

WENLOCK AND LATE SILURIAN TRILOBITE ASSOCIATIONS OF THE EAST BALTIC AREA AND THEIR STRATIGRAPHICAL VALUE

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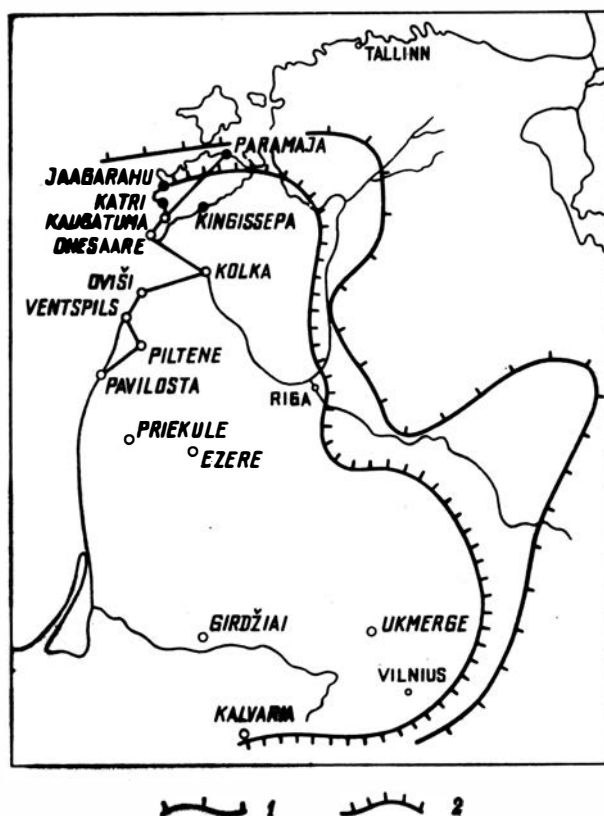
So far little attention has been paid to Silurian facies-controlled trilobite associations. Among the few exceptions are the papers on British Wenlock trilobite associations by A. T. Thomas (1979), trilobite ecology in the Ludlow of the Welsh Borderland by D. G. Mikulic and R. Watkins (1981) and the trilobite associations of the Thornton Reef in Illinois and in Paleozoic carbonate buildups by D. G. Mikulic (1976, 1980). A comparison of the trilobite associations presented in these papers with the East Baltic Silurian ones shows a taxonomic and morphologic similarity between those from related lithofacies of different regions, and evidences of their value in stratigraphic correlations.

Generally trilobites are of wide environmental range occurring from basinal graptolite mudstones up to the shoal biohermal limestones. At the same time their species are highly sensitive to facial conditions and their diversity and abundance remarkably differ in different environmental zones. The studied East Baltic Silurian trilobites come predominantly from the subsurface. In accordance with this the distribution pattern, demonstrated herein, is based mainly on the beds relatively rich in trilobites.

Fig. 1

Outcrops (dots) and borings (circles) studied.

1 - limit of the present distribution of the middle Wenlock deposits; 2 - contour of complete thickness of corresponding rocks.



This paper presents an example of the environmental control on trilobite distribution in the Wenlock and Late Silurian on the basis of a cross-section from Paramaja cliff to Pavilosta boring (Figs 1, 2). In the section (Fig. 2) mainly the areal distribution of the species is shown (the vertical ranges are given approximately) as well as the vertical and areal distribution of the twelve recognized associations. This model is based on the following facies belts (according to Nestor and Einasto, 1977): lagoon-littoral (I), shoal (II), open shelf (III), slope (IV) and depression (V). Facial interpretation of studied sections was performed by R. Einasto, thicknesses of stages and series are given according to Kaljo et al. (Калъо, 1970), Gailite et al. (Гайлите и др., 1967), Sarv (Сарв, 1977), etc.

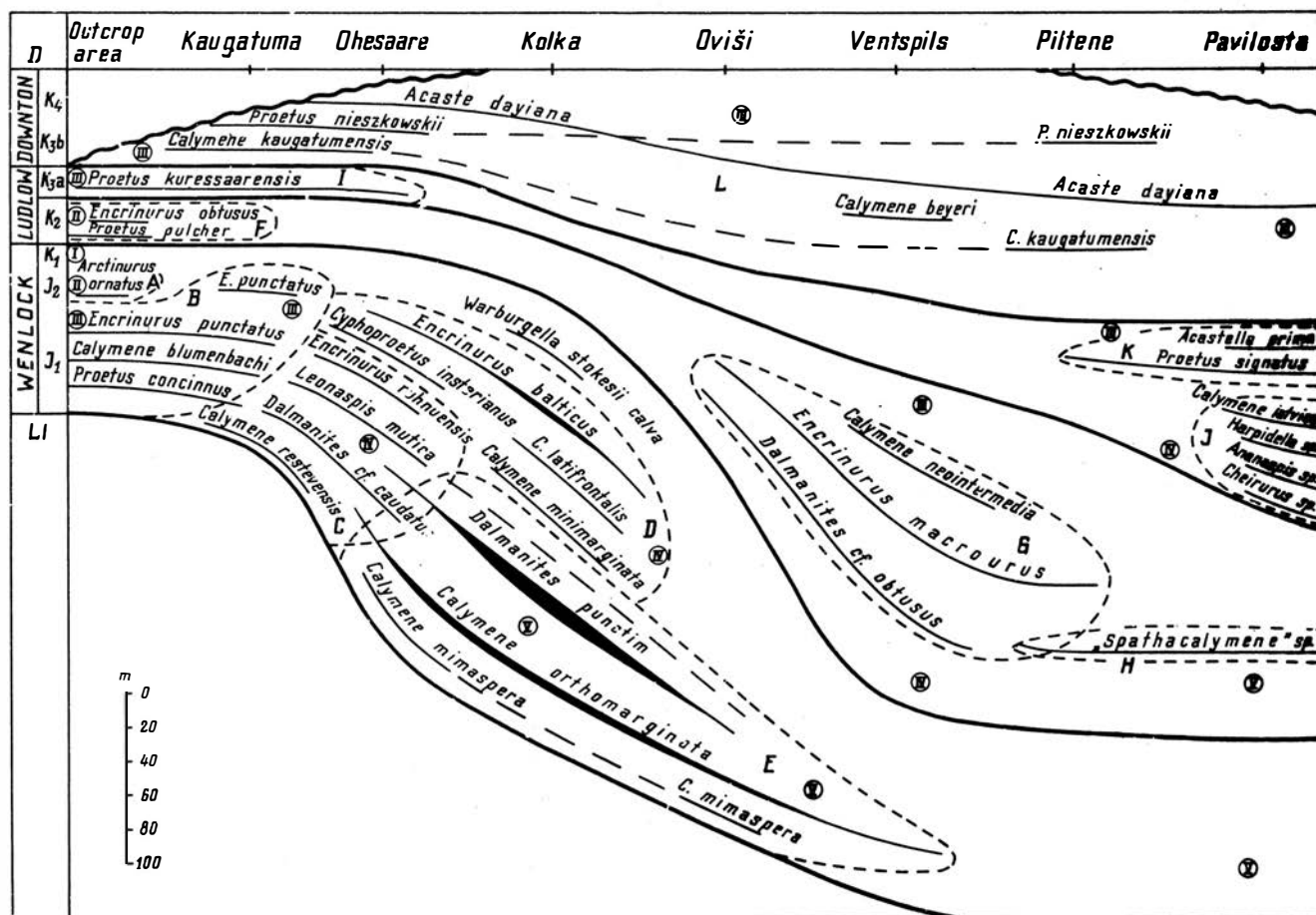


Fig. 2. Areal ranges of Wenlock and Upper Silurian trilobite species and associations between Saaremaa and Pavilosta boring (West Latvia). The thickness of range lines shows the relative abundance of the species; the areal and stratigraphical distribution of the associations is contoured by dotted line.

Associations:

A - *Arctinurus ornatus*; B - *Encrinurus punctatus*; C - *Leonaspis mutica*; D - *Encrinurus balticus*; E - *Calymene orthomarginata*; F - *Proetus pulcher*; G - *Encrinurus macrourus*; H - "*Spathacalymene*"; I - *Proetus kuressaarensis*; J - *Calymene latvica*; K - *Proetus signatus*; L - *Acaste dayiana*.

Facies belts: I - lagoonal - littoral, II shoal, III - open shelf, IV - slope, V - depression.

Wenlock. In the East Baltic Wenlock five trilobite associations have been recognized. They are treated in more detail in a forthcoming paper (Männil, 1982). From nearshore area in the direction of the open sea the associations are arranged as follows:

A. Arctinurus ornatus association occurs in nearshore reefs. It is of a rather restricted distribution and is nearly monospecific, as the nominal species (sporadically abundant) is accompanied only by rare specimens of *Calymene*.

B. Encrinurus punctatus association occurs in light-grey calcareous marls of the transitional area from the open shelf to the slope. It consists of *E. punctatus*, *Calymene blumenbachi*, *Proetus concinnus osiliensis*, *Bumastus* cf. *barriensis* and *Harpidella elegantula* and is best developed in the type area of the Jaani Formation (Paramaja cliff) on the northern coast of Saaremaa. This association is comparable with *Proetus/Warburgella* association in British Wenlock (Thomas, 1979).

C. Leonaspis mutica association is restricted to the grey marls of the slope facies belt. It is represented by *Leonaspis mutica*, *Calymene restevensis* (= *C. mimaspora livonica* Männil, 1977), *Dalmanites* cf. *caudatus* and *Encrinurus ruhnuensis*. It must be noted that in all studied sections *C. restevensis* partially precedes other species of this association, being one of the rare Early Wenlock trilobites in the East Baltic. As the association closely overlaps with lateral ones its recognition is often rather difficult.

D. Encrinurus balticus association is developed in greenish-grey marls of the slope facies belt. The most common species are *E. balticus*, *Cyphoproetus insterianus* and *C. latifrontalis*, accompanied by rare specimens of *Calymene minimarginata* and *Dalmanites* sp.

E. Calymene orthomarginata association is the most offshore one, occurring in dark-grey mudstones of the inner part of the depression facies area, often containing fragments of graptolite rhabdosoms. This association, low in diversity, consists of abundant *Dalmanites punctim*, *C. orthomarginata* and *Calymene mimaspora* (which appears by analogy with *Calymene restevensis* already in the Early Wenlock). Towards the central part of the basin the amount of other species decreases and finally the association becomes monospecific, being represented only by nominal species (in Ventspils boring).

This association is comparable with *Dalmanites/Raphiophorus* association in British Wenlock (Thomas, 1979). In the latter the calymenids of nodulosa-type (= *Tapinocalymene Siveter*, 1980) are of the same morphotype as the most deep-water calymenids of the East Baltic, having long preglabellar area, wide and long proximal part of fixed cheek relative to the glabella, etc. (*C. latigenata*, *C. orthomarginata*, "*Spathacalymene*" sp.).

Generally the East Baltic Wenlock trilobites are quite closely comparable with contemporaneous British trilobites, however their diversity is much lower. Such genera as *Trimerus*, *Schizoproetus*, *Decoroproetus*, *Raphiophorus*, *Radnorina* and the representatives of the *Delops/Miraspis* association have never been recorded from the East Baltic. This is evidently caused by more homogenous environmental conditions and by restricted collections from deep-water deposits in the East Baltic.

Ludlow. In the East Baltic Ludlow the following six trilobite associations are recognized.

F. Proetus pulcher association. It occurs in the shoal limestones of the Paadla Formation, is low in diversity and abundance. *Proetus pulcher* is the dominant, associated with rare specimens of *Encrinurus obtusus* and *Calymene* sp.

G. Encrinurus macrourus association is developed in the grey marls of Dubysa and Engure Formations of the slope facies belt of the Paadla stage and consists mainly of

E. macrourus, *Dalmanites* cf. *obtusus* and *Calymene neointermedia*.

H. "Spathacalymene" association. It is the most offshore association in Ludlow, occurring in the dark-grey marls of the inner part of the depression facies belt. It is mainly monospecific, as besides the nominal species only rare remains of *Dalmanites* sp. and *Calymene* cf. *neointermedia* have been found.

I. *Proetus kuressaarensis* association is low in diversity, occurs in clayey nodular limestones of the open shelf of the outcrop area of the Kuressaare Formation (Kudjape Member). It consists mainly of two species: *P. kuressaarensis* and *Calymene flabellata*.

J. *Calymene latvica* association occurs in greenish-grey marls of the slope facies belt of the Pagegiai Formation of the Kuressaare Stage. It is highly diverse and abundant. The association is represented by rather deep-water, mainly undescribed species: *Cheirurus* sp., *Ananaspis* sp., *Harpidella* sp., *Coniproetus* sp., *Calymene latvica*, *Proetus* cf. *signatus*, *Acastella* cf. *prima*, etc.

K. *Proetus signatus* association occurs in grey calcareous marls of the transitional area between the open shelf and slope facies belt of the same formation. The nominal species is dominant, associated with *Acastella prima*, *Encrinurus* sp., *Harpidella* sp. and *Calymene* sp.

On the whole, the offshore Ludlow trilobite associations of the East Baltic are taxonomically (by the presence of *Dalmanites* cf. *obtusus*, *Harpidella* sp., *Leonaspis* sp., *Ananaspis* sp.) quite similar to Ludlow association of mudstone and laminated shale facies in Welsh Borderland (Mikulic and Watkins, 1981).

Downton. In the studied area Downton deposits belong mainly to the open shelf belt. In accordance with this, their trilobite fauna is rather monotonous and represented mainly by species of genera *Calymene*, *Proetus* and *Acaste*. The most characteristic species with wide horizontal distribution are *Acaste dayiana* and *Proetus nieszowskii* (obviously occurring both in the Kaugatuma and the Ohesaare Stages). Thus, the whole Downton trilobite fauna has been treated as *Acaste dayiana* association (L.). Additional trilobites are of somewhat more restricted lateral and vertical ranges, among them the relatively common *Calymene kaugatumensis* and *C. schmidtii* (Kaugatuma Stage) and *Calymene conspicua* (Ohesaare Stage).

Correlational comments

A number of trilobite species and their associations, distinguished in the East Baltic Wenlock and Late Silurian, are known from similar lithofacies in other regions, yielding important data for correlation.

The most offshore Wenlock associations of *Calymene orthomarginata* and *Encrinurus balticus* are probably endemic. Outside the East Baltic their members are so far known only from erratic boulders in the territory of the German Democratic Republic (Schränk, 1970, 1972). More onshore species are of wider distribution. Thus, *Calymene restevensis*, which marks the base of the Wenlock of the East Baltic, has been described from the Restevo Beds of Podolia (Баранова, 1975). The *Encrinurus punctatus* association is of the widest geographical distribution. Most species of this association occur in Högklint, Mulde and Slite Beds of Gotland (Lindström, 1885; Hede, 1960; Tripp, 1962; Bruton, Jaanusson, Owens, Siveter, Tripp, 1979), in Wenlock of England: *Bumastus barriensis* in Woolhope and Barr Limestones (Thomas, 1978); *Proetus concinnus* in Woolhope Limestone, Coalbrookdale Formation, Much Wenlock Limestone and Lower Elton Beds (Thomas, 1978); *Calymene blumenbachi* in Much Wenlock Limestone (Shirley, 1933) and in Woolhope Limestone Formation (*C. blumenbachi* subsp. n., Siveter, 1980, pl. 100, Figs 12, 14, 16). It should be noted that the latter subspecies is probably identical with morpho of *C. blumenbachi* from Paramaja cliff. All the species of the *E. punctatus* association, known from the East Baltic, have been also found in the upper part of Restevo Beds, Demshin

Beds and lower part of the Vrublevets Beds of Podolia (Баламова, 1975; L. Konstantinenko, personal communication).

Arctinurus ornatus, occurring in reefs of the Jaaqurahu Stage, has been found in Tofta and Slite Beds of Gotland (Hede, 1960). The slope facies marls of the upper part of the same stage have yielded *Warburgella stokesii calva*, which is closely related to *W. stokesii* from the topmost Coalbrookdale Formation and Much Wenlock Limestone of England as well as from Halla unit "b" of Gotland (Thomas, 1978).

A representative of the uncommon genus "*Spathacalymene*" occurs in the Ludlow deep-water deposits (*scanicus* and *tumescens* graptolite Zones) in South-West Latvian cores. Up to the present this genus is known only from Upper Mielnik Beds of North-East Poland. "*Spathacalymene*" *brevis*, the species most similar to the Latvian one occurs in the *Cucullograptus aversus* and *Saetograptus leintwardinensis* Zones (Tomczykowa, 1970).

In onshore direction the "*Spathacalymene*" range partially coincides with the range of the *Encrinurus macrourus* association, which extends from the *scanicus* Zone almost up to the *lauensis-ctenophora* ostracode Zone. Members of this association have been long known from the Hemse Marls of Gotland (Lindström, 1885; Schmidt, 1859). It should be noted that *Dalmanites* cf. *obtusus*, which is rather frequent in Latvian borings but occurring mainly as indeterminate fragments, seems to be closely related to (if not identical with) *Dalmanites myops*, the most abundant species in mudstone, laminated shale and bioturbated siltstone facies of the Middle and Upper Elton and Lower Bringewood Beds in the Welsh Borderland. There is also *Calymene neointermedia* in the Upper Leintwardine Beds of the same region (Mikulic & Watkins, 1981). *Encrinurus macrourus* is known also from the Mielnik Beds of Poland (Alberti et al., 1982) and probably from Sokol Beds of Podolia (Konstantinenko, personal communication).

Encrinurus obtusus from the shoal facies of the Paadla Formation is known from the Hemse and Eke Beds of Gotland (Hede, 1960; Schrank, 1972).

The species of the most deep-water, *Calymene latvica* association of the Kuressaare Stage has obviously not been found in other areas so far. The main members of the subsequent *P. signatus* association - *P. signatus* and *Acastella prima* are of wider geographical distribution. They occur outside the East Baltic also in Burgsvik, Hamra and Sundre Beds of Gotland and Upper Sieldce and Lower Podlasie Beds (*formosus* and *ultimus* graptolite Zones) of Poland (Tomczykowa, 1962; Alberti et al., 1982), and apparently also in Grintshuk of Podolia.

The trilobites from the outcrop area of the Kuressaare Stage show generally low abundance and are evidently of more restricted distribution. However, *P. kuressaarensis* has been founded from Grintshuk Beds of Podolia and a species closely related to it (*P. pulcher* subsp. sensu Schrank, 1972) from the Sundre Beds of Gotland (according to H. Alberti's unpublished data).

In Downton of the East Baltic *Acaste dayiana* is of maximum areal and vertical distribution. This species associated with *Calymene beyeri* (s.l.) characterizes Lower Podlasie and Upper Rzepin Beds in Poland (Tomczykowa & Witwicka, 1974; Alberti et al., 1982), and together with *Proetus scalicus* the Skala Stage in Podolia (Баламова, 1968). The latter is closely related to another typical species of the East Baltic Downton - *Proetus nieszkowskii*.

From the above follows that trilobite species occurring in similar lithofacies have quite coeval stratigraphical ranges in rather distant sections. Trilobites occurring in the open shelf and slope facies belts are of widest geographical distribution, thus being the most valuable for stratigraphical correlations. These are mainly the representatives of the *Encrinurus punctatus*, *E. macrourus* and *Proetus signatus* associations.

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ВЕНЛОКСКИЕ И ВЕРХНЕСИЛУРИЙСКИЕ АССОЦИАЦИИ ТРИЛОВИТОВ
ПРИБАЛТИКИ

Рээт Мяннил

Трилобиты в целом отличаются широкой фациальной амплитудой, но отдельные их виды приурочены к определенным литофациям, где образуют более или менее четкие ассоциации. В венлоке и верхнем силуре Прибалтики выделены двенадцать трилобитовых ассоциаций, замещающих друг друга в пространстве и времени /рис. 2/.

За пределами Прибалтики многие виды и некоторые ассоциации встречаются в аналогичных литофациях того же стратиграфического интервала. Наиболее широко распространены представители открытошельфовых и склоновых ассоциаций, прежде всего ассоциация *Encrinurus punctatus* в венлоке и ассоциации *E. macrourus* и *Proetus signatus* в лудлове.