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The correlative significance of the Chitinozoa-bearing horizon in the Caradocian profiles of the Łeba region (NW Poland)

ABSTRACT: A rich Chitinozoa assemblage has been observed in five boreholes of the Łeba Elevation region (NW Poland) within the black mudstones bearing Lower Caradocian graptolites. These microfossils occur in a horizon of rather small thickness which, in a regional scale, may be regarded as a correlative horizon within the monotonous deposits of the graptolite facies.

INTRODUCTION

During the research work on the stratigraphy of Ordovician deposits in the Łeba Elevation an exceptionally rich Chitinozoa assemblage has been encountered in black mudstones bearing Lower Caradocian graptolites. The presence of Chitinozoa has been observed in the following profiles: Białogóra *1*, Białogóra 2, Piaśnica *2*, Dębki *3* and Mieroszyno *8* (Fig. 1). The lithological samples were dissolved in hydrofluoric acid and the microfossils thus obtained were photographed by means of a scanning electrone microscope. Five Chitinozoa species belonging to four genera have been differentiated in the collection consisting of some hundreds specimens.

The present paper has been prepared in the Stratigraphic Laboratory of the Institute of Geological Sciences of the Polish Academy of Sciences under the guidance of Dr. habil. W. Bednarczyk as a part of the research studies on problem MR *I. 16* — Geodynamics in Polish territory.

Thanks are due from the writer for accession to borehole materials to the Management of the Oil Mining Union "Geonafta" in Warsaw and the Oil Research Enterprise in Piła.

DESCRIPTION OF THE CHITINOZOA-BEARING DEPOSITS

The rocks which have yielded the Chitinozoa assemblage represent black, partly marly, mudstones, containing large amounts of bituminous substance and of pyrite.

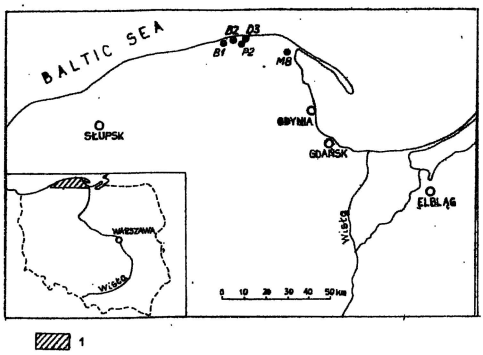


Fig. 1. Location of boreholes in the Łeba elevation

1 — investigated area, *B1* — Białogóra *1*, *B2* — Białogóra *2*, *D3* — Dębki *3*, *P2* — Piaśnica *2*, *M8* — Mieroszyno *8*

Graptolites and non-articulate brachiopods are the dominant macrofossils. The microfossils consist of Chitinozoa and some scanty scolecodont, ostracod, conodont and graptolite remains. The Chitinozoa are mostly well preserved, both compressed and not compressed forms occur; the organic detritus is often pyritised. The Chitinozoa assemblage is numerically rich but taxonomically rather monotonous.

BIAŁOGÓRA *1* PROFILE

The Chitinozoa occur at a depth between 2673.1 and 2672.0 m within the graptolite-bearing mudstone series. The presence has been observed of the following species: *Cyathochitina stentor* (Eisenack) (Pl. 2, Figs 1—3), *Rhabdochitina gracilis* Eis. and *Desmochitina* cf. *minor* Eis. Among the encountered graptolites are: *Nanograptus* cf. *lapworthi* Hadding, *Nanograptus* cf. *phylloides* (Elles & Wood), *Dicellograptus divaricatus salopiensis* Elles & Wood, *Dic.* sp., *Climacograptus brevis* Elles & Wood, *Pseudoclimacograptus* (P.) *scharenbergi scharenbergi* (Lapworth), *Orthograptus whitfieldi* (Hall), *Glyptograptus teretiusculus* (Hisinger), *Amplexograptus arctus* Elles & Wood.

BIAŁOGÓRA *2* PROFILE

At a depth between 2634.0 and 2633.0 m the presence has been observed of *Cyathochitina campanulaeformis* (Eis.), *Conochitina minnesotensis* (Stauffer) and *Desmochitina* cf. *minor* Eis. (Pl. 2, Figs 5, 6). The poorly preserved graptolite remains include i.a. *Pseudoclimacograptus* (*P.*) cf. *scharenbergi scharenbergi* (Lapw.) and *Orthograptus* sp.

PIAŚNICA *2* PROFILE

In this profile the Chitinozoa occur at a depth between 2646.3 and 2644.3 m. Among them have been differentiated *Conochitina minnesotensis* (Stauffer), *Cyathochitina stenor* (Eis.) and *Rhabdochitina gracilis* Eis. (Pl. 2, Fig. 4). These are accompanied by the graptolites *Nemagraptus gracilis gracilis* (Hall), *Hallograptus mucronatus mucronatus* (Hall), *Glyptograptus teretiusculus* (His.).

DĘBKI *3* PROFILE

In the interval 2648.2—2645.0 m have been found: *Cyathochitina stentor* (Eis.), *Cyathochitina campanulaeformis* (Eis.) (Pl. 1, Figs 1—4), *Rhabdochitina gracilis* Eis., *Desmochitina* cf. *minor* Eis. and *Conochitina minnesotensis* (Stauffer) (Pl. 2, Figs 5—6). The following have been observed

in the graptolite assemblage: *Dendrograptus* sp., *Dictyonema* sp., *Climacograptus brevis* Elles & Wood *Pseudoclimacograptus* (P.) *scharenbergi scharenbergi* (Lapw.), *Orthograptus whitfieldi* (Hall).

MIEROSZYNO *8* PROFILE

Abundant Chitinozoa remains have been found at a depth between 2813.0 and 2812.0 m. Among these have been differentiated the following species: *Cyathochitina campanulaeformis* (Eis.), *Conochitina minnesotensis* (Stauffer) and *Rhabdochitina gracilis* (Eis.). They are accompanied by an abundance of Inarticulata and the graptolites: *Lasiograptus harknessi* (Nicholson), *Hallograptus mucronatus mucronatus* (Hall), *Glossograptus* cf. *hincksii hincksii* (Hopkinson), *Pseudoclimacograptus* (P.) *scharenbergi scharenbergi* (Lapw.), *Dicranograptus ziczac* Lapw., *Corynoides* sp.

An abundant occurrence of the Chitinozoa vesicles has been observed only in the depth intervals here mentioned; above and below these depths the Chitinozoa are practically speaking absent, only some very few single specimens having been encountered here and there. The arrangement of the vesicles in the rock is an-at-random one and their accumulation often so great to make them detectable even under slight magnification or even macroscopically. The thickness of the Chitinozoa horizon ranges from 1.0 m to 3.2 m.

The sudden changes in the numbers of Chitinozoa as observed in the investigated profiles are possibly referable to changes in their environment conditions, biotic or abiotic, which have not, however, been reflected in their lithology. Such exceptionally great accumulation of the Chitinozoa remains in the deposit is perhaps due to the shallowing of the marine basin or to a slowing down of the sedimentary tempo which are commonly accompanied by an enrichment in the numbers of various organic remains.

Other, more accurately undeterminate reasons, should, however, be also taken into account when considering the uneven distribution of the Chitinozoa in the deposit, such as the redeposition of the organic detritus or its destruction due to the process of diagenesis.

BIOSTRATIGRAPHIC REMARKS

Lower Caradocian graptolites occur in the deposits containing the Chitinozoa as well as in the overlying or underlying sediments. Species such as: *Nemagraptus gracilis gracilis* (Hall), *Nanograptus* cf. *phylloides* (Elles & Wood), *Nanograptus* cf. *lapworthi* Hadding, *Hallograptus mucronatus mucronatus* (Hall), *Orthograptus whitfieldi* (Hall), *Pseudoclimacograptus (P.) scharenbergi scharenbergi* (Lapw.), *Amplexograptus arctus* Elles & Wood, *Glossograptus* cf. *hincksii hincksii* (Hop.), *Lasiograptus harknessi* (Nich.) and *Dicranograptus ziczac* Lapw. make up a characteristic assemblage of the *Nemagraptus gracilis* zone. *Cyathochitina stentor* (Eis.), whose presence has been observed among other Chitinozoa remains, confirms the Lower Caradocian age of these sediments. In the peribaltic area of Esthonia and Sweden, the stratigraphic scope of this species is confined to the Kukruse (*CII*) stage, correla-

ted with deposits of the *Nemagraptus gracilis* zone (Eisenack 1971, Laufeld 1967, Männil 1939).

The faunal assemblage occurring in the mudstones under investigation is analogous, hence it may be reasonably supposed that they are of the same age in all the profiles here considered. Therefore, sediments containing abundant Chitinozoa remains, may, on a regional scale, be regarded as a correlative horizon within the monotonous black mudstone graptolite-bearing series.

PALEONTOLOGICAL DESCRIPTIONS

Genus *CONOCHITINA* Eisenack, 1931

Conochitina minnesotensis (Stauffer, 1933)

(Pl. 1, Figs 5—6)

1939. *Rhabdochitina ? minnesotensis* n. sp.; Eisenack, p. 146, Pl. B, Fig. 13.
1962. *Conochitina minnesotensis* n. sp. Eisenack; p. 353—354, Figs 1—6.
1967. *Conochitina minnesotensis* (Stauffer, 1933); Laufeld, p. 306—307, Fig. 13.
1968. *Conochitina minnesotensis* (Stauffer, 1933); Eisenack, p. 160.
Material: ca. 100 specimens.

Description. — Vesicle elongated, straight or very slightly curves, widening out toward the base. Aboral edge terminating most commonly in a copula (Pl. 1, Figs 5,6). Length of the figured specimen 988 μ, maximum width 95 μ.

Remarks. — The holotype described by Stauffer (1933) is provided with a well developed copula terminating the aboral edge of the vesicle but forms without a copula also belong to this species.

Occurrence. — The wide stratigraphic scope of this species spreads over nearly the whole Ordovician, the Tremadocian and Lower Arenig excepted. Its presence has been observed in the USA (Stauffer 1933), West Germany and Finland (Eisenack 1939, 1962), in Esthonia (Eisenack 1962). The Łeba Elevation: Białogóra *2* profile (at a depth between 2634.0 and 2633.0 m), Piaśnica *2* (between 2646.3 and 2644.3 m), Dębki *3* (2648.2—2645.0 m), Mieroszyno *8* (between 2831.0 and 2812.0 m).

Genus *CYATHOCHITINA* Eisenack, 1955

Cyathochitina campanulaeformis (Eisenack, 1931)

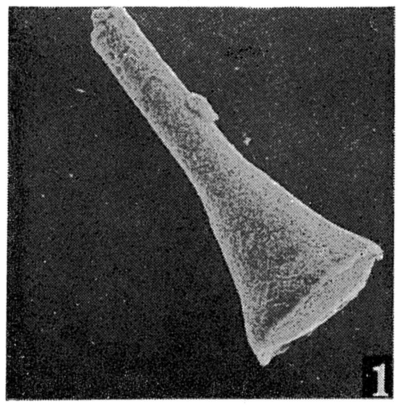
(Pl. 1, Figs 1—4)

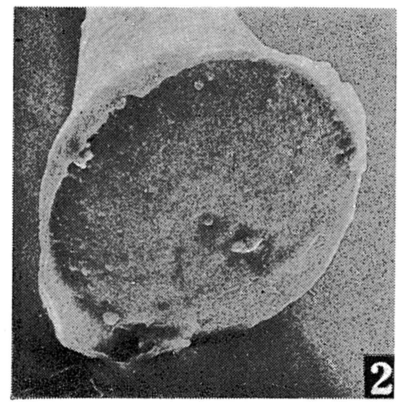
1931. *Conochitina campanulaeformis* n. sp.; Eisenack, p. 86—87, Pl. 2, Figs 1—2; Pl. 4, Figs 1, 11—13.
1939. *Conochitina campanulaeformis* Eisenack; Eisenack, p. 137, Pl. B, Figs 1—3.
1955. *Cyathochitina campanulaeformis* (Eisenack); Eisenack, p. 313.
1963. *Cyathochitina campanulaeformis* (Eisenack); Kozłowski, p. 435—439, Figs 8—10.
1967. *Cyathochitina campanulaeformis* (Eisenack); Laufeld, p. 313—315, Fig. 17.

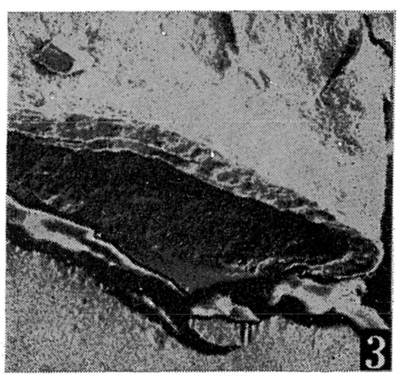
Material: 120 specimens, both, compressed and uncompressed forms.

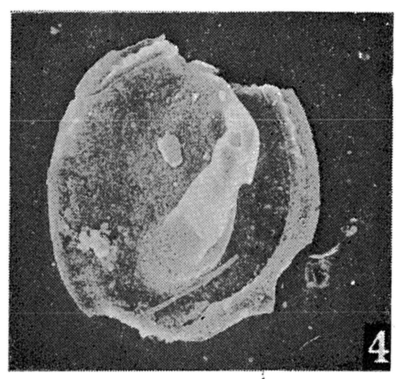
Remarks. — On the shape of the vesicle and the dimensions (length 380 μ, width 145 μ) the figured specimens are referable (Pl. 1, Figs 1—4) to the species *Cyathochitina campanulaeformis* Eisenack. From *Cyathochitina kuckersiana* (Eisenack) it differs in a less strongly developed, shorter basal flange.

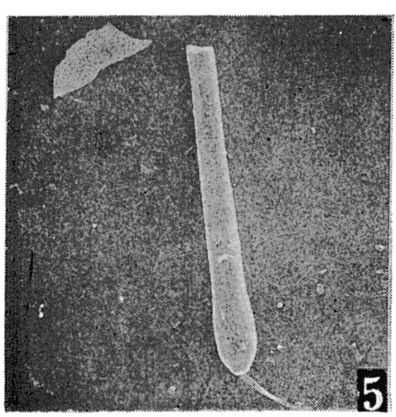
Occurrence. — Upper Caradocian/Slandrom formation and Fjäcka formation/Dalarna area in Sweden (Laufeld 1967), the Läsnamägi-Porkuni stage of Esthonia (Eisenack 1962, 1965), the Lower Caradocian/Boutetourt Formation of Virginia, USA (Laufeld 1967). Łeba Elevation: Białogóra *2* Profile (at a depth between 2634.0 and 2633.0 m), Dębki *3* (between 2648.2 and 2645.0 m), also Mieroszyno *8* at a depth between 2813.0 and 2812.0 m.

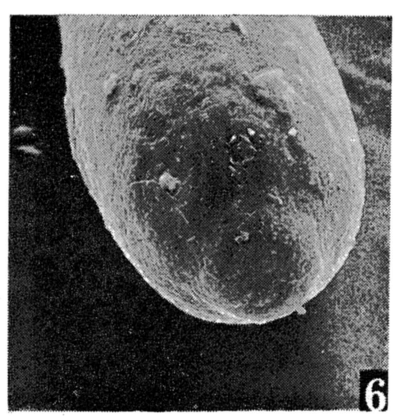




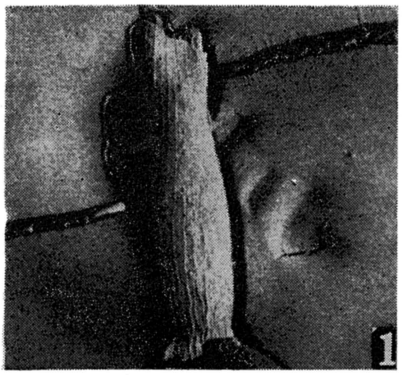


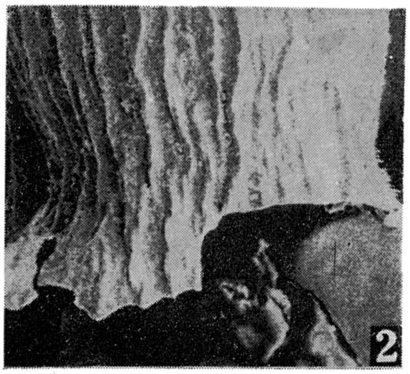


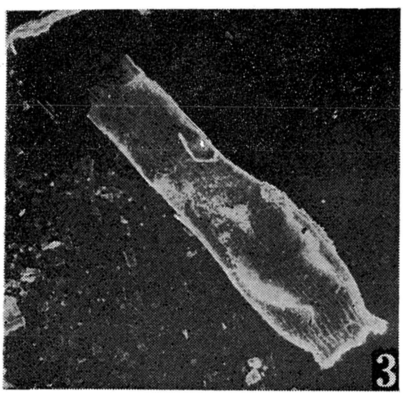


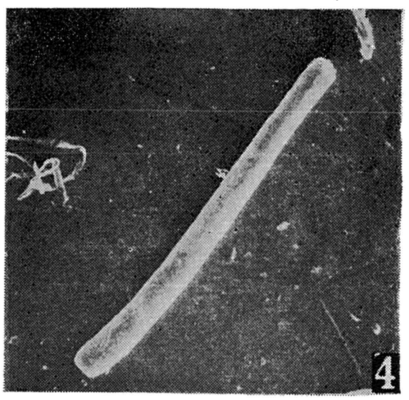


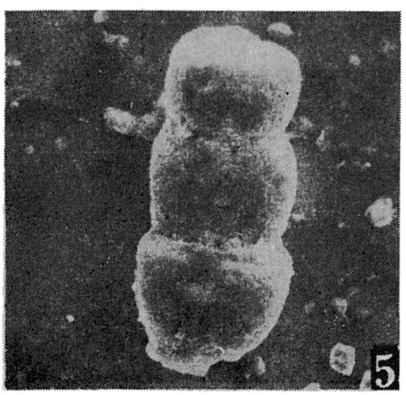
1 — *Cyathochitina campanulaeformis* (Eis.); Dębki *3* borehole, depth 2645.0—2646.0 m, ×120; uncompressed specimen.
2 — the same specimen; ×250; aboral view.
3 — the same species; Dębki *3* borehole, depth 2647.2—2648.2 m, ×300; slightly compressed specimen, aboral view.
4 — the same species; Dębki *3* borehole, depth 2645.0—2646.0 m, ×200; compressed specimen; note membranous flange at the basal edge.
5 — *Conochitina minnesotensis* (Stauffer); Dębki *3* borehole, depth 2647.2—2648.2 m, ×50.
6 — the same specimen, ×300; aboral view.

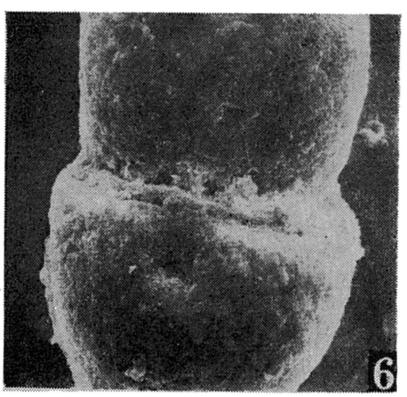












1 — *Cyathochitina stentor* (Eis.); Białogóra *1* borehole, depth 2672.0—2673.1 m, ×60; almost complete, uncompressed specimen, note longitudinal ribs in vesicle wall.
2 — the same specimen ×290; aboral part, note basal flange with undulated longitudinal ribs.
3 — the same species; Białogóra *1* borehole, depth 2672.0—2673.1 m, ×50, compressed specimen.
4 — *Rhabdochitina gracilis* Eis.; Piaśnica *2* borehole, depth 2644.3—2646.3 m, ×50; almost complete specimen.
5 — *Desmochitina* cf. *minor* Eis.; Białogóra *2* borehole, depth 2633.0—2634.0 m, ×180; chain consisting of 3 tests.
6 — the same specimen, ×330.

Cyathochitina stentor (Eisenack, 1937)
(Pl. 2, Figs 1—3)

1937. *Conochitina stentor* n. sp.; Eisenack, p. 221—222, Pl. 15, Figs 1—3.
1962. *Cyathochitina stentor* (Eisenack); Eisenack, p. 300, Pl. 14, Fig. 10.
1967. *Cyathochitina stentor* (Eisenack); Laufeld, p. 317—319, Fig. 19.
1968. *Cyathochitina stentor* (Eisenack); Eisenack, p. 168, Pl. 24, Figs 26—28; Pl. 31, Figs 5...6.
Material: ca. 50 specimens.

Description. — Vesicle elongated, length of the figured specimen (Pl. 2, Fig. 3) 1140 μ, that of the biggest specimen 1220 μ. The cylindrical or subcylindrical neck takes up ca. 40% of the length of the vesicle this being 430 μ. The maximum width of the vesicle is 266 μ, the width of the neck is 340 μ. The specimens belonging to the species here described have a very characteristic aboral edge: the vesicle is constricted in its aboral part and the sharp, very thickened basal edge is provided with a long skirt-like flange which widens rapidly. The outer wall of the vesicle is wrinkled (Pl. 2, Figs 1—3). The ribs commonly run along the whole of the vesicle, in the aboral part they are coarser and more distinct than those in the oral part (Pl. 2, Fig. 1).

Remarks. — The delicate structure of the vesicle does not favour its complete preservation, however, thanks to the characteristic shape and the wrinkled surface of the vesicle wall this species is readily distinguishable from other Chitinozoa.

Occurrence. — The Kukruse stage (Lower Caradocian) of the Peribaltic area (Eisenack 1962, Laufeld 1967), Westphalia (Eisenack 1939). Łeba Elevation: Białogóra *1* profile (at a depth between 2673.0 and 2672.0 m), Piaśnica *2* (between 2646.3 and 2644.3 m), also Dębki *3* (between 2648.2 and 2645.0 m).

Genus *RHABDOCHITINA* Eisenack, 1931
Rhabdochitina gracilis Eisenack, 1962
(Pl. 2, Fig. 4)

1962. *Rhabdochitina gracilis* n. sp.; Eisenack, p. 307, Fig. 6, Pl. 14, Fig. 2; Pl. 15, Fig. 1.
1968. *Rhabdochitina gracilis* Eisenack; Eisenack, p. 167.
Material: ca. 150 specimens.

Remarks. — The shape and measurements of the specimens under consideration (810—1180μ) make them reasonably referable to the species *Rhabdochitina gracilis* Eis.

Occurrence. — Llandeilian—Caradocian of Sweden and of the Peribaltic area (Eisenack 1968). Łeba Elevation: Białogóra *1* profile (between the depth of 2673.1 and 2672.0 m), Piaśnica *2* (2646.3—2644.3 m), Dębki *3* (2648.2—2645.0 m), Mieroszyno *8* (2813.0—2812.0 m).

Genus *DESMOCHITINA* Eisenack, 1931
Desmochitina cf. *minor* Eisenack, 1931
(Pl. 2, Figs 5—6)

Material: 4 chains consisting of 3 tests each; all deformed.

Remarks. — Owing to their strong deformation it is hardly possible undoubtedly to determine the specific appurtenance of the specimens here examined. Forms from the Łeba region resemble most strongly the specimens known from the Holy Cross Mts., by Chlebowski & Szaniawski (1974) referred to the species *Desmochitina minor* Eis.

Occurrence. — Poland, the Łeba Elevation: Białogóra *2* profile (between the depth of 2634.0 and 2633.0 m), Białogóra *1* (2673.0—2672.0 m).

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ZNACZENIE KORELACYJNE POZIOMU Z CHITINOZOA W PROFILACH KARADOKU OBSZARU ŁEBY

(Streszczenie)

W osadach ordowiku wyniesienia Łeby stwierdzono obecność bogatego zespołu Chitinozoa. Mikroskamieniałości te występują w profilu Białogóra *1*, Białogóra *2*, Piaśnica *2*, Dębki *3* oraz Mieroszyno *8*.

Osady, w których stwierdzono obecność Chitinozoa, wykształcone są w postaci czarnych, bitumicznych iłowców, miejscami marglistych z dużą zawartością pirytu. Chitinozoa towarzyszą głównie graptolity, brachiopody i małżoraczki. Spośród kilkuset okazów wydzielono 5 gatunków, należących do 4 rodzajów. Są to: *Conochitina minnesotensis* (Stauffer), *Cyathochitina campanulaeformis* (Eis.), *Cyathochitina stentor* (Eis.), *Rhabdochitina gracilis* Eis. oraz *Desmochitina* cf. *minor* Eis.

Towarzyszące szczątkom Chitinozoa graptolity takie jak: *Nemagraptus gracilis gracilis* (Hall), *Nanograptus* cf. *phylloides* (Elles & Wood), *Nanograptus* cf. *lapworthi* Hadding, *Hallograptus mucronatus mucronatus* (Hall), *Orthograptus whitfieldi* (Hall), *Pseudoclimacograptus* (*P.*) *scharenbergi scharenbergi* (Lapw.) stanowią charakterystyczny zespół dla poziomu *Nemagraptus gracilis*. Obecność pośród innych Chitinozoa *Cyathochitina stentor* (Eis.) potwierdza dolnokaradocki wiek osadów.

Chitinozoa występują tylko w poziomie o niewielkiej (1—3,2 m) miąższości, który w skali regionalnej może służyć jako poziom korelacyjny w obrębie monotonnych osadów facji graptolitowej.
