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TREMADOC OF THE EAST EUROPEAN PLATFORM: LITHOFACIES AND PALAEOGEOGRAPHY

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Abstract. In the Tremadoc the palaeobasin of the East European Platform was a NW–SE elongated inland sea between the Baltic and Ukrainian shields. It opened into the Iapetus Ocean in NNW. The present Moscow Syneclise may have had a connection with the Palaeo-Ural Sea, too. Terrigenous sedimentation represented by sandy-silty and pelitic material predominated. On the basis of the sediments preserved, we can distinguish three main regions with different sedimentary conditions in the Tremadoc basin: Scandinavia–Poland, Northern East Baltic, Moscow Syneclise.

Key words: Lower Ordovician, East European Platform, palaeogeography, lithofacies conditions.

INTRODUCTION

The aim of this paper is to present a comparative analysis of the distribution and lithological composition of the Tremadoc sediments preserved on the East European Platform (EEP) up to this day. This would give us a picture about the lithofacies conditions in different parts of the basin and general palaeogeographical situation.

As is known, the Cambrian–Ordovician boundary is not fixed yet, in spite of the work done by the Cambrian–Ordovician Working Group of the Commission on Stratigraphy, IUGS, during more than 20 years. For this reason, also the exact position of the lower boundary of the Tremadoc, and therefore that of the Pakerort Stage, is not defined unanimously. The Tremadoc–Arenig boundary is debated as well (Cooper & Lindholm, 1990; Lindholm, 1991).

In this note the Tremadoc is considered in its traditional scope, including the following intervals (Table 1): in Norway the upper part of the Alum Shale

Table 1

Stratigraphical subdivisions of the Tremadoc in the Scandinavian–Polish region

<table>
<tr><th rowspan="3">Series</th><th rowspan="3">Subseries</th><th rowspan="3">Norway</th><th rowspan="3">Sweden</th><th colspan="4">Poland</th><th>Latvia</th></tr>
<tr><th colspan="2">Polish part of the Baltic Syneclise</th><th rowspan="2">Podlasie Depression</th><th rowspan="2">Łysogóry Region</th><th rowspan="2">Jelgava Depression</th></tr>
<tr><th>Marine sections</th><th>Łeba–Gdańsk area</th></tr>
<tr><td rowspan="3">TREMADOC</td><td rowspan="2">Upper</td><td>Bjørkåsholmen Fm. (3aγ) (Ceratopyge Limestone)</td><td>Ceratopyge Limestone</td><td rowspan="2"></td><td>Lower Gardno Fm.</td><td></td><td rowspan="2"></td><td>Lower Zebre Fm.</td></tr>
<tr><td>Upper Alum Shale (3aα–β) (Ceratopyge Shale)</td><td>Ceratopyge Shale</td><td rowspan="2"></td><td rowspan="2">Clayey Complex (Dictyonema Shale)</td><td rowspan="2"></td></tr>
<tr><td>Lower</td><td>Lower Alum Shale (2e) (Dictyonema Shale)</td><td>Dictyonema Shale</td><td>Uppermost Piaśnica Fm.</td><td>Uppermost Klonówka Shale Fm.</td></tr>
</table>

Vertical ruling – gaps

Formation and the Bjørkåsholmen Formation (2e–3aγ); in Sweden Dictyonema and Ceratopyge shales, and Ceratopyge Limestone (Tjernvik, 1956); in Poland the uppermost beds of the Piaśnica Formation, the lower part of the Gardno Formation, the Clayey Complex (= the upper part of the Krzyże Beds, Znosko, 1964), and the uppermost Klonówka Shale Formation; in Latvia the lower beds of the Zebre Formation (Lutrin and Kumbri members); in Estonia most of the Kallavere Formation, the Türisalu and Varangu formations (Table 2); in Leningrad District the Tosna, Koporye, and Nazya formations; in the Moscow Syneclise the upper part of the Bugino Formation and the Ukhra Formation.

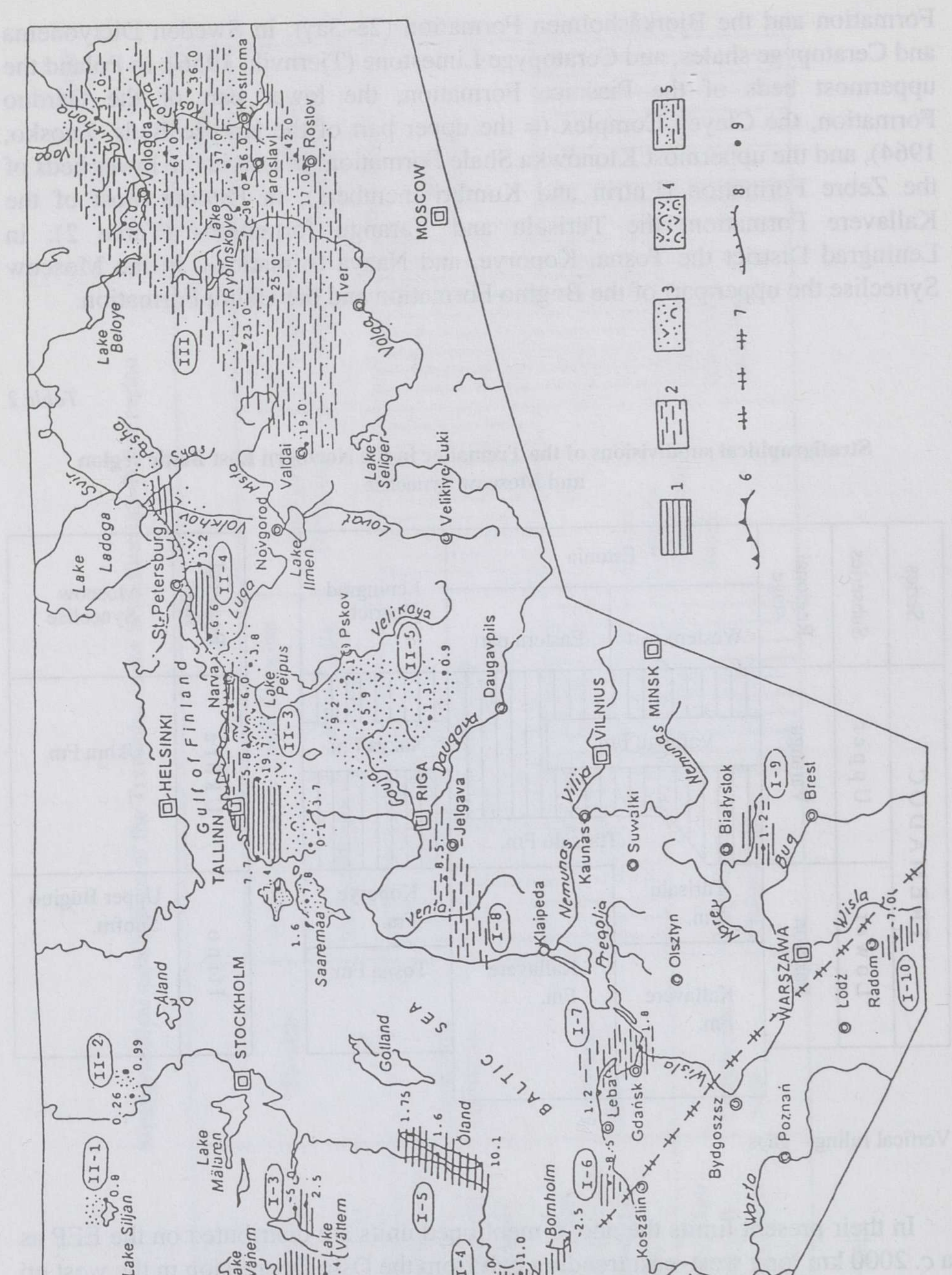
Table 2

Stratigraphical subdivisions of the Tremadoc in the Northern East Baltic region and Moscow Syneclise

Series	Subseries	Regional stage	Estonia: Western part	Estonia: Eastern part	Leningrad District	Regional stage	Moscow Syneclise
TREMADOC	Upper	Varangu	Varangu Fm.	Varangu Fm.	Nazya Fm.	Ukhra	Ukhra Fm.
			Türisalu Fm.	Türisalu Fm.			
	Lower	Pakerort	Türisalu Fm.	Kallavere Fm.	Koporye Fm.	Itino	Upper Bugino Subfm.
			Kallavere Fm.		Tosna Fm.		

Vertical ruling – gaps

In their present limits the above-mentioned units are distributed on the EEP as a *c.* 2000 km long west–east trending belt from the Oslo Depression in the west up to about 200–250 km east of the town of Vologda in the Moscow Syneclise. The north–south extension of the distribution area is prevailingly a few hundreds of a kilometre, but at the western and southwestern border of the EEP, from Jämtland in Central Sweden to Łysogóry block (Holy Cross Mountains) in Southeast Poland, it exceeds 1000 km (Fig. 1). According to palaeomagnetic data, in the Tremadoc–Arenig the EEP was located on the southern hemisphere, whereas its


OSLO
STOCKHOLM
HELSINKI
TALLINN
St.-Petersburg
RIGA
VILNIUS
MINSK
MOSCOW
WARSZAWA
BERLIN
COPENHAGEN
Gulf of Finland
BALTIC SEA
Lake Ladoga
Lake Peipus
Lake Ilmen
Lake Beloye
Lake Rybinskoye
Lake Seliger
Lake Siljan
Lake Mälaren
Lake Vänern
Lake Vättern
Åland
Saaremaa
Gotland
Öland
Bornholm
Narva
Novgorod
Pskov
Daugavpils
Jelgava
Klaipeda
Kaunas
Suwałki
Olsztyn
Białystok
Brest
Gdańsk
Łeba
Koszalin
Bydgoszcz
Poznań
Łódź
Radom
Valdai
Tver
Velikiye Luki
Vologda
Kostroma
Yaroslavl
Roslov
Volkhov
Luga
Velikaya
Daugava
Nemunas
Vilija
Pregolja
Venta
Wisła
Bug
Narew
Warta
Odra
Volga
Lovat
Msta
I-1
I-2
I-3
I-4
I-5
I-6
I-7
I-8
I-9
I-10
II-1
II-2
II-3
II-4
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III
1
2
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present western margin was turned towards the Iapetus Ocean in the north and the present southwestern margin trended from north to south, east of the Törnquist Sea (Torsvik et al., 1992).

The Tremadoc basin of the EEP can be subdivided into three main regions with different sedimentary environments: I, Scandinavia–Poland; II, Northern East Baltic (including the Dalarna and South Bothnian area); III, Moscow Syneclise (Fig. 1).

SCANDINAVIA–POLAND

This region embraces the southern part of Scandinavia and the northeastern and southeastern parts of Poland. Its western boundary proceeds west from the Oslo Depression through Scania, Bornholm, North Poland (east of Koszalin), and Łysogóry block as a Special Region in the Holy Cross Mountains (Góry Świętokrzyskie) in Southeast Poland.

In Scandinavia the Tremadoc is represented by the Dictyonema Shale, Ceratopyge Shale, and Ceratopyge Limestone (in Norway the interval 2e–3aγ by Kjerulf, see Henningsmoen, 1982; Bockelie, 1982; the upper part of the Alum Shale Formation and the Bjørkåsholmen Formation by Owen et al., 1990). In Poland, in the marine sections of the Łeba area, the lower Tremadoc is characterized by black shales which contain graptolites of the *Rhabdinopora* group and form the uppermost part of the Piaśnica Formation (Bednarczyk, 1979, 1994a; Modliński, 1988). In the continent of Poland, in the Łeba–Gdańsk area, the dark grey claystone of the lower part of the Gardno Formation belongs to the upper Tremadoc. In the Podlasie Depression the lower part of the Clayey Complex (= the Dictyonema Shale; Szymański, 1984; Bednarczyk, 1994b) is mainly assigned to the lower Tremadoc. In the Łysogóry Region these dark shales form the uppermost part of the lower Tremadoc Klonówka Shale Formation (Orłowski, 1988 = the Łysogóry Beds by Tomczykowa, 1968).

Lithology

In the Scandinavian–Polish region the Tremadoc is mainly represented by its lower unit, the Dictyonema Shale, which makes up most of the Tremadoc: Naersnes

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Fig. 1. Lithofacies map of Tremadoc sediments on the East European Platform. *1*, shale; *2*, clay; *3*, sand and silt with fragments of brachiopods; *4*, brachiopod coquina; *5*, alteration of clayey and sandy-silty sediments; *6*, Caledonian front; *7*, Törnquist–Teisseyre line; *8*, klint; *9*, borehole and thickness of the Tremadoc sediments. I-1, Oslo Depression; I-2, Västergötland; I-3, Östergötland; I-4, Scania; I-5, Öland and Småland; I-6, marine sections of the Łeba area; I-7, Polish part of the Baltic Syneclise (Łeba–Gdańsk area); I-8, Jelgava Depression; I-9, Podlasie Depression; I-10, Łysogóry block; II-1, Dalarna; II-2, South Bothnian area; II-3, North Estonia; II-4, northern part of Leningrad District; II-5, South Estonia, NE Latvia, SW part of Pskov District; III, Moscow Syneclise.

(Oslo Depression) – 6 m (Bruton et al., 1982, 1988); Scania – 5.3–16.5 m (Bergström, 1982), in marine sections of the Łeba area – up to 8.5 m (Modliński, 1988); in the Podlasie Depression – up to 1.8 m (Szymański, 1984); in the Łysogóry block – 6.8 m (in the Jelniow 2 borehole; Tomczykowa, 1968). The Dictyonema Shale is dark, horizontally fine-bedded organic-rich argillite in which dark interbeds alternate with lighter ones, poorer in organic matter. This indicates that in the conditions of general oxygen deficiency there occurred periodically a marked increase in the oxygen content in sea water, which allowed for the existence of organisms in this sea (Thickpenny, 1984; Andersson et al., 1985). The lithological composition of the section of the Dictyonema Shale shows the presence of rather big (up to 1–2 m) carbonate concretions of various sizes (Stinkstones) which have yielded the main part of trilobite fauna. There are different views about the origin of Stinkstones. Their occurrence in sections has been considered as an indicator of nearshore conditions, but according to another viewpoint, their formation is connected with the presence of intrabasin subaqueous elevations (Andersson et al., 1985).

The upper Tremadoc in Scandinavia is represented by the Ceratopyge Shale, which constitutes mostly a dark grey or black argillite (shale) with carbonate lenses and interbeds. In the uppermost Tremadoc it goes over into the Ceratopyge Limestone (the Bjørkåsholmen Formation in Norway). Very often the Ceratopyge Shale, as well as the Ceratopyge Limestone, contains abundantly glauconite grains. The total thickness of these rocks is small, in most cases not exceeding 2–2.5 m, their present distribution area is more restricted than that of the Dictyonema Shale.

In Poland the upper Tremadoc is known from the western area of the Baltic Syneclise and from the Podlasie Depression. In the western part of the Baltic Syneclise (the Białogora 1 and Gdańsk IG 1 boreholes), the uppermost Tremadoc (the *Paltodus deltifer deltifer* Subzone) is represented by dark grey claystone with intercalations of glauconitites and lenses of dolomitic limestone and it corresponds to the lower part of the Gardno Formation. The thickness of the deposits is 1–1.2 m.

In the Podlasie Depression, the upper Tremadoc is composed of black claystone of the upper part of the Clayey Complex, 1.6 m thick. It contains the graptolites of the *Bryograptus* group (e.g., the Rajsk IG 1 borehole; Szymański, 1984).

In the Lublin Slope (the Lopiennik IG 1 borehole), the black clayey shales with fragments of graptolites are 2.5 m thick. These shales belong to the upper Tremadoc (Lendzion et al., 1979).

In the Jelgava Depression on the territory of Latvia, the greyish-green clays with brownish interbeds correspond to the lower half of the Zebre Formation (Lutrin and Kumbrin members) of the upper Tremadoc. Their thickness is about 2–10 m (Gailite & Ulst, 1975).

Facies and palaeogeography

The Oslo Depression, Scania, marine sections of the Łeba area, and Łysogóry block are located in the marginal part of the EEP and represent the deepest and quietest-water part of the Tremadoc shelf sea. The same sedimentary environments occurred here already in the Middle Cambrian (Alum Shale), continuing without any notable change into the Tremadoc. According to Erdtmann & Paalits (1995) and Erdtmann (1995), this area constitutes the "Oslo–Scania–Łysogóry Outer Shelf or Shelf-marginal Confacies Belt".

In South Sweden, east of the Oslo–Scania belt, the distribution area of the Dictyonema Shale (Väster- and Östergötland, I-2 and I-3; Småland, Öland, I-5), is ascribed by Erdtmann & Paalits (1995) to the "Inner Shelf Confacies Belt", in which they distinguished the "Hunneberg–Modum Transitional Subconfacies" and "Central Scandinavian Elevation Subconfacies". The thickness of the Tremadoc sediments is rather small here – from a few centimetres up to 1.5 m, rarely more. Only at the southern end of Öland Island the thickness of 10.1 m was recorded. Erdtmann and Paalits consider this section as transitional between the outer and inner shelf types, but it may also be a part of the outer shelf, which is connected with the Oslo–Łysogóry Confacies in the form of a "tongue".

The distribution area of the Dictyonema Shale in the Podlasie Depression in East Poland (Fig. 1, I-9) may represent the inner shelf, but it may also be a "tongue" of the outer shelf (Fig. 2). The thickness of sediments is here about 1.5 m; they constitute the uppermost part of the Klonówka Shales (Krzyże Beds). The Dictyonema Shale has formed in this area partly probably in the early, partly in the late Tremadoc (Bednarczyk, 1994a).

Considerably deeper-water sediments, which have formed in the environment of normal oxygen content, are distributed in the North Poland part of the Baltic Syneclise (Fig. 1, I-7, Białogóra 1 and Gdańsk IG 1 drillcores; Fig. 2). They are represented by dark grey glauconitic clay, 1–1.2 m in thickness, which belongs to the upper Tremadoc.

The same environment can be valid for the upper Tremadoc greyish-green clays with brownish interbeds, distributed in the Jelgava Depression in the northeastern part of the Baltic Syneclise (I-8). The thickness of sediments is about 2–10 m here (Gailite & Ulst, 1975).

NORTHERN EAST BALTIC

The central and best-studied part of this region is the territory of Estonia. However, it comprises also the northern area of Leningrad District and Central Sweden (Dalarna and Finngrundet sections in the southern part of the Gulf of Bothnia). The Northern East Baltic region differs from that of Scandinavia–Poland mostly in the predominance of sandy sediments in the Tremadoc (except

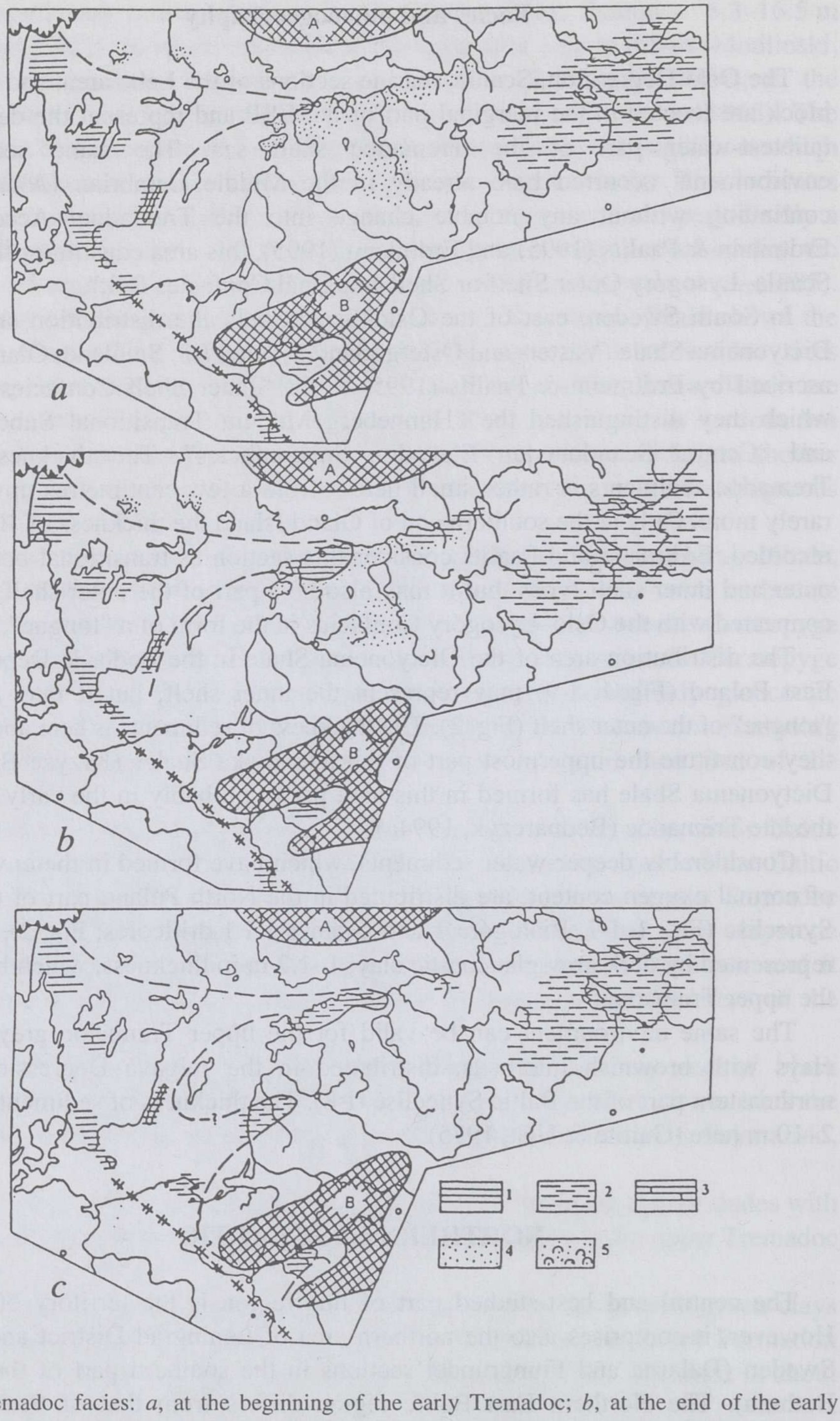

Fig. 2. Tremadoc facies: *a*, at the beginning of the early Tremadoc; *b*, at the end of the early Tremadoc; *c*, in the late Tremadoc. *A*, Baltic Shield; *B*, Mazury–Bielarus anteclise. *1*, shale; *2*, clay; *3*, limestone; *4*, sandy-silty sediments; *5*, brachiopod coquina.

the northwestern part of mainland Estonia, Fig. 2) and their more variable lithological composition.

The Tremadoc of Estonia (Fig. 1, II-3) is represented by sediments of the Pakerort and Varangu (Ceratopyge) stages (Männil & Meidla, 1994). Based on the lithological characteristics three formations are distinguished here (from base): Kallavere (sandy sediments predominate), Türisalu (Dictyonema Shale), and Varangu (glauconitic silty clays), whereas the lower part of the Kallavere Formation is assigned to the Upper Cambrian. The present distribution area of Tremadoc sediments decreases from the Kallavere Formation to the Varangu Formation.

Out of the above formations the Kallavere Formation is the most widespread and thickest (up to 15–17 m). It is distributed on most of Estonian territory and in North and East Latvia (Alūksne, Madona, and Ludza core sections). Analogous sediments, known as the Tosna Formation, are distributed also eastwards, in Leningrad District (II-4), according to the information available, at least up to the Syas River (Popov et al., 1989). In North Estonia, where the Kallavere Formation has been studied in the greatest detail, there are distinguished five lithostratigraphical units of fairly variable lithological composition: Maardu, Suurjõgi, Katela, Rannu, and Orasoja members (Heinsalu, 1987).

Lithology

The **Kallavere Formation** is characterized by three main lithological components. The co-occurrence of these components serves as a basis for the distinction of separate members.

1. Quartzose sand(stone), varigrained, predominantly medium-grained (0.25–0.5 mm), contains abundantly fragments of phosphatized inarticulate brachiopod valves of different size up to whole valves. The rock is always cross-bedded, occurring as relatively small lenses and interlayers up to rather extensive layers in the vicinity of the town of Rakvere (Raudsep & Eskel, 1980; Heinsalu & Raudsep, 1993; Heinsalu et al., 1994). It is traditionally known as "Obolus conglomerate" and is found in the Cambrian–Ordovician boundary beds in the lower part of the Kallavere Formation (Maardu and Rannu members), whereas the lower boundary of the formation is not synchronous (Kaljo et al., 1986). The "Obolus conglomerate" is characteristic of the environments with the most intensive hydrodynamic conditions.

2. Light-coloured quartzose sand(stone), fine and very fine (0.05–0.25 mm), alternating with dark interbeds of Dictyonema Shale which may range from 1 mm to 10 cm (rarely more) in thickness. The frequency of interbeds may also be different. In sand(stone) there may occur rare brachiopod fragments. The rock is predominantly horizontal-bedded. The grain size and bedding type show that the sediments have formed in quiet-water conditions. In the section they lie on the

"Obolus conglomerate" and represent most of the Kallavere Formation in North and Middle Estonia.

3. Quartzose sand(stone), mostly medium-grained (0.25–0.50 mm), darker than the rock in point 2, relatively rich in fine (1–2 mm) brachiopod debris, always cross-bedded. Known as the so-called detrital layer which corresponds to the Suurjõgi Member. Represents the uppermost part of the Kallavere Formation in the western area of North Estonia. Characterizes a hydrodynamically active environment.

The **Türisalu Formation** belongs to the Pakerort Stage in western Estonia and to the Varangu Stage in NE Estonia. It is represented by dark, mainly laminated kerogenous argillite (Dictyonema Shale) and is more uniform in western Estonia. In NE Estonia argillite contains frequent sandy-silty interbeds and pyrite lenses. The thickness of the Türisalu Formation in West Estonia is up to 7 m, in East Estonia up to 2 m.

The **Varangu Formation** overlies the Türisalu Formation and belongs to the Varangu Stage. Most often the Varangu Formation is represented by greenish-grey compact claystone with lenses of glauconitic-quartzose siltstone of different size. Sometimes the claystone has a brownish colouring because of the presence of small amounts of organic matter.

The thickness of the Varangu Formation is up to 3.3 m, but usually less than 1 m. The Varangu Formation is distributed in North Estonia, but it is missing in the easternmost part of the region.

Facies and palaeogeography

As seen from the lithology of the above-described sediments, there existed a source of sandy material supply for the Northern East Baltic region. Compared with the South Scandinavia, where organic-rich muddy sediments were formed, the depth of the sea was surely smaller in the Northern East Baltic and the sea bottom was better provided with oxygen to ensure the living activity of brachiopods. However, the periods of normal oxygen supply of the sea bottom in early Tremadoc sea alternated with oxygen-deficiency periods, which is evidenced by the occurrence of Dictyonema Shale interbeds in sandstone. One of the main reasons for facial variability of sediments could be the dissected sea bottom topography. This shows the existence of relatively deeper quiet-water parts of the basin (depressions) and subaqueous elevations with an intensive hydrodynamic regime, which sometimes could turn into islands. The occurrence of such elevations in the early period of the accumulation of Kallavere sediments is quite well expressed in the vicinity of Rakvere, where layers of Obolus coquina (phosphorite) were formed (Heinsalu & Raudsep, 1993; Heinsalu et al., 1994). A similar subaqueous elevation probably existed in the early Tremadoc sea in the neighbourhood of Maardu. There the environment favoured the accumulation of phosphatic fragments of brachiopod valves in the form of the so-called Obolus conglomerate.

West of Maardu and Tallinn up to Noarootsi, at the site of the present northwest Estonian mainland, a deeper area must have existed in the sea at the beginning of the Tremadoc. In this area organic-rich muddy clays deposited under quiet-water oxygen-deficiency conditions, but sometimes also very fine quartz grains were transported there. Under such sedimentary conditions a 0.15–0.3 m thick bed of Dictyonema Shale containing very thin interbeds of quartzose siltstone was formed. Locally, however, in this part of northwestern Estonia the lower boundary of the Kallavere Formation shows the occurrence of a few centimetre thick lenses of "Obolus conglomerate".

In the course of further development of the Tremadoc basin, presumably in the middle of Pakerort age, the sedimentation regime became more or less stable in the Northern East Baltic. At that time quartzose sands with a somewhat different grain size deposited. This process was interrupted by periods of oxygen deficiency which occurred with variable frequency in different parts of the basin. These periods were characterized by restricted influx of quartzose sand and deposition of argillaceous muds (Dictyonema Shale). Such a regime was typical of the territory of Estonia and Leningrad District (Fig. 2). An analogous regime may be observed in the Finngrundet section in the southern part of the Gulf of Bothnia at the Swedish coast (Thorslund & Axberg, 1980).

Towards the end of the first half of the Tremadoc (i.e., of Pakerort age, in the time span corresponding to the *Cordulodus angulatus* Zone level), the environments in the Northern East Baltic region of the basin became diversified. In West Estonia (up to the Kunda–Rakvere line) a new sedimentary cycle (cyclite) started with the deposition of relatively coarse-grained skeletal cross-bedded sands (Suurjõgi Member), which in the course of time were replaced by organic-rich muds (Dictyonema Shale of the Türisalu Formation). This process lasted until the end of Pakerort age. In the late Tremadoc, in Varangu (Ceratopyge) age, the reducing environment was here already replaced by sedimentary conditions with a normal oxygen regime. As a result glauconitic silty clays were formed (Varangu Formation). Nowadays these clays are mainly distributed in North and West Estonia.

In East Estonia (east of the Kunda–Rakvere line) the sedimentation of quartzose sands containing organic-rich mud interbeds continued also in the second half of Pakerort time. In the late Tremadoc (Varangu age) this process was gradually replaced by the deposition of organic-rich argillaceous mud (Dictyonema Shale), which from time to time was interrupted by the influx of sandy material forming interbeds.

The same type of Tremadoc sedimentation is characteristic also of the northern territory of Leningrad District (Fig. 1, II-4; Fig. 2). It was initiated by the "Obolus conglomerate", followed by quartzose sands with dark organic-rich mud interbeds (**Tosna Formation**), and finally by a layer of organic-rich argillaceous mud

(Dictyonema Shale of the **Koporye Formation**). The entire sediment complex was formed during Pakerort age, except Northeast Estonia, where it lasted for the whole Tremadoc. The sediments corresponding to Varangu age (**Nazya Formation**) have been found in Leningrad District only in the sections of the Nazya, Kipuya, and Lava rivers, occurring there in an inconsiderable thickness (0.05–0.25 m) (Borovko et al., 1983).

In the core sections from the southern part of the Northern East Baltic (South Estonia, North and East Latvia, Pihkva District) (Fig. 1, II-5; Fig. 2) the Tremadoc is practically represented by quartzose sands only, in places containing also Dictyonema Shale interbeds. The thickness of sediments ranges here from 1 to 9 m.

MOSCOW SYNECLISE

The Tremadoc sea, which existed in the region of the present Moscow Syneclise and where prevailingly argillaceous muds deposited, was deeper than that of the Northern East Baltic. According to Dmitrovskaya (1991), in this area sediments of the **Upper Bugino Subformation** and **Ukhra Formation** were formed. The Upper Bugino (lower Tremadoc) sediments are represented by interbedded dark grey argillites and greyish-green variably argillaceous siltstones, which in places contain quartzose sandstone lenses and interlayers. The thickness of the Upper Bugino beds in the Moscow Syneclise ranges from 10 to 25 m. By Dmitrovskaya (1991) the Upper Bugino Subformation coincides with the Itino Stage.

The Ukhra Formation that belongs to the upper Tremadoc is subdivided into two parts. Lower Ukhra beds are represented by dark grey quartzose sandstone and siltstone, the Upper Ukhra, however, is characterized by greenish-grey laminated argillites with quartzose siltstone interlayers. Their total thickness is up to 45 m. The Ukhra Formation corresponds to the Ukhra Stage (Dmitrovskaya, 1991).

The lower Tremadoc Upper Bugino sediments are distributed on the whole territory of the Moscow Syneclise and represent the upper, lithologically prevailingly argillaceous part of the Bugino sedimentary cycle. By acritarchs the Lower Bugino Subformation is attributed to the Upper Cambrian *Acerocare* Zone (Dmitrovskaya, 1991).

The Ukhra Formation represents the entire upper Tremadoc transgressive sedimentary cycle, whereas, according to Dmitrovskaya (1991), the transgression proceeded from the northeastern part of the EEP. The Ukhra sediments are distributed in the most territory of the Moscow Syneclise, missing at its southern margin (Rostov and Gavrilov Jam drillcores), south of the town of Yaroslavl.

According to Dmitrovskaya (1991), as a result of the general Late Cambrian uplift of the EEP territory, the Moscow Syneclise became separated from the western part of the basin. The boundary between the Baltic basin and the Moscow

Syneclise coincided with the southwest–northeast directed Lovat swell between Lake Ilmen and the town of Valdai. By the beginning of the Tremadoc the Moscow palaeobasin had developed into a relatively deep waterbody, in the northeast and southeast connected with the ocean. According to Dmitrovskaya (1991), the connection with the Baltic Sea was entirely missing or existed for a short time.

SUMMARY

In the epicontinental Tremadoc basin of the EEP there could be distinguished three regions with different sedimentary regimes: I, Scandinavia–Poland; II, Northern East Baltic; III, Central Russia represented by the Moscow Syneclise (Fig. 1). The most stable and of relatively deeper-water character were the environments in the Scandinavian–Polish region, where mainly organic-rich muds deposited. Deeper-water, considerably monotypical, mainly pelitic sedimentation occurred in the Moscow Syneclise. The Northern East Baltic region, which lies between the mentioned areas, was generally characterized by shallower, more varied and diverse environments, dominated by the sand-silt deposition (Fig. 2). In the middle of the Tremadoc the Northern East Baltic region, or at least its northern part, became subjected to a relatively deeper-water sedimentary regime which resulted in the formation of pelitic sediments. Presumably, at the same time there occurred opposite processes of sea bottom uplift at the western margin of the Moscow Syneclise, which led to the separation of the latter from the Baltic basin in the middle of the Tremadoc.

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TREMADOC IDA-EUROOPA PLATFORMIL: LITOFATSIAALSUS JA PALEOGEOGRAAFIA

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Praeguseks säilinud Tremadoci setendite üldise litoloogilise ehituse järgi on Ida-Euroopa platform jaotatud kolmeks piirkonnaks, mida iseloomustavad erinevad settimistingimused: I – Skandinaavia–Poola, II – Põhja-Baltikum ja III – Moskva sünekliis.

Skandinaavia–Poola piirkonnas on valdavaks kivimitüübiks tume argilliit (diktüoneemakilt) või kohati heledam savikivim. Paleogeograafiliselt vastab see piirkond Ida-Euroopa platformi äärealale ning fatsiaalselt šelfimere sügavamale ja vaiksema veega osale.

Põhja-Baltikumis valdab suuremal osal territooriumist monomineraalne kvartsliivakivi, mis regiooni põhjapiirkonnas Tremadoci läbilõike ülemises osas asendub diktüoneemakilda ja edasi heledavärvilise savikivimiga. Paleogeograafiliselt oli see piirkond šelfimere madalama veega osa, mida iseloomustasid muutlikud fatsiaalsed olud.

Moskva sünekliisis on Tremadoci setendid esindatud valdavalt peliitse materjaliga. Paleogeograafiliselt oli see ala kompenseeritud settimisrežiimiga sügavama veega basseiniosa.

ТРЕМАДОКСКИЕ ОТЛОЖЕНИЯ НА ВОСТОЧНО-ЕВРОПЕЙСКОЙ ПЛАТФОРМЕ

(литофациальные и палеогеографические аспекты)

Хельо ХЕЙНСАЛУ и Виеслав БЕДНАРЧИК

Восточно-Европейская платформа по литологической характеристике и условиям осадконакопления дошедших до нашего времени тремадокских отложений подразделяется на три региона: I – Скандинавия–Польша, II – Северная Прибалтика и III – Московская синеклиза.

Тремадокский разрез Скандинавско-Польского региона сложен в основном темными диктионемовыми сланцами. По палеогеографическому положению этот регион был наиболее глубоководной краевой частью платформы с однообразными фациальными условиями.

На большей части территории Северной Прибалтики преобладают мономинеральные, многократно переотложенные кварцевые песчаники, переходящие вверх по разрезу в диктионемовые сланцы и светлые алевритовые глины. Этот регион представлял собой мелководье тремадокского шельфового моря с относительно разнообразными и изменчивыми фациальными условиями.

Тремадокские отложения Московской синеклизы представлены в основном пелитовым материалом, что свидетельствует о более глубоководных условиях, когда прогибание дна водоема компенсировалось осадконакоплением.