Baltic Stratigraphical Association Department of Geology, Faculty of Geography and Earth Sciences, University of Latvia Natural History Museum of Latvia

# THE EIGHTH BALTIC STRATIGRAPHICAL CONFERENCE

# ABSTRACTS



Rīga, 2011

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Edited by E. Lukševičs, Ģ. Stinkulis and J. Vasiļkova



Rīga, 2011

TTÜ GEOLOOGIA INSTITUUT

**BAAMATUKOGU** 

### The Eigth Baltic Stratigraphical Conference 28 August – 1 September 2011, Latvia *Abstracts*

Edited by E. Lukševičs, G. Stinkulis and J. Vasiļkova

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### Preface

Baltic co-operation in regional stratigraphy is active since the foundation of the Baltic Regional Stratigraphical Commission (BRSC) in 1969 (Grigelis, this volume). Regular meetings, field excursions and workshops were organized by BRSC in 1970-1980s, thus promoting stratigraphical research in the former Soviet Union and contributing to the development of stratigraphical classifications and schemes used for geological mapping in the East Baltic region and NW Russia.

In October 1990 the BRSC was reorganized by its membership into a less formal organization – the Baltic Stratigraphical Association (BSA), which united the national stratigraphical commissions of Estonia, Latvia and Lithuania. The regional stratigraphical commission of NW Russia joined BSA in 2003.

Regular scientific conferences devoted to various aspects of regional geology and stratigraphy have been the main events organized by BSA. Up to now seven meetings have been held in Tallinn (1991, 1996, 2008), Vilnius (1993, 2002), Riga (1999) and St. Petersburg (2005). The Eighth Baltic Stratigraphical Conference to be held on 28 August – 1 September 2011 in Riga has attracted more than 70 participants from 10 countries. This volume includes 64 abstracts dealing with various aspects of regional geology, biostratigraphy and palaeontology, event stratigraphy, isotopic geochronology and chemostratigraphy, stratigraphical methodology, regional aspects of applied geology, sequence stratigraphy and other topics. Special sessions of IGCP Project 591 "The Early to Middle Palaeozoic Revolution" and IGCP Project 596 "Climate change and biodiversity patterns in the Mid-Palaeozoic (Early Devonian to Late Carboniferous)" will be organized in conjunction with the 8<sup>th</sup> BSC.

We welcome you in Latvia and wish you success and a nice stay here.

*Ervīns Lukševičs and Ģirts Stinkulis* On behalf of the Organizing Committee and the Latvian Commission on Stratigraphy

### Contents

Preface	3
ADSTRACTS Afenessions O The models of exoskeletal assification in Threstes vertucosus (Saaramaa	9
Fistoria) and Ungulaspis arctoa (Severnava Zembya Russia)	9
Ainspar I. Truumees I and Meidla T. Carbon isotope chemostratioranhy of the Ordovician/	)
Silurian boundary beds in central Estonia: new data from drillcores in the Pandivere area	10
Amon I. Veski S. Heinsalu A. Vassiliev I and Saarse I. The late-alacial forests of Latvia:	10
nlant macrofossil evidence from Fastern Latvia	11
Bezgodova DV. The comparison of distribution of genus Theodossia (Brachiopoda) in the	11
Frasnian of the Russian plate and South Novava Zemlva.	12
Bezusko L. Mosyakin S. and Bezusko. A. Palynological characterization of the Upper	
Pleistocene deposits of the Volhvno-Podolian area (W Ukraine): palvnostratigraphical,	
paleobotanical, paleoecological and phytogeographical aspects	13
Bičkauskas, G., Molenaar, N. and Kaminskas, D. Implications from stable <sup>13</sup> C isotope	
stratigraphy for closed system carbonate diagenesis; an example from the Upper Silurian	
Baltic Basin	14
Bitinas, A. and Lazauskienė, J. Implications of the paleoseismicity of the Eastern Baltic Sea	
region	15
Blāķe, D. and Stinkulis, Ģ. New data on the structure and origin of the Devonian Lode	
Formation	16
Bregman, E.P.H., Vircava, I., Stunda, A., Segliņš, V., Karpovičs, A. and Randers, M. Clay	
minerals composition: a useful tool for glacial till studies and reconstruction of palaeo-	
ice streams	17
Cerina, A. Plant macrofossil assemblages from the Eemian-Weichselian deposits of Latvia and	10
problems of their interpretation	18
Dronov, A.V. Trace fossils in the Ordovician of St. Petersburg region: significance for	10
Dropov A.V. Ainsoor J. Kalio D. Meidla T. Soodre T. and Finasto R. Revised sequence	19
stratigraphy of the Ordovician of Baltoscandia	20
Druzhining O Stratigraphy of the late Palaeolithic site Ryadino 5 (Šešupe river valley	20
Kaliningrad region)	21
Ekleris, A. and Radzevičius, S. Abnormal rhabdosomes of Pristiograptus (Graptoloidea)	22
Glinskiv, V. Psammosteid agnathans from the Amata Regional Stage of the Oredezh River	
Basin, Leningrad Region	23
Grigelis, A. Twenty years to run the Baltic Regional Stratigraphical Commission (1970-1990)	24
Hints, L. and Oraspold, A. Early Hirnantian brachiopod faunas along the offshore-onshore	
transect: the East Baltic case	26
Hints, O., Hints, R., Isakar, M. and Toom, U. SARV: database of geological collections of	
Estonia	27
Hints, O., Nõlvak, J., Paluveer, L. and Tammekänd, M. Quantitative stratigraphical approach to	
palaeobiodiversity of Baltic Ordovician chitinozoans	28
Ivanov, A., Lukševičs, E. and Glinskiy, V. Vertebrate assemblages from the Givetian-Frasnian	
boundary beds of the Borschovo locality (Leningrad region, Russia)	29
Jurina, A.L. and Raskatova, M.G. The progymnosperm and miospores from the Devonian Lode	20
Formation of Latvia	30
Kaljo, D., Brazauskas, A., Kaminskas, D. and Marima, T. <i>New developments in Ballic Sturian</i>	21
Kelping I Cering A Ozola I and Apsite I Palachotanical records from the densits of the	51
Raunis site	32
Kalning L. Cering A and Strautnieks I Stratigraphy and correlation of the Early Weichselian	52
Rogali Beds	33

Kharkina, M.A. Geological processes as a cause of emergencies and catastrophic events in	
Russia	34
Kiipli, E. and Kallaste, T. Correlation of the Rakvere Stage between shallow and deep shelf on	25
the basis of Rb content of the clay fraction	35
Kiipli, I., Radzievicius, S., Kallaste, I., Soesoo, A. and Voolma, M. The Silurian Geniai Tuff in	20
southern East Ballic	30
Konigshoi, P., Suttner, I.J., Boncheva, I., G. Izokn, N.G., Ta Hoa, P., Charoentitirat, T.,	
waters, J.A. and Klessling, w. Climate change and bloatversity patterns in the Mia-	27
Palaeozoic (Early Devonian to Late Carboniferous) – the new IGCP 390	31
carbonate platform margin in Konovka Sokol area. Podolia, Ultraine	20
Kruchek S A New stratigraphic charts of Precambrian and Phanerozoic deposits of Relarus	30
Lazauskiene L and Cyziene L Regional geological and structural studies of the territory of	59
Lazauskienc, J. and Cyzienc, J. Regional geological and structural studies of the territory of Lithuania	40
Łuczyński P. Stromatoporoid biostromal accumulations in the Upper Silurian of Podolia	40
(Ilkraine) as possible palaeotsunamite deposits	41
Lukševičs F. Stinkulis G. Zuninš I and Stūris V. Tanhonomy of the Late Devonian	
vertebrates from Latvia	42
Mantsurova, V.N. Stratigraphy and correlation of Lower-Middle Devonian boundary deposits	
in the Russian Plate by miospores	43
Mark-Kurik, E. Middle Devonian correlation problems in the Main Devonian Field	44
Märss, T. and Ivanov, A. A thelodont and chondrichthyans from the Middle/Upper Devonian	
boundary beds of the Middle Urals	45
Meidla, T., Ainsaar, L., Perrier, V., Tinn, O. and Truuver, K. Ostracods and stable carbon	
isotopes across the Ordovician Silurian boundary in the Jūrmala core (Latvia)	46
Mikhailova, E.D. Carbonate shoal facies of Buregi Formation (Middle Frasnian) from the	
South Lake Il'men area	47
Mikuláš, R., Beznosov, P. and Gamolyuk, O. Trace fossil assemblage of the Izhma Formation	
(Lower Famennian, South Timan)	48
Norova, L. Geotechnical properties of different aged tills in the ancient valleys of Saint-	
Petersburg area	49
Paškevičius, J., Klimantavičius, V., Radzevičius, S. and Ekleris, A. Ludlowian (Silurian)	-
graptolites from West Lithuania	50
Perrier, V., Meidla, T., Tinn, O. and Ainsaar, L. Impact of ash-falls on the diversity of	<b>C</b> 1
Ordovician ostracods	51
Pipira, D., Celiņš, I., Jaunžeikare, S., Karušs, J., Liepiņa, A., Ņelajevs, A. and Sturis, V.	50
Foraminifer assemblage from the Jurassic deposits of Latvia	52
Poldsaar, K. and Ainsaar, L. Calcareous sandstone-gravellite erratic boulders in NW Estonia –	
evidence for new near-shore palaeoenvironment of Kunda age (lower Darriwulan) or an	52
Impact event?	55
Raskatova, M.G. and Yurina, A.L. Pecultarities of Frashian miospore assemblages of ballic	54
Region	55
Raukas, A. and Zeics, V. Deglaciation chronology in Laivia and Estonia	56
Schoenemann B and Clarkson F NK Insights - fossilised eyes of the Palaeozoic	57
Schoenemann, B. and Clarkson, E.N.K. Insights – Jossitised eyes of the Tudeozoic	57
Sendenennann, B. and Clarkson, E.N.K. New insignis into intobuc eyes	58
Shoul V Levels of events in the Eccene-Olioocene of Voronezh Anteclise according to	50
nalvnological study	59
Skompski, S. Biogeographic significance of Pridolian (Late Silurian) microproblematics	60
Sokolova, E.A. Early Turonian global warming in the Pacific Ocean and some epicontinental	
basins of the Northern Hemisphere according to planktonic foraminifers	61

2
3
4
5
6
7
8
9
0
1
2

# The models of exoskeletal ossification in *Thyestes verrucosus* (Saaremaa, Estonia) and *Ungulaspis arctoa* (Severnaya Zemlya, Russia)

#### Olga B. Afanassieva

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Using Osteostraci (Agnatha, Vertebrata) as an example, the existence of two (bipolar and unipolar) types of vertical growth of the exoskeleton in some groups of early vertebrates is shown. Recently, the model of the exoskeleton ossification of the shield in Thyestes verrucosus Eichwald, 1854 from the Silurian of Saaremaa Island (Estonia) was suggested (Afanassieva 2002, 2004). Based on a new well-preserved material the reconstruction of the exoskeleton of Ungulaspis arctoa Afanassieva and Karatajūtė-Talimaa, 1998 (Early Devonian of the Severnaya Zemlya Archipelago, Russia) is given. The remains come from the upper part of the Severnaya Zemlya Formation, Lochkovian, October Revolution Island. A complex three-dimensional structure was found on the exoskeleton surface of Ungulaspis. It has been determined that this structure presents the second generation of dentine covering the first dentine generation of numerous tubercles. The model of the ontogenetic development of the exoskeleton of Ungulaspis arctoa is suggested. The superposition growth of the osteostracan exoskeleton is described for the first time using macro- instead of micromaterial. It seems highly probable that this developmental pattern of the exoskeleton was much more widespread among osteostracans than was previously thought. Although surface sculpture varies widely in this agnathan group, each osteostracan lineage usually displays one morphogenetic type of the exoskeleton (in this case, uni- or bipolar pattern of vertical growth).

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### Carbon isotope chemostratigraphy of the Ordovician/Silurian boundary beds in central Estonia: new data from drillcores in the Pandivere area

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The Hirnantian glacial event caused a global biotic crisis, which is well expressed by sea level, facies and faunal changes in tropical shelves of different continents. In marine carbonates of several palaeobasins with complete stratigraphic succession, the glaciation caused the  $\delta^{13}$ C values make positive excursion (HICE), starting in the earliest Hirnantian, rose to a peak of 7‰ followed by a plateau values, and fell to original values in the mid or late Hirnantian. The fact that this event caused a coeval shifts in carbon and oxygen stable isotope composition of different sedimentary components (biogenic carbonate and apatite, organic matter) makes this interval useful for testing the chemostratigraphical tools in correlation of sedimentary sections.

In Baltoscandian Basin carbon isotopes have been helpful for time correlation of different lithostratigraphic units, but construction and comparison of local and regional curves with the global standard curve is complicated due to gaps at the boundaries and within the Porkuni Stage. We analyzed in detail the Porkuni-Juuru interval of four new drillcore sections from the Karinu and Kamariku limestone deposits, Pandivere area, drilled by Nordkalk Co, to improve the chemostratigraphic correlation of the O/S boundary beds in the stratotypic area of the Porkuni Stage.

The Ärina Formation, Porkuni Stage, can be subdivided into three major parts in the area: lower dolomite part (Röa Mb), the middle part with various bioclastic and argillaceous limestones (Vohilaid, Tõrevere and Siuge mbs), and the upper sandy dolomite part (Kamariku Mb). Different lithologies may vary in the middle complex in short distances and no consistent succession of the formal members can be followed. Biohermal limestones are met both in the lower and middle part of the formation. The Varbola Fm, Juuru Stage, contains a thin unit of micritic limestone (Koigi Mb) at the base, overlain by argillaceous limestone with bioclastic material.

Carbon isotope values start with the  $\delta^{13}$ C values from 0 to +1‰ in top of the Adila Fm (Pirgu Stage), increasing gradually to +2 or +3‰ in the Röa Mb and reaching +4 to +6‰ in the middle part of the Ärina Fm. The  $\delta^{13}$ C values in the Kamariku Mb have clearly lower values than in the underlying complex with a gradual decrease from +4 to +2‰. Carbon isotope curve continues to fall in the basal beds of the Juuru Stage, where rocks of the Koigi Mb show values from +2 to +1‰. The lowest  $\delta^{13}$ C values, 0 to -1‰, are reached in the overlying beds of the Varbola Fm.

Hirnantian carbon isotope curves in northern Estonia usually show (e.g., Rapla and Hiiumaa sections) the HICE excursion, which is sharply cut in the top. This is interpreted as the evidence of glacioeustatically caused stratigraphic gap and missing of the upper part of the Porkuni Stage. Our detailed data, supported by earlier studies in the Pandivere area (Vistla and Neitla sections by Kaljo, Hints *et al.*) show, that the upper part of the Porkuni Stage is chemostratigraphically positioned on the falling limb of the HICE isotope event. Moreover, the basal beds of the Juuru Stage seem also situated on the falling segment of the curve, below of the low plateau. If we won't consider the diagenetical mixing and replacement of carbon in carbonates, then the question of re-evaluation of the age of these units would rise. It could be possible, that the Kamariku Mb may be of late Porkuni/Hirnantian age, like the Saldus Fm in a distal setting. As the global O/S boundary is clearly above the HICE event, the Koigi Mb may be considered to be of the latest Ordovician age. Unfortunately, lack of fossils both in the Kamariku and Koigi mbs does not allow testing this construction biostratigraphically.

# The late-glacial forests of Latvia: plant macrofossil evidence from Eastern Latvia

#### Leeli Amon, Siim Veski, Atko Heinsalu, Jüri Vassiljev and Leili Saarse

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Recent study on the late-glacial vegetation in Latvia (Lake Kurjanova) reveals interesting dynamics of tree population and the presence of conifers in the Late Glacial environment of Latvia. As one part of a larger project dealing with the late-glacial vegetation reconstruction in Eastern Baltic area we decided to investigate another Latvian site, analyse it for pollen, plant macrofossil and organic matter content to compare with published material.

The reconstruction of vegetation succession around Lake Lielais Svētiņu (Lubana lowland, Eastern Latvia) in the Late Glacial period is based on the well-dated combination of pollen and plant macrofossil analysis. The present palaeobotanical data starts at 14 600 cal y BP, at the stage GI-1e in comparison with the Greenland ice-core zones. Shrubs, sedges and grasses dominated the surroundings of the study site. The pioneer vegetation grew in open landscape and moist grounds. During late-glacial warmer time tree population developed leading to the formation of mixed pine forest. GS-1 cooling inhibited the growth of pines and deciduous trees, giving ground to the semi-open tundra community of Dryas, with dwarf birch and spruce. It is remarkable that spruce appeared rather early, in the GS-1 period, evidenced by pollen, stomata and macrofossils. At the beginning of the Holocene, spruce declined in favour of deciduous trees and shrubs.

The vegetation record differs from more northwards localities (i.e. Southern Estonia) not only for earlier start of appearance, but also environmental conditions that allowed the formation of pine forest in the warmest part of "Allerød" and introduction of spruce in the "Younger Dryas". At the same time, the whole Late Glacial period in Northern Estonia remained treeless, demonstrating that the tree-line stopped in the middle of the modern Estonian area. The limit of the late-glacial conifer distribution, however, was probably in Northern Latvia.

# The comparison of distribution of genus *Theodossia* (Brachiopoda) in the Frasnian of the Russian plate and South Novaya Zemlya

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The genus *Theodossia* is one of the most characteristic Frasnian spiriferids of the Russian plate. It appears on the Main Devonian Field in the lower part of the Semiluki Regional Stage (RS) of the Middle Frasnian and becomes one of dominating groups in the Upper Frasnian of the whole Russian plate and Ural Mountains.

While studying distribution of species of *Theodossia* in the South Novaya Zemlya, the author should have adverted to materials about distribution of this genus on the Russian plate, first of all on the Main and Central Devonian Field where the genus is most fully studied now, and where first species had been described, and from where the holotypes of the majority of species occur.

The first representative of the genus, *Theodossia svinordensis* Nalivkin, appears in the Main Devonian Field in the lower part of the Semiluki RS, the Porkhov and Svinord beds. Also according to drilling data this species is present in the same-aged deposits of the Kazanlinsk-Archedinsk depression. *Theodossia svinordensis* has been found in the upper part of the Zhandrov RS of Novaya Zemlya (this level corresponds to the Middle Frasnian).

The Porkhov and Svinord transgression on the Main Devonian Field was replaced by regression and, along with the other marine fauna, *Theodosia* disappeared. It did not appear at once when the sea returned, and is absent here in the upper part of the Semiluki RS (Ilmen and Buregy beds) and in the Rechitsa RS.

Marine environment at that time dominated in the area of the South Novaya Zemlya. Here in the uppermost layers of the Zhandrov RS the species *Theodossia svinordensis* was replaced by two local forms which inherit some of its characteristic features.

*Theodossia* appears on the Main Devonian Field again only in the lower part of the Voronezh RS, where it is presented by the species *Theodossia uchtensis* Nalivkin. Starting from this level, representatives of the genus appear in other areas of the Russian plate and in Ural Mountains. *Theodossia uchtensis* is replaced in the upper part of the Voronezh RS by *Theodossia tanaica* Nalivkin, one of the most widespread species of this level on the Russian plate.

On Novaya Zemlya in the lower part of the Menshikov RS (Menshikov RS is correlated with an interval from the upper part of the Semiluki RS to the base of the Famennian by rhynchonellids and conodonts) after occasional appearance of *Theodossia uchtensis*, *Theodossia tanaica* got wide distribution and for a while forced out local forms here. The local species, possibly related to the previous, appear again higher in the section.

*Theodossia evlanensis* Nalivkin is a characteristic form for the upper levels of the Frasnian on the Russian plate as on Novaya Zemlya.

Presence of common species in the Frasnian of the Russian plate and of South Novaya Zemlya testifies to availability of the mediated communication between these basins. But it is necessary to notice that the specimens of these species collected on Novaya Zemlya differ from those known from the Russian plate by bigger sizes, more convex shells and sometimes by more developed sulcus. This is probably related to differences in facies conditions. Also there is a probability of earlier occurrence of some species on Novaya Zemlya as compared to the Russian plate.

# Palynological characterization of the Upper Pleistocene deposits of the Volhyno-Podolian area (W Ukraine): palynostratigraphical, paleobotanical, paleoecological and phytogeographical aspects

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We summarized the results of palynological studies of the Upper Pleistocene deposits of the Volhyno-Podolian area (Artyushenko et al. 1982; Gurtovaya 1981; Bezusko 1981; Bolyhovskaya 1995; Bezusko and Bogutskiy 2004; Bezusko et al. 2008, 2010, etc.). The stratigraphic scale by A. Bogutskij (Bogucki 1972; Bogutsky et al. 2001) was used in our research. It is known that deposits of the first phase of the Gorokhov soil formation stage (paleosol complex dated by the Riss-Wurm, Mikulino, Eemian interglacial) is characterized by the forest-type spore-pollen spectra. A list of the collective fossil flora clearly shows its interglacial status. Palynological characteristics of sediments of the second phase of the Gorokhov paleosol complex (Early Valdai interstadials) show that the periglacial type of vegetation was dominant. The vegetation of optimum phases of the Early Valdai interstadials contained broadleaf tree species. In the deposits from the Upper Pleistocene loesses (Loess-I and Loess-II), pollen of herbaceous plants dominated (with a noticeable participation of Poaceae, Chenopodiaceae, Artemisia spp., Ephedra dystachya L.), and the participation of woody plants, such as Pinus sylvestris L., Salix sp., Betula sp., B. pendula Roth., B. pubescens Ehrn., B. nana L., B. humilis Schrank., Alnus (Alnaster) fruticosa Rupr., Alnus viridis (Chaix) DC. was limited. Pollen grains of thermophilic tree species were not represented in the spore-pollen spectra. Permanent components of the spore-pollen spectra were pollen grains of microtherm species and taxa now peculiar to the Carpathian highmountain flora. These palynological data indicate an increase in aridity and continentality of climate during Loess-II, as compared with Loess-I. Palynological characteristics of the sections from the Dubno paleosol complex of the Volhyno-Podolian area allowed us to identify two Middle Valdai interstadials. The list of the collective fossil flora of Dubno deposits contains more than 200 taxa identified with precision to various taxonomic ranks. In the deposits which were formed during the optimum phases of the Middle Valdai, pollen grains of thermophilic woody species were not identified. Pollen grains of thermophilic tree species also did not participate in spore-pollen spectra from sediments of the Last Glacial Maximum (LGM). Results of an environmental analysis of fossil Chenopodiaceae show that the southern and south-easterm migration pathways were especially important for the formation of species composition of chenopods in the Late Pleistocene in the Volhyno-Podolian area. It is important that the region is very perspective for solving problems of relict taxa, their refugial areas and postglacial migrations in Ukraine and Europe in general (Mosyakin et al. 2005; Mosyakyn and Bezusko 2010; Kovtun 2009, etc.). In view of that, the obtained data are important in solving the problem of existence of primary refugia of broadleaf trees in the Volhyno-Podolian area. We can conclude that no primary refugia of tree species adapted to warm and humid conditions existed in this region during the LGM. However, some woody species, such as representatives of Pinus, Betula, Alnus, Salix, were components of periglacial vegetation. We cannot exclude that some thermophilic tree species survived during previous Pleistocene glaciations, but the LGM phase was critical for their preservation in the region. Results of palynological studies indicate that the Volhyno-Podolian area (including Maloye Polesie) is perspective as a refugium of microtherm species.

# Implications from stable <sup>13</sup>C isotope stratigraphy for closed system carbonate diagenesis; an example from the Upper Silurian Baltic Basin

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The research focus on the carbon isotope variations in the Upper Silurian carbonate succession, using whole rock sample analyses (well Bebirva 111, location Lithuania). It appears that at several locations within the Silurian Baltic Basin a certain positive <sup>13</sup>C isotope event can be traced at the same stratigraphic level within the same conodont and graptolite biozones, despite of various facies and different successions. The same event has been found at several other places in the world, in different basins and successions with different lithology. It appears that the original carbon isotopic signature of the carbonates has been preserved in different lithology, different settings, each with own specific burial history. The measured section in Lithuania has been analyzed for diagenetic modifications of the original carbonate components. Only few of the components, such as most brachiopod shells and at least part of the ostracod shells, have been preserved with their original texture and chemical composition, because they were originally composed of the low-Mg calcite. Most of components have been replaced during diagenesis by the low-Mg calcite, albeit detrital grains or early marine cements, and the pores filled with burial calcite cement as well as carbonate mud. The fact, that the carbon isotope signature has been preserved despite all these major modifications during diagenesis, and each site evidently had its own set of diagenetic processes in time, has several implications on the nature of the diagenetic system. This system must have been closed more or less completely with respect to the carbon within the carbonate. To explain diagenesis in carbonates usually basin-wide fluid flow, usually with presumed meteoric origin, is invoked as trigger for replacement and cementation. This would have changed and blurred any original carbon signatures and global events and thus has to be refuted. The expanding list of both positive and negative carbon isotope events throughout the Phanerozoic, that are regionally and globally correlatable, suggest that diagenetic processes took place on a very local scale with preservation of mass within the system itself.

### Implications of the paleoseismicity of the Eastern Baltic Sea region

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Historical seismic activity in the Eastern Baltic Sea region is significantly lower comparing with the seismicity of Fennoscandian shield. Still, several tens (~ 40) of small scale seismic events with intensities of VI-VII points (MSK-64 scale) and magnitudes up to M-5 are recorded in the area (Pačėsa *et al.* 2005). Moreover, tsunami event in year 1779 is implied as occurring at the Baltic Sea coast near Trzebiatów, Poland (Morphotectonic map of the European Lowland Area). Osmussaare (Estonia) earthquake of year 1976 (with maximal magnitude up to M-4,75) and Kaliningrad (Russia) earthquakes of 2004 (with maximal magnitude up to M-5) evidence recent seismic activity of the southern part of the Baltic Sea. High seismic activity of Fennoscandian shield and adjacent Baltic Sea territories during the Late Glacial and Holocene (last 13 000 years) is well documented by numerous paleoseismic investigations and corresponding publications. The earthquakes caused landslides in glacial till, seismically-induced soft sediment deformation structures, "seismites", are common in trench exposures in the vicinity of the faults in northern Sweden and even with tsunami events reported in the Baltic Sea (Mörner 1985, 2003, 2005, 2008).

The deglaciation history in Lithuania is longer, but so far there are no any paleoseismic events recorded and published (Satkūnas *et al.* 2003). The directed paleoseismological studies of the territory of Lithuania and wider Eastern Baltic Sea Region have not been carried out up till now: several international projects were carried out in order to study, compare and correlate the Late Quaternary stratigraphy, paleogeographic phenomena in Lithuania and Scandinavia, however, any paleoseismic structures like pseudo-nodules, flame-like or deformed structures in silty and sandy sediments haven't been identified and described in Lithuania. Results of the investigations of lake deposits formed during the Late-Glacial and Holocene are reported in proceedings, dealing with aspects of their age, history of lake development, fluctuations in lake water level, former climatic conditions, vegetation composition and its changes, and to elucidate the effect of human activities on vegetation and ecosystems, but no report is presenting data or evidence of disturbances of paleoseismic origin (Satkūnas *et al.* 2003).

However, the recent detail analysis of the Quaternary deposits of the Eastern Baltic Sea Region in the background of the state-of-the-art of the modern paleoseismology has implied the other understanding. A number of the geological structures earlier interpreted as cryoturbations, glaciotectonic features or so-called water-escape structures, clearly shows all the characteristics of the liquefaction-inducted sediment deformations. Such structures have been distinguished and described in a number of localities in Estonia, Latvia, Lithuania and Belarus (Raukas and Kajak 1997; Saulite 2007). Majority of these seismites were formed during the Late Glacial and Holocene time, and several of them are related to the Middle Pleistocene, Eemian Interglacial and Early Weichselian strata.

### New data on the structure and origin of the Devonian Lode Formation

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The clayey deposits of the Devonian Lode Formation have been widely studied by palaeontologists and sedimentologists. These deposits in Latvia are important as a raw material for ceramics, therefore many drillings are made in these beds, and a clay pit exists for tens of years in Liepa. However, there are various uncertainties about the sedimentary environment of clayey deposits.

The Lode Formation corresponds to the upper part of the Gauja Regional Stage, which represents the Middle Devonian Givetian Stage (Kleesment and Mark-Kurik 1997). The lower part of the formation in Latvia is composed of the fine grained sandstone, siltstone and clayey siltstone. The proportion of clay and silt size particles in deposits is about equal. Prevalent type of deposits in the uppermost part of the sequence is very fine clay. These deposits form lenses, more than 20 m thick, which is the unique feature of the Lode Formation in Latvia (Kuršs 1992). Bedding deformations like folded structures and faults are present around these lenses in the Liepa clay pit.

The upper part of the Gauja Regional Stage in Estonia has been marked as the Lode Member. The lowermost part of the member is composed of the fine grained mostly greyish white sandstone, but in the uppermost part mainly siltstone and clayey siltstone are present (Kleesment and Mark-Kurik 1997).

There are controversial opinions about the origin of these deposits. Especially there are uncertainties about the origin of clay lenses in the Liepa clay pit. V. Kuršs (1992) is of the opinion that the clay lenses were formed in slump depressions on inclined palaeodelta slope. From the point of view of A. Pontén and P. Plink-Björklund (2007) the deformations in the Lode Formation have formed because of tectonic processes.

This study is dealing with the geological structure of the Lode Formation and its sedimentological interpretation. In this study nine outcrops of the Lode Formation in the Liepa clay pit as well as two outcrops on the banks of River Piusa in Estonia have been documented in details, and measurements of bedding elements, grain-size analysis and borehole data analysis have been performed.

Shape of clay lenses in the Liepa clay pit, orientation of their longitudinal axes and distribution of folded structures and faults along their margins lead to conclusion, that the fine clayey material accumulated as the infilling of large slump depressions during the Lode time. Grain size gradation inside these lenses suggests the transport of the clayey material with gravity flows. According to Reading and Collinson (1996) slump processes and gravity flows are present on the delta slope. Fine grained clay lenses haven't been found in the Lode Member deposits in Estonia. However, there are some clay lenses that have been washed out and transported in a short distance. The sandy sequence, indications of tidal influence and washouts, suggest that the Lode Member deposits in Estonia correspond to the delta front conditions.

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# Clay minerals composition: a useful tool for glacial till studies and reconstruction of palaeo-ice streams

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Knowledge on glacial features such as tills contributes to a better understanding of glaciations. Our study tests a new model for phasing of the MIS 6 glaciation of the Netherlands and NW Germany using clay mineralogical composition XRD analysis on tills. We sampled tills from a series of stages of glaciation of Drenthe, the Netherlands, with attention to (i) phasing, (ii) local substrate and (iii) position within ice streams. Four hundred XRD measurements confirm inferred ice-streaming in different phases of the Saalian glaciation, complementary to other till-analysis techniques.

Our main finding is that clay minerals are a useful tool for paleoenvironmental reconstruction of glacial landscapes of different ages, which give more information about material transport, positional and local conditions of till formation. Clay mineralogical analysis of tills does not demand quarry faces for sampling: cores are fine. This benefits sampling in areas such as Drenthe.

We show that in Drenthe the lower tills are subregionally formed under saline subglacial groundwater conditions. Under glaciating circumstances, shallow and deep groundwater interaction temporarily changed, as recorded in till composition. It formed a closed subglacial system, based on the presence of authigenic minerals and the ratio of illite-smectite content (TSI). The observations agree with previous paleo-geohydrological reconstructive modelling. Till types of similar TSI, but differentially affected by the post-glacial weathering and seepage of groundwater are separated. Our new approach not only allows differentiate tills based on the presence of endogeneous tills and authigenic minerals, but also gives insight in the till-forming processes and impact of weathering. It is of importance for the glaciation story as well as for modern water quality and ecology.

# Plant macrofossil assemblages from the Eemian-Weichselian deposits of Latvia and problems of their interpretation

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Eemian and Early Weichselian deposits are known in several sections in Latvia. Accordingly these are named Felicianova Formation and Rogali Beds. Felicianova (Eemian) interglacial deposits of the Upper Pleistocene in Latvia (Satiķi, Rogali, Felicianova, Kaitra, Skrudaliena, Subate sections) contain macrofossils of the three assemblages: I, II, III. The assemblage I corresponds to the climatic pre-optimum and is characterized by numerous oogonies of Characeae algae and by the remains of *Pinus silvestris* (cone, needles), *Betula nana* and *Selaginella selaginoides*. This assemblage corresponds to pollen zones F1-F2 (Meirons and Straume 1978; Meirons and Mūrniece 1982) or S, Sat1 in Satiķi site (Kalnina *et al.* 2007). The assemblage II conforms interglacial climatic optimum and can be correlated to pollen zones F3-F6 (or Sat2-Sat6), containing thermophilic plants that are extrinsic, rare or do not grow in Latvia nowadays. Seeds of *Tilia tomentosa, T. platyphyllos, Acer* sp. and *Sambucus nigra*, nutlets of *Carpinus betulus, Corylus avellana, Alnus glutinosa* and *Frangula alnus* are typical for this assemblage. Water plants *Brasenia holsatica, Scirpus lateriflorus (S. smithii), Caulinia flexilis, Salvinia natans, Trapa* sp., *Cladium mariscus* have been recorded in this assemblage, too.

The assemblage III corresponds to the post-optimum and pollen zones F7, F8 (or Sat7-Sat8). The assemblage is represented in Satiki site better than in the others. The remains of trees *Pinus silvestris* and *Picea alba* (seeds, needles) occur but remains of plants that are typical for coastal and swamp conditions, such as *Sparganium microcarpum*, *S. simplex, Eleocharis ovata, Rumex maritimus, Carex* spp., *Ranunculus sceleratus, R. repens, Stachys palustris* dominate the assemblage.

The deposits of the Rogaļi Beds overlie the Felicianova Fm with stratigraphic break and cut it at various levels. Carpological assemblages IV-VI in the sections where the Rogaļi Beds overlie the Felicianova Fm have been studied and described earlier (Ceriņa 1983, 1984; Kalnina *et al.* 2007).

The assemblage IV (Rogali, Satiki, Felicianova sections) is predominanted by *Isoetes lacustris* megaspores (oligotrophic conditions of lake), the presence of *Juniperus communis, Salix* cf. *polaris, Betula nana, Dryas octopetala, Potamogeton filiformis* etc. Re-deposited macroremains of the thermophilic flora from the Felicianova Fm occur in the composition of this assemblage, too. The deposits containing the assemblage IV can be correlated with the Nemunas Ia stadial in Medininkai 117P sequence (Satkunas *et al.* 2003).

The assemblage V (*Pinus* sp., *Picea* sp., *Betula alba*, *Isoetes lacustris*, *Caulinia flexilis* etc.) was found in the Rogali, Subate, Skrudaliena and Kaitra sections consisting of deposits formed during the interstadial. Macroremain composition of the assemblage V is the same as in the int. 10.0-8.7 m in Medininkai 117P sequence corresponding to the Jonionys I interstadial that is compared with the Brörup interstadial.

There are a lot of small remains of redeposited thermophilic plants in the assemblage VI (Rogaļi, Skrudaliena). Flora represented by Characeae, *Selaginella selaginoides, Picea* sp., *Betula nana, Arctostaphylos uva-ursi, Potamogeton filiformis, P. praelongus, Batrachium* sp. is characteristic for conditions of temperature decrease, thus it can be assumed that this assemblage has formed in one of the stadials. Assemblage VI in Skrudaliena section is very similar to the Nemunas 2d by macroremain composition.

Eemian and Weichselian deposits in the intervals where palynological and plant macroremain studies have been carried out are not dated therefore it is problematic to correlate them with <sup>18</sup>O isotope stages.

# Trace fossils in the Ordovician of St.Petersburg region: significance for stratigraphic correlation

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Ordovician deposits of St. Petersburg region contain rich and diverse trace fossil assemblages. First descriptions of trace fossils from the region date back to the middle of the 19<sup>th</sup> century (Eichwald 1840, 1860; Ozersky 1844; Schmidt 1858). Trace fossils are recorded through all the Ordovician succession. The so-called "Jõhvilithes" and especially Amphorichnus papillatus (Männil 1958, 1966) have been used for identification and correlation of the Jõhvi stage deposits in the boreholes since the 40ties of the 20<sup>th</sup> century. "Amphora-like borings" (Orviku 1960) at the base of the Volkhov regional stage (Gastrochaenolites oelandicus (Ekdale and Bromley 2002)) were also used for identification of this stratigraphic level. Trypanites borings at the bedding planes were used for local correlation by Vishniakov and Hecker (1937). Recent investigations demonstrate that an absolute majority of the Ordovician sedimentary structures visible in the natural outcrops and boreholes in the region are of biogenic origin. At present not all of these structures are recognized, identified and properly described. We are only at the beginning of this process. However, for some selected stratigraphic intervals (Billingen, Volkhov, and Kunda regional stages) this work has been already done. Stratigraphic significance of trace fossils can be demonstrated using the Volkhov Stage deposits as a case study (Dronov et al. 2002; Dronov and Mikuláš 2010).

The uppermost Billingen and Volkhovian bioclastic limestones of the St. Petersburg region usually referred as the "Glauconite Limestone" are interpreted as cool-water calcareous tempestites, which were deposited in a storm-dominated, shallow-marine environment (Dronov 1998). The carbonates are extremely condensed due to a low productivity of the homoclinal ramp "carbonate factory" and abundant discontinuity surfaces probably result from carbonate dissolution (Dronov and Rozhnov 2007). In general, the ichnodiversity of the Volkhovian ramp is relatively low but due to the condensed character of the section, density of trace fossils can be very high on some levels. Traces of boring and traces combining evidences for boring and burrowing are represented by Trypanites, Gastrochaenolites and Balanoglossites. The most widespread burrows are: Thalassinoides, Bergaueria and Chondrites. These ichnofossils have the highest stratigraphical potential and could be used for tracing individual beds and bedding plane surfaces for a long distance. Locally numerous Palaeophycus, Phycodes and Arachnostega have a limited stratigraphical potential. Representatives of Rusophycus, Planolites and Teichichnus are rare. Based on distribution of trace fossils individual beds and bedsets within the Volkhov Formation have been traced on a distance of more then 300 km from Syas River in the east to the Toila in North-Western Estonia in the west (Dronov et al. 2000). Time resolution for bed-by-bed stratigraphic correlation based on ichnofossils may reach 170 000 – 200 000 years which is much more precise than conventional biostratigraphy. Usability of trace fossils in stratigraphy however has its limitations because they depend on facies too much and usually could not be extended beyond the certain facies belt. Nevertheless, trace fossils can be used also for detecting high frequency sea level changes that can help in a more distant interfacial correlation (Nielsen 1992; Dronov et al. 2003). Trace fossil analysis has great but underestimated potential for high resolution regional correlation.

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### Revised sequence stratigraphy of the Ordovician of Baltoscandia

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Based on outcrop and drill core data the Ordovician succession of Baltoscandia is subdivided into 14 depositional sequences, modifying the former models by Dronov and Holmer (1999) and by Harris et al. (2004). Sequence (I) agrees with the Pakerort sequence of Dronov and Holmer (1999). Sequence II coincides with the Varangu Regional Stage. Previously the Varangu deposits have been interpreted as a lowstand systems tract of the Latorp sequence. Sequence III corresponds to the Hunneberg and Billingen regional stages. The sequence has the longest duration (about 12 my) and a minimal average thickness rarely exceeding 1.5 m. It represents a highly condensed stratigraphic interval of diverse lithology. Gaps and erosional surfaces are common. It could not be excluded that in future two or three separate depositional sequences will be identified in it. Sequences IV, V, VI and VII agree with the Volkhov, Kunda, Tallinn and Kegel sequences of Dronov and Holmer (1999), respectively. Sequence VIII comprises the Oandu and Rakvere regional stages. The Hirmuse Formation and lower parts of the Mossen and Variku formations can be interpreted as a transgressive systems tract while the shallow-water light-coloured micritic limestones of the Rägavere Formation, together with the upper parts of the Mossen and Variku formations seem to represent a highstand systems tract. Sequence IX comprises the Nabala Regional Stage. Argillaceous limestones of the Paekna and Mõntu formations seem to represent a transgressive systems tract deposits while micritic limestones of the Saunja Formation are interpreted as a highstand systems tract deposits. Sequence X comprises the Vormsi Regional Stage. It coincides with the sequence 2 of Harris et al. (2004). Sequence XI comprises the lower part of the Pirgu Regional Stage. In the shallow-water setting two cycles were identified within the sequence (comprising sequences 3 and 4 by Harris et al., 2004), but they can not be distinguished in deep-water red limestones and marls of the Jonstorp Formation. Sequences X and XI were assigned to the Fjäcka sequence by Dronov and Holmer (1999). Sequence XII corresponds to the sequences 5 and 6 of Harris et al. (2004) and the Jonstorp sequence of Dronov and Holmer (1999). Sequence XIII comprises the lower part of the Porkuni Regional Stage corresponding to sequence 7 of Harris et al. (2004). Sequence XIV corresponds to the upper part of the Porkuni Regional Stage. It is represented by the Saldus Formation which is mainly distributed in the central parts of the Livonian Tongue and corresponds to sequence 8 of Harris et al., (2004). The most prominent regressions, marked by unconformities and extensive erosion coincide with the top of the Ordovician, as well as with the base of the sequences VIII, XIII and XIV (early Katian, basal Hirnantian and middle Hirnantian). The most distinct sea-level highstands, marked by the widening of the relatively deep-water marine red bed facies, occurred during Volkhov-Kunda (Dapingian-early Darriwilian) and Pirgu (latest Katian) times.

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# Stratigraphy of the late Palaeolithic site Ryadino 5 (Šešupe river valley, Kaliningrad region)

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The key Palaeolithic and Mesolithic archaeological sites are investigated within the frames of the scientific project 'The Evolution of the Baltic Sea and the Stages of the Earliest Human Settlement in the Southeast Baltic' using methods of palaeogeography: geological and geomorphological study, geochemical, palynological analyses, and radiocarbon and OSL dating.

In 2010 palaeoecological research of the late Palaeolithic site Ryadino 5, situated on the left bank of the river Sheshupe (the eastern internal areas of the Kaliningrad region), had begun. In the relief, the site occupies a flat platform on the edge of a terrace (height 12 m above the water level). During excavating the part of the site (20 m<sup>2</sup>) the geological structures breaking natural "normal" stratigraphy of the cut have been found. Originally they were treated as "household holes", however archaeological and geochemical researches haven't confirmed this conclusion. Light glaciofluvial (?) sand from depth about 70 cm is penetrating into upper alluvial yellow sand, reaching the organic layer of the soil, and forming "tongue", "dome" shaped forms. At the recent moment studying of the documented structures gives the grounds to put forward the version of "palaeoseismodislocations". Further complex researches of the site Ryadino are required.

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### Abnormal rhabdosomes of Pristiograptus (Graptoloidea)

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The cases of graptolite anomalies and parasitism are very rare phenomena and these are usually observed only in chemically prepared samples. Urbanek (1958) was one of the first who described many abnormal blisters on monograptid *Heisograptus micropoma* (Jaekel) from the early Ludlow and identified these as the disturbance of a thecal membrane caused by unknown organisms, probably chitinozoans.

The material consists of specimens from seven boreholes in the western part of Lithuania, e. g. Šiupyliai - 69, Kurtuvėnai - 161, Vilkaviškis - 131, Sutkai - 87, Pilviškiai - 143, Vištytis - 17 and Milaičiai - 103. 25 abnormal graptolite rhabdosomes have been found revealing six different types of anomalities: a) blister-like, b) crunch-like, c) rhabdosomes with two virgulae, d) rhabdosomes with additional thecae, e) rhabdosomes with asymmetrical thecae, f) rhabdosomes with additional virgulae.

It was identified that the most abundant are blister-like anomalies which are related with parasites such as chitinozoans or other organisms. Other abnormal rhabdosomes were related to mechanical damage caused by environmental conditions and predator activity. It is obvious that the genus *Pristiograptus* is abundant when other graptolites become extinct. Presumably this genus is strategically better adapted to environmental changes than other genera.

Urbanek, A. 1958. Monograptidae from Erratic Boulders of Poland. Abnormalities of development and structure. *Paleontologia Polonica*, 9: 30-42.

### Psammosteid agnathans from the Amata Regional Stage of the Oredezh River Basin, Leningrad Region

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The deposits of the Amata Regional Stage (RS) are widely distributed in the eastern part of the Main Devonian Field, they crop out in the basins of the Velikaya River (Pskov Region), Oredezh and Syas' rivers (Leningrad Region), also at the Andoma Hill (Vologda Region). Psammosteids occur in all mentioned areas (Mark-Kurik and Obruchev 1965). The most representative assemblage is found in the Amata RS of the Oredezh River Basin.

According to the two last revisions of this group (Tarlo 1965; Mark-Kurik and Obruchev 1965) the following taxa have been mentioned from that interval: *Ganosteus stellatus* Rohon (Bor locality), *Psammolepis venyukovi* Obruchev (Yam-Tesovo), *Ps. undulata* (Agassiz) (Yam-Tesovo), *Psammolepis* sp. 1 (Butkovo), *Psammosteus praecursor* Obruchev (Tesovka, Yam-Tesovo, Bor), *Ps. cuneatus* Obruchev (Yam-Tesovo?), *Psammosteus* sp. 2 (Yam-Tesovo). Later a new genus and species *Oredezhosteus kuleshovi* Moloshnikov (Moloshnikov, 2009) has been described from the Amata deposits of the Yam-Tesovo locality. Moloshnikov suggested including *Psammosteus livonicus* (Obruchev) from the same stratigraphical interval of Latvia within the new genus. However, such generic belonging seems doubtful.

The new material collected during the last years from the Amata RS of the Oredezh River (Bor, Butkhovo, Goryni, Phillipovichi, Yam-Tesovo localities) are represented by the following psammosteids: *Ganosteus stellatus* (Bor), *Psammolepis venyukovi* (Bor, Goryni, Yam-Tesovo), *Ps. undulata* (Bor, Buthovo, Goryni, Phillipovichi), *Psammosteus praecursor* (Bor), *Ps. meandrinus* Agassiz (Bor). The remains of *Psammolepis venyukovi* dominate the assemblage. The reworking of the remains of *Ganosteus*, mentioned by Mark-Kurik for the Amata deposits (Mark-Kurik 1968) is sustained by the new finds of *G. stellatus* in the Bor locality. Fragment of a plate belonging to this taxon bears the sand grains between psammosteid denticles, which are strongly different from the sand grains of the fossil-bearing layer. *Psammosteus meandrinus* from the Bor locality has been found for the first time in the Amata RS deposits of the eastern part of the Main Devonian Field.

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# Twenty years to run the Baltic Regional Stratigraphical Commission (1970-1990)

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Needs of common policy in geology studies of the Baltic (Soviet) Republics (or East Baltic Region) arose despite of several circumstances:

- a strengthening of the national geological surveys;
- the rise of well-educated scientists in the basic fields of geosciences;

• a necessity of research of the Baltic Region as an entire geological evolution unit.

In particular, the stratigraphy studies sharply needed to apply a common methodology, to introduce the internationally guided rules, to develop a unification of stratigraphic classification at the local and regional levels, to adapt the constantly renewing International Stratigraphic Chart.

A background of the Baltic Regional Interdepartmental Stratigraphic Commission (BRSC; previously known as RMSK) was elaborated under guidance of the Lithuanian Geological Prospecting Institute (LitNIGRI), in 1968, within an agreement of geological institutes and geological surveys of Estonia, Latvia, and Lithuania. The Commission stated as a regional body of the All-Union Interdepartmental Stratigraphic Committee (MSK), located at VSEGEI, St. Petersburg (Leningrad). A foundation of the Baltic RMSK was signed in 1969. The structure and management of RMSK were elaborated and approved, and Commission went into a power.

Academician Prof. Juozas Dalinkevičius was appointed a first chair of the Commission but in 1970 he was substituted by Prof. Algimantas Grigelis (Vilnius). Baltic RMSK comprised the Estonian, Latvian and Lithuanian stratigraphic commissions; and the researcher groups for every geological period/system were established as a main tool of the collaborative work. A successive form of cooperation was the annual meetings (assembly) of the Commission, and thematic stratigraphic conferences held every two-three years followed by geological field excursions. This tradition is kept till now, in particular when RMSK in 1990 was reorganized into three national commissions on stratigraphy of the independent Baltic States and the Baltic Stratigraphic Association (BSA) was founded.

The Baltic RMSK worked actively during twenty years having main task to develop stratigraphy of the whole Baltic Region from a theoretically high reasoning of tentative age rocks classification to practical goals to use the stratigraphic subdivision in geological cartography and compilation of geological maps. The common problems of the regional stratigraphy of the Baltic region first were discussed in 1972.

The most remarkable achievements of the Baltic RMSK could be mentioned below:

• Elaboration of unified stratigraphic classification with correlation charts of the whole Baltic Region, that were examined and confirmed at the Baltic Stratigraphic Conference held in Vilnius, 11–12 May 1976.

• Evaluation and approval of the stratigraphic correlation charts by the All-Union Interdepartmental Stratigraphic Committee (MSK) and its publication, in 1978.

• Palaeontologic data were chosen as the main method to establish detailed stratigraphic subdivision of the Phanerozoic sedimentary rocks.

• Elaboration of principles of detailed stratigraphic legends, in 1979, and the user guide on methods of compilation of geological maps of the Baltic Region, in 1981.

• Set up of tens regional geological maps at a scale of 1:500 000 of the Baltic Republics based on the detailed stratigraphic correlation charts and its publication, in 1982.

• Regular work with regional and thematic working groups on improvement of the detailed stratigraphic charts.

• Persistent relations with the IUGS International Commission on Stratigraphy (ICS) and the International Subcommission on Stratigraphic Classification (ISSC).

The Baltic RMSK properly placed its disposal when after restoration of the independence of the Baltic Republics the self-sufficient national commissions on stratigraphy were established in Estonia, Latvia, and Lithuania in September–October, 1990. Thus, instead of the Baltic RMSK, the Baltic Stratigraphic Association (BSA) was established on 16th October 1990 in Vilnius, by the delegates of these commissions. Later, in 2003 the NW Russian National Commission on Stratigraphy joined the Baltic Stratigraphic Association.

The main goal of the Baltic Stratigraphic Association was declared to unite activity of the Estonian, Latvian and Lithuanian researchers to determine and solve the problems of the stratigraphy of the entire Baltic Region. A new Baltic Stratigraphic Association statute was approved by the first Baltic Stratigraphic Assembly in Vilnius, in 1991. The fruitful cooperation has an appropriate continuation, and the BSA regularly calls open international conferences devoted to various aspects of geology and stratigraphy. Author wishes the best success to the 8th Baltic Stratigraphical Conference – 2011.

# Early Hirnantian brachiopod faunas along the offshore-onshore transect: the East Baltic case

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Many publications deal with the topmost Ordovician Hirnantian brachiopod fauna all over the world. A substantial amount of data has been published about the Hirnantian (=Porkuni Regional Stage) in the East Baltic during the last decades. The trends of environmental changes and correlation of sections of the Porkuni Stage have been characterised by geochemical (including isotopes) and lithological criteria, and changes in the composition and distribution of micro- and macrofossils.

The present study focuses on the appearance of the Hirnantian brachiopod fauna and associated faunal shifts along the offshore–onshore transect in the East Baltic area. What happened within brachiopod faunas during great changes in the basin depth and how new invaders from the western part of the Baltic Basin influenced old associations in onshore facies? These are the main questions to be answered based on data from Baltic drill cores and outcrops. The discussed problems are also related to the correlation of the regional Porkuni, and the global Hirnantian Stage.

Most of the common brachiopods representing the Hirnantian associations in the central East Baltic have been taxonomically revised and data on their distribution enables following the onshore changes in their composition and diversity. The appearance of characteristic brachiopods of the Hirnantia Fauna in the Livonian Tongue of the Central Scandinavian facies belt (Central East Baltic) is gradual but relatively fast, corresponding roughly to the *Spinachitina taugourdeaui* chitinozoan Biozone. Brachiopod frequency and diversity rise in the overlying *Conochitina scabra* Biozone. The initial Hirnantia Fauna comprises also some pre-Hirnantian elements, common in the older or lateral lithologies. As *S. taugourdeaui* is present in the organic-rich interlayers in the reef complex of North Estonia, at least part of reefs together with underlying dolomites of the Röa Member (lowermost Porkuni Stage) are contemporaneous with the older part of the Hirnantia Fauna. In spite of rare finds, the occurrence of the brachiopod *Holorhynchus* in NW Estonia below the Porkuni dolomites should be mentioned. The occurrence of the Hirnantia fauna above the *Holorhynchus*-beds in Lithuania indicates different distribution of biofacies or a gap at the Pirgu–Porkuni boundary in that area.

The studied material allows make the following conclusions: (1) The Hirnantian fauna is opportunistic, migrating rapidly to habitable environments. It replaces the earlier faunas of relatively deep-water settings that were less suitable for many benthic organisms (overlies red-coloured strata). (2) The associations of the Hirnantia Fauna seem to be separated in space from those of reef facies in the northern East Baltic, possibly due to a pronounced sea bottom gradient between different faunas and lithologies. (3) In the eastern and southern periphery of the basin the Hirnantian strata of restricted thickness overlie *Holorhynchus*-bearing beds. (4) Wide distribution of the *Holorhynchus* fauna in the southern parts of the basin and rare occurrence of that brachiopod in Estonia (only on Saaremaa) may indicate differences in the sea bottom gradient, or pre-Hirnantian deeper erosion in the northern part of the basin. (5) Different pre-Hirnantian erosion and gaps in sedimentation in the Pirgu–Porkuni boundary interval complicate the study of lateral faunal successions.

### SARV: database of geological collections of Estonia

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Geological collections, including mineral and fossil specimens, rock samples and drill cores, constitute an essential source of information for various scientific and applied geological studies. In Estonia such collections are owned primarily by three institutions: Institute of Geology at Tallinn University of Technology (institutional acronym GIT), Museum of Geology of the University of Tartu (TUG) and Estonian Museum of Natural History (ELM). Together they make up the national geological collection, holding nearly 0.8 million storage units.

Collections can be effectively utilised only when they are appropriately catalogued and the information is readily accessible. Nowadays this is greatly facilitated by the use of electronic databases. In Estonia the first efforts in using electronic databases for collection management were made at TUG in 1994. A few years later the development of a custom database designed specifically for geological collections and related information started at GIT. This database, now known as SARV, has since then evolved from institutional desktop application into a relational client-server information system that is deployed in three institutions. SARV aims to serve the needs of collection managers as well as of researchers seeking for information or willing to store their data in a structural and easily searchable form.

The data model of SARV consists of more than a hundred related database tables, the most important of which are collection, specimen, sample, locality, drill core, preparation, analysis, reference, agent, classification, stratigraphy, location and loan. The server-side software of SARV is based on open source components, such as the Ubuntu Linux operating system, MySQL database server, Apache web server, PHP and Python scripting and various other tools. On the client (user) side the data entry and regular collection management procedures such as accessioning, keeping track of the specimens, printing labels and loan invoices, etc. are still partly grounded on a custom Microsoft Access application. However, with the emergence of new standards and technologies (e.g. AJAX, HTML5), the recent focus has been on switching to an entirely browser-based solution. An experimental web application built on top of the Django framework already replicates most of MS Access functionality and shows a good potential for full replacement of the desktop software.

SARV has a publicly accessible web interface at http://geocollections.info, where users can search for information related to individual collection objects, fossil species, stratigraphical terms, image files, etc. The data on the website can be freely used for non-commercial purposes according to the Creative Commons license. SARV can also be accessed via BioCASe (http://www.biocase.org), GBIF (http://www.gbif.org) and the recently established GeoCASe (Geosciences Collection Access Service, http://www.geocase.eu) specimen-level data networks.

As of 2011, approximately a quarter of Estonian geological collections are electronically catalogued at the unit level. The majority of the important collections, type- and cited fossil specimens in particular, are already in the database. In addition to registration of physical collection objects, the system contains a growing amount of related information starting from digitised photo archives, scanned field notebooks, results of geochemical analyses, annotated taxonomic and stratigraphical dictionaries and so on. Most of that information is freely accessible online.

In summary, we have learned that the development of a functional database is possible with rather limited resources, except time. It requires, however, tight collaboration between collection managers, researchers and technical developers. Broader benefits of the database appear when a certain critical amount of data is available digitally and when the collection-oriented data are linked to different scientific information. The recently approved national research infrastructure roadmap and a new INTERREG project enable further professional development of SARV, foster data entry and increase the visibility and application of Estonian geological collections in the coming years.

## Quantitative stratigraphical approach to palaeobiodiversity of Baltic Ordovician chitinozoans

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Chitinozoans are organic-walled microfossils, probably eggs of cryptic marine metazoans that were common and diverse from the Early Ordovician through Devonian times. Chitinozoans are useful index fossils and their biodiversity patterns have been discussed in a number of papers. In the Baltic area, the diversification of Ordovician chitinozoans has been addressed by Kaljo *et al.* (1996) and Nõlvak in Paris *et al.* (2004).

In order to increase the temporal resolution of previous diversity curves, a new data set was compiled incorporating recently acquired distributional data from eight reference sections in Estonia: the Kerguta, Männamaa, Mehikoorma, Ruhnu, Taga-Roostoja, Tartu, Valga and Viki drill cores (see Nõlvak 2010 and references therein). Additionally material from the Uuga Cliff was included. Altogether, the data set consists of 1079 productive samples and 145 species. This data set was analysed by calculating different diversity measures per regional stages, and with the CONOP9 quantitative stratigraphic tool. The latter creates a best-fit composite sequence (modelled succession of FADs and LADs), which serves as a high-resolution time scale and basis for a diversity curve.

The CONOP9 modelled diversity curve generally reflects the same trends as the conventional stage-based approach, but with more details and some minor differences. A rapid diversification of chitinozoans occurred in Volkhov to Aseri times. The Aseri to Haljala interval was characterised by a generally high diversity up to 35 species with several minor fluctuations evidenced by the CONOP9 approach. The maximum total diversity (46) and normalised diversity (34) per regional stage were observed in the Haljala and Kukruse stages, respectively. A general diversity decline started in Keila time, at the Sandbian-Katian boundary. The chitinozoan diversity was low during Oandu and Rakvere times, but a peak followed in Nabala time. The latter brief diversification episode coincided with elevated levels of phosphorus in the basin, which might have had a positive effect on the bioproduction and food supply for chitinozoan animals. The diversity curve shows a further declining trend after the Nabala peak, and the chitinozoan fauna was already strongly impoverished by Porkuni time. Radiation of Silurian chitinozoans started only in the late Aeronian.

In contrast to Nõlvak in Paris *et al.* (2004), the present data show that the Late Ordovician diversity decline of chitinozoans started in the Keila Stage rather than in the Haljala Stage. Moreover, a higher diversity than previously reported was documented throughout the succession. The CONOP9 composite sequence proved to fit well with the empirical data and complement the conventional palaeobiodiversity approach as probably the best proxy to standing diversity. The analysis revealed that the total diversity strongly overestimates the standing diversity, whilst the normalised diversity provides a good approximation to it.

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### Vertebrate assemblages from the Givetian-Frasnian boundary beds of the Borschovo locality (Leningrad region, Russia)

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A new locality of the Devonian vertebrates was discovered by the 2001 Russo-Latvian expedition at the Borschovo village, near the coast of Antonovo Lake, the Oredezh River basin, Luga District of Leningrad Region (north-west Russia). The deposits at this site are represented by the pink, yellowish-grey and light blue cross-bedded sandstone with intercalations of violet and greenish clay and mudstone. The vertebrate remains occur in two levels. The lower layer yields isolated skeletal elements of psammosteid *Psammolepis* sp., arthrodire *Plourdosteus livonicus* (Eastman), antiarch *Asterolepis* sp., acanthodian *Haplacanthus* sp., sacropterygians Dipnoi gen. indet., *Glyptolepis* sp., Porolepiformes gen. indet.

The upper layer comprises the well-preserved abundant plates of psammosteids *Psammolepis* cf. *undulata* (Agassiz), *Psammolepis* sp., *Psammosteus* cf. *cuneatus* Obruchev, *Ps. levis* Obruchev, *Ps. praecursor* Obruchev, *Psammosteus* sp.; numerous plates of *Asterolepis radiata* Rohon and *A.* cf. *ornata* Eichwald; rare plates of arthrodire *Eastmanosteus* cf. *pustulosus* (Eastman), as well rare scales and bone of porolepiform fish. Many psammosteid and antiarch skeletal elements bear the traces of some pathology: bit marks, parasites action or other illness.

*Eastmanosteus* cf. *pustulosus* was previously known only from the Gauja Regional Stage (Esin *et al.* 2000). *Psammolepis undulata* and *Plourdosteus livonicus* were reported from the Gauja and Amata regional stages (RS). *Psammosteus cuneatus* and *Ps. levis* occur in the Amata interval. *Psammosteus praecursor* and *Asterolepis radiata* are characteristic for the Amata RS and Snetnaya Gora Beds of the Plaviņas RS. The vertebrate assemblage of the Staritsa Beds, lower part of the Amata RS in the Oredezh River basin commonly includes psammosteid *Psammosteus maeandrinus* Agassiz and antiarch *Bothriolepis obrutschewi* Gross which are missing in the Borschovo, but dominating in many localities including Goryn', Bor, Milodezh, Yam-Tesovo. Possibly, the deposits from the Borschovo locality belong to the base of the Staritsa Beds where some taxa surviving from the Gauja time still occur. The Givetian-Frasnian boundary beds would require the refined revision of vertebrate distribution.

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# The progymnosperm and miospores from the Devonian Lode Formation of Latvia

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The Frasnian Lode Formation established in the north-eastern Latvia by V. Kurshs (1975) has complicated geological structure. It is rich in various fossil fish, invertebrate and plant remains concentrated in taphocoenoses designated by Latin letters A-E distributed throughout the Lode Formation. Taphocoenosis A with fish and plants has been found in 1971 in the Lode clay pit located to the south of Valmiera town. Most likely the taphocoenosis A corresponds to the upper part of the Lode Formation (E. Lukševičs pers.comm.). A. Jurina took part in collection of plant remains from this taphocoenosis. Archaeopteris fissilis and Rhacophyton sp. have been preliminary determined in the field (Jurina 1988), but these determinations were wrong. The detailed study of plants has shown that they belong to Svalbardia banksii Matten, 1981. The genus Svalbardia Høeg, 1942 is included in the Progymnospermopsida Beck, 1960. It is characterized by free sporing plants with a pteridophyte type of reproduction and foliage combined with gymnospermous anatomy. The species of Svalbardia have been described from various regions: S. polymorpha is the type species from the upper Middle Devonian or lowermost Upper Devonian of Spitsbergen; S. osmanica from the Frasnian of Russia; S. scotica from the Givetian of Scotland; S. fissilis from the Upper Devonian of Ukraine and Canada. Stratigraphical interval of the genus Svalbardia is from the Givetian to Frasnian, probably sporadically in the Famennian (Donbass). S. banksii is found only in New York State from the Frasnian Oneonta Formation, the Delaware River Flags (Matten 1981). Latvia is now a second location of this species in the world.

Miospores taken from the same clay, containing impressions of *S. banksii* are studied by M. Raskatova. Composition of the assemblage is reduced. Miospores have satisfactory and bad preservation. Clusters of small miospores (10-15 mk) with a smooth exine partially covered with sporangial tissue are found. Miospore assemblage is characterized by the dominance of the genus *Geminospora* including *G. micromanifesta*, *G. notata*, *G. rugosa* and the presence of large miospores (> 200 mk), with poorly preserved genus *Biharisporites*. Miospores of these two genera based on their size and morphology can be presumably attributed to micro- and megaspores of one plant. In addition, the assemblage contains large miospores (> 300 mk) with processes: *Ancyrospora fidus*, *A. furcula*, *Hystricosporites grandis*, some of them with lost processes and dark color. Miospores with conate ornamentation *Apiculatisporis uncatus*, *Iugisporis impolitus* are present in small number, as well as patinate miospores *Archaeozonotriletes variabilis* are present.

There is no consensus about the age of the Lode Formation in literature. Kurshs (1975; Kurshs et al. 1998) attributed this formation to the Upper Devonian (Frasnian). At present most researchers (Luksevics 2001) have come to the conclusion that the age of the Formation is the Late Givetian. We make the following conclusions about the age of thaphocoenosis A of the Lode Formation: *Svalbardia banksii* indicates the Early Frasnian, miospores – probably the Upper Givetian.

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# New developments in Baltic Silurian chemostratigraphy: results and some tasks

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Palaeozoic carbon isotope chemostratigraphy was first included in the programmes of the Baltic Stratigraphical Conferences at the  $3^{rd}$  BSC, Tallinn 1996, in a report by P. Brenchley *et al.* The first papers on the subject, however, were published two years earlier. Now we can state that carbon isotopes have become an effective stratigraphical tool, especially together with detailed biostratigraphy. Most of the respective studies have concentrated on the Ordovician. The main results were recently summarised by Ainsaar *et al.* (2010).

A series of positive  $\delta^{13}$ C excursions, serving as marker horizons for stratigraphical correlation of sections, have been established in the Baltic Silurian. The following excursions are most trustworthy: (1) the early Aeronian excursion (3.7%) in the *D. triangulatus* Biozone, (2) the early Telychian excursion (2.7%) in the *Sp. guerichi – Str. crispus* Biozone, (3) the early Sheinwoodian excursion (5.2%), with the peak in the *M. riccartonensis* Biozone or slightly above it, (4) the late Homerian excursion (4.6%), with the main peak in the *M. ludensis* Biozone and one or two smaller shifts below the main shift, (5) the middle Ludfordian excursion (8.2%), the most prominent one in the Phanerozoic. The last excursion has been correlated with the *N. kozlowskii* Biozone, but conodonts provide a direct dating – the last occurrences of *Polygnathoides siluricus* below the main shift and the appearance of *Ozarkodina wimani* and *O. crispa* above the excursion.

Our recent studies together with V. Grytsenko in the Přidoli of Podolia revealed a new excursion (4.5‰) at the junction of the Trubchin and Dzwinogorod formations and confirmed another, but earlier known elsewhere excursion (3.9‰) at the Silurian–Devonian boundary. In the East Baltic area the corresponding rocks have been studied in the Ohesaare (without top), Ventspils and Pavilosta (lower part only) cores where no excursions were revealed. Such a situation raised several questions and we decided to check the realities in the Baltic Silurian on the basis of more continuous Lithuanian core sections, including the Vidukle 61 and Šešuvis 11 (= Taurage) cores represented by deep shelf rocks of the Silurian Minija and Jura formations and the Devonian Tilže Formation (partly). Main part of our report is devoted to presentation and discussion of results of this study.

Carbon isotope chemostratigraphy has proved its efficiency when applied together with high-resolution biostratigraphy, helping to overcome ecologically (= facies dependence) caused cases of diachroneity of fossil occurrences. Having established a series of carbon isotope excursions in the Silurian, we can use those seven levels as markers for tracing certain time planes through different facies belts over the whole basin. However, at least one difficulty still exists – excursions are often linked to sea level low stands, which means that these event levels may be missing in certain sections, in peripheral ones in particular.

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### Palaebotanical records from the deposits of the Raunis site

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An outcrop of silty deposit section from the upper part of the Raunis River right bank located between the old and the new bridge of the Cesis – Veselava highway has been studied by plant macroremain and pollen analyses in several sections. The presence of macro-remains of Bryales, *Dryas octopetala, Salix polaris, Betula nana, Selaginella selaginoides* was stated for the lowermost part of the section and a large number of aquatic plants were identified, e.g. *Potamogeton filiformis*, Characeae oospore. Pollen data show abundance of the shrub and herb pollen in all lower lenses with organic matter, with dominant *Artemisia* and Cyperaceae, *Salix* abundant at some levels and presence of *Betula nana, Juniperus* and *Dryas octopetala*. Tree pollen was mainly represented by *Pinus* and *Betula*, which could be partly redeposited or transported in a long distance. A periglacial basin was surrounded by tundra and open land vegetation. In the upper part of the outcrop deposits contain no plant macroremains and yield very low amount of pollen.

Silt and clay rich in carbonate material and mollusc shells overlying the till at the depth of 3-2 m were found in several sections (ID-70, VZ, 2008). In the lower part of the section ID-70 the assemblage of the periglacial flora was found in the clay layer overlying the till, according to the data of plant macroremains. Remains of Characeae oospores, megaspores of *Selaginella*, fragments of *Dryas* leaves and nuts of *Betula nana* have been found already in the uppermost till close to the clay layer. The volume of plant remains increases in the section, however tree remains have not been found until the depth above the 2.1 m. Clay contains a lot of Characeae oospores, less *Potamogeton filiformis* remains. Both macroremains and pollen composition show the dominance of subarctic vegetation: *Dryas octopetala*, *Betula nana* and rare *Selaginella selaginoides*.

The number of mollusc and ostracode shells, as well as remains of Characeae and several species of Potamogetonaceae, increases from the depth of 2.1 m upwards in the section ID-70. Increase of *Pinus*, *Betula*, Poaceae and Cyperaceae pollen and decrease or disappearing of subarctic representatives characterizes the silt and clay in the depth interval of 2.25-1.93 m. Such plant macroremains and pollen composition suggest Early Holocene conditions during the formation of deposits in the mentioned interval. This was also confirmed by <sup>14</sup>C datings, which showed the 10570 – 10790 cal years BP both from the excavation and outcrop.

At the depth of 1.93-1.75 m freshwater limestone, peat and clay (over thin peat layer) contain the remains of Boreal type flora, consisting of tree and shrub remains (*Betula alba, B. humilis, Alnus glutinosa*). The remains of lake littoral zone and swamp flora are represented by e.g. *Sparganium, Alisma, Typha, Menyanthes*, predominantly by waterplants such as *Potamogeton natans, P. perfoliatus, P. obtusifolius, P. alpinus, Scirpus lacustris, Nymphaea alba, Hippuris vulgaris* et.al. Pollen data reflect the total dominance of *Pinus* and suggest the distribution of the Boreal type vegetation. The upper part of section is poorer in macroremains.

Comparison of palaeobotanical data from the studied sequences allows conclusions:

- 1. Plant macroremains and pollen data from the paleolake deposits in the section overlying the till reflect vegetation development from the periglacial conditions through Preboreal and Boreal.
- 2. Paleobotanical records from deposits at the Raunis site indicate the existence of Raunis Paleolake during the Late Glacial and Early Holocene.

### Stratigraphy and correlation of the Early Weichselian Rogaļi Beds

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The Quaternary deposits covering the Upper Devonian dolomites and containing three till layers have been found at the Rogali Site, Latgale Highland. In the geological section of the Rogali Site 15.8 m thick sequence of sand, silt, gyttja and clay has been found between the Weichselian and Saalian till layers. According to the lithological and paleobotanical studies (core no. 39) the lower part of the sequence has been formed under the late interglacial conditions, while the upper part of the section, subdivided as Rogali Beds, has been formed under the stadial-interstadial conditions of the Early Weichselian. Pollen data allow subdivide six pollen assemblage zones (PAZ) characterising changes in the vegetation composition and climatic conditions during sediment accumulation:

PAZ ROG1: *Betula, Betula nana*, wide distribution of *Artemisia* and Poacea pollen, presence of aquatics *Isoetes lacustris, Batrachium* sp. and tundra plants *Betula* sect. *nanae, Dryas* sp. and *Selaginella selaginoides* macroremains reflect stadial conditions comparable to the Nemunas 1a stadial;

PAZ ROG2: increase in *Picea*, *Pinus*, *Alnus*, *Corylus* and *Larix* pollen, *Picea*, *Pinus*, *Betula* sect. *albae*, aquatic plant *Caulinia flexilis*, *Batrachium* sp., *Potamogeton pusillus*, *P. obtusifolius*, *P. perfoliatus*, less *Isoetes lacustris* macroremains indicate interstadial conditions comparable to the Jonionys 1 and Brörup;

PAZ ROG3: dominance of subarctic and steppe vegetation *Betula nana*, *Duchekia*, *Artemisia*, *Helianthemum*, *Dryas*, *Selaginella*, Poaceae and macroremains of Characeae gen., *Isoetes lacustris*, *Batrachium* sp., reflects stadial comparable to the Nemunas 2a stadial;

PAZ ROG4: *Betula*, *Larix* sparse forests with *Juniperus* and presence of *Bruckenthalia*, found also in several sites of the Early Weichselian, macroremains of aquatics Characeae gen., *Caulinia flexilis, Potamogeton filiformis, P. praelongus, P. natans, P. obtusifolius, Batrachium* sp. indicate interstadial conditions probably comparable to the Jonionys 2 and Odderade;

PAZ ROG5: dominance of subarctic herb pollen and spores (stadial conditions, very conditionally comparable to the Nemunas 2b stadial);

PAZ ROG6: partly eroded interval, where pollen of interstadial/phasial *Betula*, *Larix*, *Salix* have been found together with subarctic representatives.

The composition of plant macroremains from the sequence overlying interglacial sediments at the Rogali Site is characterised by the assemblage IV where *Isoetes lacustris* megaspores showing oligotrofic conditions of the Paleolake predominate. *Juniperus communis, Salix* cf. *polaris, Betula nana, Dryas octopetala, Potamogeton filiformis* etc., as well as some redeposited macroremains of the thermophilic plants from the interglacial also have been found. The macroremain assemblage IV and PAZ ROG1 can be correlated to the Nemunas Ia stadial.

The assemblage V containing plant remains of *Pinus* sp., *Picea* sp., *Betula alba*, *Isoetes lacustris*, *Caulinia flexilis* etc. in the Rogali section and pollen spectra in PAZ ROG2 reflect the formation of deposits under the interstadial conditions and can be compared with the Jonionys I interstadial and with the Brörup interstadial.

The large number of redeposited thermophilic plant remains has been found in depth interval where plant macroremain assemblage VI has been subdivided. The flora represented by Characeae gen., *Selaginella selaginoides*, *Picea* sp., *Betula nana*, *Arctostaphylos uva-ursi*, *Potamogeton filiformis*, *P. praelongus*, *Batrachium* sp. characterised deterioration of climate and point on stadial conditions during sediment accumulation. Pollen data from the same depth interval show changes from stadial conditions (PAZ ROG3) to interstadial (PAZ ROG4) and again to stadial (PAZ ROG5).

# Geological processes as a cause of emergencies and catastrophic events in Russia

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There is the evaluation of modern geological and other natural processes on the territory of Russia causing emergencies and catastrophic events. Emergency situations are the occurrence of natural and anthropogenic geological processes leading to violation of people's living environment, life hazards and loss of property. Catastrophic event in contrast to emergency situations causes mass death of people (death of more than 10 persons).

Catastrophic event with mass death of people occur during full-scale floodings, earthquakes, tsunamis and mud flows. They are forecasted during 9-magnitude earthquakes in the Baykal rift zone, at Sakhalin and Primorye. At the Caucasus and Kamchatka ecological consequences can be intensified by occurrence of mud flows with volumes of rocks about 1 million m<sup>3</sup>. Numerous victims are possible during catastrophic floodings with area of flooding plain up to 90% and amplitude of water level changes about 5 m. In the European part of Russia they occur in some parts of Oka, Vyatka and Sosna river basins. In the Asian part of the country consenquences of catastrophic floodings might be intensified in addition by the ice obstruction with height up to 5 m. They occur at the Lena River, its tributaries Aldan and Vitim, at Yenisei and its right tributaries Chuny, Lower Tunguska and Stony Tunguska, at Tobol River and its left tributaries.

List of the natural processes causing emergency situations with several victims and huge loss of property is much longer and includes also tornados, sea water surges, landslides, dolines and extremely low temperatures. Extremely low temperatures can be life threatening at the northeast of European and Asian parts of Russia, tornados - in the central part, surges - in Saint Petersburg, at the eastern coast of Azov Sea and north-western coast of Caspian Sea, dolines - in the areas where soluble rocks are lying close to the surface. Landslides even if having high rate of displacement rarely threaten people lives, but cause huge loss of property.
# Correlation of the Rakvere Stage between shallow and deep shelf on the basis of Rb content of the clay fraction

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The correlation of the Rakvere Regional Stage between shallow and deep shelf needs refinement because of very different lithologies of these facies, and lack of strong faunal control (Hints and Meidla 1997). The Rakvere Stage, upper *clingani* graptolite zone, consists of cryptocrystalline limestone formed in the shallow shelf. The thickness of the limestone is 10-20 m in the northern Estonia diminishing to 3 m in the south, and disappearing in the W Latvia. In the deep shelf the correlative unit with limestone is black shale of the Mossen Formation (Männil 1966) or grey marlstone between the Mossen and Fjäcka black shales (Männil 1990).

Our research focused on the geochemistry of the clay fraction of the Rakvere Stage and adjacent beds. The Rakvere limestone contains less than 10% of terrigenous component. The carbonate was dissolved in 1N HCl solution, then the clay fraction was separated from the rest of the insoluble residue by settling method. The clay was analysed by x-ray fluorescence method. Rubidium content of the clay fraction was found to be the best discriminator between the Rakvere Stage and underlying and overlying stages in the shallow shelf sections. The Rb content of the clay of the Rakvere Stage is 273 ppm in average of 6 samples from the Laeva-13, Varbla and Taagepera cores. The highest value was 311 ppm in the Laeva-13 core. The overlying Paekna and Saunja formations of the Nabala Stage reveal, correspondingly, 260 ppm (in average of 3 samples) and 249 ppm (4 samples), from the Laeva-13, Varbla and Taagepera cores. The Vormsi Stage has Rb content of 222 ppm (4 samples, from the Laeva-13 and Taagepera cores), and the Pirgu Stage 178 ppm (5 samples from the Laeva-13 core). Underlying the Rakvere Stage, the Oandu Stage had Rb content of 230 ppm (3 samples from the Laeva-13 and Ristiküla cores), and the Keila Stage 229 ppm (7 samples from the Laeva-13 and Ristiküla cores). In the deep shelf (Aizpute-41 core) the highest Rb contents were in the uppermost boundary layer of the black shale and overlying grey marlstone. The sample from the black shale/grey marl transition, the depth 1042.4 m, has Rb content of 300 ppm. The 2 m thick sampled section of the overlying grey marlstone reveals upward diminishing contents: 275, 268, and 255 ppm. The underlying 2.4 m thick black shale unit has descending Rb contents 250, 248 and 247 ppm. On the basis of given Rb data we suggest that the Rakvere Stage in the deep shelf section is correlative with the uppermost centimetres of the black shale of the Mossen Formation plus the overlying 0.4 m thick grey marlstone, with determined Rb contents of 275 and 300 ppm. Rubidium can replace K in the crystal lattice of illite (Akul'shina 1967). High Rb content in the Rakvere Stage may be caused either by higher content of illite in comparison with the under-and overlying stratigraphic units, or increased K-Rb replacement in the weathering profile during illite formation characteristic of the particular Rakvere time, or both.

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# The Silurian Geniai Tuff in southern East Baltic

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K-bentonites (altered volcanic ashes) in Baltoscandian sedimentary sections evidencing of volcanism at nearby plate margins were found from the Upper Ordovician through lower Silurian to the lower part of the upper Silurian. In the East Baltic area ash beds from more than 100 volcanic eruptions have been identified in Llandovery and Wenlock.

During the field works in Latvia and Lithuania 32 volcanic ash samples were taken from the Aeronian and lower Telychian. Thickness of ash beds varies from 1 mm to 3 cm. Stratigraphic position of the ash beds was established using paleontological determination of graptolite index species. All samples were analyzed by X-ray diffractometry (XRD) for identifying major minerals and determination of magmatic sanidine phenocryst composition. The samples of sufficient size (at least 8 g) were subjected to the standard X-ray fluorescence (XRF) analysis for major and trace elements. Ten samples were analyzed for trace elements by the inductively coupled plasma mass spectrometry (ICP-MS).

According to these data several new bentonites were found below the well-correlated Osmundsberg K-bentonite. We propose stratigraphic name Geniai Tuff for this eruption layer with anomalous concentrations of REE. Geniai Tuff was discovered in Geniai-1 depth 1752.1 m, Ventspils-D3 depth 848.5 m and Vidale-263 depth 754.4 m near the Aeronian/Telychian boundary. According to the XRD analysis one of the major minerals in Geniai Tuff is goyazite-florencite (Sr, Ce, La, Al phosphate). This mineral has not been previously found in the East-Baltic ash beds. Goyazite-florencite associate with authigenic K-feldspar and kaolinite. Based on the above unusual composition, these finds are interpreted as originating from the same volcanic event – the Geniai eruption. Study of the Geniai Tuff by the EDS microanalysis showed that concentrations of anomalous elements within the bed form two cycles reaching extremely high values in millimetre-scale horizontal lenses: up to 12% P and Sr, up to 6% of Ce and 3% of La. These concentrations indicate that thin lenses within Geniai Tuff consist almost entirely of mineral goyazite-florencite. According to XRF and ICP-MS analyses aluminous phosphate in Geniai Tuff of goyazite SrAl<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>(OH)5×(H<sub>2</sub>O) vary 57-61%, florencite (REE)Al<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>(OH)<sub>6</sub> - 35-39% and crandallite CaAl<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>(OH)5×(H<sub>2</sub>O) - 0-14%.

At the time ca 437.8 Ma ago Geniai Tuff of anomalous geochemical composition with high contents of REE, strontium and phosphorus was emplaced into the southern East Baltic sediments. High contents of these elements possibly indicate carbonatite eruption. Strontium isotope ratio indicates enriched mantle source. This eruption probably followed the collision of Avalonia and other smaller continental blocks with Baltica, forming Central European Caledonides. Dissolution of supposed major Na-carbonate material in sedimentary environment causes extreme residual enrichment of the ash bed with immobile elements. Volcanic ash bed of so anomalous composition can be easily identified and forms a perfect marker horizon for stratigraphy.

# Climate change and biodiversity patterns in the Mid-Palaeozoic (Early Devonian to Late Carboniferous) – the new IGCP 596

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The Mid-Paleozoic conforms to a time interval of dynamic long-term climate change, which was accompanied by substantial variations in biodiversity. Within the framework of this project we intend to increase and refine the documentation of biodiversity mainly in tropical realms during Early Devonian - Early Carboniferous times and identify links to climate change. Groups distinctive for different ecosystems, especially indicating terrestrial, neritic and pelagic marine environments, are land plants, phytoplankton, foraminifers, sponges, corals, arthropods, cephalopods, echinoderms, brachiopods, bryozoans, conodonts and fishes. In addition to general diversity patterns of different fossil groups, we will study three distinctive intervals in detail, which should document biodiversity and the intensity of evolutionary-pressure during (1) greenhouse (Givetian), (2) beginning climate change (Early-Middle Frasnian; e.g. punctata-Zone) and (3) icehouse conditions (Late Famennian–Tournaisian).

Results of this project should show whether climate change (e.g. interaction of  $CO_2$  and temperature) from greenhouse conditions during the Early-Middle Devonian to icehouse conditions during the Late Devonian - Early Carboniferous represents a major trigger for variations in biodiversity or if a combination of multiple factors is responsible for such changes.

Related to this study, a network of taxonomic workers will be established, which will help to update the systematics of Mid-Paleozoic terrestrial and marine organisms. These datasets will be made available to the public by using existing e-infrastructures such as the Paleobiology Database.

The benefit of this project regards scientific as well as social purposes. On the one hand results of the project might help to understand our present day situation and climate change in future by documentation of Mid-Paleozoic climate change and its effect on biodiversity. On the other hand, our novel combination of global earth system sciences and analytical paleobiology will help to integrate and educate young researchers responsible for the preservation of knowledge in future.

# Lateral facies transitions on the Silurian carbonate platform margin in Konovka-Sokol area, Podolia, Ukraine

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The Konovka and Sokol Formations represent lowermost Ludlovian deposits of a Silurian carbonate platform, forming a part of the Podolian plate in south-western Ukraine (Abushik *et al.* 1985). Both formations consist of a wide spectrum of facies, ranging from peritidal laminated dolomites, through reef limestones, to open shelf, shallow water marls and limestones. The studies on the Silurian succession of Podolia, have so far focused mainly on vertical facies succession (Nikiforova 1972), whereas the lateral facies transitions have hitherto been poorly understood (Predtechenskij *et al.* 1983).

We present a preliminary report of high-resolution fieldwork analysis of lateral facies changes within the Konovka-Sokol Formations in their stratotype region. In the studied area the outcrops along the meandering Dniester River and its tributaries, allow to make a three dimensional picture of the transition between the platform interior facies and those of the offshore area. Spectral gamma profiles allow make a detailed correlation of the profiles from various sedimentary environments. The platform interior consists of peritidal dolomite facies with tidal channels infilled by coarse grained material derived from sand-gravel shoal areas. This material is also present as grains and intercalations in the most distal parts of the peritidal areas (Skompski *et al.* 2008). The shoals are mainly composed of reworked stromatoporoids. The patch reefs are separated from this zone by backreef marly facies with abundant open marine benthic fauna. The reefs are composed of corals and crinoids and occupied a relatively low-energy environment that was probably located below a fair weather wave base. The reef talluses form intercalations in backreef and forereef sediments.

Rapid lateral facies changes that are observed in the studied area put in question the use of traditional "flat" lithostratigraphy in the region, and shows that the stratigraphic scheme needs to be upgraded in the future.

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# New stratigraphic charts of Precambrian and Phanerozoic deposits of Belarus

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New refined and supplemented stratigraphic charts of Precambrian and Phanerozoic deposits of the territory of Belarus, draft versions of which were published in 2005 (Lithosphere, 2005) have been issued at the end of 2010 (Kruchek et al. 2010). The charts were compiled by a team of 43 authors working for various geological institutions of Belarus. As compared to the Stratigraphic Charts of Belarus published in 1981 (Golubtsov, 1983), the new ones are distinguished by a wealth of details and abundant factual evidences used for their substantiation. According to the Stratigraphic Code (Zhamoida, 2006) all the fifteen stratigraphic charts including the crystalline basement (Archean – Lower Proterozoic) and the platform cover (Upper Proterozoic – Holocene) consist of the International (General) Stratigraphic Chart, the biozonal standard, regional stratigraphic subdivisions and their palaeontological description, correlation of local stratigraphic sections by their facies zones, and are correlated with stratigraphic charts of adjacent regions of the Baltic area, Russia, Ukraine, Poland, sometimes, with stratigraphic standards of the East European Platform, or Western Europe. A number of methods (bio-, litho- and climatestratigraphic, mineralogic and geochemical, geophysical, isotopic and radiological ones and others) were applied, advances made by palaeontologists and stratigraphers of foreign countries, in particular, by the Interdepartmental Stratigraphic Committee of Russia were taken into account wherever possible when charts were created. Some refinements which concern dating the boundaries of stratigraphic units (systems, series, stages) were introduced in most charts, except for that of the Precambrian, according to the International Stratigraphic Charts of 2004 (Gradstein et al. 2004). New charts are intended for use in the territory of Belarus in 21 century when performing saturation prospection and exploration of minerals (rock and potassium salt, oil, fuel shale, brown coal, bauxite and dawsonite ores, agrochemical and structural materials, etc.) and in medium- and large-scale geological mapping, when compiling legends to a new series of national geological maps on scales of 1:200 000, 1:50 000 and in other research and industrial geological activities, as well as in lectures given in higher educational establishments. The issued charts are of interest to researchers and practical geologists from foreign geological institutions involved in geological activities in regions adjacent to the territory of Belarus.

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# Regional geological and structural studies of the territory of Lithuania

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The geological and structural mapping, studies of the structural evolution of sedimentary basins provide basic information for the prospecting of natural resources, territorial development and land-use planning, evaluation of contaminated territories, assessment of natural hazards etc. Several projects initiated by Lithuanian Geological Survey were oriented towards the better understanding of the geological and tectonic structure, as well as tectonic evolution of the territory of Lithuania and the adjacent areas. The aforementioned investigations resulted in compilation of digital geological maps of sub-Quaternary of the whole territory of Lithuania and Lithuania and Belarus cross-border zones, as well as the set of 21 structural maps of the referenced strata of Lithuania. In order to characterise the basic features of the tectonic framework, structural maps of reference horizons at a scale 1:200 000 were compiled.

From the geodynamic point of view the area of Lithuania covers the major part of the Baltic Sedimentary Basin that is located in the south-western part of the East European Craton. Subsidence prevailed during the Paleozoic with occasional short-term uplift events, while non-deposition environment prevailed throughout the Latest Paleozoic – Cenozoic time span interrupted by shorter sedimentation events. Thus, the Baltic Sea region experienced the long-termed tectonic and structural evolution. The main structuring phase took place during the latest Silurian – earliest Devonian, relating to the far-field stress transmission from Scandinavian Caledonides due to the hard coupling between Baltica and Laurentia, while soft collision along the amalgamation zone of the Eastern Avalonia to the Baltica did not play any significant role in structuring, though was important for the basin subsidence (Sliaupa *et al.* 2002).

The distribution of the sedimentary cover in Lithuania has close relationships to the tectonic structure of the crystalline basement and is confined to the major basement blocks. Traditionally, the sedimentary cover of the Baltic region is subdivided into the Baikalian, Caledonian, Hercynian and Alpine structural complexes, based on the tectonic events in the region. Baikalian and Caledonian complexes gradually submerge to the NW following the dip of the crystalline basement. The major structural elements of these two complexes are all defined by features within the underlying Precambrian crystalline basement. The thickness of the Baikalian complex varies from 30 to 265 m. The thickness of Caledonian complex varies from 400 m in the eastern part of the Baltic Syneclise to 2500 m to the SW. The structural setting of the Hercynian complex differs considerably from the underlying complexes as well from the structural pattern of the crystalline basement. The top of the Hercynian complex is dipping northwards; thickness reaches up to 800 m. The Alpine complex occurs mainly in the S and SW of the Baltic Depression. The sedimentary cover is crowned by several dozen meters thick glacial Quaternary deposits.

The crystalline basement of Lithuania is strongly dissected by tectonic faulting. Two major types of faults prevail in the region, i.e. the oldest pre-platform and younger platform fault systems. The former are defined only in the crystalline basement and do not dissect the sedimentary cover, whereas the latter penetrate into the sediments overlying the crystalline basement. The faults dissecting the sedimentary cover are oriented N-S, W-E, NW-SE and NE-SW predominantly. Two dominating families of reverse faults, oriented W-E (WSW-ENE) and SW-NE (SSW-NNE) can be distinguished: the former shows transpressional geometries and the latter are mainly compressional faults (Sliaupa *et al.* 2002).

# Stromatoporoid biostromal accumulations in the Upper Silurian of Podolia (Ukraine) as possible palaeotsunamite deposits

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Tsunami is a common phenomenon and one of the most dangerous natural hazards of the modern world. More than 20 tsunami waves inundating the land to the height of more than 3 meters have been recorded worldwide during the last decade. Two very recent tsunamis (25<sup>th</sup> December 2004 on the Indian Ocean and 11<sup>th</sup> March 2011 in Japan) have caused enormous economical loses and a great number of casualties. Taking into account the relative high frequency of tsunamis in historical times, it can be expected that the geological record of similar events from fossil formations should be accordingly rich. Meanwhile, palaeotsunami deposits are surprisingly rare, mainly because of the difficulty of discerning them from sediments formed by other processes, such as e.g. storms. The stromatoporoid biostromal accumulations in the Upper Silurian of Podolia are presented here as a possible effect of tsunami waves.

In the Late Silurian the Podolia region (Ukraine) was a part of a vast carbonate shelf that rimmed the East European Craton. The central position on the shelf was occupied by stromatoporoid-coral shoals, which separated inner shelf facies from outer shelf deposits dominated by limestones and marls with abundant and diversified benthic fauna. The inner shelf facies, which are represented mainly by laminites and dolomicrites with eurypterids and ostracods, show various symptoms of onshore redeposition of offshore and barrier material (Skompski *et al.* 2008). Their most common appearance is the abundance of thick stromatoporoid beds within fine-grained peritidal deposits. Until recently they have been treated as *in situ* accumulations marking the periods of maximum eustatic rises (Predtechenskij *et al.* 1983). However the last studies have proved that in fact the beds consist mainly of redeposited stromatoporoids forming parabiostromes (sensu Kershaw 1994).

The process of the formation of stromatoporoid parabiostromes has been investigated in a number of outcrops of the Malynivtsy Beds (Ludlow) along Smotrich River in the vicinity of Kam'janec Podil'skyj, and of the Skala Beds (Pridoli) south of Skala Podil'ska along Zbruč River. The detailed studies that focused on stromatoporoid morphometric features (Łuczyński *et al.* 2009), such as latilaminae arrangement, burial ratio and overall shape, have revealed that the specimens originally inhabited a setting, in which calm periods were punctuated by high-energy episodes with high deposition rates. Most probably, these high-energy phenomena, which caused destruction of original stromatoporoid habitats, their onshore redeposition and final accumulation of stromatoporoid beds within fine-grained peritidal deposits, were tsunamis. This leads to reinterpretation of the hitherto existing scheme, which attributed facial changes to eustatic sea level fluctuations.

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# Taphonomy of the Late Devonian vertebrates from Latvia

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The taphonomy of Devonian vertebrate assemblages is not well studied but is important for understanding the palaeoecological conditions of the environment where diverse fishes and early tetrapods lived, as well as of the extent to which fossils actually represent original living communities. Here we present the taphonomic analysis of selected fish and tetrapod assemblages from the Upper Devonian deposits of Latvia, characterised by accumulations of well preserved remains, and provide comparison with assemblages from some neighbouring areas within and outside the Main Devonian Field. The Upper Devonian assemblages from Latvia studied in details during last four years include those from the Langsede (Ogre Fm), Skujaine (Tervete Fm) and Pavāri (Ketleri Fm) sites. All assemblages are restricted to sandy deposits yielding vertebrate remains usually dominated by Bothriolepis and Holoptychius, with associated acanthodians, osteolepiforms and lungfishes, in places also with other placoderms, psammosteid heterostracans (only Langsēde), tetrapods (only Pavāri), and actinolepids. Marine invertebrates are usually absent. Typically vertebrate assemblages are characterized by a relatively low diversity, similar age of individuals, low rate of fragmentation, but high degree of bone disarticulation and sorting, which indicate reworking and short transportation prior to the final burial. Vertebrates are represented mostly by disarticulated skeletal elements, but some articulated skeletal elements also have been found; the fragmentation index and the disarticulation index vary from site to site. All vertebrate assemblages from Latvia compared here have been formed in the shallow water of a sea-coastal zone and all are associated with sandy to clayey deposits. Vertebrate remains from carbonate sections (Lyarskaja and Lukševičs 1991) usually are distributed sporadically and do not form accumulations, contrary to the Silurian of Estonia (Märss et al. 2003) and some Devonian vertebrate localities around the Old Red Sandstone continent, e.g. the Andreyevka-2 site in Central Russia (Alekseev et al. 1994) or the Sosnogorsk site at Izhma River in South Timan (Beznosov 2009). Vertebrate burial patterns are rather similar when comparing Frasnian and Famennian assemblages, demonstrating the significance of the sedimentation rate, hydrodynamic regime and oxygen content within the sediments.

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# Stratigraphy and correlation of Lower-Middle Devonian boundary deposits in the Russian Plate by miospores

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Lower-Middle Devonian boundary deposits on the Russian Plate are represented by terrigenous, salt, anhydrite-dolomitic and limestone rocks. Palynozone succession on the Russian Plate has been determined and traced (Avkhimovich *et al.* 1993) but in some cases their correspondence to regional strata requires further investigations.

The studied sections of the southeast of the Russian Plate (Volgograd Volga region) differ from sections of the Central regions in absence of the salt member. The basal section is represented by terrigenous deposits for which *Retusotriletes clandestinus* zone has been established (Nazarenko and Tchibrikova 1984). It is characterized by abundant spore species with indistinct area and numerous plicae. These deposits have limited distribution. The *R. clandestinus* miospore zone corresponds to the Takatin and Viazov horizons or Regional Stages (RS) of the Unified Stratigraphic Devonian Scale (USDS) of the Russian Platform (Resolution... 1990) and the lower part of the Ryazhsk RS of the Central region of the Russian Plate (Rodionova *et al.* 1995).

The Morsov Formation consisting of the three members overlie it. The lower, dolomite-argillitic member includes the miospores of Diaphanospora inassueta zone. It is characterized by D. inassueta, D. inassueta var. craspedon, D. impolita, Punctatisporites tortuosus, Dibolisporites capitellatus, D. crassus and Apiculiretusispora aculeolata and corresponds to the Koivin and Biya RS of the USDS (1990). The middle anhydrite-dolomitic member is characterized by miospores of D. inassueta zone too (Mantsurova 1989). Calyptosporites velatus first appears in the upper part of this zone. Thus the lower and middle members have been correlated with the upper part of the Ryazhsk RS of Central regions of the Russian Plate, Koivin and Biya horizons of Eastern regions of the Russian Plate, Vitebsk RS of Belarus and the Rezekne Formation of Baltic region (Tschibrikova 1962; Arkhangelskaya 1985; Obukhovskaya 1999; V. Obukhovskaya 2003). The miospore association of the D. inassueta zone is compared with that from the Grandispora douglastovnense-Ancyrospora eurypterota zone distinguished in the Emsian-Eifelian boundary deposits of different regions of Western Europe (Richardson and McGregor 1986). The upper argillite-dolomitic member contains miospores of the Periplecotriletes tortus-Calyptosporites velatus zone and corresponds to the Klintsov RS of USDS of the Russian Plate, Adrov, Osveya and Gorodok RS of Belarus; Pärnu and the lower part of the Narva RS of Baltic region (Rodionova et al. 1995; Kedo and Obukhovskaya 1981; Nenastieva 1981 etc.). P. tortus, Elenisporis biformis, Sinuosisporis sinuosus, Retusotriletes fragosus, Calyptosporites velatus, Grandispora naumovae are typical for this zone. Miospore composition can be compared with that of the Calyptosporites velatus-Rhabdosporites langii zone, studied from the lower part of the Eifelian Stage of Western Europe and Canada (Richardson and McGregor 1986; Arkhangelskaya et al. 1990). Ostracods of the Aparchitellina agnes-Cavellina explicata zone have been discovered in the deposits of this member.

The overlying *Rhabdosporites langii-Cirratriradites monogrammos* zone corresponds to the Mosolov and Chernojar RS of USDS of the Russian Plate, Kastjukovichy horizon of Belarus, the upper part of the Narva RS of Baltic region (Arkhangelskaya 1974; Kedo and Obukhovskaya 1981; Nenastieva 1981 etc.). The Mosolov RS is represented by the limestone containing brachiopods and ostracods of the Mosolov age.

In the USDS of the Russian Platform (Resolution... 1990) the boundary between the Lower and Middle Devonian is traced conditionally at the base of the Biya RS. Palynological data and correlation of sections allow assuming, that this boundary should be placed at the top of the Biya RS, i.e. in the base of the Klintsov RS which corresponds to the base of *Periplecotriletes tortus-Calyptosporites velatus* zone.

# Middle Devonian correlation problems in the Main Devonian Field

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The web version of the Devonian stratigraphical scheme of Estonia by the Estonian Commission on Stratigraphy of 2007 has recently been improved and presented in English and Estonian. The scheme with comments is now submitted to the Estonian Journal of Earth Sciences to be published as a paper by Elga Mark-Kurik and Anne Põldvere (Geological Survey of Estonia). Two variations of absolute age dating are shown: accepted by the International Commission of Stratigraphy (2009) and published by Kaufmann (2006). They differ particularly in the age of the Emsian/Eifelian and Eifelian/Givetian boundaries (5.6 and 3.7 Ma).

In our region, however, main problem is to establish international stage boundaries, based on key fossils, particularly on conodonts, miospores and fossil fishes. It is generally known that conodonts occur on rare levels only. They have been found mainly in the upper part of the Narva Formation (Kernavé Mb) in Lithuania and in the Amata Fm in the eastern part of the MDF (Ivanov *et al.* 2005). During the 1<sup>st</sup> half of the 20<sup>th</sup> century fish assemblages were traditionally used in biostratigraphy, e.g. by Gross, Obruchev and other authors. Also gaps were considered significant.

The Eifelian/Givetian boundary became well established when characteristic conodonts and associated with them acanthodians conformed its position between the Narva and Aruküla Fms and their coeval units. The Kernavé Mb appears to be one of the key levels for correlation of the Baltic and Scottish sequences, containing several common fossil fish genera and even species, e.g. *Rhamphodopsis* and *Coccosteus cuspidatus*.

But the case with the Givetian/Frasnian or the Middle/Upper Devonian boundary appeared to be more complicated. According to Gross (1942, 1951) the boundary was between the Amata and Plaviņas Fms (using recent unit names). Obruchev (1951), comparing fish assemblages and particularly gaps in the MDF and Scotland suggested that in the eastern part of the MDF the Gauja Fm and even the upper part of Tartu Fm (now Burtnieki Fm) was not present. He concluded that in the Baltic area the boundary should be between the Upper Tartu and Gauja fms. The result was that this boundary position was accepted all over the East European Platform. For a long time there were no other evidences until miospores were produced from claystone of the upper part of the Gauja Fm in Estonia (Mark-Kurik *et al.* 1999). The Givetian age of the Gauja Fm became probable.

Recent data show that gaps were overestimated. The Burtnieki fish fauna have been found in the Luga–Oredezh River basins. On the one hand, it became evident that the upper part of the Burtnieki Fm, the Abava Mb, considered earlier as the basal part of the Gauja Fm had specific transitional fish assemblage. The unit was already recognized as the "Úbergangsschichten" by Gross (1942). As it contained some fish genera (*Watsonosteus, Microbrachius*), earlier known as Scottish endemics, and also a tristichopterid, the member became a second key level for interregional correlation. On the other hand, a large *Asterolepis* species (*A. essica*), very common *Laccognathus*, and lacking of huge arthrodires *Homostius* and *Heterostius* in the Abava Mb shows the closeness of the unit with the Gauja Fm.

Several authors have supposed that the Givetian/Frasnian boundary could be on some level in the Amata Fm, but to confirm this idea conodont and miospore evidences are badly needed.

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# A thelodont and chondrichthyans from the Middle/Upper Devonian boundary beds of the Middle Urals

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Recently A.Z. Bikbaev and M.P. Snigireva (Ekaterinburg) gave us for study a collection of samples with vertebrate microremains from the Pokrovskoye section, the eastern slope of the Middle Urals, Russia. Vertebrates occur in the interval from the late Givetian *disparilis* conodont Zone to early Frasnian *falsiovalis* Zone. Scales of a turiniid thelodont, teeth and scales of chondrichthyans, plate fragments of placoderms, scales of acanthodians, teeth and scale fragments of a struniiform sarcopterygian, teeth, jaw fragments and scales of actinopterygians have been listed (Bikbaev *et al.* 2002, Ivanov 2008).

Two samples containing turiniid thelodont scales come from the beds corresponding to the *disparilis* Zone, just below the occurrence of *Skeletognathus norissi*. Thelodonts are known to first appear in the Middle–Upper Ordovician on the Severnaya Zemlya Archipelago and reach as high as the Upper Frasnian, Upper Devonian of Western Australia. As a whole, over 50 thelodont genera have been found from different palaeocontinents. The turiniid thelodont from Pokrovskoye comes from the highest stratigraphical level for thelodonts of Laurussia. The Middle Devonian thelodonts identified so far are *Turinia* Powrie, *Amaltheolepis* Ørvig, *Skamolepis* Karatajūtė-Talimaa and *Jesslepis* Turner. The scales of Pokrovskoye thelodont belonging to a new taxon have four morphological types of crowns: (1) smooth, flat and rhomboidal; (2) smooth, slightly convex, with strongly elongate posterior part; (3) tripartite crown with the medial plate and lateral downstepped two ridges on both sides; ridges end with free spines; (4) medial crown plate and lateral ridges ending with a posterior point. The crown surface, especially the side ridges, is finely striated. The anterior spur of the base is horizontal or almost vertical.

Chondrichthyans are found in the whole boundary interval and are represented by teeth of phoebodontids *Phoebodus fastigatus* Ginter et Ivanov and *P. latus* Ginter et Ivanov, scales of *Ohiolepis* and *Cladolepis* types, ctenacanthids and possibly neoselachians. The find of *Phoebodus latus* in the *falsiovalis* Zone is the oldest occurrence of the species known so far. Thus, the boundary of the *Phoebodus sophiae* and *P. latus* phoebodontid zones can be recognized at the base of the Frasnian.

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# Ostracods and stable carbon isotopes across the Ordovician Silurian boundary in the Jūrmala core (Latvia)

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Geological records indicative of the Hirnantian glaciation reflects a gradual cooling which culminated in the double glacial maximum of the early Hirnantian and caused dramatic changes in the composition in all marine invertebrate fossil groups. We intend to describe related changes in ostracod composition in the critical interval and stratigraphic context of the results.

Jurmala section in Latvia represents deeper part of the palaeobasin in the East Baltic area. The uppermost Katian, the upper part of the Pirgu Regional Stage (St) is represented by a succession of micritic limestone (Paroveja Formation, Fm) and marl (Kuili Fm). The Porkuni St, the Baltic equivalent of the Hirnantian Stage, is characterized by argillaceous limestone (Kuldiga Fm) and overlying sandy oolitic limestone (Saldus Fm). These beds are covered by argillaceous limestone (Stačiunai Fm), traditionally correlated with lowermost Llandovery (Juuru St).

Composition of pre-Hirnantian ostracode fauna from upper part of the Pirgu Stage in the Jūrmala core is typical of the Livonian and Scandinavian basins, comprising Airina cornuta, Daleiella rotundata, Spinigerites spiniger, Sigmobolbina camarota, Pullvillites laevis, Hippula edolensis. Most of the species disappear at the lower boundary of the Kuldīga Fm, only a few ranging into the lowermost Kuldīga Fm. The Kuldīga Fm is characterized by the Harpabollia harparum association sensu Meidla, 2007. The nominate species was not recorded but other taxa specific to this association are Aechmina groenwalli, Scanipisthia rectangularis, Pseudoancora confragosa, Circulinella gailitae. A low diversity assemblage in the Saldus Fm contains only C. gailitae. A new assemblage appears in basal part of the Stačiunai Fm, with Longiscula smithii, Rectella procera, Microcheilinella mobile, M. rozhdestvenskaja and Bipunctoprimitia bipunctata being represented. This assemblage is well known from the lowermost Silurian strata in northern and cental Estonia, appearing right above the gap which is mostly thought to comprise the Late Hirnantian and likely also the earliest Llandovery in this area. A stable carbon isotopic curve produced for the same stratigraphic interval displayed the Hirnantian carbon isotope excursion (the HICE event) which is considered to represent the glaciation-triggered perturbations in carbon cycle. The curve shows rapid increase of  $\delta^{13}$ C values from +1 to +5% in the lowermost part of the Kuldīga Fm, a gradual decrease to +2% in the Saldus Fm and further decrease up to 0% in the Stačiunai Fm (about 10 m above the top of the Saldus Fm).

The appearance of ostracod taxa which usually are considered as characteristic of the Silurian takes place in the interval which corresponds to the middle part of the falling limb of the carbon isotopic curve. Considering the smooth lowering of the isotopic curve, the gap at the boundary between the Saldus and Stačiunai formations is supposedly minor only. If this is true, the Jūrmala core could likely be considered one of the most complete sections in the Ordovician-Silurian boundary interval in Estonia and Latvia.

It is generally accepted that the late Hirnantian comprises a post-glacial episode and is characterized by low carbon isotopic values. Data from the Jūrmala core do not agree with this model. If we consider the possibility of diagenetic overprint of the stable carbon isotopic signal being unlikely, the position and palaeontological indication of the lower boundary of the Silurian System in deeper shelf sections of the Baltoscandian Palaeobasin may need reconsideration.

# Carbonate shoal facies of Buregi Formation (Middle Frasnian) from the South Lake II'men area

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Continuous sections of the Buregi Formation have been studied in a cliff between mouths of rivers Savvateika and Psizha as well as along downstream part of the Psizha River. This is the area where the Buregi Beds were originally established in 1930 by R.F. Hecker. According to modern stratigraphic scheme, these sections are the stratotype of the Buregi Formation, which corresponds to the Semiluki (Daugava) Regional Stage (RS). The Buregi Formation coincides with the local conodont zone *Polygnathus efimovae* and ostracod zone *Milanovskia bicristata*.

The lower member of the Buregi Formation consisting of bioclastic and shelly limestones 60 to 120 centimeter thick is recognized as carbonate shoal facies. These facies are traced on the distance more than 150 km from the South Lake II'men area to the basin of the Neman River. The contact of shellstones with the underlying II'men Beds shows abrupt changes in lithologic composition and various erosional features. In some cases the contact surface is uneven, with "pockets" and lenses of bioclastic limestones, ferruginous concretions, hematite nodules, rounded limestone clasts. In other cases this contact is marked by a thin layer of laminated argillaceous limestones. The upper boundary is usually expressed by an abrupt change of lithological composition: the uneven surface of shellstones is overlain by mudstones with characteristic platy jointing.

The considered member consists of grainstones, packstones and wackestones and contains numerous fossils: brachiopods (predominantly), gastropods, bivalves, cephalopods (rarely), crinoids, ostracods, worm tubes, fish remains (rarely), conodonts; oogonia of *Chara* algae are present in the upper part of the member. The rocks are massive or laminated, sometimes coarse grading is present. Bioturbation is common. Bed surfaces are usually uneven. Sedimentation breaks are marked by solid substrate surfaces with trace fossils, by hard ground surfaces, "pavements" of brachiopod valves encrusted by numerous *Spirorbis* tubes, iron oxide crusts. The *Glossifungites* trace fossil association is widespread, which indicates the areas with highest wave activity.

The carbonate shoal facies of the Buregi Formation in the South Lake II'men area are represented by diverse deposits formed under various sedimentary environments. Different lithologies often replace each other along the strike or are absent in some places. Massive packstones and wackestones with burrows are present among them, as well as poorly bedded brachiopod shellstones with chaotically oriented valves, bedded brachiopod-bivalve and gastropod-brachiopod-bivalve grainstones and packstones. Wackestones with large and small fish bone fragments are present as well; sometimes they contain well preserved shells of *Pseudoatrypa uralica*.

Autochtonous burials of brachiopods *Pseudoatrypa uralica* and *Cyrtospirifer tenticulum*, worms (*Spirorbis*), burrowing organisms are present in some places in the carbonate shoal facies in the South Lake II'men area. Subautochtonous burials contain *Anathyris helmerseni*, *Rhytialosa petin*, most ostracods and oogonia of *Chara* algae. Burials of crinoids, cephalopods, fishes, some brachiopods and gastropods are allochtonous.

Thus, the lower member of the Buregi Formation in the South Lake II'men area has been formed under conditions of high water energy above the basis of wave in a vast epeiric sea. Up to two levels of seawater lowstand are recognized during its formation. In some cases, the upper transgressive succession is preserved.

# Trace fossil assemblage of the Izhma Formation (Lower Famennian, South Timan)

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The Izhma Formation crowns the Devonian sequence in the Ukhta Anticline. It corresponds to the Zadonsk RS of the Lower Famennian (*crepida* CZ) and is represented by transgressive shallow-water marine deposits which are underlain by lacustrine or lagoonal sediments of the Sosnogorsk Formation. In its type section, the formation is subdivided into two members; its total thickness reaches 20 m. The lower member is represented by the interbedding of nodular limestones and clays; the upper one is composed mostly of variable limestones. Trace fossils are very abundant and diverse. They occur throughout the whole section of the formation. However, some ichnotaxa are extremely rare.

Trace fossil assemblage of the Izhma Formation includes *Bergaueria*, *Chondrites*, *Diplichnites*, *Diplocraterion*, *Gastrochaenolites*, *Lockeia*, *Palaeophycus*, *Piscichnus*, *Planolites*, *Protovirgularia*, *Ptychoplasma*, *Rhizocorallium*, *Skolithos*, *Thalassinoides*, *Treptichnus*, *Trypanites* and *Undichna*. Also few indetermined ichnotaxa and a probable new ichnogenus have been found. *Chondrites* is the most common trace fossil; it occurs in both members and is represented by two ichnospecies – C. targionii and C. intricatus. Thalassinoides and *Planolites* ichnofabrics are slightly less frequent. Most of other ichnotaxa have so far been found in the upper member only. Quite specific tongue-like large oblique burrows probably belonging to a new ichnogenus are present on the basal surface of a single bed within the lower member.

# Geotechnical properties of different aged tills in the ancient valleys of Saint-Petersburg area

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Quaternary deposits in Saint-Petersburg area cover the uneven surface of pre-Quaternary rocks. The main palaeographical peculiarities of certain stages during the Quaternary within St. Petersburg are as follows:

Stage 1, Middle Pleistocene (390 000-140 000 years ago). This time span is marked by two glaciations (Dniepr and Moscow ones) and two interglacial periods. Glacial deposits form "low" and "middle" till beds which lie only within buried valleys on the most part of the city's territory. Stage 2, Late Pleistocene (140 000-10 000 years ago). Interglacial Mikulino (Eemian) time and Valdaian (Weichselian) period deserve particular attention. The climate of Mikulian time was the warmest and most humid which affected the development of life. The last glacial topsoil on the analyzed territory refers to the Luga stage of the Valdaian glacial period. Within the limits of St. Petesburg the Luga till is spread everywhere and is characterized by uneven topography. The depth of the till bed changes from metres to the first dozens of metres, and locally it crops out to the surface. The upper till bed has the most practical importance in the practice of city building. Stage 3, Late- and post-glacial period. Geological history of the St. Petersburg territory during

Stage 3, Late- and post-glacial period. Geological history of the St. Petersburg territory during this period is linked to the evolution of the Baltic Sea, which is marked by 5 cycles of transgressions with periodic formation of fresh and brackish reservoirs (formation of ice-lakes, the Baltic Ice Lake, the Yoldia Sea, Ancylus Lake, the Litorina Sea, formation of marshes). Thus different genetic types of deposits are distinguished in the section of the Quaternary (glacial, fluvioglacial, limnoglacial and postglacial sea, lake and marsh formations).

The analysis of buried river valleys spreading and infillings has a great geological, hydrogeological, geotechnical and geoecological value for the city's territory. Deep incisions are fixed in the northern part of St. Petersburg (near the square of Muzhestva), on the Vasiliyevsky island (along the Smolenka River) and in the ancient Neva River valley (pra-Neva). Buried paleovalleys represent complicated geological objects with different geotechnical and hydrogeological properties. The thickness of Quaternary deposits changes greatly within incisions (outside paleovalleys it is less than 30 m and in thalveg zones of paleovalleys it increases up to 120 m). The composition, state and properties of rocks are also changeable. Intermoraine pressure water-bearing horizons are formed and natural and natural-technogenic processes destroying the stability of territory become apparent. Complicated geoecological situation is formed here. Thus such incisions require detailed research of geotechnical properties, hydrodynamic and hydrochemical regime, the character of technogenic contamination and transformation of underground waters.

Solving engineering-geological tasks on these territories most attention should be paid to tills. The Vendian and Paleozoic rocks, older glacial deposits, and partly magmatic and metamorphic rocks from Finland and Scandinavia provided the initial material for the formation of tills. As a result of self-compression the muddy till could become more solid and durable. At the same time our large-scale experiments showed that differentiated approach to these sediments is needed depending on the type of geological section, the depth of lying and the contamination level. Indicators of durability, deformational capability and physical condition of these genetically different solid formations are greatly variable. In most cases they can not serve as the bearing horizon for rammed in and bored piles at constructing and reconstructing of ground structures.

# Ludlowian (Silurian) graptolites from West Lithuania

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The Milaičiai-103 well is located in the western part of Lithuania. The Ludlowian part of the section is composed of carbonate rocks. The total thickness of Ludlow is more then 166 m (1301 - 1163.5 m interval). The lower boundary is unclear as no core was from the part below 1301 m. Graptolites have been found in clayey marl interbeds.

Progenitor - scanicus (1301 - 1284 m) and *incipiens* (1269 - 1263 m) biozones have been distinguished in the Gorstian. Between *progenitor* - *scanicus* Biozone and *incipiens* Biozone is interval without graptolites (1284 - 1269 m). There have been distinguished *scanicus* - *incipiens* Interzone.

*Praecornusus* (1263 – 1259 m), *cornutus* (1259 – 1255 m), *bohemicus tenuis* (1254 – 1235.3 m) biozones have been distinguished in the lower part of Ludfordian. The interval from 1235.3 to 1182.2 m is without graptolites. Just few *Monograptus balticus* Teller has been found in 1216.42 – 1210 m. So, this interval is tentatively attributed to *balticus* Biozone. There is *valleculosus – formosus* Biozone described in 1182.2 – 1163.3 m interval of the Milaičiai – 103 well. The graptolites are very rare in this biozone.

First graptolite fauna, which is typical for Ludlow, appears at the end of Wenlock. At the beginning of Ludlow absolutely new monograptid groups appear, such as *Bohemograptus*, *Saetograptus*, *Neodiversograptus*, *Lobograptus* and *Monograptus uncinatus*. These groups also co-existed with Wenlockian graptolites such as *Colonograptus*, *Pristiograptus auctus* and older ones, more conservative *Pristiograptus* ex. gr. *dubius* graptolites. Sicula rings emerge on the siculae of all graptolites at the Wenlock/Ludlow boundary. The number of sicular rings varies from 3 to 8 in Gorstian. At the beginning of the Ludfordian *leintwardenensis* Biozone monograptids were significantly decreasing. In this biozone all species of *Labograptus* and *Cucullograptus* disappear, but species of genus *Pristiograptus* were numerously increasing. New specialized species in Lithuania were decreasing, assuming that it is related to deepening of the Baltic basin. On the other hand there is a small outspread of graptolite species at *formosus* Biozone in Ludlow.

# Impact of ash-falls on the diversity of Ordovician ostracods

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The impact of two Ordovician ash-falls of different intensities was studied in order to determine the different recovery patterns of the benthic faunas (ostracods) in the Baltoscandian area (Estonia). The Kinnekulle bentonite has a very large geographical extend (Denmark westernmost Russia); it marks the base of the Keila Regional Stage (former Ristna Substage; Sandbian) and is 40 cm thick in the Põõsaspea section (North West Estonia). Located approximately 5 m above the latter, the Grimstorp bentonite marks the base of the former Laagri Substage (Sandbian) and is nearly 10 cm thick in the Ristna section (North West Estonia).

High resolution sampling (bed by bed) was performed and the distribution of ostracods was recorded and analyzed. More than 80 species of ostracods both palaeocopes and 'non palaeocopes' were identified. In Põõsaspea section very important faunal changes are observed above the Kinnekulle bentonite. The five pre-crisis dominant species are not found in the section above the bentonite and one species (*T. memorabilis*) gets extinct. In Ristna section the impact of the Grimstorp bentonite is less dramatic. Strong similarities in the abundance and diversity changes are observed after both bentonites.

These results show that significant ash-falls (e.g., Kinnekulle) lead to strong faunal renewal and extinctions, at least locally. If the volcanic episode is less prominent (e.g., Grimstorp), only local temporary extinctions are observed. In both case, recolonization of the environments occurs rapidly after the crisis and follows several distinct steps:

- Post-event ecosystem with 'survival faunas' (~5-10 cm; very low abundance; relatively high diversity).

- Early stages of recovery with 're-colonizing faunas' (~5 cm; high abundance; low diversity). In both studied sections, one species (opportunistic taxa) dominates the ecosystem.

- Return to more stable conditions (~50 cm; average abundances; more diverse assemblages).

- Finally, normal 'climax assemblages' with specialized taxa (high abundance; high diversity).

# Foraminifer assemblage from the Jurassic deposits of Latvia

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Stratigraphical subdivision of the Jurassic deposits of Latvia is based on fossil molluscs, in particular on ammonite zonation. At present there is the common notion that the Jurassic deposits of Latvia correspond to the Callovian whereas there is no sufficient evidences yet of the presence of the Oxfordian deposits notwithstanding the option about Oxfordian in the vicinity of Rucava (Brangulis *et al.* 1998). Foraminifer assemblage from the glaciodislocated inclusion of the Jurassic clayey deposits within the Quaternary deposits has been studied. The outcrop is located in south-western Latvia on the left bank of the Lose River about 200 m from the mouth into the Venta River, where dark grey to black clayey deposits were collected by L. Lukševiča in 2004.

In total 301 specimens of foraminifers from seven chemically processed samples were recognized with great (34%) prevalence of Epistominidae, particularly *Epistomina nemunensis*. The next most abundant taxa (21% of all specimens) are members of Ceratobuliminidae such as *Paulina* sp. and supposedly *Cancrisiella rowdaensis*. A large number of Lenticulinidae (25%) is represented by *Lenticulina tympana*, *L. brueckmanni*, *Planularia cordiformis*, *P. cf. feifeli*, *Astacolus vacillantes*, A. cf. *dalinkevichiusi* and *Astacolus* sp. Although in less amount (<10%), but rather great diversity of Nodosariidae is represented: *Dentalina* sp., *Marginulina* sp., *Amphycoryna* sp., *Palmula* sp., *Hormosina* sp., *Oolina lineata* are found. There are also <10% of taxon somewhat similar to *Epistomina turgidula*.

Range zone of the taxon with the most frequent occurrence *Epistomina nemunensis* is referable to all the Oxfordian (Grigelis 1985; Kuznetsova *et al.* 1996). Supposedly also the second most abundant group (Ceratobuliminidae) conforms with the Oxfordian (Kuznetsova *et al.* 1996); in addition to that both Ceratobuliminidae, and Epistominidae in particular reached the maximum within the Lower Oxfordian (Grigelis 1996). *Lenticulina tympana* and *L. brueckmanni* indicate the Lower Oxfordian (Grigelis 1985; Kuznetsova *et al.* 1996). Other recognized species of Lenticulinidae largely but not always conforms with the Oxfordian: *Planularia cordiformis* is distributed throughout the whole Jurassic, *P. cf. feifeli* – in the Oxfordian and Kimmeridgian, *Astacolus vacillantes* – in the Callovian to Oxfordian, and *A. cf. dalinkevichiusi* – in the Middle Callovian (ibid.).

Supposedly the studied foraminifer assemblage corresponds to the Oxfordian stage. This conclusion is well supported by the abundance of *Epistomina nemunensis* which is characteristic for the Oxfordian. In general epibathial (Basov and Kuznetsova 2000) foraminifer assemblage is represented in the studied glaciodislocated Jurassic clayey deposits, while no foraminifer fossils have been found in the clayey deposits at Strēļi site near the studied outcrop. That could be evidence indicating continental freshwater sedimentation at Strēļi in the Callovian.

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# Calcareous sandstone-gravellite erratic boulders in NW Estonia – evidence for new near-shore palaeoenvironment of Kunda age (lower Darriwilian) or an impact event?

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Numerous microfossils from S-Sweden and abundant extraterrestrial chromite grains from several locations in Sweden and China have been discovered within a narrow mid-Ordovician stratigraphic interval. It is suggested that meteorite shower and influx of extraterrestrial material up to two orders of magnitude higher than at present took place in the lowermost part of Kunda Stage (lower Darriwilian) at 466-467 My (Schmitz *et al.* 2003). The meteorite shower is associated with the largest documented L-chondritic asteroid disruption event at ~470 My. In this study we analyzed sedimentary environments in NW Estonia that were deposited under high hydrodynamic conditions close to this time interval.

Middle Ordovician sedimentary succession in N-Estonia starts with the Pakri Fm in a shallow part of the carbonate ramp. Pakri Fm is an elongated bed of sandy limestone and limy sandstone stretching from NW Estonia to the island of Gotska Sändön, Sweden. This up to 4 m thick formation is composed of well-rounded quartz and bioclastic material deposited in wave action zone. Such quartz arenite is not characteristic to mid-Ordovician succession in Baltoscandia, where carbonates of this age are extremely poor in sand-sized siliciclastic material. Additionally, Pakri Fm and its underlying strata are heavily brecciated and penetrated by sandstone intrusions in Osmussaar Island, NW Estonia (Osmussaar Breccia) in an area larger than 5000 km<sup>2</sup>. Brecciation is believed to be initiated by unknown impact event or impact triggered earthquake (Alwmark *et al.* 2010).

Recently, numerous limy sandstone erratic boulders (Tahkuna erratics) were discovered in a narrow distribution area in N-Hiiumaa Island, W-Estonia, approximately 100 km from Osmussaar. Based on the fossil composition, these boulders represent another mid-Ordovician high-energy siliciclastic sedimentary facies. Comparative thin section examination of Pakri Fm, Osmussaare Breccia, and Tahkuna erratics concluded that all rock types are almost identical by mineral composition. Main constituent is wellrounded quartz (56-90%). Dictyonema argillite, pyrite, feldspar, glaucony (expt. Tahkuna erratics), and phosphorous ooids were common secondary components. Additional search for planar deformation features (PDFs) or planar fractures (PFs) in quartz, as clear indications of impact metamorphism, was carried out. No shock-lamellae were found (no. studied samples - 29). However, quartz grains often exhibited well defined deformation lamellae. Extensive calcite twinning, micro-fractures and replacement of quartz grains by mosaic calcite were observed in Osmussaar Breccia. Such deformations are characteristic of diagenetically altered sedimentary rocks but can also be found as low-grade metamorphic features in impact or earthquake related formations. Based on the results of present study we conclude that the newly studied Tahkuna erratics along with eastward located fine-grained Pakri Fm and Jentzchiconglomerates, found exclusively as erratics in N-Europe and SE-Sweden, form a distinctive uniform mid-Ordovician near-shore palaeoenvironment of Kunda age. We agree with earlier researchers (Alwmark et al. 2010) that this formation probably witnessed an impact event or impact triggered earthquake near Osmussaar Island during the mid-Ordovician meteorite shower interval.

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# Peculiarities of Frasnian miospore assemblages of Baltic Region

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Frasnian miospores of Baltic Region were studied during the last decades of the 20<sup>th</sup> century by a large group of Latvian and Russian palynologists (Ozoliņa V.R., Starikova S.N., Kedo G.I., Obukhovskaya T.G, Raskatova L.G., etc.). It allowed to divide the Upper Devonian deposits of Latvia and to correlate them with the same-aged deposits of nearby regions. The purpose of the present work is to study Frasnian miospores on earlier partly published materials of Latvia and Russia, detailed elaboration of existing biostratigraphic scheme of the Frasnian Stage, audit of some outdate definitions of miospores and also transfer of taxa from old system to the new one. The material described herein was extracted from Frasnian deposits on the territory of Latvia in boreholes Bauska – 5, 13; Daugavpils 1-T; Ilūkste – 6; and also in Russian region (Pskov, Velikie Luki) – 9, 38. The Frasnian stratigraphic scale of the western region of Russian Platform, worked out by the big collective of geologists including I. Dalinkjavičius (1939, 1948), P. Liepiņš (1950, 1951), N. Delle (1935, 1937, 1942), V. Sorokin (1978, 1981, 1984), is used in this study.

The oldest assemblage of Frasnian miospores was distinguished from the Plavinas RS by the authors of this paper. It is characterized by poor composition of miospores close to miospore assemblage from Rudkinsky deposits of the Central Devonian Field (CDF). The authors have established the miospore assemblage for younger sediments of the Dubniki RS noted the dominance of the genera Cyclogranisporites, Geminospora, Reticulatisporites, and Conversucosisporites, which is typical to the Geminospora semilucensa - Perotriletes donensis Zone. Miospore assemblage of the Daugava RS is characterized by the dominance of the genera Retusotriletes, Geminospora, Stenozonotriletes, Verrucosisporites, and Cymbosporites. In this assemblage the first appearance of Archaeoperisaccus has been noted. The Daugava assemblage in the Main Devonian Field (MDF) is close to the Semiluki miospore assemblage of CDF and corresponds to the lower part of the Archaeoperisaccus ovalis - Verrucosisporites grumosus Zone. There were no miospores within the sediments of the Katleši RS. The Pamūšis RS is characterized with miospore assemblage in great detail. The predominance of three miospore genera was set out: Geminospora - 4 species (24%), Archaeoperisaccus - 5 species (14%) and Calamospora - 3 species (17%). Pamūšis miospore assemblage is compared with the XV miospore assemblage of the lower Voronezh subhorizon of CDF in species diversity and percentage and corresponds to the middle of the Archaeoperisaccus ovalis - Verrucosisporites grumosus Zone. The following genera were distinguished in the Stipinai RS: Kedoesporis, Geminospora, Lophozonotriletes and Verrucosisporites, which makes it possible to compare this assemblage to the upper part of the Archaeoperisaccus ovalis - Verrucosisporites grumosus Zone and with the XVI miospore assemblage of the upper Voronezh subhorizon of CDF.

The study of Frasnian miospore assemblages in Baltic Region allowed allocate miospore zonation for some parts of the section according to Avkhimovitch *et al.* (1993). The research was supported by Russian Foundation for Basic Researches; project N11-04-01604a.

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# Deglaciation chronology in Latvia and Estonia

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The study of the deglaciation chronology in Latvia and Estonia has a long history. Up to the sixties of the last century the investigators had no physical dating methods and the time scale based on varvometric method, introduced by the Swedish geologist G. de Geer (1912) who divided the deglaciation history of Scandinavia into Daniglacial, Gotiglacial and Finiglacial, each of which had different palaeoglaciological conditions. During last decades different dating methods, including <sup>14</sup>C, ESR and luminescence methods, and <sup>10</sup>Be techniques have been used, but they could not help essentially improve the existing stratigraphical charts and many problems of topical interest in the history of deglaciation have not been solved yet.

Up to eighties big hopes were paid to the radiocarbon method but the use of it is limited due to the absence of good interstadial sections for dating, redeposition of organic matter and contamination with young and ancient carbon. On the base of Raunis section in Central Latvia the beginning of the late-glacial interval was established for the territories of both republics. Raunis Interstadial sediments below Haanja till were dated by different laboratories as  $13,390 \pm 500$  (Mo-196),  $13,250 \pm 160$  (TA-177),  $13,320 \pm 250$ (Ri-39) conventional <sup>14</sup>C ages. The Raunis section together with the Kurenurme section in Estonia (piece of wood dated  $12,650 \pm 520$  (TA-57) and organic detritus  $12,420 \pm 100$  (Tln-35)) allowed to establish also the age of the Haanja and Otepää ice marginal zones. However, new data from the test boreholes attest that Raunis bed is not covered by till and cannot be used for determination of the maximum absolute age of the Haanja (Luga) stage of the Late Weichselian (Valdaian) glaciation in the East European Plain. Obviously also that mentioned above radiocarbon dates give overestimated age of the Haanja phase that does not fit in the timing of the deglaciation history of the Last Fenno-Scandinavian ice sheet. It is possible that glacier recession from the Haanja phase ice marginal zone occurred rather during Bølling interstadial and could be correlated to MWP 1A event. Certainly this problem needs further investigations. Unfortunately majority of the <sup>14</sup>C dates obtained from subtill and intertill sequences with organic remains in Estonia and Latvia are younger than one would expect on the basis of the conventional radiocarbon method. Therefore, the reliability of the geological age of main ice-marginal zones based on radiocarbon dates is rather questionable.

In 1999 a collaborative research "Developing an improved chronology of the southern margin of the Scandinavian ice sheet" was undertaken to date deposits and landforms of the Scandinavian ice sheet in Belarus, Poland, Lithuania, Latvia, Estonia and Finland with <sup>10</sup>Be method. Joint work was organised by P.U. Clark and V.R. Rinterknecht, U.S.A. In reality application of the <sup>10</sup>Be method to establishing boulder exposure ages on the top of end moraine belts yielded highly variable results, because it is not known how long the investigated boulders have been in the forest, under snow cover or below the waters of the Baltic Sea. Nevertheless, nine samples from the North-Lithuanian (Haanja) zone have a weighted mean age of  $13.0 \pm 0.8$  <sup>10</sup>Be ka yrs, close to radiocarbon and varvochronological measurements (Rinterknecht *et al.* 2006).

During last years in joint projects with Polish and Lithuanian colleagues there are dated a lot of waterlaid sediments with OSL method. The obtained results demonstrated a big variety of dates, and many of them are fully non-realistic. It is understandable, because sedimentation environment (subglacial, englacial, supraglacial, proglacial), turbidity and depth of water, velocity of outwash streams and transport duration, incorporation of older unbleached particles are different. It means, that stratigraphic conclusions based on different isotopic methods, are not quite reliable yet.

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# Silurian time scale and regional records

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Some developments in the conceptual base and the practical use of stratigraphy have taken place over the last decades. We refer, here, to the construction of the geological time scales in its intimate sense and to the tools (numerical methods) used to achieve this goal. The Silurian time scale itself is the most resulting example to discuss the matter and the Silurian succession of the Baltic area the place to discuss its regional aspects.

The Silurian geological standard is completely defined by boundary stratotypes (GSSP). That enforced its continuity in time, i.e. no gaps, no overlaps between successive units. But, such inauguration of these points converts the standard into a real (and only!) time scale, despite the ordinal nature of so depicted units. A foregone consequence of this statement is the need to date numerically (in My) the GSSPs. In theory, that means linking the ordinal geologic time scale to the regular physical time, thus specifying the duration of introduced intervals in My too. The last attempt to calibrate the Silurian time this way used the graptolite composite, i.e. sequence of the first- and last-appearances of species, using computer program CONOP9. Such composite, is a high-resolution tool to date any records in sections used to construct it. Thus, the conventional global graptolite zones (although in someway revised form) were scaled in My. Further, global conodont zones are additionally positioned also in relation to the graptolite zones. Now, all graptolite bearing sections used in the construction of this composite, as well the GSSPs fixed in some of them, can be located in relation to this time scale, i.e. to be dated accordingly. But the Silurian time as defined above must be described on an independent time axis, more exactly, as the fourth dimension in spatial (three-dimensional) stratigraphic constructions, allowing give an age to records and rocks anywhere.

Documentation of any regional records lies in connecting them with their rock-units, which are piled up in their own three-dimensional space. To attribute the same age to spatially distant parts of each rock-unit as well as to find relevant temporal relationships between all of them can be done using some time-indicative tools, such as conventional biozones or the more functional palaeontological composites. The regional stages unifying, in one or another way, presumed contemporaneous formations or members, are successfully associated in the Silurian of Baltic region. In spite of their inexplicit format these stages must be also considered as a time intervals, which position (age) needs fixing on the Silurian time scale. Doing that, we can estimate the distribution of fossils in scaled (roughly but still) time (biodiversity dynamics), specify various aspects of sedimentation rate (including gaps and erosion), or the behavior of physical or chemical components in sections (to show climate and sea level standings), i.e. to describe any changes in sections in time, to give scaled geologic history.

The stratigraphic distribution of some Silurian brachiopods from Estonia, sequence stratigraphic classification of the Silurian succession in North Baltic, chitinozoan regional composite and its application in this region are given as examples how to perform temporal framework and use it in a proper way.

# Insights – fossilised eyes of the Palaeozoic

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The eyes of ancient arthropods can sometimes be remarkably well preserved, as a result of range of different conditions of fossilisation. Eyes can be observed not only in trilobites, but also in many other invertebrates, from the lower Cambrian onwards, such as in the Chengjiang Lagerstätte of China, which yields the oldest compound eyes known. Similarly, from the somewhat younger Furongian Alum Shale of Sweden, the Devonian of the German Eifel, the Jurassic Solnhofen Lagerstätte up to the fascinating Eocene amber fossils of the Baltic, the external morphology of the visual systems may be readily reconstructed. This allows not only the acuity of vision in these compound eyes to be estimated, but also the so-called eye parameter to be established. This is a measure of the compromise between the need for a minimum amount of light gathering in order to function and the requirement to achieve the highest acuity of a compound eye possible, under given light conditions. Thus it is possible to assign the owners of these eyes to specific habitats, defined by light intensities, even million of years after they lived, which can bring new insights into their palaeoecological contexts.

# New insights into trilobite eyes

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The external morphological structures of ancient eyes, arising from various conditions of fossilisation can be investigated, which gives many new insights into the biology of their owners. Internal structures, however, such as the sensory cells, are not yet known, because soft parts fossilisation, especially at the cellular level, is most uncommon. Using x-ray tomography, however, it can be shown that traces of the sensory cells in the eyes of middle Devonian phacopine trilobites are sometimes preserved. These indicate that these compound eyes are constructed in the same way as those of diurnal arthropods living today, such as bees, dragonflies and many crustaceans (apposition eye). Those shown here document the oldest sensory cells known.

# Needs for revision of Quaternary stratigraphy of Latvia

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There was a time to celebrate the century of Quaternary stratigraphical studies in Latvia and during this time more than 40 different Quaternary stratigraphical classifications and terminology (schemes) were proposed. It is very important heritage and heavy duty to keep the balance between different analytical data and their interpretation consequences. As the authors of the most substantial studies should be mentioned P. Galenieks, V. Zāns, A. Dreimanis, E. Grīnbergs, V. Stelle, J. Straume and I. Daņilāns, as well as the number of others. The sixties and seventies of previous century were the most productive years, when for needs of systematic geological mapping hundreds of test wells and outcrops were studied in details for Quaternary geological and stratigraphical constructions. During the next decades the number of studies declined and substantial discoveries did not follow. It is important to take into account that from the year 1956 the local stratigraphical scheme of Latvia was always based on interregional correlations with particular sections in the area of the Baltic States and NW Russia. Quaternary subdivision and data from the major sections in the area of the Nordic countries should be considered as well.

Due to limited number of studies, the data available in the eighties did not satisfy the conditions of stratotype, parastarotype and trustful or stronghold sections to support national stratigraphic classifications of Quaternary stratigraphy. As the result, most of stratigraphical units were developed in correlation with successful studies in neighbouring countries. At this time any single Quaternary stratigraphic unit in Latvia did not correspond to the conditions of the former Stratigraphical Code and Guidelines of International stratigraphic classification and terminology. At the same time during the next decade only particular studies and details were discussed in the scientific publications, demonstrating limited local development potential.

In Latvia the stratigraphic classification of the Quaternary accepted in 1986 is still valid. Applications of these stratigraphical constructions were discussed during following 25 years, but only new local geographical names and abbreviations were introduced. Later the number of scientific stratigraphical studies was substantially reduced and this characterizes this period in Eastern European study area in general. During the next years reprocessing of old data from the well known sections dominated. This makes any modern regional comparisons and correlations, and sometimes even setting the research priorities for detailed studies complicated.

Currently the data and evidences available from existing studies and laboratory tests is not sufficient to support, maintain and develop the existing stratification system of Quaternary deposits in Latvia. It is proposed to introduce widely scientifically accepted Quaternary stratigraphy classification and terminology of Norden countries proposed by J. Mangerud, S.T. Andersen, B.E. Berglund and J.J. Donner in 1974 at least until new and scientifically justified studies will allow to expand and develop this proposal.

Therefore, in Latvia it is proposed to relate the Latgale glacial environments and sediments and underlaying Quaternary deposits with the Menapian Glacial. The beginning of the Middle Pleistocene is remarkable with rich in contrasts environmental conditions: they are represented by Cromerian (Žīdiņi) deposits and following Elsterian (Lētīža) glacigenic deposits. The Late Pleistocene begins with the Holsteinian (Pulvernieki) Interglacial and is followed by the Saalian (Kurzeme) Glacial. In the Late Pleistocene the second cycle begins starting with the Eemian (Felicianova) Interglacial and concluding with the last or Vistula (Latvija) Glacial. The boundary between the Late Pleistocene and Holocene is still conventional and is assumed as chronostratigraphical at the level of 10K <sup>14</sup>C years BP.

# Levels of events in the Eocene-Oligocene of Voronezh Anteclise according to palynological study

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During geological history of Voronezh anteclise (VA) in Eocene-Oligocene time the composition of flora was subjected to changes under the influence of varying environmental conditions such as climate, land paleogeography, large water areas etc. These factors influenced vegetation. Permanent rejuvenation of flora took place due to alternate loss and gaining of different taxa. The evolution of flora is expressed in synchronously morphologically alternating spore and pollen complexes. The entire region was characterized by quite similar climate. The greatest fluctuations were observed at the beginning and in the middle of Eocene and on the boundary of Eocene-Oligocene that caused expansion of moderate flora into lower latitudes. The main tendency of climate and flora changes is oriented to gradual progressive cooling.

Palynoflora of Eocene time is characterized by great variety and riches of taxonomic composition. The Early-Paleogenic VA flora underwent the first considerable transformation in the Early and Middle Eocene when planetary warming caused its enrichment in the plants from the Tethys area and the increase in taxonomic variety. In the middle of Eocene the boundary of Boreal area moved to the north. The described palynoflora confirms the occurrence of subtropical climate during the Eocene time that used to change its "face" under the influence of changing geologic events. Alteration of flora confirms the existence of summer humid subtropical climate that changed into winter humid one (that is similar to Mediterranean) in Kiev time (a climatic optimum). It also confirms the presence of deciduous, subtropical, tropical and evergreen forests. By the end of Eocene large leaf early paleogenic flora had ceased its existence because many "formal" genera eliminated from its composition. VA Eocene flora is mixed and it is difficult to find its analogues in the present Earth's flora.

The change in flora composition took place in the Late Eocene, where the portion of heatmoderate elements increased. Subtropical flora of the Late Eocene began to obtain mesophilic features. The boundary between Eocene and Oligocene is characterized by essential global climatic changes (fall of temperature) and by changes in composition of flora (transitional floras). The Eocene-Oligocene boundary was marked by biotic crisis that caused the change of boreal flora. Subtropical type changed into a new type of boreal flora. This type of floras with a definite set of genera of arboreal gymnosperm and leaf-falling angiosperm plants was called "Turgayan flora" by A.N. Kryshtofovich. It includes a complex of plant genera adapted to living in moderate - warm humid climate. They proved to be more plastic and viable. The beginning is characterized by the greater role of pines, Taxodiaceae, many genera of leaf-fall Dicotyledonous trees and bushes of Oligocene especially broadly-deciduous as well as by reduced number of subtropical and tropical plants species. The Early-Paleogenic large-leaf flora disappears mostly at the end of Eccene due to the beginning of global cooling. By the end of the Early-Oligocene ancient archaic forms of angiosperm and gymnosperm plants typical for previous epoch disappear. By the end of Oligocene the "phenomenon" of leaf-fall reaches its maximum and the flora of a typical "Turgayan" ecological type develops on the territory under investigation, in which leaf-fall, heatmoderate species dominated, develop. The flora of this type has reached its maximum during Oligocene and the first part of Miocene.

# Biogeographic significance of Pridolian (Late Silurian) microproblematics

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An appearance of numerous intercalations of stromatoporoid beds within peritidal laminated and dolomitized succession is characteristic feature of the Pridolian (Late Silurian) complex, exposed along the Zbruch River (Podolia, Ukraine). There are several arguments pointing that accumulations of stromatoporoids were generated during high-dynamic depositional events, characterized by on-shore transport (Skompski *et al.* 2008).

An enigmatic microproblematicum *Tuxekanella* Riding and Soja (1993) has been identified as particular component of bioclastic matrix in the stromatoporoid beds. Its most specific feature is the bundled appearance of tubes and their constant diameter, which in 3D-specimens attains 40-120  $\mu$ m. The newly found specimens suggest most probably the algal nature of this enigmatic microfossil.

An investigation of occurrences of *Tuxekanella* indicates that originally these forms did not grow in shoals dominated by stromatoporoids or on the tidal flats. Most probably they were related to lagoons, extending between the stromatoporoid and tidal zones. Both forms, stromatoporoids and microproblematica, were mixed during onshore transport related to high-energy episodes of deposition.

*Tuxekanella* is known only from two extremely distant regions at the moment: Podolia and the Alexander terrane in Alaska. According to Antoshkina and Soja (2006) this terrane in the Late Silurian was located to the northeast of Alaska, and showed paleobiogeographic links with the north Uralian margin of the Baltica continent and with the Salair island arc of southeast Siberia. The biogeographic similarity of faunal assemblages (specifically stromatolites and sphinctozoan sponges) of these three regions was interpreted to be explainable by their location along the Uralian Seaway.

According to another hypothesis proposed by Wright and Wyld (2006) the Alexander Terrane originated in a peri-Gondwanan setting and migrated northward through the Ligerian Ocean along the southwestern margin of Laurentia. It is obvious that the latter hypothesis, although assuming an extremely long migration of the Alexander Terrane, can offer explanations for the presence of *Tuxekanella* in Alexander Terrane and in Podolia. Verification of this model needs additional faunal studies, which would need to find evidence in Podolian sections of microbial associations from the Alexander Terrane.

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# Early Turonian global warming in the Pacific Ocean and some epicontinental basins of the Northern Hemisphere according to planktonic foraminifers

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The Mesozoic rocks of the Pacific Ocean are covered with a dense network of deep water wells. But, at high latitudes in Northern hemisphere, the Upper Cretaceous deposits are unavailable. At high latitudes in Southern hemisphere, such deposits are revealed but not described from micropalaeontological viewpoint. Thus, the studies of thanatocenoses of planktonic foraminifera (PF) in high-latitude epicontinental basins are rather good complement to materials derived during the studies of oceanic profiles.

The climatic zonation is reconstructed for the Late Cenomanian (the bed of *Whiteinella archaeocretacea* Zone) and the Early Turonian (*Helvetoglobotruncana Helvetica* Zone). For PF, four types of thanatocenosis are determined: Boreal, Warm Austral, Intermediate, and Thetyan.

In the Upper Cenomanian sediments, the Warm Austral subtype of thanatocenosis, characterized by relatively depleted generic PF structure and dominating (up to 51%) content of the temperate group, is found in the South Pacific sediments at 35° S (hereinafter, the paleolatitudes are used). The South Intermediate Climatic Zone, characterized by the predominance of subtropical species and almost equal number of specimen belonging to tropical and temperate groups, covers the water area from 33° S to 20° S. The Thetyan Zone covers the area between 20° S and 5° N. Slightly to the North, in the sediments tapped by the well 310A and in the profiles of the Carpathians, Mangyshlak and the Caspian region, the intermediate type of thanatocenosis is found, consisting by 65% of subtropical group shells. For the Poland profiles, the Boreal thanatocenosis is typical.

In the Low Turonian sediments, the systematic PF content changes drastically, on both species and genus levels. The species of *Rotalipora* genus are totally extinct. Genera *Dicarinella* and *Marginotruncana* emerge and rapidly evolve. 20 PF species widely dispersed in the Cenomanian cease to exist, and their place is taken by 18 Turonian species. Across the Pacific Ocean, the pronounced Thetyan type of thanatocenosis is developed. The Intermediate Climatic Zone is found only in the Mangyshlak and the Caspian regions, while the Boreal type of thanatocenosis is found in the Poland profiles only.

*Conclusions*. The deep water well logging and the analysis of epicontinental basins show that the climate in the Late Cretaceous was homogeneous and mild, as compared with today's climate.

1. The Southern Hemisphere was warmer than the Northern Hemisphere.

2. In the Late Cenomanian, there were no sharp changes in the climate. The parameters of water masses remained stable, as well as the PF biocenoses formed in such water masses and the PF thanatocenoses found in the relevant sediments.

3. The Early Turonian saw sharp warming. The boundaries of all climatic zones shifted towards the Poles. The global climate change was crucial milestone for PF biota. In the warm homogeneous water masses, new PF genera emerged and rapidly evolved.

# Dolocretes as indicators of the subaerial exposure episodes in the Baltic Devonian palaeobasin

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Calcretes are near-surface secondary carbonate accumulations, which form both in vadose and phreatic zone, and in ancient sequences are indicators of subaerial exposure (Wright, 1990). They usually occur as hard crusts and form in arid and semi-arid climate environment. Dolocretes are similar to calcretes by origin but differ by composition as are made of dolomite.

From 2002 to this time dolocretes have been found in several stratigraphic intervals of the Devonian sequence in Latvia. Outcrop and thin section studies done by the authors of this presentation and students of the University of Latvia Ilze Metāle, Ints Indāns, Armands Liberts, Uldis Kļaviņš, and Armands Petrikas allowed to identify dolocretes in the Gargždai Beds (lowermost Devonian) in south-eastern Latvia, the Aruküla Fm (Eifelian) in north-western Latvia, the Burtnieki Fm (Givetian) in western Latvia and in spots in north-eastern Latvia, the Amata Fm (Frasnian) in whole area of its distribution in Latvia, the Katleši Fm (Frasnian) in north-eastern Latvia. All formations except the Šķervelis Fm are dominated by siliciclastics, and dolocretes are present there as hard plates, veins and other inclusions.

Dolocrete identification is based on the features such as branched and cellular fabric of dolomite veins and slabs, presence of pure dolomite aggregates without admixture of sand grains, horizontal layer-like distribution of dolomite inclusions, infilling of desiccation cracks with dolomite, and some other mineralogical and structural evidences.

In the Burtnieki, Amata and Katleši fms the dolomite inclusions are related not only to these definite Devonian stratigraphic units, but also to separate intervals within these units. In the Amata Fm content of dolomite inclusions sharply increases upwards, and near its upper boundary crusts, tens of centimetres thick inclusions with abundant dolomite cementation are present. In recent studies in western Latvia carbonate crusts have been found in several intervals of the Amata Fm. Distribution and fabric of carbonate crusts suggest that these are the groundwater dolocretes. Distribution of dolocretes indicates more than one subaerial exposure event during the Amata time. In the Burtnieki Fm the carbonate crusts are found in intervals not related to the boundaries of stratigraphic units. In the Katleši Fm massive, up to 1 m thick dolocrete is associated with the sandy interbed within the clay deposits.

Carbonate deposits of the Nīkrāce Member, upper part of the Šķervelis Fm, are rich in features typical for carbonate crusts which indicate that almost all the dolostone sequence of the Nīkrāce Member, 5 m thick, is dolocrete (Stinkulis 2008).

Dolocretes are important as these carbonate crusts directly show such subaerial exposure episodes which are difficult to identify by other features. Widespread distribution of dolocretes in distinct intervals of the Amata and Šķervelis fms, possibly also other units, could be used as criteria to define the sequence boundaries at these stratigraphic levels when the sequence stratigraphic approach is applied to study the development of the Baltic Devonian palaeobasin.

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# Features of carbonate-terrigenous sedimentation in the Semiluki time in the eastern part of the Main Devonian Field

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Sedimentary environment of carbonate-terrigenous rocks of the II'men and Buregi beds of the Semiluki RS, Frasnian, Upper Devonian of the Main Devonian Field (MDF), has been studied. Beds (thickness 23 m) are exposed in outcrops on the southern coast of the II'men Lake. Hecker's (1933) and Sorokin's (1978) reconstructions of sedimentation on the MDF were mainly based on fossil associations. Present study is based on the structure-genetic method (Shishlov 2010) and includes study of primary characteristics of rocks: colour, structure, texture, bioclasts, extraclasts, intraclasts, cement and bedding features. The study includes visual observation of rocks in outcrops, optical-microscopic research and quantitative determination of insoluble rest. Reconstructions of sedimentary environment are based on water dynamics, distance from the shore and sediment composition.

Terrigenous deposits corresponding to the II'men Beds (thickness 15 m) are represented by bluegray plastic micronized thin-bedded clay with violet spots. Clay include rare thin layers (1-10 cm) of silt and packstone-rudstone with skeletal fragments of ostracods, brachiopods, crinoids, fish detritus, clay intraclasts and terrigenic influx of quartz (1-5%). Clay was deposited in a quiet-water regime and can be identified as low-energy deposits. We consider that packstone-rudstone and silt beds were accumulated in the environment with intense wave activity, such as storms (tempestites). Light-gray quartziferous and micaceous sandstone covers clay beds. Sandstone consists of a very-fine to medium sized quartz grains (more than 90%), mica, zircon, tourmaline, garnet (1-2%). Cement is carbonate spar (1-10%). Cross and wave bedding is recognized in this sediments. Light-gray sandstone is typically overlain with red-brown sandstone with wave bedding. Film-type cement is represented by iron hydroxides and carbonate (calcite or dolomite) (10-20%). Based on high concentration of finer terrigenous material, cross- and wave-bedded stratification, poor fossils these sandstones correspond to the near-shore extremely shallow-water environment with active-water regime.

Buregi carbonate rocks (thickness 8 m) overlie II'men terrigenous sediments and are represented by alternation of calcareous clay and light-gray or pinky-gray bioclastic sandy packstone-floatstone. Waterworn fossils are abundant and include fragments of brachiopods, gastropods, ostracods, crinoids and fish remains (10-50%). Extraclasts (40-50%) are represented by quartz and mica; intraclasts include clay fragments. Dolomitisation (3-5%) and voids with sparry calcite cement are typical. Packstone represents submarine bars marked by traces of wave activity. Calcareous clay is formed in wave shadow of bars. Packstone-floatstone is usually overlain by bryozoan-gastropod-brachiopodous packstone and wackestone with sharp contact. Packstone and wackestone contains quartz influx (<5%), numerous skeletal remains, which size and preservation increase upwards. Primary sedimentary structures have been completely obliterated by bioturbation. Limestones were deposited in a near shore high energy marine environment. Bioclastic limestone is overlain firstly by light-gray flag-like mudstone with iron-manganese dendrites, singular shells of bivalves and burrows, slightly dolomitized and than by "lumpy" mudstone. Extraclasts are minor and contain quartz less than 1%. Mud matrix and limited siliciclastic influx give us a suggestion that lithotypes were deposited in a low energy environment.

Il'men and Buregi sediments were deposed in the normal water basin in a near-shore open shallow-water and relatively deep-water environment. Deposit succession demonstrates regressive-transgressive sequences.

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# Do *Cymopolia*-like dasyclad algae from the Kalana Lagerstätte prove 400 Million year long evolutionary stasis?

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Much of our understanding of the diversity and anatomy of the earliest macroalgae comes from their well-preserved carcasses of calcium carbonate. However, these fossils represent only a small portion of algal flora that was flourishing in the shelf areas of the past seas and oceans. The non-mineralized or weakly calcified algal species, that are rarely preserved and have been found in few lagerstättes only, suggest, that the extent of their stratigraphic ranges and richness of their geologic history has been underestimated.

The Silurian (Aeronian) algal Lagerstätte in Kalana, Estonia, has revealed the rich nonmineralized algal flora, comprising species attributable to Rhodophyta and Chlorophyta. The latter is mainly represented by the order Dasycladales – group of unicellular, but huge, morphologically complex green algae, which are generally supposed to be easily fossilizeable due to their extracellularly laid calcareous coat.

Based on radially symmetrical euspondyl thallus architecture, periodically occurring constrictions along the stalk that give the plant segmented appearance and tufts on branched laterals at the growing tips of the plants, close relationship with extant genus *Cymopolia* is suggested for one of the most abundantly occurring dasyclade species in the Kalana Lagerstätte. Occasional specimens show rounded structures on the segments that could be interpreted as reproductive structures – gametangia. If this interpretation is true, and the gametangia are attached to the primary laterals (= choristosporate morphological type of the cell), the only major difference of this Silurian species from extant *Cymopolia barbata* lies in the missing of calcium carbonate skeleton.

The evidence from the Kalana Lagerstätte suggests that some of the present-day dasyclad algae, e.g *Cymopolia*, may be real living fossils, which have maintained their basic morphology almost unaltered for over 400 million years, with the main innovation being the extracellularly laid calcium carbonate skeleton.

# Ordovician microfauna from the Mishina Gora section, Russia

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Mishina Gora impact structure is situated in NW Russia, east of Lake Peipsi. The 60-70 degrees tilted blocks in an old limestone quarry present a unique opportunity to study Ordovician succession in an area otherwise covered with Devonian sediments. Stratigraphically, the section ranges from the Middle Cambrian Sablinka Formation up to the Middle Ordovician Uhaku (or even Kukruse?) Stage. However, field observations, as well as microfaunal studies have revealed that due to dislocations, part of the strata is "repeated", i.e. they recur in the section several times. Lithologically, as well as faunistically, the section shows transitional characteristics between the shallow-water North Estonian facies and the deeper Central Baltoscandian facies.

The micropalaeontological samples, treated with sodium hyposulphite, yielded rich fauna, with ostracods as the most numerous and taxonomically diverse fossil group. Calcitic ostracod carapaces are well preserved in most part of the section. However, similarly to most of the eastern Baltic area, dolomitization has destroyed most of the carbonate fauna in the Billingen and lower part of the Volkhov stage.

Samples from certain levels also yielded abundant remains of microscopic gastropods, juvenile brachiopods, sponge spicules, bryozoans and echinoid fragments. Less numerous were prasinophyte and graptolite finds. Unique faunal elements are fossilized bivalved pedicellaria of echinoderm (probably starfish) that have been originally described under generic name *Bursulella*.

# Ostracods in Swedish and Lithuanian Ordovician-Silurian boundary sections

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Ordovician climate resembled today's tropics in most parts of the Earth, but a cooling about 450 million years ago turned the Earth a very cold place. The so-called Hirnantia glaciation introduced the second largest extinction in the history of Phanerozoic life. We intended to analyse response of the marine crustacean faunas to this rapid change and trace this event horizon from the well studied eastern Baltic area up to Sweden, with poorly known record of this event. Cold-climate immigrants (so-called Hirnantian fauna) are well documented also in the erratics from Borenshult, Sweden, and we intended to trace them in some bedrock section nearby.

We analyzed material from Ordovician –Silurian boundary sections from the Råssnäsudden section in Sweden (expected to expose Hirnantian: Bergström and Bergström 1995) and from the Paroveja section (as a reference section) in Lithuania.

We found that the Paroveja section contains the specific assemblage of higher-latitude immigrant taxa, the *Harpabollia harparum* association, but the Råssnäsudden and Paroveja sections share only a few eurytopic species. Råssnäsudden and Borenshult were more similar, sharing some species but not the members of the Hirnantia fauna. Presence of the pre-Hirnantian or Silurian taxa but lack of the *Harpabollia harparum* association suggested a big sedimentational gap in Råssnäsudden section. Stable carbon isotopic data confirmed our hypothesis: no indication of disturbances of the global carbon cycle which might refer to the formation of glaciers could be recognized. Both in Borenshult and in Paroveja material species from the typical Hirnantia fauna and the anomalous stable carbon isotopic ratios were present. In spite of lack of the glaciation-related horizon, transition from the Ordovician to the Silurian was well recognizable at Borenshult, although the basal Silurian layers contained ostracods material of the so-called recovery fauna: mostly juvenile forms in relatively low abundance.

# Recurrent forms of brachiopods and mollusks of the II'men and Buregi beds from the II'men glint

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The II'men glint is up to 15 m high cliff stretching in a distance of 8 km along the southern coast of the lake II'men. II'men and Buregi beds of the Rdeija Formation (Semiluki Regional Stage of the Frasnian) crop out here. The II'men Beds are represented by sandy-clayey deposits with rare layers of bioclastic marls. Plastic bluish clay with lenses of bioclastic limestone is observed at the base of the cliff. The thickness of the clay reaches 10 m. The upper part of the II'men Beds is sandy (up to 4 m), where the remains of brachiopods *Lingula amalitzkii*, *Crania proavia* and algae *Trochiliscus* have been found in a weakly cemented fine-grained sandstone. The Buregi Beds overlie the II'men sandstones with sharp contact. At the base of the Buregi Beds numerous remains of marine invertebrates are observable as the red coquina. Flaggy limestone with tracks of worms and lumpy dolomitic limestone are developed above the coquina.

The II'men-Buregi stage of the development of the sea in the NW of the East European platform is characterized by the extinction of marine fauna, first of all, articulate brachiopods. Last representatives of the groups which have appeared during the previous epoch (Svinord, Schelon time) disappear. According to V.S. Sorokin (1978), the studied area belonged to an internal depression of the sea with normal salinity, thus the remains of articulate brachiopods characterize certain ecological range (Sorokin 1978). Comparison of frequency of various taxa of brachiopods from the II'men and Buregi beds of Southern Priilmenja shows that *Cyrtospirifer schelonicus* is the most frequenty found taxon from the II'men Beds. The most typical species for the Buregi Beds are *Cyrtospirifer tenticulum*, *Atrypa uralica* and *Chonetipustula petini*. *Cyrtospirifer schelonicus* is characterized by the easiest adaptability to changes of character of the seabed and hydrodynamical regime (Sorokin 1978). High adaptability is distinctly seen in the changes of such features of the shell morphology as the shape, form of area etc. (Nalivkin 1941). Among representatives of *C. schelonicus* from studied region forms with narrow shell adapted for the hard ground and with high area prevail. Similar shells of *C. tenticulum* from the Buregi Beds testifie similar conditions during the Buregi time.

Bioclastic limestone of the Il'men and Buregi beds contains numerous, but taxonomically narrow assemblage of marine invertebrates including brachiopods, bivalves and gastropods. Comparison of assemblages of brachiopods and mollusks from the II'men and Buregi beds of the glint demonstrates the following regularity. Brachiopod fauna from these beds contains four common species (total number of brachiopod from the II'men Beds is 6 species, from the Buregi Beds 4 species). Gastropods of Il'men and Buregi beds contain two common species (4 and 6 species accordingly). Assemblages of bivalves contain two common species (7 and 8 species accordingly). Bivalve Schizodus devonicus is typical species for the Frasnian of the Main Devonian field. Strongly pronounced recurrent distribution of articulate brachiopod is observed within the II'men and Buregi beds, but it is not shown for gastropods and almost not shown for bivalves. Two reasons could be established for such a distribution. At first, not equivalent level of scrutiny of studies with respect to brachiopods and bivalves from the Frasnian deposits of the Main Devonian field. At second, the big energetic activity of the Frasnian bivalves, leading to speciation explosion. Systematic variety of the Frasnian bivalves of the Main Devonian field testifies in favor of the last hypothesis. It is possible to draw a conclusion that recurrent forms aren't characteristic for the actively developing fauna.

## Litorina transgression in Estonia

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Water level changes of the Baltic Sea during the Holocene were greatly influenced by the existence or absence of the connection between the Baltic Sea basin and ocean. Freshwater (Baltic Ice Lake and Ancylus Lake) and brackish-water stages (Yoldia, Litorina and Limnea Sea) have been recognized in the Baltic Sea history (Björck 1995 a.o.), since the Litorina stage the Baltic Sea has a permanent connection with an ocean. However, the time when the connection established is not well determined. The saline water ingression into the Baltic started likely between 9800 and 8800 cal yr BP, but Litorina transgression occurred later. Around 8500 cal yr BP the eustatic sea level rise exceeded the isostatic uplift in southern part of the Baltic Sea basin and the Litorina Sea transgression started (Berglund et al. 2005). In SE Sweden five transgressive events between 8500 and 5000 cal yr BP occurred (Berglund et al. 2005). In Finland only one uniform transgression has been described (Miettinen 2002). Signs of the two transgressions were found in NW Russia (Miettinen et al. 2007). In Estonia two or three transgression waves have been described (Kessel and Raukas 1979, Lepland et al. 1996). However, latest studies support one Litorina Sea transgression (Saarse et al. 2009a, b). To clarify the character and timing of the Litorina transgression in Estonia several lagoons have been examined. The results indicate that low water level existed around 8700-8200 cal yr BP and massive peat accumulation occurred. The peat accumulation was interrupted about 8200 cal yr BP because of the sea level rise, and the Litorina transgression started. The transgression reached its maximum level in Estonia around 7800–7700 cal yr BP, and a water level rise was ca 4-5 m. The water level remained relatively high up to 7000-6900 cal yr BP and thereafter started to decrease as the eustatic sea level rise slowed down significantly.

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# Late-Glacial deglaciation and vegetation dynamics in the eastern Baltic region

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The presentation focuses on the current state of the reconstruction of environmental conditions in the eastern Baltic area, from Lithuania in the south to Estonia in the north during the late-glacial time c. 15 000 – 11 650 cal. yr BP. Several new AMS <sup>14</sup>C dated sediment sequences elucidating the re-establishment of plant cover, succession of vegetation types and palaeoclimatic conditions by pollen and macrofossil studies have shown sensitive reaction to palaeoenvironmental events of the North Atlantic region during the Last Termination. A new central Latvian site Lielais Svētiņu (Lubāna lowland) revealed organic sediments of the Bølling warming (GS-1e), so far the northernmost evidence of Bølling in the Baltic area. We analysed 5 late-glacial sediment sections along a North-South transect of ice recession dating back to 14 600 cal yr BP (Lakes Udriku, Haljala, Nakri and Lielais Svētiņu + Solova bog). They yielded a high-resolution signal of well dated Bølling/Allerød warming including pollen accumulation rates (PAR) and parallel macrofossil investigations to separate the local and regional vegetation signal in a barren glacial landscape. For the first time in the Baltic late-glacial geology a continuous record covering the full lateglacial period since the Bølling has been analysed showing that the vegetation of the Bølling warming in Latvia is of tundra type with predominantly arctic willows and Ericacea. The floristic succession in Southern Estonia started later, and is as follows: 14000 - 13500 cal yr BP mostly treeless; 13500 - 13300 cal yr BP (birch) forest tundra; 13300 - 12800 cal yr BP birch and pine forest (indicated by macros and PAR exceeding the forest-limit), whereas the same period in Latvia shows threefold higher tree (pine) PAR's and pine macros indicating a denser conifer forest. Spruce arrives at 12 500 cal yr BP indicated by stomata and needles; 12 800 - 11 650 cal yr BP YD scattered trees, mostly treeless and 11 650 cal yr BP Holocene vegetation expansion. At the same time North-Estonian sites reveal treeless tundra conditions throughout the investigated period. The present evidence clearly shows large differences in ice retreat speeds, early ice free conditions in northern Estonia and a transition of vegetation types with late glacial forests in the south to open treeless heath tundra in the north.

# Modern problems of the Quaternary stratigraphy and geochronology of Belarus

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The analysis of the oxygen-isotopic, carbon-isotopic, insolational, thermomagnetic and temperature scales on the geochronological basis from the oceanic and marine deposits, soil-bed series and ice core in the relationship with the outcomes of palynological studies of the lake-paludous deposits of Belarus has allowed to conduct an interregional correlation of the natural events at a qualitative level with the allowance for their climate-stratum rhythmicity (8 glaciations and 8 interglaciations) during the Glaciopleistocene (last 750-800 thousand years) on the terrain of Central Europe (Belarus, Poland and Ukraine).

The attention has been paid to the detailed microstratigraphy of the oldlakes strata, belonging to 11 oxygen isotope levels of the Alexandria interglaciation, and all 5 isotopic-oxygen levels of the Murava interglaciation, availability of the macrosuccesions of palaeophytocenoses, justified by a multioptimality of interglaciations and similarity of uneven-aged phyla on pollen diagrams. The comprehension of the large complexity of the palaeogeographycal situation of the Glaciopleistocene has been approved, and a series of palynological characteristics of the main components of an environment has justified a capability of consideration of the interglacial epoch in the quality of palaeoecosystems.
### Microfacies of the Billingen-Aseri carbonate deposits along the Baltic-Ladoga Klint

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The microfacies were distinguished based on distribution of associations of lithotypes of carbonate rocks in the natural outcrops along the Baltic-Ladoga Klint. The macrofacies were genetically interpreted considering distribution of the main types of microfacies in a different parts of homoclinal carbonate ramp, formulated by E. Flugel (2004).

The tidal deposits of the inner ramp are spread in the northwestern Estonia to the west of Tallinn and include Kunda (sandy fine-grained mudstones) and lowermost Aseri Regional Stages (echinoderm-algae dolomitized wackestones with admixture of quartz grains to the east of Tallinn and echinoderm-algae packstones with phosphate ooids to the west of Tallinn).

The uppermost *O. evae* conodont zone (Billingen RS, quartz-glauconitic sand and sandstone, packstone with various benthic fauna) probably should be referred to the sandy shoals and banks of the inner ramp. The echinoderm-ostracod packstones with goethite-hydrogoethite ooids (*L. variabilis* conodont zone and the base of the *Y. crassus* Zone) in the Klint outcrops to the east of Tallinn were probably formed under the same conditions.

Protected-marine settings of the inner ramp are characterized by the bioclastic packstones with numerous echinoderms and wackestones with ostracods. In the outcrops of St. Petersburg Region these deposits correspond to the *B. triangularis* - lower part of *L. variabilis* conodont zones. In the northern Estonia they compose lower part of the Kunda RS (Mäekalda road section and further to the east) and lower part of the Aseri RS (Sõtke River).

The sediments formed in the open-marine settings of the inner ramp (trilobite-echinoderm packstones) compose several stratigraphic intervals exposed along the Baltic-Ladoga Klint line from the Syas River on the east to the western most regions of the North Estonian Klint. In the eastern part of the territory (Lynna River) they form boundary interval of the *B. navis* and *M. parva* conodont zones and also *L. variabilis* Zone. In northeastern Estonia these sediments corresponds to the lower part of the Kunda RS.

The sediments of the mid-ramp settings are represented by poorly stratified, nonbioturbated mudstones of the Valgejõe Member of the Loobu Formation (Sõtke River) and bioturbated ostracod-echinoderm wackestones with glauconite grains, and trilobite-echinoderm packstones (lower part of the Kunda RS and base of the Aseri RS in the Russian part of Baltic-Ladoga Klint). The outer ramp deposits occupied eastern part of the region of Ladoga Klint and represented by echinoderm-trilobite and echinoderm-brachiopod-ostracod wackestones. They are typical for the Simankovo Formation.

Distribution of the carbonate microfacies along the profile of the Baltic-Ladoga Klint reflects onset of transgression and include microfacies from tidal-dominated environments of the inner ramp at the base of the succession to the relatively deep-water environments of the outer ramp at the top of the seccession. The sediments of the eastern parts of the Baltic-Ladoga Klint are relatively deep-water and correspond to the middle and upper outer ramp settings.

Flugel, E. 2004. *Microfacies of Carbonate Rocks. Analysis, Interpretation and Application.* Springer, Berlin Heidelberg New York. 976 p.

## Stratigraphic and biogeographic significance of Cambrian Stage 2 and 3 trilobites from the Holy Cross Mountains, Poland

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The Holy Cross Mountains (HCM) represent one of the very few areas in Europe where Palaeozoic rocks are exposed in the direct vicinity of the Teisseyre-Tornquist Line. Their basement belongs to the Trans-European Suture Zone (TESZ) - one of the main geotectonic domains in Europe (Berthelsen 1992). Differences in facies development, stratigraphy and tectonic evolution have resulted in the sub-division of the HCM into two regions: the Kielce Region in the south and the Lysogóry Region in the north, understood as units of proximal or exotic provenance (Nawrocki and Poprawa 2006 and references therein). Cambrian Stage 2 and 3 trilobites come from the southern part of the area and occur in siliciclastic rocks: sandstones in the west and siltstones and shales in the east. The trilobite assemblages are dominated by representatives of the Ellipsocephalidae that display a significant evolutionary pattern. The oldest assemblage contains e.g. Strenuella polonica, Strenuella zbelutkae, Berabichia oratrix and Sectigena sandomirensis (Orłowski 1985 and unpublished data), accompanied by the holmiids Holmia marginata, Schmidtiellus panowi and Kjerulfia orcina (Orłowski 1974). This fauna, indicative of the Holmia-Schmidtiellus Assemblage Zone, passes upwards into a protoleniddominated assemblage of the Protolenus-Issafeniella Zone. Here, the ellipsocephaliids are represented by Issafeniella orlowinensis, Issafeniella trifida, Kingaspidoides sanctacrucensis, Protolenus (Protolenus) expectans, Protolenus (Hupeolenus) czarnockii and Hamatolenus (Hamatolenus) glabellosus (Żylińska and Szczepanik 2009), accompanied by the eodiscids Cobboldites comleyensis and Serrodiscus primarius (Orłowski 1985; Żylińska and Szczepanik 2009), and give direct correlation to the 'Ornamentaspis' linnarssoni Zone of Scandinavia and the Hupeolenus and Cephalopyge notabilis zones of Morocco. The assemblage is followed by a kingaspidoid-ornamentaspidoid-dominated fauna with paradoxidiids of the Eccaparadoxides insularis and Ptychagnostus praecurrens zones corresponding to the Cephalopyge notabilis Zone of Morocco (Żylińska and Masiak 2007; Żylińska and Szczepanik 2009). Although the Kielce Region is considered a proximal terrane dextrally relocated along the TESZ margin of Baltica, which is evidenced by deep seismic sounding profiles and palaeomagnetic data, the recognized trilobite assemblages display similar evolution of assemblages as in West Gondwana and Avalonia rather than in the Baltica palaeocontinent.

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Ékelale & Brouley 2001 Gastro chocenolite, oelandicy, (mun ann) Balano glossites (vaula and)

Trypanites .



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ABSTRACTS

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