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YNGVE GRAHN

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ABSTRACT

Grahn, Yngve, 1980-05-05: Early Ordovician Chitinozoa from Öland. Sveriges geologiska undersökning, Ser. C, No. 775, pp. 1–41, Uppsala 1980.

The chitinozoans from fourteen localities through the Ontikan (Early Ordovician) strata of Öland, southeast Sweden, have been investigated. Fifteen species of the genera *Conochitina, Cyathochitina, Desmochitina, Lagenochitina,* and *Rhabdochitina* are described. Only one species, *Lagenochitina tumida,* has a restricted stratigraphical range.

INTRODUCTION

The Isle of Öland is situated in the Baltic, southeast of the mainland of Sweden. Marine Cambrian and Ordovician sediments form the bedrock of the island (Fig. 1). The Lower Ordovician has a maximum thickness of 30 m in the south and about 10 m less in the north. The strike of the strata is roughly parallel to the length orientation of the island, and the dip is generally less than 2° eastwards.

This paper is the first of three dealing with Ordovician Chitinozoa from Öland. It is based on three borings and eleven outcrops in Ontikan (Early Ordovician) beds (Fig. 1). Ontikan beds include strata from the base of the Zone of *Tetragraptus approximatus* up to the *Didymograptus bifidus – Didymograptus murchisoni* zonal boundary (Fig. 2). The definition of the Ontikan Stage has been discussed by Jaanusson (1957:151–155; 1960b:292–302).

At present it is not possible to review concisely the lithologies of the Ontikan of Öland, because the lithologies are different in the north and south of the island and, furthermore, change locally within these areas. Secondly, very little is known about sequences of the Volkhov and Kunda Stages in southern Öland. However, Fig. 2 is an attempt to summarize the Ontikan stratigraphy of Öland.

HISTORICAL REVIEW

Linnarsson (in Nathorst 1881:593) and Tullberg (1882) made the first attempts to subdivide the Ordovician limestones of Öland. Both Linnarsson's and Tullberg's classifications were lithostratigraphical and based on rock colour. Tullberg (1882:232) subdivided Linnarsson's "Upper Red Orthoceras Limestone" into a lower part yielding trilobites of the *Megalaspis gigas* group and an upper part with *Asaphus platyurus*. The same year Holm pointed out the possibility of subdividing the upper Lower Ordovician of northern Öland using trilobites. Based upon trilobites, the first "complete" biostratigraphical zonation of the "Orthoceras limestone" of the island was established by Moberg (1890). His zonation was based on a sequence of strata in southernmost Öland. For almost sixty years Moberg's classification found wide use. For the lower part of the sequence he suggested the following units:

Gigas Limestone	
Transition Beds	
	Upper *Asaphus* Limestone
Asaphus Limestone	Sphaeronite Band
	Lower *Asaphus* Limestone
Limbata Limestone	
Planilimbata Limestone	

Holm (1893) introduced the *Vaginatum* Region for beds with *Endoceras vaginatum* which correspond to the *Asaphus* to *Gigas* limestone inclusive. In the sea-stack area

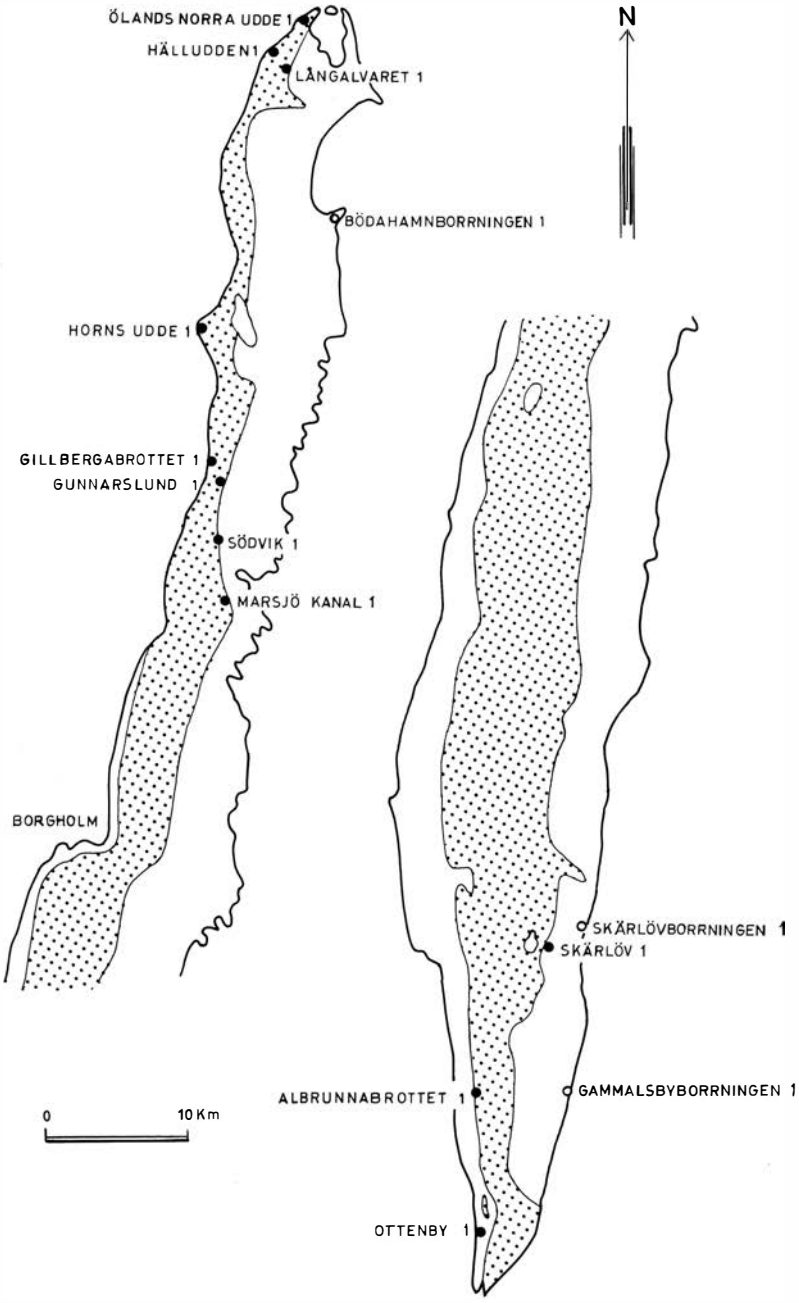


Fig. 1. Map showing Ontikan (Early Ordovician) localities. Filled circles indicate outcrops and open circles borings. The distribution of Ontikan rocks at the base of the Pleistocene is screened on the figure. Pre-Ontikan beds crop out to the west and post-Ontikan beds to the east.

BRITISH SERIES	BALTOSCANDIAN STAGES	BALTOSCANDIAN SUBSTAGES	BRITISH GRAPTOLITE ZONES	TRILOBITE ZONES	CONODONT ZONES	LITHOLOGY
LLANVIRN	KUNDA B_{III}	ALUOJA	DIDYMOGRAPTUS "BIFIDUS"	*MEGISTASPIS GIGAS*	*AMORPHOGNATHUS VARIABILIS*	RED AND GREY AND GREEN-MOTTLED ARENITIC LIMESTONE IN NORTH. REDDISH BROWN LIMESTONE IN SOUTH
				MEGISTASPIS OBTUSICAUDA		
		VALASTE		*ASAPHUS RANICEPS*		GREY ARENITIC AND SOME GLAUCONITIC LIMESTONE IN NORTH. MORE RED-MOTTLED LIMESTONE IN SOUTH
?		HUNDERUM	?	*ASAPHUS EXPANSUS*		GREY GLAUCONITIC LIMESTONE IN NORTH. NON-GLAUCONITIC LIMESTONE IN SOUTH
ARENIG	VOLKHOV B_{II}	LANGEVOJA	DIDYMOGRAPTUS *HIRUNDO*	*ASAPHUS LEPIDURUS*	*MICROZARKODINA PARVA*	GREY GLAUCONITIC LIMESTONE IN NORTH. MORE REDDISH LIMESTONE IN SOUTH
		"LIMBATA"		?	*PAROISTODUS ORIGINALIS*	RED–BROWN TO GREY LUTITIC LIMESTONE
			DIDYMOGRAPTUS *EXTENSUS*	*MEGISTASPIS LATA*	*BALTONIODUS NAVIS*	
					BALTONIODUS TRIANGULARIS	
	LATORP B_{I}	BILLINGEN		*MEGISTASPIS ESTONICA*	*PRIONIODUS EVAE*	RED–BROWN AND GREY GLAUCONITIC LIMESTONE, IN CENTRAL ÖLAND RED LIMESTONE
				MEGALASPIDES DALECARLICUS	*PRIONIODUS ELEGANS*	
		HUNNEBERG	(TETRAGRAPTUS *APPROXIMATUS*)	*MEGISTASPIS PLANILIMBATA*	*PAROISTODUS PROTEUS*	RED OR GREY GLAUCONITIC LIMESTONE
				MEGISTASPIS ARMATA		

Fig. 2. Diagram showing correlation and lithology of Ontikan rocks on Öland. Based mainly on Jaanusson (1955, 1960b, pers. comm. 1979) and Lindström (1971).

at Byerum (NW Öland) Andersson (1895) distinguished within the *Asaphus* Limestone an oolitic limestone bed followed by glauconitic limestone and then non-glauconitic limestone. Wiman's descriptions to the geological map sheets (1902a, 1902b, 1904a, 1904b) do not add to the pioneer papers referred to above.

Moberg and Segerberg (1906:43) proposed that the lowermost *Planilimbata* Limestone belonged to the underlying *Ceratopyge* Beds. In two papers Regnéll (1940, 1942) subdivided the *Planilimbata* Limestone into two lithologically and palaeontologically defined zones in central Öland (Upper and Lower *Planilimbata* Limestone). He considered that the Lower *Planilimbata* Limestone should include the upper parts of the *Ceratopyge* Beds.

Through the work of Bohlin (1949, 1955) and Tjernvik (1956) a modern trilobite zonation was established for the Lower Ordovician of Öland (Fig. 2). Except for those lowermost, the trilobite zones are still in use, formalized into stratigraphical units. Revision of these units is badly needed. Correlation with graptolite zones has been established through the work of Tjernvik (1956), Jaanusson (1960b) and Skevington (1965). Lindström (1960, 1971) showed that conodonts were valuable zone fossils especially in the lower part of the Lower Ordovician (Fig. 2).

The stratigraphy used here (Fig. 2) was introduced by Jaanusson (1960b). As stated in the Introduction, the Ontikan sequence comprises strata from basal Arenig to the base of the *Didymograptus murchisoni* zone.

Eisenack (1962a, 1968b, 1976b) described Ontikan Chitinozoa from three localities on Öland. Two of these, Hälludden and Horns udde, are treated in this paper. From the latter locality Eisenack reported four species of which one, *Conochitina* cf. *elegans,* has not been recovered in this study. He suggested a

Hunderum age for these samples, but most probably they are from Upper Langevoja. This is also true of the third locality, Köpings klint, where a single sample yielded the following chitinozoans: *Conochitina minnesotensis, Cyathochitina calix, Desmochitina* cf. *cocca,* and *Rhabdochitina gracilis.*

SAMPLES AND LOCALITIES

In all, 235 samples from fourteen localities have been examined. Each of these samples were crushed to hazelnut-sized pieces, then 50 g of the crushed sample as a standard was put in 600 cc polyethylene beakers. The chips were treated with 10% hydrochloric acid until the reaction almost ceased. Concentrated acid was then added. After dissolution in hydrochloric acid the samples were etched in concentrated hydrofluoric acid and finally in concentrated nitric acid. Samples still rich in kerogen after this treatment were boiled for ten minutes in nitric acid. Between the various acid treatments the residue was diluted with water, and then rinsed through a nylon sieve (36 μm) under gently running water. The organic residue was stored in 60 ml beakers with distilled water and a few drops of formaldehyde until being picked for SEM-studies.

Altogether about 8000 specimens of Chitinozoa were recovered. Only about 50% of the localities and about 22% of the samples yielded chitinozoans.

The main field work was carried out by Sven Laufeld in August 1966, and I completed it in August 1978. The localities studied (Fig. 1) are described in alphabetical order, and their positions are given in UTM co-ordinates.

ALBRUNNABROTTET 1, WC 8880 4375, c. 2 950 m SSE of Södra Möckleby church.

Topographical map sheet 3G Kristianopel NO. Geological map sheet Ac 7 Ottenby.

Quarry, c. 1 km E of the main road between Södra Möckleby and Ventlinge.

Reference point: Quarry wall in the southernmost part of the quarry.

Upper Cambrian – Lower Valaste.

My study was restricted to the Tremadocian – Lower Valastean sequence. For sampling, see Fig. 3. No Chitinozoa were recorded.

BÖDA HAMNBORRNINGEN 1, XD 2556 4680, c. 1 950 m E of Böda church.

Topographical map sheet 5H Borgholm NV/NO. Geological map sheet Ac 5 Oskarshamn.

Core drilling (T.D. 167.5 m) made by the Palaeontological Institute of Uppsala University in 1948 at the beach c. 400 m NW of Böda pier-beacon. The diameter of the core is 7 cm.

Archaean – Lower Kukruse (Upper Llandeilo).

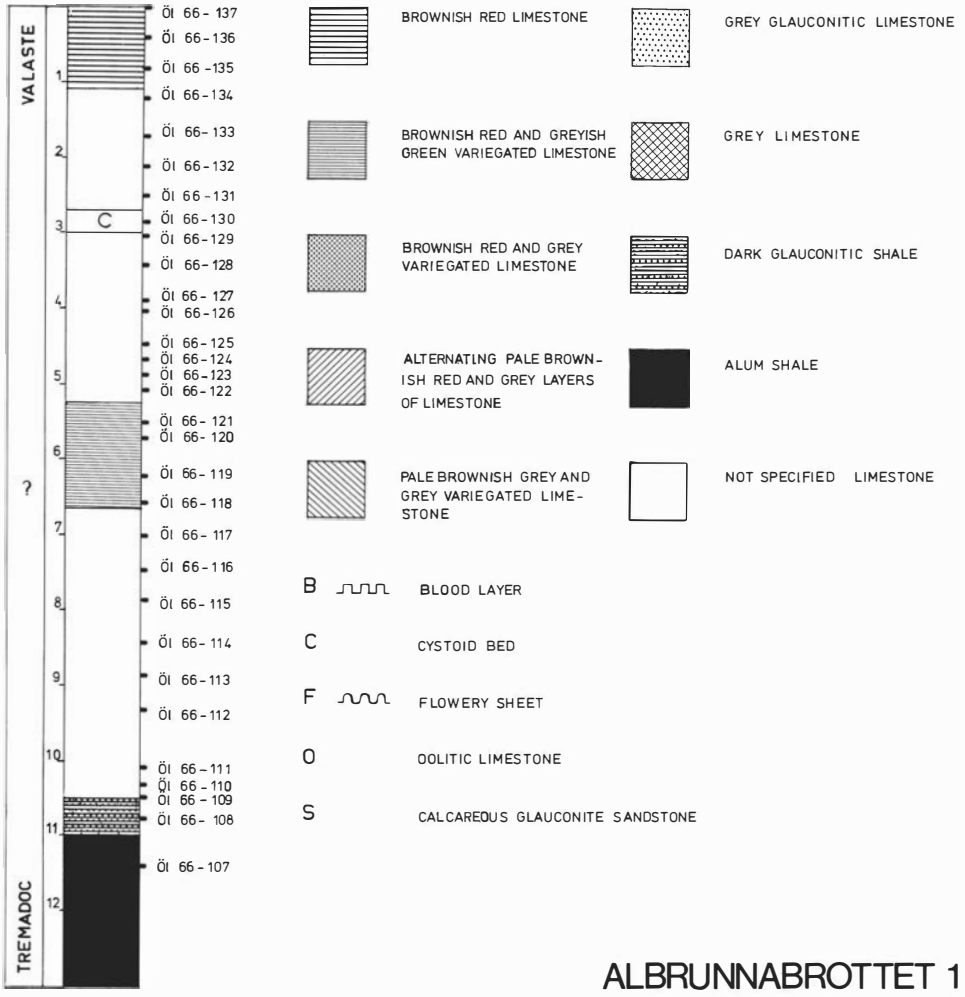


Fig. 3. Albrunnabrottet 1, lithology and sample levels. Based mainly on Laufeld (unpublished material).

References: Bohlin 1955, pp. 111–151; Hessland 1955, pp. 35–110; Jaanusson 1955, pp. 153–174; Jaanusson 1960a, pp. 231–246; Lindström 1960, pp. 88–96; Tjernvik 1956, pp. 154–155; Waern 1952, pp. 223–250.

Thirty-five samples were processed from the Billingian-Aluojan of the Ontikan part of the core, shown in Fig. 4.

GAMMALSBYBORRNINGEN 1, WC 9510 4295, c. 1 900 m NE of Gräsgård church.

Topographical map sheet 3G Kristianopel NO. Geological map sheet Ac 7 Ottenby.

Core drilling (T.D. 54.58 m) made by the Geological Survey of Sweden in 1943

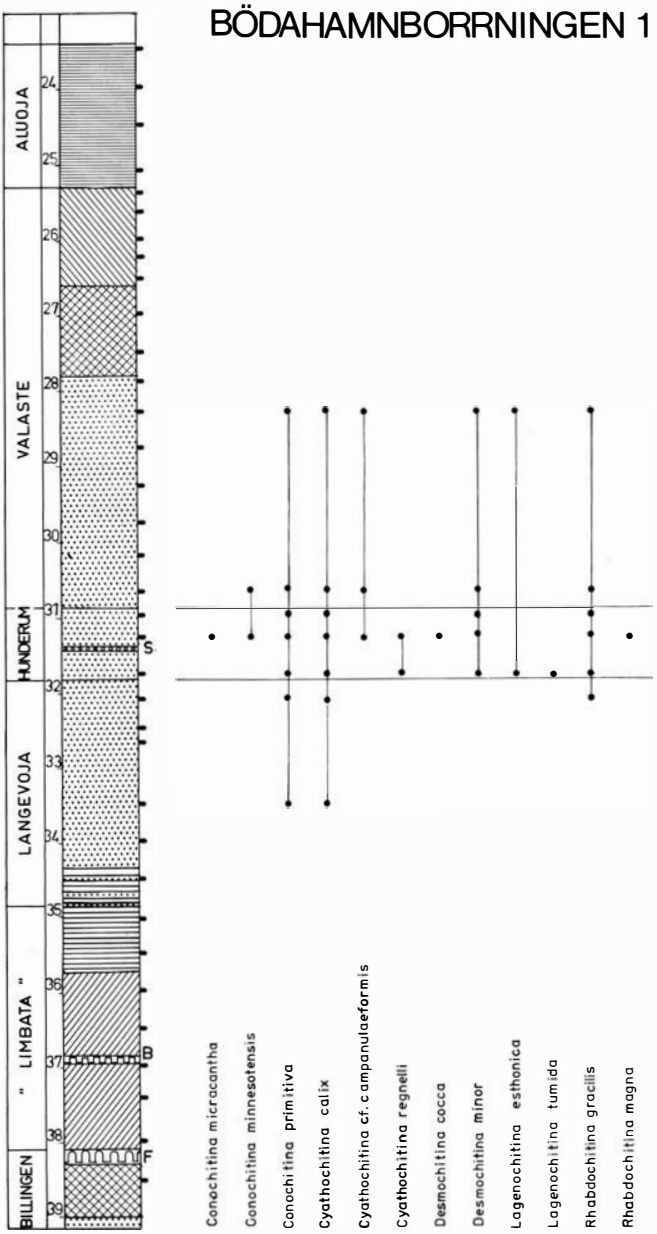


Fig. 4. Bödahamnborrningen 1, lithology and sample levels in the Ontikan part of the core. Based on Jaanusson (1955). For legend, see Fig. 3.

at the beach c. 275 m N of the harbour of Gräsgård. The diameter of the core is 7 cm.

Lower Cambrian – Uhaku (Llandeilo).

References: Jaanusson 1960a, pp. 258–268, 270–271; Westergård 1944, pp. 1–13; Westergård 1947, p. 3.

From the interval 13.83 to 29.18 m thirty-eight samples were processed. None yielded Chitinozoa.

GILLBERGABROTTET 1, XD 1500 3125, c. 4 400 m WSW of Källa church.

Topographical map sheet 5H Borgholm NV/NO. Geological map sheet Ac 8 Mönsterås med Högby.

Quarry near the coast c. 400 m NE the triangulation point at Grytehamn.

Reference point: Quarry wall in the northernmost part of the quarry.

"Limbata" – Valaste or Aluoja.

References: Bohlin 1949, pp. 543–544.

The stratigraphy used here (Fig. 5) is based on trilobites (Jan Bergström, unpublished material) and conodonts (Anita Löfgren, unpublished material). According to Bergström (unpublished material) the sequence between 3.35 and 4.30 m is equivalent to the Hjorthamn (now officially spelt Jordhamn) Limestone (Bohlin 1949:544). This characteristic limestone is in part grey to brownish-black with a slightly reddish tint and rich in glauconite. The bed forms a good index horizon in the parish of Persnäs. The age is probably Middle Valaste. From this unit and down to the pale brownish limestone within the "Limbata" Limestone the beds are more or less glauconitic.

GUNNARSLUND 1, XD 1575 2985, c. 3 650 m NNE of Persnäs church.

Topographical map sheet 5H Borgholm NV/NO. Geological map sheet Ac 8 Mönsterås med Högby.

Quarry c. 1 250 m ENE of point 14.10 at Adolfsro and N of the road. The quarry lies NW of the quarry mentioned by Bohlin 1949, p. 546 and Jaanusson 1960a, p. 223.

Upper Aluoja – Lower Aseri (Upper Llanvirn).

References (to the area in general): Bohlin 1949, p. 546; Jaanusson 1960a, p. 223.

Red and grey-green variegated limestone of Late Aluojan age is overlain by reddish-brown Segerstad Limestone (Upper Llanvirn). One sample was taken 2 cm above a stylolite seam in uppermost Aluoja. No Chitinozoa were recorded.

HÄLLUDDEN 1, XD 2305 5900, c. 550 m NW of point 1.71 at Nabbelund.

Topographical map sheet 6H Kråkelund SV/SO. Geological map sheet Ac 5 Oskarshamn.

Cliff section along the shore, from Höga Flisa c. 1 250 m NE of the lighthouse at the harbour of Byxelkrok to Hälluddsvik c. 550 m NW of point 1.71 at Nabbelund.

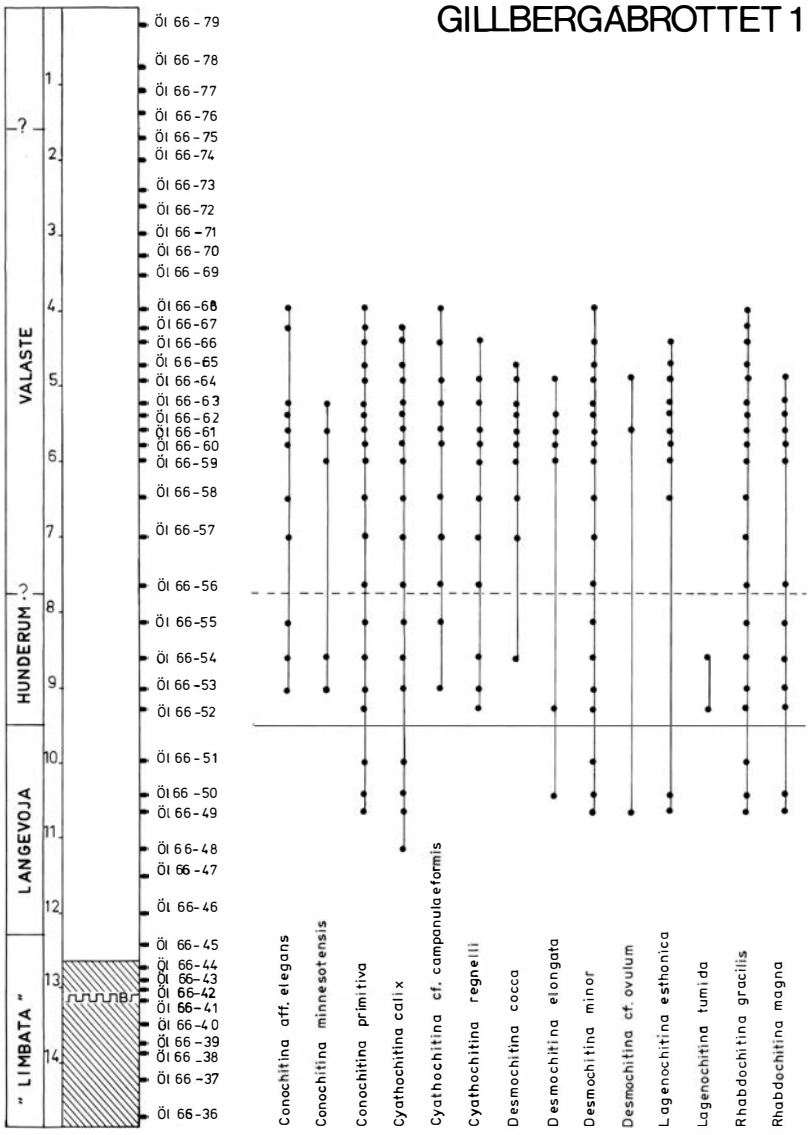


Fig. 5. Gillbergabrottet 1, lithology and sample levels. Based on Laufeld (unpublished material). For legend, see Fig. 3.

Reference point: Cape at Hälluddsvik.

"Limbata" – Lower Valaste.

References: Bohlin 1949, pp. 540–542; Bulman 1936, pp. 1–107; Eisenack 1968b, p. 186; Eisenack 1976b, pp. 181–203; Hadding 1958, pp. 133–134; Holm 1893, p. 15; Holm 1895b, pp. 332–339; Jaanusson 1957, pp. 158–159; Skevington 1963, pp. 1–62; Skevington 1965, pp. 1–74; Wiman 1904a, pp. 43–44.

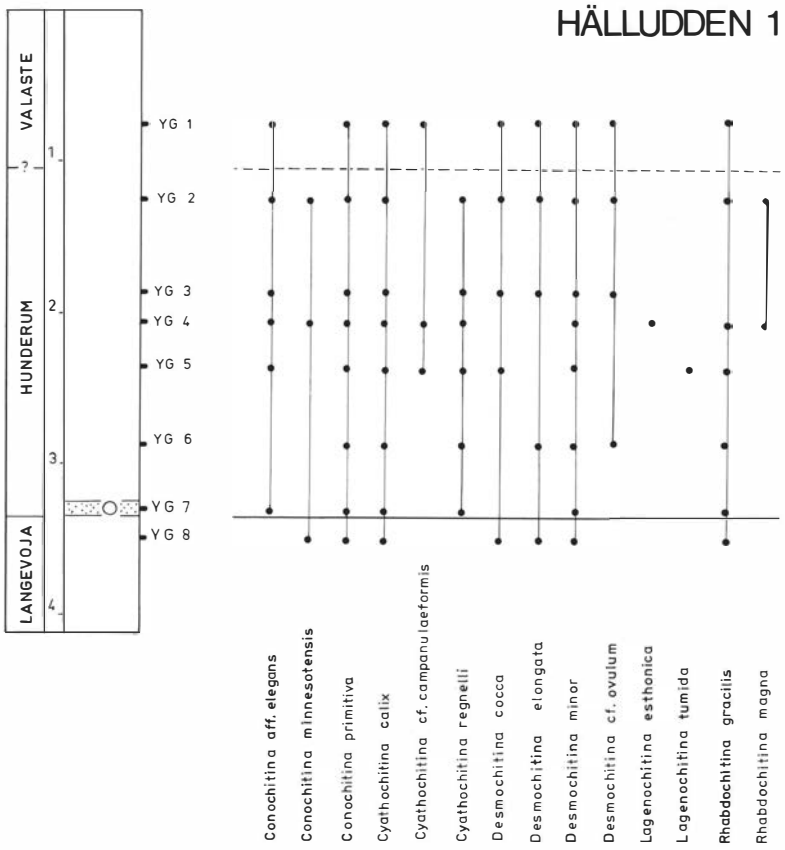


Fig. 6. Hälludden 1, lithology and sample levels. For legend, see Fig. 3.

Hälludden is the classic locality for the Ontikan of Sweden. The oldest strata, of "Limbata" age, are found near Byxelkrok and successively younger strata crop out to the NE. The youngest strata, of Early Valastean age, are found near Hälluddsvik. The locality will be discussed in detail in a later paper. At the sampled section c. 650 m SW of the reference point (Fig. 6) the beds are glauconitic.

HORNS UDDE 1, XD 1485 4078, c. 7 750 m NW of Högby church.

Topographical map sheet 5H Borgholm NV/NO. Geological map sheet Ac 8 Mönsterås med Högby and Ac 5 Oskarshamn.

Cliff section along the shore, from c. 600 m SE to c. 2.5 km NE of the lighthouse at Horns udde.

Reference point: The lighthouse at Horns udde.

Upper Cambrian – Langevoja.

References: Eisenack 1968b, p. 186; Hadding 1927, pp. 84–85, 87; Hadding 1932,

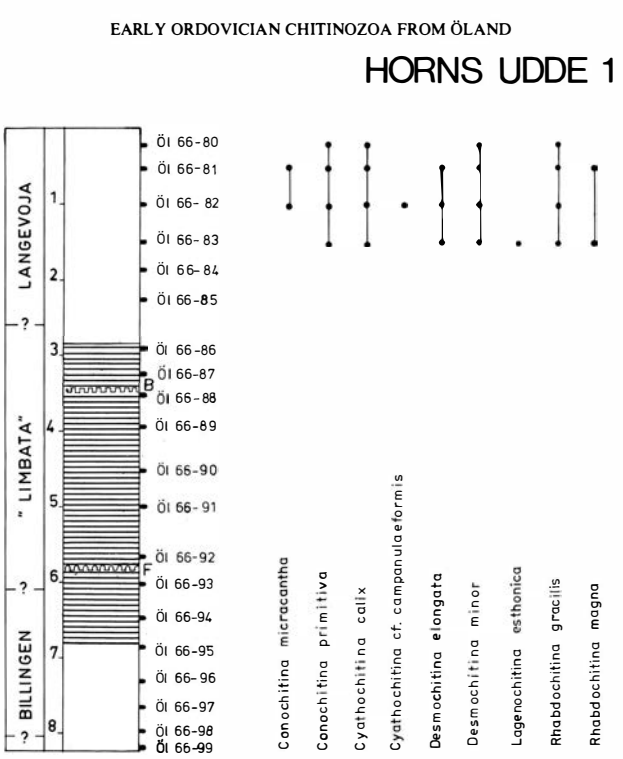


Fig. 7. Horns Udde 1, lithology and sample levels. Based on Laufeld (unpublished material). For legend, see Fig. 3.

pp. 14–25; Lindström 1963, pp. 246–249; Tjernvik 1956, pp. 153–154; Tullberg 1882, pp. 226–227; van Wamel 1974, pp. 10, 16, 27, 32, 42–44, chart 4–5; Wiman 1904a, pp. 43–44; Wiman 1904b, pp. 53–54.

The oldest beds are found SE of the lighthouse and successively younger strata crop out towards NW and NE. The sampled section (Fig. 7) is c. 2.1 km NE of the reference point and comprise the interval between Hunneberg? and Langevoja.

LÅNGALVARET 1, XD 2317 5665, c. 2 400 m ENE of the lighthouse at the harbour of Byxelkrok.

Topographical map sheet 6H Kråkelund SV/SO. Geological map sheet Ac 5 Oskarshamn.

Ditch section, N of a small bridge across the road to Torp, c. 200 m NW of the W corner of Ölanda airstrip. For detailed description, see Bohlin 1955.

Upper Aluoja.

References: Bohlin 1955, pp. 127–128.

A 0.64 m section was measured by Bohlin at this locality. From top to bottom (lithologies mainly after Bohlin) the following chitinozoans were recorded.

0–0.20 m Oolitic, grey and pale brown limestone rich in fossils.
Öl 66–35 (0–0.07 m). *Conochitina primitiva, Cyathochitina calix* and *Desmochitina cocca.*
Öl 66–34 (0.07–0.14 m). *Conochitina primitiva* and *Cyathochitina calix.*
Öl 66–33 (0.14–0.20 m). *Conochitina micracantha, Conochitina primitiva, Cyathochitina calix, Desmochitina cocca,* and *Lagenochitina esthonica.*

0.20–0.29 m Grey, fossiliferous limestone, red in basal part.
Öl 66–32 (0.20–0.29 m). *Conochitina micracantha, Conochitina primitiva, Cyathochitina calix, Desmochitina cocca, Lagenochitina esthonica,* and *Rhabdochitina gracilis.*

0.29–0.40 m Variegated, red and grey limestone.
Öl 66–31 (0.29–0.40 m). *Conochitina micracantha, Conochitina primitiva, Cyathochitina calix, Desmochitina cocca,* and *Lagenochitina esthonica.*

0.40–0.51 m Variegated, red and grey limestone rich in orthoceratites.
Öl 66–30 (0.40–0.51 m). *Conochitina primitiva, Cyathochitina calix* and *Desmochitina minor.*

0.51–0.64 m Variegated, red and grey limestone.
Öl 66–29 (0.51–0.64 m). *Conochitina micracantha, Conochitina primitiva, Cyathochitina calix,* and *Desmochitina minor.*

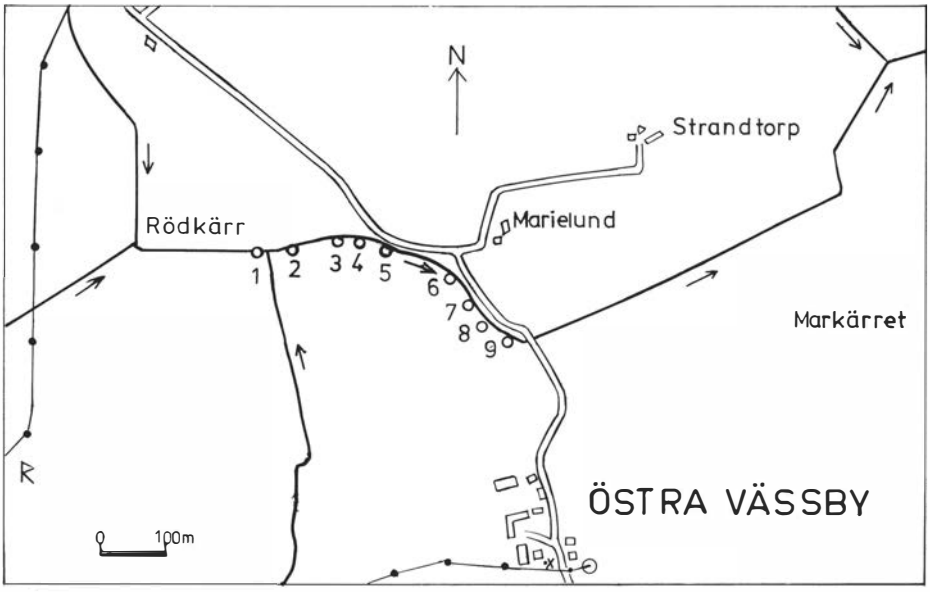


Fig. 8. Sketch map of sample localities at Marsjö kanal 1. Reference point around 10 m E of sample point 1.

MARSJÖ KANAL 1, XC 1380 2238, c. 1700 m NNE of Föra church.

Topographical map sheet 5H Borgholm SV. Geological map sheet Ac 8 Mönsterås med Högby.

Drainage ditch section from the old road between Källa and Alböke to the east coast of the island at Vässby fjärd.

Reference point: Where a stream joins Marsjö kanal from S.

Kunda – Aseri (Upper Llanvirn).

References: Bohlin 1949, pp. 548–549.

An excellent section through Kunda beds is accessible in a drainage ditch from the former lake Marsjön to the east coast. At the reference point a series (Fig. 8) of samples was taken from Upper Valaste to Upper Aluoja. None of these samples yielded chitinozoans.

ÖLANDS NORRA UDDE 1, XD 2540 6067, c. 900 m W of the lighthouse on the northern tongue of Öland.

Topographical map sheet 6H Kråkelund SV/SO. Geological map sheet Ac 5 Oskarshamn.

Shore exposure at high water separated from land by a shallow channel. For detailed description, see Bohlin 1949.

Lower Valaste.

References: Bohlin 1949, pp. 539–540; Holm 1882b, pp. 63–64; Wiman 1904a, p. 44.

One sample was collected in the uppermost part of a grey, somewhat glauconitic limestone. The following chitinozoans were recorded: *Conochitina primitiva, Cyathochitina calix, Cyathochitina* cf. *campanulaeformis, Desmochitina cocca, Desmochitina minor, Lagenochitina esthonica,* and *Rhabdochitina gracilis.*

OTTENBY 1, WC 8715 3335, c. 2 950 m WSW of Ås church.

Topographical map sheet 3G Kristianopel NO. Geological map sheet Ac 7 Ottenby.

Cliff section along the shore c. 450 m W of the manor of Ottenby. For detailed description, see Tjernvik 1956.

Tremadoc – "Limbata".

References: Hadding 1932, pp. 14–25; Hadding 1958, pp. 110–111, 131; Lindström 1963, pp. 249–251; Tjernvik 1956, pp. 145–149 (further references).

In this section only the interval Tremadoc to Lower Billingen was sampled (Fig. 9). No Chitinozoa were recorded.

SKÄRLÖVBORRNINGEN 1, WC 9765 5490, c. 2 800 m SSE of Hulterstad church.

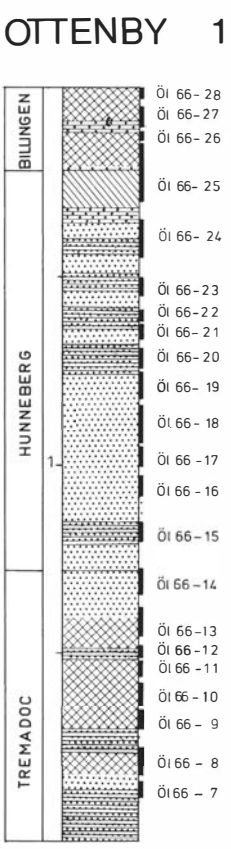


Fig. 9. Ottenby 1, lithology and sample levels. Based on Laufeld (unpublished material) and Tjernvik (1956). For legend, see Fig. 3.

Topographical map sheet 4G/4H Kalmar SO/Runsten SV. Geological map sheet Ac 6 Kalmar.

Core drilling (T.D. 60 m) made by the Geological Survey of Sweden in 1946 immediately N of the harbour of Skärlöv. The diameter of the core is 7 cm.

Lower Cambrian – Lasnamägi (Llanvirn).

References: Jaanusson 1960a, pp. 268–271; Westergård 1947, pp. 1–12.

Fourteen samples were collected in the interval 5.97 to 11.19 m. Only one sample, probably of Aluoja age, in the Ontikan sequence (6.76–6.80 m) yielded chitinozoans. The following species were recorded: *Conochitina primitiva, Cyathochitina calix, Cyathochitina regnelli, Desmochitina cocca, Desmochitina minor, Lagenochitina esthonica, Rhabdochitina gracilis,* and *Rhabdochitina magna.*

SKÄRLÖV 1, WC 9532 5390, c. 3 950 m SSW of Hulterstad church.

Topographical map sheet 4G/4H Kalmar SO/Runsten SV. Geological map sheet Ac 6 Kalmar.

Abandoned quarry c. 250 m NNE of triangulation point 12,0 at Skärlöv.
Upper Aluoja – Lower Aseri (Upper Llanvirn).
References: Jaanusson 1960a, p. 251.

A reddish-brown limestone with grey spots is overlain by reddish-brown Segerstad Limestone (Upper Llanvirn). One sample was collected 70 cm below the surface in a limestone of Late Aluojan age. No chitinozoans were present.

SÖDVIK 1 XD 1465 2580, c. 2 700 m WSW of Persnäs church.
Topographical map sheet 5H Borgholm NV/NO. Geological map sheet Ac 8 Mönsterås med Högby.
Ditch section N of the main road between Källa and Södvik, c. 200 m N of Södvik school.
Upper Aluoja.
References: Jaanusson 1960a, p. 225, lines 18–19.

A 0.95 m section of Upper Aluojan Limestone was measured and sampled. Immediately S of this locality Segerstad Limestone (Upper Llanvirn) crops out. From top to bottom the following chitinozoans were recorded.

0–0.10 m	Grey limestone.
	YG 9 (0–0.05 m). *Conochitina primitiva, Cyathochitina calix, Desmochitina minor,* and *Rhabdochitina magna.*
0.10–0.25 m	Reddish limestone.
	YG 10 (0.10–0.15 m). No chitinozoans.
0.25–0.45 m	Variegated, red and grey limestone.
	YG 11 (0.25–0.30 m). No chitinozoans.
0.45–0.65 m	Grey limestone.
	YG 12 (0.45–0.50 m). *Cyathochitina calix, Desmochitina cocca* and *Desmochitina minor.*
0.65–0.95 m	Variegated, red and grey limestone.
	YG 13 (0.65–0.70 m). No chitinozoans.

DESCRIPTIONS OF CHITINOZOA

In this paper no taxonomic rank above genus is used. Probably chitinozoans are polyphyletic, and therefore a suprageneric classification is of no value. For practical reasons the genera and species are described in alphabetical order. The terminology used is that of Laufeld 1974:38. The dimensions given in the descriptions are in micrometres. All measurements were made with an eyepiece micrometre and with an accuracy of $\pm$ 2 μm. Micrographs were taken on the Cambridge Mark II a Stereoscan Electron Microscope (SEM) at 20–30 kV.

Genus Conochitina Eisenack, 1931, restricted 1955

Conochitina aff. *elegans* Eisenack, 1931

Fig. 10 A-D

1976b *Conochitina elegans* – Eisenack, p. 188; Pl. 2:6–7

DESCRIPTION – *Conochitina* species with a slender and elongated conical vesicle. In some specimens the body tapers gradually into a cylindrical neck approximately halfway along the length. The base is concave and shows a concentric structure, and the basal edge is rounded. The neck widens slightly at the aperture which is straight. The vesicle wall is perfectly smooth.

DIMENSIONS – Total length 293–732, max. width 48–98, width of the aperture 41–73.

REMARKS – The Öland specimens differ from *Conochitina elegans* Eisenack, 1931, in not having an oral constriction of the basal edge nor convexity in the middle of the vesicle. Furthermore, *Conochitina elegans* has a smooth and slightly convex base (Laufeld 1973: Pl. 1:2). Specimens similar to *Conochitina elegans* have been reported also from the Wenlockian and Ludlowian of Gotland (see Laufeld 1974:59–60). The overall morphology of both the Ontikan and Silurian populations falls within the range of variation given by Eisenack (1959: Fig. 1) for Caradocian material. It is not known how the base of the Silurian specimens is constructed. It seems possible, however, that the populations discussed constitute three different taxa.

OCCURRENCE – Öland: The Hunderum and Lower Valaste (uppermost Arenig to Lower Llanvirn).

Conochitina micracantha Eisenack, 1931

Fig. 10 E-H

1931 *Conochitina micracantha* n.sp. (pars) – Eisenack, pp. 84–85; Pl. 1:19
1959 *Conochitina micracantha* ssp. *micracantha* – Eisenack, p. 7; Pl. 1:5
1965 *Conochitina micracantha* ssp. *micracantha* – Eisenack, p. 123; Pl. 9:4–5
1968b *Conochitina micracantha* ssp. *micracantha* – Eisenack, p. 162; Pl. 26:26–27; Pl. 32:2–4
1969 *Conochitina micracantha* – Jenkins, pp. 10–12; Text fig. 4; Pl. 1:17–21
1971 *Conochitina micracantha* – Laufeld, p. 293; Pl. 2i
1976b *Conochitina micracantha micracantha* – Eisenack, p. 188; Pl. 2:10
1979 *Conochitina micracantha* – Paris, p. 32; Pl. 3:8A–B

DESCRIPTION – *Conochitina* species with a conical body and a subcylindrical neck which comprises about 1/3 of the total length and is slightly widened at the

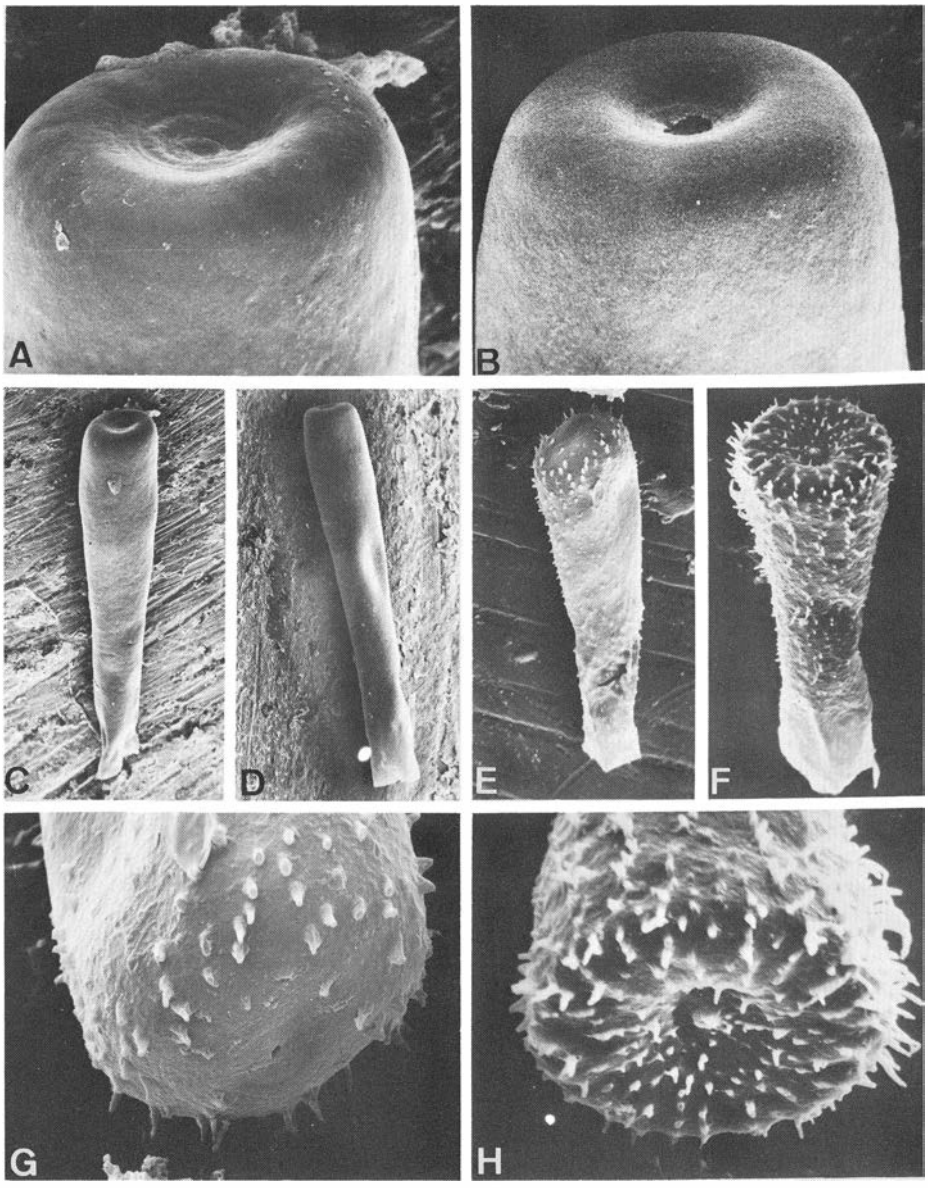


Fig. 10. A–D. *Conochitina* aff. *elegans* Eisenack, 1931. A, C. Gillbergabrottet 1, Valaste (Öl 66–62). B, D. Hälludden 1, Hunderum (YG 4). E–H. *Conochitina micracantha* Eisenack, 1931. E, G. Horns Udde 1, Langevoja (Öl 66–82). F, H. Långalvaret 1, Aluoja (Öl 66–29).

A, C. SGU Type 525. A. Oblique aboral view. Note the concentric structure in the concave base, SEM x510; C. Oblique lateral view, SEM x90. B, D. SGU Type 526. B. Oblique aboral view, SEM x700; D. Lateral view, SEM x100. E, G. SGU Type 534. E. Distorted specimen in oblique lateral view, SEM x190; G. Oblique aboral view. Note the simple spines, SEM x640. F, H. SGU Type 541. F. Oblique lateral view, SEM x220; H. Oblique aboral view, SEM x500.

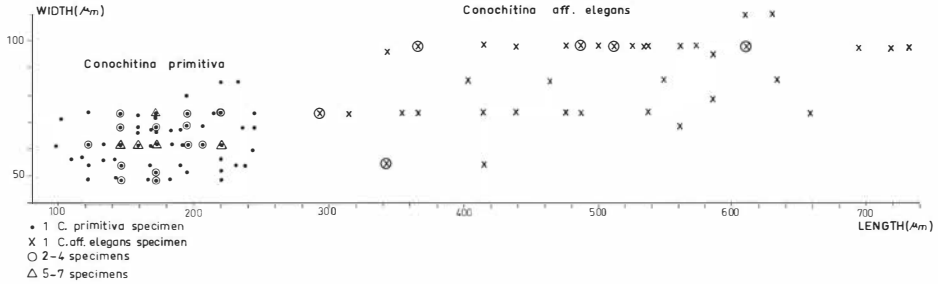


Fig. 11. Diagram showing the length:width ratio between *Conochitina* aff. *elegans* and *Conochitina primitiva*. The measurements of specimens similar to *Conochitina? simplex* Eisenack, 1931 lie within the field of those for *Conochitina primitiva*. Based on 176 obervations.

straight aperture. The flexure is distinct. The base is flat or somewhat convex and has an aboral scar. The basal edge is gently rounded. Orally of the basal edge there is a constriction beyond which the vesicle is slightly convex. Simple spines cover the whole vesicle but are best developed on the body.

DIMENSIONS – Total length 171–427, max. width 73–159, width of the aperture 37–73.

REMARKS – The spinose ornamentation of *Conochitina micracantha* varies considerably. The spines may cover part or all of the vesicle. It is interesting to note that the degree of ornamentation seems to vary stratigraphically. Jenkins (1969:10–12) reported that *Conochitina micracantha* from Upper Viola Limestone (Upper Caradoc – Lower Ashgill) in Oklahoma, U.S.A. has its ornamentation mainly concentrated to the basal part. Specimens of the same age from Podolia, U.S.S.R. (Laufeld 1971: Pl. 2i) and Portugal (Paris 1979: Pl. 3:8A) have the same kind of ornamentation. A majority of the Baltic specimens, which in general are reported from older strata, have an ornamentation that covers the whole vesicle.

OCCURRENCE – Öland: Upper Langevoja (Eisenack 1976b) to the Hunderum (Upper Arenig to Lower Llanvirn) and Upper Aluoja (Lower Llanvirn).

Aseri (Upper Llanvirn) to Nabala (Upper Caradoc), Estonia (Eisenack 1959, 1965, 1968b). Louredo Formation (Caradoc), Serra de Buçaco, Portugal (Paris 1979). Upper Viola Limestone (Upper Cardoc to Lower Ashgill), Oklahoma, U.S.A. (Jenkins 1969). Molodova Beds (Upper Caradoc to Lower Ashgill), Podolia, U.S.S.R. (Laufeld 1971).

Conochitina minnesotensis (Stauffer, 1933)

Fig. 12 A-D

1933 *Rhabdochitina? minnesotensis* n.sp. – Stauffer, p. 1209; Pl. 60:39
1939 *Rhabdochitina? minnesotensis* – Eisenack, p. 146; Pl. B:13

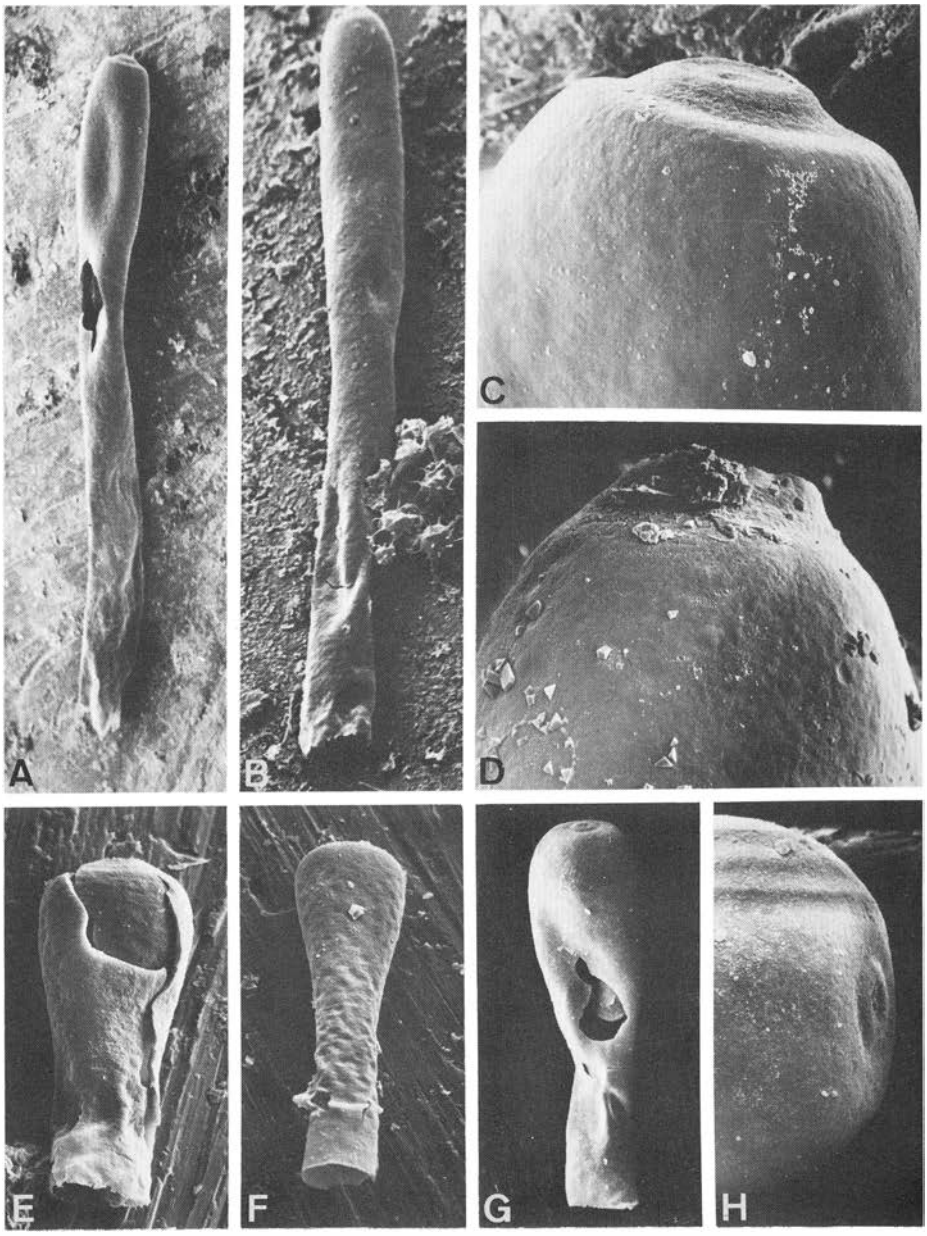


Fig. 12. A–D. *Conochitina minnesotensis* (Stauffer, 1933). A, C. Hälludden 1, Hunderum (YG 4). B, D. Hälludden 1, Langevoja (YG 8). E–H. *Conochitina primitiva* Eisenack, 1939. E. Hälludden 1, Hunderum (YG 4). F. Långalvaret 1, Aluoja (Öl 66–29). G-H. Hälludden 1, Valaste (YG 1).

A, C. SGU Type 520. A. Distorted specimen in lateral view, SEM x90; C. Aboral view, SEM x590. B, D. SGU Type 521. B. Lateral view, SEM x110; D. Aboral view, SEM x570. E. SGU Type 545. Lateral view. Note the similarity to *Conochitina? simplex* Eisenack, 1931, SEM x210. F. SGU Type 544. Lateral view, SEM x170. G, H. SGU Type 527. G. Lateral view, SEM x220; H. Aboral view. Note the basal process, SEM x670.

1962b *Conochitina minnesotensis* – Eisenack, pp. 353–354; Text figs. 1–6
1965 *Conochitina minnesotensis* – Eisenack, p. 126; Pl. 10:7–8
1967 *Conochitina minnesotensis* – Laufeld, pp. 306–307; Figs. 13 A–B
1969 *Conochitina minnesotensis* – Jenkins, pp. 17–18; Pl. 4:1–2, 4–5; Pl. 5:1–5

DESCRIPTION – A large *Conochitina* species with a long subcylindrical veiscle that tapers slightly towards a round base. In general the base has a basal process which is flat and wide. The aperature is straight. The vesicle wall is perfectly smooth.

DIMENSIONS – Length up to 1342, max. width 73–122.

OCCURRENCE – Öland: Upper Langevoja (Upper Arenig) to Lower Valaste (Lower Llanvirn).

Volkhov (Upper Arenig) to Porkuni (Upper Ashgill), Estonia (Eisenack 1962b, 1965). Decorah Formation (Lower Caradoc), Minnesota, U.S.A. (Stauffer 1933). Dalby and Skagen Limestone (Upper Llandeilo to Middle Caradoc), Dalarna, Sweden (Laufeld 1967). Herscheider Shale (Caradoc?), Westphalia, West Germany (Eisenack 1939). Upper Viola Limestone (Upper Caradoc to Lower Ashgill), Oklahoma, U.S.A. (Jenkins 1969).

Conochitina primitiva Eisenack, 1939

Fig. 12 E-H

1934 *Conochitina* sp. indet (ex. aff. *C. claviformis*?) – Eisenack, p. 62; Pl. 4:13
1939 *Conochitina primitiva* n.sp. – Eisenack, pp. 138, 140, 142; Pl. B:7–8
1962a *Conochitina primitiva* – Eisenack, pp. 293–294; Pl. 14:11–12
1967a *Conochitina primitiva* – Rauscher & Doubinger, p. 481; Pl. 3:5
1967b *Conochitina primitiva* – Rauscher & Doubinger, p. 313; Pl. 4:3
1969 *Conochitina primitiva* – Umnova, p. 329; Pl. 1:17
1970 *Euconochitina primitiva* – Rauscher, p. 122; Pl. 1:11–12
1974 *Conochitina primitiva* – Henry, Nion, Paris & Thadeu, pp. 313–314; Pl. 1:5, 8, 11; Pl. 2:9
1976b *Conochitina primitiva* – Eisenack, pp. 187–188; Pl. 2:11

DESCRIPTION – *Conochitina* species with a conical body. The cylindrical neck comprises about 1/2–1/3 of the total length and widens slightly towards the straight aperture. The base is flat to convex and may have a basal process. No ornamentation has been observed. The basal edge is rounded.

DIMENSIONS – Total length 98–244, max. width 48–90, width of the aperture 27–48.

REMARKS – Morphologically *Conochitina primitiva* is a very variable species. In the Ontikan of Öland there are specimens similar to *Conochitina? simplex* (Eisenack 1931, Pl. 2:15; cf. also Eisenack 1939, Pl. B:8) but they lie completely within both the length:width ratio and morphological variation of *Conochitina primitiva* (Fig. 11, 12 E). Hence, they are here included in *Conochitina primitiva*.

Whether *Conochitina? simplex* is a distinct species or should be included in *Conochitina primitiva* requires special study. *Conochtina primitiva* is best distinguished from *Conochitina* aff. *elegans* by its shorter length (Fig. 11).

OCCURRENCE – Öland: Upper Langevoja (Upper Arenig) to Lower Valaste (Lower Llanvirn) and Upper Aluoja (Lower Llanvirn).

Volkhov (Upper Arenig) to Jõhvi (Upper Caradoc), Estonia (Eisenack 1934, 1962a). The Hunderum (Upper Arenig to Lower Llanvirn), Dalarna, Sweden (Eisenack 1962a). Kunda (Upper Arenig to Lower Llanvirn), Moscow Syneclise, U.S.S.R. (Umnova 1969). Calymene Shale (Llanvirn), Normandie (Rauscher & Doubinger 1967a, 1967b) and Calvados (Rauscher 1970), France. Louredo Formation (Caradoc), Serra de Buçaco, Portugal (Henry et al. 1974). Herscheider Shale (Caradoc?), Westphalia, West Germany (Eisenack 1939).

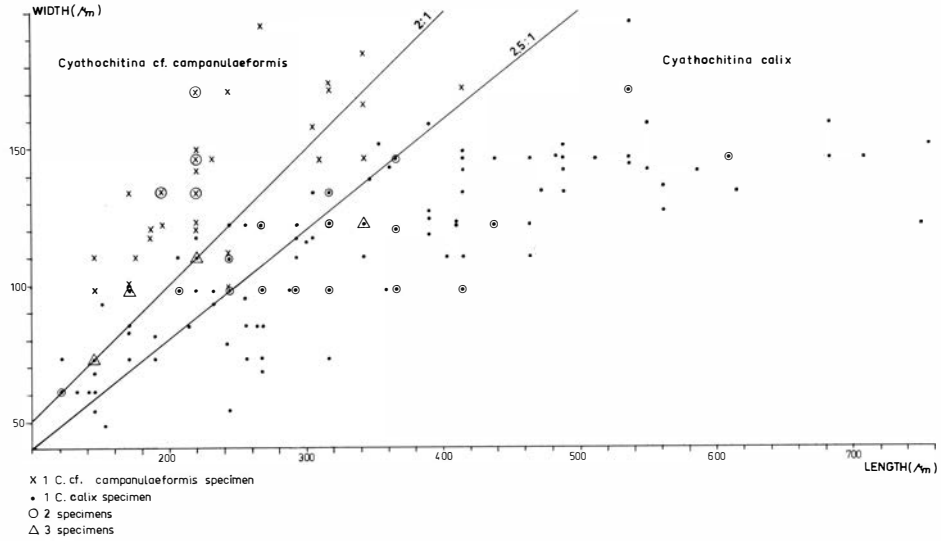


Fig. 13. Diagram showing the length:width ratio between *Cyathochitina calix* and *Cyathochitina* cf. *campanulaeformis*. Based on 158 observations.

Genus Cyathochitina Eisenack, 1955

Cyathochitina calix (Eisenack, 1931)

Fig. 14 A-G

1931 *Conochitina calix* n.sp. – Eisenack, p. 87; Text fig. 1; Pl. 2:3; Pl. 4:14
1939 *Conochitina calix* – Eisenack, p. 137; Pl. B:4–5
1958 *Cyathochitina calix* – Eisenack, p. 400; Pl. 2:26–27
1962a *Cyathochitina calix* – Eisenack, pp. 296–297; Pl. 14:3–4
1965 *Cyathochitina calix* – Eisenack, p. 128; Pl. 11:1–2
1967 *Cyathochitina calix* – Jenkins, p. 456; Pl. 71:5–7
1968b *Cyathochitina calix* – Eisenack, p. 168; Pl. 31:8–9, 27
1976b *Cyathochitina calix* – Eisenack, p. 187; Pl. 2:3

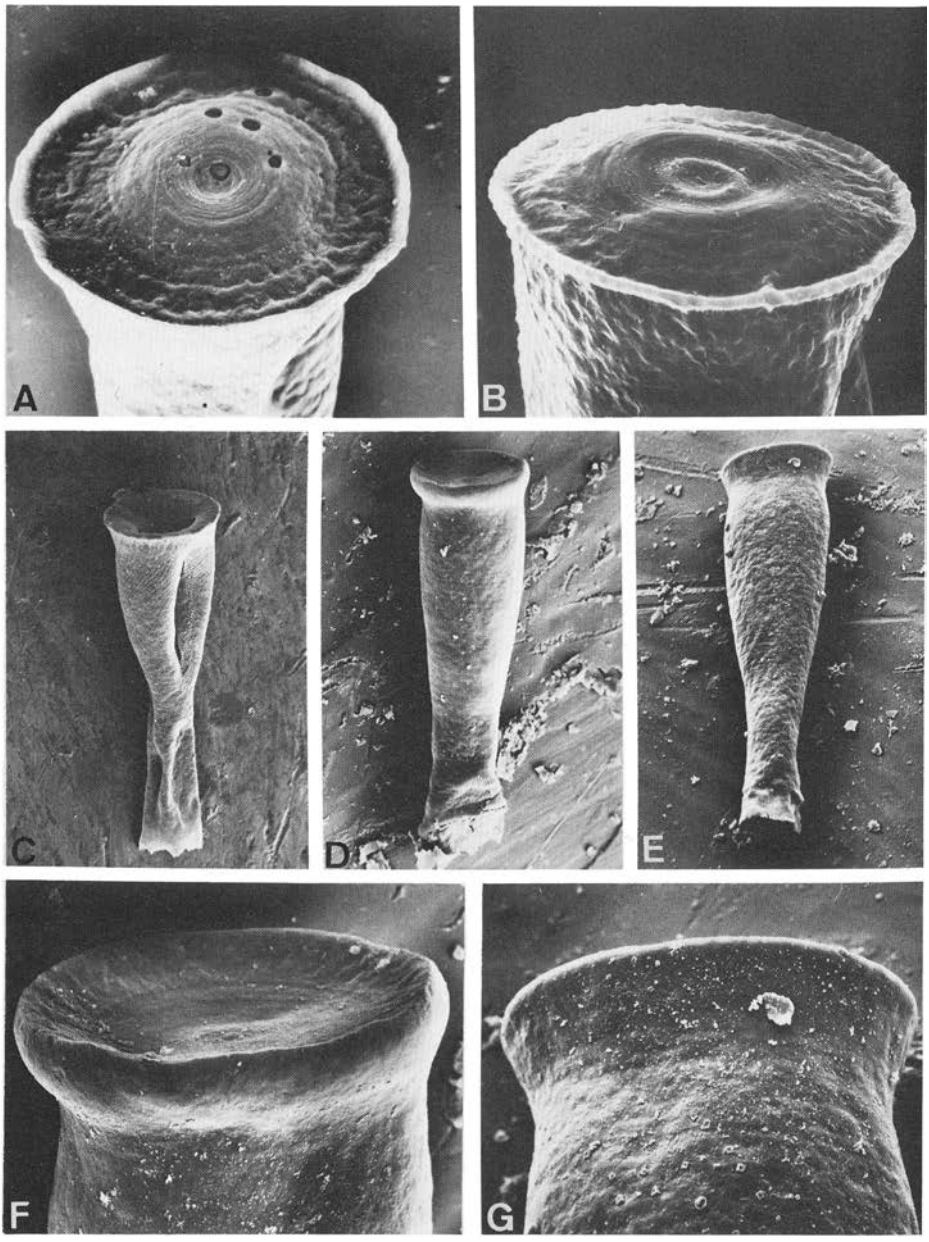


Fig. 14. A–G. *Cyathochitina calix* (Eisenack, 1931). A–B. Hälludden 1, Valaste (YG 1). C. Hälludden 1, Hunderum (YG 7). D–G. Hälludden 1, Hunderum (YG 4).

A. SGU Type 532. Aboral view. Note the perforations, SEM x250. B. SGU Type 547. Aboral view, SEM x360. C. SGU Type 535. Lateral view. Note the thickenings in a spiral pattern, SEM x70. D, F. SGU Type 512. D. Lateral view, SEM x100; F. Aboral view, SEM x350. E, G. SGU Type 513. E. Oblique lateral view, SEM x100; G. Oblique aboral view, SEM x350.

DESCRIPTION – *Cyathochitina* species with a conical body. The base shows concentric structures. A rounded basal process may be developed at the aboral pole. The basal edge carries a short carina. The body is slightly convex but tapers towards the cylindrical neck. The aperture is straight. The flexure is distinct. The vesicle wall is smooth or provided with spiral thickening.

DIMENSIONS – Total length 110–756, max. width 48–195, width of the aperture 24–98, length of the carina 2–24.

REMARKS – *Cyathochitina calix* differs from *Cyathochitina* cf. *campanulaeformis* in having a more elongated and slenderer form. In the Ontikan of Öland only about 5% of the *Cyathochitina calix* specimens fall below a length: width ratio of 2:1 compared to 82% for *Cyathochitina* cf. *campanulaeformis* (Fig. 13). Forms transitional to *Cyathochitina* cf. *campanulaeformis* occur. In the Welsh Borderland *Cyathochitina calix* specimens are much stouter than the Baltic specimens and the length:width ratio is only 1.5–2.1:1 (Jenkins 1967).

OCCURRENCE – Öland: Upper Langevoja (Upper Arenig) to Lower Valaste (Lower Llanvirn) and Upper Aluoja (Lower Llanvirn).

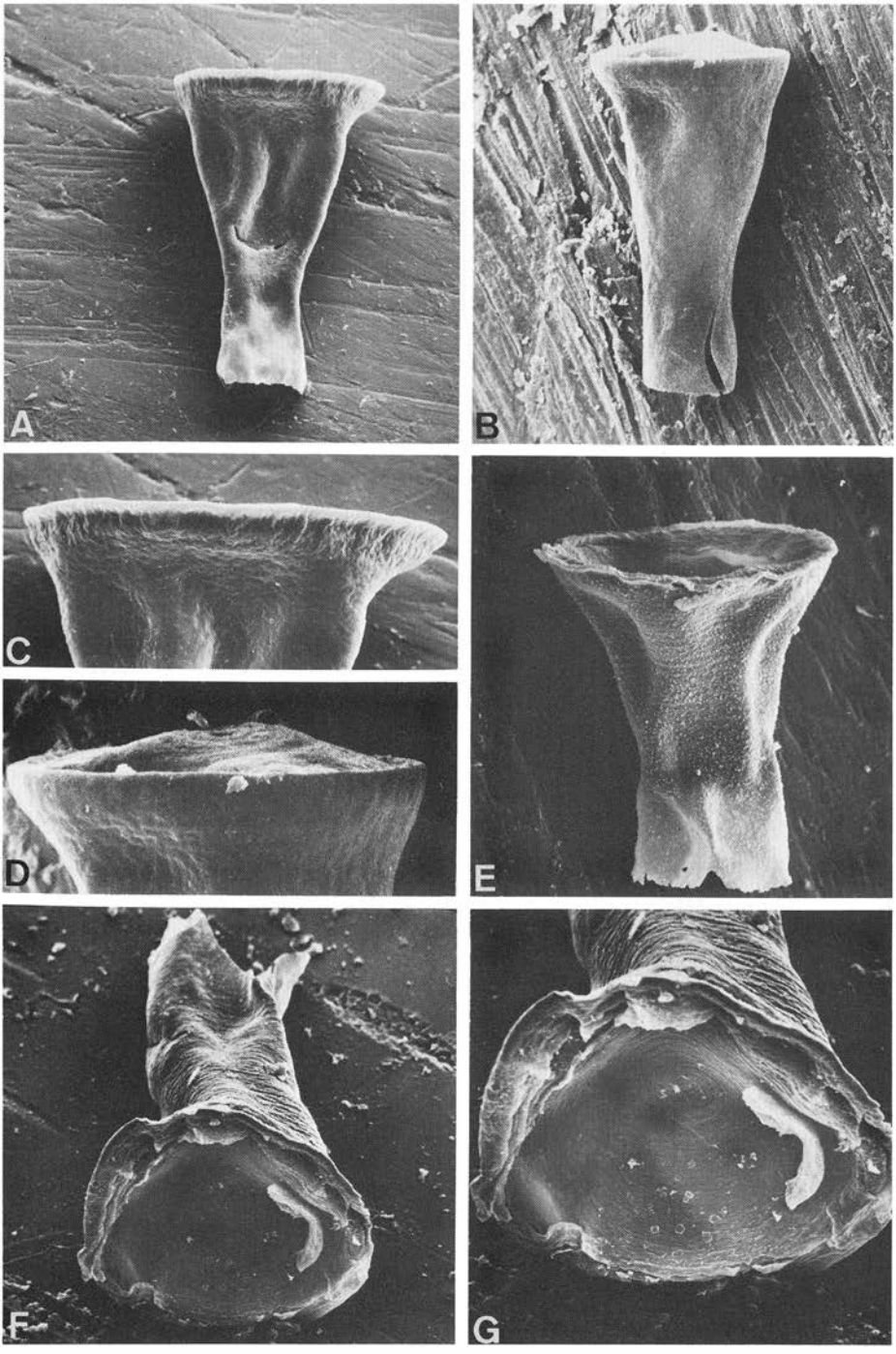
Volkhov (Upper Arenig) to Aseri (Upper Llanvirn), Estonia (Eisenack 1958, 1962a, 1968b). The Hunderum (Upper Arenig to Lower Llanvirn), Dalarna, Sweden (Eisenack 1962a). Hope Shales (Lower Llanvirn), Welsh Borderland (Jenkins 1967). Herscheider Shale (Caradoc?), Westphalia, West Germany (Eisenack 1939).

Cyathochitina cf. *campanulaeformis* (Eisenack, 1931)

Fig. 15 A-D

1931 *Conochitina campanulaeformis* n.sp. – Eisenack, pp. 86–87; Pl. 2:1–2; Pl. 4:1, 11–13
1939 *Conochitina campanulaeformis* – Eisenack, p. 137; Pl. B:1–3
1948 *Conochitina campanulaeformis* – Eisenack, p. 112; Figs. 1,7–9
1962a *Cyathochitina campanulaeformis* – Eisenack, pp. 297–298; Text fig. 3; Pl. 14:5–7
1963 *Cyathochitina campanulaeformis* – Kozłowski, pp. 435–439; Figs. 8–10
1967 *Cyathochitina campanulaeformis* – Jenkins, pp. 456–458; Pl. 71:8–11
1967 *Cyathochitina campanulaeformis* – Laufeld, pp. 313–315; Figs. 17 A–F
1968a *Cyathochitina campanulaeformis* – Eisenack, p. 89; Pl. 23:14
1968b *Cyathochitina campanulaeformis* – Eisenack, p. 168; Pl. 24:1–3; Pl. 29:18–19; Pl. 32:5 A–B
1971 *Cyathochitina campanulaeformis* – Laufeld, p. 294; Pl. 1B
1972 *Cyathochitina campanulaeformis* – Eisenack, p. 119; Pl. 32:1–11
1975 *Cyathochitina campanulaeformis* – Tynni, pp. 48–49; Fig. 46 C
1976b *Cyathochitina campanulaeformis* – Eisenack, p. 187; Pl. 2:4
1978 *Cyathochitina campanulaeformis* – Grahn, p. 10; Figs. 4E, 5D

DESCRIPTION – *Cyathochitina* species with a bell-shaped body. The base has concentric structures similar to those in *Cyathochitina calix* and the basal edge carries a carina. The flexure is distinct. The neck is subcylindrical and comprises 1/3–1/2 of the total length. The aperture is straight, and the vesicle wall is smooth.


A
B
C
D
E
F
G

DIMENSIONS – Total length 146–464, max. width 98–195, width of the aperture 48–98, length of the carina 12–37.

REMARKS – *Cyathochitina* cf. *campanulaeformis* differs from *Cyathochitina campanulaeformis* in not having the characteristic longitudinal thickenings on the vesicle wall (cf. Laufeld 1967, Figs. 17 E–F; Eisenack 1968b, Pl. 32:5 A–B; Grahn 1978, Figs. 4E, 5D). In the Ontikan of Öland about 82% of the *Cyathochitina* cf. *campanulaeformis* specimens fall within the length: width ratio 1.25–2:1 and the rest between 2–2.5:1 (Fig. 13). The Lower Ordovician specimens in Baltoscandia are comparable in size with those from the Lower and Middle Ordovician of the Welsh Borderland.

OCCURRENCE – Öland: Upper Langevoja (Upper Arenig) to Lower Valaste (Lower Llanvirn).

Kunda (Upper Arenig) to Porkuni (Upper Ashgill), Estonia (Eisenack 1962a, 1968a, 1968b). Hope Shales (Lower Llanvirn) to Meadowton Beds (Lower Llandeilo), Welsh Borderland (Jenkins 1967). Base of *murchisoni* Zone (Upper Llanvirn) to *triangulatus* Subzone (Middle Llandovery), Sweden (Laufeld 1971). Dalby to Slandrom Limestone (Upper Llandeilo to Upper Caradoc), Dalarna, Sweden (Laufeld 1967). Herscheider Shale (Caradoc?), Westphalia, West Germany (Eisenack 1939). Middle Ordovician in Bohemia (Eisenack 1948). Middle Ordovician erratics from Poland (Kozłowski 1963). Molodova Beds (Upper Caradoc to Lower Ashgill), Podolia, U.S.S.R. (Laufeld 1971). *Dalmanitina* Beds (Upper Ashgill) to the Zone of *Monograptus revolutus* (Lower Llandovery), Skåne, Sweden (Grahn 1978).

Cyathochitina regnelli Eisenack, 1955

Fig. 15 E-G

1955 *Cyathochitina regnelli* n.sp. – Eisenack, pp. 313–314; Pl. 1:7, 18
1968b *Cyathochitina regnelli* – Eisenack, p. 169; Pl. 30:7
1976b *Cyathochitina regnelli* – Eisenack, p. 187; Pl. 2:5

DESCRIPTION – *Cyathochitina* species with a subconical vesicle. The base is convex to almost flat, with concentric structures. The basal edge has a transparent carina. Orally of the basal edge the body is concave, then after 1/2–3/4 of the total

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Fig. 15. A–D. *Cyathochitina* cf. *campanulaeformis* (Eisenack, 1931). A, C. Bödahamnborrningen 1, Hunderum (31,25–31,30 m). B, D. Hälludden 1, Hunderum (YG 4). E–G. *Cyatochitina regnelli* Eisenack, 1955. E. Långalvaret 1, Aluoja (Öl 66–29). F–G. Hälludden 1, Hunderum (YG 4).

A, C. SGU Type 536. A. Lateral view, SEM x220; C. Aboral view, SEM x370. B, D. SGU Type 530. B. Lateral view, SEM x240; D. Aboral view, SEM x480. E. SGU Type 537. Lateral view, SEM x290. F, G. SGU Type 514. F. Lateral view, SEM x400; G. Aboral view. Note the transverse thickenings, SEM x560.

length becomes cylindrical in a neck that widens towards the aperture. The aperture is straight and very wide compared with the base. The vesicle wall is covered with transverse thickenings.

DIMENSIONS – Total length 98–171, max. width 48–146, width of the aperture 34–68, length of the carina 2–12.

OCCURRENCE – Öland: Upper Langevoja (Upper Arenig) (Eisenack 1976b) to Lower Valaste (Lower Llanvirn).

The Hunderum (uppermost Arenig to Lower Llanvirn), Dalarna, Sweden (Eisenack 1955, 1968b).

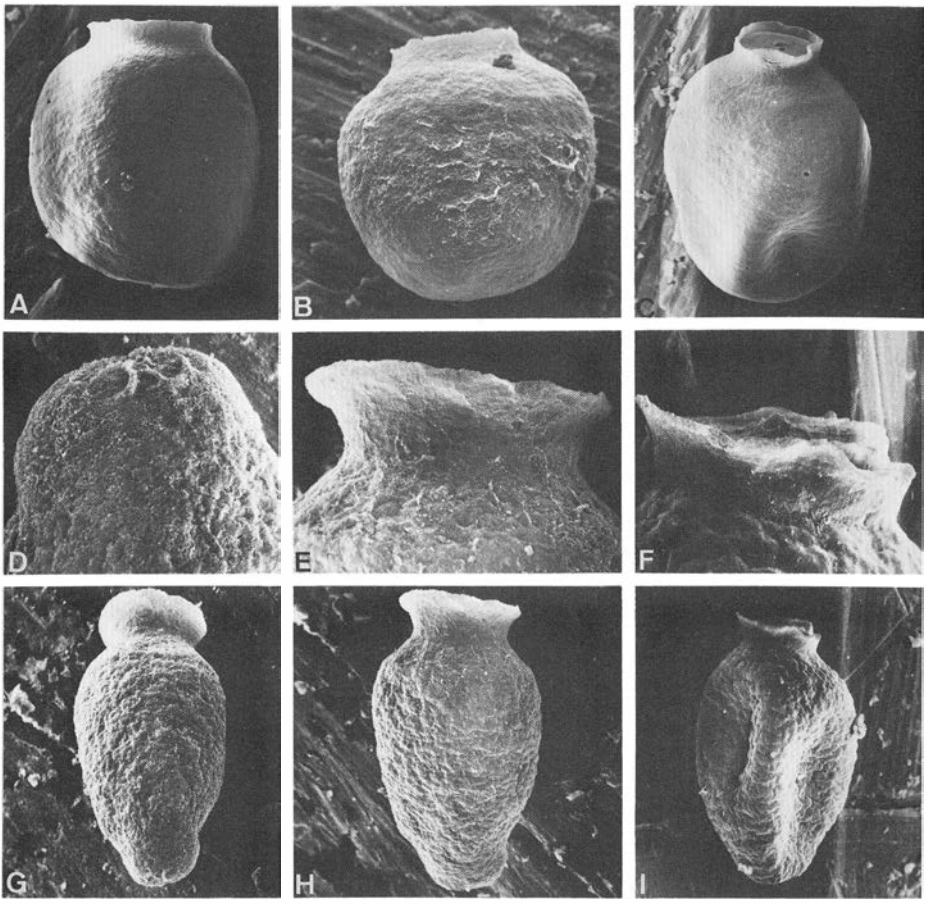


Fig. 16. A–C. *Desmochitina cocca* Eisenack, 1931. A. Horns Udde 1, Langevoja (Öl 66–82). B. Gillbergabrottet 1, Valaste (Öl 66–64). C. Långalvaret 1, Aluoja (Öl 66–32). D–I. *Desmochitina elongata* Eisenack, 1958. D–I. Gillbergabrottet 1, Valaste (YG 1).

A. SGU Type 542. Lateral view, SEM x310. B. SGU Type 538. Lateral view, SEM x310. C. SGU Type 523. Lateral view. Note the operculum, SEM x270. D–E, G–H. SGU Type 528. D. Aboral view, SEM x880; E. Oral view. Note the oblique angle of the collar, SEM x770; G. Oblique lateral view. Note the aboral part, SEM x310; H. Lateral view, SEM x310. F, I. SGU Type 529. F. Oral view, SEM x840; I. Lateral view, SEM x270.

Genus Desmochitina Eisenack, 1931

Fig. 16 A–C

Desmochitina cocca Eisenack, 1931

1931 *Desmochitina? cocca* n.sp. – Eisenack, p. 94; Pl. 3:14–15
1962a *Desmochitina minor* f. *cocca* – Eisenack, p. 304; Pl. 16:14–15
1967 *Desmochitina minor* f. *cocca* – Jenkins, pp. 460–461; pl. 71:12–13
1974 *Desmochitina minor* f. *cocca* – Henry, Nion, Paris & Thadeu, pp. 317–318; Pl. 2:4–5
1976b *Desmochitina minor* f. *typica* (pars) – Eisenack, p. 189; Pl. 2:19

DESCRIPTION – *Desmochitina* species with a spherical to subspherical vesicle. The collar is short and cylindrical with a straight aperture. Where visible, the operculum is a simple disc. The vesicle wall is perfectly smooth.

DIMENSIONS – Total length 68–134, max. width 61–98, width of the aperture 29–54, max. length of the collar 20.

REMARKS – Henry et al. (1974) remark that *Desmochitina cocca* from the Louredo Formation in Portugal has a concentric pattern on its base. Such a structure has not been observed in the specimens from Baltoscandia and the Welsh Borderland.

OCCURRENCE – Öland: Upper Langevoja (Upper Arenig) to Lower Valaste (Lower Llanvirn) and Upper Aluoja (Lower Llanvirn).

Aseri (Upper Llanvirn) to Kukruse (Upper Llandeilo to Lower Caradoc), Estonia (Eisenack 1962a). Glenburrell Beds (Lower Caradoc), Welsh Borderland (Jenkins 1967). Louredo Formation (Caradoc), Serra de Buçaco, Portugal (Henry et al. 1974).

Desmochitina elongata Eisenack, 1958

Fig. 16 D-1

1958 *Desmochitina minor* f. *elongata* n.f. – Eisenack, p. 398; Pl. 2:31–32
1968b *Desmochitina minor* f. *elongata* – Eisenack, p. 180; Pl. 24:23–25
1976b *Desmochitina* cf. f. *elongata* – Eisenack, Pl. 2:24–25

DESCRIPTION – *Desmochitina* species with elongated, ellipsoidal vesicle and ovoid base. The collar is attached at an oblique angle to the vesicle. The vesicle wall is wrinkled.

DIMENSIONS – Total length 93–134, max. width 48–93, width of the aperture 29–54, length of the collar 2–20.

REMARKS – Eisenack (1976b, Pl. 2:28) reported *"Desmochitina juglandiformis"* from Lower Valaste (Lower Llanvirn) at Hälludden, Öland. I found a similar specimen (Fig. 16 D–E, G–H) at the same locality. The two specimens mentioned do not belong to *Desmochitina juglandiformis* but are *Desmochitina elongata* specimens deformed at the base.

OCCURRENCE – Öland: Upper Langevoja (Upper Arenig) to Lower Valaste (Lower Llanvirn).

Volkhov (Upper Arenig), Estonia (Eisenack 1958, 1968b).

Desmochitina minor Eisenack, 1931

Fig. 18 A-D

1931 *Desmochitina? minor* n.sp. – Eisenack, p. 93; Pl. 3:10–11
1958 *Desmochitina minor* f. *typica* – Eisenack, p. 398; Pl. 2:29
1962a *Desmochitina minor* f. *typica* – Eisenack, pp. 303–304; Pl. 16:3–8
1965 *Desmochitina minor* f. *typica* – Eisenack, p. 130; Pl. 10:16–17
1967 *Desmochitina minor* – Laufeld, pp. 328–329; Figs. 25 A–D
1968a *Desmochitina minor* f. *typica* – Eisenack, p. 90; Pl. 23:15–16
1968b *Desmochitina minor* f. *typica* – Eisenack, p. 180; Pl. 24:21
1969 *Desmochitina minor* – Jenkins, pp. 20–21; Pl. 6:1–4, 6–7, 10–12
1971 *Desmochitina minor* – Laufeld, p. 294; Pl. 2:2P
1975 *Desmochitina minor* f. *typica* – Tynni, p. 49; Text fig. 47B
1976b *Desmochitina minor* f. *typica* – Eisenack, pp. 188–189; Pl. 2:13–18
1976b *Desmochitina minor pachys* n.f. – Eisenack, p. 189; Pl. 2:20–23
1979 *Desmochitina minor* – Paris, pp. 37–38; Pl. 2:9A–B

DESCRIPTION – *Desmochitina* species with ellipsoidal to spherical vesicle. The base is convex to rounded. The colonial collar is attached at an acute angle to the vesicle. The vesicle wall, except for the collar, is covered by coalescent or simple spines or spinose thickenings.

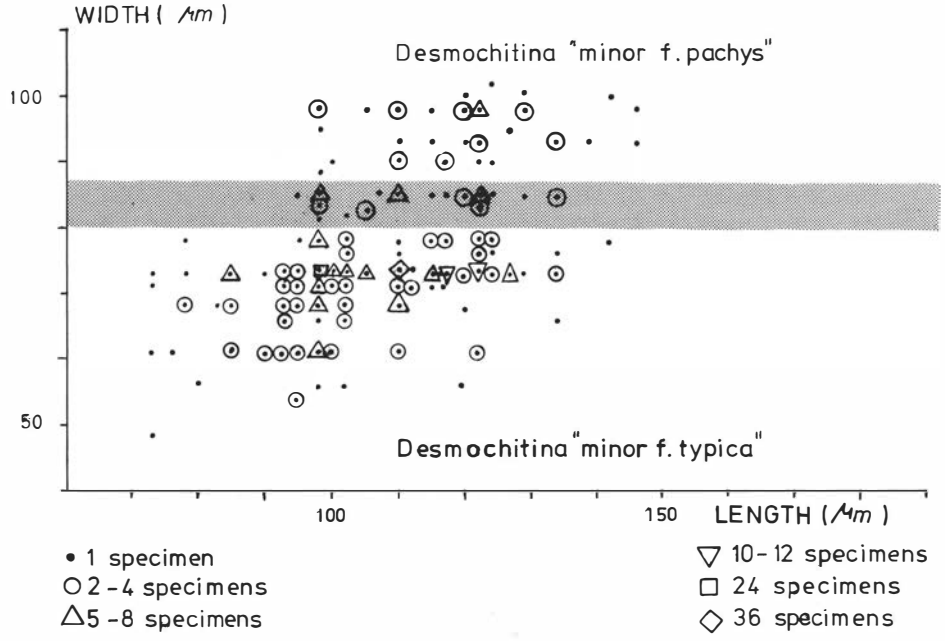


Fig. 17. Diagram showing the length:width ratio between *Desmochitina "minor* f. *pachys"* and *Desmochitina "minor* f. *typica"*. Transitional forms occur in the screened interval on the figure. Based on 240 observations.

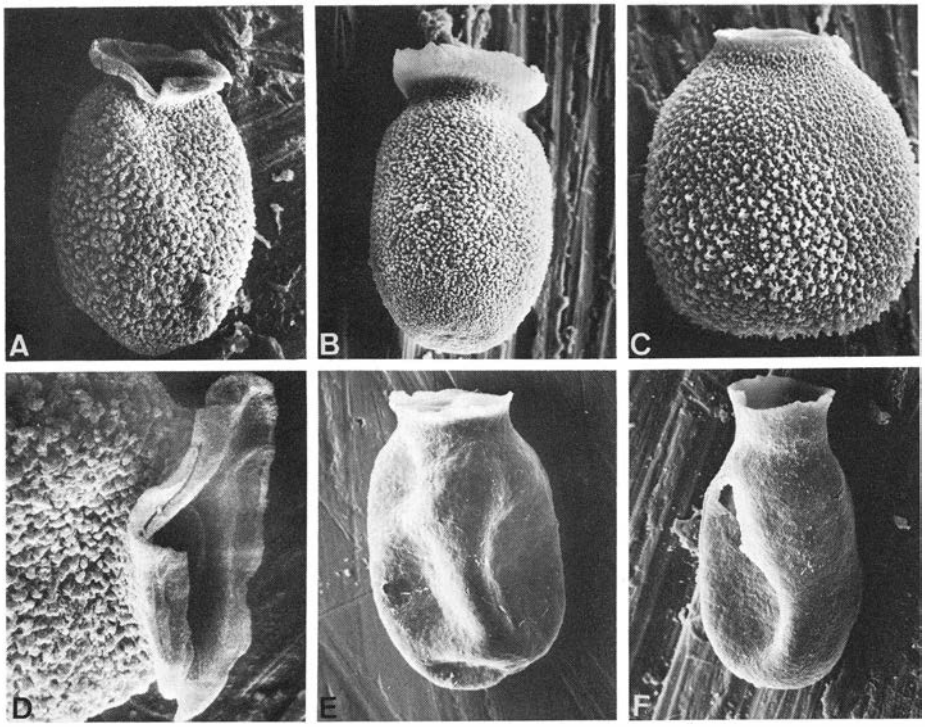


Fig. 18. A–D. *Desmochitina minor* Eisenack, 1931. A, D. Hälludden 1, Hunderum (YG 3). B. Horns Udde 1, Langevoja (Öl 66–83). C. Gillbergabrottet 1, Valaste (Öl 66–65). E–F. *Desmochitina* cf. *ovulum* Eisenack, 1962. E. Hälludden 1, Hunderum (YG 6). F. Gillbergabrottet 1, Langevoja (Öl 66–49).

A, D. SGU Type 531. A. Lateral view, SEM x380; D. Oral view, SEM x940. B. SGU Type 524. Oblique lateral view (*Desmochitina "minor* f. *pachys"*), SEM x260. C. SGU Type 543. Lateral view. Note the coalescent spines, SEM x380. E. SGU Type 539. Lateral view, SEM x290. F. SGU Type 540. Lateral view. Note the well-developed collar, SEM x250.

DIMENSIONS – Total length 73–159, max. width 37–117, width of the aperture 24–78, length of the collar 2–24.

REMARKS – *Desmochitina minor pachys* Eisenack 1976b differs from a typical *Desmochitina minor* specimen by its larger and more spherical vesicle. In general, its collar is also larger. There is, however, a continuous transition between the two (Fig. 17), and the spinose ornamentation is similar (Fig. 18B). Since *Desmochitina minor pachys* and *Desmochitina minor* do not form two different populations (comparison based on ornamentation and length: width ratio) the former is included in *Desmochitina minor*.

OCCURRENCE – Öland: Upper Langevoja (Upper Arenig) to Lower Valaste (Lower Llanvirn) and Upper Aluoja (Lower Llanvirn).

Volkhov (Upper Arenig) to Porkuni (Upper Ashgill), Estonia (Eisenack 1958, 1962a, 1965, 1968b). The Hunderum (uppermost Arenig to Lower Llanvirn)

(Eisenack 1962a) and Dalby to Slandrom Limestone (Upper Llandeilo to Upper Caradoc), Dalarna, Sweden (Laufeld 1967). Louredo Formation (Caradoc), Serra de Buçaco, Portugal (Paris 1979). Molodova Beds (Upper Caradoc to Lower Ashgill), Podolia, U.S.S.R. (Laufeld 1971). Viola Limestone (Upper Caradoc to Lower Ashgill), Oklahoma, U.S.A. (Jenkins 1969).

Desmochitina cf. *ovulum* Eisenack, 1962

Fig. 18 E-F

1962a *Desmochitina minor* f. *ovulum* n.f. – Eisenack, p. 305; Pl. 17:8–9
1969 *Desmochitina minor ovulum* – Umnova, p. 355; Pl. 2:9
1974 *Desmochitina minor* f. *ovulum* – Henry, Nion, Paris & Thadeu, pp. 318–319; Pl. 1:4, 13; Pl. 3:8; Pl. 5:1–2,4
1976b *Desmochitina minor* cf. f. *ovulum* – Eisenack, p. 189; Pl. 2:26–27

DESCRIPTION – *Desmochitina* species with an ellipsoidal to ovoid vesicle. The base is ovoid. The collar is conical to subcylindrical and well developed. The vesicle wall is perfectly smooth.

DIMENSIONS – Total length 100–134, max. width 54–73, width of the aperture 37–71, length of the collar 10–24.

REMARKS – *Desmochitina* cf. *ovulum* differs from *Desmochitina ovulum* by its smaller size.

OCCURRENCE – Öland: Upper Langevoja (Upper Arenig) (Eisenack 1976b) to Lower Valaste (Lower Llanvirn).

Volkhov (Upper Arenig), Moscow Syneclise, U.S.S.R. (Umnova 1969). Aseri (Upper Llanvirn) to Kukruse (Upper Llandeilo to Lower Caradoc), Estonia (Eisenack 1962a). Louredo Formation (Caradoc), Serra de Buçaco, Portugal (Henry et al. 1974).

Genus Lagenochitina Eisenack, 1931

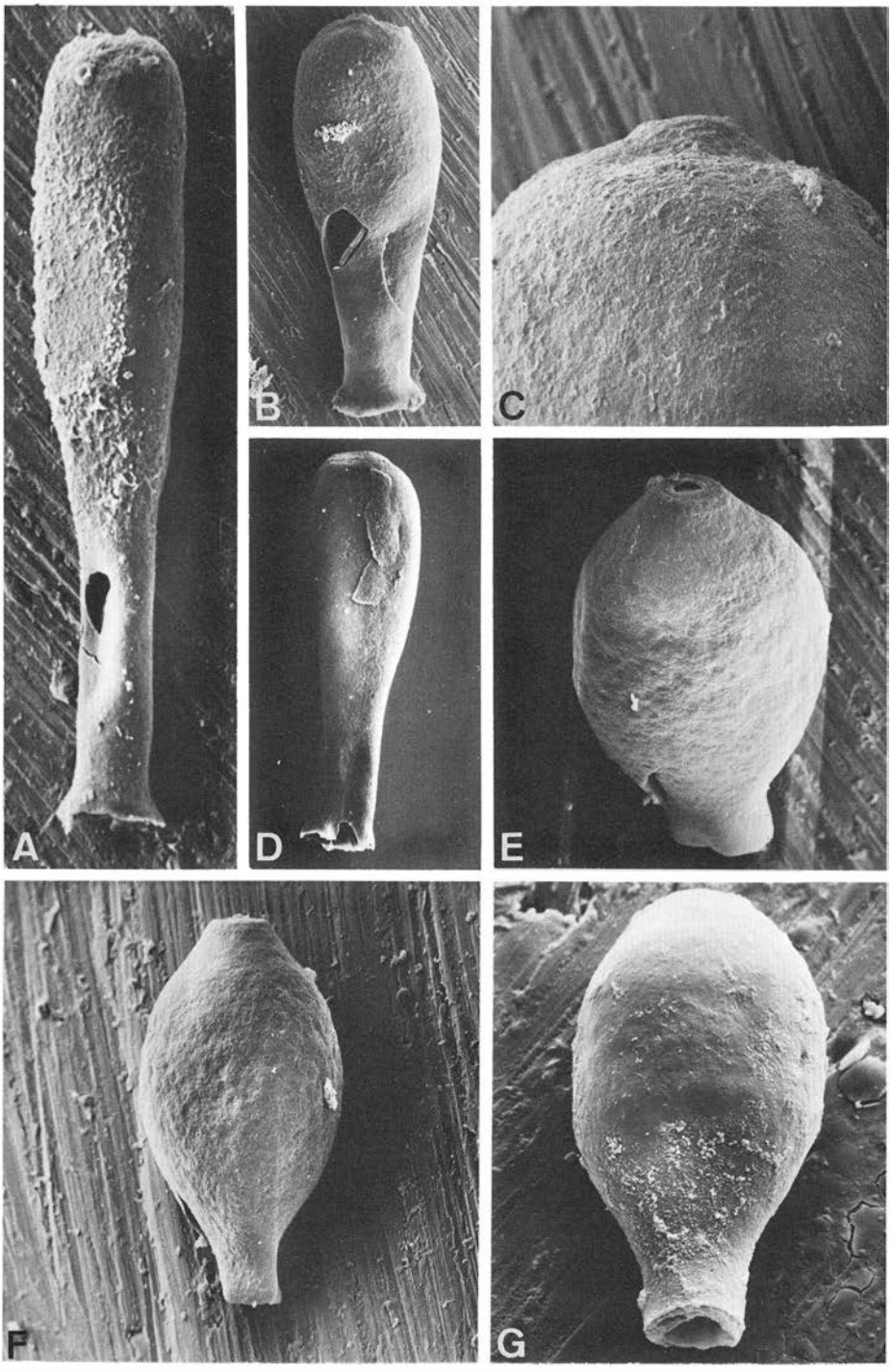
Lagenochitina esthonica Eisenack, 1955

Fig. 19 A-D

1955 *Lagenochitina esthonica* n.sp. – Eisenack, p. 311; Pl. 1:8–9
1967 *Lagenochitina esthonica* – Jenkins, pp. 463–464; Pl. 74:4–5

Fig. 19. A–D. *Lagenochitina esthonica* Eisenack, 1955. A–C. Horns Udde 1, Langevoja (Öl 66–83). D. Gillbergabrottet 1, Valaste (Öl 66–66). E–G. *Lagenochitina tumida* Umnova, 1969. E–G. Gillbergabrottet 1, Hunderum (Öl 66–52).

A. SGU Type 515. Lateral view, SEM x80. B–C. SGU Type 516. B. Lateral view. Note the typical lip, SEM x70. C. Aboral view. Note the basal process, SEM x310. D. SGU Type 533. Lateral view, SEM x70. E–F. SGU Type 517. E. Oblique lateral view. Note the basal process, SEM x180; F. Lateral view, SEM x170. G. SGU Type 518. Lateral view, SEM x310.


A
B
C
D
E
F
G

1968b *Lagenochitina esthonica* – Eisenack, p. 156; Text fig. 1; Pl. 24:10; Pl. 29:25
1976a *Lagenochitina esthonica* – Eisenack, Figs. 6, 22–23
1976b *Lagenochitina esthonica* – Eisenack, p. 186; Pl. 2:1; Text fig. 2

DESCRIPTION – *Lagenochitina* species with a subcylindrical to ovoid body. The base in convex. Short forms generally have a rounded basal process. The neck is subcylindrical and has a characteristic lip flaring sharply below the straight aperture. The vesicle wall is smooth.

DIMENSIONS – Total length 159–1000, max. width 61–268, length of the neck 49–512, width of the neck 73–134, width of the aperture 48–220.

REMARKS – In the Ontikan of Öland and Tremadoc? of Skåne two *Lagenochitina esthonica* populations are easily distinguished by size. It requires larger populations than those available now to find whether this is enough to justify a splitting into two different taxa. So far, *Lagenochitina esthonica* is the oldest known chitinozoan species in Baltoscandia.

OCCURRENCE – Öland: Upper Langevoja (Upper Arenig) to Lower Valaste (Lower Llanvirn) and Upper Aluoja (Lower Llanvirn).

Tremadoc?, Skåne, Sweden. Latorp (Lower Arenig) to Volkhov (Upper Arenig), Estonia (Eisenack 1955, 1976b). The Hunderum (uppermost Arenig to Lower Llanvirn), Dalarna, Sweden (Eisenack 1955). Lower Hope Shales (Lower Llanvirn), Welsh Borderland (Jenkins 1967).

Lagenochitina tumida Umnova, 1969

Fig. 19 E-G

1969 *Lagenochitina tumida* n.sp. – Umnova, p. 338; Pl. 2:33–34

DESCRIPTION – *Lagenochitina* species with a subspherical to ovoid body and a distinct flexure. The neck is cylindrical and comprises up to 1/3 of the total length. Some specimens have a neck that widens at the straight aperture. A rounded basal process may occur. The vesicle wall is perfectly smooth.

DIMENSIONS – Total length 165–318, max. width 98–171, width of the aperture 30–67.

REMARKS – The specimens from Öland show greater variation in size than that reported by Umnova.

OCCURRENCE – Öland: Lower Hunderum (uppermost Arenig).

Volkhov (Upper Arenig), Moscow Syneclise, U.S.S.R. (Umnova 1969).

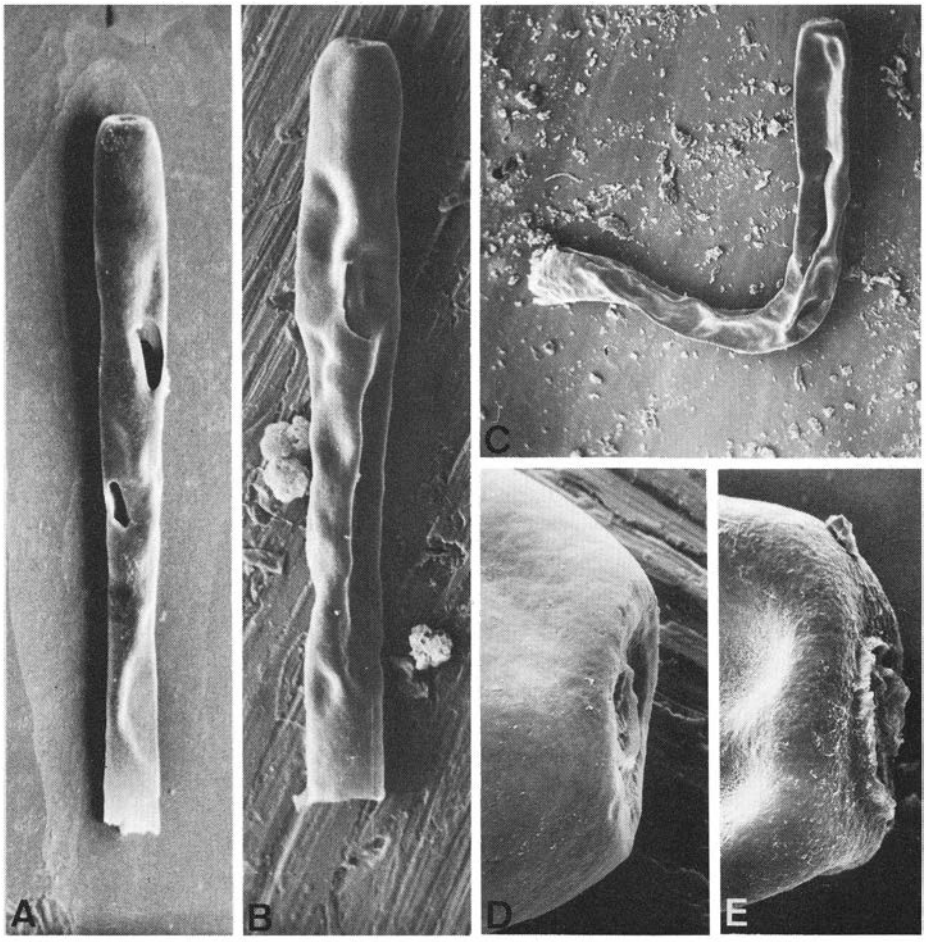


Fig. 20. A–B, D. *Rhabdochitina gracilis* Eisenack, 1962. A. Bödahamnborrningen 1, Valaste (28,29–28,33 m). B, D. Hälludden 1, Hunderum (YG 3). C, E. *Rhabdochitina magna* Eisenack, 1931. C, E. Gillbergabrottet 1, Valaste (Öl 66–59).

A. SGU Type 548. Lateral view, SEM x130. B, D. SGU Type 546. B. Lateral view, SEM x120; D. Aboral view, SEM x620. C, E. SGU Type 522. C. Lateral view. Note the widening of the neck at the aperture, SEM x80; E. Aboral view, SEM x620.

Genus **Rhabdochitina** Eisenack, 1931

Rhabdochitina gracilis Eisenack, 1962

Fig. 20 A-B, D

1962a ***Rhabdochitina gracilis*** n.sp. – Eisenack, pp. 307–308; Text fig. 6; Pl. 14:2; Pl. 15:1
1968a ***Rhabdochitina gracilis*** – Eisenack, p. 88; Pl. 23:6
1978 ***Rhabdochitina gracilis*** – Grahn, p. 10; Figs. 5C, E

DESCRIPTION – *Rhabdochitina* species with subcylindrical vesicle. The base is convex with a broadly rounded basal edge. The aperture is straight. Some specimens have a basal process. The vesicle wall is perfectly smooth.

DIMENSIONS – Max. length 1830, width 24–78.

REMARKS – *Rhabdochitina gracilis* differs from *Rhabdochitina magna* by its slenderer form and cylindrical neck.

OCCURRENCE – Öland: Upper Langevoja (Upper Arenig) to Lower Valaste (Lower Llanvirn).

The Hunderum (Upper Arenig to Lower Llanvirn), Dalarna, Sweden (Eisenack 1962a). Aluoja (Lower Llanvirn) to Kukruse (Upper Llandeilo to Lower Caradoc), Estonia (Eisenack 1962a). *Dalmanitina* Beds (Upper Ashgill), Skåne, Sweden (Grahn 1978) and Baltic erratics of the same age (Eisenack 1968a).

Rhabdochitina magna Eisenack, 1931

Fig. 20 C, E

1931 ***Rhabdochitina magna*** n.sp. – Eisenack, pp. 90–91; Text fig. 4; Pl. 3:16, 18
1962a ***Rhabdochitina magna*** – Eisenack, pp. 292–293; Text fig. 1; Pl. 14:1; Pl. 15:5
1965 ***Rhabdochitina magna*** – Eisenack, p. 127; Pl. 10:10
1967 ***Rhabdochitina magna*** – Jenkins, pp. 466–467; Pl. 74:6,9–10,12
1968a ***Rhabdochitina magna*** – Eisenack, p. 87; Text fig. 12
1968b ***Rhabdochitina magna*** –Eisenack, p. 167; Pl. 32:1
1976b ***Rhabdochitina magna*** – Eisenack, p. 187; Pl. 2:8–9
1977 ***Rhabdochitina magna*** – Achab, p. 424; Pl. 5:3, 6, 10, 11
1978 ***Rhabdochitina magna*** – Achab, pp. 310–311; Pl. 3:8–10

DESCRIPTION – A large *Rhabdochitina* species with a cylindrical vesicle that widens slightly at the straight aperture. The base shows the same variety of shape as that pointed out by Eisenack (1962a, p. 293; Text fig. 1), but is in general flat with a rounded basal edge. Basal process has not been observed. The vesicle wall is perfectly smooth.

DIMENSIONS – Max. length 1830, width 85–122.

OCCURRENCE – Öland: Upper Langevoja (Upper Arenig) to Lower Valaste (Lower Llanvirn), Upper Aluoja (Lower Llanvirn) and Dalby Limestone (Upper Llandeilo) (Eisenack 1962a).

Aluoja (Lower Llanvirn) to Aseri (Upper Llanvirn) and Nabala (Upper Caradoc) to Porkuni (Upper Ashgill), Estonia (Eisenack 1962a, 1965, 1968a, 1968b). Meadowtown Beds (Lower Llandeilo), Welsh Borderland (Jenkins 1967). Vauréal Formation (Ashgill), Anticosti Island, Quebec (Achab 1977, 1978).

STRATIGRAPHY

The most striking feature of the chitinozoan distribution is the small number of short-ranging species. Only one species is restricted to one unit, viz. *Lagenochitina tumida* to the lower part of Hunderum. In addition to that species, four others, viz. *Cyathochitina* cf. *campanulaeformis, Cyathochitina regnelli, Desmochitina elongata,* and *Lagenochitina esthonica* are unknown from strata younger than the Aluoja. All other species recorded here range through the entire Ordovician. On northern Öland the first chitinozoans appear in the middle Langevoja, whereas in the southern part only one sample in the Ontikan sequence (most probably Aluoja) yielded Chitinozoa. The small size of the Aluojan chitinozoans is also worthy of note.

At the start of Langevoja time the sedimentation in northern Öland changed from lime mud to skeletal sand which continues through to the top of Ontikan (Jaanusson 1955). The chitinozoans up to Valastean strata are concentrated in grey glauconitic limestones which indicate a slightly reducing environment and, probably, a comparatively slow rate of sedimentation. When the environment in northern Öland changed to more oxidizing conditions at the end of Valaste time, the chitinozoans disappeared. During Aluoja time the environment was mainly oxidizing. One explanation for the absence of Chitinozoa in the Ontikan sequence in southern Öland might be the more oxidizing conditions there. The palaeoecology of the Ontikan chitinozoans will be treated in more detail in a later publication.

LANGEVOJA

No chitinozoans in the present material are restricted to this unit. The abundance of chitinozoans in the Langevoja has a maximum of close to 6 specimens per gram of rock but in general is below 4.

HUNDERUM

From the base of the Hunderum the abundance of chitinozoans increases to a maximum in the middle of the unit. *Conochitina* aff. *elegans* and *Lagenochitina tumida* appear for the first time. The latter species is an excellent index fossil restricted to the lower part of Hunderum. The abundance of chitinozoans is 1–6 specimens per gram of rock in general, with a maximum of about 16 specimens per gram of rock.

VALASTE

The abundance of chitinozoans decreases during the Valaste, and they disappear in the middle part of the unit. *Conochitina micracantha* and *Lagenochitina tumida* are absent from the Hunderum. The abundance of chitinozoans is 1–4 in general, with a maximum of 9 specimens per gram of rock.

ALUOJA

The last occurrence of Chitinozoa in the Ontikan is from the Zone of *Megistaspis gigas*. All the species present in Aluoja are known already from the Langevoja. From Valaste the following species are absent: *Conochitina* aff. *elegans, Conochitina minnesotensis, Cyathochitina* cf. *campanulaeformis, Desmochitina elongata,* and *Desmochitina* cf. *ovulum*. The abundance of chitinozoans is low, in general below 1 specimen per gram of rock, with a maximum of about 1.5 specimens per gram of rock.

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ERRATUM

P.4 line 11. the Ontikan Stage Should be: the Ontikan Subserie

P.8 line 4. the Billingian - Aluojan of Should be: the Billingenian - Aluojan of

P.20 line 20. Upper Cardoc to Should be: Upper Caradoc to

P.29 line 2. Fig. 16 A-C. Shall stay between line 3 and 4.
line 23. Fig. 16 D-1. Should be Fig. 16 D-I.

P.41 line 32. — Geol. Surv. ... Shall stay on line 31 after Bothnian Sea.

PRISKLASS D

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