

CORRELATION OF THE EAST-BALTIC AND GOTLAND SILURIAN BY
CHITINOZOANS

V.-K. Nestor

Taxonomy and distribution of chitinozoans in the Silurian of Gotland have been studied by A. Eisenack (1962, 1964 etc.), P. Taugourdeau and B. Jekhowsky (1964) and especially by S. Laufeld (1974, 1979 etc.). Chitinozoans of the corresponding part of the East Baltic Silurian have been mainly studied from the Estonian borings at Ohesaare, Ruhnu, Varbla, Kipi, Kaugatuma, etc. and also from a number of the borings in West Latvia - Pavilosta, Ventspils and Kolka. A part of these materials (Мяннийль, 1970; Nestor, 1975; Нестор, 1982a, 1982б, 1982в), as well as some data based on the outcrops (Eisenack, 1968; 1970 etc.) have been published earlier.

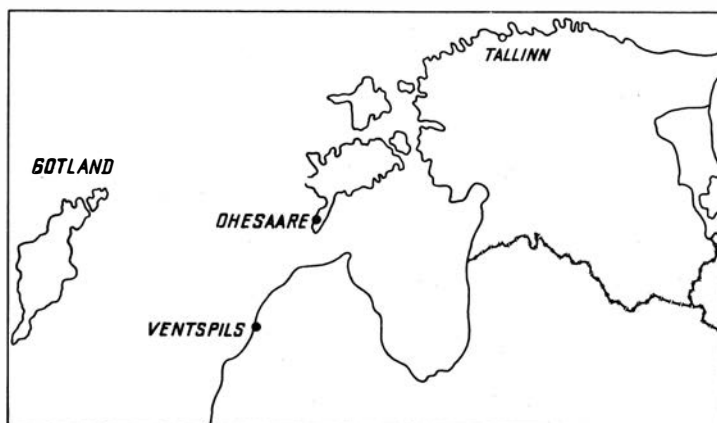


Fig. 1

Location of the main boreholes.

Location of the main boreholes is shown in Fig. 1. The Ohesaare and Ventspils borings were selected as the key sections since the relations between chitinozoa and graptolite zonation are better known. The succession of selected chitinozoan species in the Silurian of Gotland and the corresponding part of the Ohesaare boring are given in Fig. 2. Graptolites from the Ohesaare boring, including those from samples dissolved on chitinozoans, were identified by D. Kaljo (Кальо, 1970). The ranges of the selected chitinozoan species in the boundary beds of the Wenlock and Ludlow in the sections of Ventspils boring and Gotland are shown in Fig. 3. In the Ventspils section graptolite zones are given according to R. Ulst, though these data are still unpublished.

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The comparison of the stratigraphical ranges of chitinozoan species in the Silurian of the East Baltic and Gotland (Laufeld, 1974, 1979) permits the following conclusions to be made.

The Lower Visby Marls of Gotland are usually correlated with the uppermost beds of the Adavere Stage (=Regional Stage, see this book, p. 6) (Martinsson, 1967; Кальо, 1970, etc.). Laufeld (1974) recorded *Margachitina margaritana* from the topmost part of the Lower Visby Beds in Buske and about 8 m below the Lower Visby - Upper Visby bound-

ary in Irevik 3. . The appearance of *M. margaritana* in Estonian sections marks the base of the Jaani Stage (Мяньиль, 1970; Нестор, 1982a). Therefore it is possible that the uppermost part of the Lower Visby Beds corresponds to the lowermost beds of the Jaani Stage.

In the Upper Visby Marls excluding some topmost meters (Laufeld, 1974, 125) there occurs *Angochitina longicollis*, a characteristic species for the Velise Formation of the Adavere Stage and for the lowermost beds of the Jaani Stage (Мяньиль, 1970; Нестор, 1982a). In the latter *Angochitina longicollis* associates with some other species (*Gotlandochitina* n. sp. 1, G. n. sp. 2 etc.) and this part of the sequence has been distinguished as a local zonal unit J_1^I (Нестор, 1982a), which in the Ohesaare section coincides with the graptolite zone of *C. murchisoni*. Therefore we may assume that the main part of the Upper Visby Beds corresponds to the same stratigraphical interval.

Conochitina proboscifera is the dominant species in the Lower Wenlockian Beds of Estonia. The beds with abundant *C. proboscifera* above the range of *Angochitina longicollis* and gotlandochitinas are distinguished as a local zonal unit J_1^{II} (Нестор, 1982a). Its upper boundary is marked by almost complete disappearance of *Conochitina proboscifera* and abundant appearance of *Conochitina* cf. *claviformis*. In the Ohesaare section this interval roughly coincides with the graptolite zone of *M. riccartonensis*. It is notable that on Gotland, according to S. Laufeld (1974, 1979) *C. proboscifera* (s.l.) ranges from the Lower Visby Beds up to the top of the Högklint Beds, and species is found also from the lowermost part of the Slite Beds. Only the distribution of *C. proboscifera* forma *gracilis* is restricted to the Upper-Visby Beds and Högklint "a". In Estonian sequence (in the Ohesaare, Ruhnu, Varbla, Kipi, Tõlla and Pulli sections) the continuous range of *C. proboscifera* (s.l.) is analogous to the range of *C. proboscifera* f. *gracilis* on Gotland. In higher beds of some sections only single scattered specimens of this species have been found, but different formas of *C. proboscifera* in Estonian sections have not been differentiated so far.

In Estonian sequence clear changes of the chitinozoan assemblage take place at the boundary between the beds J_1^{II} and J_1^{III} in the Ohesaare section (at the depth of about 330 m, Нестор, 1982a), which coincides there with the Lower- and Middle-Wenlockian boundary (Кальо, 1970). Instead of *Conochitina proboscifera* *C. cf. claviformis*^x appears there in great numbers. Possibly this stratigraphical level can also be traced on Gotland, at the boundary of the subdivisions "a" and "b" of the Högklint Beds. Högklint "b" and "c" are characterized by *Desmochitina densa* and *Conochitina mamilla* (subdivision b), *C. flamma* and *C. leptosoma* (b, c) and *Desmochitina acollaris* (c) (see Laufeld, 1974, 1979). The uppermost part of the Jaani Stage includes also *Conochitina* cf. *mamilla*, which is an index-species of the beds J_1^{III} and by *Desmochitina acollaris* which first occurs in the beds J_1^{IV} (Нестор, 1982a). This allows to correlate beds J_1^{III} and J_1^{IV} correspondingly with the subdivisions "b" and "c" of the Högklint Beds. In the Ohesaare core this part of the Jaani Stage contains graptolites (Кальо, 1970). *Pristiograptus sardous* occurs in beds J_1^{III} (327-331 m) and *Monograptus flexilis* in beds J_1^{IV} (311.7-8 m).

In the middle part of the Wenlock the rapid renewal of the chitinozoan assemblage took place. *Clathrochitina clathrata*, *Gotlandochitina martinssoni* and *Linochitina cingulata* appear one after another in the succeeding subdivisions of the Slite Beds (d, e)

^x *C. claviformis* has not been identified by S. Laufeld (1974) on Gotland but we consider that part of specimens included by him to the species *C. leptosoma* (Fig. 29-B), *C. aff. proboscifera* and probably also *C. aff. elegans* (the latter from Klinteberg to middle Hemse) may belong to that species.

and in the lowermost beds of the Jaagarahu Stage in the Ohesaare core (see Laufeld, 1974: 126; Hecrop, 1982a, b). It allows to correlate roughly these parts of sequences of both areas.

Succession of the appearance of *Conochitina argillophila*, *C. pachycephala* and *Gotlandochitina tabernaculifera* in the uppermost Wenlock is the same in the Ohesaare boring and on Gotland. In the upper part of the Jaagarahu Stage in the Ohesaare core at the depth of 172.6 m the first representatives of the genus *Sphaerochitina* appear. The Estonian species of *Sphaerochitina* differ from the sphaerochitinas in the Halla and Mulde Beds on Gotland, but it seems likely that the first appearance of this genus in both areas indicates a close age of these beds. The Rootsiküla Stage contains only scattered

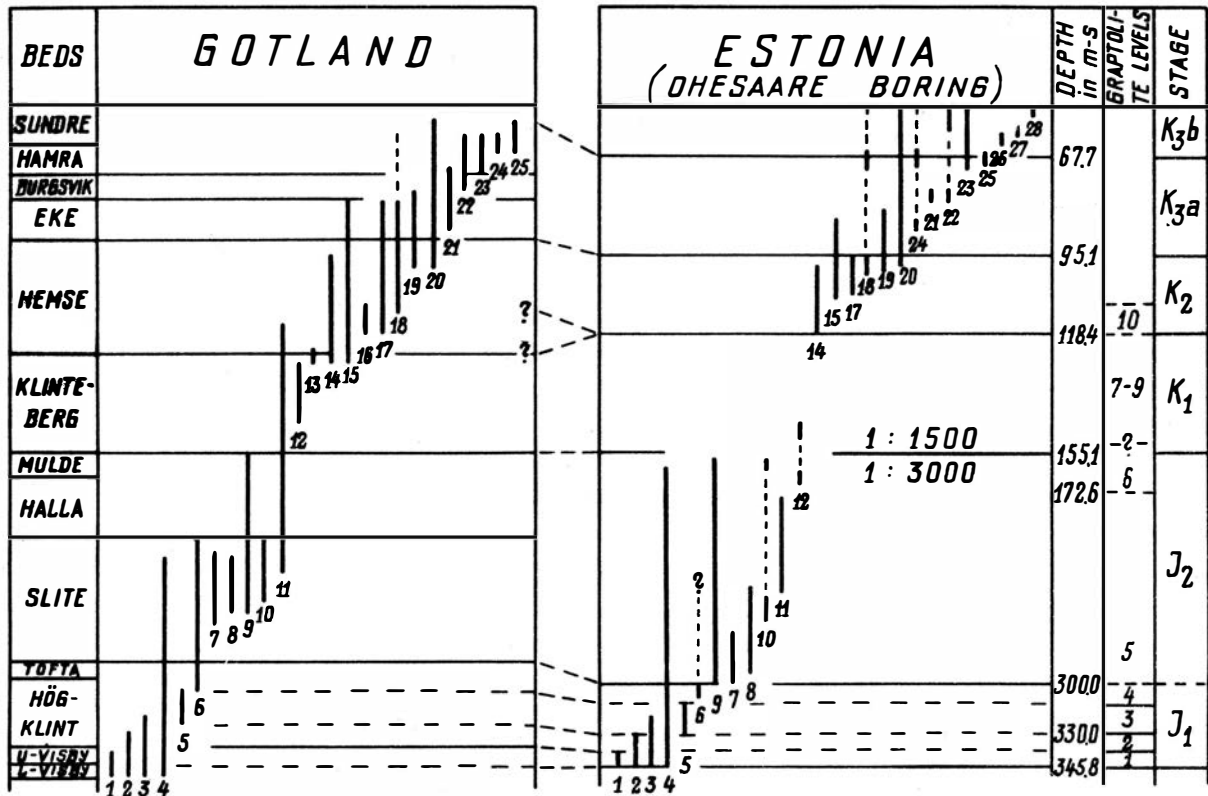


Fig. 2. Stratigraphical ranges of selected chitinozoan species in Silurian of Gotland (Laufeld, 1974) compared with Estonian.

I Chitinozoan species: 1 - *Angochitina longicollis* Eisenack; 2 - *Conochitina proboscifera* Eisenack; 3 - *Desmochitina densa* Eisenack; 4 - *Margachitina margaritana* (Eisenack); 5 - *Conochitina mamilla* Laufeld; 6 - *Desmochitina acellaris* Eisenack; 7 - *Clathrochitina clathrata* Eisenack; 8 - *Gotlandochitina martinssoni* Laufeld; 9 - *Linochitina cingulata* (Eisenack); 10 - *Conochitina argillophila* Laufeld; 11 - *Conochitina pachycephala* Eisenack; 12 - *Gotlandochitina tabernaculifera* Laufeld; 13 - *Gotlandochitina militaris* Laufeld; 14 - *Conochitina latifrons* Eisenack; 15 - *Angochitina elongata* Eisenack; 16 - *Ancyrochitina desmea* Eisenack; 17 - *Conochitina lauensis* Eisenack; 18 - *Angochitina echinata* Eisenack; 19 - *Eisenackitina philipi* Laufeld; 20 - *Eisenackitina lagenomorpha* (Eisenack); 21 - *Conochitina granosa* Laufeld; 22 - *Conochitina intermedia* Eisenack; 23 - *Sphaerochitina sphaerocephala* Eisenack; 24 - *Pterochitina pervivellata* Eisenack; 25 - *Gotlandochitina villosa* Laufeld; 27 - *Ancyrochitina fragilis* Eisenack; 28 - *Eisenackitina cf. elongata* Eisenack.

II Graptolite levels: 1 - *C. purchissoni* Zone; 2 - *M. riccartonensis* Zone; 3 - *P. sardous* Subzone; 4 - interval with *M. flexilis*; 5 - interval with *M. flemingii* and its subspecies; 6 - interval with *G. nassa*; 7-9 - interval presumably corresponding to the *M. ludensis*, *N. nilssoni* and *L. scanticus* Zones; 10 - interval presumably corresponding to the *M. tauragensis* Zone.

specimens and only in its lower part, that do not enable the correlation with the Gotland sequence. It should be noted that the index-species of the Klinteberg Beds *Gotlandichitina tabernaculifera* in Estonia occurs already in the uppermost beds of the Jaagarahu Stage.

Craptolites are rare in the upper part of the Wenlock of the Ohesaare core. According to finds of *M. flemingii* and its subspecies (see Кальо, 1970; Hecrop, 1982b) the so-called "*flemingii* Beds" have been distinguished (interval 174-302 m). *G. nassa* is found in the Ohesaare boring at the depth of 166.4 m and also in the Ruhnu core (pers. comm. by D. Kaljo, see Hecrop, 1982b).

The correlation of the Wenlock and Ludlow boundary beds in the East-Baltic and Gotland is based on the section of the Ventspils boring in West Latvia. In this section R. Ulst has established Ludlow graptolite zones up to the *M. tauragensis* Zone (incl.) (see Fig. 2). On the level of the *N. nilssoni* and *L. scanicus* Zones (interval 610-662 m) there occur chitinozoans: *Conochitina* cf. *lagena*, *C. n. sp. 1*, *Rhabdochitina* sp. 1 and *R. sp. 2*, which have not been found so far in the Upper Silurian of Estonia and Gotland. These species associate with *Conochitina pachycephala*, *C. cf. claviformis* (= aff. *elegans* ?), *C. tuba*, *Ancyrochitina gutnica*, which were earlier known from the Klinteberg Beds. Unfortunately most of the species of *Sphaerochitina* and *Gotlandochitina*, recorded from Gotland, do not occur in the Ventspils core. In the topmost Klinteberg Beds there occur together *Gotlandochitina militaris*, *Conochitina latifrons* and *Angochitina elongata*. In the Ventspils section these species appear one after another in the Dubysa Formation in the uppermost part of the *L. scanicus* and in the lowermost part of the *M. tauragensis* Zone. According to that, the greater part of the Klinteberg Beds is evidently older than the base of *M. tauragensis* (= *tumescens*) Zone and may correspond to the Lower Ludlow graptolite zones *N. nilssoni* and *L. scanicus* (see also Martinsson, 1967). It is likely enough that the lowermost Hemse Beds, characterized by *Conochitina tuba*, *C. pachycephala*, *C. aff. elegans* (= *C. cf. claviformis*), *Ancyrochitina desmea*, are missing in Estonia or possibly, partly correlate with the Rootsiküla Stage (see also Jenkins & Legault, 1979).

In Estonia the next stratigraphical level determined by chitinozoans is the lowermost part of the Paadla Stage. At that level in the Ohesaare core there appear *Conochitina latifrons* and *Angochitina elongata*, whose appearance in the Ventspils section falls into the range of *M. tauragensis*. Accordingly, the lower boundary of the Paadla Stage, as it is defined in the Ohesaare core is evidently not older than the *M. tauragensis* Zone. Therefore, in Estonian sections beds, corresponding to the Lower Ludlow graptolite zones *N. nilssoni* and *L. scanicus* are either missing or correlate with a certain part of the Rootsiküla Stage.

In the lower - middle part of the Hemse Beds *Conochitina lauensis* and *Angochitina echinata* make their appearance and *Conochitina tuba*, *C. pachycephala*, *C. aff. elegans* and *Ancyrochitina desmea* disappear. In the section of Ventspils analogous changes take place within the interval of about 535-570 m, in the topmost beds of the Dubysa Formation and lowermost part of the Pagegiai Formation.

Unfortunately the lower and middle beds of the Paadla Stage in the Ohesaare core contain a reduced number of species. Besides *Conochitina latifrons* and *Angochitina elongata* there occur only *Ancyrochitina* cf. *diabolus* and *Sphaerochitina* sp. Though appearance of *Conochitina lauensis* at the depth of 110.5 m is noteworthy, these data are still not sufficient for exact correlation of the Hemse Beds and the Paadla Stage. Interval of the possible position of the base of the Paadla Stage in the Hemse Beds is given in Fig. 2.

According to S. Laufeld (1974, 127) chitinozoan assemblage of the uppermost part of the Hemse Beds and the lower part of the Eke Beds differ a little from one another.

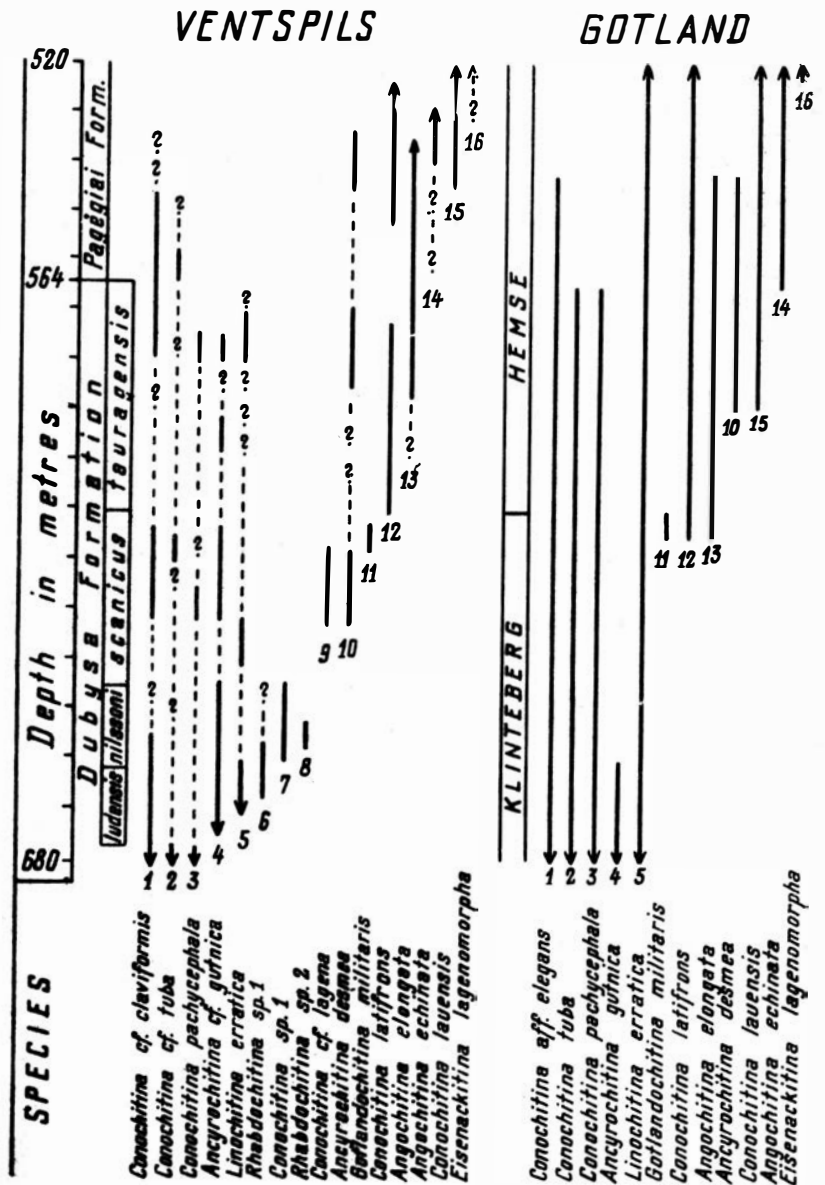


Fig. 3. The succession of selected chitinozoan species in Wenlock-Ludlow boundary beds of the Ventspils section and Gotland.

Sphaerochitina acanthifera appearing in the lowermost Eke Beds, has not been found in the East Baltic. This species proved to be facies-controlled to a very great extent (S. Laufeld, 1974:123, 127). The Eke Beds are mainly characterized by *Eisenackitina lagenomorpha*, *E. philipi*, *Conochitina lauensis*, *C. granosa* and *Angochitina elongata*. Still, the first species appears already in the uppermost Hemse Beds but is represented there by untypical specimens (see Laufeld, 1974: 82). Similar untypical form of *E. lagenomorpha* appears in the Ventspils boring from the depth of 516 m (one dubious specimen already at 532 m) and occurs in Ohesaare in the interval of 95.1 - 99.5 m, corresponding to the uppermost part of the Paadla Stage. The Eke assemblage occurs also in the Ohesaare section, but *Conochitina lauensis* is there mainly restricted to the Paadla Stage and *Eisenackitina philipi* to the lowermost Kuressaare Stage with certain overlap of the ranges.

The upper boundary of the Eke Beds is characterized by disappearance of *Conochitina lauensis* and *Angochitina elongata*. *Eisenackitina philipi* occurs also in the lower part of the Burgsvik Beds. According to S. Laufeld (1974:127) the Burgsvik Beds represent a short time interval with very rapid sedimentation and fossils occurring are greatly dependent on facies.

In the Hamra Beas there appear together *Sphaerochitina sphaerocephala*, *Pterochitina pervivelata*, *Gotlandochitina villosa* and *Eisenackitina oviformis*. Analogous assemblage occurs in the upper part of the Kuressaare Stage in the Ohesaare core. It is noteworthy that *Pterochitina pervivelata* and *Eisenackitina oviformis* are present in Ohesaare already in the lower part of the Kuressaare Stage, at the depth of 89.3 m. In conclusion, the succeeding ranges of *Eisenackitina philipi*, *Conochitina granosa* and *Sphaerochitina sphaerocephala* in Ohesaare core are the most characteristic features of the Kuressaare Stage.

No new species appear in the Sundre Beds; only gradual disappearance of taxa is taking place there. Thus it is difficult to make a certain comparison with the East Baltic sections.

In the Kaugatuma Stage of Ohesaare core as well as in the other East Baltic sections a number of new species appear: *Ancyrochitina fragilis*, *Eisenackitina* cf. *elongata*, *E. filifera*, *Fungochitina pistilliformis* etc., not recorded from Gotland but forming a well-known chitinozoan assemblage of the so-called Beyrichia Limestone described by A. Eisenack (1955, 1968, 1971) from the upper Silurian erratic boulders.

The present paper deals only with the distribution of more essential species, common for both areas. The total number of species is much greater than is given in Fig. 1. It should be noted that some of the species recorded from Gotland and not mentioned here either (1) are rare in the East Baltic (2) occur with some doubt, due to bad preservation; (3) have not been established so far. On the other hand, some of the East Baltic species are probably new, not recorded from Gotland up to now.

In summary, notwithstanding certain differences, probably caused partly by subjectivity of interpretation of the material, partly by ecological reasons, in general the taxonomic content and distribution of chitinozoans of both areas are rather similar and the differences in our opinion are of no considerable influence on the correlation.

Besides, stratigraphical ranges of the most important chitinozoan species in Britain (Aldridge et al., 1979) and Belgium (Verniers, 1981) also indicate certain similarities compared with the East Baltic and Gotland. Though these data are given schematically, they show clear difference in Lower Wenlock (*Conochitina proboscifera*, *C. acuminata*, *Angochitina longicollis*) and Middle Wenlock (*Linochitina cingulata*, *Conochitina tuba*, *C. gutta* etc.) chitinozoan assemblage. Finding out species of worldwide distribution and establishing sure relationships of their ranges with graptolite zones very likely enables to use chitinozoans for age determination in shelly sequences, where graptolites are lacking.

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КОРРЕЛЯЦИЯ РАЗРЕЗОВ СИЛУРА ПРИБАЛТИКИ И О-ВА ГОТЛАНД ПО ХИТИНОЗОЯМ

В. Нестор

Сравнение данных распространения хитиной в силурийских разрезах Эстонии /скв. Ожесааре/, Латвии /скв. Вентспилс/ и острова Готланд позволяет сделать следующие корреляционные выводы:

1. Основная часть мергелей Висбю и слои Хёгклинт соответствуют янискому горизонту - зонам *Conochitina proboscifera* и *C. claviformis* /Нестор, 1982а, б/.

2. Последовательное появление видов *Clathrochitina clathrata*, *Linochitina cingulata* и др. как в яагарахуском горизонте, так и в слоях Слите позволяет грубо сопоставить эти части разреза /см. рис. 2/.

3. Поскольку в Эстонии роотсикулаский горизонт охарактеризован хитинозойми слабо, эта часть разреза сопоставима с готландским через скв. Вентспилс /см. рис. 3/, где пограничные слои венлока и лудлова содержат и граптолиты.

4. Наличие *Conochitina laeensis*, *Eisenackitina lagenomorpha* и др. в слоях Хемсе и в паадласком горизонте позволяет сопоставить эти части разреза /см. рис. 2/.

5. Последовательность видов *Eisenackitina philipi*, *Conochitina granosa* и *Sphaerichitina sphaeroscephala* характерна для курессаареского горизонта и слоев Эке, Бургсвик, Хамра и Сундре.