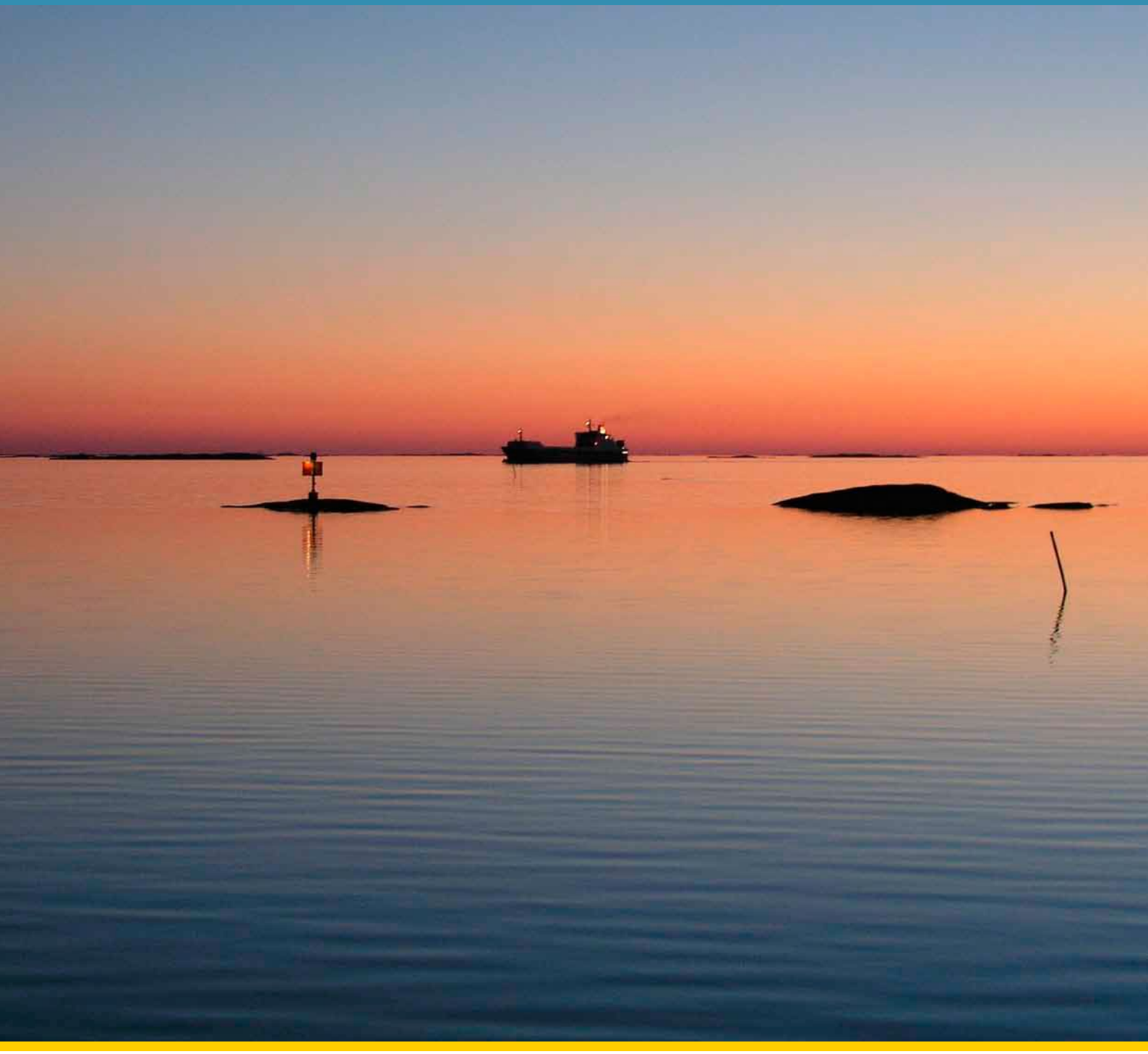
GEOLOGICAL SURVEY OF FINLAND

Guide 57

2012



Abstract Book

**11th Colloquium on Baltic Sea Marine Geology,
Helsinki 19–21 September 2012**

Joonas Virtasalo and Henry Vallius (eds.)

Unless otherwise indicated, the figures have been prepared by the authors of the abstracts.

ISBN 978-952-217-196-2 (PDF)
ISBN 978-952-217-197-9 (paperback)
ISSN 0781-643X

Layout: Elvi Turtiainen Oy
Printing house: Juvenes Print – Tampereen Yliopistopaino Oy

GEOLOGIAN TUTKIMUSKESKUS **GEOLOGICAL SURVEY OF FINLAND**

Opas 57 Guide 57

11th Colloquium on Baltic Sea Marine Geology Helsinki 19th−21st September 2012 Abstract Book

Edited by

Joonas Virtasalo and Henry Vallius

Espoo 2012

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Virtasalo, J. & Vallius, H. (eds.) 2012. 11th Colloquium on Baltic Sea Marine Geology, Abstract Book, Helsinki 19th−21st September 2012. *Geological Survey of Finland, Guide 57*, 106 pages and 24 figures.

PREFACE

The Geological Survey of Finland (GTK) wishes you all welcome to the Baltic 2012, The 11th Colloquium on the Baltic Sea Marine Geology, in Helsinki, Finland, September 2012. The venue for the meeting is m/s Silja Serenade, which will cruise on route Helsinki-Stockholm-Helsinki during the conference.

The first colloquium on the Baltic Sea Marine Geology was held in Parainen, Finland in 1987. The conference was such a success that it has been circulating around the Baltic Sea countries since then. "The Baltic" – Marine Geological Conferences have been held in Germany (Rostock 1991), Poland (Sopot 1993), Sweden (Uppsala 1995), Lithuania (Vilnius 1997), Denmark (Hirtshals 2000), Russia (Kaliningrad 2002), Estonia (Tartu 2004), Latvia (Jurmala 2006), Norway (Oslo 2008, The Baltic Sea Geology Session in the IGC meeting), and Russia (St. Petersburg 2010). Now, after a quarter of a century the conference is back in Finland.

Today the Baltic 2012 Conference will bring together more than 80 scientists and university students from 9 countries around the Baltic Sea and from the Europe, which all have a passion for marine geology.

Rapidly growing population and increased activities in coastal and marine areas have enhanced the use of seas and seafloor worldwide, also in the Baltic Sea. This has brought new challenges to gain knowledge from broad cross-border marine areas. Today the need for marine data including seafloor geological information is urgent, which is reflected in our scientific themes. The information we geoscientists can provide forms a basis for improved management, for implementation of policy strategies (e.g. the European Marine Strategy Directive) in the Baltic Sea environmental issues, and for adaptation to future climate change.

60 abstracts in this volume include oral presentations and poster presentations. All abstracts are printed in an alphabetical order of the first author. We would like to thank all authors for their contribution to this abstract volume.
Welcome to Helsinki and m/s Silja Serenade

Aarno Kotilainen and Anu Kaskela,
On behalf of the organizing committee

Keywords (GeoRef Thesaurus, AGI): marine geology, Baltic Sea, symposia

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MAPPING OF CELLULOSE FIBRE-LADEN SEDIMENTS ALONG THE VÄSTERNORRLAND COAST

by

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During 2010 and 2011, the Geological Survey of Sweden (SGU), in co-operation with the County Administration in Västernorrland, investigated twenty-two areas along the Västernorrland coast of the Bothnian Sea using hydroacoustics (Multibeam Echo Sounder, Swathsonar, Side-Scan Sonar, Sub-Bottom Profiler and Seismics) as well as groundtruthing (sediment sampling and visual observations). The aim was to locate and quantify the volume of accumulations of pulp and fibrous sediments as well as the degree of pollution in these sediments. Within the project, studies and developments were performed of using different hydroacoustic methods to detect, in specific, sediments rich in fibres discharged from the pulp-mill industries.

The county of Västernorrland has experienced an industry dominated by pulp factories producing or contributing to the production of different kind of wooden products, such as, pulp and particle boards between the late 19th and 20th Century. Several steps within the manufacturing processes required different types of chemicals and substances, such as mercury and a variety of chlorinated compounds. The factories were, in most cases, located in the direct vicinity to watercourses and the wastewater was often discharged untreated into the streams. Apart from toxic substances large amounts of fibrous material from the raw wood cultivation were discharged into the wastewater, transported and accumulated in calm environments downstream. In some places, these fibre accumulations contain immense amounts of contaminants and are considered as environmental risks since the land uplift (ca 7 mm/year) results in increased exposure of waves and currents and thus an increased risk of resuspension of sediments and consequently a releasing of the contaminants embedded in the sediments.

The results from the hydroacoustic measurements show that accumulations of pure cellulose and fibres are possible to distinguish using specific or a combination of hydroacoustic instruments. Apart from anomalies in roughness in the seabed surface, sediment gas can be used as an indicator of fibrous accumulations. The fibrous accumulations generate large quantities of gas in the sediments as a result of the degradation of organic material. This phenomenon also affects the physical environment around these accumulations through the cause of anoxia/hypoxia.

Pure cellulose deposits are usually found in the vicinity of the factory wastewater outlet. The content of fibrous material in the sediment then usually de-

creases with increasing distance from the source. Wooden chip and splinters diluted in postglacial clay gyttja are found in large areas around some industries and prove that factory discharges also have been transported and spread by currents. Comparisons between the different investigated areas show that very high concentrations of PCBs are found in Ångermanälven and in Svartviken, south of Sundsvall. In the Sundsvall region high concentrations of PAHs and DDTs have been detected. The highest heavy metal concentrations are found in Alnösundet and north of Alnösundet where mercury show values within class 5 according to the Swedish EPA's classification system for contaminants in marine sediments.

RECONSTRUCTION OF PALEODYNAMICS OF THE CURONIAN SPIT DUNES BASED ON THE GROUND-PENETRATING RADAR (GPR) SURVEY AND GEOCHRONOLOGICAL DATA

by

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Curonian Spit – a narrow sandy barrier separating the Curonian Lagoon from the Baltic Sea – is one of the most unique places in both cultural and geological terms. The Curonian Spit, both the Lithuanian and the Russian parts, are included into the UNESCO list of cultural heritage monuments. From the geological point of view it is still "alive" environment, generally composed of aeolian deposits, characterized by the phase activity. During the Holocene active and passive (stable) periods of dune formation (phases) were interchanging. Quiet periods, when dune surface used to be covered by vegetation and soil layer used to be formed, were regularly changed by aeolian activity periods during which the soil used to be destroyed or covered with a layer of new sand. Thus, the buried soils (paleosoils) were formed. These paleosoils have significantly different lithological and physical characteristics from the aeolian sands which are dominant in the geological cross-section of the Curonian Spit. With the help of modern geophysical and geological techniques – ground-penetrating radar (GPR) and geochronological research – the detailed investigations of paleosoils were carried out in the Dead (Gray) Dunes region located between Juodkrantė and Pervalka settlements in the central part of the Lithuanian half of the Curonian Spit. According to the results of radiocarbon (^{14}C) dating carried out during the last decade, a few generations of paleosoils were distinguished. The mentioned generations were formed approximately 5800-5600, 3700-3500, 2500-2350, 1350-1170 and 700-650 calendar years BP. Geophysical survey using ground-penetrating radar („Radar Systems" GPR „Zond 12-e"; 300 MHz antenna; 400 V pulse generator; maximal penetrating approximately until 33 meters) enabled to create a three-dimensional model of soil surfaces. A series of paleogeographic reconstructions for different phases of aeolian activity reflecting geological development (paleodynamics) of the Curonian Spit dunes in the Dead (Gray) Dunes region were carried out as a final result of the mentioned investigations.

This research was funded by a grant (No. MIP-11131) from the Research Council of Lithuania

HIGH-RESOLUTION MAPPING OF UNDERWATER LANDSCAPES TO THE NORTH OF THE SAMBIAN PENINSULA (SOUTH-EASTERN BALTIC)

by

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Main difference between aquatic and terrestrial landscapes is in the presence of water environment with its specific physical and chemical characteristics and lack of light on the major part of the marine bottom area. Accordingly the methods of bottom landscapes investigations differ. Bottom landscapes investigation is a quite new trend in modern geography and that is why there is no unified methodology for its mapping.

At present there are two main principles in bottom landscapes research: the classical method using diving and a new method of using hydro acoustic surveys. We have used the last one consisting of processing and interpretation of echosounding and side-scan sonar data. Echosounding and side-scan sonar data were processed in hydrographical software Hypack 2011. ArcGIS 9.2 software was used for data interpretation and bottom landscapes mapping.

The bottom of the near shore zone of the Sambian peninsula is well studied not far from the 15 m isobaths only. Investigation area was chosen deeper than 15 m isobaths because of wave action on the bottom can reach the depth of 30 m when strong storms occur. Side-scan sonar investigations of the bottom of key area have shown intensive lithodynamic processes. There are strong erosion and no sedimentation of the bottom sediments on the whole area. Bottom landscapes map of key area of Russian part of South-Eastern Baltic was composed in scale 1:25 000 (Fig. 1).

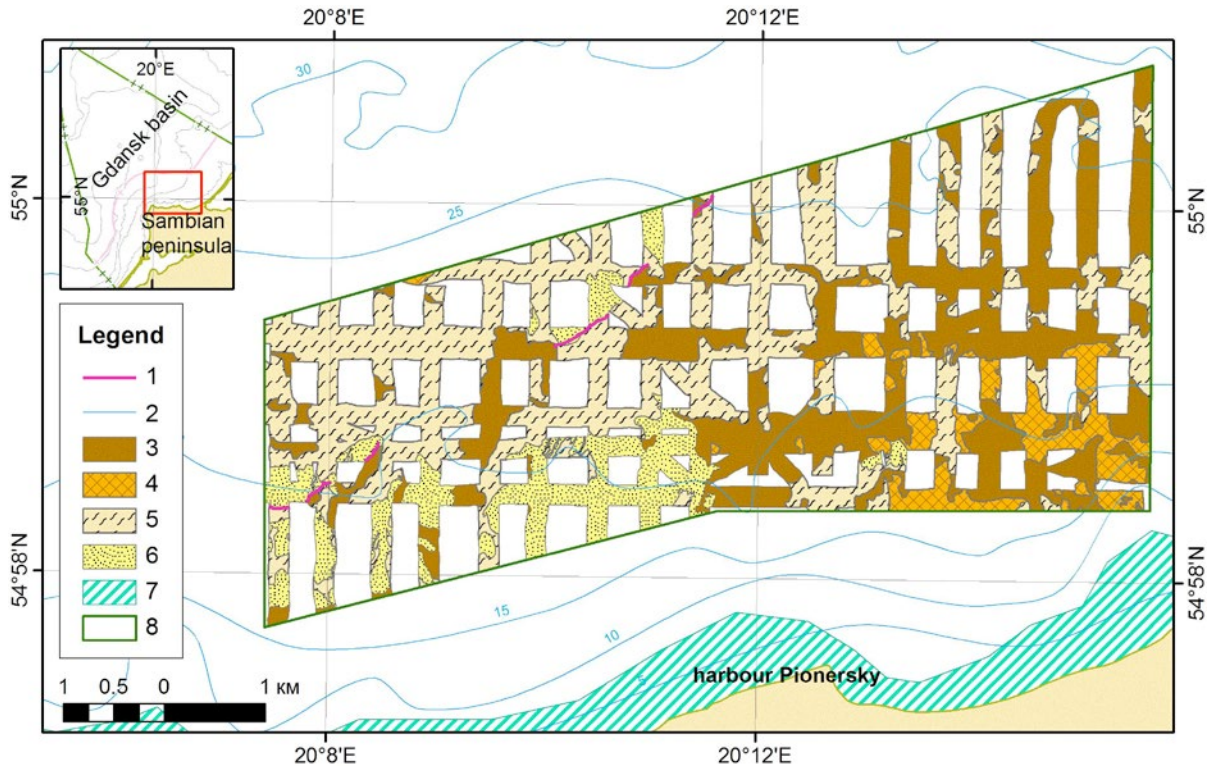

Fig.1. Bottom landscapes map of key area of Russian part of South-Eastern Baltic (1 – erosion escarps, cliffs; 2 – bathymetric lines, m; 3 – boulders, pebbles, gravel, intense submarine erosion; 4 – sands with gravel and pebbles, weak submarine erosion; 5 – middle- and coarse-grained sands with clear ripple traces on the surface, none sedimentation (transit); 6 – fine-grained sands, wave accretion; 7 – euphotic zone; 8 – border of key area).

THE BIOGENIC COMPONENTS IN THE SEDIMENTS OF THE BALTIC SEA

by

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The biogenic components (C_{org}, N, SiO_{2am}, $CaCO_3$, P) were investigated chemically (Emelyanov et al 2002) in the surficial (0–5 cm) sediments (1511 samples) and the 60 cores. Biogenic remains were studied in the fractions 1–0.1 and 0.1–0.05 mm under microscope. The maximal contents of C_{org} (13.03%, 0.70% N) were obtained in the pelitic mud of the deepest part of the Gotland Deep. The average content of C_{org} in the sediments is increasing in the order sand (S) – (0.30%), coarse aleurites (Ca) (0.83%), fine aleuritic mud (Fam) (1.64%), aleuropelitic mud (Ap) (2.82%), pelitic mud (P) (3.38%) (Fig. 1). The distribution of the C_{org} depends on the depth and on the content of the <0.01 mm grain size. One should not compare the contents of C_{org} in the sand and pelitic mud or operate with the data in average contents in the bulk sediment (sand+silt+mud) sample.

The average content of N, P, SiO_{2am} and $CaCO_3$ are in creasing in the same order. The maximal contents of C_{org}, N, SiO_{2am}, and P are found in the pelitic mud: N – 0.70%; SiO_{2am} – 5.52%; P – 0.73%; $CaCO_3$ – 19.01%. There were investigated more than 50 microelements in the carboniferous mud of the Baltic Sea

The composition of carboniferous mud of the Gotland Deep was compared with the carboniferous of Jurassic-Cretaceous argillites of Bazhenov Formation of the Western Siberia (Gavshin & Zakharov 1996, SNIIGGiMS 1982).

The carboniferous mud of the Baltic Sea deeps is analogue of the oil bearing carboniferous argillites of Bazhenov Formation and with oil bearing black shales (Baturin & Emelyanov 2011).

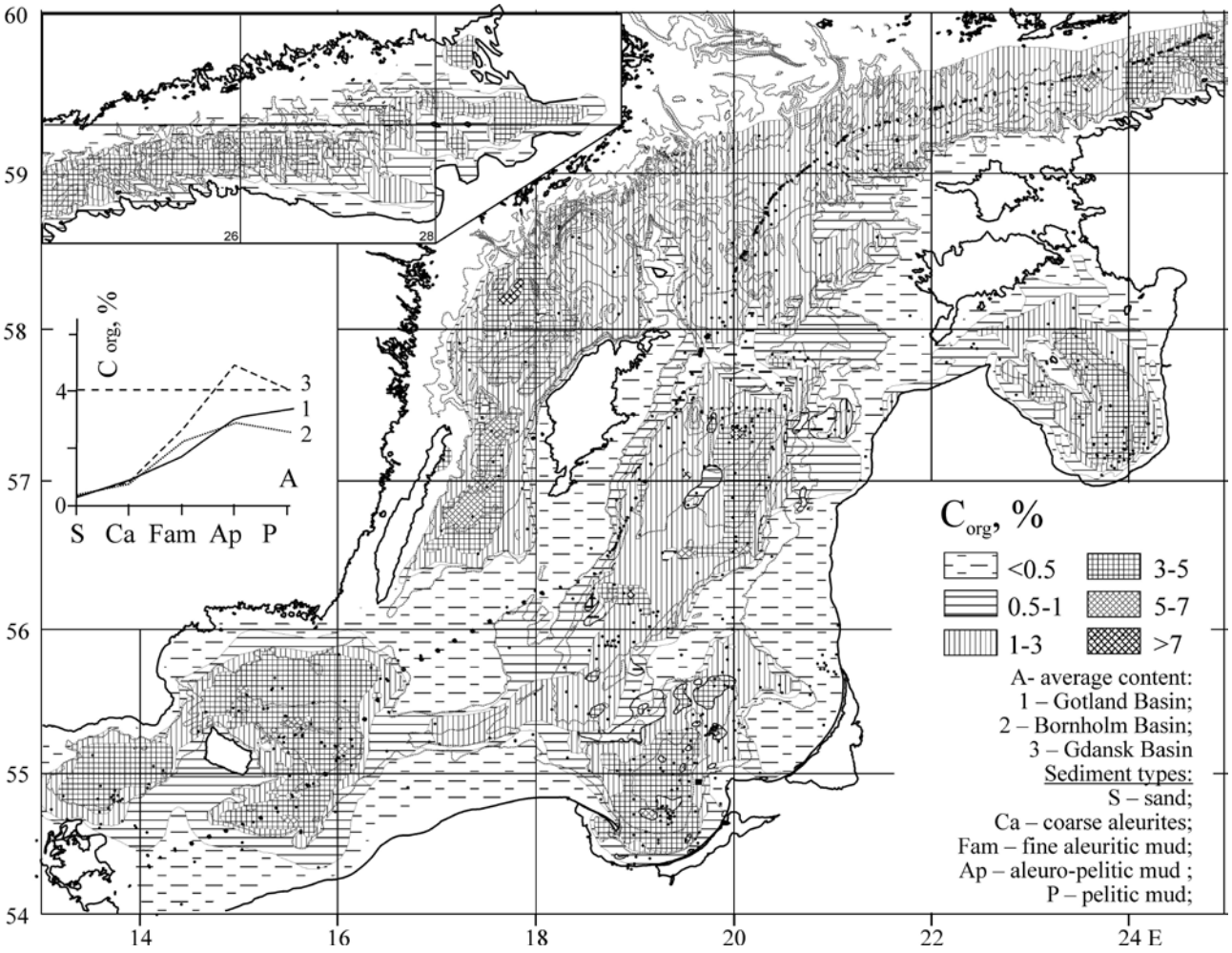

Fig. 1. The content of C_{org} in the surficial sediments.

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NEAR BOTTOM SEDIMENT TRANSPORT IN SOME POSSIBLE WIND FARM LOCATIONS IN THE ESTONIAN COASTAL SEA

by

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On the base of available geological database, long time wind measurement data and existing electricity network two investigation polygons were centred out for the environmental study of possible offshore wind farms in the Estonian coastal sea near the capital Tallinn. The both polygons are locating near the north-west coast of Estonia, where a third of Estonian population is leaving. The first place (~20 km^2) is locating in Tallinn Bay about 13 km away from the capital of Estonia Tallinn. There is possible to put up about 100 turbines (3MW, 80–105 m high). The second region locates nearby the SW coast of Suur-Pakri Island about 50 km to the west from Tallinn. Available territory for wind farm here (the coastline incl.) is 15–16 km^2, what enables to put up 60–90 turbines (200–300 MW). It is very important to know as the environmental parameters of undisturbed situation as well the possible risks and extension of impacts by building masts and installing cables into the sea.

Sediment resuspension depending on the wind and wave activity in these two polygons and in some coastal areas of the Tallinn Bay was investigated. Data recorded by acoustical Doppler velocymeter (ADV) combined with a turbidity sonde and by a pressure wave gauge were analyzed (Fig. 1). For the flow visualization (Fig. 2) a unique underwater video-sonde was constructed in the Centre of Biorobotics.

A simplified model of Nielsen (1992) is describing well the start up of bottom sediment resuspension in the coastal zone of NW Estonia. Running the model has shown, that currents will have a significant impact to the sediment resuspension only if their speed reached 15–20 cm/s that means it is induced by the wave orbital velocities as a so high current load occurs very seldom in Estonian sea areas. The PIV experiments have proved that this technique is able to scan *in situ* the near bottom velocities including vorticity movement, but to achieve higher precision the laser beam technique must be used.

Authors are thankful to *Estonian Science Foundation* (grants 7000, 7283 and 9052) and to *EEA and Norwegian Kingdome* (grant EMP53) for the financial support.

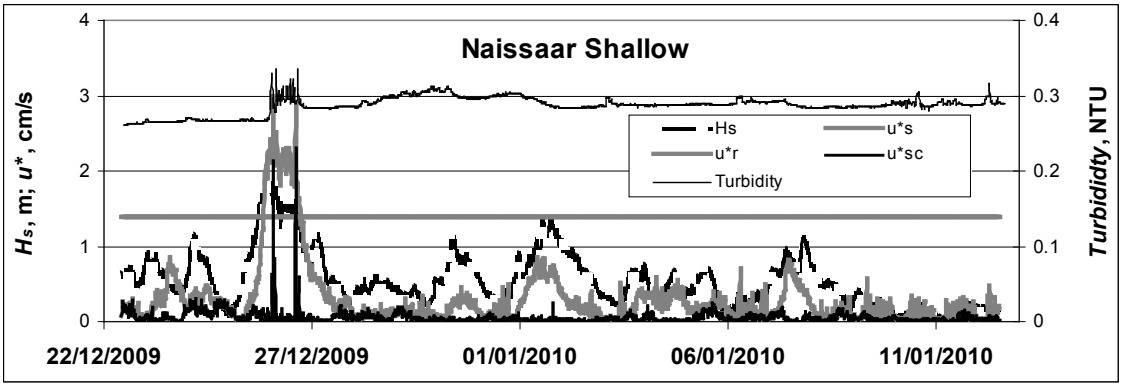

Fig.1. Measured (turbidity and significant wave height H_s) and calculated (critical shear velocity u_r^*, scin friction velocity u_s^* and current skin friction velocity u_{sc}^*) parameters in the Naissaar shallow.

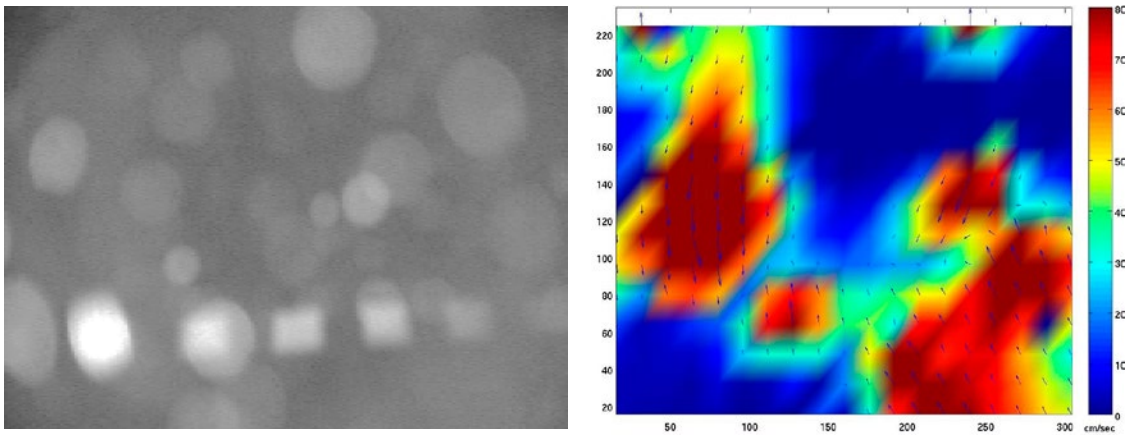

Fig. 2. A night snapshot of an underwater movie clip (left) and calculated vorticity values for the flow-detected vortex (right).

GEOLOGICAL SEQUENCE OF THE SOUTH-EASTERN SEGMENT OF THE BALTIC SEA

by

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The Baltic Sea is known as a young postglacial body, and the geological sequence of the pre-Quaternary follows onland structures stretching from both eastern and western sides. The South-eastern segment is composed of Devonian-Paleogene sedimentary rocks, with geological contours showing development of Permian-Mesozoic Polish-Lithuanian Syneclise.

The sub-Quaternary surface that truncates these rocks was formed in the Late Paleogene and Neogene, during the latest episode of peneplanation in the Baltic region. It is suggested that many deeply buried incisions in this surface were inherited from the pre-Quaternary and later were reshaped by Pleistocene glaciers (Gelumbauskaitė & Grigelis 1997). Pleistocene and Holocene deposits occur almost everywhere. The data of marine geological-geophysical investigations undertaken in the Central Baltic between Gotland and the Latvian–Lithuanian coast gave understanding of the tectonic structure of the pre-Quaternary basement, the morphology of the sub-Quaternary peneplain, the Pleistocene and Holocene formation and depositional history (Figs. 1& 2).

The poster presents detailed recent updating of geological maps, i.e. maps of tectonical setting, pre-Quaternary geology, sub-Quaternary surface, Quaternary thickness, Holocene thickness, and W–E seismogeological profile through the study area.

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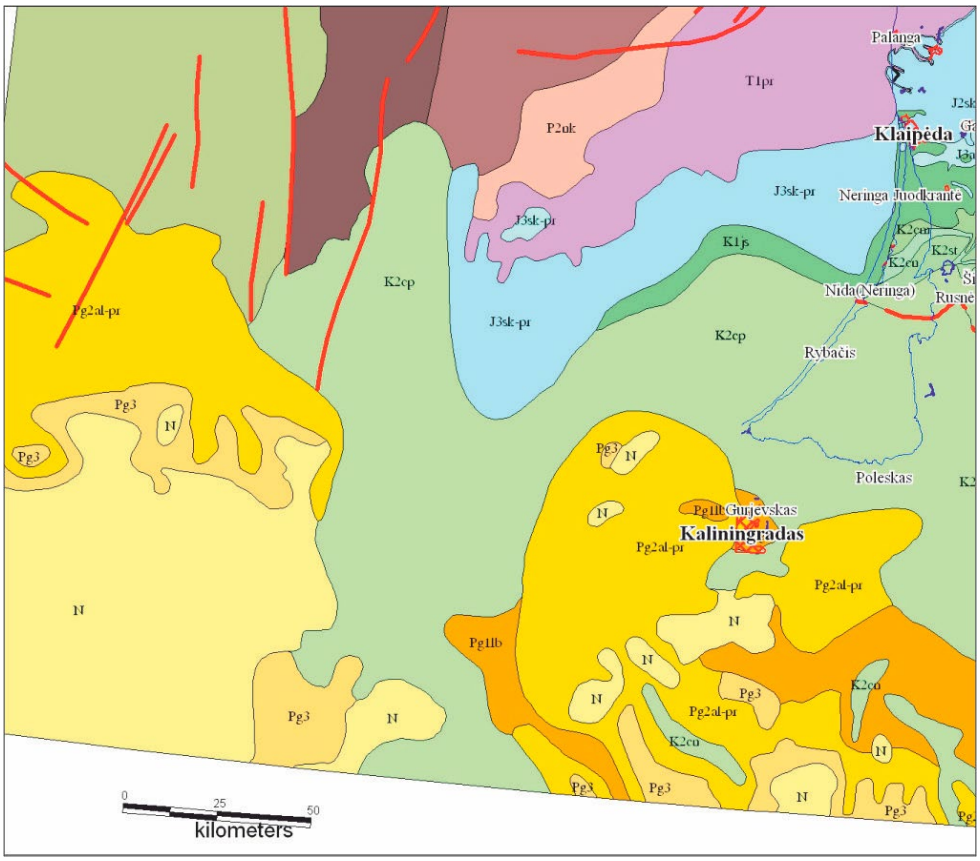

Fig. 1. Basic map of the south-eastern Baltic Sea; after A.Grigelis & J.Čyžienė 2011, unpubl.

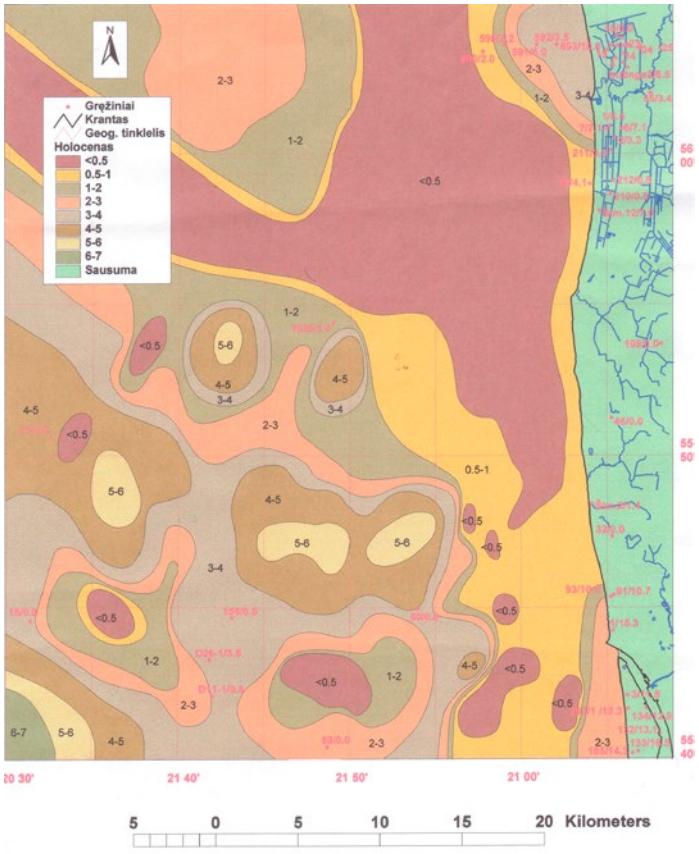

Fig. 2. Thickness of Holocene sediments of the south-eastern Baltic Sea; after L. Ž. Gelumbauskaitė 2011, unpubl.

SHORELINE CHANGES IN NORTHERN ESTONIA DURING THE LITORINA SEA

by

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Currently most of the Estonian territory is covered with high-resolution airborne laser scanning LIDAR elevation data. In addition, implication of modern GIS-based software and modern digital terrain model allows reconstruction of ancient coastlines as well as sea bathymetry and mainland relief with better accuracy. Precise chronology for the past shore levels can be obtained from sediment records of small lake and bog basins, whereas the emergence of the basin from the sea can be identified by diatom evidence and isolation level can be dated by AMS ^{14}C method on terrestrial macrofossil remains.

New results of litho-, bio- and chronostratigraphical investigation from five isolation basins and evidence from the earlier studies were used for creation of GIS-based shore displacement model and reconstruction of paleoenvironment along North Estonian coastline for the last 8000 cal yr BP. The lakes are located in the Gulf of Finland drainage system at different altitude and isolated from the sea between 5500 and 1200 cal yr BP depending on the rate of the glacio-isostatic rebound.

The modelling results show that during the Litorina Sea transgression maximum the shoreline located ca. 22.1 m above sea level (a.s.l.) at Lake Tänavjärv, 21.9 m a.s.l. at Lake Klooga, 20.5 m a.s.l. at Lake Harku, 18.8 m a.s.l. at Lake Lohja and 17.7 m a.s.l. at Lake Käsmu due to differences in land uplift rate. The general trend along North Estonian coast is the regression of sea level and enlargement of peninsulas north- and westwards due to still lasting land uplift. The land uplift rate which was about 3 mm yr^{-1} during 5000 cal yr BP has been decreased to 2 mm yr^{-1} at present.

GEOLOGICAL INVENTORIES AS A PART OF HABITAT MAPPING PROJECT FINMARINET IN RAUMA ARCHIPELAGO, SEA OF BOTHNIA

by

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Inventories and planning for the marine Natura 2000 network in Finland (FINMARINET) is a Life+ -funded project that carries out inventories of the marine habitat types of the EU Habitats Directive along the Finnish coastline including the Finnish territorial waters and the Finnish exclusive economic zone (EEZ). The major Finnish marine Natura 2000 sites and their adjacent areas potentially valuable for the extension of the Natura 2000 network will be assessed. The main objective is to produce cartographic images to underpin decision making regarding the key marine habitat types related to the Habitats Directive. The project is coordinated by the Finnish Environment Institute (SYKE), with four associated beneficiaries: Geological Survey of Finland (GTK), Metsähallitus Natural Heritage Services, Åbo Akademi University and the University of Turku. The FINMARINET project is implemented in close relationship to the Finnish Inventory Programme for the Underwater Marine Environment (VELMU).

GTK has carried out marine geological inventories in 5 research areas. In 2011 inventories were made in Rauma archipelago Natura 2000 site and its neighbourhood. The research area covered about 200 km^2 ranging from the inner archipelago to the open sea. All together some 421 kilometres of acoustic survey lines were run including continuous sub bottom profiling, reflection seismic, side scan sonar and multibeam echo sounding. In addition 23 bottom samples were taken supported with 24 drop video recordings on all sampling sites. All acoustic survey profiles were interpreted. Surface geological maps were drawn based on the acoustic data supported by bottom sediment samples. Outputs of the geological studies consist of substrate, seafloor feature and landscape maps.

When compiling the maps, special emphasis was given to the topmost centimetres of the sediment layers. Traditional surface geological maps, which usually describe the uppermost one meter of the sediment layers, are not always the ideal starting point for biological studies and marine habitat mapping. Thus, the sediment classification and the interpretation process were slightly altered to better fit the requirements of habitat mapping. In addition, the automated approach to classify seafloor surface material was tested.

THE LATE QUATERNARY BALTIC SEA BASIN – A MODELLING APPROACH

by

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The Baltic Sea Basin and its sediments serve as a textbook for the Quaternary climate and environmental history of the Baltic Sea area and the North Atlantic realm. Sediments within the sub-basins reflect changes in forcing processes such as glacio-isostatic adjustment (GIA), ice sheet dynamics, climatically controlled eustatic changes, atmospheric dynamics, hydrographic regime and sediment supply. Throughout the Baltic Sea Basin data from seismic profiling are available to describe the thickness and distribution of Quaternary sediments. For late glacial to recent stratigraphic units, sediment cores provide proxies for the reconstruction of the paleo-environment. The Baltic Sea Basin thus serves as an ideal case for the application of basin analysis methods to study multi-scale processes controlling the silica-clastic fill of this intra-continental basin. We show the application of these methods to test conceptual models for the development of the central Baltic Sea in space and time from the Late Pleistocene to the modern warm period. Sediment-echosounder profiles, together with gravity core data have been used to describe 12000 years of basin history. Physical sediment parameters measured with a multi-sensor core logger (MSCL) serve as reference variables for the physico-stratigraphic zonation and basin wide correlation of sediment cores. Physico-stratigraphic zones have been determined by the application of multivariate classification techniques to sediment-physical and geochemical (XRF) data. This zonation coincides widely with the main stages of the geological development of the Baltic basin (Andren et al. 2011). The older sequences (A zones) consist mainly of fresh water sediments from the Baltic Ice Lake and the Ancylus Lake. The shift to a brackish-marine environment as the results of the Littorina transgression is marked in the sediment column by a change from homogeneous to laminated sediments of the B zones due to the establishment of a halocline and anoxic bottom water.

Thickness maps of A and B zones sediments have been constructed by interpolation of stratigraphic surfaces. Whereas the lacustrine A zone sediments a coast-to-basin system prevailed, the deposition across the basin was dominated by a basin-to-basin transport after connections to the North Sea opened during

the Littorina transgression. Basin-to-basin transport resulted in the accumulation of "submarine deltas" in front of the channel mouths as transit pathways between the basins. Dated basin sediments allow time series analyses of facies variation. We see a periodical change of the NAO on the centennial time scale as the reason for facies shifts. Time series analyses of physical and geochemical sediment proxies of the depositional environment reveal remarkable periodicities of about 900 and 1500 years. Similar periods are reported from marine sediments from the Northern Atlantic and the Greenland ice cores. According to our hypothesis, this periodicity in the Baltic Sea sediments represents a global climate signal. "Backstripping" of the basin fill leads to the reconstruction of paleo-bathymetric scenarios serving as start conditions and validation schemes for "forward morphodynamic modelling" of basin- and coastal-processes.

We plan to extend the application of the methods to the time span MIS-5 to MIS-2 after IODP-347 core-data is available.

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PALEOCEANOGRAPHIC VARIABILITY IN THE CENTRAL BALTIC SEA DURING THE LAST CENTURIES

by

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Geochemical studies in the currently euxinic Central Gotland Basin and Landsort Deep (Baltic Sea) are conducted to understand and connect paleoceanographic and paleoclimatic variability documented in both basins. Environmental conditions in the deep basins of the Baltic Sea strongly depend on saline and oxygen-rich inflows from the North Sea. Morphological as well as hydrographical peculiarities determine the strength of saline and oxic inflow events and thus, the strength of deep water ventilation. Sedimentary responses to oxic inflows are investigated by analyzing laminated sediment sequences of short sediment cores from both basins. This study mainly focuses on authigenic manganese phases (Mn(Ca)-carbonate, Mn-sulfide) precipitating during the re-establishment of anoxic conditions after oxic events. XRF core scanning (Fig.1), SEM-EDX, ICP-OES, and ICP-MS are applied, determining type and abundance of authigenic minerals as well as associated trace elements. Mn-enrichments in the short core of the Central Gotland Basin are mainly related to Mn(Ca)-carbonates, resulting from saline and oxic inflow events (Matthäus 2006) recorded during the last 130 years. However, pronounced euxinic conditions during stagnation periods in this basin seem to prefer authigenic pyrite formation rather than Mn-sulfides or Mn(Ca)-carbonates. In contrast, the Landsort Deep generally shows a higher abundance of Mn(Ca)-carbonate and a dominance of Mn-sulfides which is most likely caused by a different hydrographic regime. Oceanographic time series and biological monitoring data along with ^{210}Pb and ^{137}Cs dating support the temporal allocation of Mn-enrichments to oxic inflow events and enable a chronostratigraphy of recent sediments of the Central Baltic Sea.

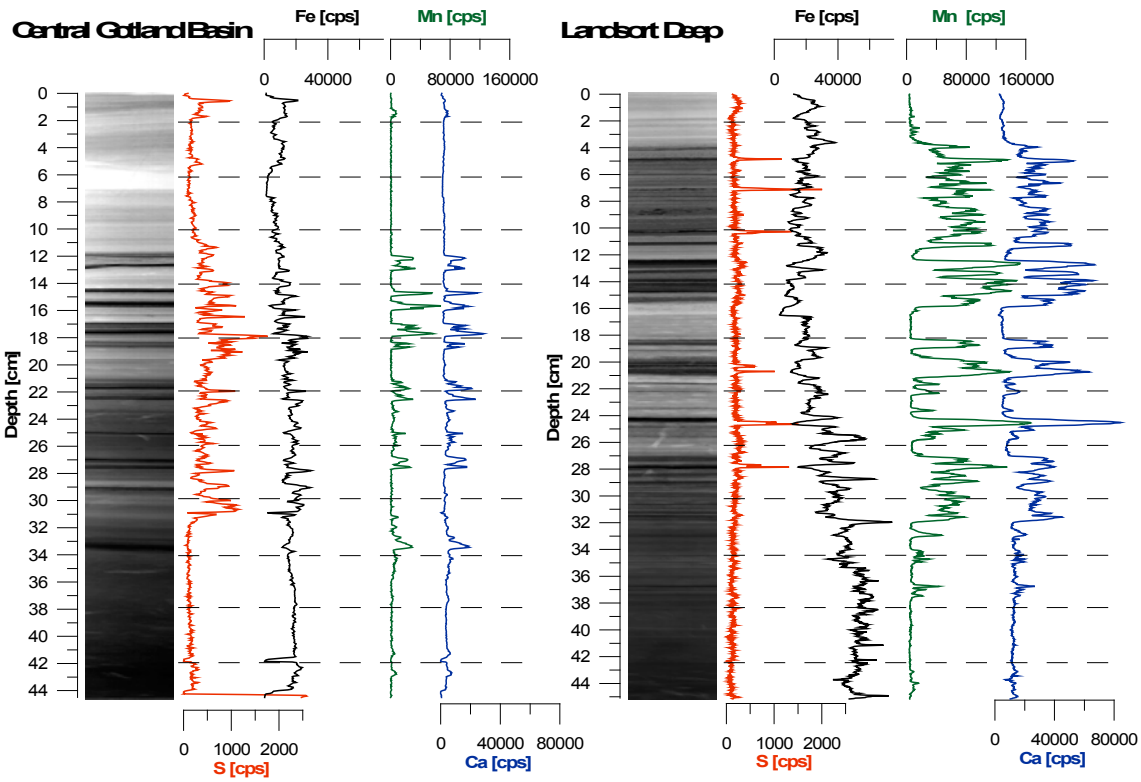

Fig. 1 Radiographs and corresponding XRF scanning profiles of the elements S, Fe, Mn and Ca [cps] of short sediment cores from the Central Gotland Basin and the Landsort Deep.

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DATING OF THE ANCYLUS LAKE TRANSGRESSION MAXIMUM IN WESTERN ESTONIA

by

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The post-glacial evolution of the Baltic Sea has been governed in particular by interactions between the deglaciation dynamics, glacio-isostatic land-uplift and eustatic ocean level changes that have led to repeated transgressions and regressions. Our study area, western Estonia, is characterised by a slow glacio-isostatic land uplift and the landscape is relatively flat. Therefore, even a small increase or decrease in relative sea level of the Baltic Sea has induced the flooding or emergence of substantial coastal areas and significant configuration of the coastline. Therefore, in the region under discussion geologists have discovered many localities, where terrestrial peat or paleosoil beds are buried under the transgressive deposits of the Ancylus Lake and the Litorina Sea. The altitude and radiocarbon dating of these buried organic-rich layers is often the basis for the reconstruction of local shoreline displacement curves. ^{14}C dates yielded from the layers of the buried terrestrial organic sediments indicate the age of relative sea level regression, however, transgression sediments are mostly devoid of datable material.

The sediment core was taken from Lake Ermistu (58°21'27''N; 23°59'03''E, water depth 1.4 m) and investigated by diatom, pollen, plant macrofossil and geochemical analyses and dated by AMS radiocarbon dates. Coastal formations of the Ancylus Lake run alongside the south-western side of the lake. The base of the core consists of a 30-cm thick woody fen peat layer dated to 11,400–10,900 cal yr BP that corresponds to Yoldia Sea low-stand level. The peat is overlain by calcareous coarse detritus gyttja bed that is sandwiched by two marked 1–2 cm sand layers. Diatom evidence suggests relatively high water level for the lake that existed in the depression, whereas the two sand layers contain diatoms e.g. *Aulacoseira islandica*, typical of the very large freshwater environment, and presumably show double inundation of the waters of the Ancylus Lake. According to our interpretation, these sediments are bracketing the period of the Ancylus Lake transgression maximum and are dated to ca. 10,300 cal yr BP.

A series of GIS-based temporal 3D paleogeographic maps for different time periods, that visualise the coastline development, the sea bathymetry and the mainland relief, are reconstructed for the region.

FOSSIL LAGOONAL SEDIMENTS ON THE WESTERN COAST OF THE GULF OF GDANSK – A NEW DATA ON PROCESSES FORMING COASTAL TERRACE IN THE LATE HOLOCENE

by

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The sandy-muddy lagoonal sediments were found at the depths from 4−7 m to 7−10 m below sea level along ca. 10 km of western coast of the Gulf of Gdansk. The sediments are underlain by coarse and medium-grained, calcareous sands, most probably of Pleistocene age. Above the sandy-muddy sediments, marine and eolian sands occur (Fig. 1).

Such lagoonal deposits were not previously known in this area. They were investigated using following analyses: ^{14}C datings (5 samples of mud and 2 samples of shells), pollen (16 samples from 1 core) and diatom (32 samples from 2 cores), grain size distribution (ca. 60 samples from 6 cores).

Age of samples of mud vary from 6029−5717 to 4527−4224 cal. years BP (68.2% prob.). *Cerastoderma* sp. and *Scrobicularia* sp. shells takeng from the same muddy layers were dated to 2045−1510 and 2339−1736 cal. years BP. This indicates that the radiocarbon age of mud is about 3900−2400 years too old due to the admixing of reworked old organic matter.

According to pollen analyses examined sediments accumulated after 3700−3200 cal. years BP but before 1200 cal. years BP. This is in coherence with radiocarbon age of marine shells.

Diatom analysis showed that most taxons are cosmopolitan, occurring in brackish reservoirs today. The spectrum is dominated by diatoms characteristic mainly for muddy and sandy habitat. The increase of benthic species in the upper part of sediments indicates the shallowing of the lagoon, while the occur-

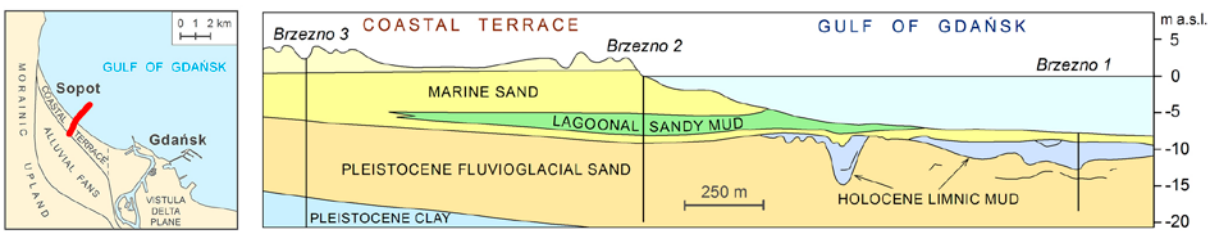

Fig. 1. Geological cross-section of the coastal terrace sediments.

rence of brackish and marine forms could be a result of more frequent storm overflows.

Most probably the beginning of the lagoon is related to the ceasing of the Littorina transgression ca. 7400–6800 cal. years ago. Sea level in this period was lower than today by ca. 7–5 m and morainic upland on western coast of the Gulf of Gdansk started to be eroded. The eroded material could be a source for the barrier which during next ca. 4000 years grew enough to reduce the impact of waves and allowed the deposition of sandy mud in the shallow reservoir. The barrier was periodically teared down during storms surges (inserts of sandy layers and the occurrence of brackish and marine diatoms in sediments). Barrier slowly migrated westward, in direction perpendicular to land. Finally lagoon was completely filled by sand and ca. 1500–1000 cal. years ago formed a coastal terrace. The shallowing of the lagoon was most probably accelerated by the supply of sand from Vistula outlet, which was formed south of the lagoon ca. 3000 years ago.

BORNHOLM BASIN: A KEY STUDY AREA FOR DISTRIBUTION OF METHANE IN THE BALTIC SEA SEDIMENTS

by

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In connection with the EU BONUS project BALTIC GAS, one of the deliveries has been to produce a map of methane distribution in the Baltic Sea sediments. This is one of the data inputs for calculation of the potential existent methane volume in the Baltic Sea seabed sediments, which is based on general acoustic information from archive data supplemented by data collected during the project.

Detailed information has been collected in key areas like the Bornholm Basin, where intensive shallow seismic profiling and sampling have been carried out to describe the general setting and to find the distribution of methane in the seabed sediments. Sediment deposition in the Bornholm Basin has been studied extensively in the past, but often only on the basis of one or a few sediment cores (e.g. Emeis et al. 2000). Despite a rather uniform bathymetry in the central part of the basins, several studies show a rather inhomogeneous sedimentation pattern (Christoffersen et al. 2007) and studies along the margins of the basin show a strong influence of near bottom currents created by periodical intensive storm induced saltwater inflow events from the North Sea (Sivkov et al. 2002).

We have found new evidence of morphological pre-defined large tectonic structures and syn-tectonic sedimentation features in the Late- and Postglacial deposits as well as evidence for well developed erosional and depositional systems. The latter can be attributed to near bottom currents that have characterised the region throughout the Holocene. Homogeneous sediments in the cores indicate dominating oxic conditions in the western part of the Baltic Sea during the Holocene. However, internal reflectors show major differences in accumulation rates and basin wide unconformities reflect large shifts in sedimentation that has taken place, probably due to inflow changes that might be related to major climate changes as described from the Gotland Deep (Zillen et al. 2008).

A close relation is seen between methane distribution and near bottom current sediment deposition. Contour current levee banks with high sedimentation rates and their relation with methane and geochemical elements have been investigated.

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CLIMATE INFLUENCE ON SEDIMENT CONDITIONS AND POSSIBLE OLIGOTROPHICATION OF THE BALTIC SEA

by

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Several authors have argued that the presently quantitatively most prominent driving force for erosion/resuspension of old sediments is the crustal rebound after the last glaciation of Scandinavia that every year lifts up and exposes old clays to the more energy-rich parts of the water mass of the Baltic Sea. If the resulting relative water level decreases, stops or even gets negative (sea level rises) due to climate-induced melting of ice and eustatic changes, the input from erosion to bulk sediment accumulation will decrease to a large extent and subsequently lead to both quantitative and qualitative changes in the sediment accumulation in the Baltic Sea. To estimate these posiible changes we have related our calculations to three different water level scenarios that have been presented in recent years. In this paper we present conservative calculations of these possible changes that may lead to significant (in the order of 30% and 75% in the Ensamble average and High case scenarios resp.) decreased erosion of old clays. The resulting decreasing sediment accumulation in the Baltic basins will cause a 2−3-fold increase of the organic content in the sediments. In another paper presented at this conference we demonstrated that old post-glacial and glacial clays contain considerable amounts of mobile phosphorus. Decreased erosion due to raising water levels may subsequently lead to considerable reductions of bioavailable phosphorus input from erosion. On the contrary to many other predictions of the effects of climate change an oligotrophication of the Baltic is likely to occur. A possible future oligotrophication along these lines may be enhanced by less windy conditions in the Baltic Sea area. If the land up-lift is considered a first order driving force for erosion, wave and current action may be considered a second. Eckhéll et al. (2000) presented a linear relationship between the annual frequency of strong winds ($\geq$ 14 m s^{-1}) and bulk sediment accumulation rate in the offshore areas of the NW Baltic Proper. This relationship is based on a 45-year record of wind conditions at Gotska Sandön (N Baltic Proper) showing

3-year running averages of strong wind frequencies of 3–6% in the period of time 1950s–early 1980s. In the 1980s the frequency decreased to 1–2%, peaked again in the early 1990s with 3–6% and thereafter decreasing. The present situation with annual frequency of strong winds (≥ 14 m s^{-1}) at a level of 0.5–1% from the late 1990s until now has not been registered earlier during the last 60 years. If this long-term wind record is an indication of climate change it suggests that the Baltic Sea, in controversy with the prevailing opinion, is moving in the direction of calmer wind conditions rather than the opposite. This would also imply less input of mobile phosphorus deriving from erosion of old clays. Our oligotrophication hypothesis will be compared with existing climate change scenarios.

OLD CLAYS − A FORGOTTEN SOURCE OF PHOSPHORUS TO THE BALTIC SEA

by

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The Baltic Sea area is subjected to a considerable land up-lift after the last glaciation of Scandinavia. In the Baltic Proper the crustal rebound is ranging from 0 mm yr^{-1} in the south to 5 in the north and in the Gulf of Bothnia it ranges from 5 to 9 mm yr^{-1}. This triggers off a gradual exposition of old glacial and post glacial clays to waves and currents leading to substantial erosion along the Baltic coastal areas. Estimates from literature yield that as much as 70−80% of the bulk accumulation of fine material in the Baltic Sea derives from relocalisation of old sediments. Our hypothesis is that a substantial part of the sediment phosphorus may be in the form of mobile phosphorus. We also hypothesize that due to the overall large bulk sediment input from erosion the bioavailable portion of phosphorus is important for the mass balance of phosphorus in the Baltic Sea ecosystem. Within a joint NMR/EU project, speciation of Baltic glacial and post-glacial clays (n=52) resulted in a total phosphorus content of 310−1446 with a median value of 701 μg g^{-1} dw (SD=199). The corresponding values of potentially mobile P were 33−582 with a median value of 119 μg g^{-1} dw (SD=92), which as an average constitutes 18% of the total phosphorus content. Based on literature data from 105 dated sediment cores the dry matter deposition in the entire Baltic Sea has been estimated to 95.000.000 tonnes yr^{-1}. Assuming that 70−80% of this derives from erosion of old clays and that the median mobile phosphorus content is 119 μg g^{-1} dw, 7 900−9 000 tonnes potentially mobile phosphorus may be released to the water mass per year, which is 28−32% of the total (background and anthropogenic) annual input of phosphorus to the Baltic (28 400 tonnes). Part of the potentially mobile phosphorus pool is readily bioavailable. Taking into account that most of the erosion takes place above the halocline, erosion-derived phosphorus is released to the surface water, which even more emphasizes the possible importance of this input. If these data are representative for large areas in the Baltic Sea, the bioavailable input of phosphorus from erosion is certainly an important factor to consider in nutrient mass balances and when measures to combat eutrophication in the Baltic Sea

are to be taken. Ignorance to include this source in mass calculations will lead to erroneous expectations of possible improvements in relation to measures taken.

QUANTIFYING SEDIMENT-WATER EXCHANGE OF PHOSPHORUS THROUGH MASS-BALANCE MODELLING

by

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Sediment-water exchange of phosphorus is a potentially important process for the trophic state of coastal ecosystems since phosphorus is one of the elements that may stimulate primary production in the aquatic environment (Guildford & Hecky 2000). The lack of phosphorus-binding capacity in sediments at low redox-potential (Mortimer 1941) is recognized as an important mechanism for eutrophication-related effects in some areas.

Although being recognized as potentially important most ecological models treat the sediment compartment as a black box that either supply or drain the water column of its phosphorus content in order to fit the mass-balance. In this study we used a new dataset of a hundred sediment characterisations from the Stockholm inner archipelago in combination with an extensive water chemistry dataset and information from geological maps to quantify the order of magnitude of several important processes that act on the standing stock of phosphorus in the sediment compartment, e.g. settling, sediment burial, resuspension including the effects of land uplift and molecular diffusion using a validated mass-balance model (Malmaeus et al. 2008). The model was also used to simulate the effects of different scenarios e.g. a decrease in apparent land uplift due to rising sea levels and changes in redox status of the sediments. The uncertainty in the modelling framework was assessed by applying Monte Carlo simulation.

It was found that accumulation areas with recent sedimentation of cohesive fine matter covers 70% of the study area. The total amount of mobile phosphorus in the sediments was estimated to 400 tonnes. This figure can be compared with the amount of phosphorus in the water column of approximately 50 tonnes and the yearly input from Lake Mälaren of 150 tonnes. Clearly, the processes creating sediment-water interactions of phosphorus is of profound importance for the water quality in the inner Stockholm archipelago.

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EMODNET-GEOLOGY – EUROPEAN CO-OPERATION TO CREATE HARMONIOUS DATA ON SEAFLOOR GEOLOGY

by

Anu Kaskela[1], Aarno Kotilainen[1], Ulla Alanen[1], Alan Stevenson[2] and EMODNET-Geology partners

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The EMODNET-Geology (2009–2012) was one of the European Marine Observation and Data Network projects and it was funded by EU Commission. There were altogether 14 partners from the geological surveys of Europe, and NERC/BGS coordinated the project. EMODNET-Geology project compiled and harmonized available information on seafloor geology, seabed substrates, seafloor geology, geological boundaries and faults among others from the Baltic Sea, Greater North Sea and Celtic Sea (http://www.emodnet-geology.eu/). The data is targeted for use in marine assessments at European level.

We will present the final EMODNET seabed sediment map at the scale of 1:1 million with confidence assessment. The map was compiled from various local and regional seabed substrate maps. Where necessary, the existing substrate classifications were harmonized into a shared classification scheme taking into account the integration with hydrographic, chemical and biological studies. The EMODNET reclassification scheme consists of four substrate classes defined on the basis of the modified Folk triangle (mud to sandy mud; sand to muddy sand; coarse sediment; mixed sediment) and two additional substrate classes (diamicton, rock). In addition to substrate map, an index map that identifies initial data layers and provides information on metadata (variation in remote observation, interpretation and ground-truthing methods) was created. The seabed substrate map (GIS) and other data produced by EMODNET-Geology project is available through OneGeology-Europe portal.

The focus of the EMODNET-Geology was not only to deliver digital information on marine geology, but also to highlight data gaps and areas where we should place more survey efforts in future. In addition, we have provided some case studies that emphasize the need for large scale surveys and data using modern techniques including e.g. multibeam echosounder (MBE).

VARIATIONS IN QUANTITY AND SPECIES OF PHOSPHORUS IN THE SETTLING MATTER IN THE NORTHERN BALTIC SEA ARCHIPELAGOS

by

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Eutrophication is considered the major environmental problem in the coastal and archipelago areas of the northern Baltic Sea. Nutrient concentrations in water are still high in spite of significant reductions of nutrient discharges from point sources during the past decades. Diffuse nutrient loading from land and internal loading from sea bottom affect the quality of archipelago waters. The internal loading of phosphorus from sediments to water takes mainly place during anoxic conditions, when iron-bound phosphorus is released back to the water. Poor oxygen conditions in shallow coastal areas and high phosphorus concentrations in sediments enhance the deterioration of archipelago waters.

The objective of the present research was to study the temporal and spatial variation of different phosphorus species in newly accumulated sediments in the Finnish and Swedish archipelago areas. Sediment traps were used to collect settling material at nine mooring sites. In Sweden the traps were kept in water throughout the year, in Finland and Åland during the open water season. Different phosphorus forms in the sediment trap samples were analyzed with a sequential extraction method. The fractionation method allows the estimation of the potentially mobile phosphorus pools in the samples. The results were compared with phosphorus levels in the topmost 1–2 cm layer of the surface sediment samples and phosphorus concentrations in the overlaying water. Samples from the sediment surface and the water column were collected by repeated sampling.

The results show that the amounts of total phosphorus and different phosphorus forms in the deposited material vary greatly both temporally and spatially. It is important to know the composition of the newly deposited sediments in order to estimate their role as a source for phosphorus. To our knowledge, there is only scarce research on phosphorus species in the settling particulate matter in the Baltic Sea.

SPATIAL VARIABILITY OF THE SOUTH-WESTERN BALTIC HOLOCENE SEDIMENTS REFLECTED BY THE GEOCHEMISTRY, DIATOMS AND RADIOCARBON DATING

by

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Marine sediment cores from the Pomeranian Bay and Arkona Basin were analysed in terms of geochemical composition, diatom assemblages and radiocarbon dating in order to evaluate the spatial differences of the Atlantic ingression, better known as the Littorina transgression, on the environment of the south-western Baltic basin. The data show that the Atlantic ingression had a strong influence on the evolution of the hydrographic system, which has been substantially changed from the Ancylus Lake to the Littorina Sea.

The age of the onset of the Littorina transgression in the sediments from Pomeranian Bay was dated to 7600–8000 cal BP. A little bit younger age of 7200 cal BP was estimated in the Arkona Basin and Szczecin Bay (Borówka & Cedro 2011, Rößler et al. 2011). In the polish middle coast the age of first marine sediments were older and estimated to 8550 cal. BP (Rotnicki 2009), and 8640 cal BP (Witkowski et al. 2009). The differences between the age of Littorina Sea onset are due to the tectonic activity of the basins belonging to different neotectonic structural units and different rate of vertical crustal movement. The problem regarding vertical crustal movement that affect the estimated age of the marine ingression onset is more complex due to a few factors, such as the uplift of the Fennoscandia, and the subsidence of a belt surrounding the Baltic Shield.

In the investigated sediments the onset of marine ingression was reflected by increases of the most geochemical parameters, particularly magnesium, iron and biogenic silica. This sediment was characterised by abundant diatom flora represented by many brackish and marine species. The highest salinities in the most of the cores were estimated in the younger sediments. Likely these sediments represent the culmination of the marine ingression. The difference of depth between sediments from the onset and sediments from the culmination of the marine ingression was over a dozen centimetres in the cores from Arkona Basin. In cores from Pomeranian Bay this difference reaches even one meter.

The above mentioned remarks allow the conclusion that culmination of the marine ingression appeared a few hundred years afterwards in the western cores from Arkona Basin, and almost two thousand years later in the eastern cores from Pomeranian Bay. The most important fact is that the rate of environmental change was faster in Arkona Basin than in Pomeranian Bay, where it was a gradual process.

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DO SOMETHING – A MESSAGE FROM INTEGRATED SEDIMENT AND MODELLING STUDIES OF INFLOW PROJECT

by

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Global climate change, growing population and increased activities in marine and coastal areas have threatened the marine environment worldwide. This deterioration is valid also for the Baltic Sea, the European inland sea. Effective and sustainable marine management, and more reliable scenario simulations of the future Baltic Sea, depend on improved understanding of the natural variability of the Baltic Sea ecosystem, and its response to climate and human induced forcing.

The INFLOW project has used integrated sediment multi-proxy studies and modelling to reconstruct past changes in the Baltic Sea ecosystem (e.g. in saline water inflow strength, temperature, salinity, redox and benthic faunal activity over the past 6000 years, concentrating on time period that covers two natural climate extremes of Little Ice Age and Medieval Climate Anomaly); to identify the forcing mechanisms of those environmental changes; and to provide scenarios of impact of climate change on the Baltic Sea ecosystem at the end of the 21st century.

New results of natural past changes in the Baltic Sea ecosystem, received in the INFLOW project, provide a discouraging forecast for the future of the sea. Integrated modeling and sediment proxy studies reveal increased sea surface temperatures and extended seafloor anoxia (in deep basins) also during earlier natural warm climate phases such as the Medieval Climate Anomaly. The INFLOW project has shown also that there is strong natural variability at millen-

nial to multi-decadal timescale which will have some impact on the future Baltic.

Modelling and sediment proxy results suggest that under future IPCC scenario of a global warming there is likely no improvement of bottom water conditions. Thus, the already taken measures towards a better Baltic Sea are insufficient to guarantee a healthier future for the Baltic Sea. Therefore nutrients loads, among other, need to be reduced in the future too in order to minimize the effect of sea surface temperature changes.

INFLOW (2009–2011) was one of the BONUS Research Programme (http://www.bonusportal.org/) projects that generate new knowledge in support of decision-making in the Baltic Sea region. It was funded by national funding agencies (e.g. Academy of Finland), the EU Commission and participating institutes. GTK coordinated the INFLOW project that had 9 partners in 7 countries of the Baltic Sea Region: Finland, Norway, Russia, Poland, Germany, Denmark, and Sweden. Further information about the INFLOW project can be found at: http://projects.gtk.fi/inflow/index.html

TOPCONS – TRANSBOUNDARY TOOLS FOR SPATIAL PLANNING AND CONSERVATION IN THE GULF OF FINLAND

by

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The Gulf of Finland is highly used transboundary waterbody in the northern Baltic Sea. It is strongly impacted by marine traffic, land use, riverine runoff and various environmental gradients (like salinity). The environmental problems include eutrophication and seafloor hypoxia among others. Recent studies suggest that ongoing climate change might increase environmental problems in the future. A need for common management approach has arisen from the trilateral co-operation between Russia, Estonia and Finland. Furthermore, implementation of the HELCOM Baltic Sea Action Plan and EU legislation require unified marine spatial tools.

TOPCONS is a new Finnish-Russian co-operation project that will develop innovative spatial (GIS/map based) tools for the regional planning of the sea areas in the Gulf of Finland, the Baltic Sea. The aim is to convey knowledge especially on the most diverse and sensitive areas, that are under anthropogenic pressure. These marine spatial planning (MSP) tools will improve management and sustainable use of marine resources, to ensure the wellbeing of the Baltic Sea.

TOPCONS gathers and utilizes both existing and new data on the geology, biology and human pressures in the eastern Gulf of Finland. The datasets will be combined in the GIS-environment. Selected sub-areas will be mapped and studied in detail (e.g full coverage MBE among other acoustic surveys), in order to investigate the correlation between geo- and biodiversity. One of the key research questions is, if the location of biologically diverse areas could be modelled based on environmental parameters like bathymetry, topography, seabed substrate and wave exposure. Harmonisation of methodologies, terminology and data are also an essential part of the project.

TOPCONS produces knowledge that can be directly utilized for the ecosystem-based managementof the seas. In the future, tools developed in the TOPCONS project can be expanded to cover wider sea areas, by including data on local conditions.

TOPCONS is co-ordinated by Kotka Maritime Research Centre. Other Partners are Finnish Game and Fisheries Research Institute, Geological Survey of Finland (GTK), University of Helsinki, A.P. Karpinsky Russian Geological Research Institute (VSEGEI), Interdisciplinary Expert group at St. Petersburg Research Centre of Russian Academy of Sciences (IEG SPbRC RAS) and Russian State Hydrometeorological University (RSHU).The budget of this three-year-

project is 1.7 million Euros, and it is financed by the European Neighbourhood and Partnership program (ENPI CBC) and the participating organizations in Finland and in Russia.

LONG-TERM CHANGES OF SEDIMENTARY PHOSPHORUS IN THE GULF OF FINLAND

by

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The environmental problems of the Baltic Sea include eutrophication, occasional algal blooms, seafloor hypoxia and hazardous substances. The enhanced eutrophication over the past decades is mainly due to anthropogenic nutrient loading. Internal loading from seafloor sediments might also enhance eutrophication, by providing nutrients into the water column. Recent studies suggest that ongoing climate change might increase environmental problems in the future. We have used surface sediment and long sediment core data to study environmental history and trends in sedimentary phosphorus, among other nutrients, in the Gulf of Finland, the Baltic Sea, over the past 6000 years or so.

We have studied long sediment cores and short surface sediment cores from tree Sites, from the western (Site JML), central (Site GF2) and eastern Gulf of Finland (Site F40). These open sea Sites are located in the water depths of 80, 84 and 38 meters, respectively. The short sediment cores were recovered using a GEMAX twin barreled gravity corer, and long sediment cores using a piston and a gravity corer. Detailed analyses of sediments include e.g. ICP-MS geochemical, total carbon, LOI, sediment fabric/structure and mineral magnetic studies. The age model for these sediment cores is based on AMS-^{14}C-, palaeomagnetic-, ^{210}Pb- and ^{137}Cs dating, and Pb-content records.

Results from sediment studies indicate that sedimentary phosphorus (total P) level (between around 700 and 1000 mg/kg) as well as C:P ratios varies over the past 6000 years. Distinct increase of total phosphorus in the uppermost sediment column, up to 3000 mg/kg, is clearly seen in the data. In this presentation we will discuss about possible effects of climate (change) on nutrient input and accumulation into the Gulf of Finland, and the role of the seafloor sediments in internal loading and eutrophication.

This work is a part of INFLOW project (2009–2011) that was one of the BONUS+ research programme (http://www.bonusportal.org/) projects that generate new knowledge in support of decision-making in the Baltic Sea region. The INFLOW project was funded by national funding agencies (like Academy of Finland), the EU commission and participating institutes.

Geologian tutkimuskeskus (GTK) coordinated the INFLOW project that had 9 partners in 7 countries of the Baltic Sea Region: A.P. Karpinsky Russian Research Geological Institute (VSEGEI), Russia; University of Szczecin, Poland; Leibniz Institute for Baltic Sea Research Warnemünde (IOW), Germany; Geological Survey of Denmark and Greenland (GEUS); Lund University, Sweden; Swedish Meteorological and Hydrological Institute (SMHI); Unifob AS,

Bjerknes Centre for Climate Research, Norway; Department of Geosciences and Geography, University of Helsinki, Finland

Further information about the INFLOW project can be found at:
http://projects.gtk.fi/inflow/index.html

BURIAL OF ORGANIC PHOSPHORUS WITH SEDIMENT IN THE FINNISH AND SWEDISH ARCHIPELAGO, THE BALTIC SEA

by

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Organic phosphorus (P) is abundant in the sediments of the Baltic Sea. Despite that part of it is mineralized and recycles dissolved P back to water column, part of organic P will be buried. Degradation of organic matter, and organic P, can continue relatively deep in the sediment, but mineralization – as well as reduction − induced transformation processes of P are most pronounced in the surface sediment layers. This is reflected by the decreasing organic and iron-bound P concentrations with sediment depth. It has been shown that reactive P is mainly buried as organic forms in the deep accumulation basins in the open Baltic. Although the Finnish and Swedish archipelago areas are relatively shallow, they have many sheltered basins that accumulate organic P transported from land or produced in the system.

In this study, we examined the vertical distribution of organic P in sediments of archipelago areas to get an overview on the significance of burial of organic P in these areas. Sediment samples were collected with a gravity-corer in the Finnish (63 sites) and Swedish (12 sites) archipelago. Concentration of organic P was determined using a sequential extraction method, which allows distinguishing between two fractions of organic P: labile, potentially mobile organic P and residual P, which is mainly refractory organic material. Smallest determined organic P concentration in the sample cores was assumed to represent the buried fraction.

The results show that in the studied 75 sediment cores, on average 30% of total P in the sediment surface layer was organic. The range in the whole core was 40−50%, being slightly higher in the Swedish archipelago than in the Finnish one. At all sites, organic P content was at least 10% of total P within the analyzed 20−60 cm depth layers. Assuming that sediment accumulation rate and quality of depositing material have not changed significantly, coarsely one third of organic P was buried in the small basins in the archipelago, while two

thirds of it (the more labile organic P forms) was mineralized and released from sediment to water, or transformed into other solid phase forms. Generally, the organic P fraction decreased with depth but, at some of the sites, the organic P fraction varied or even increased with depth. This indicates that the quality of the deposited material or the sedimentation rate may have changed at those sites during the examined time range. The fraction of organic P that was assumed to be buried was approximately the same in the two archipelago areas.

PALAEOGEOGRAPHICAL RECONSTRUCTIONS AND STONE AGE SETTLEMENT IN THE NARVA-LUGA KLINT BAY, EASTERN GULF OF FINLAND

by

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In early phases of cultural development human populations in the Baltic Sea region have been faced with significant marine transgressions and regressions due to the melting of the continental ice sheet and glacio-isostatic land uplift. Geoarchaeological studies in the southern Baltic Sea area have revealed a number of Mesolithic and Neolithic settlement sites lying at the bottom of the present-day Baltic Sea due to Holocene eustatic sea-level rise. In the northern Baltic Sea areas prehistoric coastal settlements have been uplifted and are located at a successively lower elevation due to glacial rebound. Our study area, the Narva–Luga Klint Bay in the eastern Gulf of Finland, is located in the transitional zone where prehistoric man was faced with transgressions and regressions of the shifting coastline due to competition between glacio-isostatic land uplift and eustatic sea-level rise. Narva-Luga Klint Bay is coastal lowland with slow land uplift and complex Holocene water-level changes with alternating lake and marine stages. Palaeogeographical reconstructions were made to help to describe and understand the development of the landscape and the Stone Age settlement in the area.

Shore displacement during Holocene in the Narva–Luga Klint Bay area was reconstructed by GIS-based modelling. Palaeo-water levels were interpolated in time and space by combining coastal landform elevations and relative sea level change curve data. Palaeo-terrain altitudes were calculated by subtracting the palaeo-water level surfaces from modern digital terrain model. Resultant shore line positions were corrected by Quaternary sediment maps and previous geological knowledge about the area. Palaeogeography was reconstructed for time

slices with significant landscape changes and developments of the Stone Age settlement.

The initial human settlement in the Narva–Luga Klint Bay was associated with the palaeo-Narva River. During the Littorina Sea regression the formation of a large semi-enclosed lagoon opened new possibilities for the development of coastal settlement in the area. The lagoon shores were preferred living environments for hunter-gatherer groups of the Mesolithic and Neolithic periods. After drying of the lagoon settlement concentrated along rivers.

EXPERIENCE OF USE OF MULTIRADIAL ECHOLOCATION IN THE EASTERN PART OF GULF OF FINLAND AS THE BASE OF RESEARCH AND MAPPING OF UNDERWATER LANDSCAPES AND MONITORING OF GEOLOGICAL ENVIRONMENT OF THE BOTTOM OF COASTAL SHOALS

by

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In 2011 in the frame of the project "State monitoring of the geological environment of the eastern Gulf of Finland" VSEGEI carried out detail survey of the sea bottom within the key area situated in the Vyborg Bay using multibeam echosounder «Simrad-EM 3002», side-scan sonar Edge Tech 4200 SP and device for measurement of a sound speed in water SVP-14.

The study area is characterized by some unique features. Several pock-marks up to 10–15m in diameter have been found on bottom surface. This fact testifies active geological processes which have caused their occurrence. The northwest part of the chosen area is characterized by active anthropogenic influence.

The 3D image of the bottom surface performed as a result of the presented work allows to reveal the details of underwater bottom relief and distribution of surface bottom sediments (Fig. 1). The area is characterized by various sedimentary conditions from zones of active bottom erosion of glacial till outcrops to zones of silty-clayey sedimentation. Considering significant variety of facial conditions of sedimentation within limits of the area, the received materials will be a basis for large-scale mapping of subaqueous landscapes on the basis of abiotic factors. Appearance of zones of abnormal bioproductivity and development atypical biocoenosis it is possible to expect in view of mentioned above pock-mark and ferromanganese ore-formation within small area. Chosen key area has a doubtless scientific significance from the point of view of studying of an ecological condition of an environment of Gulf of Finland and a biodiversity.

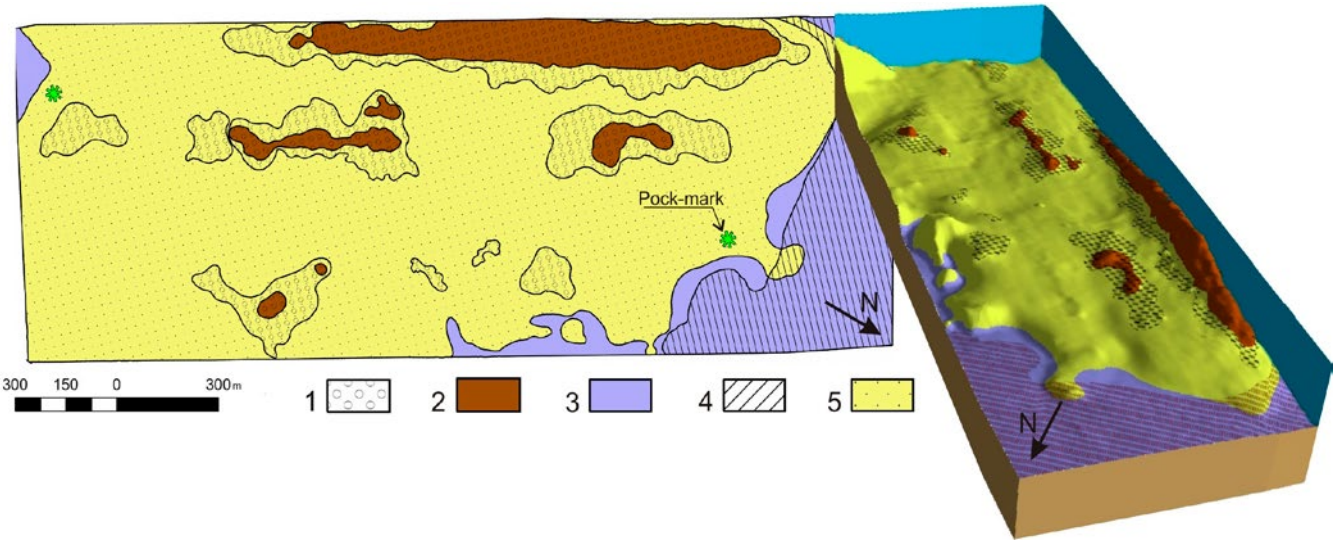

Fig. 1. The scheme of distribution of superficial bottom formations.
(1-boulders, 2-boulders, rubble, gravel, 3-sands, 4-aleuro-pelits, 5-zone of technogenic influence)

PREPARATION FOR CCS IN FINLAND – CARBON CAPTURE AND STORAGE PROGRAM (CCSP)

by

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Finland is aiming at reducing its CO_2 emissions by more efficient energy use, more nuclear power, more use of renewable fuels and through Carbon Capture and Storage (CCS). CCS is a climate change mitigation tool which captures the CO_2 emissions from power plants and industrial processes, transports them via pipeline or shipping, and then permanently stores the captured CO2 in depleted oil and gas fields or deep, underground saline formations or other suitable underground layers.

The first Finnish CCS project was called "Application of carbon capture and storage in Finland (CCS Finland)" and ran from 2008–2010. CCS Finland focused on solutions conceivable in the Nordic geographical location and for the energy infrastructure of Finland. The project was mostly concerned with commercial applications and with the most potential capture methods in the near and mid-term future. The outcome of the project was a roadmap to application of CCS in Finland.

Based on the CCS Finland studies the largest point sources of CO_2 emissions in Finland are power plants, oil refineries and heavy industry, which are all situated in the coastal region. It seems that CCS will not be offering an easy answer for Finland because there is no suitable geological formation for long-term storage of CO_2 in the predominantly crystalline bedrock of Finland. Transportation of CO_2 out of Finland will thus play an important role in the application of CCS, due to large distances to areas with high potential for storage. Depending on the geography and on the transportation distance required, marine transportation could, at least in the beginning, be a cheaper solution compared to pipe transport. This transportation will require development of terminals, ships, intermediate storages and especially procedures and legal options concerning cross boarder transportation. Mineral carbonation could also in the future offer an alternative for Finland.

The current Finnish CCS Program (CCSP) started in March 2011. The CCSP program objective is to develop CCS-related technologies and concepts, leading to essential pilots and demonstrations by the end of the program 2014–2015. A further objective is to create a strong scientific basis for the development of CCS components, concepts and frameworks, and to establish strong international networks that enable active international CCS co-operation. Potential for the geological storage of CO_2 in the Baltic Sea region will be more deeply studied in the program.

COMBINED LAND- AND SEA-BASED GEOLOGICAL MAPPING ALONG THE COASTLINE OF SKÅNE

by

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During 2012, the Geological Survey of Sweden (SGU) is conducting a combined land- and sea-based geological mapping along the coastline of Skåne, southern Sweden. The aim of the mapping is to produce geological information for, e.g., erosion risk assessments in relation to future sea level changes, beach classifications in relation to marine pollution response, a better understanding of coastal sediment transport patterns as well as physical and marine spatial planning in general. The geographical limits for the mapping are 200 m within the present shoreline and/or areas below 3 m above present sea-level on land, and approximately 500 m outside the present shoreline at sea, all depending on local conditions. The methods involve, e.g., conventional land-based geological field mapping, analyses of the new Swedish height model, analyses of LIDAR-data, acquisition of Multibeam-, Swathsonar-, Side-Scan Sonar-, Sediment profiler- and Seismic-data as well as ground-truthing. Here, the preliminary results from the investigations are presented.

THE KATTEGAT READVANCE

by

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Evidence is presented in this poster that the Low Baltic ice stream created a readvance and entered the southern Kattegat and reached the coastal area in the Halland province about 14 300–14 500 cal years BP.

During the Weichselian maximum the ice movement was from the northeast in southwestern Sweden and Denmark. The ice marginal became thinner during the deglaciation. By this thinning the South Swedish Highland became an obstacle and directed the flow into a new path mainly following the Baltic basin morphology – the Low Baltic ice stream. This ice stream created an easterly ice movement within the southwestern margin of the Scandinavian Ice Sheet.

From a Danish perspective this ice stream initially influenced the southern part of Denmark. As the ice stream became stronger it gave rise to the Baelthav readvance followed by a readvance through the Öresund area into the southern Kattegat. This later event is here named the Kattegat readvance. Huge amounts of erratic clasts, mainly flint, with provenance from the Öresund area were transported by this ice stream into the Kattegat and the Halland province. Seismic profiles of the stratigraphy within the southeastern Kattegat show clay strata rich in coarse clasts and glaciotectonical deformed strata upon undisturbed glaciomarine clay deposited during the deglaciation of the ice from the northeast. The deposition of the erratic clasts from the Öresund area is dated by 30 radiocarbon shell datings, which show that the Kattegat readvance protruded the Kattegat and reached the Halland province about 14 300–14 500 cal years BP.

There are several earlier reports which describe a transgression in the Skåne and Halland provinces. This transgression most probably was caused by flooding following the formation of the marginal glacial lakes to the east of the ice during the Kattegat readvance.

INTERANNUAL, DECADAL AND LONG-TERM VARIATIONS IN THE WAVE FIELDS AT THE LATVIAN COAST OF THE BALTIC PROPER

by

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Recent analysis of long-term visual wave observations and numerical hindcasts for the Baltic Sea has exposed an interesting spatial pattern in long-term trends and decadal variations in several wave properties (Soomere & Räämet 2011). While the overall wave intensity in this basin apparently has not experienced considerable changes since the 1970s, certain wave properties evidently have undergone significant decadal and long-term variations in different parts of the Baltic Sea. These local and regional changes, which optionally involve extensive alterations in the typical wave approach directions, may be responsible for a number of reported coastal damages and variations in the intensity of coastal processes.

Most of numerically hindcast sizeable changes have occurred in domains that are not covered by wave measurements or observations. A key area in the central part of the Baltic Proper where long-term wave hindcasts suggest a major increase in the wave height over the last decades is the nearshore of the Kurzeme Peninsula (Soomere & Räämet 2011). We present an analysis of recently digitized data of visual wave observations from this area (Ventspils, Latvia, 57°24'N, 21°32'E), covering the years from 1954 to 2011. The observation site is open for a wide range of wave approach directions (from SW to NE). The basic characteristics of the local wave climate at Ventspils (such as the long-term average wave height, empirical distributions of wave heights and periods) match the current knowledge about the basic wave properties in the region, obtained from numerically reconstructed wave properties for the entire Baltic Sea for the years 1970–2007 based on the third generation wave model WAM Cycle 4 and adjusted geostrophic winds.

A comparison of the temporal course of the wave height with the similar data from other wave observations sites at the eastern Baltic Sea coast (Vilsandi and Pakri in Estonia, Nida in Lithuania) reveals several peculiarities in the interannual, decadal and long-term variations of wave properties in different part of the Baltic. Relatively short-term interannual changes are almost coherent along the entire coast. Decadal changes may be completely different for the southern and northern part of the Baltic Proper. The formal linear trends persist for a few decades but are strongly masked by decadal and especially extensive interannual variability. The strongest increasing trend is evident at Ventspils in 1970–2007 in both visually observed and numerically simulated wave data. The observed data

shows, however, that an equally steep decrease in the wave heights occurred at this site in the 1950s and the 1960s. No statistically significant trend in the annual mean wave height exists at any of the observation sites for longer than two or three decades. This feature suggests that although wave properties may have exerted significant decadal changes in different sub-basins of the Baltic Sea, the long-term properties of the Baltic Sea wave fields have remained essentially the same over the last half century.

REFERENCE

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DEFORMATION OF CAMBRIAN BLUE CLAY IN THE COASTAL ZONE OF EASTERN GULF OF FINLAND

by

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During the Soviet era, Russian researchers mapped geologically the eastern part of Estonian coastal waters (Gulf of Finland, east of 27°E). Marine geological investigations were resumed recently by the Geological Survey of Estonia in the course of 1:50 000 geological mapping of the NE part of Estonian mainland. A 217 km set of profiles was made in the area using seismo-acoustic profiling system EdgeTech 3200 XS, and controlled by 59 grip scoop samples.

As a result, a surprisingly wide (2–3 km) area of outcropping Lower Cambrian sediments was revealed in the nearshore area of eastern Gulf of Finland. Lower Cambrian Blue Clays with relatively few interbeds of siltstones and sandstones typically show a faint sub-horizontal pattern of seismic reflections. Here, sometimes, even layering was substituted by "hilly" structures of unknown origin.

Possible analogues of such structures on the Estonian mainland are found between Sillamäe and Narva (*e.g.* so-called Vaivara Sinimäed (Vaivara "Blue Hills")), but also in Ivangorod and in southern suburbs of St. Petersburg, Russia (*e.g.* Dudergof Heights, Popovka River). All these dislocations are situated a few kilometres "behind" the Baltic Klint. Geologists have discussed the origin of these upheaval disturbances for almost 200 years.

Historically oldest theory to explain these dislocations – tectonical – is almost forgotten at the moment. Nowadays most researchers look at these structures as of glaciotectonic origin, mainly as glacial megablocks or rafts transported by the glacier from the edge of the Klint to the present location. The discovery of deformed bedrock in the coastal sea, north of the Baltic Klint, does not allow overlooking the tectonic processes and/or amounts to strong evidence in favour of a third theory of diapiric origin.

According to this concept, uneven vertical load of glaciers during the decay of last glaciation forced weakly lithified Cambrian claystones into anticlinal folds like salt diapirs. Authors suggest that the process probably took place during multiple glacial advances. It was triggered by the existence of tectonic faults fracturing both the Lower Cambrian clay and competent Ordovician limestone cover. Such faults performed also as pathways routing highly pressurised subglacial water to the deeper parts of clay, thus increasing the ability of latter to swelling. Active moving of glacier surely added to the final/reshaping touch up of structures, but even then the main direct glacial effect was short-distance squeezing of composite ridges, not long-distance transport of huge erratics.

The research was financially supported by the Estonian Science Foundation grant No. 7860.

SPATIAL AND VERTICAL DISTRIBUTION OF SEDIMENT PHOSPHORUS FORMS, NORTHERN BALTIC SEA ARCHIPELAGOS

by

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Anthropogenic nutrient loading has enhanced accumulation of phosphorus in the sediments of the Baltic Sea archipelago areas during the past decades. Phosphorus release from sediment, so called internal loading, is probably keeping up high nutrient levels even in shallow areas counteracting mitigation of eutrophication. Previous studies on phosphorus in the Baltic Sea sediments concentrate mainly in the open sea; there are only few studies concerning sediment phosphorus in the northern Baltic Sea archipelagos. However, the sedimentary environments in the shallow and mosaic archipelago areas differ distinctively from those in the open Baltic Sea. Accumulation of organic and fine grained sediment is common in shallow coastal areas in the shelter of islands, whereas strong bottom currents maintain erosion in deep troughs between the islands. Degradation of the settling organic matter increases seasonal hypoxia, which in turn causes phosphorus release by reduction of iron oxides.

Spatial and vertical distribution of phosphorus was studied by analysing sediment samples from 380 stations of different seabed substrate types, in the archipelagos in Sweden and Finland. Sequential extraction method was applied to investigate the distribution of different phosphorus forms in the sediments. The fractionation was used to evaluate the potentially mobile pool of phosphorus, i.e., how much phosphorus may be released for primary production. The results to be presented reveal the areas of intense phosphorus release in the archipelagos, and give indication on the overall sediment phosphorus contents in the study area. This information can be used when estimating required reductions in anthropogenic nutrient loading and targeting the reductions to areas where they are the most cost efficient. The information should be exploited in coastal and marine planning to obtain a healthier Baltic Sea.

RECONSTRUCTION OF POST-GLACIAL ENVIRONMENTAL HISTORY AND STONE AGE SETTLEMENT BY THE TÕRVAJÕE BASIN IN NARVA–LUGA KLINT BAY, NE ESTONIA

by

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The Tõrvajõe basin is located in NE Estonia in the Estonian part of the Narva–Luga Klint Bay, between the Baltic Klint and Sininõmme costal dunes. Narva–Luga Klint Bay is characterized by slow post-glacial isostatic uplift (about 0–1 mm/yr) and slowly undulating low topography (0–11 m a.s.l). Changes of the water-level of the Baltic basin have at times flooded the area, and at times, it has emerged as terrestrial land. Oscillations of the water level were accompanied by different beach processes like formation of near shore spits, bars, dunes and smaller water bodies, e.g. the Tõrvajõe basin, behind them. The Tõrvajõe area is particularly interesting for reconstruction of palaeoenvironmental history because of abundant archaeological findings around the basin, of which the oldest is from the Mesolithic period around 8.5 cal ka BP and the majority, indicating very intense habitation, from the Neolithic period.

The aim of this research is to investigate and associate paleoenvironmental conditions and water-level changes with Stone Age settlement pattern in the Tõrvajõe area. Development history of the basin was studied using lithostratigraphy, pollen, diatom, and loss-on-ignition analyses, radiocarbon dating, and GIS-based palaeogeographic reconstruction. Results show four developmental stages in the postglacial history of the basin: Ancylus Lake lagoon, mire, freshwater lake/lagoon during the Litorina Sea and mire. During the Ancylus Lake transgression at about 10.8–10.2 cal ka BP a spit started to form north of the basin and a lagoon evolved behind it. Later, in relation to the Ancylus Lake regression, the basin dried up. Formation of paleosoil and fen peat started to take place in higher areas from about 9.1 cal ka BP. Findings of fishing tools and an elk antler from the Siivertsi site, indicate human activity in the Tõrvajõe area already during the Mesolithic period. Recent datings (ca 8.0 cal ka BP) from the antler and the overlaying peat layer discard the previously proposed idea of a boat accident on the Ancylus Lake lagoon, and relate the finds with suggested settlement by Narva River palaeostreams during the Early-Litorina Sea water-level low-stand. During the Litorina Sea transgression at about 8.5–7.3 cal ka BP the Tõrvajõe basin filled again with water. It is debated whether the basin had a connection with open waters during the Litorina Sea stage or not. Diatom analysis results indicate freshwater conditions with appearance of a few brackish water species. Large influx, and therefore also outflux rates of the Narva River water must have restricted penetration of Litorina Sea water into the basin

even in case of a connection. The sheltered shores of this freshwater lake/lagoon were favourable living environments for Neolithic people between ca 7.1–6.0 cal ka BP as appears from the 14 Neolithic settlement sites found around the basin. Due to continuous land-uplift the lake/lagoon started to overgrow again at 6.0–5.5 cal ka BP. This caused the people to abandon the Tõrvajõe area and establish new settlement sites in more northern localities which mostly concentrated along the ancient rivers in Narva–Luga Klint Bay.

A NEW HOLOCENE SHORE DISPLACEMENT CURVE FOR THE NARVA–LUGA AREA, EASTERN GULF OF FINLAND

by

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Based on geological and archaeological proxies from NW Russia and NE Estonia and GIS-based modelling, Holocene shore displacement in the Narva–Luga Klint Bay area in the eastern Gulf of Finland was reconstructed. A set of 45 previously published and 20 new radiocarbon dates from sediment sequences and archaeological sites, as well as the palaeoshoreline elevations, were used for the reconstruction. The shore displacement curve displays three regressive phases in the Baltic Sea history, interrupted by the Ancylus Lake (*c.* 10.9–10.2 cal. ka BP) and Littorina Sea transgressions (*c.* 8.5–7.3 cal. ka BP) with magnitudes of 9 and 8 m, respectively. The results show that the highest shoreline of Ancylus Lake at an altitude of 8–17 m was formed around 10.2 cal ka BP and that of the Littorina Sea at an altitude of 6–14 m, around 7.3 cal. ka BP. Reconstructed relatively slow Littorina Sea level rise and its acceleration around 7.8–7.6 cal. ka BP is in good agreement with the shore displacement curve by Yu et al. (2007) from SE Sweden and related probably with the final decay of the Labrador sector of the Laurentide Ice Sheet. Around 7.3 cal. ka BP relative sea-level rise turned into sea level fall due to deceleration in eustatic sea-level rise and continuing land uplift. This deceleration can also be observed in the southern Baltic (Lampe et al. 2011), as well as in the North Sea basin (Behre 2007), manifesting the end of the melting of large ice sheets in the Northern Hemisphere. Our study could not provide additional evidences of small-scale transgressions in the eastern Gulf of Finland as described by Sandgren et al. (2004) and Miettinen et al. (2007). In the conditions of slowly and almost linearly rising sea level the initial faster relative sea-level fall took place in the Narva–Luga area between 7.3 and 5.0 cal. ka BP. Together with gradual decrease in shoreline tilting gradients, this indicates the exponential-like decay in isostatic rebound.

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RECONSTRUCTION OF EASTERN LITORINA SEA COASTAL ZONE WITHIN ST. PETERSBURG (7700−4500 CAL. YR BP) BASED ON RESULTS OF THE ARCHEOLOGICAL SITE OKHTA-1 STUDY

by

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Easternmost coast of the Gulf of Finland in the range of St. Petersburg is one of the most difficult objects for paleogeographical reconstructions due to very high level of anthropogenic transformation of surface relief and upper part of geological sequence during 300 years of city development. From this point of view it is difficult to overestimate the importance of the archeological site Okhta-1, which was found in 2008 during protective archeological excavations by North-Western Research Institute of Cultural and Natural Heritage in the centre of Saint-Petersburg at the confluence of Okhta River with Neva River. As a result of the research numerous cultural remains of an ancient settlement were discovered. The archaeological collection of the monument consists of about 12 000 items. It contains several groups of pottery, a wide variety of stone tools, jewelry made of amber, wood and bark. Joint geoarcheological investigations of this archeological site allowed to make much more clear conception of regional development of St. Petersburg area during Late Holocene. During first transgressive-regressive phases of Litorina transgression (7700–6500 cal yr BP) within significant part of St. Petersburg area a lagoon system has been formed. The lagoon was separated from the open sea by Ligovskaya sand spit of 10 km long and up to 1.5 km wide (Fig.1). During beginning of Litorina regression area of archeological site Okhta-1 was situated in the northern part of paleo-lagoon, near paleo-strait. Inner lagoon coast was favorable to first appearance of Neolithic people here about 6150 cal BP. By the time 5500 cal BP, as a result of Litorina regression, central and southern part of study area were drained. Several small river flows acting periodically were characterized by high energy, formed local alluvial deposits. In the south-western part of study area the sand bar was separated from the mainland by fluvial channel, where Neolithic wooden constructions, numerous ceramic fragments and stone tools were found. Between 5200 cal yr BP and 4500 cal yr BP a new transrgessive-regressive stages are fixed. Due to stabilization of the sea level the shoreline within study area again be-

came favorable for dwelling and fishing activity of ancient people. Within lower (near-shore) part of study area the fishing zone was situated, within central "hill" – inhabited zone during Early Metal period. Investigations were support by RFBR grant 12-05-01121-a.

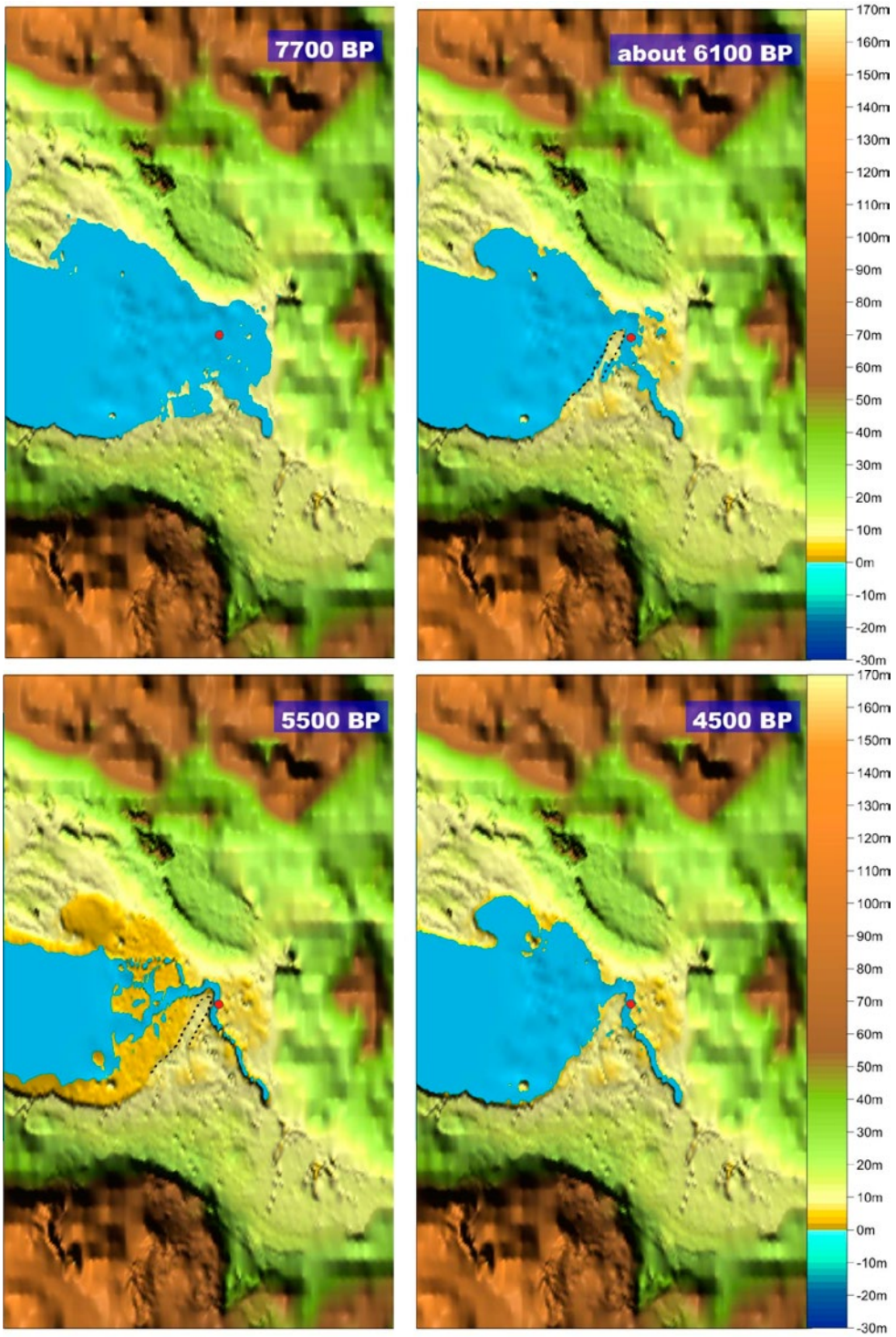

Fig. 1. Scheme of the coastal lines for different phases of Litorina Sea development. Area of Okhta-1 archeological site is marked by red point

NEW DATA ON THE NEVA RIVER ONSET – RESULTS OF INFLOW PROJECT FOR THE EASTERN GULF OF FINLAND (THE BALTIC SEA)

by

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Problem of the Neva River (a huge stream between Ladoga Lake and the Baltic Sea) onset is still one of the debatable questions of the Gulf of Finland Holocene geological history. According to different authors the dates of its possible forming varies in wide range – from late Pleistocene to 1500 cal. years BP. All previously available geological data about the Neva River formation are indirect as they are based on onshore sedimentologic sequences analyses.

New data about Holocene geological history of the Baltic Sea was received during INFLOW project ("Holocene saline water inflow changes into the Baltic Sea, ecosystem responses and future scenarios", 2009−2011) in the frame of the BONUS research program. Several long sediment cores along the Baltic Sea transect from Skagerrak to the eastern Gulf of Finland were taken. Detailed grain-size, chemical, pollen, sedimentary fabric (including ichnofossils), mineral magnetic, palaeomagnetic and radiocarbon analyses were performed from sediment core of F40 key-site, located in the local sedimentation basin of the eastern Gulf of Finland. The results allowed to fix the number and intensity of transgressive-regressive phases and long-term inflows of saline waters to the Gulf of Finland during Littorina and post-Littorina time of Late Holocene.

At the core depth of 205−208 cm a significant change of all chemical and physical parameters was discovered. Complete difference in ichnofauna below and under this boundary, and significant decrease in bromine (Br) content (as an indicator of palaeosalinity), among other observed changes, allowed to interpret this layer as sediment layer formed after the Neva River onset. Radiocarbon and palaeomagnetic analysis suggest an age of about 3100 cal. years BP for this event.

THE RISE AND FALL OF SURFACE SEDIMENT PHOSPHORUS RETENTION FOLLOWING A PERIOD OF OXYGENATION

by

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The retention of phosphorus (P) in sediments is a fundamental process controlling the eutrophication of the Baltic Sea coastal zone, as a small decrease in sediment P retention can result in dramatic increases in water column P concentrations. Because iron oxides bind phosphate, oxygen can regulate sediment P retention; consequently, oxygenated surface sediments improve sediment P retention. However, the oxygen status in Baltic Sea coastal sediment is dynamic. Recently, a period of oxygenation has occurred in many of the deeper basins in the Svealand archipelago. Although these processes are vitally important for sediment P dynamics, few measurements of the build-up and losses, in situ, of redox sensitive P exists in literature. Here, we present data on P accumulation in surface sediments during an oxic period. We found extremely high P concentrations in the top 2 cm of sediment (8 mg P/g DW), which are primarily explained by accumulation of Fe-P. In 2011, the sediment became anoxic, and the majority of this P fraction was lost. Our data demonstrate the importance of oxygen in controlling sediment P retention, and provide unique in situ measurements of P accumulation and release.

NEW DATE CONCERNING A GEOLOGICAL STRUCTURE OF THE CURONIAN SPIT AND ITS SUBMARINE COASTAL SLOPE

by

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The Curonian Spit is the biggest sand accretion form in the Baltic Sea. It's located on Russian and Lithuanian territory. A total length of the Spit is 100 km, a width varies from 0.5 km to 3.5 km. The Spit separates a freshwater lagoon from the sea, its name is Curonian Gulf (Fig. 5).

The Curonian Spit is an ephemeral form from the moment of its formation in the Holocene, because of hydrodynamic and aeolian activities, and also a fluctuation of the sea level. By this moment almost whole territory of the Spit has been stabilized by a human, except open dunes on the gulf's coast, which are subjects to sand migration.

The Spit was generated on a glacial accumulative plain, forming barrier spits between glacial islands. The modern relief of the Spit has the local surface lower areas, originated from the valleys of ancient rivers that existed here before the formation of the Spit. Glacial deposits are eroded on a sea bottom, forming a boulder bench. At the first stage of the development the Spit was located far to the west. Silty muds was accumulated in a lagoon, behind of the Spit. Nowadays there are outcrops of dense deposits with high organic content at the bottom at a depth of 5−15 m, so-called "lagoon marls" (dated as 5510−6260 cal.BP) (Figs. 1 and 4).

A geological structure of the Curonian Spit on Russian territory has a low exploration maturity. The geological investigation of the Curonian Spit and its underwater slope was carried out by VSEGEI in the summertime 2011. It affords an opportunity to refine on the current conceptualization of the geological structure and the developmental history of the Curonian Spit in the Holocene. The investigation consisted of the GPR (Ground Penetration Radar) profiling on the land, the seismic-acoustic profiling (Fig. 4) on the submarine coastal slope and field observation on the beach and shallow water. The new date of the Spit's structure and submarine coastal slope were got; also the outcrops of ancient peats were detected on a shallow water by a shore line (Figs. 2 and 3).

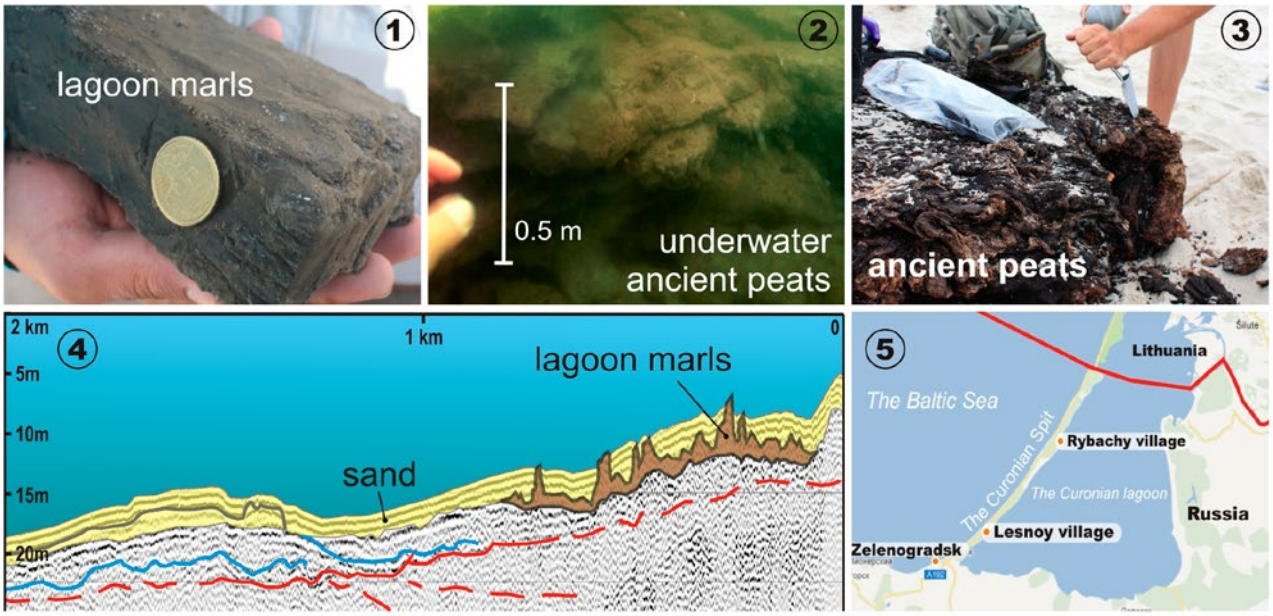

Fig. 1 The sample of the lagoon marls.
Fig. 2. The outcrop of ancient peats at submarine coastal slope.
Fig. 3.The fragment of ancient peats on the beach.
Fig. 4.The seismic-acoustic cross-section of the submarine coastal slope of the Curonian Spit near Lesnoy village.
Fig. 5.The schema of area of the investigation.

ECOLOGO-GEOLOGICAL ZONING OF THE EASTERN GULF OF FINLAND AND ITS COASTAL ZONE

by

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The Baltic Sea is characterized by exceptional hydrographic and ecological features and high sensitivity of its living resources to changes in the environment. At the same time, vigorous economic activities and coastal zone development takes place. There has been a rapid increase in cargo turnover through the ports located in St. Petersburg and Leningrad Oblast. Active development of the transport complex is accompanied by elevated environment load that can result in accidents and waters area pollution.

Another important factor affecting the geological environment of the Baltic Sea and its part, the Gulf of Finland, is the construction and operation of the North European gas pipeline.

On the map of ecologo-geological zoning of the eastern Gulf of Finland shows water areas and coastal zones, where the manifestations of unfavourable geological and anthropogenic phenomena and processes are more possible. This probability is determined from a sum of features indicating the status of the geological environment, or ecologo-geological criteria. There are direct and indirect features indicating the geological environment upset. Indirect indicators are those, which largely determine the ecological state of the geological environment, but at the same time they are not direct indicators of its deterioration. Direct indicators reflect the real violation of the ecological system status and are direct indicators of environmental disturbance. Mapping various ecological and geological criteria for the water area allows its assessment as regards the environmental risk and identification of areas, where the disturbance of geological environment is most probable.

Thus, the ecologo-geological map or map of environmental geological zoning means the mapping of ecologo-geological criteria such as geological targets, phenomena and processes, as well as the results of human activities affecting or those that can affect, under certain conditions, the ecological status of the geological environment.

Main criteria for zoning the eastern Gulf of Finland and its coastal zone are as follows: I. Engineering and geological indicators of geological situation; II. Litho-dynamic indicators of geological environment; III. Natural processes and phenomena in the coastal zone; IV. Geochemical indicators of geological situation; V. Hydro-geochemical indicators of the geological situation; VI. Indicators of anthropogenic stress.

CAPACITY AND RESERVOIR PROPERTIES OF PROSPECTIVE FOR CO_2 GEOLOGICAL STORAGE BALTIC SEA STRUCTURES

by

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Baltic countries are located at the Baltic sedimentary basin, a 700x500 km synclinal structure. Prospective for CO2 geological storage (CGS) Cambrian structural traps, represented by Cambrian sandstones with good reservoir properties and clayey cap rocks, occur in Latvia. Until now CO2 storage capacity of 16 onshore largest Latvian structures was estimated and reported as 400 Mt. This study is focused on E6 and E7 structures located in the Liepae offshore area of Latvia, one of the biggest (6000 km2) tectonic elements of the offshore part of the Baltic syneclise. According to old exploration data these structures were estimated as prospective for gas storage.

The E7 offshore structure is located 85 km far from the Latvian cost. Cambrian Deimena Formation, 57.5 meters thick fine-grained quartzite sandstones are interlayered by some mm to 3–4 cm of black clayey rocks. The absolute depth of the top of the Deimena structural trap is 1389 m, and estimated by seismic data area is 39 km2. The best reservoir properties among two studied structures are found in the offshore structure E6, located at 37 km from the Latvian cost. Oil-impregnated sandstone occurs in the 53 m thick Deimena Formation, absolute depth of its top is 875 m, and estimated area is 560 km2.

Reservoir sandstones from the both structures were sampled in two boreholes. Chemical and mineralogical compositions of 15 reservoir rocks samples were studied by XRF, XRD and SEM analyses. Porosity, permeability and seismic velocities were measured in IFPen and compared with exploration data. Permeability of the reservoir rocks from the offshore structure E6 is 9–440 mD, while in the E7 structure permeability range (0.1–170 mD) is wider. Previous average porosity value for the E6 structure was 21%, but the new measured average porosity is 25%, reaching up to 33% in some samples. Measured porosity for E7 structure is in a range of the previous average values (13%).

CO2 storage capacity of the structures was estimated with different reliability (conservative and optimistic). Low storage efficiency factor (4% for both structures) was used for conservative estimation, while higher values (10% for E6 and 20% for E7) were applied for an optimistic case. Both conservative and optimistic capacities were calculated using different values of reservoir rock porosities (minimum, maximum and average). Estimated optimistic CO2 storage capacity was 230–430 Mt in the E6 and 25–60 Mt in the E7 structure. Conservative CO2

storage capacity was 90−170 Mt in the E6 and 5−12 Mt in the E7 structure.

According to our results the offshore structure E6 is the most prospective for CO2 geological storage in the Baltic region. Its conservative capacity (160 Mt) is the largest among all Latvian onshore and offshore structures studied so far. Optimistic maximum capacity of two offshore structures (430 Mt in E6 and 60 Mt in E7) is larger than total capacity of the 16 onshore Latvian structures (400 Mt). Updating of CO2 storage capacity in the Baltic Region and their reservoir properties is important for researchers, policy makers and regulators and stakeholders taking decisions about demonstration and industrial CGS projects. Obtained results give new capabilities for economic and geochemical modeling of regional cross border capture-transport-storage scenarios in the Baltic Sea Region.

THE LITTORINA AND POSTLITTORINA BOTTOM CURRENTS VARIABILITY IN THE BORNHOLM DEEP

by

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The new data on bottom currents activity during the Littorina and Postlittorina stages is presented on the basis of grain size analysis of the sediment core 303770 (1040 cm length, depth 91m), which was retrieved during a cruise of RV 'Poseidon' in 2005 and analysed in the frame of the INFLOW project (Fig. 1). Sampling at 2 cm interval and using a Fritsch laser analyser 'Analysette-22' for grain-size analysis allowed detailed sediment fractionizing through the core. Organic matter was eliminated from the analysed samples by soaking in a solution of H_2O_2. Sodium tripolyphosphate and ultrasonic cleaner "Laborette 17" were used for particle dispersing.

According to palynological analysis the sediments from 21 to 750 cm are typical Littorina Stage mud deposited during three climatic periods: the Atlantic (750–440 cm), the sub-Boreal (440–140 cm) and the sub-Atlantic (140–20 cm). Below 750 cm it is Ancylus lake deposits (Fig. 2). Average sediment accumulation rate according to results of palynological analysis is 0.99 mm/year.

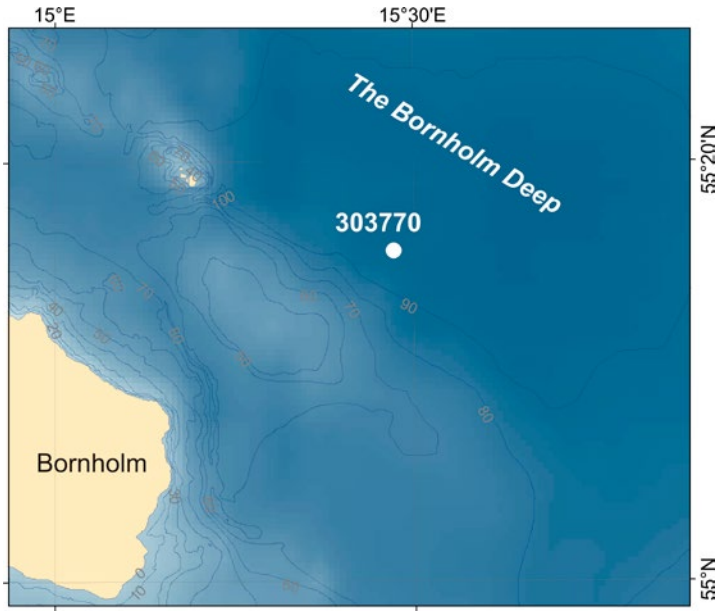

Fig. 1. Core 303770 location.

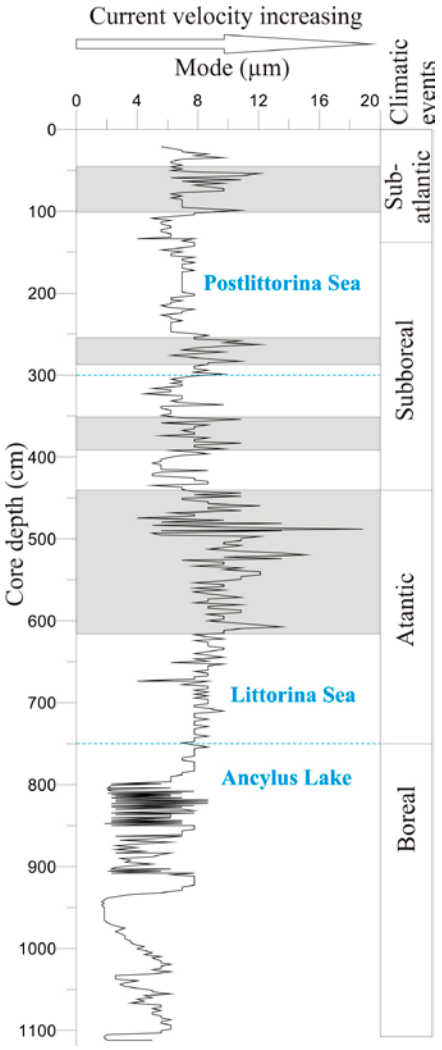

Fig. 2. Sediment modal grain size (Mo) and climatic periods of core 303770, grey color shows increasing of the bottom currents activity.

It is assumed that the grain size of fine-grained sediments reflect the velocity of the bottom current transporting suspended sediments. In conditions of relatively deep-water areas of silty-clayey mud accumulation, the grain size distribution of sediments is controlled mainly by so-called 'fractionation during deposition' of suspended matter. A higher bottom current velocity causes increases in silty-particle amounts and prevents deposition of the finest particles. Deposition of clay and fine silt mode are suppressed under bottom currents; therefore, the fine-silty grain size fraction is mostly sensitive to variations in bottom current velocity.

It must be taken into account that inference of temporal variation in the current velocity based upon downcore grain size analysis may be ungrounded if the sediment load composition was essentially changed during the period of sediment accumulation. However, the assumed stability of sediment load in the Bornholm Deep enables reconstruction of changes in the bottom current activity during the Littorina and Postlittorina stages using sediment grain size parameters. That is why we do not consider early stages which have another sedimentation conditions.

Increased current velocities in the Baltic Sea deeps take place during saline water inflows from the North Sea. According to the sediment grain size 4 events of bottom current increasing are distinguished in the Bornholm Deep during the Littorina and Postlittorina stages (Fig. 2). The longest event is observed on the middle of the Littorina stage. The last increasing of bottom current is related to the sub-Atlantic Chronozone (approx. 2000 years ago). There is a bottom hydrodynamic activity decreasing in the modern time.

NEW SEDIMENTOLOGICAL DATA FOR THE GDANSK BASIN AS A RESULT OF ENVIRONMENTAL MONITORING OF KRAVTSOVSKOE OILFIELD (D-6) IN 2003–2011

by

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New data on sedimentation conditions and organic matter distribution in the Gdansk Basin are regularly received since 2003 in the frame of industrial environmental monitoring of Kravtsovskoe oilfield (LUKOIL-KMN Ltd.) (Fig. 1). Echosounding and seabed acoustic profiling allowed specifying structure and thickness of Holocene mud in the Gdansk Deep, as well as revealing acoustical anomalies and pockmarks associated with high content of hydrocarbon gases in the mud.

Side-scan sonar profiling let to essentially detail bottom sediment distribution, and in combination with echosounding to study the location of ancient coastlines. Extensive areas of bottom erosion and dynamic sands with ripple marks were revealed in the coastal zone. In particular, outcrops of ancient lagoon mud were mapped near the Curonian Spit. Changeability of toxic metals (Hg, Pb, Cr, Cu, Cd, Ba) which are controlled according HELCOM recommendations in the surface sediments (0–5 cm) was evaluated. Regional background values for these metals were suggested separately by averaged data for clay and coarse sediments for geoecological purposes. Schemes of suspended matter distribution in the surface and sub-bottom water layers were created using mean values. Mean perennial locations of halocline and oxicline were specified. This study was supported by the RFBR 11-05-05051-b.

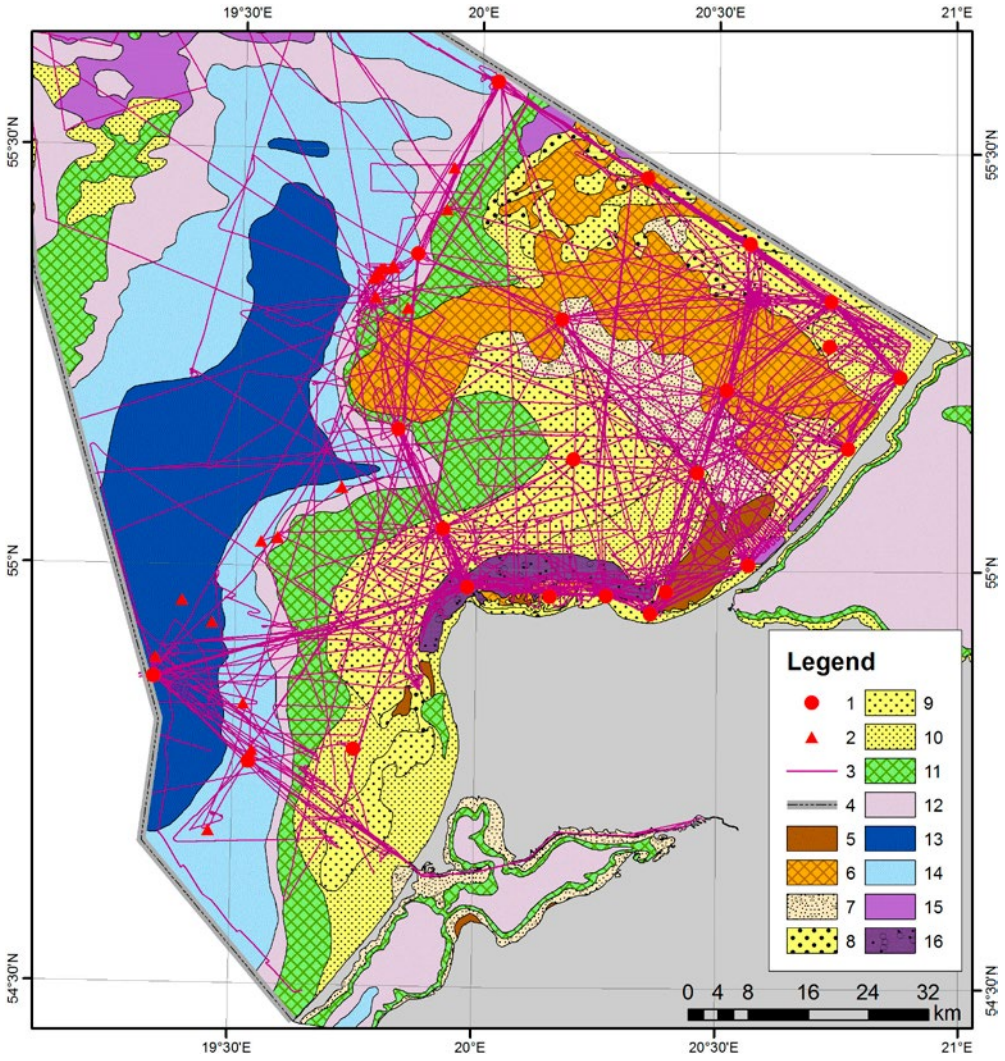

Fig. 1. Scheme of sedimentological data (2003-2011): 1 – sampling points of monitoring; 2 – other sampling points; 3 – acoustical profiles; 4 – Russian zone borders; types of sediments (Petrov 2010): 5 – boulders, pebbles, gravel; 6 – sands with pebbles and gravel; 7 – sands of various grain-size; 8 – coarse-grained sands; 9 – medium-grained sands; 10 – fine-grained sands; 11 – silty and clayey sands; 12 – clayey silty mud; 13 – clayey mud; 14 – silty clayey mud; 15 – submarine outcrops of Quaternary deposits; 16 – local outcrops of bedrocks.

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HYDRO ACOUSTIC DATA AS INPUT FOR DEFINING VEGETATION COVERED AREAS

by

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In 2009 and 2010 the Geological Survey of Sweden conducted a survey of the coastal part of Hano Bay adjacent to the county of Blekinge. The survey was part of the regular marine geological mapping programme. The aim was to produce maps and geospatial data showing the distribution of sediments with a resolution suited for a presentation scale of 1:100 000. Bathymetric data, side scan sonar, subbottom profiler and seismic profiles combined with ground truthing have been used to interpret the distribution of various types of sediments.

The Geological Survey of Sweden was commissioned by the Swedish Environmental Protection Agency to utilise the results and data from this survey in the EU-project Marmoni, The aim of Marmoni is to find innovative approaches for marine biodiversity monitoring and assessment of conservation status of natural values in the Baltic Sea. The work commissioned (within action A 4.2 of Marmoni) was to enhance the spatial resolution of the interpretation of the topmost layer of sediments beyond that normally done for marine geological maps and, further, to use the hydro acoustic data as indicator of vegetation-covered areas of the seabed.

Tentative results indicate that the hydro acoustic data routinely collected in the marine geological mapping programme can be used for establishing the distribution of vegetation if certain conditions are met.

ON THE STABILITY OF CURONIAN SPIT UNDER CHANGING WAVE CLIMATE

by

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The Curonian Spit is narrow sandy peninsula that is formed through intense wave-driven sand drift and extends from the Sambian peninsula (Russia) to Klaipeda in Lithuania. This fragile structure, with a total length of about 98 km and width of 0.4–4 km is under continuous impact of wind and waves. Because of its highly curved shape and the presence of a two-peak directional distribution of winds, it apparently is highly vulnerable with respect to potential changes in the wave propagation direction. Such changes have been recently detected for several parts of the Baltic Sea (Räämet et al. 2010, Kelpšaite et al. 2011).

We analyse potential alongshore sediment transport along the Curonian Spit under the existing and a selection of possible future wave climates, with the goal to quantify the vulnerability of the spit with respect to systematic changes in the wave approach directions. The potential transport rate is evaluated using the CERC model for a fixed grain size. The wave time series are modelled using the WAM wave model with a resolution of about 3 nautical miles, an extended spectral range for short waves and a temporal resolution of 1 hour for 1970–2007. The model is forced by geostrophic winds from the Swedish Meteorological and Hydrological Institute. Changes to the wave climate are simulated by systematically rotating the contemporary wave approach direction.

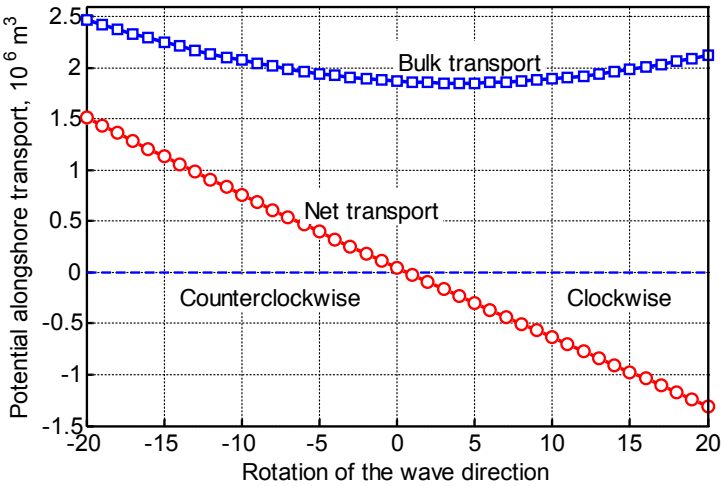

Fig. 1. Annual mean bulk (blue squares) and net (red circles) transport per coastal section along the Curonian Spit for rotated wave climates in 1970–2007.

The modelled overall potential net transport along the spit forms a very small fraction, about 1% of the relevant bulk transport (Fig. 1). Therefore, the spit is in an almost perfectly equilibrium shape under the existing wave climate. A systematic rotation of the wave approach direction leads to a linear increase in the net transport rate whereas the bulk transport rate insignificantly changes. A rotation by more than 10° results in disappearance of convergence points along the spit and possibly to substantial coastal damage. The damage apparently will depend on the direction of the rotation. A counter-clockwise rotation would lead to intense net transport to the north. The resulting sediment flow not necessarily damages the spit as the sediment deficit may be compensated by material eroded from the Sambian Peninsula. A clockwise rotation of the wave climate will eventually cause rapid erosion of unprotected sections of the beach because there would be no compensating sediment flux across Klaipeda Strait.

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RE-PROCESSING OF 2D SEISMIC REFLECTION DATA FROM THE BALTIC SEA

by

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During the 1970's and 80's Oljeprospektering AB (OPAB currently Svenska Petroleum) acquired large quantities of seismic data in order to better characterise the hydrocarbon potential of the Baltic Sea basin southeast of Sweden. These data consist of over 33000 km of 2D marine profiles from numerous surveys with varying acquisition parameters. Few of these profiles have been re-processed or re-interpreted since the original acquisition. However, in recent years this sizable 2D seismic data set has become available for scientific use through the Geological Survey of Sweden (SGU). Since significant advances in computer hardware and seismic data processing technology have been made since the late 80's we considered it worthwhile to revisit these data. As through re-processing and re-interpretation the data can potentially provide valuable constraints on the understanding of the stratigraphy and structure of the Baltic Sea basin, and help better characterise its resources. In this study, several short 2D seismic reflection lines from this dataset have been re-processed from raw shot gathers using modern techniques and computer hardware. A re-processing workflow has been developed which focuses on removing two significant forms of noise that are often present in the data, namely side scattered and multiple noise. FK filtering is used to attenuate side scattered noise, while deconvolution applied in the

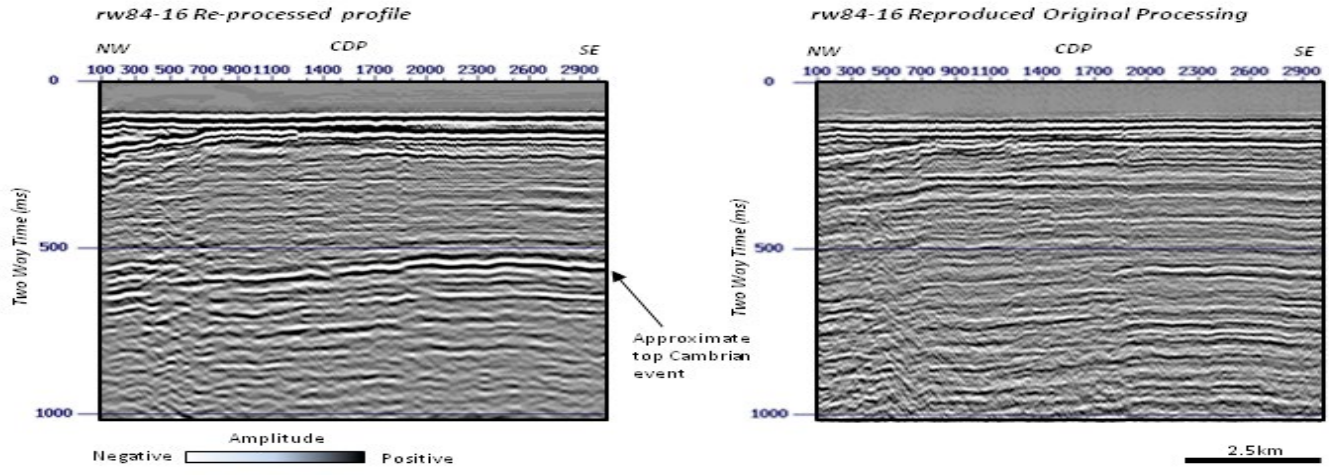

Fig. 1. Same subset of stacked seismic section, processed with revised processing sequence and reproduced original processing sequence from 1984.

tau-p domain and the parabolic radon de-multiple method are used to attenuate multiple noise. A significant improvement has been achieved in the final stacked images when compared to the reproduced original processing sequence (Fig. 1). As a result, a more confident interpretation of the sedimentary sequence can be made, which differs from the interpretation of the original data. Given the improvement we obtained, we are currently re-reprocessing several basin scale profiles within the Swedish Baltic Sea to better define the stratigraphy and to re-evaluate current geological interpretations.

We have reprocessed lines from a small part of a large dataset of 2D seismic reflection data acquired in the Baltic Sea. However, the potential benefits of a comprehensive seismic data re-processing program are wide ranging. Such a program could provide valuable information for a number of research areas. These include the evaluation of the CO2 storage potential in Scandinavia and the Baltic states, improving the understanding of Baltic Sea geology and evaluating remaining hydrocarbon potential.

GEOLOGICAL AND ENVIRONMENTAL RISKS FOR THE COASTAL ZONE OF THE EASTERN GULF OF FINLAND – OBJECTIVES AND FIRST RESULTS OF CLIPPLIVE PROJECT

by

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Study and prediction of coastal hazards is very important problem for the Eastern Gulf of Finland. Results of state monitoring of geological environment undertaken in 2004−2011 by specialists of the Department of marine and environmental geology of VSEGEI and State Geological Company "Mineral" has shown that the most intense exogenous processes observed within the easternmost part of the Gulf of Finland coastal zone, mostly belongs to St. Petersburg city.

Monitoring study carried out during autumn and beginning of winter 2011−2012 serious has revealed an intensification of coastal processes as a result of extreme storms. In the Eastern Gulf of Finland 26−28 of November and 23−31 of December a storm surge (with wind speed up to 24−28 m/s and water level outside St. Petersburg Flood Protection Facility up to 235 cm above normal sea level) occurred. Wave impact on the coasts was more intense due to absence of ice cover as December 2012 was the warmest since beginning of weather observation. Severe storm caused extreme erosion damage of the coastal dunes with forming of active escarpment, destruction of coast protection and recreation infrastructure, complete transformation of sand accretion spits. Effect of storm surge was much higher outside the Flood Protection Facility as a result of its impact on hydrodynamic regime. Such a great damage of the coasts was observed for the first time during last 20 years, so one of important tasks is to estimate impact of climate change and anthropogenic activity on the coastal zone development.

To assess the integrated geological and environmental risks for the built areas, e.g. coastal zone, in the Gulf of Finland region caused by geological peculiarities of the region is the main aim of new ENPI project ClipPLivE (Climate Proof Living Environment) started in 2012. The project consortium includes State Geological Company "Mineral", VSEGEI, Geological Survey of Finland, Committee for Nature Use, Ecological Safety and Environmental Protection of St. Petersburg City, Regional Councils of Kymenlaakso and Uusimaa and Helsinki Regional Environmental Service Authority.

Among the main tasks of the project is a compilation of map for current geological and environmental risks and environmental risks under climatic change, modelling study of nearshore sediment transport processes and morphological changes in a coastal zone and enhancement of adaptation strategies applicable for identified climate change risks related impacts in built areas. VSEGEI will produce risk maps for the Eastern Gulf of Finland coastal zone.

As the first results of the projects the dataset of coastal zone monitoring stations (2004–2011) was developed, maps of coastal types and beach width and scheme of erosion rates based on field observations and remote sensing data analysis were complied. The longshore sediment transport parameters were calculated. Results received are a background for the map for current geological and environmental risks compilation.

FEATURES OF THE DISLOCATION ZONE OF COMPLEX IMPACT STRUCTURES: MARINE IMPACT STRUCTURES NEUGRUND AND KÄRDLA (BALTIC SEA, ESTONIA)

by

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Most of the some two hundred recognized and suggested hypervelocity meteorite impact sites around the Earth are located on land. Only ten are completely at the sea floor: Bedout, Eltanin, Ewing, Lumparn, Mjölnir, Montagnais, Neugrund, Shiva, Silverpit, and Tvären, and five partially: Charlevoix, Chesapeake Bay, Chicxulub, Kara, and Kärdla. In the Baltic Sea region, four similar structures have been found: Lumparen, Tvären, Kärdla and Neugrund. The two latter are located some 50 km apart along the Estonian coast of the Baltic Sea.

The Neugrund meteorite impact crater is located in the seabed at the entrance of the Gulf of Finland (59°20'N; 23°31'E). The outer limit of the about 535 My old meteorite crater passes through the Osmussaar Island to the southwest of the impact centre. The meteorite impact origin of the structure was proved in 1996 by PDF-quartz findings. The 5 km wide Neugrund Bank that forms the seafloor at the location of the crater proper, consists of limestone. The bank rises above a semicircular ridge of roche moutonnées, or "sheepbacks" that forms the inner crater wall. The inner crater has a 7 km rim-to-rim diameter and is surrounded by the outer crater, c. 18 km in diameter. The occurrence of a central uplift inside of the crater proper has not been proved yet.

The structure has been studied by continuous seismoacoustic and sidescan sonar profiling, and by diving and sampling of submarine outcrops in the course of 14 marine expeditions during 15 years (1996–2012). Several hundred samples of impact breccias have been collected and investigated from erratic boulders distributed by glacial action in the west Estonian mainland, islands and the sea floor. The crater area is not expressed well on the aeromagnetic map, and a high resolution gravity map for the crater area is not yet available. There are no drillings of the crater proper where the post-impact deposits must be preserved. Application for future drillings are planned to propose also to the IODP.

The crater was buried shortly after the impact in Early Cambrian in a shallow epicontinetal sea with siliciclastic deposition. It has recently been partially re-exposed by Quaternary erosion in the erosion cut of the Baltic Klint. The Neugrund crater is the best preserved and exposed marine meteorite crater in the world. The craters Ries Nördlingen in Germany (14.5 My; D 24 km; D of

the inner crater 8 km) and Gooses Bluff in Australia (142 My; D 22 km, D of the inner crater 6 km) are similar by building with the Neugrund crater.

The Kärdla meteorite impact crater, with its centre at 58°58'N, 22°46'E, is located partly on the northeastern coast of the Hiiumaa Island in western Estonia, but mostly in the Kärdla Bay northeast of the island. The impact origin of the about 455 My old meteorite crater was proved by findings of PDF-quartz om 1981. The inner crater has a 4 km rim-to-rim diameter and a central uplift of c. 800 m in width and more than 100 m in height. An outer crater, c. 12 km in diameter, surrounds the inner crater. The well-preserved buried inner crater is outlined in the landscape by a circular ridge of bedrock uplift. The perimeter of the outer crater is outlined on the seafloor by a semicircular ridge of narrow shoals. The supposed ring fault area circumscribing the dislocation zone was investigated with continuous seismic profiling. Some dislocation zones were also revealed that may be interpreted as an outer limit of the crater. The well expressed gravity anomalies above of the ring wall and absence these above of the ring fault refer that dislocations inside of the zone of dislocations are connected only by the sedimentary target rocks. Variable height of the rim wall (50–240 m) and very asymmetric location of the outer and inner crater (the centre of the inner crater is budged c. 3 km to southwest in regard with the centre of the outer crater) refer to an oblique impact. The Shoemaker or Teague Ring crater in Australia (570 My; D 30 km; D of the inner crater 12 km; the centre of the inner crater budged 8 km) is similar by morphological features with the Kärdla crater.

ANALYSIS OF RELATIONSHIPS BETWEEN NEAR-SHORE HYDRODYNAMICS AND SEDIMENT MOVEMENT ON OSMUSSAAR ISLAND, WESTERN ESTONIA

by

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Osmussaar is an approximately 1 km wide and 5 km long relict island of the Baltic Clint, overlain by a thin layer of Quaternary deposits, which emerged from the Baltic Sea about 3000 years ago as a result of postglacial rebound. An Ordovician limestone cliff up to 7 m in height is the most characteristic feature on the northern part of the island, whereas 2–3 m high accumulative gravel-pebble beach ridges cover the southern part of the island. The main shore processes are erosion from the Osmussaar Cliff, which recedes approximately 9 cm/yr, longshore southward transport of gravel-pebble and accumulation of material as beach ridges at the southern end of the island.

Coastal slope is very steep on the eastern side of the Osmussaar Island – the depth increases to 20 meters in less than 500 m. Coastal sea is very shallow (less than 5 m deep) for up to 1 km from the shoreline on the western side of the island due to the limestone bench. The island is exposed to storms from western and northern sectors. Therefore, gently deepening sea, well exposed to the storm waves, on the western coast of the island serves ideal location to study sediment transport on the near-shore zone. The aim of the study is to analyze the relationships between near-shore wave parameters, sea-levels and sediment movement on the limestone bench located on the western side of the Osmussaar Island.

A field experiment was carried out on the western coast of Osmussaar from September through November 2011. 8 patches of painted sediment of different grain size (three classes: 1−2.5 cm, 2.5−5 cm and 5−10 cm all in different color) were placed on the near-shore sea bottom in 0.5–4 m depth. Leica CS09 RTK-GPS (accuracy between 1−2 cm) was used to mark the locations of painted sediment patches. The patches were photographed in September and in November. Photographs were compared and changes in the sediment patches were analyzed.

Wave measurements were carried out *in situ* to analyze the hydrodynamic conditions during the study period. The hydrodynamic study is based on measurements of waves and currents using the Doppler-effect applying current profiler (RDCP-600 by AADI Aanderaa) at the Sundgrund Bank in September – November 2011. Additional measurements were performed at Sundgrund at the depth of 2 m using 3 MHz ADP (by YSI/Sontek) in September 2011. Additionally, sea-level and wind data from Dirhami and Pakri weather stations operated by Estonian Meteorological and Hydrological Institute was used.

During a checkup in November, it appeared that all the sediment patches in the 3–4 m depth were scattered completely but in the 1.5–2.5 m depth only finer-grained fractions were washed out and the contours of the patches were distorted. No visible changes were registered in the shallower depths (0.5–1 meter).

The mean wind speed during the strongest storm of the study period reached 16 m/s. The measured maximum wave heights during the same period reached 3.4 m in 11 m deep coastal waters. As there were no strong storms combined with high sea levels, we can conclude that the waves of moderate storms in mean sea level conditions are capable of moving sediment fractions with the diameters of 1–10 cm closer to the shore in the more than 2 m deep basin. Accumulation of such fractions in described conditions occurs in the depth of ca. 2 m, where swash is unable to shift the sediment further on. These deposits get onto the shore in case of very strong storms in high sea level conditions when the waves reach near the mean shoreline.

GROUND-PENETRATING RADAR STUDY IN THE JÄGALA ARCHAEOLOGICAL SITE

by

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The Jägala archaeological site is situated in the northern Estonia on the right coast of the Jägala River mouthing into the Baltic Sea. The Jägala–Jõesuu hill fort and dozen settlements of different age were previously discovered and studied in Jägala. Being located in the pre-Klint area on a top of Litorina Sea marine sediments, partially reworked by wind, some of the settlements are considered to be situated on the beach, reflecting the shore-displacement chronology. In the course of rescue excavations in summer 2011 a large complex of field remains, presented by two buried within aeolian sands chronologically different layers, presumably covering an extensive area of 2300 m^2, was detected. Palaeofield remains, in places covered by organics, were distinguished by darker ploughmarks consisting of charcoal particles.

Performed in July 2011 ground-penetrating radar (GPR) fieldworks aimed to establish extent of the field remains. Radar Systems Inc. equipment on the frequency of 900 MHz was used. Electromagnetic wave velocity of 8.2 cm/ns was found by hyperbolic method to correspond to dry sand subsurface. Around 30 test-pits were created in order to control existence of the palaeofield layers and to correlate them with appropriate reflectors, which are caused by contrast in the dielectric constant. According to preliminary results of combined data, the uppermost layer is associable with strong continuous reflector on the average depth of 1 m. Below the upper layer another of similar character, but fragmental strong reflector is distinguishable. This might be associated with the lowermost palaeofield layer, although evidences are absent so far because its depth is not covered by test-pits data.

PREGLACIAL CUESTA RELIEF OF THE NORTHERN BALTIC PROPER

by

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The Baltic Sea fills a depression (BSD) in the continental crust with the deepest point of 459 m (Landsort Deep) below the sea level. The origin of the BSD, how and when this topographically lowered area under the present World Ocean level was formed, has been a subject of fierce discussions and controversies for more than a century. Considering its highly varying substratum and tectonic setting, as well as the complex shape, morphology and bathymetry of the BSD, it is obvious that this depression is an outcome of combined geological processes – tectonic, erosional and glacioisostatic. The role and input of each factor in the formation of the whole BSD, as well as its different parts and branches, is still a very poorly studied and discussed subject.

Regarding the erosion and its possible agents, more attention has been recently paid to the scraping role of the Pleistocene glaciers. So far, the preglacial erosion, particularly the role of large rivers that developed on the southern slope of the tectonically uplifted Baltic Shield during the Cenozoic, has been very little discussed. However, we must admit that the preglacial relief, being heavily obliterated by the erosion of Pleistocene glaciers, is, furthermore, largely buried under glacial and postglacial sediments.

Interpretation of seismic lines shot during the Swedish–Estonian cooperation project (1990–2004) has enabled to compile a detailed map and a 3D model for the bedrock relief between the Estonian islands of Hiiumaa and Saaremaa in the east and the Swedish islands of Gotska Sandön and Gotland in the west. Although the outlines of the cuesta relief east of the Baltic Sea have been known for a long time, the asymmetrical cuesta valleys are nowhere as explicitly expressed as below the central part of the Baltic Sea. A landscape where slightly south-westwards tilted plateaus alternate with northeast to southwest-directed escarpments (klints) clearly dominates in the bedrock relief of the northern Baltic Proper.

Formation of a cuesta relief, a type of topography eroded largely by rivers, requires a definite geological setting – a homocline sequence of sedimentary rocks that is made up of lithologically contrasting layers, i.e. where soft and easily erodible rocks are in succession alternating with the hard erosion resistant ones. This is exactly what we have on the southern slope of the Baltic Shield. Thus, in front of the Baltic and Silurian klints, the running Cenozoic rivers that sculptured alternating plateaus and escarpments, had to traverse the southern slope of the Baltic Shield. They both flew into the supposed larger north-southerly river of Eridanos, which crossed the present western Baltic Sea area. The east

westerly migrating mouth area of Eridanos, with more than 1.5 km of thick deltaic sediments, has been discovered between northern Poland and the North Sea.

Unlike their mainland sections, the submarine Baltic and Silurian klints have been neither exhumed nor reworked by the abrasion of the present Baltic Sea. Thus, they reveal a morphology that was left behind by the rasping Pleistocene glaciers. The northeast to southwest-oriented cuesta plateaus and klint escarpments are dissected and levelled by the north-southerly valleys of the Pleistocene glaciers. The number, depth and width of the valleys, i.e. the amount of the bedrock eroded by the glaciers, increases towards Gotland. The klint sections between the glacial valleys are normally well preserved, i.e. their Cenozoic appearance has not been changed very much by the ice sheet.

The largest glacial valley runs directly northeast to east of the Swedish islands of Gotland and Gotska Sandön. Both the Baltic and the Silurian klints are heavily destroyed and smoothed along this pathway of glaciers. This valley, being surrounded by and filled with a thick sequence of glaciofluvial sediments, embraces also one of the deepest areas in the northern Baltic Proper – the Fårö Deep. With respect to the surrounding areas, the Fårö Deep appears in the bedrock relief as an approximately 50 m deep depression just in front of the Silurian Klint. It is obvious that the highly pressured melt-water below the glaciers has been acting as a supportive erosional agent to form a similar isolated depression in the glacial valley.

1500 YEARS HISTORY OF CLIMATE AND SEA-LEVEL CHANGES RECORDED IN COASTAL PEATLAND OF PUCK LAGOON (SOUTHERN BALTIC)

by

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The research was carried out on coastal peatland of Puck Lagoon in close vicinity of Puck (NW part of the Gulf of Gdańsk). The analysis of core ZP 11 was performed in a range: AMS ^{14}C datings, ^{18}O and ^{13}C, palynology, plant macrofosils, diatoms and chemical composition (Fig. 1). Radiocarbon dating and palynological analysis showed that the 1.2 m core section records events that took place in the second half of Subatlantic, from about 1800 cal. y. BP to the present. The samples for analyses were taken from the intervals of 5 cm, which according to age-depth model gives a resolution of approximately 100 years.

Minima and maxima $\delta^{18}O$ well correlate with changes in solar activity that recognized, by e.g. Steinhilber et al. (2009). Among other things, $\delta^{18}O$ maxima attributable to the Medieval Warm Period (ca. 800–1100 AD) are clearly separated by a minimum of covering a minimum of solar activity before the Oort minimum. Clearly indicated by $\delta^{18}O$ minimum is also a main phase of the Little Ice Age around 1650–1850 AD, which is the period fit well to Maunder and Dalton minima Since the XIX century, there is an increase $\delta^{18}O$ values, which is consistent with the contemporary climate warming. In the analyzed core there is no correlation curves $\delta^{18}O$ and $\delta\ ^{13}C$. Emeis et al. (2003) demonstrated the relationship between water salinity and the $^{13}C/^{14}C$ isotope ratio in organic carbon in surface sediments of the Baltic. Elevated values of $\delta\ ^{13}C$ in peat therefore may indicate increased salinity and increased water levels and more frequent and stronger storms. The stormy periods, according to $\delta\ ^{13}C$, diatoms, pollen, plant macrofossils and geochemical indicators, occurred in years: 200–300, 450–700, 1300–1500 AD and since the beginning of the twentieth century. During the last 1800 years average water level in Puck Lagoon rose ca. 1.0–1.2 m, probably in cyclic mode.

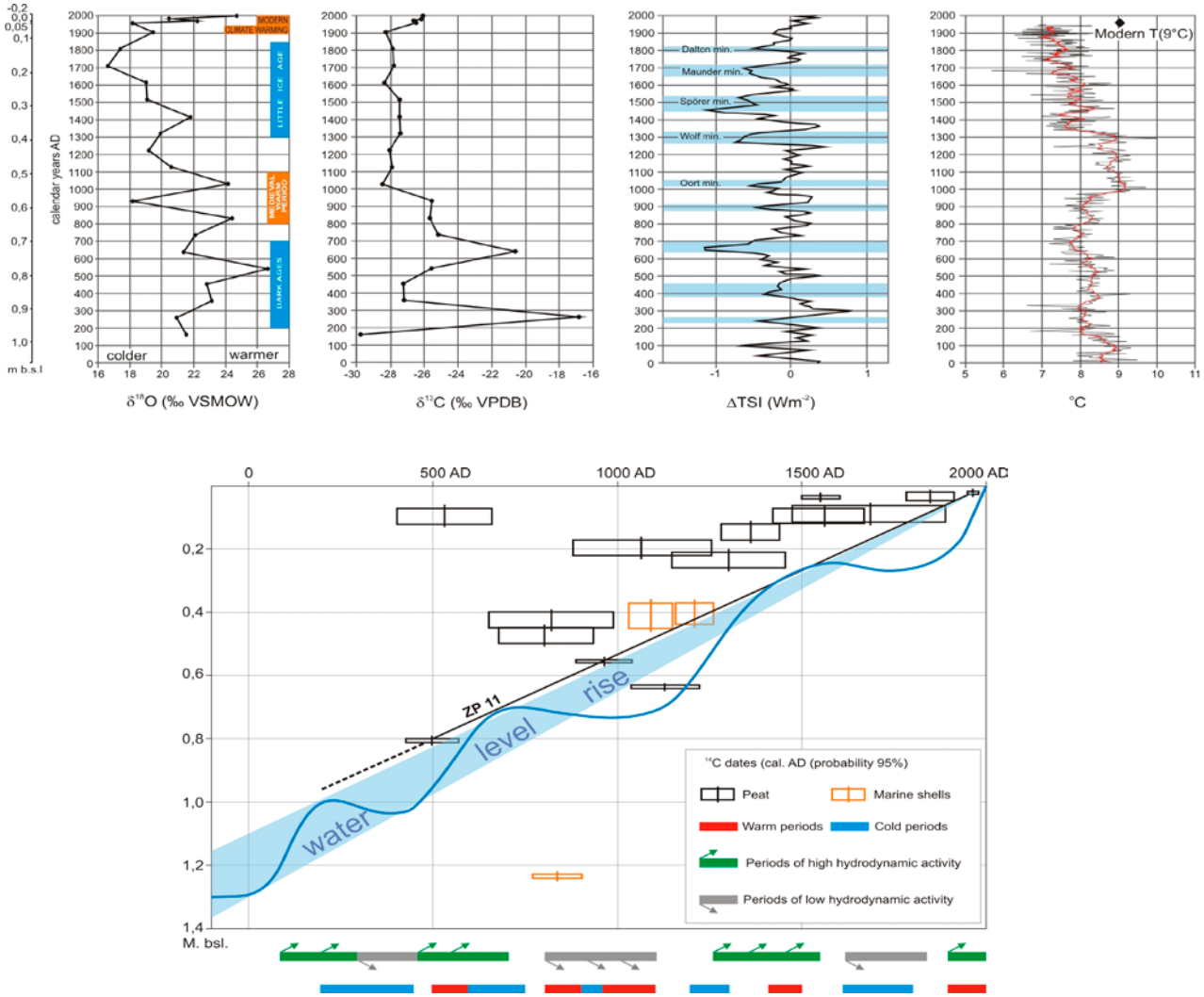

Fig. 1. Correlation of $\delta^{18}O$ and $\delta^{13}C$ record in core ZP 11 with solar activity (Steinhilber et al. 2009) and temperature of north Atlantic (Sicre et al. 2008) and curve of rsl rise.

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PHOSPHORUS SORPTION BEHAVIOUR IN SURFACE SEDIMENTS IN THE GULF OF FINLAND, BALTIC SEA

by

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Eutrophication caused by excess availability of nutrients is a severe problem in the Baltic Sea and it induces the risk for sea bottom hypoxia. The Gulf of Finland is one of the most eutrophied basins in the Baltic Sea, and it is affected by hypoxic near-bottom water inflows from the Baltic Proper.

Oxygen depletion further feeds eutrophication by promoting release of phosphorus (P) from reducible iron(oxyhydr)oxides in sediments. However, P is released from the sediments also in oxic conditions, for instance, as a result of organic matter decomposition and bioturbation. In addition, P adsorption onto iron(oxyhydr)oxides is at least partly reversible and can result in P release even if particle surfaces were oxidized. Significant spatial variation in the sediments' P storages and their chemical composition suggests variation also in P sorption properties of the sediments.

We investigated P sorption and desorption in surface sediments in the northern coast of the Gulf of Finland, in the northern Baltic Proper, and in the open Gulf of Finland, by equilibrating dried sediments with solutions of varying phosphate concentrations. In addition, we analysed sediments' physico-chemical properties, such as specific surface area (SSA), concentration of organic matter, iron-, aluminium-, and manganese-oxides, in order to find out, whether these factors explain the P sorption behaviour in the sediments.

According to our preliminary results, P sorption behaviour varied among the study sites. Coastal sediments with high iron and aluminium concentration had high SSA and showed generally effective P sorption. Sediments with relatively small SSA, instead, had poor affinity for P. In open sea sediments, sites with high organic matter and oxygen concentration in the near-bottom water showed ordinarily good ability for P sorption. Poor P sorption was found at open sea sites with low ambient oxygen concentration in the near-bottom water and high total P concentration in the sediment. Our results suggest also that efficient P sorption may occur in open sea sediments exposed to hypoxia, after the sediments are re-oxidized. In these sediments, iron-bound P was possibly released during hypoxic conditions but there was still enough iron left to regenerate effective P sorption capacity after oxidization of the sediments.

HEAVY METALS IN THE SURFACE SEDIMENTS OF THE BALTIC SEA – ANY CHANGES IN 20 YEARS?

by

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The Baltic Sea as an enclosed shallow regional sea is easily affected by pollution as well as natural load of heavy metals. Through the last decades all Baltic Sea basins have been extensively charged with an excess of heavy metals, which has been seen as increased concentrations of these metals in the sedimentary column. There have, however, been differences in the amount of accumulation of the different metals and spatially there have also been rather big differences in the load in the different subareas of the Baltic Sea. It is almost impossible to get a complete picture of the sedimentation processes and net accumulation of the metals in all areas. It is, however, much easier to estimate the situation today after many years of investigations than it was twenty years ago. Except cadmium there has been a change for better in the load of the most harmful metals, and the highest concentrations are normally not to be found in the sediment surface anymore. But because of the irregular nature of the sea floor processes one can still not be sure if the metals buried in the sediments will remain stored there or if they will be reworked, eroded and re-suspended in the water column at a later stage.

THE TIMING OF THE BALTIC ICE LAKE IN THE EASTERN BALTIC

by

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A shoreline database for the eastern Baltic, covering lateglacial and Holocene, was compiled. At the present the database includes about 1500 sites from Estonia, Latvia, southern Finland and NW Russia. The shoreline altitudes were interpolated to the water level surfaces using the point kriging approach for 5 different stages of the BIL.

The highest shoreline of the BIL in Estonia was formed concurrently with or before the formation of the Pandivere ice marginal zone (Estonia) and the lowest concurrently with the formation of the Salpausselkä endmoraines (Finland). The reliability of shoreline and bathymetry reconstructions of the BIL stages is good, depending on the accuracy of the shoreline proxy data. However the reliability of the timing, specially the age of the highest shoreline of the BIL in Estonia, is still in discussion. The ages of BIL stages were grounded on the biostratigraphical records, varve counts and on correlation of ice marginal zones. There was well-accepted knowledge that Pandivere ice marginal zone (Estonia) correlates with a Neva ice marginal zone (NW Russia) dated by varve chronology about 13,300 cal yr BP.

Recent studies of lateglacial sites in northern Estonia, however, indicate that the age of the Pandivere ice-marginal zone is about 13,800 cal yr BP. The age is determined by several AMS dates from macro remains. So the age of the highest shoreline of the BIL in Estonia is about 500 yr older, which seems to be reasonable as it simplifies the correlation with neighboring areas.

POTENTIAL CO_2 STORAGE FORMATIONS BENEATH THE BALTIC SEA

by

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The atmospheric CO_2 content (currently ~390 ppm) should not exceed 450 ppm if the target is to limit the mean global temperature rise to 2 °C. Geological storage is one of the few options to remove CO_2 in large enough quantities over short enough time to make a difference. Potential for geological CO_2 storage was previously identified in Mid-Cambrian and Lower Devonian sandstones, buried to depths exceeding 800 m required for supercritical CO_2 in the southeastern Baltic Sea (Shogenova et al. 2009).

We have ranked potential CO_2 storage sites beneath the Baltic Sea based on geological, resource and societal criteria. The four most promising areas are: Slupsk Border Zone, Gdansk–Kura Depression, Liepaja–Saldus Ridge, Latvian–Estonian–Lithuanian Border Zone (Fig. 1).

Slupsk Border Zone has the highest priority because it contains the Mid-Cambrian Dalders monocline, which is a large reservoir with a volume estimate of ~300 million barrels of recoverable oil. A significant part of the Dalders monocline is accessible in Swedish territory. When the Latvia/Lithuania border is ratified, all of the Dalders structure could be accessible for oil field development with CO_2 enhanced oil recovery (EOR).

Gdansk–Kura Depression is a large regional structure with Mid-Cambrian sandstone reservoirs suitable for CO_2 storage. The area has existing oil production offshore Poland and Russia.

Liepaja–Saldus Ridge is a regional faulted zone with a complex structure. The ridge has several Mid-Cambrian sandstone structures with CO_2 storage potential offshore Latvia including the Dalders monocline.

Latvian–Estonian–Lithuanian Border Zone is a monoclinal structure with Mid-Cambrian and Lower Devonian sandstone reservoirs. An underground gas storage facility at Inčukalns (Latvia) proves the CO_2 storage capacity of the Mid-Cambrian sandstone. However, only a small area is sufficiently deep for CO_2 storage.

We invite all relevant parties (authorities, geological surveys etc.) to join to promote geological CO_2 storage in the Baltic Sea region.

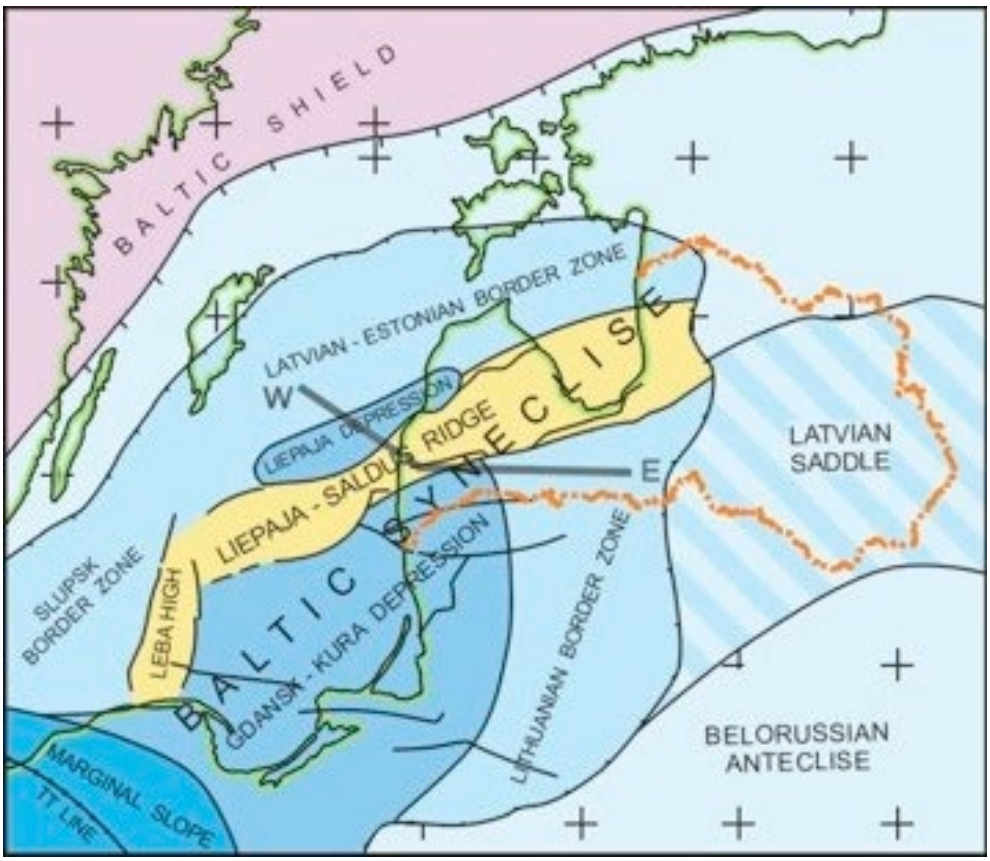

Fig. 1. Map of the Baltic Sea with potential CO2 storage sites labelled.

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SULFUR AND IRON ISOTOPE HETEROGENEITY IN PYRITE FILLINGS OF HOLOCENE WORM BURROWS

by

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The upper part of Holocene post-glacial lacustrine (Ancylus) clays in the Baltic Sea basin contains small, burrow-like and irregularly-shaped pyrite concretions (Fig. 1). The burrow-like concretions were formed in reducing worm-burrows in oxic surface sediments, where organic coatings on the burrow walls supported intense microbial activity (Virtasalo et al. 2010). The burrow-like concretions have cores of framboidal pyrite and overgrowths of poorly crystalline FeS_2.

Ion microprobe analyses of the core framboids display $\delta^{34}S$ values close to marine sulfate (~+21‰), indicating episodic saline inflows from the North Sea as the sulfate source. The FeS_2 overgrowths on the framboids have significantly lower $\delta^{34}S$ values (~–20‰), indicating later precipitation from porewater H_2S that was strongly enriched in ^{32}S by intense bacterial sulfate reduction (Virtasalo et al. 2010).

$\delta^{56}Fe$ values of the framboids are exceedingly low, down to –3.1‰, while the overgrowths have higher $\delta^{56}Fe$ values (–2.1 to +1.4 ‰). $\delta^{56}Fe$ values reflect the preferential capture of ^{54}Fe to pyrite in the diagenetic sequence and the ^{56}Fe-enrichment of remaining porewater (Virtasalo et al. 2012). Available data does not allow discriminating between microbial and abiotic pathways in the Fe-isotope fractionation. However, microbial Fe reduction pathways generally are faster, which leads us to propose a stronger microbial contribution during the framboid precipitation.

The irregularly-shaped concretions were formed in sediment pores not enriched in organics. They display extremely low $\delta^{34}S$ values (>–45.7‰), indicating late precipitation from strongly ^{32}S-enriched H_2S. Their extremely high $\delta^{56}Fe$ values (<+4.1‰) poin toward precipitation from strongly ^{56}Fe-enriched residual fluids.

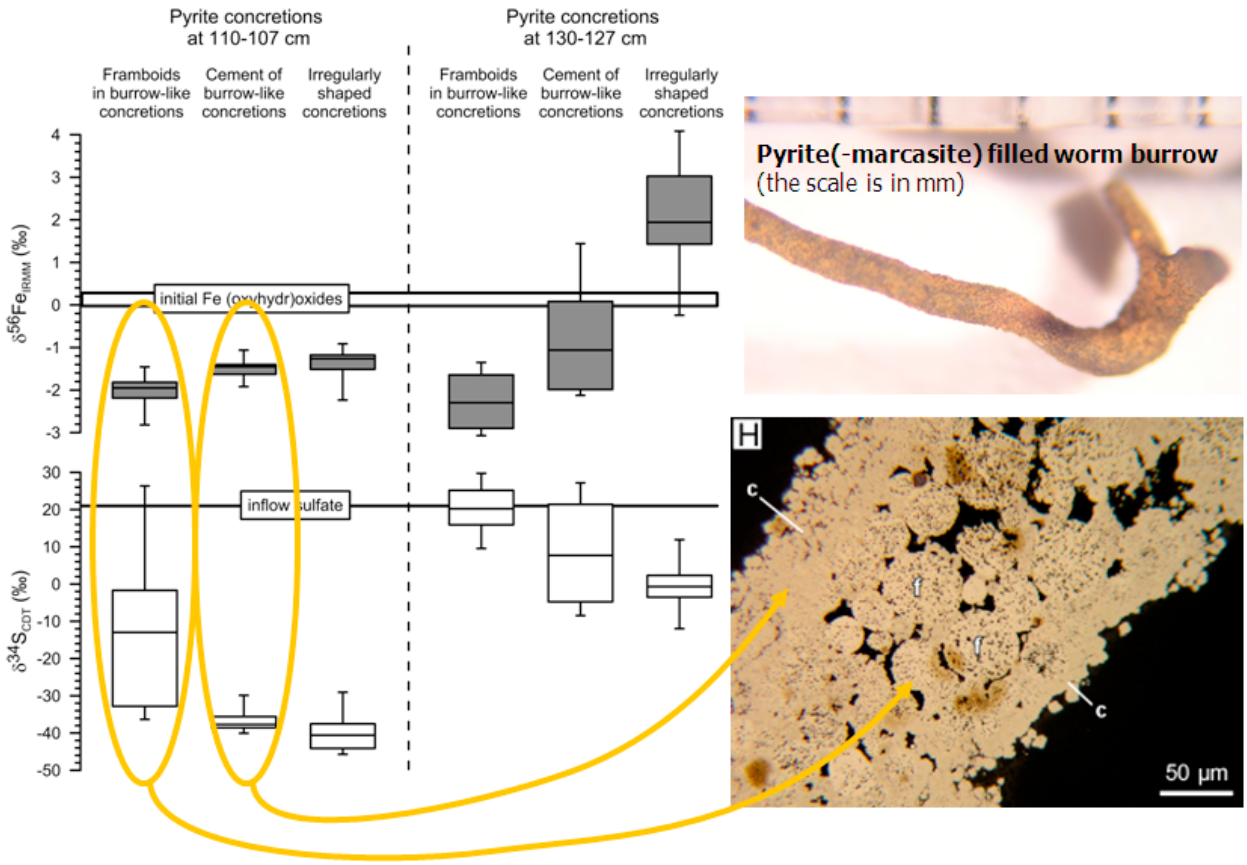

Fig. 1. Upper right: magnified picture of a burrow-like pyrite concretion. Lower right: micrograph of a burrow-like pyrite concretion composed of framboids (f) and poorly crystalline FeS2 cement (c). Left: Iron and sulfur isotopic compositions of the framboids and cement of burrow-like concretions and of irregularly-shaped concretions separated at the depths of 130–127 cm and 110–107 cm in the core MGML-06-7. S data are from Virtasalo et al. (2010) and Fe data are from Virtasalo et al. (2012). The "initial Fe (oxyhydr)oxides" represent the combined isotopic range of suspended matter in boreal rivers and of igneous rocks. The "inflow sulfate" represents the composition of the North Sea sulfate.

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DECADAL VARIATIONS OF SIMULATED SEDIMENT TRANSPORT PATTERNS ALONG THE EASTERN COAST OF THE BALTIC SEA

by

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The eastern coasts of the Baltic Sea mainly consist of relatively soft and easily erodible sediment and are sensitive to large hydrodynamic loads. These coasts develop mostly under the influence of wave action. Recent studies show that large variations in wave properties (like the average significant wave height and wave height in extreme storms) have occurred in certain domains during last decades. It is natural to expect that these variations are reflected in the intensity or direction of coastal processes. The aim of this study is to quantify possible changes in the sediment transport and to identify particularly vulnerable areas.

The study area is an approximately 700 km long section of the eastern Baltic Sea coast from Sambian peninsula until Pärnu Bay in Estonia. Most of this area is exposed to the two-peak distribution of the predominant winds that blow either from SW or W, or from NNW. Wave driven potential longshore sediment transport was simulated for 38 years (1970–2008) using the CERC formula with a resolution of about 3 nautical miles based upon numerically simulated long-term time series of wave properties along the beach. This method assumes that the wave-driven longshore sediment flow is proportional to the beaching rate of the longshore component of wave energy flux. The calculations are performed for a fixed grain size of coastal sediments. We use the time series of wave fields modelled by A. Räämet using the WAM wave model with an extended spectral range for short waves and with a temporal resolution of 1 hour for the entire Baltic Sea. The model is forced by geostrophic winds from the Swedish Meteorological and Hydrological Institute.

The total amount of sediment brought into motion by waves alongshore (bulk transport) and the residual sediment motion in some direction (net transport) was evaluated for about 5–6 km long coastal sections. Bulk transport was the largest along the Sambian Peninsula and the Kurzeme Peninsula. As expected, the modelled net sediment flux was mostly counter-clockwise, with only small sections of a reversed direction. The flux has a discontinuity at the Kolka Cape where most of sediment brought there by waves is deposited and only a small fraction is carried further along the coast of the Gulf of Riga. Net transport in the Gulf of Riga clearly exceeded similar transport for the southern part of the Baltic Proper coast. This feature suggests that the coasts of the gulf are still far from an equilibrium state.

The annual values of bulk and net transport rates revealed almost periodic, synchronous variations with a typical time scale of about 8–10 years. While the bulk transport revealed a clear increasing trend, the net transport increased only until the mid-1990s and decreased since then. Systematic erosion and accumulation areas were identified using the concept of divergence and convergence points of net transport. Interestingly, the Akmenrags cape divides the eastern Baltic Sea coasts into two almost separated sediment compartments. Flux divergence occurs (and, consequently, erosion dominates) frequently near Klaipeda while the Curonian Spit regularly hosts a flux convergence zone and thus is frequently filled by sand under the existing wave climate.

RECENT DIATOM ASSEMBLAGES OF THE BALTIC SEA AND THEIR CHANGES ALONG THE WHOLE SALINITY GRADIENT

by

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Diatoms (Bacillariophyceae) belong to the best proxies in reconstructing environmental changes over geological history of the Baltic Sea during the Late Glacial and Holocene. The palaeoecological potential of diatoms is very high, the best results in terms of paleoinferences are achieved with respect to salinity, pH and trophic status.

The aim of our study was to develop a diatom-based salinity transfer function for palaeoreconstructions in the Baltic Sea. Here we present species composition of diatom assemblages in bottom sediments collected along the whole salinity gradient within the Baltic Sea, as a base for calibration set which has been used in transfer function analyses. Diatoms species occurred in samples from sediments which we studied were represented by typical marine species in Skagerrak and Kattegat (salinity higher than 30psu), and purely freshwater taxon in the northern part of the Bothnian Bay with salinity lower than 3 psu.

As a result of diatom analyses of surface sediment, several well developed recent diatom assemblages have been distinguished. These assemblages encompass the transect from the Southern Kattegat through Baltic Proper to the Bothnian Bay, additional group was distinguished in the Northern Kattegat and Skagerrak.

The materials for the study originated from cruises during Project INFLOW supported by the BONUS PLUS programme.

DEVICE FOR TAKING SAMPLES FROM THE BBL

by

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A serious need of a sampler enabling taking of undisturbed samples from the bottom boundary layer (BBL) stood up, when the Nord Stream project began become the reality. It was known, that in some places of the Gulf of Finland some hazardous elements and compounds, such as Hg and dioxins, are deposited in the soft sediment. Already in 1975 Martin Voll started develop a sampler for taking undisturbed samples from the BBL. The device was continuously improved and protected with a number of patents. In 1988/1989 Voll used his device (Fig. 1) during the Pacific Ocean expedition, and water decaying bacteria were found at a depth of 6000 m at the bottom of the Pacific Ocean.

Unfortunately the Voll sampler was stolen from the depot in 90-ties, and this was the reason we had to develop a new (and improved) variant. We had to solve four tasks in a one solution: (1) to avoid the disturbance of BBL by landing of the sampler, (2) to take simultaneously samples from the soft sediments and BBL (liquid and/or semi-liquid), (3) to close the corer for water and semi-liquid sediment and (4) to separate them before lifting the device up from the bottom. A new device for taking samples from the bottom boundary layer of a water body (Fig. 2) was worked out in the Marine Systems Institute in cooperation with a firma Dimentio LLC and protected at first with the Estonian patent application (P200900068, 09.09.2009) and then with the US patent application (US 2011/0083520 A1, 08.09.2010).

Compared to the sampling devices, which have been and are used, this new device enables simultaneous taking of undisturbed profiled samples as of the bottom (soft) sediment as well of BBL and water, i.e. to get samples with their composition and stratification representing the actual condition at the site as truthfully as possible. This is achieved due to shock absorber units, separating the samples already in the bottom before lifting the sampler. Onboard the sampling tubes could be *disassembled to the sections in form of vessels where the liquid and semi-liquid samples could be treated in the simplest way.*

This sampler will be constructed by Dimentio LLC and tested by Marine Systems Institute during 2012/2013.

Authors are thankful to *Enterprise Estonia*, Estonian *Environmental Investment Centre* and *Estonian Science Foundation* (grant 9052) for the financial support and to *Patent Agency Turvaja LLC* for the help by forming the US patent application.

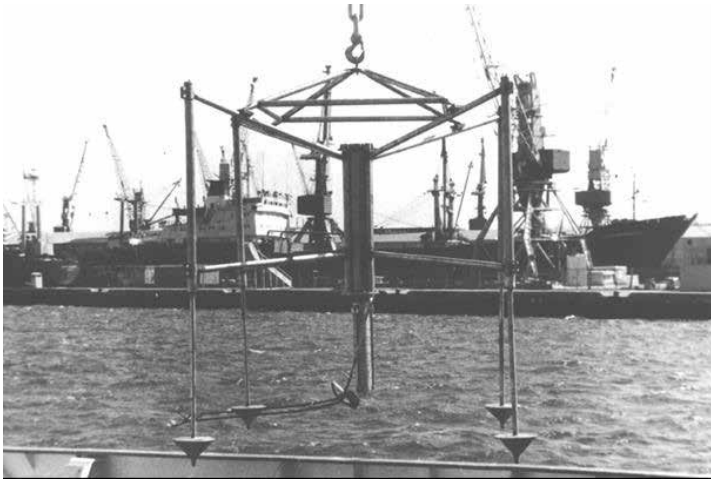

Fig. 1. Voll sampler in reality.

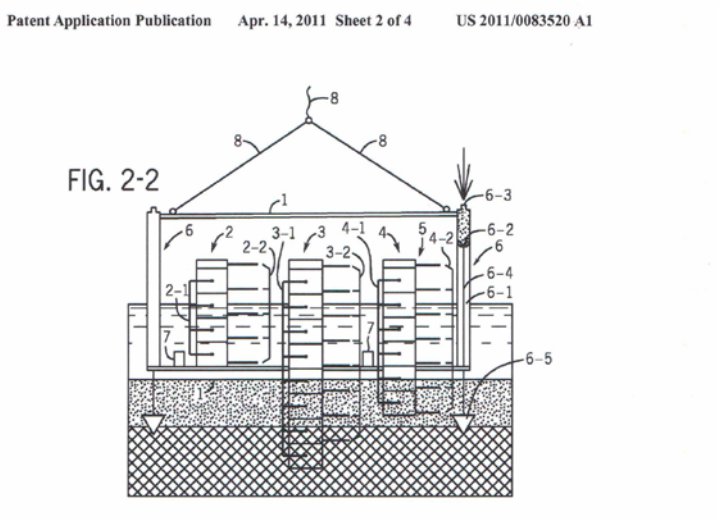

Fig. 2. Principal scheme of the device in the bottom of a water body before lifting it up [28]. 1-supporting frame; 2,3,4 - sampling tubes: 2-1, 3-1, 4-1 - sections, 2-2, 3-2, 4-2 – horizontal valves; 5 – control unit; 6- shock absorber unit; 6-1 – cylinder, 6-2 – hydraulic plunger, 6-3 – nozzle, 6-4 – support road, 6-5 – footing; 7 – additional weight; 8 – cable.

MICROBIAL COMMUNITIES AND PROCESSES IN IRON-MANGANESE CONCRETIONS OF THE GULF OF FINLAND

by

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Large and dense (0.5–50 kg m^{-2}) Fe/Mn concretion deposits cover about 10% of the bottom surface of the Gulf of Finland. Concretions are from millimetres up to centimetres in size and their concentrations of Fe and Mn are high. Due to their geochemical properties concretions may have significant effect on the cycling of Fe, Mn and P in the Baltic Sea. Spherical concretions, formed from alternating Fe and Mn layers, are porous, fragile and their interior is often hollow. The physical and chemical characteristics indicate that concretions themselves may serve an excellent site for microbial life. We studied the microbial diversity hosted by the concretions by using epifluorescencemicroscopy and DNA-based methods such as cloning of community 16S rRNA-gene and sequencing. Our results demonstrated that concretions host a diverse bacteria community with an average density of 6.7 x 10^7 cells g^{-1} DW. The sequencing studies showed that one third of the cloned sequences were related to uncultured, unclassified bacteria and half of the cloned sequences were affiliated to Proteobacteria. The closest matches to the sequences found from the concretions of the Gulf of Finland were obtained from ocean crust, sediments and e.g. from Fe-oxidizing biofilms and contaminated sites. The oxidation experiments of Mn and Fe with concretions revealed that microbes extracted from the concretions enhanced the oxidation of Mn favoring enrichment of bacteria such as *Sphingomonas*, *Pseudomonas* and *Bacillus*. In the Fe oxidation experiments oxidation of Fe was observed only in those inoculates where concretion suspension was alive. In the reduction experiments, in turn, the addition of bioavailable C triggered the dissolution processes in concretions which were observed as an increase in concentrations of Fe, Mn, P and As in the ambient solution. As a summary, our studies have shown that an individual concretion forms a microcosm which is colonized by diverse and mostly unknown prokaryotes and that the community is capable to reduce and oxidize Mn and Fe. Our findings support the view that the formation and dissolution of concretions is microbially mediated.

ATYPICAL UNDER-WATER LANDSCAPES WITHIN THE RUSSIAN PART OF THE BALTIC SEA

by

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Geological survey carried out by VSEGEI in the Russian part of the Baltic Sea allowed to produce maps of the bottom sediments. Bottom sediments within the investigated area are represented mainly by sands and silty-clayey mud. The distribution of the different types of these terrigenous sediments is controlled by sea depth, near-bottom hydrodynamic, distance from the coasts, sources of sediment and other factors. Within the area of the Russian part of the Southern-Eastern Baltic Sea the distribution of the bottom sediments represents classic circum-continental zoning. Within the eastern Gulf of Finland the distribution of the sediments is rather more complicated being relatively mosaic, but totally depends on the same factors. Accordingly normally it is possible to characterized and map underwater landscapes or biotopes by means of main selecting environmental parameters used in the frame of BALANCE Project namely: sediment type, photic depth and water salinity.

Whereas detailed underwater mapping using side-scan sonar, seismic acoustic profiling and VideoROV allowed to find several types of specific geological conditions or abnormal biotopes. One of the examples of such abnormal biotopes was found to the north of the Curonian Spit, where some extensive outcrops of laminated dense clays, partly covered by sand, were mapped at depths of 5–15 m. The radiocarbon (14C) dating of three samples of these clays (5510–6260 in calibrated years BP) showed that they were formed in the Litorina time. It is improbable that clayey sediments could accumulate in shallow water conditions near the coast of the open sea. Therefore these deposits are likely to be lagoon sediments (mud, marl, gittja) formed during the Holocene within the lagoon between the ancient spit and the mainland. Mud was compacted and dehydrated by the spit moving to the East. Outcropped dense clays are characterized by high concentration of organic matter and their mechanical properties are especially favorable for benthic community development. If to compare with surrounding sandy fields these clay outcrops represent specific oases for life. Comparable local benthic oases were found near the Sumbian Peninsula. In that case they are concerned with the outcrops of Paleogene soft sedimentary rocks forming walls 2−5 m high above the bottom covered by sand. The walls are totally penetrated by cavities and holes partly formed by erosion processes, partly by benthic activity.

In the eastern Gulf of Finland ferromanganese concretion's fields can be regarded as mostly specific biotopes. These fields are situated on the margins of basins containing Late Holocene mud and occur at depths of 20–100 m. These fields can extend a few kilometres but this depends on the relief of the sea floor and the extent of the muds. A gentle slope (up to 1–2 degrees) is most favourable for the occurrence of such concretions fields. Investigations of the total protein in individual sections of spheroidal concretions indicated very high levels of microbiological activity, especially within the surface layers of the concretions. Numerous fine, almost filamental structures are observed within the concretions, many of which appear to be spirals several nanometers in diameter, which lie within the size range of nanobacteria. These marks of microorganism activity indirectly confirm the assumption that the high growth rates of Baltic Sea concretions result from the catalytic influence of microorganisms on redox processes occurring at the concretion surface. Under-water visual observations have shown that within the areas of actively growing concretion fields the amount of some macro-benthos species such as *Saduria entomon* increases compared with adjacent areas where concretions are absent. Possibly specific conditions of biota development can be expected within the areas of poorly studied pockmarks which were found in the eastern Gulf of Finland.

Investigations were fulfilled with the support of the Russian Foundation for Basic Research (grant RFFI-11-05-01093-a) and TOPCONS project of ENPI program.

THE BALTIC SEA: PHYSICAL FORCING ON LONG-TERM TRENDS IN HYPOXIA

by

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One of the most profound effects on the health of the Baltic Sea is the expansion of hypoxia (< 2mg/l dissolved oxygen) due to increased anthropogenic nutrient loading. Hypoxia in the Baltic Sea is not unique to the modern era, but superimposed on a natural variability of oxygen depletion that has occurred in the deeper basins in the Baltic Sea during the majority of the Holocene (Zillén et al. 2008). As part of the EU BONUS+ program, this study aim to increase the understanding of the physical (natural) forcing on long-term trends in Baltic Sea hypoxia. We use sediment data and a oxygen dynamics model coupled to a circulation model of the Baltic Sea to explore if reconstructed shifts in oxygen conditions during the last two millennia i.e. during the Medieval Warm Period / Little Ice Age Oscillation (MWP/ LIA) can be explained by physical forcing parameters (i.e. temperature, fresh-water input, wind speed and productivity) driven by oceanographic and atmospheric changes over the North Atlantic region. We show that change in wind speed is by far the most significant single physical factor affecting the oxygen conditions in the basin. Model scenarios with decreased/increased wind speed (15% < than the control) in combination with less productivity rates (25% < than the control) can explain the shifts in oxygen status during the MWP/ LIA Oscillation. Ocean and atmospheric changes in the North Atlantic region have played an important role on the long-term changes of hypoxia in the Baltic Sea, where wind activity has been the single strongest physical factor affecting the oxygen status of the bottom waters. In conclusion, global warming, with projected increases in temperature, will not alone catalyze any further expansion of hypoxia in the Baltic Sea. Instead, physical forcing through wind stress and anthropogenic pressures via eutrophication, have the largest effect on the present state and the future of the Baltic Sea.

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This book contains abstracts submitted for presentation at the 11th Colloquium on the Baltic Sea Marine Geology, Helsinki, 19-21 September 2012. The venue for the meeting is m/s Silja Serenade, cruising on route Helsinki-Stockholm-Helsinki. This colloquium is a continuation for the Baltic Sea marine geological conference series that was initiated in Parainen, Finland, in 1987. After a quarter of a century circulating in the Baltic Sea countries, the colloquium is cordially welcomed back in Finland. The colloquium gathers more than 80 scientists and university students from nine countries around the Baltic Sea and from the Europe, which all have a passion for marine geology. The 60 abstracts in this volume include oral and poster presentations, printed in an alphabetical order of the first author. We would like to express our thanks to all authors for their contribution to this volume, and wish everybody a pleasant and successful colloquium.

ISBN 978-952-217-197-9 (paperback)
ISBN 978-952-217-196-2 (PDF)
ISSN 0781-643X