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The proposed boundary level of the Pirgu Stage is correlated by chitinozoans with the base of the *complanatus* graptolite Zone (Nölvak and Grahn, 1993, fig. 2; Webby *et al.*, 2004, Fig. 2.1).

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FREQUENCY PATTERNS OF CHITINOZOANS AND SCOLECODONTS ACROSS THE LLANDOVERY–WENLOCK BOUNDARY INTERVAL IN THE PAATSALU DRILL CORE, WESTERN ESTONIA

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Quantitative data are extensively used in palaeoecology but may also contribute to a better understanding of environments and deposition regime, palaeobiology and stratigraphy. Frequency patterns of different Early Palaeozoic fossil groups are nevertheless seldom studied jointly and in a detailed temporal and spatial framework. Our present study focuses on the Llandovery–Wenlock boundary interval in the Paatsalu drill core, western mainland Estonia. This interval was selected for a pilot study due to the availability of much background information and the presence of several event levels in the succession of the upper Raikküla, Adavere and Jaani regional stages (Aeronian to lower Sheinwoodian). First, the transition from the Rumba Fm. to the Velise Fm. embraces a rapid facies change that reflects the most extensive flooding of the Baltic Shelf during the Silurian. Second, it covers the much debated Llandovery–Wenlock boundary and the Ireviken Event that has been recognised as an important isotope event and extinction level for several fossil groups. The primary aim of this study was to document and mutually analyse frequency patterns of three common microfossil groups – chitinozoans, scolecodonts and conodonts – representing different modes of life and largely different ecological niches.

Broadly the studied succession is composed of nodular limestones of the Nurmekund and Rumba Fms and dolomitic marls of the Velise and Mustjala Fms (see Fig. 1). Scolecodonts and conodonts were extracted by acid digestion from ca 300–500 g samples, whilst 5–50 grams of each sample was treated separately for chitinozoans. All microfossils were then picked, identified and counted from the residues. At the time of writing this summary, the conodont data were still being assembled and thus they are not discussed here except for the biostratigraphical background.

Chitinozoans. The chitinozoan collection consists of nearly 50 different species. One sample contains usually 5–8 but occasionally 12 species. Chitinozoan frequency per gram varies from less than 1 to about 20 in the Llandovery and from 30 to 170 in the Wenlock. A marked increase in abundance is registered at the Llandovery–Wenlock boundary.

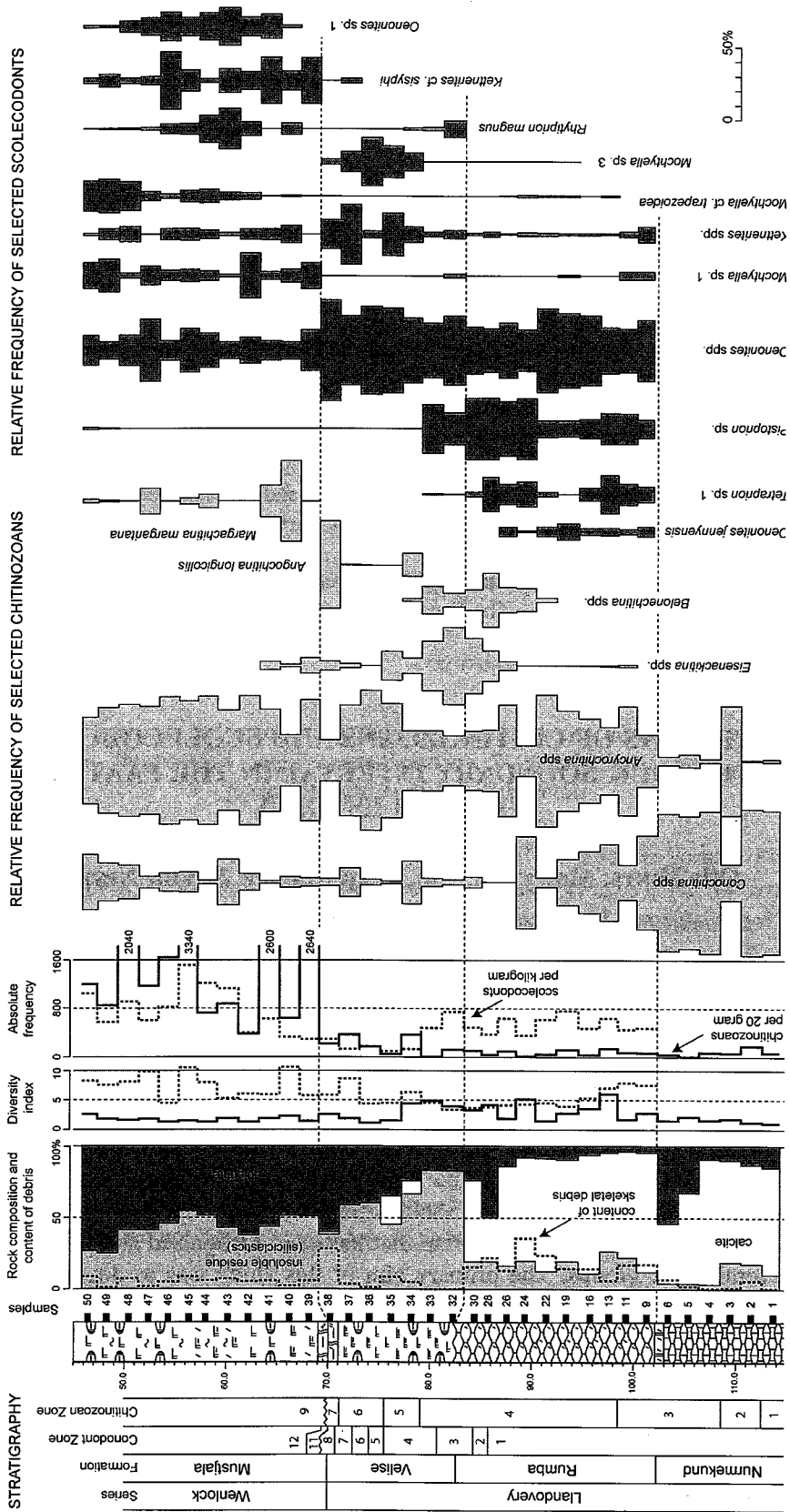


Fig. 1. Stratigraphy, lithology and distribution of selected chitinozoans and scolecodonts in the Paatsalu (527) drill core, western mainland Estonia. Conodont zones: 1 – *Distomodus staurognathoides*?, 2 – *Pterospathodus eopennatus* ssp. n. 1, 3 – *Pt. eopennatus* ssp. n., 2, 4 – *Pt. amorphognathoides angulatus*, 5 – *Pt. amorphognathoides lennarti*, 6 – *Pt. amorphognathoides lithuanicus*, 7 – *Pt. amorphognathoides amorphognathoides*, 8 – Lower *Pseudooneotodus bicornis*, 11 – Lower *Kockelella ranuliformis*, 12 – Upper *Kockelella ranuliformis* (note that 9 and 10, Lower and Upper *Pt. pennatus procerus* and Upper *Pseudooneotodus bicornis* are missing). Chitinozoan zones: 1 – *Euconochitina electa*, 2 – *Ancyrochitina convexa*, 3 – *Conochitina alargada*, 4 – *Eisenackitina dolioliformis*, 5 – *Angochitina longicollis*, 6 – *Conochitina proboscifera*, 7 – *Conochitina acuminata*, 9 – Interzone IV (note that 8, *Margachitina margaritana* zone s. str. is missing). The diversity index is calculated using the well-known Simpson's formula. The counts of scolecodonts were obtained by the most common diagnostic element in the sample. Full sample numbers are preceded by "OM4-".

The most common genera occurring abundantly, but in varying proportions, throughout the studied interval are *Conochitina* and *Ancyrochitina*. In some intervals *Eisenackitina*, *Angochitina* and *Margachitina* may reach considerable relative frequency, accounting for more than 50 % of vesicles in a sample. The frequency patterns are rather fluctuating at the species level, which is partly due to the fact that several species are stratigraphically restricted and the sampling density was not high enough. One species may ultimately make up more than 95 % of the assemblage (*Euconochitina electa* in sample 1). It is common, however, that the dominant species accounts for 50–70 % (e.g., *Ancyrochitina ancyrea* s. lato, *Conochitina elongata*, *Angochitina longicollis*, *Margachitina margaritana*).

Scolecodonts. The jawed polychaete fauna was very rich for the most of the interval studied. Although detailed taxonomic study of the collection is still going on, it is evident that it contains no less than 60, and possibly more than 70 apparatus-based species. Up to 27 species were recorded in one sample. The absolute frequency reaches from about 100 to 1500 per kilogram (the counts are obtained by the most frequent diagnostic element of every taxon identified in a sample; taken that polychaete jaw apparatus may consist of tens of elements, the total number of all scolecodonts may be several times higher). The fauna is generally dominated by polychaetaspids, mochtzellids and paulitinids, and occasionally by rhytiprionids. Particularly common is the genus *Oeononites*, which accounts for 15–70 % of all specimens (see Fig. 1). *Pistoprion*, *Mochtyella* s. lato, *Rhytiprion*, *Kettnerites* and *Tetraprion* are also very common but their frequency displays marked variations. For instance, *Pistoprion* predominates in the Rumba Fm. and the lowermost Velise Fm., but is subsequently absent until the few uppermost samples in the Mustjala Fm. As indicated by the studies from elsewhere, particularly Gotland, the ranges of several jawed polychaete species are apparently longer than those recorded in the Paatsalu core.

Comparison of frequency curves of both groups reveals that the absolute frequency of chitinozoans is on average 10–100 times higher than that of scolecodonts. The Nurmekund and Rumba Fms are generally benthos-dominated and accordingly the abundance of scolecodonts is relatively high and that of planktic chitinozoans low. In the Velise Fm., scolecodonts decrease in abundance and chitinozoans increase, hence showing also negative correlation. On the other hand, the Mustjala Fm. is characterised by a high abundance of both groups. That is, the corresponding environment had to be very suitable for both chitinozoans and jawed polychaetes. Besides this large-scale pattern, it appears that a smaller-scale pattern can be recognised and the fluctuations in the abundance of both groups are in a rather good positive correlation, particularly in the Rumba Fm. Moreover, most of the smaller-scale frequency peaks coincide with the increase in siliciclastics, which, together with supposedly different habits of chitinozoans and jawed polychaetes, may indicate fluctuations in compaction and/or deposition rate. Interestingly, however, the most significant change in the carbonate/siliciclastics ratio at the Rumba–Velise transition (between samples 30 and 32) occurs without marked changes in absolute abundance of either chitinozoans or scolecodonts (increased frequency of scolecodonts in sample 32 may be due to inadequate sample size). Moreover, relative abundance of several predominating chitinozoans and scolecodonts changes only very slightly at this boundary (see the patterns of *Ancyrochitina*, *Conochitina*, *Belonechitina*, *Eisenackitina*, *Pistoprion* and *Oeononites* in Fig. 1).

The absence of the *Margachitina margaritana* Chitinozoan Zone, and the Upper *Pseudooneotodus bicornis* and *Pterospathodus pennatus procerus* Conodont zones indicate that most of the Ireviken Event interval (including the Llandovery–Wenlock boundary) corresponds to a gap in the Paatsalu drill core (cf. Nestor, 1994; Jeppsson and Männik, 1993). It is therefore not unexpected that the frequency changes at this level (between samples 38 and 39) are very sharp. Although the changes in polychaete assemblages are less abrupt than in case of chitinozoans, they also display disappearance, appearance and marked decrease/increase in the abundance of several taxa. Particularly notable are the decrease in *Oeononites* spp., disappearance of *Mochtyella* sp. 3 and increase in *Kettnerites* cf. *sisyphi*

and *Mochtyella* sp. 1. For detailed study of the Ireviken Event and its effects on chitinozoans and polychaetes, however, a more complete section is needed.

It is also evident that, based on one section only, the frequency changes as documented here cannot always be fully understood and interpreted. Thus it remains currently unclear whether the species-level frequency changes like, e.g., the peaks in *Rhytiprion magnus*, *Kettnerites* cf. *sisyphi*, *Oenonites* sp. 1 and *Mochtyella* sp. 3 ex gr. *fragilis* can be traced spatially and whether they occur in the same stratigraphical position.

Also, current sampling density was insufficient to reveal whether certain abrupt changes in assemblage composition (e.g., *Conochitina/Ancyrochitina* ratio and *Pistoprion/Oenonites* ratio between samples 22 and 24, see Fig. 1) are actually continuous but rapid, or truly abrupt and marking missing time and rock.

Therefore we plan to extend our research to other localities and increase the stratigraphical resolution at the most intriguing levels.

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MICROFOSSIL DYNAMICS AND BIOSTRATIGRAPHY IN THE UHAKU–KUKRUSE BOUNDARY INTERVAL (ORDOVICIAN) OF NE ESTONIA

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The boundary between the regional Uhaku and Kukruse stages has usually been drawn at the base of the lowest commercially important kukersite seam (bed A) in NE Estonia as proposed already by Bekker (1924). In spite of the fact that the Kukruse Stage as a whole can be widely correlated all over the Baltic Palaeobasin with the help of numerous micro- and macrofossils (e.g., Männik, 1986), precise determination of its lower boundary may be complicated where the corresponding oil-shale beds are missing. Moreover, since the Kukruse Stage has been considered as an approximation of the *Nemagraptus gracilis* Biozone, its lower boundary is commonly correlated with the lower boundary of the global Upper Ordovician Series. Since the formal establishment of the latter GSSP in Fågelsång, Sweden, it has been a tempting task to find criteria for more precise correlation of this level to Estonian sections.

To help solving these questions, we aimed at obtaining new data on the distribution of common acid-resistant fossils, particularly graptolites, conodonts, chitinozoans and scolecodonts across this boundary in the type area in NE Estonia. A new series of samples was collected from the Uhaku–Kukruse boundary interval (with emphasis on frequency patterns in the upper part of the Uhaku Stage) from the Viru Mine, and some older and unpublished collections were re-examined.

The **conodont** fauna in the Viru and Kohtla sections is represented by a rather invariable association throughout the studied interval. The absolute frequency of conodonts (elements per kg) is higher in the lower part of the sequence reaching nearly 500 (Fig. 1). The conodont yield was considerably lower in the samples taken from kukersite beds (those are not shown in Fig. 1). Otherwise there seems to be no clear relationship between, e.g., carbonate content and frequency of conodonts. The conodont fauna is predominated by *Baltoniodus variabilis*, *Semiacontiodus carinatus* and *Panderodus sulcatus* and *Drepanoistodus* that represented by two species. *B. variabilis* is a very common form in the upper Uhaku–lower Kukruse interval in whole Baltoscandia. It is important for stratigraphy although distinguishing from the ancestral *B. prevariabilis* may be complicated. The latter species was not found in the studied sections but occurs in several drill cores. The most important find from the Kohtla section is *Amorphognathus tvaerensis* that first appears ca 30 cm above the base of the Kukruse Stage. This is so far the earliest find of *A. tvaerensis* in Estonia allowing the corresponding biozone to be drawn lower than suggested previously (eventually approximated with the base of the Kukruse Stage). *Pygodus anserinus* – index species of the preceding biozone has not been recovered from