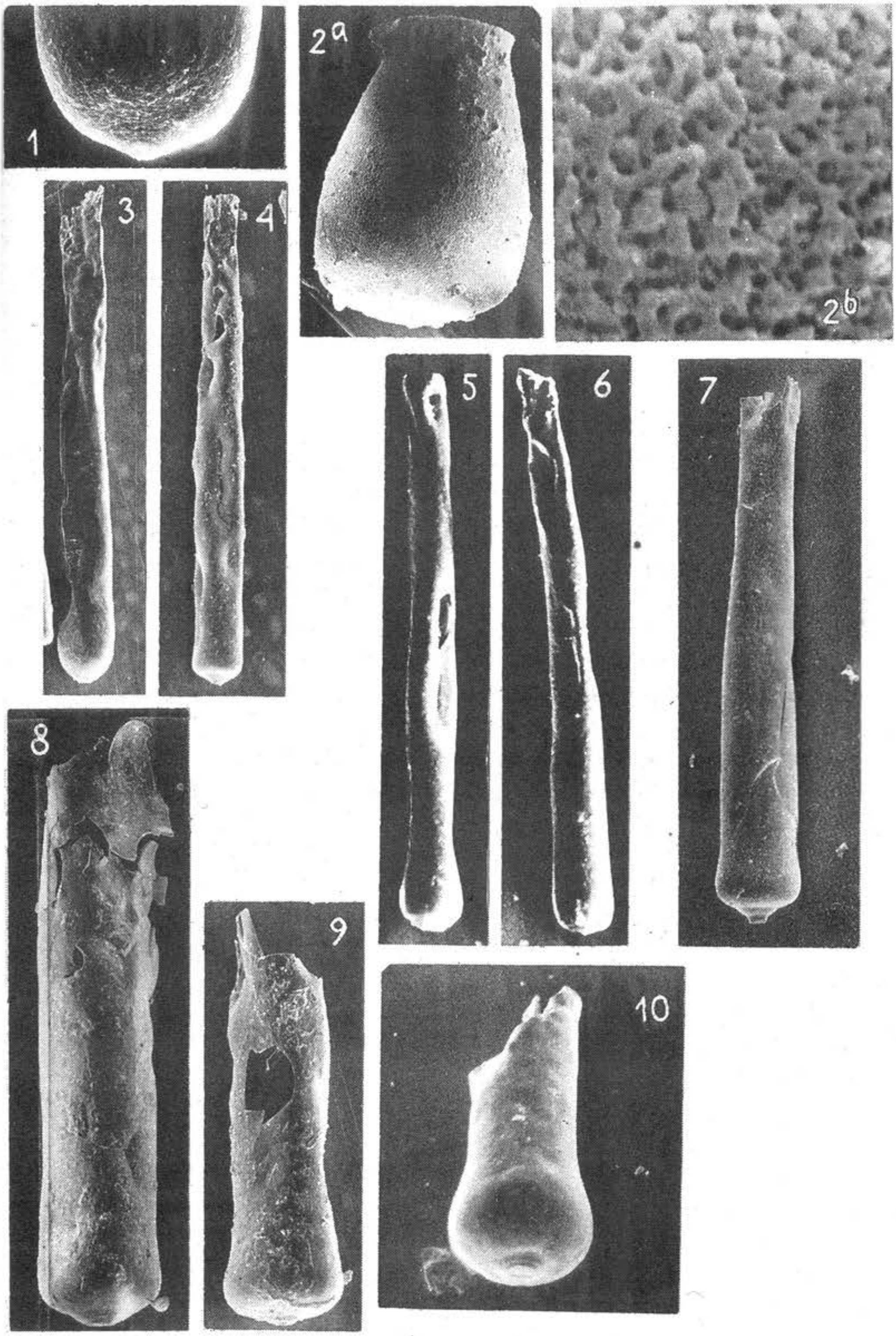
Figs 1–2. *Eisenackitina lagena* (Eisenack), Jaagarahu Stage. 1 – vesicle base Ch 354/9462, Ventspils core, depth 699 m; x 260. 2 – Ch 355/1578, Ohesaare core, depth 260.3 m; 2a – x 245, 2b – x 3920.

Figs 3–4. *Conochitina leptosoma* Laufeld, Ohesaare core, depth 305.45 m; Jaani Stage. x 105; 3 – Ch 97/1948; 4 – Ch 126/1948.

Figs 5–6. *Conochitina* cf. *leptosoma* Laufeld, Ruhnu core, depth 392.8 m; Jaagarahu Stage; x 120. 5 – Ch 356/1753; 6 – Ch 357/1753.

Figs 7–10. *Conochitina* cf. *mamilla* Laufeld; Jaani Stage. 7–8 – Kipi core, depth 115.15 m. 7 – Ch 358/1552; x 105. 8 – Ch 359/1552; x 200. 9 – Ch 360/9214, Ninase outcrop; x 200. 10 – Ch 127/9274, Pulli core, depth 10.5 m; x 200.

XV



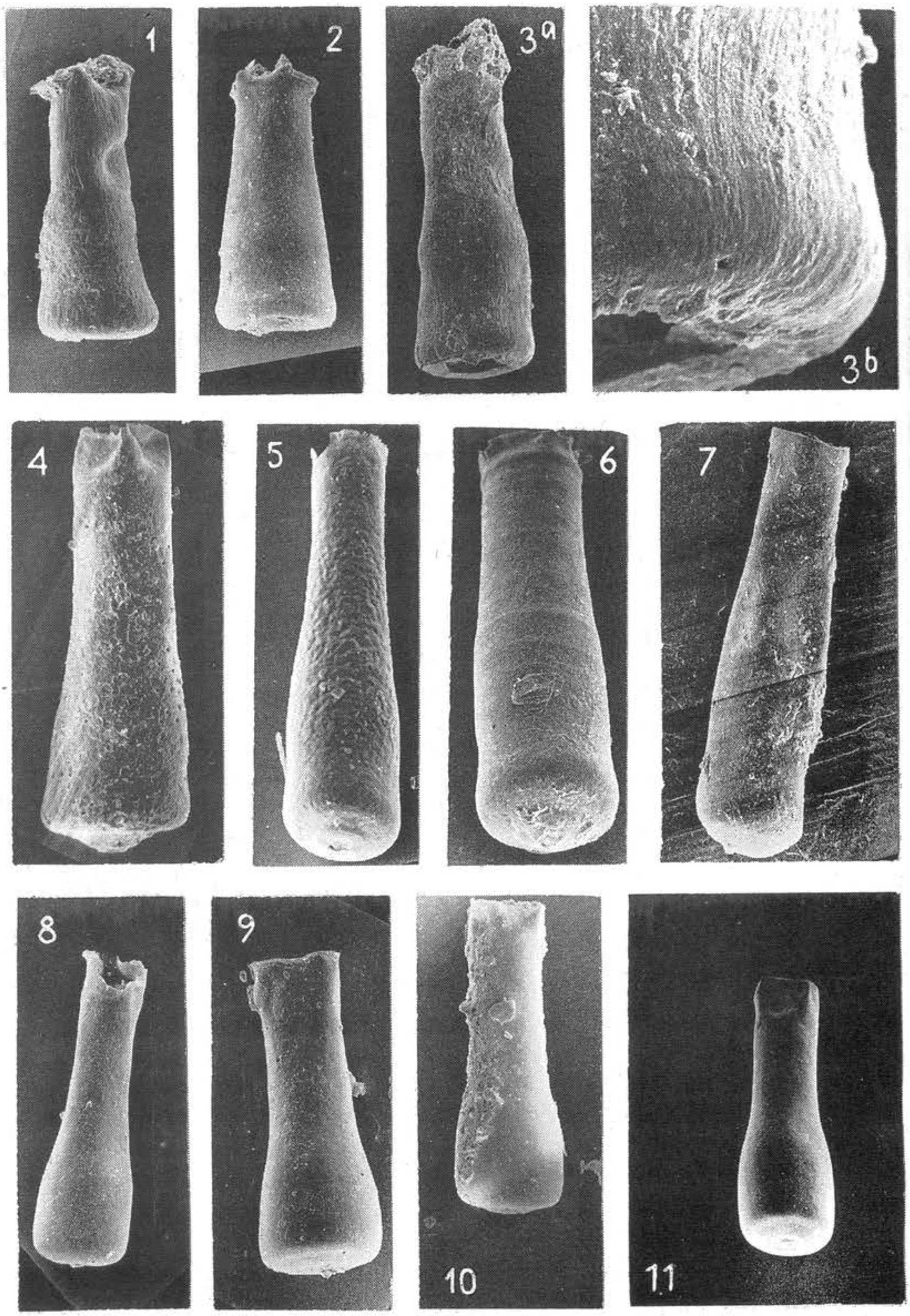

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Plate XVI

Figs 1–3. *Conochitina linearistriata* Nestor; Jaagarahu Stage. 1 – Ch 175/1581, Ohesaare core, depth 243 m; x 245. 2 – Ch 139/1586, Ohesaare core, depth 223.65 m; x 245. 3 – Ch 174/1590 (HT), Ohesaare core, depth 206 m; 3a – x 200, 3b – x 1630.

Figs 4–6. *Conochitina pachycephala* Eisenack; Jaagarahu Stage. 4 – Ch 361/1582, Ohesaare core, depth 232.3 m; x 245. 5 – Ch133/1578, Ohesaare core, depth 225.05 m; x 200. 6 – Ch 362/1590, Ohesaare core, depth 206 m; x 200.

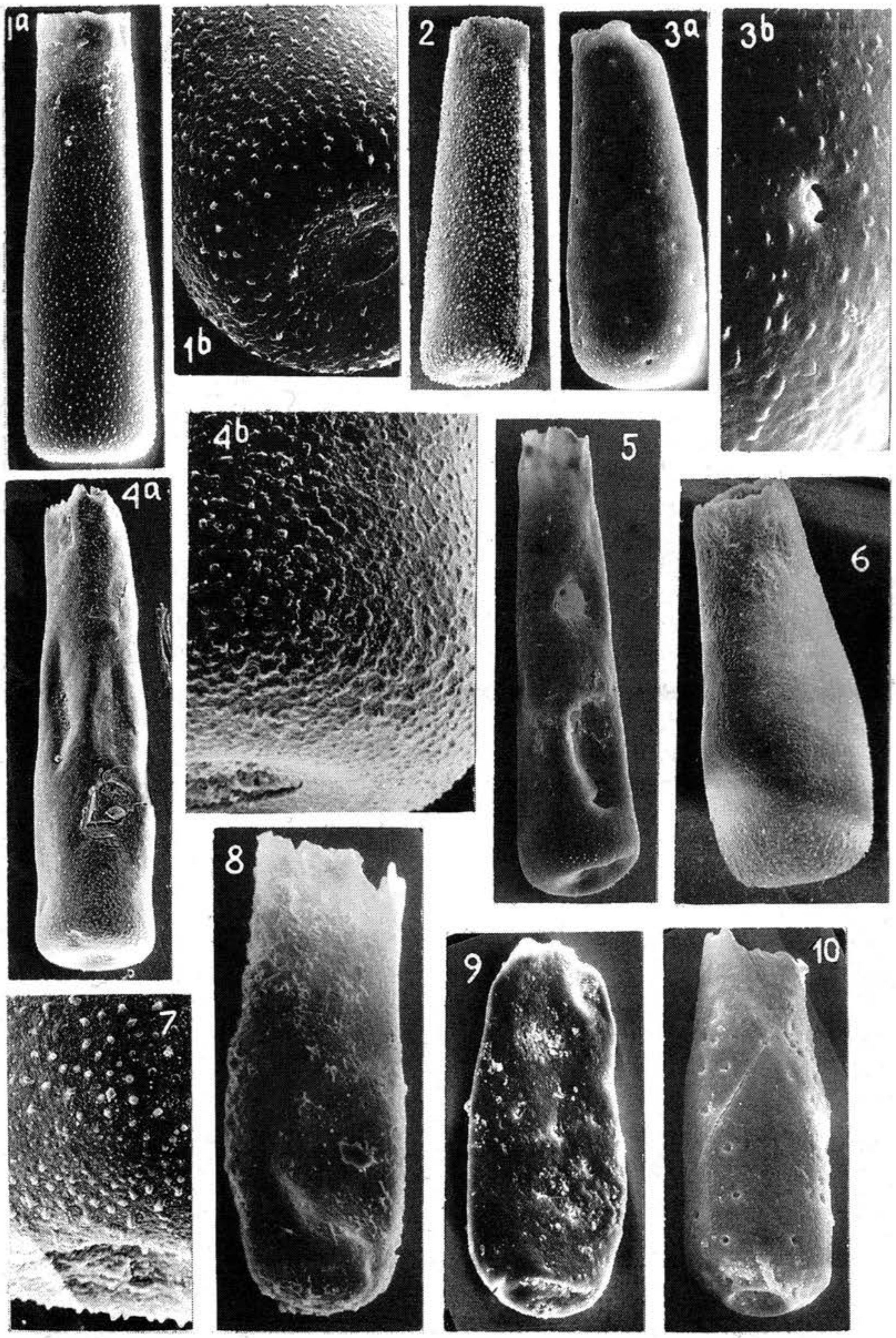
Fig. 7. *Conochitina* aff. *pachycephala* Eisenack. Ch 363/1837, Ruhnu core, depth 388.65; Jaagarahu Stage; x 200.

Figs 8.–11. *Conochitina subcyatha* Nestor; Jaagarahu Stage. 8 – Ch 167/977 (HT), Ohesaare core, depth 218.05 m; x 245. 9 – Ch 168/773, Ruhnu core, depth 333 m; x 245. 10 – Ch 135/1587, Ohesaare core, depth 225.05 m; x 200. 11 – Ch 169/1765, Ruhnu core, depth 365 m; x 200.

Plate XVII

Figs 1–7. *Belonechitina postrobusta* (Nestor); Juuru Stage. 1 – Ch 300/10540, Laeva 18 core, depth 140.7 m; 1a – x 240, 1b – x 760. 2 – Ch 23/1430 (HT), Ikla core, depth 515.7 m; x 200. 3 – Ch 301/1914, Häädemeeste core, depth 390 m; 3a – x 360, 3b – x 2000. 4 – Ch 302/6457, Tartu core, depth 188.7 m; 4a – x 200, 4b – x 1085. 5 – Ch 301/1914, Ohesaare core, depth 411 m; x 250. 6 – Ch 303/1438, Ikla core, depth 504.2 m; x 365. 7 – Ch 304/1438 (detail), Ikla core, depth 504.2 m; x 1085.

Figs 8–10. *Conochitina* cf. *protracta* (Zaslavskaja); Raikküla Stage. 8 – Ch 307/945, Ikla core, depth 422.9 m; x 365. 9 – Ch 305/1820, Ruhnu core, depth 496.9 m; x 265. 10 – Ch 306/9053, Häädemeeste core, depth 232.4 m; x 305.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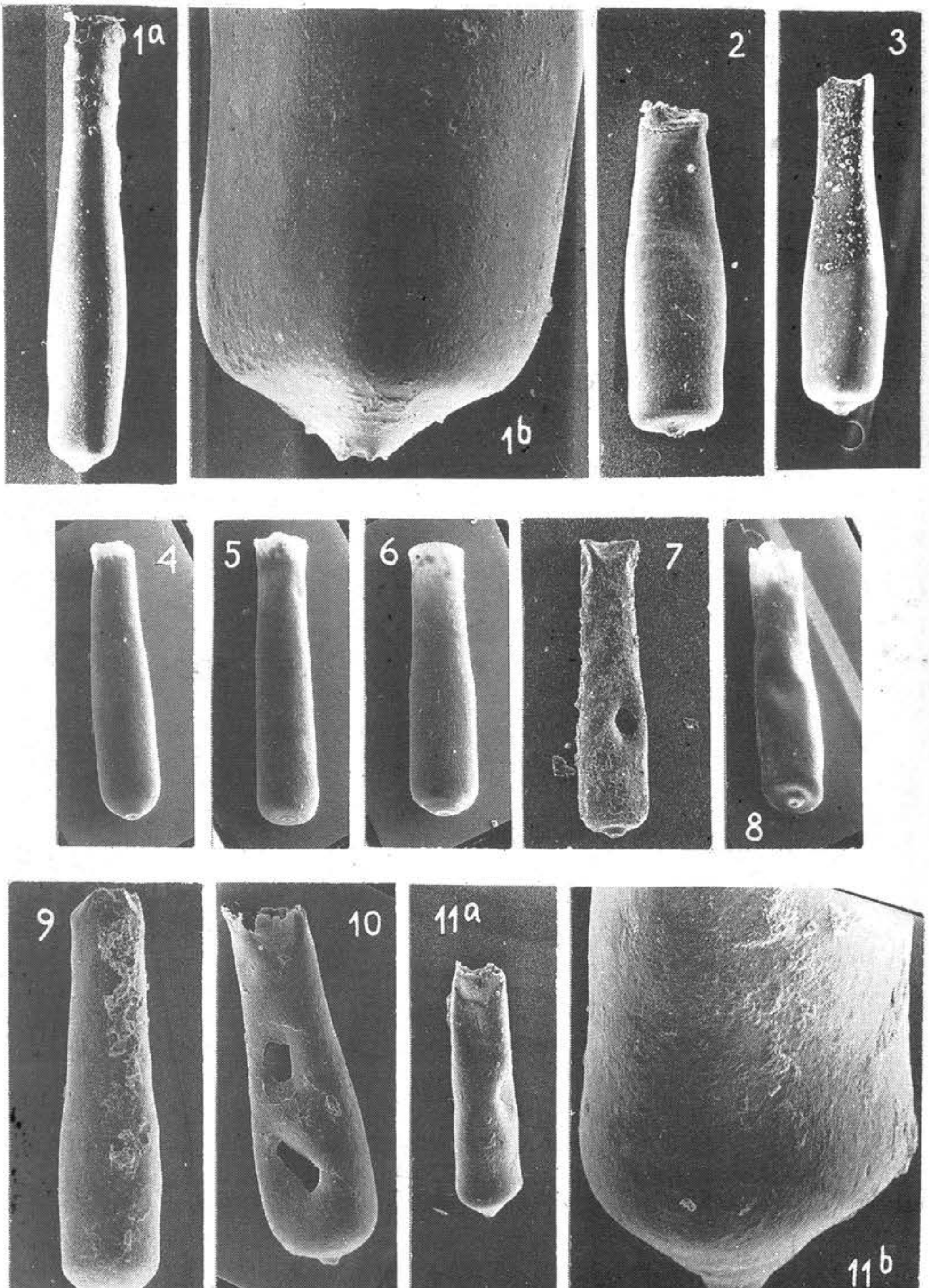
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Plate XVIII

Figs 1–3. *Conochitina proboscifera* Eisenack. 1–2 – Kipi core, depth 136.85 m; Jaani Stage. 1 – Ch 308/1542; 1a – x 105, 1b – x 525. 2 – Ch 99/1542; x 105. 3 – Ch 102/1963, Ohesaare core, depth 342.2 m; Jaani Stage; x 105.

Figs 4–8. *Conochitina praeproboscifera* sp. n. 4–6 – Vängla outcrop; Adavere Stage; x 120. 4 – Ch 229/1940; 5 – Ch 230/1940; 6 – Ch 228/1940. 7 – Ch 227/1141, Ikla core, depth 305.5 m; Adavere Stage; x 105. 8 – Ch 224/276 (HT), Varbla core, depth 160.15 m; Adavere Stage; x 140.

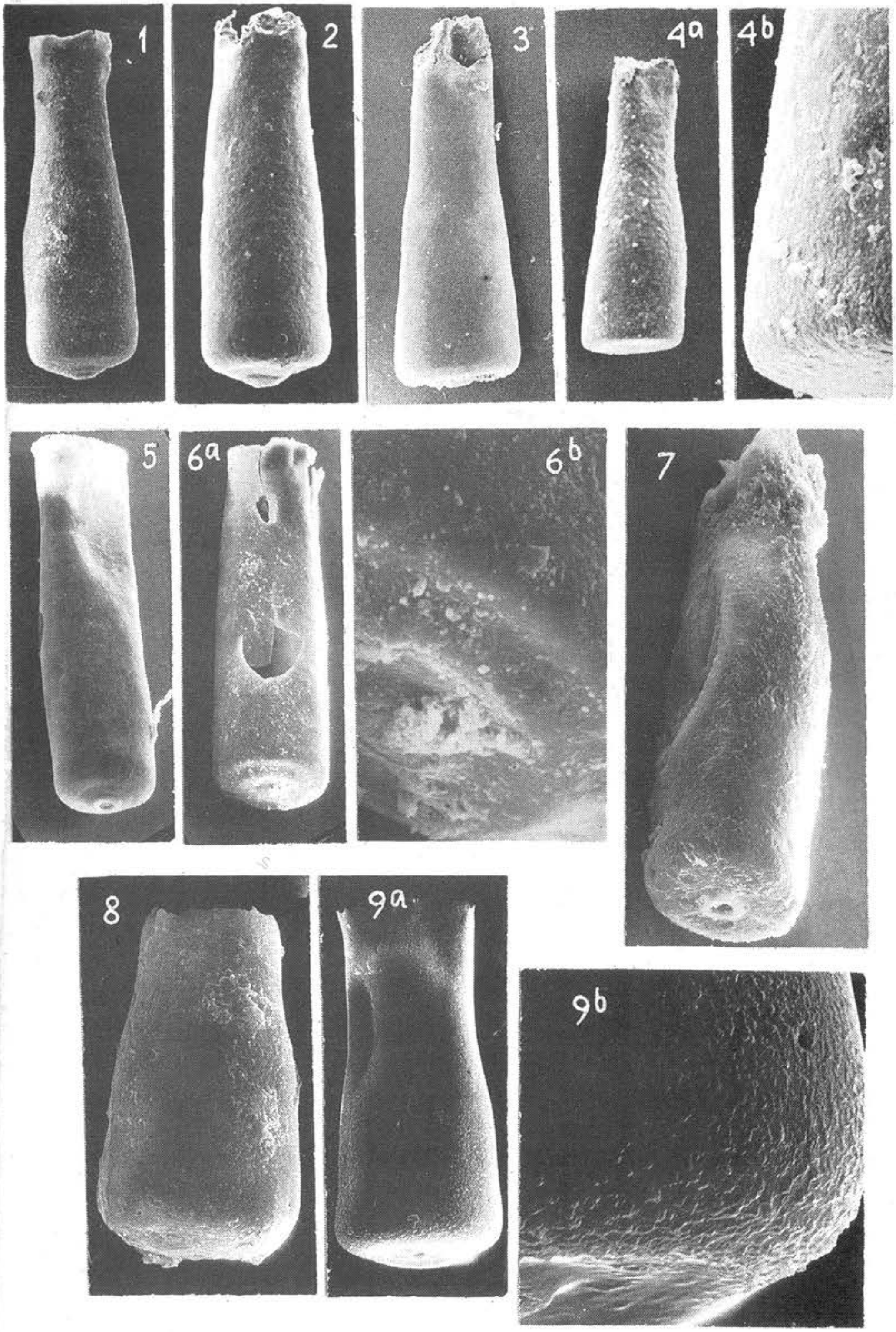
Figs 9–11. *Conochitina* aff. *proboscifera* Eisenack. 9–10 – Ohesaare core, depth 243 m; Jaagarahu Stage. 9 – Ch 310/1981; x 200. 10 – Ch 311/1981; x 245. 11 – Ch 312/1583, Ohesaare core, depth 227.5 m; 11a – x 105, 11b – x 525.

Plate XIX

Figs 1–4. *Conochitina tuba* Eisenack; Jaagarahu Stage. 1 – Ch 313/1587, Ohesaare core, depth 213.5 m; x 200. 2 – Ch 314/1529, Ikla core, depth 212.4 m; x 200. 3 – Ch 315/1765, Ruhnu core, depth 356 m; x 200. 4 – Ch 440/1584, Ohesaare core, depth 225.05 m, 4a – x 200, 4b – x 1085.

Figs 5–7. *Conochitina* aff. *tuba* Eisenack; Raikküla Stage. 5 – Ch 316/952, Ikla core, depth 370.8 m; x 215. 6 – Ch 317/1109, Ikla core, depth 323.4 m, 6a – x 220, 6b – x 1040. 7 – Ch 441/1108, Ikla core, depth 326.6 m; x 340.

Figs 8–9. *Conochitina visbyensis* Laufeld; Ohesaare core, depth 349.4 m; Adavere Stage. 8 – Ch 318/1996; x 445. 9 – Ch 319/1996; 9a – x 560, 9b – x 2000.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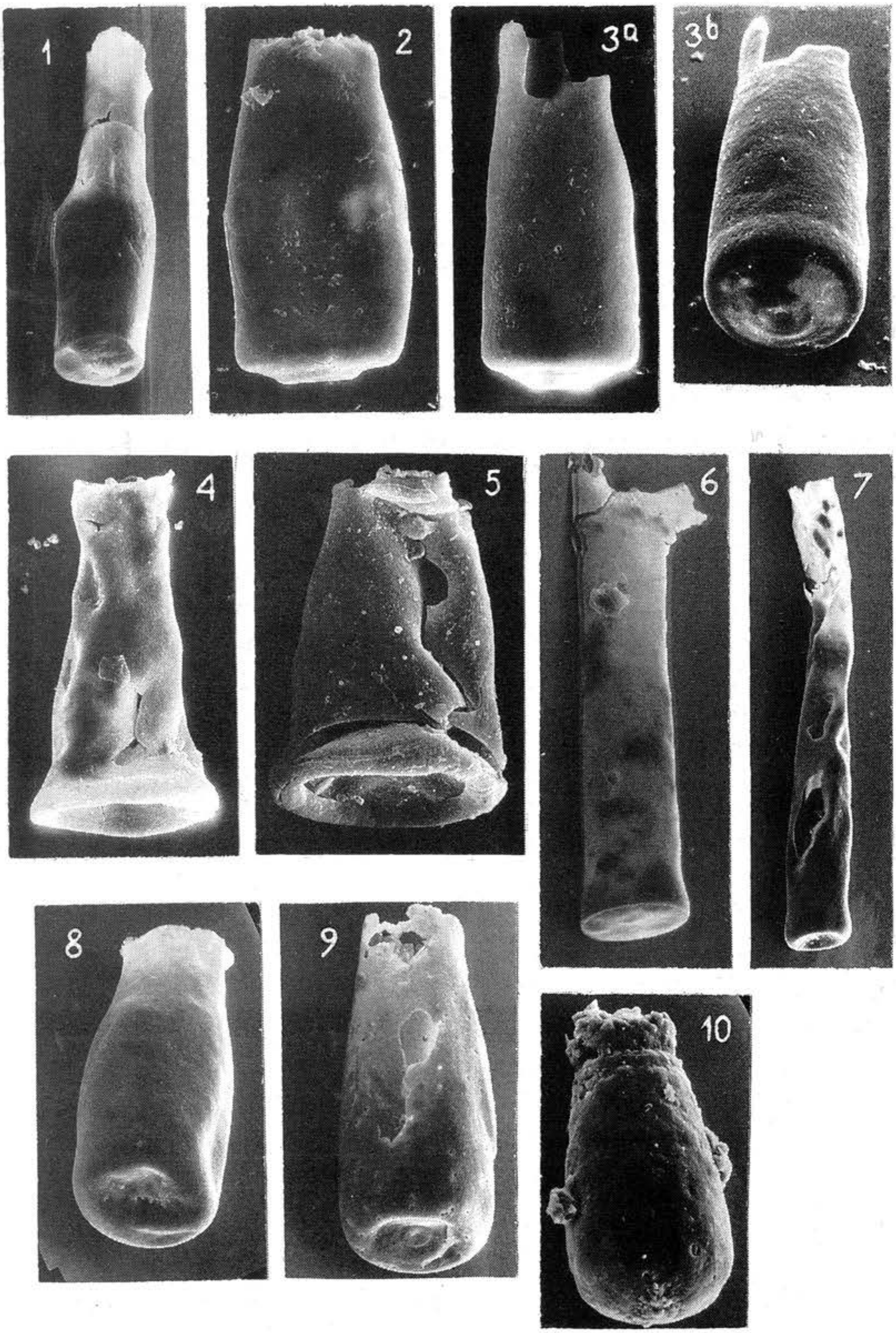
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Plate XX

Fig. 1. *Conochitina*? sp. 1. Ch 222/1387, Varbla core, depth 154.7 m; Adavere Stage; x 430.

Figs 2–3. *Conochitina* sp. 2; Adavere Stage. 2 – Ch 320/9233,Pulli II core, depth 59.8 m; x 215. 3 – Ch 321/1275, Varbla core, depth 156.9 m; 3a – x 260, 3b – x 280.

Figs 4–5. *Conochitina*? sp. 3. Adavere Stage; x 305. 4 – Ch 322/1388, Varbla core, depth 152.6 m. 5 – Ch 323/1731, Ruhnu core, depth 463.2 m.

Figs 6–7. *Conochitina* sp. 4; Adavere Stage. 6 – Ch 218/1213, Emmaste core, depth 37.3 m; x 300. 7 – Ch 324/1271, Varbla core, depth 149.85 m; x 165.

Figs 8–10. *Conochitina* sp. 5; Adavere Stage. 8 – Ch 232/1940, Vängla outcrop; x 330. 9 – Ch 325/1940, Vängla outcrop; x 360. 10 – Ch 326/10139, borehole No. 324, depth 51.5 m; x 485.

Plate XXI

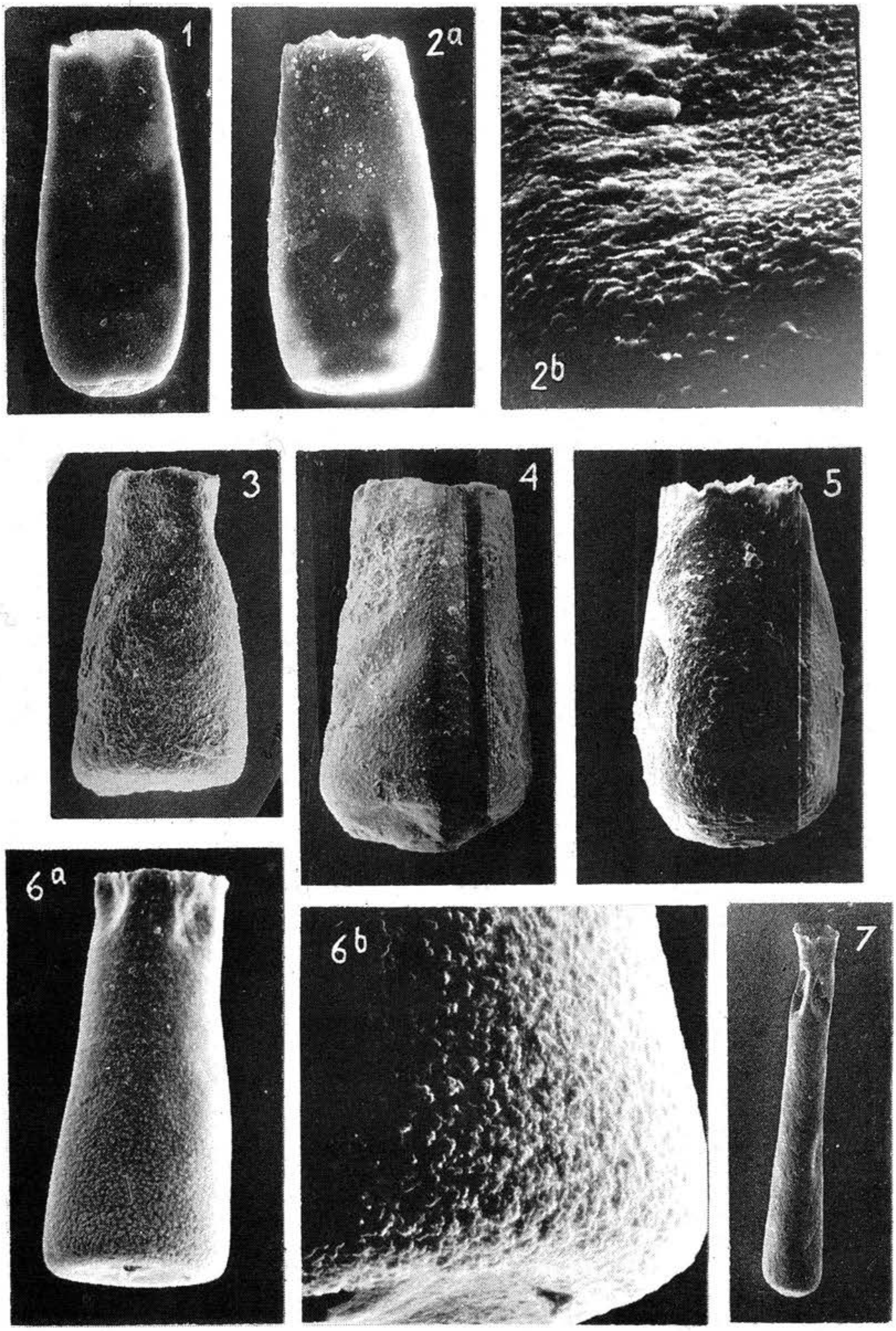
Figs 1–2. *Conochitina* sp. 6; Adavere Stage. 1 – Ch 327/10366, Nagli core, depth 621 m; x 270. 2 – Ch 328/744, Ohesaare core, depth 356.26 m; 2a – x 295, 2b – x 2320.

Figs 3–4. *Conochitina* sp. 7. Jaagarahu Stage. 3 – Ch 329/645, Ohesaare core, depth 222.5 m; x 350. 4 – Ch 330/1596, Ohesaare core, depth 191.1 m; x 365.

Fig. 5. *Conochitina* aff. sp. 7. Ch 331/645. Ohesaare core, depth 222.5 m; Jaagarahu Stage; x 365.

Fig. 6. *Belonechitina* sp. 1. Ch 140/1591, Ohesaare core, depth 202.8 m; Jaagarahu Stage; 6a – x 365, 6b – x 1630.

Fig. 7. *Conochitina* sp. 8. Ch 144/1608, Ohesaare core, depth 161 m; Jaagarahu Stage; x 105.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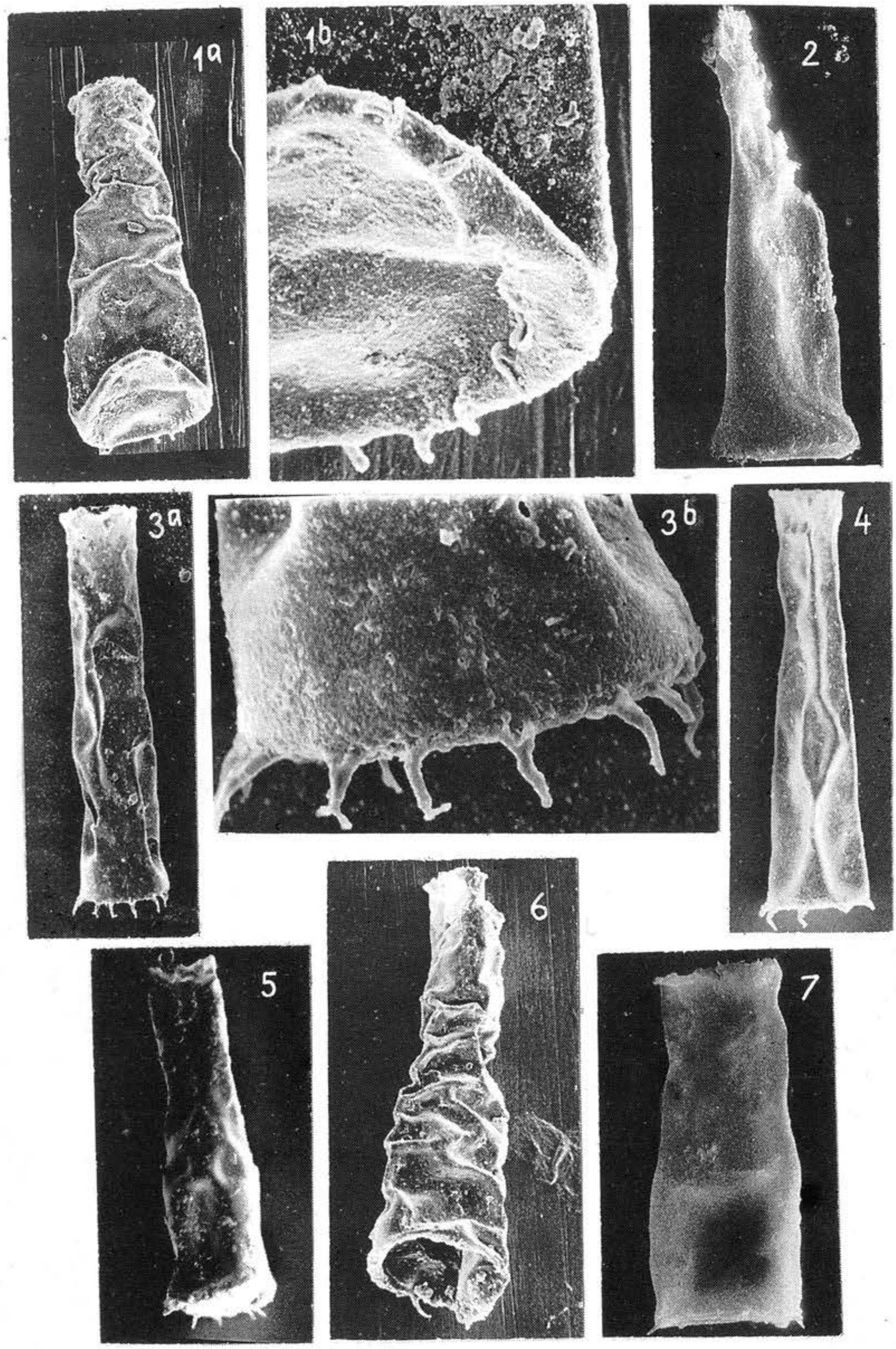
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Plate XXII

Figs 1–2. *Spinachitina freagilis* (Nestor); Juuru Stage. 1 – Ch 9/1983 (HT), Ohesaare core, depth 466.5 m; 1a – x 245, 1b – x 1085. 2 – Ch 365/10392, Nagli core, depth 679.4 m; x 355.

Figs 3–4. *Spinachitina maennili* (Nestor); Raikküla Stage. 3 – Ch 2/1462 (HT), Ikla core, depth 462.9 m; 3a – x 280, 3b – x 1085. 4 – Ch 366/1919, Ohesaare core, depth 391.35 m; x 200.

Fig. 5. *Spinachitina* cf. *maennili* (Nestor). Ch 217,1718, Ruhnu core, depth 489.45 m; Adavere Stage; x 245.

Fig. 6. *Spinachitina* sp. Ch 367/1431, Ikla core, depth 514.6 m; Juuru Stage; x 365.

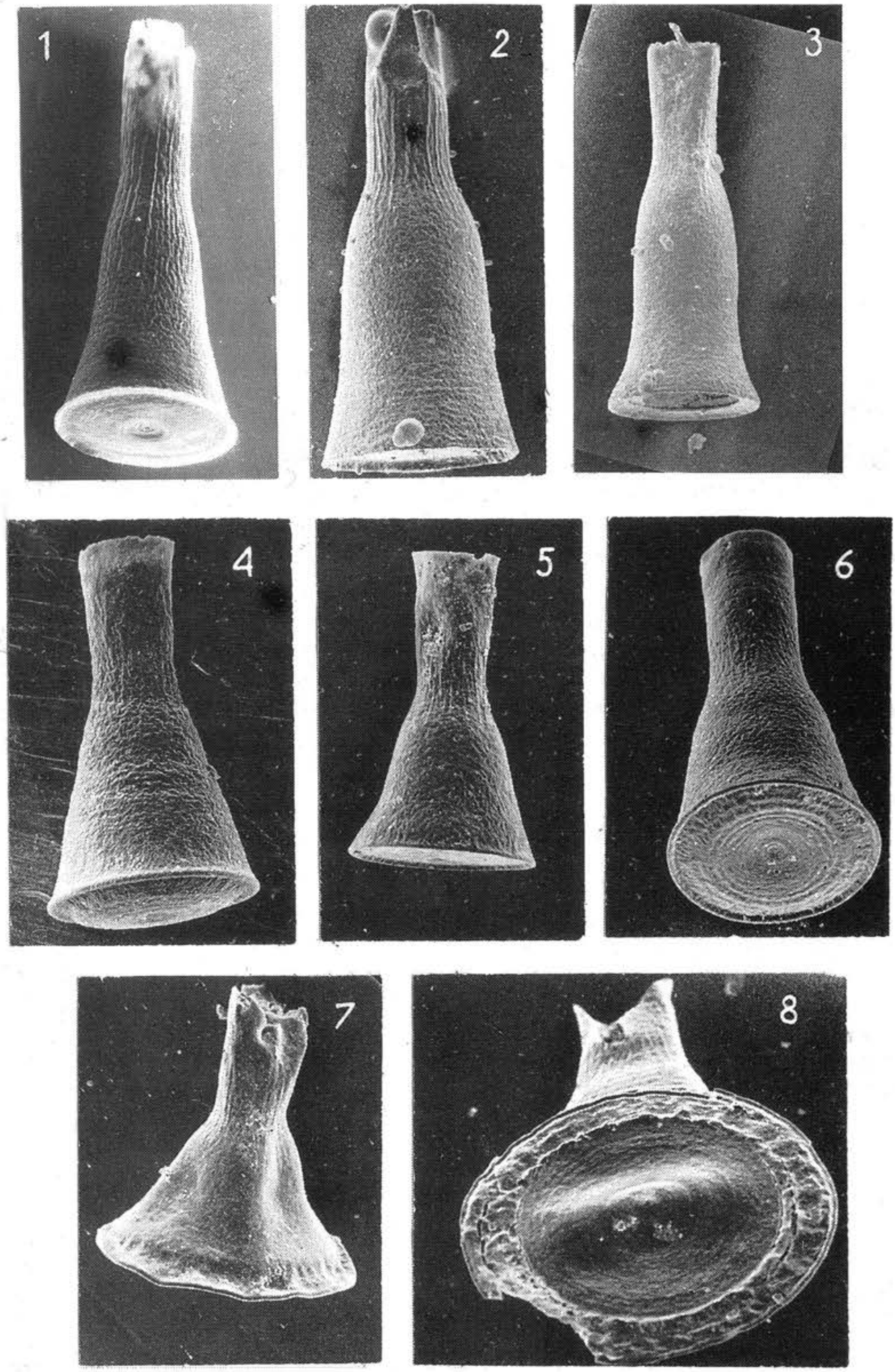
Fig. 7. *Spinachitina* sp. Ch 368/10354. Nagli core, depth 645.5 m; Adavere Stage; x 420.

Plate XXIII

Figs 1–3. *Cyathochitina calix* (Eisenack); Raikküla Stage. 1 – Ch 42/611, Ohesaare core, depth 399 m; x 205. 2 –3 – Ruhnu core, depth 576.2 m; 2 – Ch 370/1685; x 200. 3 – Ch 41/1685; x 135.

Figs 4–6. *Cyathochitina campanulaeformis* (Eisenack); Juuru Stage; x 200. 4 – Ch 372/1988, Ohesaare core, depth 441.5 m. 5–6 – Seliste core, depth 340.3 m. 5 – Ch 373/9540; 6 – Ch 374/9540.

Figs 7–8. *Cyathochitina kuckersiana* (Eisenack). Varbla core, depth 189.8 m; Raikküla Stage; x 200. 7 – Ch 375/1367; 8 – Ch 376/1367.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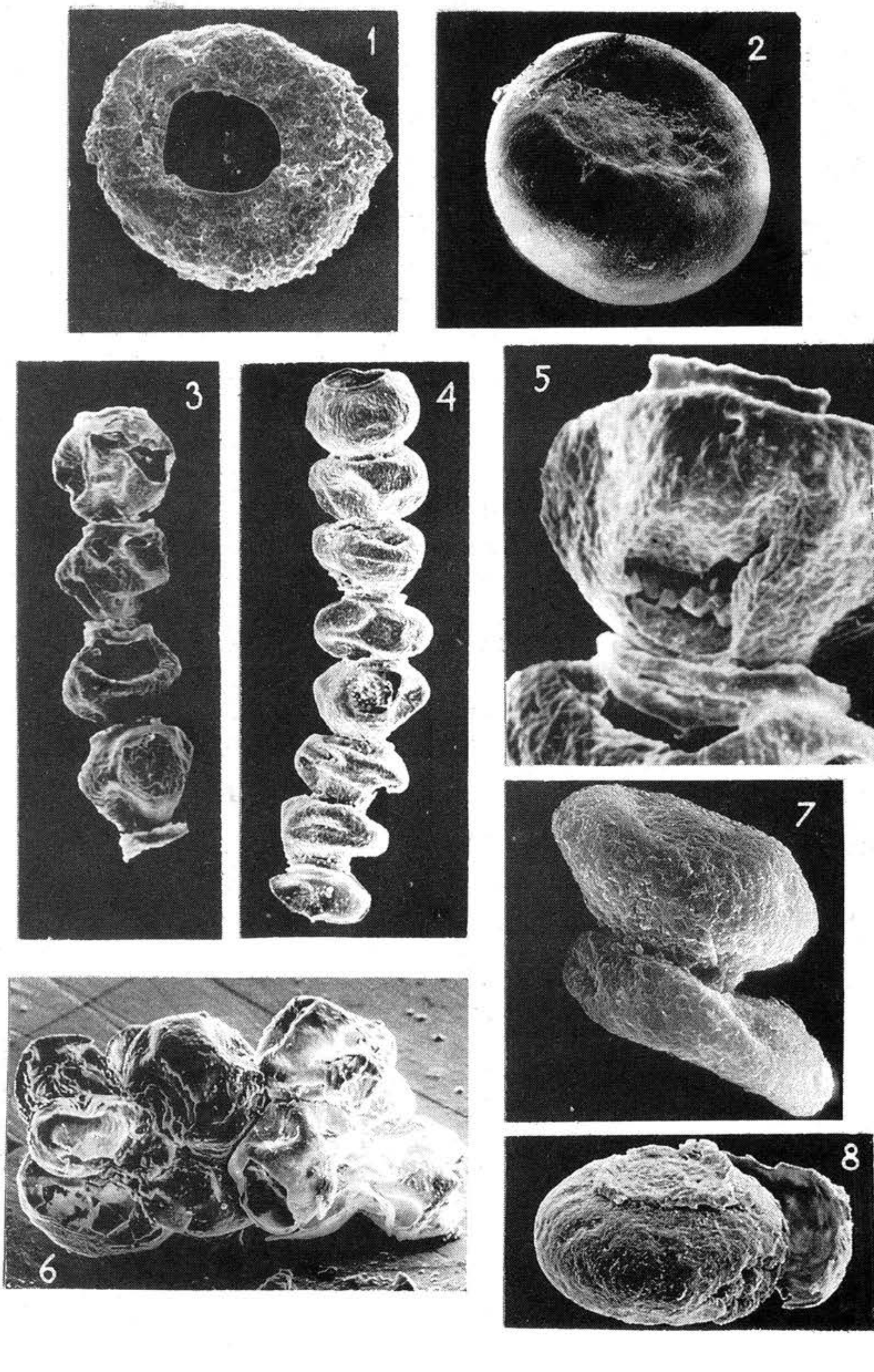


Plate XXIV

Figs 1–2. *Calpichitina acollaris* (Eisenack); Jaani Stage; x 365. 1 – Ch 148/1828, Ruhnu core, depth 417.5 m. 2 – Ch 377/9227, Suuriku outcrop.

Figs 3–5. *Densichitina densa* (Eisenack); Adavere Stage. 3 – Ch 378/1089, Kirikuküla core, depth 18.8 m; x 365. 4 – Ch 100/9272, Pulli core, depth 37.25 m; x 200. 5 – Ch 442/1087 (detail), Kirikuküla core, depth 21.5 m; x 1085.

Fig. 6. *Densichitina* sp. Ch 379/1942; Ohesaare core, depth 338.25; Jaani Stage; x 365.

Figs 7–8. *Densichitina opaca* (Laufeld); Jaani Stage. 7 – Ch 380/1963, Ohesaare core, depth 342.2 m; x 605. 8 – Ch 147/9272, Pulli 2 core, depth 14.2–3 m; x 525.

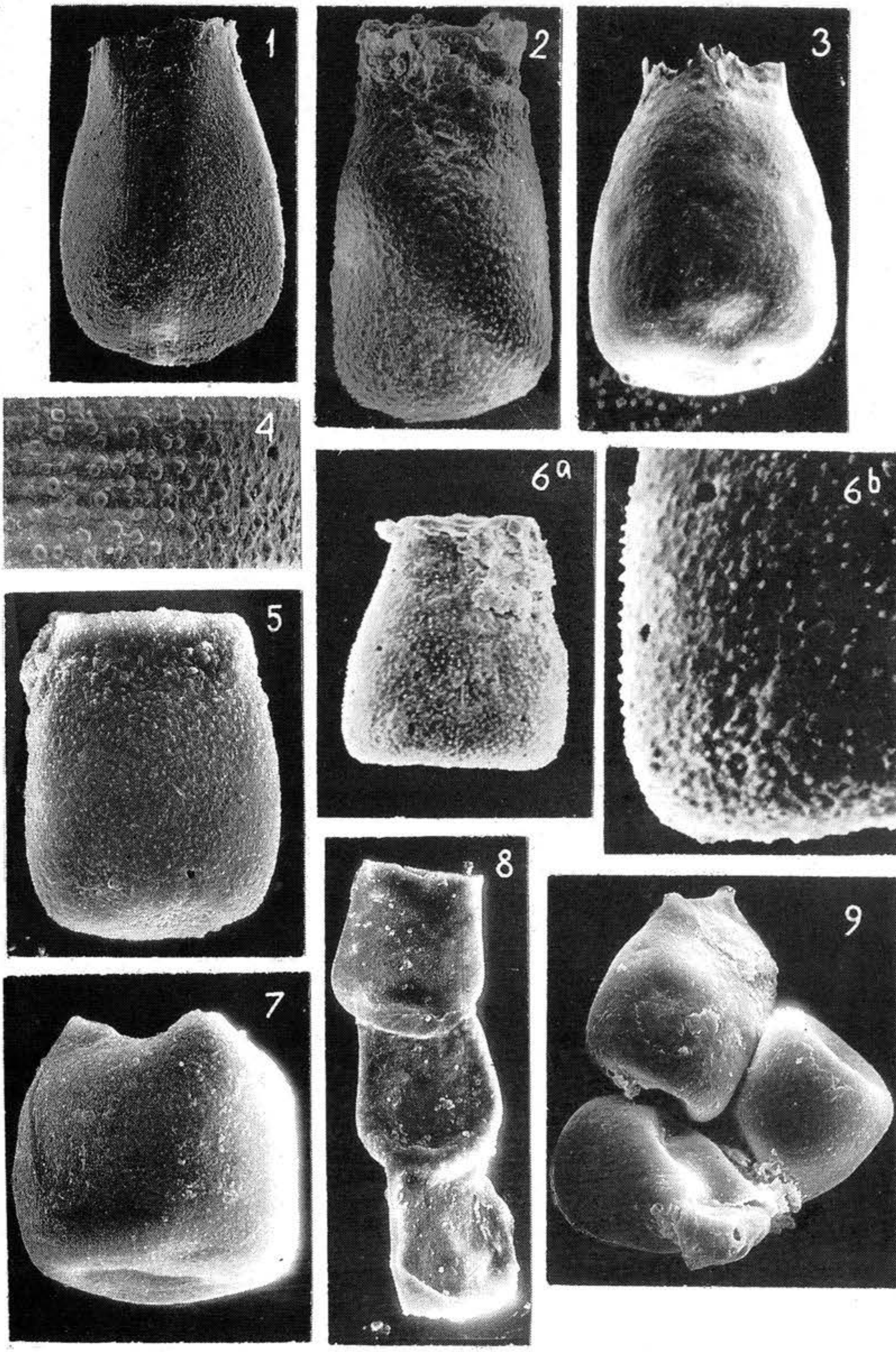
Plate XXV

Figs 1–4. *Eisenackitina dolioliformis* Umnova. 1 – Ch 110/9188, Tôlla core, depth 126.10 m; Jaani Stage; x 365. 2 – Ch 381/1395, Varbla core, depth 141.35 m; Adavere Stage; x 365. 3 – Ch 382/1399, Varbla core, depth 132.9 m; Jaani Stage; x 365. 4 – Ch 443/9233 (detail), Pulli 2 core, depth 59.8 m; Adavere Stage; x 1085.

Figs 5–6. *Eisenackitina* sp. 1. 5 – Ch 383/1733, Ruhnu core, depth 459.2 m; Adavere Stage; x 700. 6 – Ch 384/1963, Ohesaare core, depth 342.2 m; Jaani Stage; 6a – x 525, 6b – x 1630.

Figs 7–9. *Nanochitina nana* gen. et sp. n. 7 – Ch 385/10373, Nagli core, depth 609 m; Jaani Stage; x 735. 8 – Ch 386/10370, Nagli core, depth 615.3 m; Adavere Stage; x 335. 9 – Ch 387/1962 (HT), Ohesaare core, depth 343.75 m; Jaani Stage; x 410.

XXV



XXVI

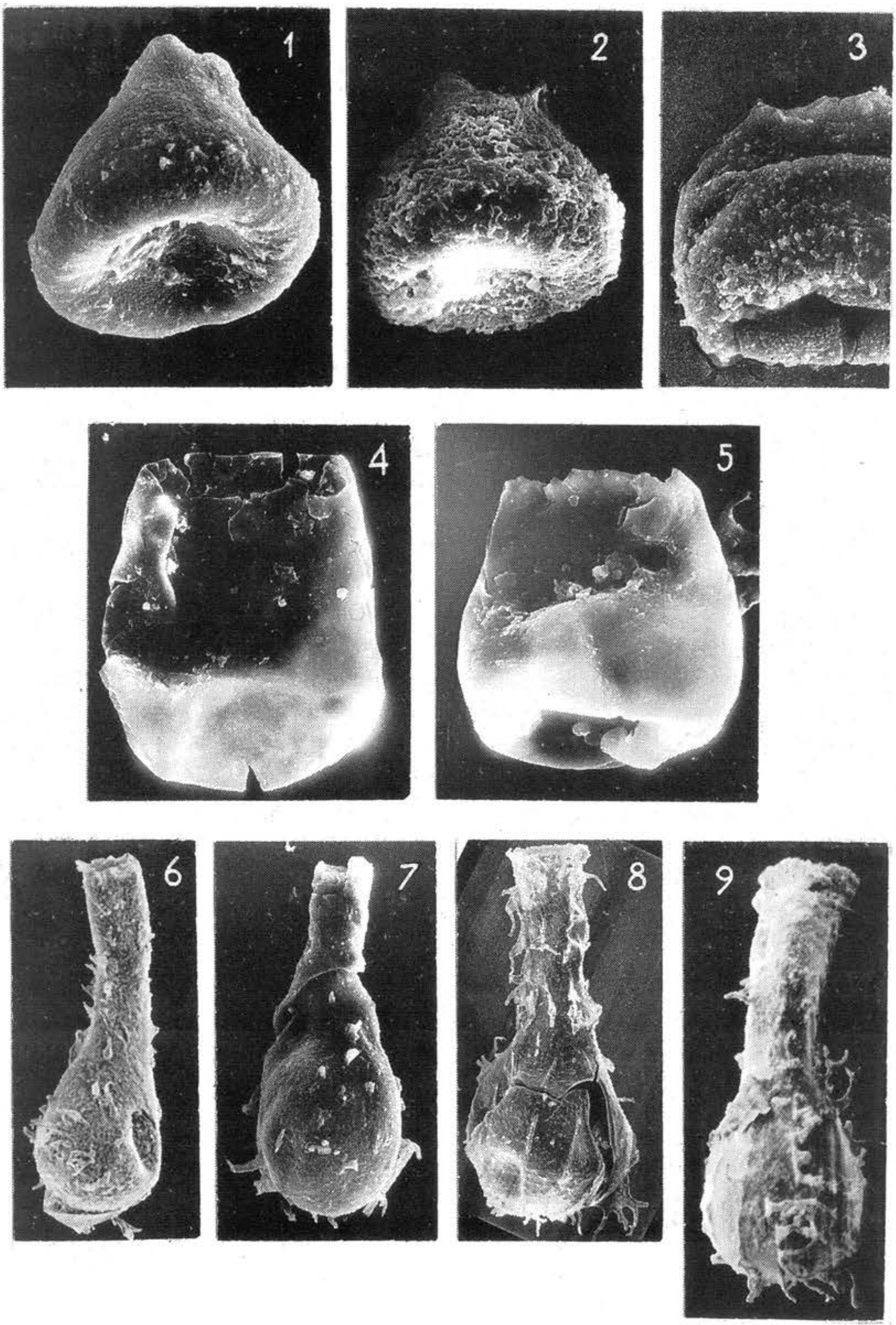


Plate XXVI

Figs 1–3. *Eisenackitina*? sp. 2. Nagli core, depth 611.9 m; Adavere Stage. 1 – Ch 388/10372; x 440. 2 – Ch 389/10372; x 515. 3 – Ch 444/10372 (vesicle fragment); x 275.

Fig. 4. *Eisenackitina*? sp. 3. Ch 390/9018, Häädemeeste core, depth 311.23 m; Raikküla Stage, x 420.

Fig. 5. *Eisenackitina*? sp. 4. Ch 391/650, Ohesaare core, depth 169.5 m; Jaagarahu Stage; x 710.

Fig. 6. *Gotlandochitina*? *angusta* Nestor; Jaani Stage. Ch 111/1736 (HT), Ruhnu core, depth 454.05 m; x 200.

Fig. 7. *Gotlandochitina* cf. *angusta* Nestor. Ch 392/10356, Nagli core, depth 641.2 m; Adavere Stage; x 310.

Figs 8-9. *Gotlandochitina costata* (Umnova); Jaagarahu Stage. 8 – Ch 157/1572; Ohesaare core, depth 291.3 m; x 350. 9 – Ch 393/1757, Ruhnu core, depth 379 m; x 365.

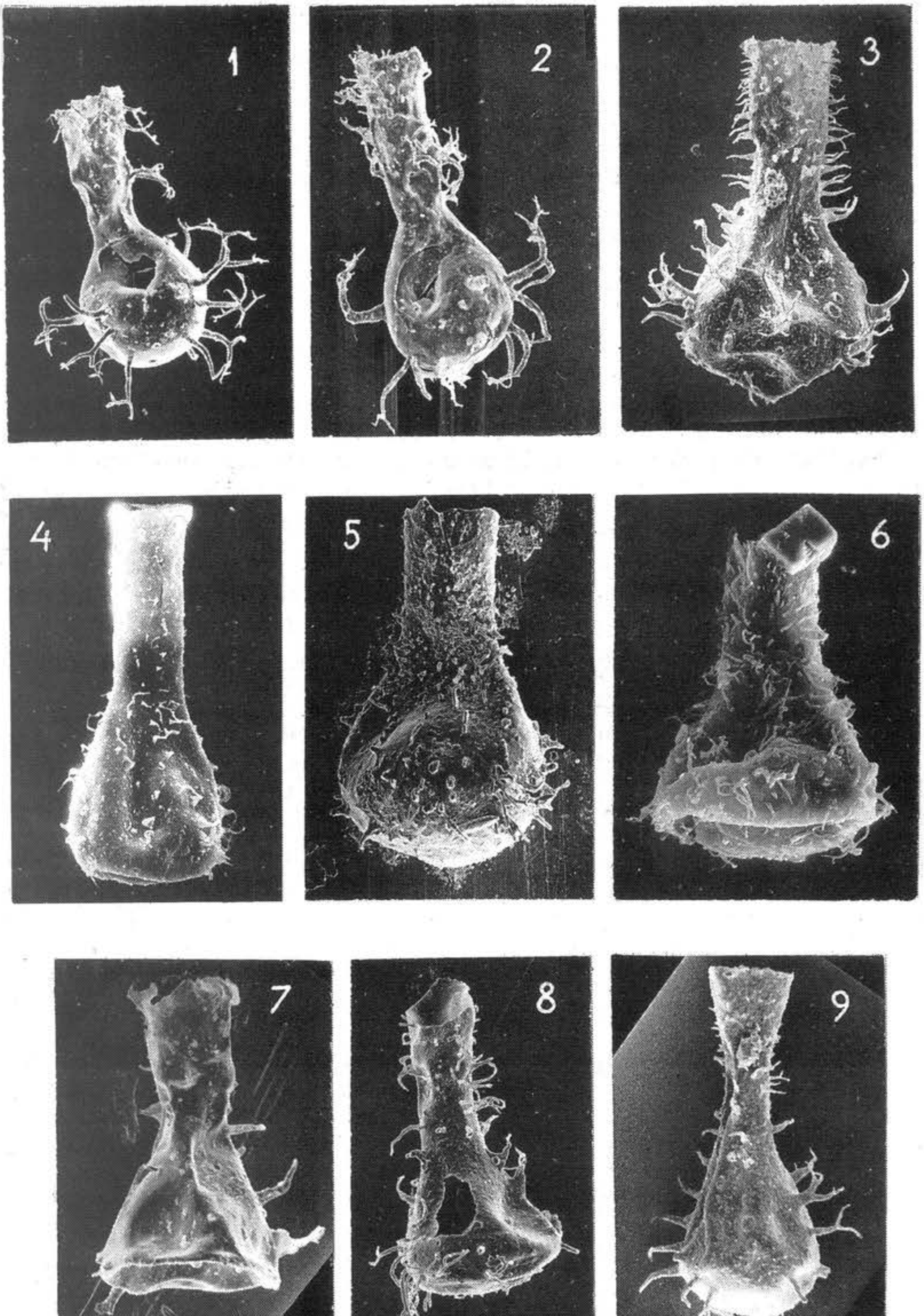
Plate XXVII

Figs 1–2. *Gotlandochitina magnifica* Nestor, Ruhnu core, depth 454.05 m; Jaani Stage; x 245. 1 – Ch 394/1736 (HT). 2 – Ch 395/1736.

Fig. 3. *Gotlandochitina martinssoni* Laufeld, Ch 156/1572, Ohesaare core, depth 291.3 m; Jaagarahu Stage; x 350.

Figs 4–6. *Gotlandochitina ruhnuensis* Nestor. 4 – Ch 466 /10669, Jaagarahu core, depth 42.6 m; Jaani Stage; x 320. 5 – Ch 912/9188, Tõlla core, depth 126.1 m; Jaani Stage; x 350. 6 – Ch 397/1093, Kirikuküla core, depth 11.5 m; Adavere Stage; x 510.

Figs 7–9. *Gotlandochitina spinosa* (Eisenack); Jaagarahu Stage; x 350. 7 – Ch 159/1577, Ohesaare core, depth 266.5 m. 8 – Ch 398/1580, Ohesaare core, depth 247.5 m. 9 – Ch 161/1602, Ohesaare core, depth 178.9 m.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XXVIII

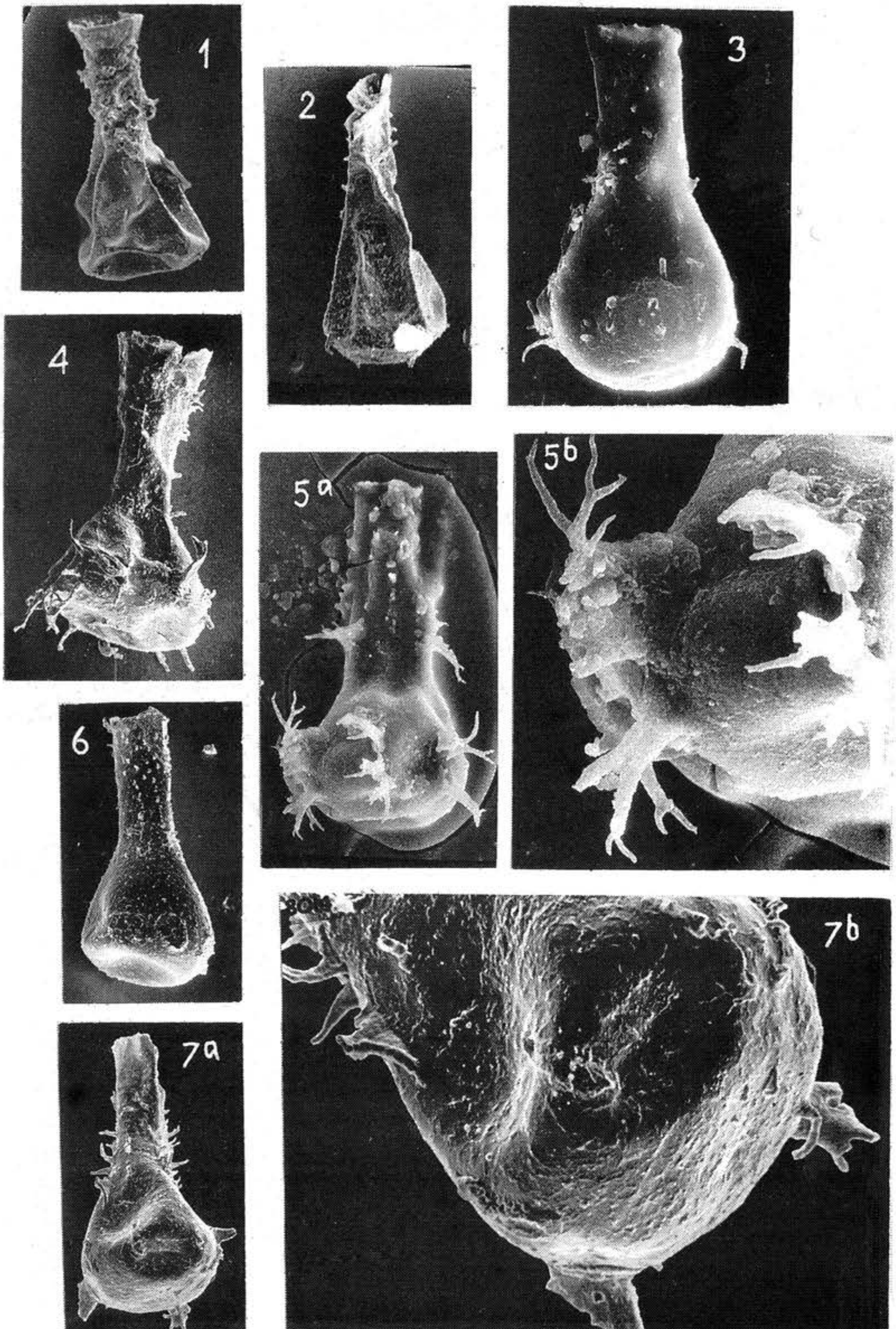


Plate XXVIII

Figs 1–2. *Gotlandochitina tabernaculifera* Laufeld, Ohesaare core, depth 145 m; Rootsiküla Stage; x 525. 1 – Ch 162/658; 2 – Ch 399/658.

Fig. 3. *Gotlandochitina* sp. Ch 400/1738, Ruhnu core, depth 441.65; Jaani Stage; x 310.

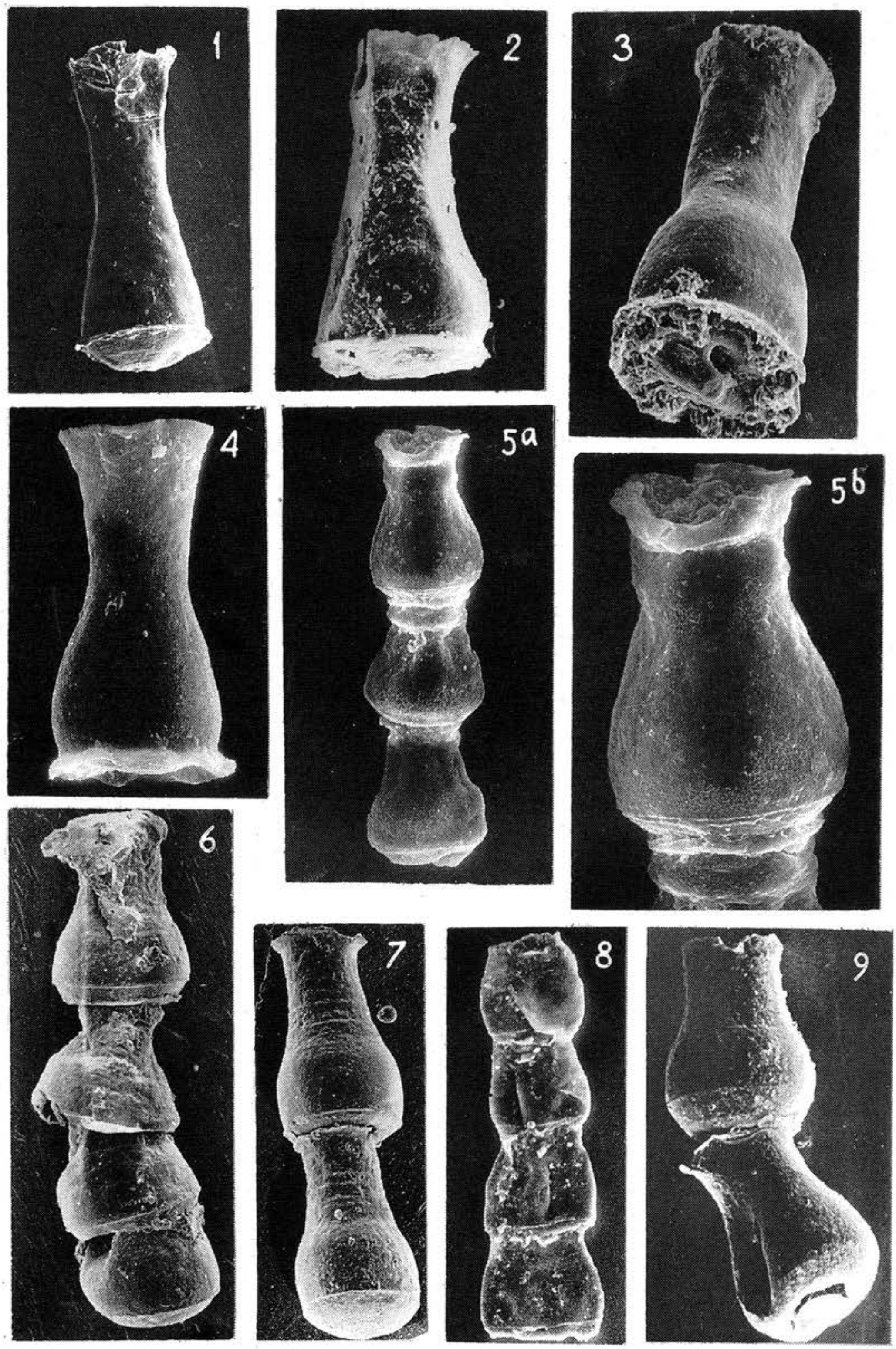
Figs 4–5. *Gotlandochitina uncinata* Laufeld; Jaagarahu Stage. 4 – Ch 402/1760, Ruhnu core, depth 371.5 m; x 350. 5 – Ch 401/1761, Ruhnu core, depth 368.5 m; 5a – x 395; 5b – x 1120.

Figs 6–7. *Gotlandochitina* cf. *valbyttiensis* Laufeld; Jaagarahu Stage. 6 – Ch 403/1962, Ohesaare core, depth 282 m; x 365. 7 – Ch 158/1842, Ruhnu core, depth 370 m; 7a – x 245; 7b – x 1085.

Plate XXIX

Figs 1–4. *Cingulochitina cingulata* (Eisenack); Jaagarahu Stage. 1 – Ch 151/1952, Ohesaare core, depth 294.16 m; x 350. 2 – Ch 404/1969, Ruhnu core, depth 344.5 m; x 525. 3 – Ch 405/1578, Ohesáare core, depth 260.3 m; x 525. 4 – Ch 406/1764, Ruhnu core, depth 359.25 m;x 510.

Figs 5–9. *Cingulochitina crassa* sp. n. 5 – Ch 407/9458 (HT), Ventspils core, depth 708 m; Jaagarahu Stage; 5a – x 320, 5b – x 720. 6–7. Ventspils core, depth 701 m; Jaagarahu Stage; x 365. 6 – Ch 408/9461; 7 – Ch 409/9461. 8 – Ch 410/9475, Ventspils core, depth 663 m; Rootsiküla Stage; x 230. 9 – Ch 163/1773, Ruhnu core, depth 333 m; Jaagarahu Stage; x 365.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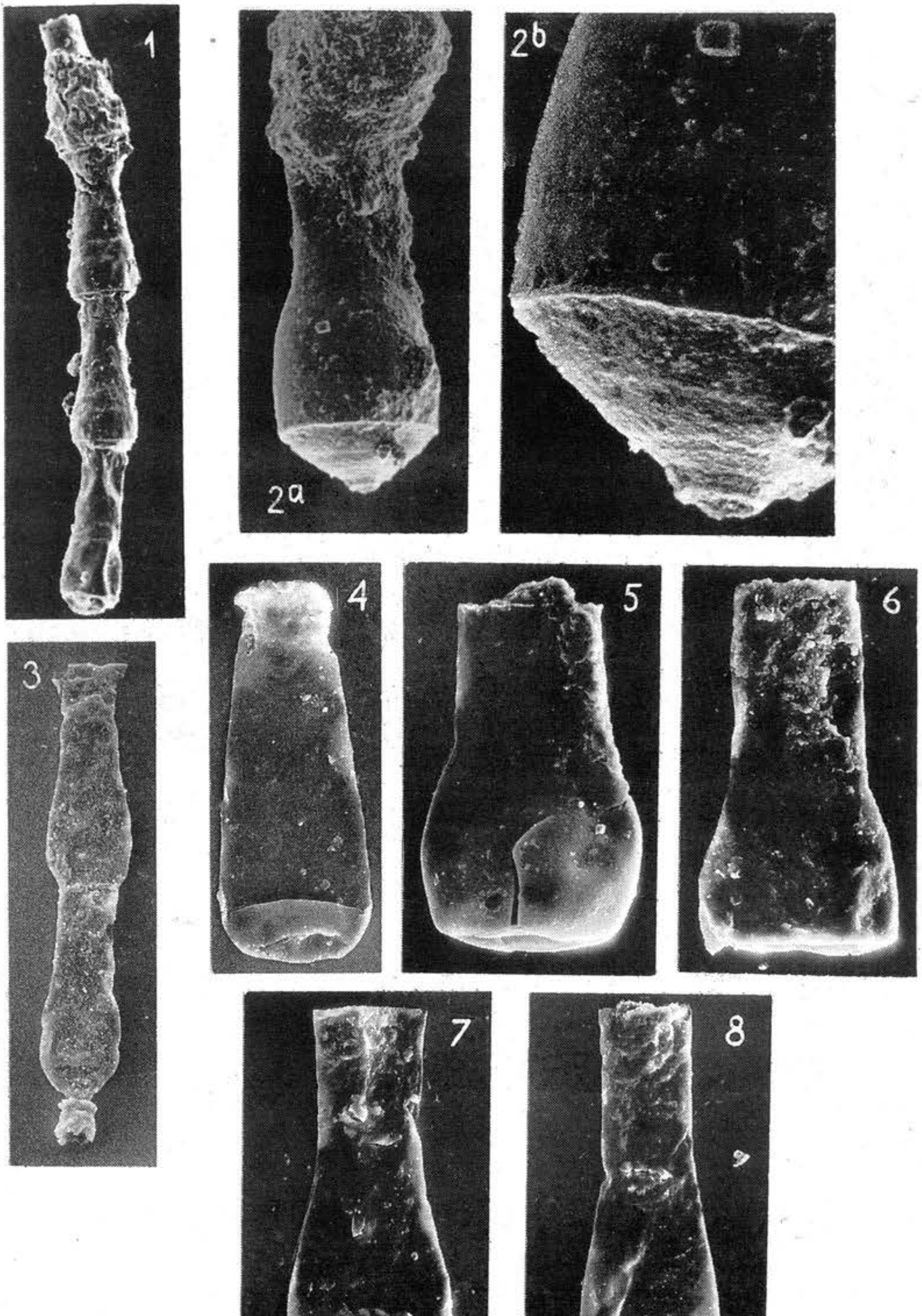


Plate XXX

Figs 1–2. *Cingulochitina baltica* sp. n., Jaagarahu Stage. 1 – Ch 152/1959 (HT), Ohesaare core, depth 245.6 m; x 200. 2 – Ch 411/644, Ohesaare core, depth 244 m; 2a – x 525; 2b – x 1630.

Fig. 3. *Linochitina odiosa* Laufeld. Ch 412/9428, Ventspils core, depth 767 m; Jaagarahu Stage; x 200.

Fig. 4. *Vitreachitina* sp. 1. Ch 413/10354, Nagli core, depth 645.4–6 m; Adavere Stage; x 330.

Figs 5-6. *Vitreachitina* sp. 2. 5 – Ch 414/10364, Nagli core, depth 625.1 m; Adavere Stage; x 455. 6 – Ch 415/10452, Viki core, depth 171.6 m; Adavere Stage; x 455.

Figs 7–8. *Vitreachitina* sp. 3, Nagli core, depth 633.1 m; Adavere Stage. 7 – Ch 417/10360; x 370. 8 – Ch 417/10360; x 345.

Plate XXXI

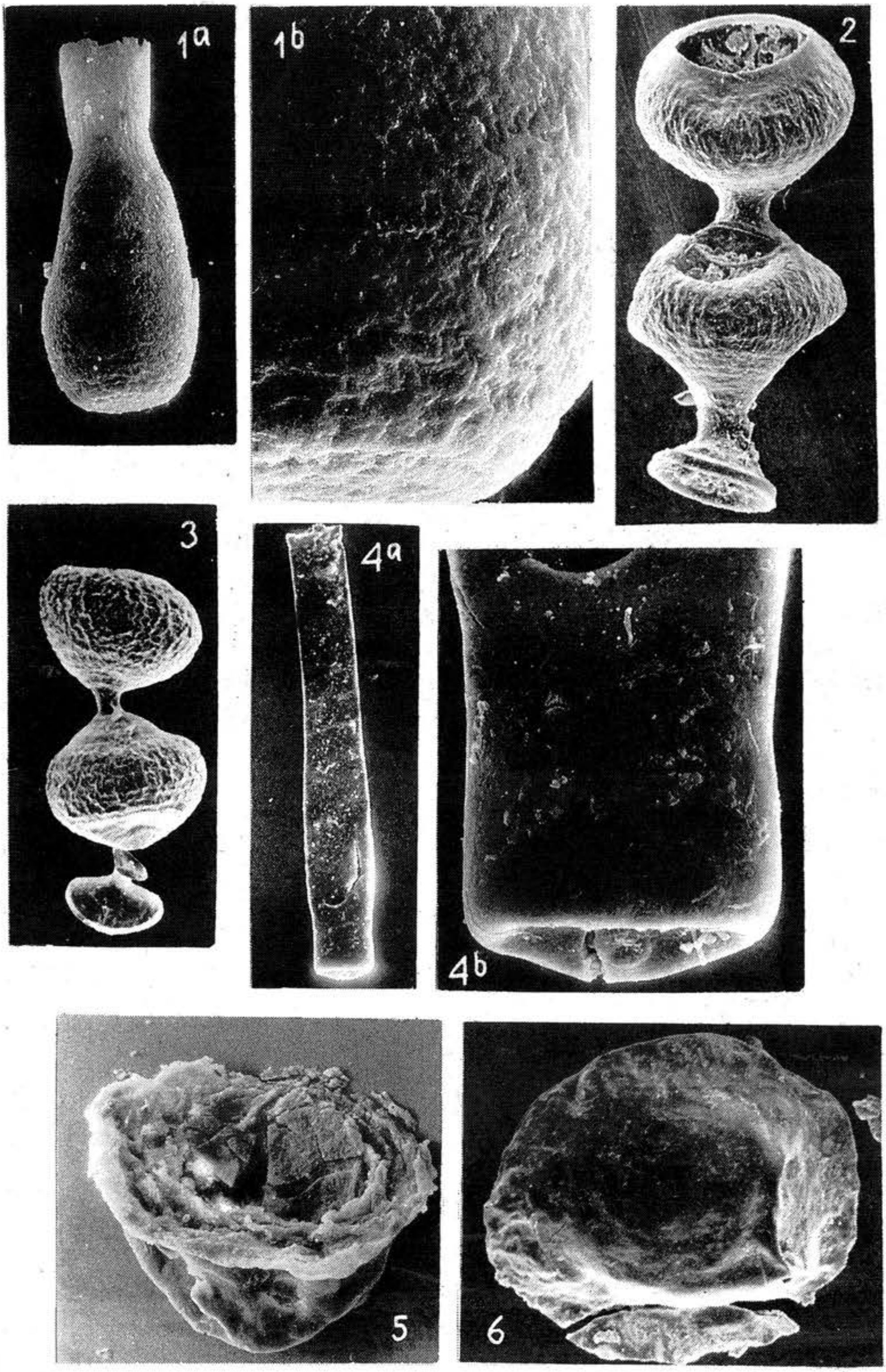
Fig. 1. *Lagenochitina*? sp. Ch 418/10395, Nagli core, depth 676 m; Juuru Stage; 1a – x 190, 1b – x 920.

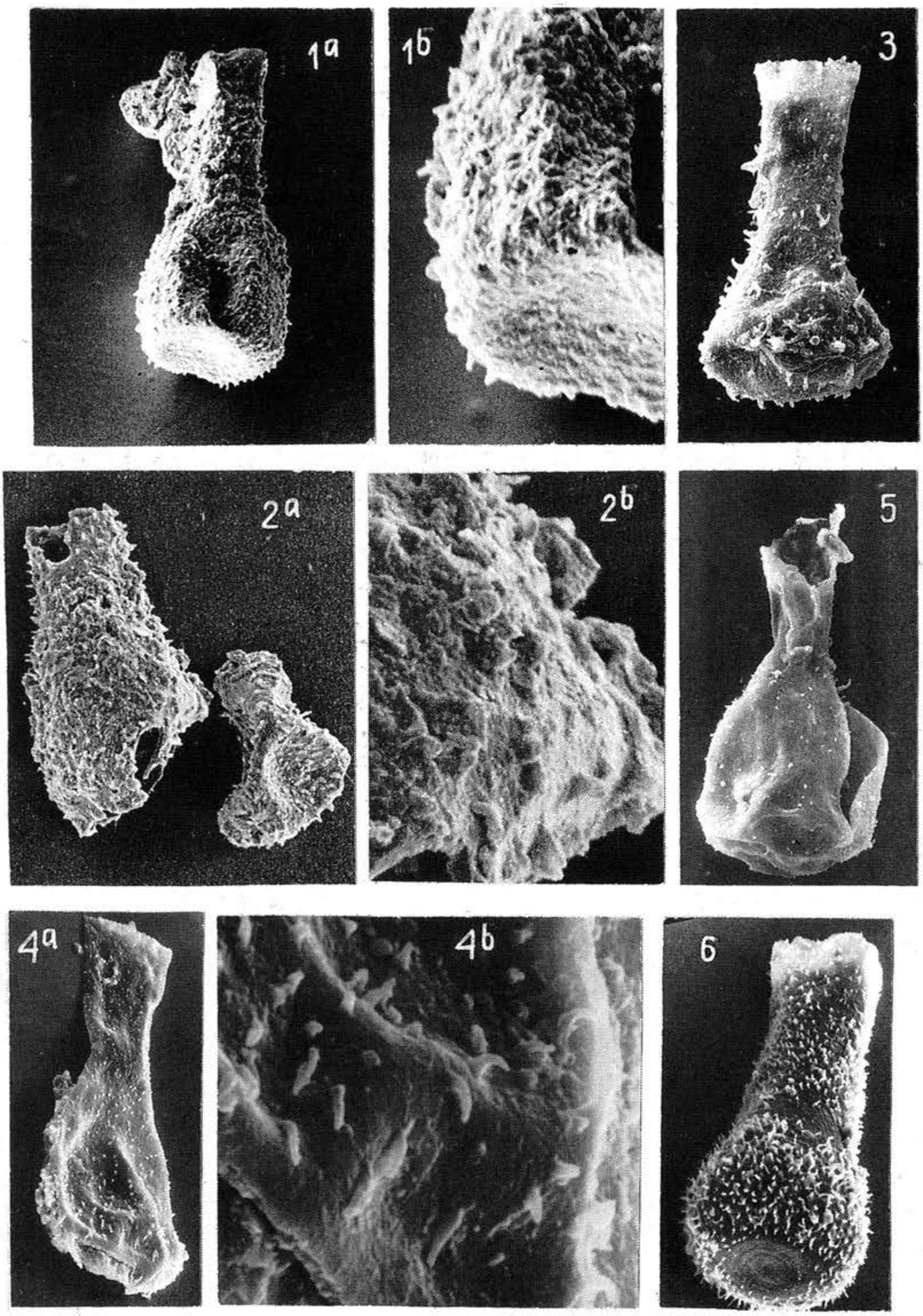
Figs 2–3. *Margachitina margaritana* (Eisenack). 2 – Ch 108/9269, Ohesaare core, depth 300.7 m; Jaani Stage; x 365. 3 – Ch 419/1604, Ohesaare core, depth 174.4 m; Jaagarahu Stage; x 365.

Fig. 4. *Rhabdochitina*? sp. 1, Ch 420/9474, Ventspils core, depth 667 m; Rootsiküla Stage; 4a – x 105, 4b – x 580.

Figs 5–6. *Pterochitina macroptera* (Eisenack), Pulli core, depth 17.7 m; Jaani Stage. 5 – Ch 421/9269; x 260. 6 – Ch 108/9269; x 200.

XXXI




1a
1b
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2a
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Plate XXXII

Figs 1–3. *Sphaerochitina indecora* Nestor; Jaagarahu Stage. 1 – Ch 164/650 (HT), Ohesaare core, depth 169.5 m; 1a – x 365, 1b – x 1085. 2 – Ch 165/1876, Ruhnu core, depth 290 m; 2a – x 365, 2b – x 1630. 3 – Ch 481/10908, Ohesaare core, depth 165.9 m; x 400.

Fig. 4. *Sphaerochitina* sp. 1. Ch 423/952, Ikla core, depth 370.8 m; Raikküla Stage; x 360.

Fig. 5. *Sphaerochitina?* sp. 2. Ch 482/10902, Ohesaare core, depth 161.2 m; Raikküla Stage; x 480.

Fig. 6. *Sphaerochitina*? sp. 3. Ch 424/1793, Ruhnu core, depth 589.2 m; Juuru stage; x 440.