THE TECTONIC FACTOR IN THE GEOLOGICAL HISTORY OF THE EAST BALTIC BASIN DURING THE SILURIAN

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Résumé

D'après les changements de faciès, la structure cyclique des séquences, l'alternance des épaisseurs des sédiments, etc. dans le développement du bassin silurien de Baltique orientale, on peut définir trois cycles sédimentaires essentiels : 1) Llandoverien inférieur et moyen, 2) Llandoverien supérieur et Wenlockien, 3) Ludlovien et Downtonien. Il y a quelques variations par rapport au schéma mentionné en certaines parties du bassin, en fonction des différents caractères et de l'intensité des mouvements tectoniques. Ainsi, le Llandoverien a son épaisseur maximale dans la dépression d'Esthonie méridionale, le Wenlockien dans celle d'Irben et le Ludlovien et Downtonien dans celle de Lithuanie polonaise.

Резюме

По смене фаций, цикличному строению разрезов, распределению мощностей и т.д. в развитии Прибалтийского бассейна выявляются три крупных цикла: а) ранне-среднелландоверийский; б) позднелландоверийско-венлокский; в) лудловскодаунтонский. В отдельных районах бассейна имеются некоторые отклонения от этой схемы, обусловленные разным характером и интенсивностью тектонических движений. Так, лландовери является наиболее мощным в Южно-Эстонском прогибе, венлок в Ирбенском прогибе, а лудлов и даунтон в Польско-Литоской впадине.

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At the Institute of Geology of the Academy of Sciences of the Estonian SSR, a series of lithofacies maps of the Silurian of the East Baltic have been compiled, which allow us to trace the development of the eastern part of the East Baltic basin. The changes in the faunistic composition have been studied at the Institute, as well. Relevant researches were carried out by lithologists A. AALOE, E. JÜRGENSON, R. EINASTO, paleontologists D. KALJO, E. KLAAMANN, E. MARK-KURIK, REET and R. MANNIL, H. NESTOR, M. RUBEL, L. SARV, V. VIIRA and, besides, by A. ROOMUSOKS from Tartu State University and research workers of the Institute of Paleontology of the USSR Academy of Sciences, G. ASTROVA and G. KOPAYEVICH. In the main, the results of their studies have been published in the monograph « The Silurian of Estonia » [Editor KALJO, 1970], and partially they are about to be completed. As far as possible, use has been made of the data obtained by Latvian [L. GAILITE, R. ULST, and others] and Lithuanian colleagues [I. PASKEVICIUS, P. LAPINSKAS, I. SALADZIUS, and others]. The author wishes to express here his deepest gratitude to them for their valuable help and collaboration.

In the main lines, the configuration of the East Baltic basin (fig. 1) is determined by the outline of the syneclise situated between the Baltic shield and the Byelorussian-Masovian anteclyse. According to the data of deep borings and geophysical researches, the geological structure of that region, in spite of its platform character, is rather complicated (RUKHOVEC, 1970; FAJTEL'SON, MISHINA, 1970; *et al.*).

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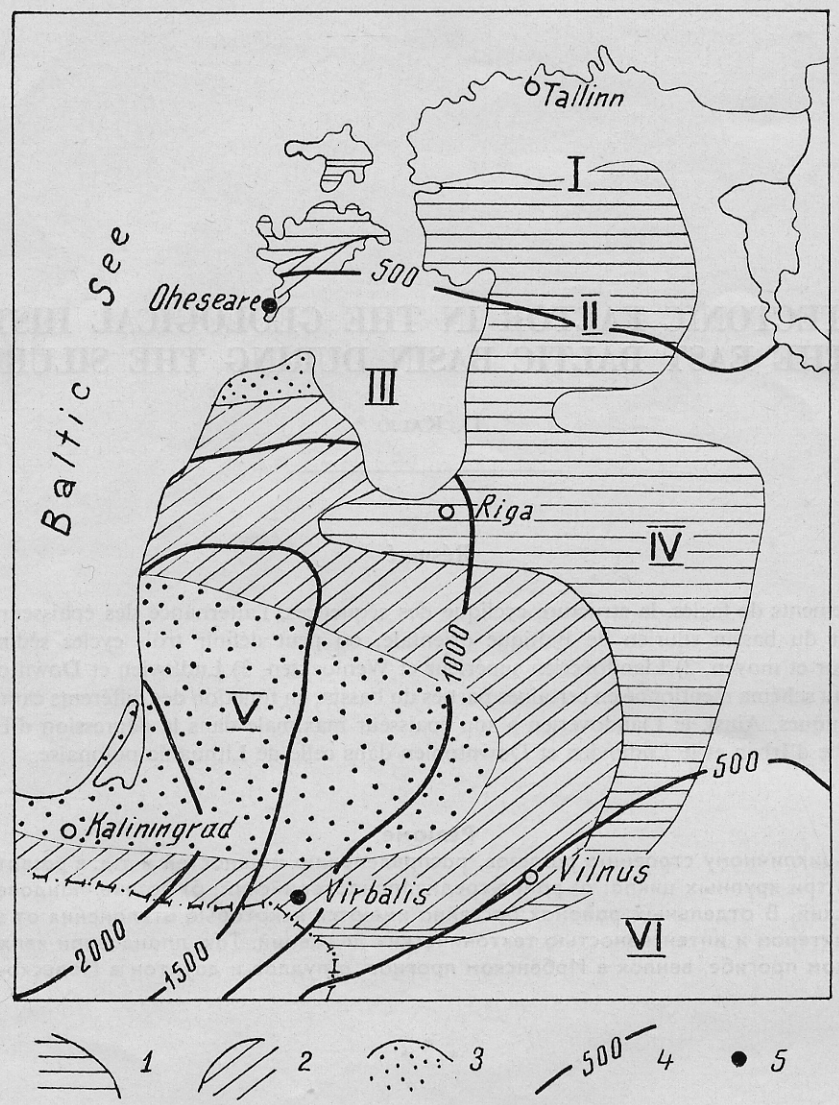

FIG. 1. — *Distribution of Silurian deposits in the East Baltic.*
1. — Lower Silurian; 2. — Upper Silurian; 3. — Lower Devonian; 4. — The depth of the crystalline basement; 5. — Boring; I. — The southern slope of the Baltic shield; II. — South-Estonian depression; III. — Irben depression; IV. — Latvian depression; V. — Polish-Lithuanian trough; VI. — Byelorussian-Masovian anteclise.

The role of the tectonic factor in the development of the East Baltic basin is revealed both in the spatial change of facies and in the rythmical and cyclical structure of the sequences, as well as, in the alternation of the thicknesses of sediments, in the presence of hiatuses, etc.

In the above-mentioned work, « The Silurian of Estonia », the following succession of facies is considered to be typical of the Silurian East Baltic basin (in the order of their distribution beginning from the shore) :

1. The near-shore quiet-water (lagoon) facies of primary dolomites with an impoverished fauna; only eurypterides, stromatoliths and lingulids are met with.

2. The near-shore mobile-water (shoaly) facies of grainy and biomorphous calcareous deposits with bioherms and biostromes and a rich coral-and-stromatoporoid assemblage, algae, and brachiopod communities of the *Pentamerus* and *Linoporella* type.

3. Moderately shallow-water (detritic) facies, of mainly detritic carbonate deposits with a varied fauna (brachiopods, e.g. the community of *Stricklandia*, bryozoa, molluscs, corals, ostracodes, trilobites, etc.).

4. Distant shallow-water (transitional) facies of terrigenous-carbonate deposits with a rich ostracode-brachiopod-trilobite assemblage (e.g. community of *Clorinda*).

5. Off-sea facies of terrigenous or terrigenous-carbonate deposits with graptolites. They seldom include inarticulate brachiopods, hyolithids and cephalopods.

Unfortunately, it is not always possible to trace all the facial transitions according to the state of preservation and accessibility, but even in its incomplete stage, the scheme permits us to gain a better idea of the regularities in the development of the basin.

If, in the Silurian, the position of the East Baltic basin in relation to the equator has determined the arid type of sedimentation in the basin, then the character of the concrete tectonic movements, together with the continuous change of the facies, has determined the changes in the fauna (of course, within certain limits, in consideration of the general character of the North-European biogeographical province). The latter fact constitutes a supplementary difficulty in stratigraphy, since instances of the « sliding » of the shelly fauna in time are rather common. Thus, *Stricklandia lens* and *Coelospira duboisi* are known to occur in the Lower Llandovery (G^{1-2}) in North Estonia, whereas in South Estonia they are distributed in the Middle Llandovery (G_3). Splendid instances of the different age of a number of stromatoporoids on the islands of Saaremaa and Gotland have been cited by K. Mori [1968].

It seems that the further fate of the macropalaeontological methods in biostratigraphy depends to a great extent upon the solution of the problem of faunas « sliding ».

The tectonic movements considerably influence the composition of deposits, and therefore the cyclic character of the sequences is very well illustrated with the help of the curves showing the content of terrigenous material (insoluble residue) in the rock. Experience shows that generalized curves (fig. 2A) render the more general tendencies of the basin's development rather well, whereas the less generalized ones (fig. 2B) show the rythmical construction of the sequence or the local cycles.

A comparison of the generalized curves with the change of the facies on the basis of the series of lithofacial maps, with a consideration of the above-quoted sequence of the facies, shows that the minimum content of terrigenous matter in deposits corresponds to the regression whereas the maximum reflects the transgression of the sea. Here, as a rule, the transgressive phase of the cycle is of a shorter duration, and the regressive phase usually proceeds more gradually and at a comparatively slower pace.

In the Silurian development of the northern part of the East Baltic basin, the following major cycles may be defined (fig. 2A) : 1) the Early and Middle Llandoverian; 2) the Late Llandoverian and Wenlockian (including the beginning of the Ludlovian, as well); 3) the Ludlovian and Downtonian.

The minimums of the content of terrigenous material, i. e. the regressive phases coincide with the Middle Llandoverian (uppermost part of G_3) and the end of the Wenlockian — beginning of the Ludlovian (J_2-K_1). The maximum of the transgressive phase was evidently at the beginning of the Wenlockian (lowermost part of G_1).

It may be of interest to note that it was during the transgressive phase of the second cycle that numerous beds of metabentonite clays were accumulated, which are regarded as products of an intensive volcanic activity in the Caledonian geosyncline [Jurgenson E, 1964].

In the southern part of the East Baltic basin (Lithuania and, partially Latvia) the cycles somewhat deviate from the above-presented scheme. As known [see Mannil, 1966; Gailite, Rybnikova, Ul'st, 1967; Paskevicius, 1968], due to a regression at the end of the Ordovician and beginning of the Silurian, the Lower Llandoverian is mainly missing in central part of East Baltic basin, and, in addition the Middle Llandoverian — in its Southeastern parts. In Estonia, the Middle Llandoverian is represented by carbonate rocks (various limestones and dolomites, including primary ones) of the regressive phase of the first cycle. In Latvia and partially in Lithuania, on that level graptolitic marls and claystones (argillites) are distributed, constituting the transgressive phase of the first cycle. Thus, in the last-mentioned region the first cycle of the Silurian stays behind that of Estonia by a half of a cycle.

In the Wenlockian, the course of development of both regions proceeded in a similar way : the regression developed by degrees, reaching its maximum at the beginning of the Ludlovian. Further on, both regions showed differences, once again : after the transgressive phase, at the end of the Ludlovian and the beginning of the Downtonian (fig. 2A), in the northern part of the East Baltic basin followed a gradual regression, whereas in the southern part, two complicated maxima of the content of terrigenous material in the rocks were observed, occurring in the middle of the Ludlovian and in the second half of the Downtonian (fig. 2B).

In total, in the Silurian of the southern part of the East Baltic basin the following main cycles may be observed : *a*) the Middle and Late Llandoverian; *b*) the Wenlockian (including the beginning of the Ludlovian); *c*) the Ludlovian; *d*) the

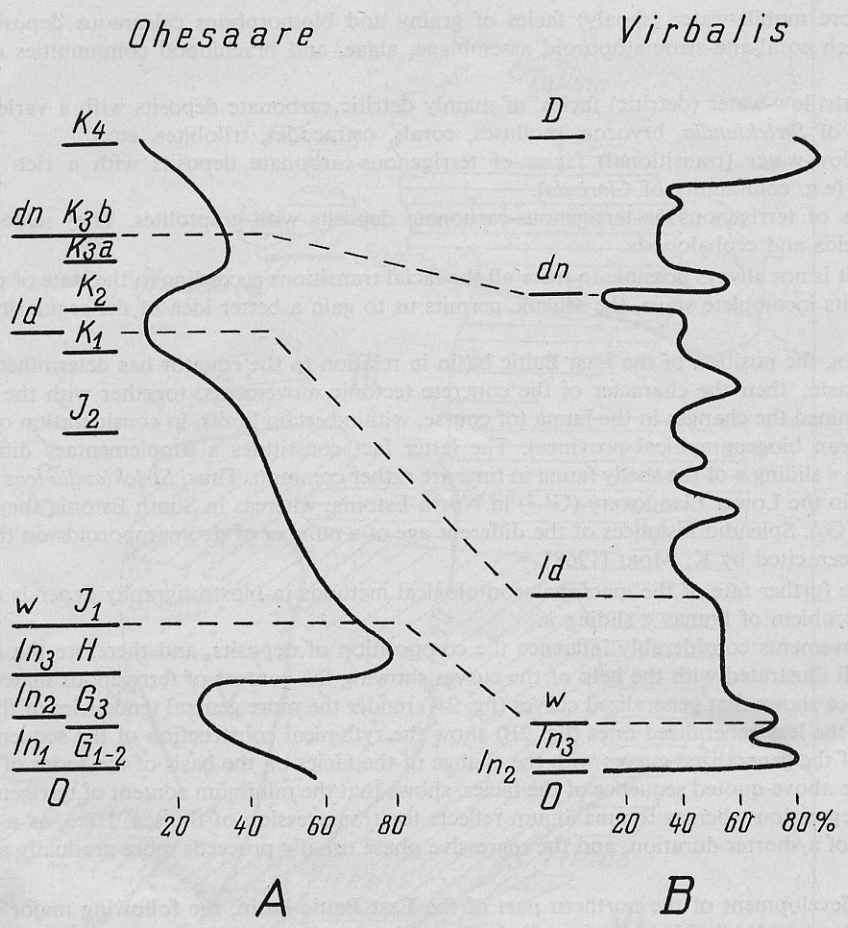

FIG. 2. — *Content of terrigenous material in the Silurian deposits of the East Baltic, according to two boring profiles (thickness of the sequences approximated to 450 m).*

A — According E. JÜRGENSON in KALJO D. [1970]; O — Ordovician : ln_1 — ln_2, ln_3 — Lower, Middle, Upper Llandoverian; W — Wenlockian; ld — Ludlowian; Dn — Downtonian; stages : G_{1-2} — Juuru, G_3 — Raikküla, H — Adavere, J_1 — Jaani; J_2 — Jaagarahu, K_1 — Rootsiküla, K_2 — Paadla, K_3a — Kuressaare, K_3b — Kaugatuma, K_4 — Ohesaare, D — Devonian.

Downtonian. It is possible that the first two cycles ought to be regarded as one, since the regressive phase (the Late Llandoverian) between them is less significant than in the other cases.

For understanding the reasons of the differences in the cyclical character of the northern and southern parts of the basin, it is useful to take a glance at the distribution of the thicknesses of the deposits. Thus, the Llandoverian is the thickest in the South-Estonian depression (fig. 1, II), the Wenlockian — in the Irben depression (fig. 1, III) [KALJO, editor, 1970], and the Ludlovian and Downtonian — in the Polish-Lithuanian trough, and the Downtonian, particularly, in the south-western part of the latter, in Kaliningrad region.

If we regard the thickness of the deposits as a measure of the tectonic movements, we have to state two circumstances : 1) during each epoch, there was a certain region of maximum sinking, and 2) the centres of maximum sinking, gradually, in wave-like movements, shifted in the south-east direction. It is probable that this phenomenon may be explained by the differential movement of tectonic blocks. The said is also proved by a number of phenomena of a more particular character : for example, by a regressive shift of the zone of distribution the *Pentamerus oblongus* community in South Estonia and others.

The determining role of tectonic movements in the development of the East Baltic basin in the Silurian is obvious. But in stratigraphy the cyclic nature of the development must be treated with caution. In reality, if the most significant cycles are revealed in conformity within the limits of the almost entire basin (for example, the Early Wenlockian transgression and the regression at the border of the Wenlockian and Ludlovian), then other cycles may prove of a rather controversial nature. This may be probably explained by the fact that separate regions of the basin were tectonically active at different periods of time : the Polish-Lithuanian trough was in a stage of activity in the Late Silurian, whereas the Irben depression had already completed that stage.

(During the report, coloured lithofacial maps will be demonstrated).

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