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held in Rostock from October 21 to October 26, 1991

edited by

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PREFACE

From October 21 to October 26, 1991, the Second Marine Geological Conference - The Baltic - was held in Rostock, Germany. Initiated and organized by the Geological Survey of Finland the first congress of this series (in Parainen/Finland, 1987) was the starting point for an improved exchange of knowledge and a more intensive co-operation between the marine geologists of the countries surrounding the Baltic.
On behalf of the director of the Institute of Marine Research Warnemünde the Baltic marine geological community was invited to Rostock for the second meeting during the first conference.
In spite of all the political changes, especially in the East European states, more than 120 participants from all countries around the Baltic (including Lithuania, Latvia, Estonia), Great Britain, Bulgaria and the USA joined the conference.
It was organized by Prof. D. LANGE and Dr. W. LEMKE and supported by grants of the German Research Community (Deutsche Forschungsgemeinschaft). Special attention to the meeting was given by the local government of Mecklenburg/Vorpommern. An adress of the Prime Minister Dr. A. GOMOLKA welcomed all the participants.

Within three days the scientific programme was dominated by oral presentations and posters on the geological development of the Baltic region and sedimentological contributions. On the other hand there were presented new results concerning environmental, biogeochemical and prospection problems.
An important role in the scientific programme was played by contributions regarding mapping and research methodology.

The last day of the meeting was dedicated to a field excursion to the Isle of Rügen. Colleagues from the Geological Survey of Mecklenburg/Vorpommern and the Geological Institute of the Greifswald University, respectively, gave an overview about the Cretaceous and Quaternary development in the northeastern part of the isle.

During the conference it was possible to visit three research vessels from Latvia ("Izyskatel"), Russia ("Plamya"), and Sweden ("Ocean Surveyor").

Besides the scientific presentations there were several opportunities to discuss about the future of geological research in the Baltic area. These discussions showed the need for an enhanced international co-operation, considering, particularly, the changing political conditions on the southern shores of the Baltic. Meetings like the Second Marine Geological Conference - The Baltic - are a most valuable tool for both, stimulating and coordinating the scientific research on an international scale. So the participants decided to continue meetings like this. The next one will be held in Sopot (Poland) in 1993. It will be organized by the Branch of Marine Geology of the Polish State Geological Institute.

The present assemblage of, partly, extended abstracts of presentations is suggested to give an insight into the diversity of topics covered by different contributions. Even though it was not possible to publish complete manuscripts we hope to encourage the exchange of information between the interested scientists.

The editors

CONTENTS

DIATOM ECOSTRATIGRAPHY OF THE HOLOCENE IN THE CENTRAL BALTIC SEA

Andrea Abelmann (Alfred-Wegener Institute for Polar and Marine Research, Bremerhaven, Germany)

The Holocene paleoenvironmental evolution of the central Baltic Sea basins and an ecostratigraphical diatom zonation for the delineation of the Baltic Stages is developed, based on the occurrence and distribution of distinct diatom associations.

The diatom record indicates that the individual subbasins represented isolated sedimentary environments during the early Holocene (Yoldia Stage). During this time period brackish-marine conditions were only observed in the northwestern part of the Baltic Sea (Karlsö Basin), linked to a marine ingression, which crossed the southern part of Sweden. At about the same time interval, the environment in the Dansk Bay is characterized by freshwater conditions, which are linked to a higher river discharge of the Weichsel river. This partition is presumably caused by a general lower water level in the Baltic Sea area, which led to a separation of the basins by sills.

After a general rise of the water level at the onset of the limnic Ancylus Stage (about 9.500 - 8.500 B.P.) more uniform conditions have been developed in the central Baltic Sea area. Consequently, these and younger sediment sequences can be correlated across the central Baltic Sea, based on the diatom ecostratigraphical zonation.

BEDROCK BASIN OF THE GULF OF FINLAND AS A PART OF THE BALTIC-WHITE SEA FORM AT THE BOUNDARY OF FENNOSCANDIAN SHIELD

A. Amantov (All-Union Geological Institute, St. Petersburg, Russia)

The Gulf of Finland is confined to a general negative form (GF) of the bedrock relief at the boundary of the shield. One of the edges of GF is formed by the peneplained surface of the Pre-Late Vendian basement, constituted by Archean and Svecokarelian Early Proterozoic rocks accompanied by Gothian formations in the Gulf. It gradually submerges under the sedimentary cover of the plate. Its other edge is defined by a system of denudative escarpments due to which the cover monoclinally occuring on the slopes of the shield thins away.

But such typical situation for GF observed in the Gulf is rarely changed (in Lake Ladoga, Kandalaksha-Dvina bays of the White Sea etc.) only when Proterozoic graben-like structures (e. g. Riphean-Iotnian in age) were opened for selective denudation. Here modifications of bedrock basins overdeepened by outlet glaciers were formed. They are subordinate in GF system. These examples of huge glacial activity claim to return to the problem of origin of the GF in the whole for revaluation of the contribution of the Plio-Pleistocene glacial erosion into Cenozoic denudation.

New data supporting this idea can be mentioned. They are:
1. numerous fragmentary scarps (clints) on outcrops of resistant rocks on different levels (eastern part of the Gulf) and even in the overdeepened northern part of Lake Ladoga at -250 - 200 m, however, in Gorlo-Voronka of the White Sea there is to be seen a gradual directed reduction of scarps as well as a boundary trench with simultaneous appearance of thick fluvioglacial sediments;
2. orientation, morphology and correlation of buried channels (with bottoms at a level of up to -200 m in the Narva bay of the Gulf);
3. findings of boulders of sedimentary rocks in tills the modern distribution boundary of which is now displaced in distal direction.

PRINCIPLES, METHODS AND RESULTS OF GEOLOGICAL MAPPING OF THE BALTIC SEA

A. Amantov, S. Manuilov, A. Rybalko (All-Union Geological Institute, St. Petersburg, Russia)

Different geological maps (bedrock, Quaternary deposits, lithology of surficial sediments) supplemented by structural-tectonic, geomorphological, bedrock relief and mineral resources maps have been compiled (as usual in 1 : 500.000, 1 : 200.000). During the last years a geoecological map which illustrates and forecasts the situation in the environment and anthropogenic pressure on the surficial sediments was added to this set of maps.

Data obtained by geological methods and primarily multifrequency continuous reflection seismic profiling with high-frequency subbottom profiling, echo-sounding, electrical and magnetic exploration methods were verified not only by pipe-cores and dredging material but also by cores of marine borings. New boreholes which penetrated the whole sedimentary sequences onshore and deep subbottom quarries with outcrops of Quaternary deposits and Vendian sediments (in the Leningrad dam region) were used for identification of practically all seismic markers of the created three-dimensional models and for the unterstanding of the lateral changes of these reflection boundaries. Changes of minor erosional forms of bedrock relief on crystalline rocks due to physico-mechanical properties of the latter were applied to bedrock mapping, too.

While mapping Quaternary deposits a new classification with the detailed establishment of genetic types of marine sediments on a dynamic base was realized.

While mapping surficial sediments the principle of determination of recent and relict formations was used, the area of the latter being almost half of marine bottom.

SEISMIC PROSPECTION METHODS IN THE SOVIET SECTOR OF THE BALTIC SEA

V.I. Aristov (Soyuzmorinzhgeologiya - BMIGE, Kaliningrad, Russia)

The task to estimate oil and gas prospects of the Soviet sector of the Baltic Sea emerged in connection with the discovery of several oil deposits at adjacent territories.
Since 1964 methods in use have been airborne magnetics, gravimetry, geoelectrics and seismics. The basic method was that of reflected waves (RWM), at some profiles the method of refracted wave's correlation (RWCM) was applied. Since 1972 the common depth point method (CDP) was employed. Prior to 1987 the studies were 24-fold, later 48-fold and 96-fold.

The area covered by regional studies was 35.000 square kilometres. The grid for the bulk of the offshore areas was 2x2 km. Prospective areas were covered by more detailed studies. However, the knowledge about the lower part of the sedimentary cover still remained unsatisfactory. This is due to the complex geological structure of the area, especially in regions with Permian salt formations which prevent a reliable tracking of deep boundaries. Structures are selected for deep drilling by the position of the seismic level "O" attributed to the upper part of Ordovician. The depth of this prospective horizon reduces from south-west to north-east from 3 km up to 700-500 m. In the north-east reef formations of Ordovician and Silurian ages may be also prospective.

The geological interpretation of geophysical data resulted in numerous maps reflecting the geological structure of the whole sedimentary cover from the basement up to the Mesozoic inclusive. They allowed to perform a structural-tectonic classification tracing structural boundaries of 2nd and 3rd order and local structures. On this base deep drilling was performed in order to estimate the oil and gas stock of certain regions.

In 32 boreholes drilled within the activity area of the international company "Petrobaltic" (USSR, GDR, Poland) there was carried out vertical seismic profiling (VSP) from one or two excitation points. In some holes the methods of referenced hydrograph (RHM) and of time multiplexed horizon tracing (TMTHH), respectively, were applied. In these measurements various types of probes including a component probe with controlled clamp have been involved. The data obtained made it possible to characterize velocity profiles in various parts of the Baltic, to discover different types of longitudinal and exchange waves, to determine the existence of seismic boundaries in previously almost unexplored areas and to find out structural features of separate profiles adjacent to the holes.

The exploration of oil prospective Middle-Cambrian sandstones

with a relatively small thickness and low velocity parameters is hindered by a cover of Ordovician carbonates with a high velocity. In order to explore these deposits a special complex of investigation and processing methods was employed. Within Block D more than 70 km of CDP records have been processed passing by two oil fields and a number of prospective zones.
The CDP recording was 96-fold with a sampling rate of 2 microseconds. The data were processed employing an effective seam model (ESM) developed in the VNII Geofisika by CONDRATIEV. This model delivered fine lamination in the interval from Ordovician carbonates down to the surface of the crystalline basement. The minimal thickness of detected seams is 7-10 m. The prospective layer could be traced, changes of its structure and velocity reductions within this layer could be specified. Moreover, it was possible to locate thin laminations in the deposit's cover related to lens-type deposits of oil bearing sandstones.

We consider this processing method to be very helpful under the complicated conditions of the Baltic Sea syneclise. It is intended to apply this method to the other structures discovered during the last years with the aim to find out the most promising ones.

REGIONALIZATION OF SHELF AREAS BY LANDSCAPE TYPES

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The best approach to a complex investigation of natural conditions and resources is the environmental one. Looking for indicators of environmental conditions it is most suitable to consider not specific animals or plants but the whole living community - the biocenosis. In our reserarch work the sea floor is studied as a kind of geographic complex (geosystem), consisting of the interacting with each other components: relief, water column, sediments, benthos.

One of the most important units of the subaqueous landscape is the landform which represents a bottom part attributed to mesoforms of the relief. A classification of landforms is made by four principal features:
- the genesis of the landform
- the bottom relief
- lithological characteristics of the sediment
- the benthic community

Following the region off the port of Liepaja shell be presented as an example showing some basic landform types. This region can be subdivided into three areas corresponding to the main morphological structures; the East-Gotland depression, the Wentspil step, the Gdańsk-Gotland saddle and the Liepaja rise.

The first area composed of three landforms is situaded in the East-Gotland depression, which is filled in with fine-grained sedimentary material. In the centre of the depression (at depths between 95-100 and 140 m) the first landform is located. It is covered by sandy silt over clayey silt. Typical organisms of this area are *Nereis diversicolor* and Oligochaeta.
The second landform is connected to the slope of the East-Gotland depression (at depths between 60-65 and 95-100 m). It is formed by clay on sandy silt and characterized by the occurence of *Nereis diversicolor* and *Macoma baltica*.
An intermediate landform at depths from 95 to 102 m is represented by sandy silts over sandy clayey silts and digging animals.

The second area is related to the Gdańsk-Gotland saddle and the Wentspil step. It is forked by two landforms corresponding to the structures mentioned above.
The first landform situated on the Gdańsk-Gotland saddle is a slightly inclined plain. It adjoins the East-Gotland depression from the south-west at depths from 45 to 60 m and is characterized by very fine sand over sand and by the occurence of bivalves and digging animals like *Macoma baltica, Nereis diversicolor* and Oligochaeta.
The landform on the Wentspil step adjoins the East-Gotland depression from the north-west at depths between 35 and 60 m.

This ridge is directed to the East-Gotland depression and consists of very fine sand. The benthos is represented by *Macoma baltica* and *Mya arenaria*.

The third area at depths between 10 and 35-40 m belongs to the Liepaja rise and forms a slightly inclined accumulation plain. The landforms in the south-western part of the area at depths between 30 and 40 m are composed of different sized sands over clay and middle sands. The benthos is dominated by *Mya arenaria* and *Macoma baltica*.
Another landform formed by coarse-grained lag sediments over sand provides favourable conditions for the occurence of seaweed and sessil animal forms. It is situated in the coastal zone at depths between 10 and 30 m and influenced by waves and coastal currents. The ecological situation in this area is the result of interacting natural and anthropogenic factors.
The degree of anthropogenic contamination in this area was investigated for the following substances: oil hydrocarbons, synthetic surface-active agents (SSAA), polynuclear aromatic hydrocarbons (PAH), phenols and heavy metals (Cu, Pb, Cd, Hg).
The concentration of oil products in the sediment was proved to be equivalent to the natural background. The heavy metal concentrations exceed the maximum permitted values in some places by a factor of four.
The oil content in coastal sediments from north of the port Liepaja is 0.01-0.04 mg/g. This concentration increases with the distance from the shore reaching a maximum value of 0.08 mg/g at a distance of 32 km off the coast.
According to this the amount of phenoles increases from 0.2-0.4 mg/g near the shore to 0.6-0.1 mg/g farther away.
Also the PAH concentration increases with the distance from the shore.
The occurence of heavy metals in the coastal zone is confined to spots because of the export of fine grained material into the East-Gotland depression.
The transport of pollutants in the coastal zone (at depths from 15 to 20 m) is mainly alongshore and at the open sea more or less cyclonic.

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EVIDENCE OF OIL CARRIER BEDS BY AN EFFECTIVE COVER METHOD - SEISMIC PROCESSING OF DATA FROM THE BALTIC SEA SYNECLISE

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(Soyuzmorinzhgeologiya, BMGEE, Kaliningrad, Russia
Vneshgeophysika, Moscow, Russia)

Oil and gas deposits of the Baltic Sea syneclise are connected to sands and clays of the middle Cambrian *Paradoxides paradoxissimus* strata. They are characterized by homogeneous sandstone lenses in heterogeneous sandstones situated in anticlinal structures.

Acoustic models developed on the base of drilling results show a thin lamination. Due to a larger portion of sandstones in oil carrier beds there is a smaller amount of *Paradoxides paradoxissimus* clay resulting in a general reduction of acoustic stiffness. At the same time the clay content in overlying Ordovician carbonates diminishes producing a higher acoustic stiffness. Thus, there is a higher sound velocity contrast between Ordovician and Cambrian sediments in oil containing structures.

The main objective of the CDP method in our studies is to locate middle Cambrian sediments in time sections. The solution of this problem is complicated by the soft character of these low velocity deposits and by the fact that they are directly beneath Ordovician carbonates with a high velocity. In CDP time sections the reflections of Ordovician rocks (O) and of the crystalline basement (PR) can be traced (see Fig. 1). Between these two boundaries a homogeneous double-phase interference vibration occurs, which corresponds to our interval of interest. Locating the horizon of interest in seismic sections it is useful to trace the lateral changes of acoustic parameters in order to decide if there is oil or not. This procedure is part of a seismic signal form study investigating the frequency composition of a wave field, i.e. a dynamic interpretation.

The task to restore the detailed acoustic characteristic of a medium using seismic records is contrary to the procedure employed to develop synthetic seismograms on the basis of acoustic complex data. For this reason it is called reverse dynamic task (RDT). Its general solution contains incorrect procedures, so even small errors of the input data may result in the loss of important information during transformation. However, by the application of dynamic processing procedures it is possible to simplify a seismic model significantly.

Different variants of a RDT solution depend on the basis of the dynamic interpretation by the CDP method. Its aim is to obtain a detailed geoacoustic model of a geological section using complete information about the form of reflected waves.

If there are even small scale interferences (in per cent units) due to the limited frequency range of seismic recording the RDT solution doesn't have the character of a singularity without prior introduction of further information. That means that two seismic traces with almost similar forms may correspond to absolute different sedimentary models. Therefore a sedimentary model restored in the result of a RDT solution under very low interference levels may not reflect the real geological situation without the prior use of additional information.

In order to create detailed seismoacoustic models of geological sections by the use of the form of reflected waves we employed a dynamic interpretation of an effective seam model. This effective seam model solves the RDT task of a seismic survey or performs the inversion of seismic traces (which is the same). To trace sedimentary units with a reduced acoustic stiffness because of oil presence, the CDP method was applied to drilled structures (Fig. 2-4):

D - 5 there is no oil
D - 6 oil deposit is present
D - 29 drilling was not yet conducted, prospection should be done

Comparing the seismoacoustic sectors (Fig. 2-4) it can be noticed that sandstones of our interest are not present in the vicinity of the structure D 5, but they appear near the D 6-2 hole out of the boundaries of an oil deposit. The sandstone lens near D 6-2 can be traced in two profiles (Fig. 2, 3). Furthermore, it is observed within the limits of the structure D 6 and in the D 29 structures.

Generally there is an obvious velocity contrast between the Ordovician carbonates and the middle Cambrian *Paradoxides paradoxissimus* strata in the D 29 structure. As mentioned before this can be connected to the presence of oil bearing sandstones in the sedimentary cover.

The method presented here proved to be capable to trace special physical features of oil bearing sediments and to detect oil prospective areas even under conditions of low velocity sections and weak reflectivities.

It is recommended to process CDPM profiles from boreholes in prospective sedimentary structures in the same manner. This will permit to evaluate oil prospects and to optimize the location of further drillings at minimal expenses.

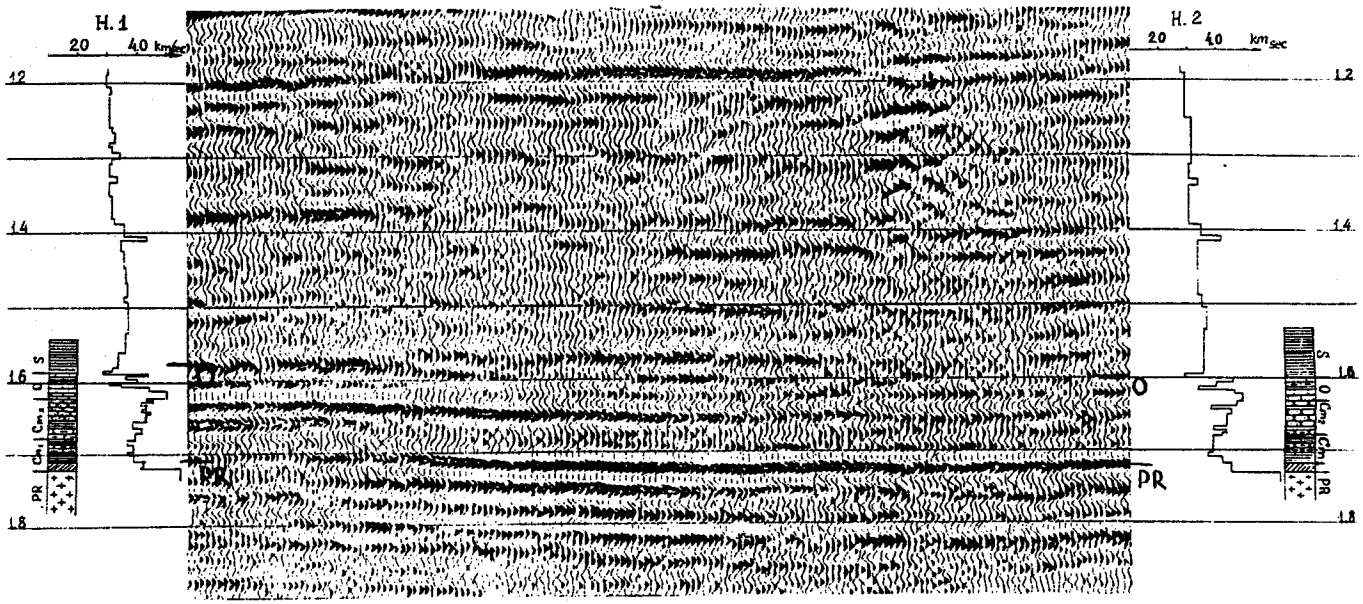
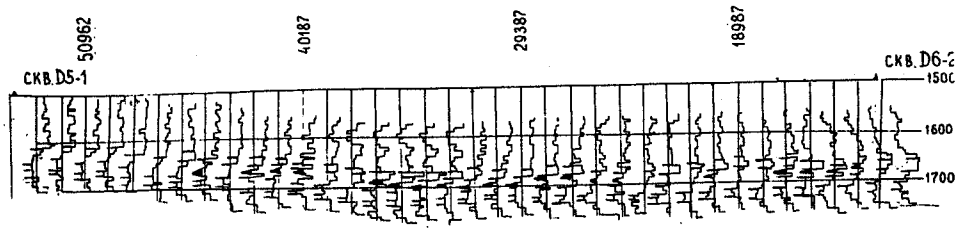
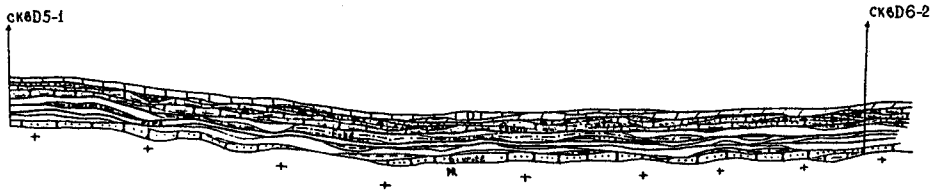


Fig . 1. INITIAL SEISMIC SECTION.



SEISMOACOUSTICAL STRATUM MODEL OF ENVIRONMENT.

Fig. 2



GEOLOGICAL SECTION ALONG PROFILE 901004 THROUGH STRUCTURES D6 AND D5.

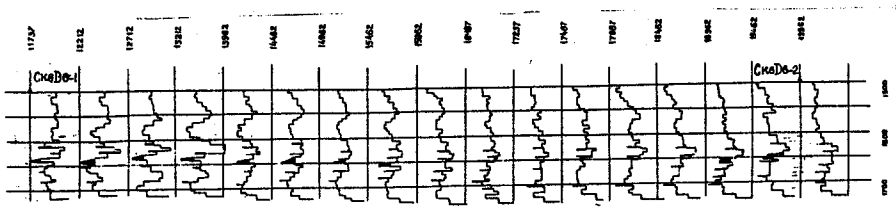
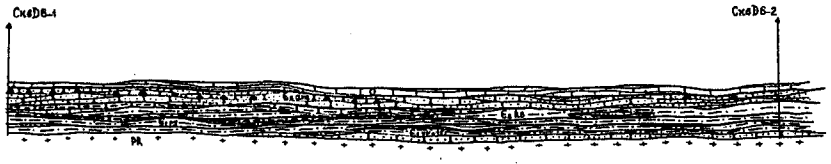
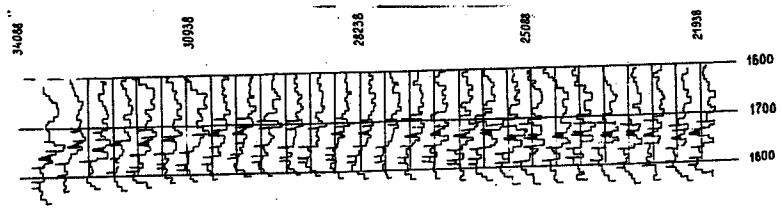


Fig. 3 SEISMOACOUSTICAL STRATUM MODEL OF ENVIRONMENT.

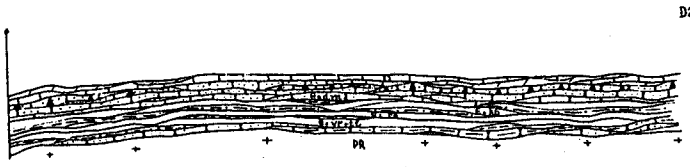


GEOLOGICAL SECTION ALONG PROFILE 901004 THROUGH STRUCTURE D6.



SEISMOACOUSTICAL STRATUM MODEL OF ENVIRONMENT.

Fig. 4



GEOLOGICAL SECTION ALONG PROFILE 901004 THROUGH STRUCTURE D29.

CONVENTIONAL MARKS:

ACOUSTICAL HARDING

SANDSTONE

SILTSTONE

INTERVALS OF LOWER ACOUSTICAL HARDING IN THE DEIMENAS OVERHORISON.

OIL SANDSTONE

SHALE

SEISMIC MAPPING OF PLEISTOCENE CHANNELS IN KIEL BAY (WESTERN BALTIC)

Roland Atzler, Friedrich Werner (Geological-Paleontological Institute, University of Kiel, Germany)

Parts of seismic records from the NE-Kiel Bay are shown. Corresponding line interpreted sections are plotted in scale. Also shown is a trackplot with the seismic sections in real positions. Examples of special structures observed in Kiel Bay are given for discussion.

The used seismic sections are part of a mapping project of Pleistocene channels in the Kiel Bay.

We try to investigate various channel systems, generations and forms and to relate them to different glacial stages.
Seismic investigations show a great variety of glacial forms which help to understand the evolution of the Western Baltic during the last iceages.
The measurement is done with an ORE boomer unit. The high-frequency seismic signal (0,5 - 3 kHz) allows the resolution of very fine bottom structures together with a great penetration depth. Up to now we have driven several 100 seamiles of seismic tracks which cover almost the whole area of Kiel Bay.
The normal depth of penetration is about 15 metres, at isolated places going down to 80 metres. This method can not be used for areas with a predomiance of mud sediments containing gas (e.g. Eckernförde Bay and Flensburger Förde).

ACCUMULATION, COMPACTION, AND EROSION OF FINE-GRAINED MARINE SEDIMENTS

Valter Axelsson (University of Uppsala, Sweden)

The rate of sediment accumulation, the gravitational compaction, and the erodibility of fine-grained sediments are studied in some bays and basins of the western Baltic Sea. In several of these bays and basins, annually laminated, modern deposits and datable turbidites, storm deposits, or dredge-silt layers may be used to test models for sediment deposition and sediment reworking. The formation of cyclic and event types of stratification are observed by comparing stereoradiographs of sediment cores collected from selected locations during different seasons, and sometimes also before and after a specific event such as a major storm. Sediment compaction and gaps in the sedimentary sequence are determined by using radiographically calculated sedimentation-compression curves, relating void ratio to effective overburden pressure. The interparticle electrochemical forces increase in strength with the packing, and with increasing specific surface area of the deposits. Accordingly, void ratio as a measure of the compaction, and grain size as a measure of the specific surface area probably are the two most crucial physical parameters in studies of the erosion resistance of more or less cohesive, marine sediments. Therefore the conditions for erosion and resuspension of the fine-grained bottom deposits are determined by the use of a new diagram, relating critical erosion velocity to void ratio and grain size.

MICROELEMENTS IN THE BALTIC SEA SEDIMENTS

G.N. Baturin (Institute of Oceanology, Moscow, Russia)

The study of geochemistry of microelements in the Baltic Sea sediments promotes the general knowledge concerning the marine sedimentation, as well as contrasting behaviour of elements under the influence of a changing near bottom hydrochemical environment and the response to the anthropogenic stress imposed on the basin. Our study is based on materials gathered during the 24th cruise of RV "Professor Shtokman" in the Bornholm Deep and the Baltic Proper including sampling of sediments, iron-manganese nodules and sulfide nodules. The analyses have been carried out by atomic absorption and neutron-activation methods.

The comparison of analytical results for sediments with average oceanic sediment composition (Baturin, 1988) has shown that the Baltic muds are enriched in K, followed by other alkaline elements (Li, Rb, Cs), but at the same time they are lower in alcaline earths (Sr, Ba) and only slightly higher in Be. It is also important that Baltic sediments are several times lower in Ca, compared to oceanic ones.

The behaviour of elements of the 3rd group of the Periodic table is not uniform: the Sc and light rare earth element (La, Ce, Nd) contents are comparable to the oceanic level whereas the intermediate and heavy REE are lower. The hydrolizing elements (Ti, Ge, Zr, Hf, Th) as well as elements of the 5th group (V, Ta, As, Sb) are similar to the oceanic level. The elements of the Zn group and U are distinctly enriched: Cd up to 10 times, Hg up to 5, Zn and U up to about 2 times. A number of other ore metals are essentially lower in the Baltic sediments (Ni, Co, Cu), in contrast to Pb which is about 2 times higher compared to the ocean. The only one analyzed sample of gyttja showed the relative enrichment in Fe, Mn, and P, followed by a series of microelements (As, Sb, U, Sr, Ni, Co, Zn, V, Mo, Cd), in contrast to Cu, Li, Cs, Hf, Th.
The two sediment cores from the Bornholm Basin revealed an essential enrichment of the upper layer by As, Sb and Pb, which is considered as evidence of anthropogenic influence.
The ferro-manganese nodules are enriched as compared to sediments by As, Fe, Sr, Mn, Mo, Ni, P, Sb, Zn, Ba, Cd, Ca, Co, Cu and Pb, but oceanic nodules are much richer in all these elements except P and As.
The sulfide nodules are also enriched compared to sediment by As, Fe, Cd, Co, Zn, Cu, Ni, Pb and Sb, but having a much lower content of other microelements.

These results demonstrate an essential difference in marine and oceanic sedimentation as well as some comparable features in the diagenetic process of iron-manganese concentration.

GEOTECHNICAL AND GEOECOLOGICAL MAPPING OF THE BALTIC SEA BOTTOM IN CONNECTION WITH HYDROCARBON PRODUCTION PROSPECTS (METHODS AND BASIC RESULTS)

Y.P. Bezrodnykh, A.F. Namestnikov, D.H. Latsis
(Soyuzmorinzhgeologiya - VNIIMORGEO, Riga, Latvia)

Oil prospecting in the Soviet sector of the Baltic Sea has demonstrated the necessity of specialized environmental studies in prospective offshore areas. Such studies comprise geotechnical and geoecological seabottom mapping, thus providing the basis for optimum choice of oil production technologies taking into consideration possible ecological impact.

The seabottom is considered to be the foundation of offshore structures during geotechnical mapping and a part of the offshore environment during geoecological mapping. An integral part of such studies - modern geological and lithodynamical process studies are conducted in order to investigate their influence on offshore structures and underwater pipelines as well as factors influencing the accumulation of pollutants entering the sea.

The mapping is conducted using the scale 1:25.000 to 1:200.000 covering prospective areas and their environs where pipeline construction is possible.
The methods of mapping comprise a set of traditional marine geological investigations in combination with geotechnical, hydrobiological and geochemical studies. The application of digital sub-bottom profiling systems enhances the quality of soil spatial changeability investigations.

As a result, the structure of sub-bottom soils, variations in their composition and geotechnical properties have been studied and the state of the underwater ecology of main prospective areas has been evaluated.

GEOLOGICAL HISTORY OF THE BALTIC BASIN DURING MESOZOIC AND CENOZOIC

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During Late Permian and Triassic in the Central-European region dominated regional subsidence, associated with a new phase of rifting. During Lower Triassic, under conditions of Thetys transgressions of low intensity, through the Polish Trough occured the development of lagoonal and marine shallow-water environments with an accumulation of variegated clays, marls with gypsum and anhydrites, and, in boundary regions, of continental variegated sandstones and clayey conglomerates with a uranium mineralization. The thickness of the Lower Triassic within the Baltic Sea area is 200-400 m. During Middle and Upper Triassic in the Baltic basin prevailed a lacustrine-alluvial facies, and at the end of Late Triassic (Rhaetian), layers of transgressive marine sandstones and red kaolinic crusts with a thickness of up to 40 m.

Cyclic elevations of the sea level during Liassic were part of a vast transgression of the Thetys and Arctic Seas, associated with the splitting of Pangaea and the Cimmerian tectogenesis. The thickness of the Lower Jurassic continental and estuarine-marine facies in the Baltic depression is up to 80 m, and the thickness of marine and paralic sediments west of Bornholm increases up to 100-500 m. During Dogger there prevailed terrigenous sedimentation with a thickness of deltaic, estuarine, lagoonal and littoral-marine facies of 100-150 m. During Late Jurassic the basin was of maximum size and was filled up with littoral-marine thin-layered glauconitic, carbonaceous and siliceous deposits with a thickness of up to 300 m.

At the boundary between Jurassic and Cretaceous there was a regional regression, associated with Late Cimmerian and the opening of the Arctic and North Atlantic rift system. During Neocomian the marine basin expanded over the Western Baltic only. After a long interruption the global Late Albian transgression manifested itself in the Polish-Lithuanian Basin by the accumulation of uniform series of glauconitic quartz sands and aleurites, with interlayers of siliceous and calcareous sandstones and phosphorites; the thickness of the Aptian-Albian in the western Baltic is up to 30-40 m; in Soviet Pribaltics up to 107 m. The Upper Cretaceous thalassocratic stage in the Baltic basin is represented by the accumulation of carbonaceous sediments: from glauconitic marls to chalk. In marginal areas of the basin were formed mainly terrigenous sandstones and aleurites, calcarenites with interlayers of phosphorites, opokas, argillites and conglomerates with a thickness of up to 70-140 m in the south-western Baltic and up to 600-800 m in Hanø Bay, respectively.

With the culmination of the Laramian movements in the Paleocene there was the onset of the spreading in the Norwegian-Greenland Basin. The Lower Paleocene basin in the south-eastern Baltic is characterized by a glauconitic-siliceous formation (thickness up

to 20-40 m); in the western Baltic and Jylland, Danian and Montian series are represented by limestones and marls, glauconitic sands and clays with thicknesses of up to 150 m. During Paleocene the marine basin in the southern part of the depression lost its connection with Thetys, while in the west there was formed an inversion orogenic barrier - the Kujawa-Pomeranian Ridge. Until Middle Eocene the basin was a bay of the North Sea. Later on communications with southern seas resumed again with a peak of the transgressional development in the Late Eocene. The Eocene in the Baltic basin is represented by marine and continental facies with a thickness of up to 50-60 m including glauconitic quartz sands and aleurites with interbeds of lignites and silicites, and inclusions of phosphorites, amber and volcanic ash. The following regression, at the boundary between Eocene and Oligocene, the so-called Rupelian Sea with its monotonous terrigenous facies expanded over the southern part of the depression. In the Kaliningrad region deposits of the Rupelian sea of low thickness (glauconitic-quartz sands and aleurites with phosphorites) represent the transgressive, and in north-eastern Poland (red aleuropelites with brown coals) the regressive stage of this basin.

During Late Oligocene in the Central-European basin developed a continental regime with wide-spread occurence of coal-bearing lacustrine-swampy facies. At the end of Miocene-Early Pliocene, the Polish lowland was involved into a transgression from the Carpathian foredeep. At this time the vast shallow-water Poznanian basin was formed, which possibly covered the adjacent part of the Baltic depression. During Middle-Upper Pliocene there was a regression leaving only the big lacustrine basins. The Poznanian transgression resulted in backwater of rivers of the Baltic drainage system, which was formed at the end of Miocene (with the beginning of the elevation of Fennoscandia) due to the formation of large drainage lakes. Miocene deposits were preserved on the Baltic bottom in littoral areas of Poland, and, here and there (together with Pliocene), in buried river valleys.

During Preteglian (2.2 - 2.5 million years ago) in Scandinavia yet existed a small glacial cover. Lower-Quaternary preglacial cyclites and lacustrine-fluvial sediments are known in Poland and Soviet Pribaltics and are supposed to be in some valley incisions on the Baltic bottom. The Menapian (Günz) glaciation eroded most of the Miocene-Low-Quaternary sediments of the Baltic river system. The Baltic Sea area is covered today mainly by deposits of the Middle Quaternary and the last (Vistula) glaciation. Some data indicate an expansion of the Baltic basin by the presence of marine Holsteinian, Eemian and Lower Vistula formations.

FLUID FLOWS OF HYDROCARBON GASES FROM THE BOTTOM OF THE BALTIC SEA

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Seepages of hydrocarbon gases, associated with fluid flows at the bottom of the Baltic Sea, were studied in detail by means of a series of methods. Forms of gas seepage, confined to regions of acoustic anomalies in Paleozoic and Mesozoic sediments, are represented at the bottom surface by isometric and oval crater-like forms (pockmarks) with a size ranging from 10-30 to 70-100 m and a depth of up to 1-2 m, as well as by linear patterns in the form of narrow trenches with depths of up to 5-7 m, a width of up to 100-200 m and a length of up to several miles. Acoustic anomalies of areal and concentrated type manifest themselves in old valley downcuttings, associated with faults of north-eastern, sublatitudinal and submeridional trends. Concentrated anomalies are located in fissure or tube-like regions and are often associated with buried craters. A thin layered structure in the form of a gas cavity ("pillow") can be sharply distinguished under such craters at depths of up to 5-10 m. Gas "pillows" are not necessarily associated with craters, but they are surrounded by vast gas aureoles.

Areal anomalies of the Gdansk Basin usually are connected with complex tectonic structures. In the southern part of the Gotland Basin there were traced numerous seepage channels of fluid flows of fissure type without any distinct acoustic anomalies. These channels in the form of narrow trenches are orientated along zones with indications of recent tectonic movements.

Sediments in the region of fluid flow seepage are cavernous and often characterized by a network of open polygonal fissures. These young Holocene gas-charged muds have anomalous physical parameters: density approaches to 1.0 g/cm^3, porosity is about 90-95 %, sound velocity decreases to 800 m/s. In the upper layer (0-40 cm) the gas-charged sediments contain gases in dissolved form. Cores taken from pockmark trenches also consist of upper-Pleistocene moraine-like clays with notable traces of gas turbations. The formation of joints in moraines is associated with an irregular compaction due to frost deformation. The gas filling of pores and fissures is a result of neo-tectonic movements, when channels for fluid supply have been renewed.

The gas mixture in the sub-surface layer (40-300 cm), where its concentration is up to 300-500 cm^3/kg of raw sediment, contains a predominant portion of methane and CO_2; here and there helium, hydrogen and methane homologues were found. Measured values of ^{13}C in methane are -(48.5 - 55.8) ‰. Slightly increased values of ^{13}C in methane testify in favour of either petrogenic or biogenic gas sources.

The influence of fluid flows leads to anomalous diagenetic processes, i.e. products of sulphate reduction and other reactions discharge into the near-bottom water. Furthermore,

increased concentrations of suspensions containing a great amount of helium-like aggregates are observed. In the near-bottom waters anoxic conditions connected with high concentrations of H_2S, organic P and in some places monoaromatic hydrocarbons start to develop.
During the processes of fossilization of organic matter and the chemosynthesis influenced by fluid hydrocarbons a significant enrichment (by a factor of 1.5 - 2) in organic carbon occurs. On the other hand oxygen-free conditions in near bottom waters alone cannot lead to an enrichment of organic matter in the sediments of the Baltic Sea. This shows the important role played by fluids in the formation of oil parent-rocks such as Kimmeridge clays in the North Sea Basin or Mid-Cretaceous black shales.
Data on the distribution of acoustic anomalies and gas sources could be used, therefore, for hydrocarbon exploration.

THE STRUCTURE OF THE PLATFORM COVER OF THE EASTERN BALTIC BASIN ACCORDING TO SEISMIC AND DRILLING DATA

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The area under discussion (Kaliningrad, Lithuanian and Latvian offshore areas) corresponds to the axial zone of the Baltic syneclise. From the point of view of regional structure within the Caledonian complex two depressions divided by a transverse late Caledonian high are singled out. The basement depth in the central axial depression, open towards the young platform, reaches 3,3 km while in the northern, tectonically isolated, depression it is 1,8 km. The high situated between the depressions is characterized by block plicated dislocations oriented WSW-ENE which can be followed from the Latvian coast as far as the Swedish offshore area. The central axial depression is complicated by gently sloping longitudinal bars oriented SW-NE, divided by troughs of similar nature. In its southern part (the Gdańsk Bay) the stretch is quite different (latitudinal-transverse to the axis of the syneclise). In the proximal part of the depression in lower Paleozoic deposits early Permian diabase sills occur.

The Caledonian complex is dominant in the sedimentary cover. Its thickness reaches 2 km in the southern part. The deposits of the complex are little eroded in both depressions; maximum erosion is observed in the high dividing them. The Hercynian (Devonian) complex up to 0,8 km thick lies mostly monoclinally and pinches gradually out in the southern and the northern directions from the central part of the area. The latitudinal zonation of the thickness of the complex is due to big block tectonic movements along latitudinal faults. An Alpine complex up to 1,4 km thick is present in the south and south-east within the superposed depression filled with Zechstein-Mesozoic deposits.

THE RECENT SEDIMENTATION PROCESSES IN THE LENINGRAD BIGHT (NEVSKAYA GUBA)

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The Leningrad Bight is situated at the Eastern part of the Gulf of Finland. The total square of the Bight is about 400 sq.km. Nowadays it became an inner-town basin, separated from the Baltic Sea by the Leningrad hydrobuilding dam constructions. The natural sedimentation scheme, settled during 2.000 years, was awfully changed by the technogenic rebuilding of the sea bottom relief and shores. The conditions of the terrigenous material transition through the Leningrad Bight were changed by active sediment accumulation zones.

The composition of the sediment load entering the Bight was also considerably changed. The recent sediments are anomalously enriched by technogenic components (heavy metals, organic material, oil-derivatives etc.). Large spots of a secondary pollution of the basin are formed.

In the near future the necessity of a deposition processes management will become indispensable. Otherwise the expenses needed for the mechanical cleaning of the sea-channel and the restoration of the beaches will grow enormously. The environment quality will inevitably get worse. The results of our sedimentation processes survey can serve as a basis for such a management in order to supply a forecast of the environment's development.

NUTRIENTS IN RECENT SEDIMENTS OF VEJLE FJORD, KATTEGAT AND BORNHOLM BASIN: A COMPARISON

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Sediment samples from 3 different field campaigns (Vejle, Sept. 1988; Bornholm, Oct. 1989 and Kattegat, Sept. 1990) were analyzed for grain-size, organic matter and concentration of nutrients. As the samples were collected in the same season, differences between areas are assumed not to depend on seasonal variations.

The maximum concentrations of nutrients in the water column are highest in Vejle Fjord followed by Kattegat and Bornholm Basin. In spite of this, there are great interareal similarities in the concentrations of nutrients in the sediments on the parts of the bottoms which can be influenced by frequent resuspension. The frequency of resuspension-episodes is measured in Vejle Fjord and estimated for the Kattegat and the Bornholm Basin. Such estimations are based on computed wave orbital velocities near the bottom. The reason is that continuous current measurements in Vejle Fjord and Kattegat 1 m above the bottom show current velocities most of the time well below the critical threshold velocity for sediment movement. In Vejle Fjord threshold velocities were only reached during 0.4 % of the year. This suggests that redistribution of sediments and their content of nutrients strongly depend on the combined effects of waves and currents.

The concentrations of nutrients in deeper water are much higher and lowest in Kattegat. The lowest rate of deposition of nutrients is also found in Kattegat.

Water			Sediment							
			Shallow water				Deep water			
	NO_2+NO_3 (mg/l)	PO_4(P) (mg/l)	Depth (m)	IG (%)	Tot-N (%)	Tot-P (%)	Depth (m)	IG (%)	Tot-N (%)	Tot-P (%)
Vejle	0.70	0.055	0-2	1.8	0.04	0.02	4-18	15.0	0.62	0.12
Kattegat	0.20	0.032	15-25	1.9	0.04	0.02	24-40	8.1	0.19	0.05
Bornholm	0.05	0.022	35-50	1.9	0.06	0.03	50-95	12.1	0.56	0.14

Table 1: Maximum concentrations of nutrients in surface waters and average content of nutrients and organic mmatter (IG) in the sediments. Note the different definitions of shallow and deep water in the three areas

There is a strong and similar correlation between the content of organic matter and both N and P in Vejle Fjord and Bornholm

Basin. In the Kattegat, with frequent resuspension-episodes, there is also a strong correlation. Here, however, lesser N concentrations are observed relative to C. This could suggest that there is a preferential loss of N compared to C during transport. In Vejle Fjord there is also a strong correlation between the clay % and the concentrations of nutrients, whereas in Bornholm Basin the nutrients are best correlated to the silt %.

The C/N ratio is often used to characterize the organic matter with respect to origin and degree of decomposition. However, most sediments consist of a mixture of more or less refractory organic matter with completely different C/N ratio which to some extent baffles the interpretation of registered ratios. Also, microbial decomposition of the organic matter during settling in the water column increases the C/N ratio. However, with these complexities in mind, the C/N ratio turned out to be a good tool to discriminate between transport/erosion bottoms and accumulation bottoms. In areas with no resuspension, as the central parts of the Vejle Fjord, the C/N ratio is about 8 or near to the Redfield ratio observed in the phytoplankton. In areas with no marine sedimentation, i.e. parts of deeper water in the Kattegat and parts of the shallow water in the Bornholm Basin, where till material is still exposed on the sea-bottom, The C/N ratio is 24-26. Transport bottoms showed intermediate C/N ratios in the range of 12-16.

ON ENVIRONMENTAL MONITORING OF THE NEAR-BOTTOM LAYER IN THE BALTIC BASIN

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In order to understand the trends and to control contamination of both near-bottom sea water and sediments, a multi-disciplinary environmental monitoring programme is needed. This should include long-term investigations of hydrophysical, hydrochemical and optic parameters, as well as studies on suspended material and continuing sampling of sediments. Groups from the University of Hawaii, Institut für Angewandte Physik der Universität Kiel, and the Shirshov Oceanology Institute will begin these joint studies employing Pop-Up samplers and self contained bottom stations. The bottom stations will include a Neil-Brown package with flux-gate compass, Doppler current meter, pressure and temperature sensors, plus C-T probes, hydrochemical modules, sediment traps, and optical monitoring with photomultipliers. These are to be deployed in several sites over the region of investigation, and will provide synchronous time series data. It is expected that features of the time variation of the delivery of polluting material to the sea floor and its transformation will be revealed. The combined observations should permit distinction between background conditions such as bioactivity, and results of pollution. It may also be possible to identify the source of the polluting material by correlations between currents and other parameters.

MAGNETOSTRATIGRAPHICAL CORRELATION OF HOLOCENE BOTTOM DEPOSITS ON THE BASIS OF PALEOSECULAR VARIATIONS OF GEOMAGNETIC FIELD

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A series of sediment sections in the Baltic and White seas were studied. There are variations of remanent magnetization along sections, which reflect paleosecular variations of the geomagnetic field (PSV). We carried out paleomagnetic correlation of sections in every basin by similarity of moving vector trajectories. Gaps in paleomagnetic records were filled up by data of the same age from neighbouring sections. This correlation permitted to reconstruct the succession of variations of the geomagnetic field direction in the Allerødian-Atlantic time (from 7.000 to 11.000 years ago) for every region. This succession is connected with lithostratigraphical divisions and by palynological data with the climatostratigraphical scale.

Resulting trajectories can be divided into a series of circles PSV with a duration of 600 - 1.200 years.

PSV circle is an almost closed loop, described by a geomagnetic field vector. It is determined that these circles have individual characteristics. These characteristics are useful for a subdivision of circles in sections and their correlation. The correlation may have an accuracy no less than 200 - 300 years.

The comparison of PSV circles in the Barents and White seas allowed to synchronize the studied sediments in these basins. Nonsynchroneity of palynologically determined boundaries was revealed during this investigation. So, the rise of temperature corresponding to the Preboreal-Boreal boundary took place in the Onega Gulf region more then 1.000 years earlier than in the region of the Gulf of Finland.

MARINE SEDIMENTS OF THE MIDDLE- AND LATE-VISTULIAN IN THE NORTHERN PART OF THE LOWER VISTULA REGION

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Results of field research and a number of TL and ^{14}C dates allowed to subdivide the glaciogenic deposits of the Vistulian (=Weichselian) glaciation in the northern part of the lower Vistula region into three large chronostratigraphic units, corresponding to two megastages or glacial cycles and a separating them non-glacial lengthy interval, called the Grudziądz (Graudenzer) Interstadial.

Within the Grudziądz Interstadial was formed the lower, older series. It was deposited in association with areal dissipation of the ice sheet and a general rise of the sea level during the Middle-Vistulian deglacial hemicycle. This series is represented by glacial-marine deposits and also by real marine sediments (sites Mała Słońca, Ryjewo). Both types of sediments contain redeposited mollusc shells, dated by ^{14}C to the interval from 37.400 ± 1.600 (Lu-1326) to more than 42.300 (Lu-1327) years B.P. Apart from appropriate sedimentary structures, the marine environment is also confirmed by the presence of trace elements (Li, Ba, Ga, Ni, Cr) and isotopes of ^{18}O and ^{13}C in pure calcium carbonate precipitates. The TL-dates relate the marine deposition to the time interval between 53.100 ± 8.000 and 42.200 ± 6.500 years B.P.

Marine deposits of the Late Vistulian are particularly well developed in the exposure at Gniewskie Młyny, known from the literature as a classic site of marine deposits containing mollusc shells (BEHRENDT 1865, JENTZSCH 1896, GALON 1934, GADOMSKA 1938, KOTAŃSKI 1956, MRÓZEK 1961, DROZDOWSKI 1986). It is likely that the transgression was accompanied by glacioisostatic lowering of the area. The upper part of the series, consisting predominantly of fine- and medium-grained sands, is considered to represent the maximum phase of the transgression, whereas the lower portion, composed of gravels and coarse-grained sands, represents the initial phase. This fining-up sequence of marine deposits is succeeded immediately by a till layer, indicating a rapid advance of the ice sheet in an aquatic environment.

Shells of *Cardium edule*, *Macoma baltica*, *Arctica* (=*Cyprina*) *islandica* and *Nassa reticulta* taken from the lower part of the series were dated by the ^{14}C method (HÄKANSSON 1976). The results were: inner fraction of shells -41.800 (+3.550/-2.450) years (Lu - 1072:1) and outer fraction -37.200 (+2.300/-1.800) years B.P. (Lu 1072:2). These data seem to connect the existence of the molluscs to the sea existing during the Grudziądz Interstadial. The deposition time of the shells was assessed by means of TL dating of the grain-mass of the sediments. The results obtained are as follows: basal portion of the capping till bed -18.400 ±

2.800, fine-grained sand 2 m below the base of the dated till bed -17.600 ± 2.800 years B.P.

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DIATOM BIOSTRATIGRAPHY AND PALEOECOLOGY OF THE FINNISH GULF IN HOLOCENE

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New data concerning the biostratigraphy and paleoecology of the Finnish Gulf's eastern part are presented. They are based upon studies of diatoms, pollen, spores and radiocarbon datings. Diatoms are investigated at 8 sites within the Gulf of Finland and also in transects at the Finnish Gulf's coast.

The stages of the Yoldian Sea in the sediments of this region are characterized by pure ecologically mixed diatom assemblages: *Aulacosira islandica subsp. helvetica, Achnanthes taeniata, Campylodiscus echeneis*. In synchronous sediments of the onshore transects a noteable amount of brackish-water marine species was discovered: *Nitzschia naviculares, N. punctata, Diploneis smithii*.

The diatom assemblages of the Ancylus Lake both in the sediments of the recent Finnish Gulf and in the onshore transects include planktonic and littoral species of large lakes: *Aulacosira islandica subsp. helvetica, Gyrosigma attenuatum, Epithemia turgida, E. hyndmanii*.

In the region of the village Veshevo (near the town Viborg) the transgression of the Ancylus Lake started in Preboreal time, earlier than 9.220 ± 70 years ago (LU - 2181). In the section Nevsky Lesopark in the Leningrad region organic sediments of the Mastogloia stage were formed about 7.580 ± 90 years ago (LU - 2371).

In the bottom sediments of the Finnish Gulf's eastern part diatom assemblages of the Littorina Sea correspond to brackish-water marine conditions. In open regions of the Gulf planktonic species like *Coscinodiscus commutatus, C. lacustris var. septentrionalis, Cyclotella caspia, Actinocyclus ehrenbergii, Chaetoceros holsaticus* dominate.

In sediments of the coastal regions the brackish-water lagoonal flora of the Littorina Sea is variably represented by the following species: *Campylodiscus clypeus, C. echeneis, Nitzschia circumsuta, N. scalaris, Navicula peregrina, Melosira moniliformis*.

The composition of diatom assemblages in Littorina Sea sediments of the Leningrad region shows that two small transgressions took place there.

The expansion of fresh-water diatoms in the sediments of the post-Littorina period is connected with a transgression of the Lake Ladoga in Subboreal time. The maximum of the Ladoga transgression was 3.000 years ago, when the river Neva has been formed, providing the flow of Ladoga Lake waters into the Gulf of Finland.

METHODS OF GEOLOGICAL SHELF SEA MAPPING (EXEMPLIFIED BY THE BALTIC)

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Recently completed works on compiling a geological map of the Baltic Sea floor on a scale of 1:500.000 (GRIGELIS et al. 1989) involved many geologists from Russia (Kaliningrad and St. Petersburg), Latvia, Lithuania and Estonia. The Atlantic Department of the P.P. Shirshov Institute of Oceanology has carried out about 50 geological-geophysical expeditions since 1960, during which geomorphology, tectonics, recent sediments and Pre-Quaternary rocks of the Baltic Sea floor have been investigated. Before the Baltic was divided into economic zones these investigations covered practically the entire aquatory of the Baltic Sea except the Gulf of Bothnia. The Kaliningrad Sea Geophysical Survey has performed a detailed examination of the deep bottom geology within the Soviet economic sector in order to find hydrocarbon-bearing structures.

The materials obtained were summarized in reports, published in geological magazines and monographs. Geological maps on various scales were compiled both for individual regions and the entire sea (Geology of the Baltic Sea, 1976). Since 1978 Lithuanian geologists took part in the Baltic marine geological research according to a contract regarding scientific co-operation aboard the research vessels of the Institute of Oceanology (Atlantic Department). The aim was to collect sufficient data for compiling a Baltic geological map on a scale of 1:500.000. Later on, geologists from Latvia and Estonia joined these works and carried out investigations aboard their vessels.

Compiling geological maps of any sea should be based upon a number of methods: 1) detailed studies (at polygons) of the bottom relief; 2) studies on the thickness of Quaternary sediments (CSP); 3) investigations on Pre-Quaternary formations and other special features, which could be elucidated by different geophysical methods. Geological maps of the adjacent onshore areas at the same (or a larger) scale are of special importance. The knowledge about the geology of these regions facilitates the interpretation of data obtained offshore.

Mapping and examination of Pre-Quaternary deposits at the Baltic sea floor is difficult because of the irregular distribution of exposures and thus insufficient drilling. While there is a sufficient number of such outcrops in the Northern Baltic and in the southern area of the Baltic Proper, the Gotland and Gdańsk Deeps and their slopes are covered by Holocene muds, sands, boulders and pebbles.

Often the outcrops of Pre-Quaternary rocks are confined to paleoshoreline scarps, cliffs, trough cuttings and bank slopes. The great altitude (up to 130-150 m) of some scarps enables

their selective dredging. The obtained samples from different depths are used to determine stratigraphic boundaries at the sea floor.

The method of dredging, applied in this work, proved to be quite reliable. This was demonstrated by further works involving "Mir" submersibles during the 22th cruise of r/v "Akademik Mstislaw Keldysh" (1991). If the thickness of Quaternary sediments is not larger than 10-15 m mapping and sampling of the underlying formations is possible by uniflow percussion corers able to penetrate into morainic deposits. The integrated application of all the methods mentioned above enabled us to compile a geological map of the Central Baltic on a scale of 1:500.000. The eastern part of this map on a smaller scale has been published in the book "The Baltic", in Finland (1988).

A series of maps (geomorphological, geological, map of Quaternary deposits) for the entire Baltic aquatory with explanations is being published by the All-Union Geological Institute (St. Petersburg). A monograph in Russian and English is being published as well.

STRATIGRAPHY OF THE BALTIC SEA SEDIMENTS

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The following methods were used to subdivide the Baltic sediments stratigraphically: lithological, palynological and diatom analyses as well as absolute dating (^{14}C). Hundreds of cores have been investigated. Recently benthic and planktonic foraminifera were studied to trace the inflow of saline North Atlantic water into the Baltic. First this was done by SAIDOVA, who investigated the cores of the 26th cruise of r/v "Akademik Kurchatov". Our investigations, based mainly on the material sampled during the 24th cruise of r/v "Professor Shtockman" refer to various regions of the Baltic Sea.

According to planktonic foraminifera (*Globigerina quinqueloba, G. pachyderma dex.* et al.) a core from the southern part of the Kattegat Strait could be subdivided into two horizons corresponding to the Littorina and Post-Littorina stages of the Baltic development. The correlation of benthic foraminifera species (*Cribrononion asklundi, Elphidium excavatum, Ammonia breccarii, Bulimina marginata, Nonionellina labradorica* etc.) allowed to distinguish 4 subhorizons, which represent the Upper and the Lower Atlanticum, the Subboreal and the Subatlanticum.

In 10 cores of the Borholm Deep foraminifera were found only in insufficient amount. The presence of foraminifera, among which *E. excavatum* and *E. incertum* prevailed, allowed to determine, however, whether the sediments had been deposited in a fresh-water or marine environment (Atlanticum, Subboreal and Subatlanticum periods). Saline water diatoms *Rhabdonema arcuatum* and *Rhizosolenia hebetata* indicate saline inflow into the Yoldia Sea.

A core from the Arkona Basin contained planktonic and benthic foraminifera only in its upper section corresponding to the Atlantic period.

Two cores from the Gotland Deep were studied. According to the presence of benthic (*E. askundii, E. incertum, E. excavatum*) and planktonic (*G. pachyderma dex., G. quinqueloba, Globigerinita glutinata*) foraminifera their upper section was deposited mainly during the Littorina stage. Their correlation with cores studied by SAIDOVA enabled us to subdivide it into the Limnea, Littorina and Mastogloia phases.

Stratigraphic boundaries determined within the cores by foraminifera are in accordance with the results of litholgical, palynological and diatom analyses and with the radiocarbon data.

Paleomagnetic and other physical methods have been successfully applied to the subdivision of glacial clays.

A RECONSTRUCTION OF THE PALEOGEOGRAPHIC SITUATION OF THE BALTIC SEA IN THE EARLY HOLOCENE

E. M. Emelyanov, E.A. Romanova (Institute of Oceanology, Kaliningrad, Russia)

A method for the development of paleogeographical maps is presented, which is based on the interaction between the two main late postglacial factors, i.e. tectonic development of the area (glacioisostatic effect) and eustatic changes of the water level. E.A. ROMANOVA has constructed diagrams of the total structural uplift of Fennoscandia for 8 sections of time, from 10.500 to 7.000 years ago with intervals of 500 years. The diagrams were made using 40 curves of ancient levels for different regions of Fennoscandia. The bottom relief and the coast lines of ancient basins of the Baltic were reconstructed; 8 maps for hypsometric levels of the early stages of sea development were compiled. N. PUNNING's eustatic curve of the Baltic Sea was used in this work.

Lithological maps for three main Pre-Littorina stages (Baltic Ice Lake, Yoldia Sea and Ancylus Lake) are combined with hypsometric level maps (EMELYANOV, ROMANOVA). The maps were compiled on the basis of 535 cores and data obtained by the Atlantic Geology Laboratory, Atlantic Department of the Institute of Oceanology, USSR Academy of Sciences, during the last 25 years.

Many cores were investigated (grain-size analysis, mineralogical and chemical composition, physical properties) in order to get lithological information. The generalized geological profiles were stratigraphically subdivided according to lithological data, ^{14}C, benthic foraminifera, diatoms and palynological methods. Generalized geological sections preceded map compiling.

Lithological maps in combination with hypsometric level maps are simulations of sedimentation conditions during Late Quaternary time.

GEOLOGICAL MAPPING IN THE BALTIC SEA BY SUBMERSIBLES "MIR" AND COMMON METHODS

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In March-April 1991 an expedition into the Baltic Sea was performed aboard the r/v "Akademik Mstislav Keldysh" equipped with submersibles of the type "Mir". During the expedition were carried out: 1) geological mapping of the bottom; 2) studies on sedimentogenesis and its relation to hydrodynamics; 3) geological observations. The depth range studied was between 39 m and 189 m. Five dives were performed at the polygons IV and V in the Northern Baltic covering 24 miles near the bottom. 54 samples of Pre-Quaternary rocks, 16 samples of recent sediments and 17 samples of near bottom water were taken, 30 pictures and 2.5 hours of videorecording were made.

For the bottom region a vertical zonation could be observed:
1) The bottom of the basin (usually with a O_2 content below 0.3-0.5 ml/l) is covered by semi-fluid black hydrotroilitic mud (in a depth between 120 m and 130 m), no signs of life could be observed. In the upper part of this zone, on the surface of the hydrotroilitic mud, there are spots (or even a 1-2 cm thick layer) of yellow and white mud. This is probably a microbiological "carpet" with metastable forms of sulphates (of barium? or others).
2) Above the yellow and white layers (or spots) there is a zone of "pure" light-grey mud (in water depths from 130-100 m to 120-70 m, depending on the water structure). Here numerous isopoda *Mesidethea entomon*, and individual specimens of flat-fish occur. The isopoda usually inhabit bushes of red seaweed.
3) Upwards a zone of blocks, boulders and even pebbles follows (120-70 m). This is a hydrodynamically active zone with no accumulation but erosion of mud. Here outcrops of bedrock occur frequently. Some individuals of flat-fish were observed. Glacial boulders and blocks of granite and gneiss cover the mud (clay) surface. There are funnels of non accumulation (or erosion) around the boulders and blocks.
4) In the top zone of banks (70-39 m) sand, gravel and bedrock are exposed. The rocks are covered by molluscs.

Within the clint area outcrops of distinctly laminated Late Cambrian and Ordovician sandstones, limestones and marl were discovered and investigated. They are supposed to be identical to the corresponding rocks onshore (in Estonia) judging by their age (determined by faunistic inclusions), by their $CaCO_3$ and C_{org} content and their lithology. Some of the limestones and marls contain lentils appearing like brown inclusions of pseudo-oolite (coprolite).

Ferruginous (ochreous) soft interlayers of irregular form were discovered in some exposures. Their Fe-content in these

interlayers, however, appeared to be rather low (4.1% Fe, 0.5% Mn, 0.0021% Cu, 0.0021% Ni and 0.0016 % Co. The ochreous rocks probably represent either 1) an ancient (relict) crust of underwater weathering or 2) a secondary ferruginization of limestone and marl interlayers. In some cases similar ochreous interlayers are observed in sandstone outcrops.

Numerous "fractures" exist in the surface of muddy bottom at depths between 179 m and 166 m. These fractures in the bottom remind of takyrs. Their form is irregular, they are 1-2 m long and 2-5 cm wide, their edges are slightly raised. They were observed both on even bottom and on low (relative height up to 2-3 m) hill-like elevations. Usually the fractures are of hexagonic form. Probably, these "takyrs" are the result of underwater weathering of loose mud.

Benthic and planktonic organisms, apart from isopoda and flat-fish, were represented (very seldom) by gobies and some individuals of sprat. Cod was not observed. Thus, the region under investigation is very poor in living organisms.

The bottom appeared to be surprisingly "free" from objects of human activity. Only sometimes bottles were seen and once - a metal tube. Polyethylene articles, so characteristic for the Red and Mediterranean Seas were practically absent.

The use of "Mir" submersibles in the Baltic Sea research turned out to be rather effective. Observations from the submersibles showed the effectiveness and reliability of common geological research methods like dredging, grab sampling, gravity coring and CSP. The visibility near the bottom (2-4 m) is sufficient for manned submersibles.

AN APPROACH TOWARDS A GEOMORPHOLOGICAL AND SEDIMENTOLOGICAL MODEL FOR OFFSHORE AREAS, EXEMPLIFIED FROM SKÅNE

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On offshore and shelf areas, sand is transported as bedload by geostrophic, tidal, or wind-driven currents. The turbulence required to put the sediments in motion, is to a large extent supplied by surface waves. Although many orders of magnitude smaller than the transport in the breaker zone, the shelf sediment transport is important in the geological perspective. The crucial point is not *how often* the threshold of sediment transport is reached, but the *total transport* during centuries or millenia.

Computer simulations were performed to calculate the integral of sediment transport with respect to the natural frequency distribution of wave heights and of currents. The sediment transport was calculated as a function of current velocity and turbulence, where the latter is a function of current and wave parametres. Empirical values were used as efficiency factor.

It was noted that the variation of sediment transport as a function of grain-size, depth, wave height, wave period, and current velocity, is complicated. The effect arouses by taking the integral of all wave heights into the calculations, rather than using the significant wave.

In a computer model, calculations were made on each grain-size in a log-normal distribution, in order to find out how the sediments are being sorted during transport down the shelf, and where deposition of different fractions occur. The results came reasonably close to field data from eastern Skåne. Notably, the model predicted that a sediment type that has in the past been suggested to be palimpsest, may in reality be recent. Also, the formation of some sand deposits could be explained.

A MULTISENSOR EXPERIMENT ON RESUSPENSION EFFECTS OF TRAWL FISHERY IN THE WESTERN KIEL BAY: GEOLOGICAL AND PHYSICAL INVESTIGATIONS

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The knowledge of spatial and temporal variations of present sediment accumulation rates in near-coast sediments is important for assessing the distribution processes of sediment constituents including trace metals from anthropogenic sources. Kiel Bay is one of several areas in the Western Baltic Sea, which are highly affected by trawl-net groundfishery. Since 1987 the Geological Institute investigates the influence of trawl-net tracks on surface sediments, particularly in areas of muddy sediments.

In 1988 started the collaboration between the Geological Institute and the Institute of Applied Physics to investigate the suspension cloud originated by the otter boards and by the trawl net during trawling. The inner Eckernfoerde Bay was selected as investigation area, because fishing in this region normally is not allowed. So it is possible to study the morphological evolution of this track over a long period without disturbances from further groundfishery activities.

In January 1991 the suspension cloud was studied by a two ship experiment. The first ship RV "Alkor" dragged a trawl net over about 2 km while the second RV "Littorina" examined the spreading of the suspended sediment.

At the beginning of the track a drifting buoye with its sail below the halocline was positioned from RV "Littorina" to observe the movement of the bottom-layer. The drifting buoye is equipped with a microprocessor system which controls a Decca-Navigator and stores its position each minute. All data can be received by radio transmitter.

Following the wake of RV "Alkor" in a cross-section station grid the turbidity of the water column was determined by a fast dropping CTD-system including a turbidity sensor. For continuous recording a high frequent echo sounder operating at 690 kHz and 230 kHz was used.

Parallel to the hydrographic survey the disturbance of the surface near sediments was determined by side-scan sonar and by an ROV video equipment.

The results showed a current velocity of the bottom layer of about 10 cm/s and due to this slow motion the dispersed suspension cloud settled slowly in the local area near to the

track.

Due to the strong groundfishery activities in Kiel Bay a considerable amount of sediment is resuspended. The sandy sediments will settle locally but the mud can be transported over a long distance, if stronger bottom currents occur.

THE TVÄREN BAY CRATER - OFFSHORE DRILLING OF A MIDDLE ORDOVICIAN ASTROBLEME IN SE CENTRAL SWEDEN

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The Tvären Bay structure, located at the Baltic coast 72 km SSW of Stockholm, was discovered by B. ASKLUND and A.H. WESTERGÅRD in 1927. A description of the Ordovician sequence in the boulder fan SE of the Bay (Fig. 1) was given by THORSLUND (1930). ASKLUND (1931) described the circular depression in the seabed, which he interpreted as of volcanic origin. FREDERIKSSON and WICKMAN (1963) suggested that the crater might be an impact structure. Geophysical investigations (FLODÉN et al. 1986) revealed the details of the crater morphology and the extension of the crater infill. Offshore drillings in October 1991 revealed 143 m of impact and post-impact crater infill. Seismic profiling, performed in order to locate optimal drilling sites, showed that the infilling of the crater (Fig. 1) was more complete than previously known. The diameter of the crater is about 2 km, the depth just under 300 m.

METHODS. The Tvären Bay drillings were performed from a raft put together of 11 sections of military "bridge-type" pontoons, put to our disposal by the Svea Engineering Regement. The 37 tons heavy raft measured 15 x 10 m and behaved extremely stable even in high winds. The drilling platform was anchored in the four corners by 1 m^3 stones and tightened up with 10 mm wires. Handling of the hydraulic drill-rig was performed by Kärnborrning AB, Sweden.

Two drill-cores were recovered of the Tvären astrobleme. The first site (Tvären I in Fig. 1) was located on the crater wall in the SE part of the structure at a water depth of 29.5 m. The drilling ended at 55.85 m. The second site (Tvären II in Fig. 1) was located to the NW part of the crater at a water depth of 37.5 m, the post-impact Ordovician sedimentary bedrock was reached at 81.75 m and the drilling ended in impact breccia at 224.4 m. The daily recovered 42 mm core at this site was around 30 m.

RESULTS. The Tvären cores are subject to stratigraphic, lithologic and petrographic investigations, presently only preliminary notes can be given. At the time of the impact the crystalline basement was covered by Lower and Middle Ordovician limestones thick enough to dominate the back-surge deposits in the crater. The epicontinental sea was rather deep in the region and the water was probably never totally expelled from the crater area; no heat-welded dry-phase deposits are present, or they are not reached by the drilling. According to published data and to a single specimen of *Neoasaphus cf. ludibundus* found at -131.1 m in the early post-impact deposits of Tvären II, the

most likely age of the impact corresponds to the lower part of the Middle Ordovician Idavere stage.

Core description. The crater fill sequence starts with a 5 m thick sub-autochthonous breccia of basement rock fragments in a finegrained and partly chloritized matrix. The lower boundary of this unit was not reached by the drilling. With a sharp boundary follows a single 58 m thick turbidite with fragments of Ordovician limestone belonging to different stratigraphic levels. Basement fragments form several percent of the rock, too. A finding of *Sphaeronites sp.* at -214.5 m in the impact breccia indicates Kunda Stage for some of the pre-impact Ordovician fragents here. The unit is graded from coarse limestone-dominated breccia in the lowermost part through gravelly breccia, coarse and greywacke-like sandstone, and siltstone, to light grey mudstone at the top. The graded deposit is interpreted as a product of back-surge and is equated with the back-surge breccia and back-surge turbidite complexes of the Kärdla impact crater in NW Estonia.

The post-impact fossiliferous sedimentation in Tvären is represented by 80 m of grey, carbonatic mudstone with scattered laminae and lenses of limestone. Due to the fjord-like conditions in the still more than 150 m deep crater, the sediments are dark with relatively high organic content. Mudslides from the crater flank caused some deformed bedding and occasional turbiditic beds and laminae.

CONCLUSIONS. The crater infill of the Tvären astrobleme contains valuable information for the general interpretation of crater sequences in shelf areas. Comparisons of crater infill deposits in craters of different sizes, formed under different water depths and other local conditions, will provide new possibilities to reconstruct and interpret poorly preserved as well as more complicated crater sequences, among them those of the Dellen and Lockne craters of central Sweden.

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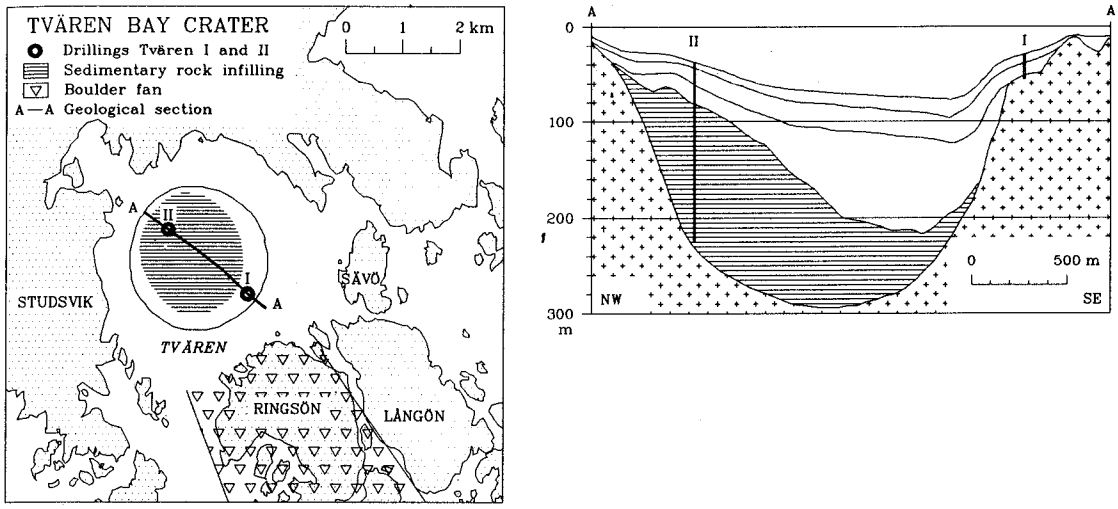

Fig. 1: The Tvären Bay impact crater in SE central Sweden

SOME IMPLICATIONS OF GAS AND FLUID SEEPAGES ON THE GEOLOGY OF THE BALTIC SEA

Tom Flodén, Per Söderberg (Department of Geology and Geochemistry, Stockholm University, Sweden)

Gas- and fluid-related structures in the seafloor and in the upper seabed sediments have been reported from shelf areas around the world, and their influence on the ecosystem has been discussed (HOVLAND & JUDD 1988). Modern bioherms and carbonate reefs have furthermore been shown to form in close association with active hydrocarbon seepages in the North Sea and the Gulf of Mexico (HOVLAND 1990). Carbonate cemented Holocene sandstones with internal pipe-like structure, reflecting gas flow, are reported from western Kattegat (JØRGENSEN 1989).

Biogenic, but also thermogenic gas structures have been recorded within the glacial and postglacial deposits of the Swedish coastal areas, too (FLODÉN & SÖDERBERG 1988). They occur in areas of crystalline bedrock as well as in areas of sedimentary bedrock, and are found in original positions of formation as well as in reservoirs formed by gas migration. Seabed migration patterns of thermogenic gas from fracture zones in crystalline bedrock are revealed by the locations of bubblemarked outflow areas.

INFLUENCE OF GAS ON MODERN BALTIC ECOSYSTEMS. The main gas source within the crystalline Swedish coastal areas is inevitably biogenic gas produced in the postglacial sediment. Additionally, thermogenic gas is shown to rise to the seafloor from low levels in the earths crust creating extensive fields of bubblemarks along the major tectonic lineaments. As in the North Sea, gas influence on the ecosystem is evident, two examples are given.

At Vettershaga in the northern Stockholm Archipelago thick, highly gas-producing, algal mats occur in a local spot, some 200 x 100 m large (SÖDERBERG & FLODÉN 1991). The tectonic setup and chemical analysis of gas collected from the bottom moraine here, indicate that thermogenic gas is released from fractures in the bedrock too, leaking through the sediment and promoting algal growth at this local spot and nowhere else in the vicinity.

A somewhat different influence is found at the entrance of Bråviken Bay some 100 km SW of Stockholm. Locally along the tectonic lineament, which forms the northern shore of this Bay, almost continuous gas seepages have been reported. The gas vent areas on the seafloor here conforms with extensive accumulations of bivalves, almost mussel-banks, which is not a typical feature in this region.

Observations of modern gas-influenced sediment structures and

ecosystems can be used to interpret fossil structures, too. The aim of this paper is not to present fully evidenced interpretations, but to point to some structures in the Baltic Paleozoic, which possibly formed due to influence from gas or fluid seepages.

FOSSIL GAS AND FLUID SEEPAGES IN THE BALTIC. The significance of gas and fluid seepages have so far not been considered in the discussion of the Baltic sedimentary bedrock, although they may be closely linked to sedimentary structures of highly different developments.

The Kalmarsund sandstone. Along Kalmarsund, the strait between Öland and the Swedish mainland, the Lower Cambrian sandstone is well cemented and has a red-striped appearence. It has a sound propagation velocity of close to 5.000 m/s. On the small islands along the western coast in northern Kalmarsund it can partly be characterized as a "pipe rock", the pipes attributed to the trace fossil *Scolithus linearis*. Below Öland, on the other hand, the corresponding sandstones are generally white and are partly very loose, they have a sound propagation velocity in the magnitude of 2.700 m/s. From indications in multi-channel seismic recordings this narrow zone of well cemented Cambrian sandstone extends southwards from Kalmarsund, too, approaching the Fennoscandian Border Zone closely E of Bornholm.

This zone, here named the Kalmarsund Zone, is interpreted as one in a set of NNE-SSW trending tectonic zones which extend from the E Bornholm area towards west-central Baltic (FLODÉN 1984). The pipe-rock in northern Kalmarsund is interpreted as the visual evidence of the gas, and possibly fluids, which once leaked through the sand from deep levels in the crystalline bedrock along this tectonic zone, cementing the sandstone along the lineament. Similarly well cemented Cambrian sandstones are found along other lineaments too, e.g. in the Simrishamn area of Scania and on Bornholm.

Ordovician mounds. Carbonate mounds are distinctive features in the Upper Ordovician of the Gotland region (FLODÉN 1980). The formation of these oil-bearing structures may have similarities to the gas-promoted algal mats of the Vettershaga area mentioned above, but also to other hydrocarbon-associated mound structures (HOVLAND 1990). A preferred occurence of the Baltic algal mounds along tectonic lines is so far suggested, however.

Silurian bioherms. Throughout the main development of the Baltic Silurian Basin, extensive carbonate reef-banks formed alongshore in this tropical sea. On the seaward slopes of these barriers there developed strings of bioherms (FLODÉN 1980:183). In a similar way as described for the modern sediments of the Stockholm Archipelago (SÖDERBERG & FLODÉN 1991), lateral migration of gas from the central parts of the Baltic Silurian Basin may have occured. Leakages of gas and fluids along the seaward slopes of the reefal barriers would result due to the general shoreward thinning of the stratal sequence but mainly due to

compaction of the sediments below the heavy reef-barriers, blocking the natural shoreward migration channels. The location of these bioherms to probable leakage areas suggest that these build-ups are seepage-associated similarly to their modern equivalents.

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MORPHODYNAMICAL INTERPRETATION OF HEL'S PENINSULA COAST LINE FRAGMENT (NEAR JASTARNIA) USING MULTITEMPORAL AERIAL PHOTOGRAPHS

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Introduction

The authors propose a new methodical complex analysis of shore line dynamics based on the interpretation of multitemporal panchromatic aerial photographs. It was carried out for Hel's peninsula fragment near Jastarnia.
Historical aerial photographs used in the investigation date back to 1947, 1953, 1973 and 1984. On the base of the photographs taken in 1984 and their interpretation "The Photointerpretation's Map of Coastal Zone" on a scale of 1:500.000 was produced using a stereoplotter. "The Photointerpretation's Map of Coastal Zone of Hel's Peninsula Fragment" was made by the District Enterprise of Surveying and Cartography in Sczcecin in co-operation with and on the base of methods proposed by the authors. The project was supported by the Ministry of Transport and Marine Administration in 1990.
A series of "The Photointerpretation's Maps of Changes of Coastal Zone" on a scale of 1: 5.000 was produced on Kartoflex using historical photographs taken in 1947, 1953 and 1973. The maps comprise many morphological elements of the coastal zone like: underwater long shore bars, shoreline, micro lagoons, micro cliffs, dune base line, dune ridge line, cliff base line, cliff edge line, groynes, hydrotechnical constructions, development area, roads, paths, forests and railways. Many of them influence marine dynamics, some not.
"The Photointerpretation Maps of Changes" consider only locations of elements influencing dynamics like: underwater long shore bars, shoreline, micro lagoons, micro cliffs, dune base line, dune ridge line, groynes and hydrotechnical constructions comparing each location on the historical photographs with the one taken in 1984.

Methods and Results

The shore line is the most changeable element of the coastal zone. A location on the shore line is highly influenced by the local hydro- and sediment dynamics. The location of the dune base line (DBL) is the result of long-period marine processes. Variations of the beach width factor (BWF) and the location of the dune base line (DBL) were proposed by the authors as the most useful morphodynamical elements for historical comparisons. The comparison of DBL locations in the years 1947, 1953, 1973 and 1984 gave not very well defined results in the one map, however.
The authors suggest to analyse coastal dynamics on specially designed spatial and temporal-spatial diagrams of DBL

variations. It is proposed to draw straight lines perpendicular to the general direction of the coast line every 25 m. On these lines the vectors of DBL changes between subsequent locations are measured. A first diagram was constructed based on the vector sum of DBL variations compared to the state of 1947. A second diagram is based upon the scalar sums of DBL variations compared to 1947. Both diagrams characterize the dynamics of the coast in spatial terms, but they are hardly suitable to cover DBL variations in time. Therefore it is suggested to interprete coastal dynamics by temporal-spatial diagrams.
So the authors constructed a third diagram based on a three dimensional function of scalar sums of DBL variations. The first dimension considered is the location along the coast, the second is time and the third dimension is the value of vector sums of DBL variations in relation to 1947. A similar diagram using scalar sums of DBL variations is the fourth one constructed by the authors.
A fifth diagram considers a three dimensional gradient function of scalar sums of DBL variations in time. The first dimension is the location along the coast, the second one is time and the third dimension is the value of time-dependent gradients of vector sums of DBL variations compared to 1947.
For more complete characterization of the coast the "beach width factor" (BWF) was introduced. The beach width was measured every 25 m in the aerial photographs. The values were divided by the average width of the beach (for every location separately).

BWF=1 means that in this place the width of the beach is equal to the mean beach width

BWF<1 means that the beach is more narrow than the average at this location

BWF>1 means that the beach is more wide than the average in this place

So a sixth diagram was plotted based upon a three dimensional function of the beach width factor (BWF). The first dimension here is the location along the coast, the second one is time and the third dimension is the value of BWF.
This BWF as a factor of short period trends of the coastal development is more adequate for comparing long sections of the coast with similar ones. Usually BWF is smaller than 1 for erosion and bigger than 1 for accumulation areas.

Conclusions

The complex analysis of shore line dynamics based upon historical aerial photographs gives the possibility to record the most important morphodynamical elements and to analyse their temporal and spatial variations.
The authors state that dune base line (BSL) and beach width factor (BWF) are useful for the analysis of coastal dynamics. A more complete interpretation is possible by the use of different diagrams proposed by the authors.
The analysis of vector sums gives a trend of the coastal development in time, whereas the interpretation of scalar sums indicate the spatial variations.
The most important phenomena - morphodynamical nodes were found,

where a full stabilization of morphodynamical processes was observed.
Morphodynamical indexes (vector and scalar sums of DBL and BWF) suggested by the authors are universal and useful in the analysis of any part of dune coasts.

MORPHOSTRUCTURE AND GEOMORPHOLOGICAL MAPPING OF THE BALTIC SEABED: SCALE 1 : 500.000

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The Geomorphological Map for the Baltic Sea at a scale of 1 : 500.000 was compiled by the author's collective in 1988. The composition of the map is based upon standard principles of representation of land and sea bottom topography. Based on the legend, genetically homogeneous surfaces and their elements along with subaqueous and subareal processes are discussed. It shows the morphostructural features of the sea floor and adjacent land in late Pleistocene and Holocene, and the basic stages in the development.

The importance of the Pleistocene glaciation in the formation of both land surface and sea surface has been emphasized, the limited extent of topographic forms of subaqueous origin has been attributed to the young geological age of the Baltic Sea. Such landforms as denudation escarps (glints), elements of the old coast line in the form of cliffs and accumulation forms on the adjacent land and on the sea floor, glacial exaration valleys, rills of postglacial discharge and fluvioglacial deltas, such marginal formations as ridges and swells, paleo- and recent river valleys forming the erosion drainage network give insight into the geomorphology of the region.

The authors believe that the principles and the methodology of the interpretation of geomorphological and geological data and those of the map compilation can be applied to geological survey and other studies of the offshore areas of the Baltic Sea as well as for the programme of the lithomonitoring of the Baltic Sea.

"QUICK SEDIMENTS" AS A CAUSE FOR SUBMARINE WASHOUTS AND STRATIGRAPHIC BREAKS

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On the boundary Pleistocene-Holocene is accomplished a drastic change in the Black Sea sedimentation, connected with the transgressional increase of the sea level and the transition from a lacustrine to the marine stage of development. The separate stages of this development are recorded by specific sediment layers which mark the different phases of sedimentation: terrigenous sedimentation of lutites during the Late Pleistocene - chemogenic sedimentation of calcareous muds "Seekreide" on the Pleistocene-Holocene boundary - biogenic sedimentation of sapropels during the Early-Middle Holocene. During the carried out detailed investigations of more than 300 cored columns of Upper Quaternary sediments of the Western Black Sea depression, the manifestation of a regional submarine washout has been established on the Pleistocene-Holocene boundary. The washout is extremely wide and comprises almost the whole depression - from the shelf edge to the abyssal plain. As a rule, it is connected to the top of the interval, represented by chemogenic calcareous muds of "Seekreide" type.
These sediments consist of fine silts mainly, chemogenic calcites, grains (up to 70 - 80 %), and some silty-clayey terrigenous component. Their water content and specific physicomechanical properties (extremely soft and incoherent) make them unstable and liable to resuspension under dynamic influence - hydraulical or seismical. The peculiar "quick sediments" are the reason for the regional submarine washout and the stratigraphic break in the deep-water part of the Black Sea basin.

THE ANCYLUS AND LITORINA TRANSGRESSIONS OF THE BALTIC IN SW FINLAND

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The extent and age of the Ancylus and Litorina transgressions was studied by means of shore marks in the field, biostratigraphy from several lake and bog basins, and radiocarbon determinations in the area of the Salpausselkä zone, between Espoo and Salo in southwestern Finland. The study was part of the sea level project of IGCP, No. 200.

The rapid Yoldia regression in the Baltic from 10.200 to about 9.700 BP was followed by the Ancylus transgression, involving a rise in water level of 2 - 8 m in the research area. Evidence of this rise is visually seen in 10 basins, and in loss on ignition and diatoms. The duration of the transgression was dated to the Betula pollen zone, from 9.700 - 9.400 to 9.200 - 9.000 BP. The transgression is visible in SW Finland as far as the zone of the 3. Salpausselkä, the 0 isobase for the transgression. The altitude of the transgression varies from 62 to 82 m, and the gradient of the shoreline A I is about 0,5 - 0,4 m/km (Fig. 1).

The following Ancylus regression was first rapid but became slowly at about 8.500 - 8.000 BP, when the rate of land uplift became nearly as high as the rise in water level in the investigation area.

The duration of the Litorina transgression, involving a rise in water level of 1-4 m, was dated to 7.000 - 6.400 BP. The transgression is visually seen in the Bastukärr basin, situated near Karjaa between the 1. and 2. Salpausselkä, where its amplitude is about 1 - 2 m. The altitude of the transgression varies from 35 to 45 m and the gradient of the shoreline L I is about 0,2 - 0,15 m/km.

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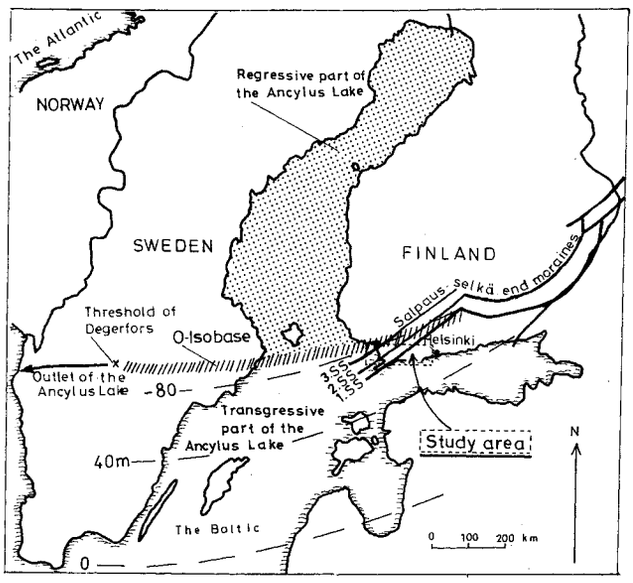

Fig. 1: The Baltic with the transgressive (southern) and regressive (northern) parts of the Ancylus Lake, the first outlet of the Lake at Degerfors, Sweden, the 0-isobase of the transgression, and the study area in SW Finland

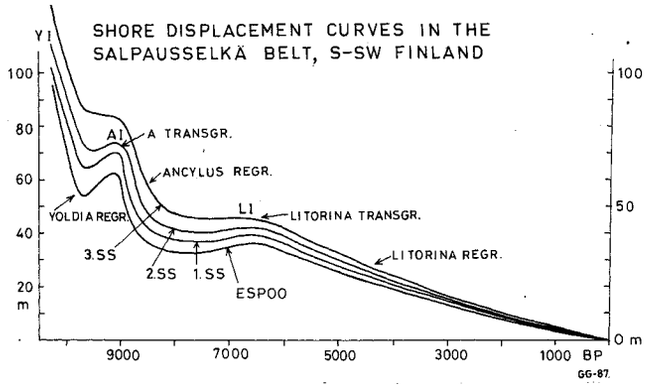

Fig. 2: Shore displacement curves for the areas of Espoo, Salpausselkä I (1. SS), Salpausselkä II (2. SS), and Perniö-Salo (3. SS), SW Finland

STRUCTURE AND STRATIGRAPHY OF QUATERNARY DEPOSITS OF THE SE BALTIC

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The SE part of the Baltic comprises the following structural regions: East Gotland and Gdansk depressions, Ventspils and Neman paleodepressions, Liepaja and Sambija-Kura neotectonic structural highs. There exposures of Mesozoic, early Cenozoic and middle Pleistocene deposits are observed. Late Pleistocene deposits are predominant on paleodepression surfaces. The depression bottom is overlain by Holoccene sediments. Buried paleodepressions filled by early Pleistocene deposits have been discovered in all morphostructural regions. The most complete stratigraphic sections have been observed in paleodepressions. The maximum Quaternary cover thickness reaches 150 m.

Lower Pleistocene is represented by Letizh horizon (Oka, Elster), divided into Vetsvagars (moraine) and Sudrabe (limnoglacial sediments) subhorizons. Interglacial marine sediments of Ulmale horizon (Likhvin, Holstein) and Kurzeme superhorizon (middle-Russian, Saale) comprising Staldzene (desalted marine basin sediments) and Užava (glacial sediments) horizons correspond to the middle Pleistocene.

In upper Pleistocene the Prangli horizon (Mikulino, Eem) and the Baltic superhorizon (Valdai, Weichsel) have been distinguished. The latter is divided into Lichupe (marine sediments) and Kura (glacial, limnoglacial sediments) horizons.

The Holocene horizon is divided into three subhorizons. Marine and lacustrine-marine sediments are predominant there: autochthonous (residual) boulders and pebbles (less than one metre thick) and allochthonous sandy, silty deposits with a thickness of up to 20 m.

The seafloor area (approximately 3.000 km^2 at 10-90 m depth) is covered by 2-4 m thick river Neman paleodelta sands; silty sand, silt and clayey silt of four generations. The youngest sands have been dated by ^{14}C as 4.220 ± 30 - 1.700 ± 50 B.P.

PRE-QUATERNARY GEOLOGY AND MAPPING OF THE BALTIC SEABED: SCALE 1 : 500.000

Algimantas Grigelis (Lithuanian Geological Institute, Vilnius, Lithuania)

The geology of the basement under the Baltic Sea area is characterized by a wide range of formations from Archean-Proterozoic to Neogene in age. The development of the Baltic Sea region seems to be fairly complex. The northern part is marked by the elevated above sea level crystalline basement of the southern slope of the Baltic shield, and the south-western one - by the deep (6-10 km) Danish-Polish depression. Half open to the south-west is the largest marginal depression of the East European platform, i.e. the Baltic syneclise, its sedimentary basins are rich in such natural resources as oil, gas, rock and potash salt, thermal waters, building material.

The Geological Map for the pre-Quaternary for the Baltic Sea and adjacent land areas at a scale of 1:500.000 was compiled by the author's collective in 1988. This map provides a geological account on the study of a shelf pericratonic sea covering fairly diverse geological-structural areas. The map shows the distribution and geological boundaries of 180 stratigraphic units including tectonic fault zones. The units are correlated with those of the Baltic Sea area and its adjacent land regions, they are marked by regional indexes. The geological boundaries of stratigraphic units were drawn with the account for the pre-Quaternary topography.

The folio of geological maps of the Baltic Sea can be assumed as a foundation of comprehensive study of both environmental conditions and establishment of the environmental control of the Baltic region. The problems can be resolved only using the system approach and by means of permanent planned works.

RIP CURRENT ON THE POLISH BALTIC COAST - AGENT OF GEOLOGICAL IMPORTANCE

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This paper considers the nature and sedimentary significance of rip currents. Rip currents are the main factor responsible for the transportation of coarse sediments from the littoral zone into greater depths. Such sediments, deposited outside the zone of wave deformation may be identified as storm rip current increments within sediments deposited during fair weather. Composite beds deposited during a given wave cycle by storm rip currents are closely similar to "Turbidites" and many so-called "Fluxoturbidites" described from flysch deposits. Thus, a rip current origin should be considered in the analysis of any record of graded bedding or other structures usually explained by turbidity action, rip current origin does not require steep slopes enabling development of suspension currents. Furthermore, recent deposits related to storm activity are sometimes similar to the rip current deposits and are suggested to be, in many cases, of storm rip current origin.

Using data gathered in studies conducted on the recent Baltic coast, supplemented by experimental work and hydrodynamical considerations, a sedimentary model is created, which may be used to interpret possible rip current deposits among shallow water "Turbidites", as either modern storm sediments or ancient "Tempestites".

THE LOWER/MIDDLE CAMBRIAN FILE HAIDAR FORMATION IN THE CENTRAL BALTIC SEA AND SOUTH-CENTRAL SWEDEN

Stefan Hagenfeldt (Geological Institute, Stockholm University, Stockholm, Sweden)

It is suggested that the File Haidar Formation comprises the Lower and Middle Cambrian below the Alum Shale Formations. The span includes the *Holmia inusitata* Zone to the *Paradoxides paradoxissimus* Stage. The File Haidar Formation occurs in south-central Sweden and the Baltic Sea. The composition of the File Haidar Formation differs between the Central Baltic Sea and south-central Sweden. In turn, the File Haidar Formation in these areas differs from the Söderfjärden in the Bothnian Sea and on Åland. The File Haidar Formation is similar to parts of the Cambrian in the East Baltic Area. The Lower Cambrian part of the File Haidar Formation reflects the opening of the Iapetus Ocean. A maximum transgression phase is thought to have been connected with a fast sea floor spreading rate during *Holmia kjerulfi* time. The Lower and Middle Cambrian transition is connected with a regression phase, not demonstrated in the East Baltic Area. In the Middle Cambrian sequence there is indirect evidence of a subduction zone towards the west beginning during *Ptychagnostus praecurrens* time. The subduction initiated the Middle Cambrian sedimentation in south-central Sweden, on the East European Platform, and along the Caledonian Mountain Range. At the same time sedimentation ceased in the Central Baltic Sea.

SEAFLOOR SAND AND GRAVEL INVESTIGATIONS IN THE ARCHIPELAGO SEA AND IN THE GULF OF FINLAND

Ami Häkkinen (Geological Survey of Finland, Espoo, Finland)

The lack of sand and gravel deposits in dense populated coastal areas of southern Finland, environmental concerns and increasing economical importance, activated detailed Quaternary marine geological seafloor mapping in the 80's. The investigations started in the Gulf of Finland offshore the cities Kotka and Helsinki and have been continued in the Archipelago Sea in the offshore area off Turku.

The Geological Survey of Finland (GSF) has been performing echosounding, side scan sonar and continuous seismic profiling as well as vibrohammer coring onboard r/v "Kaita" and r/v "Geola", to investigate the extent of submarine sand and gravel deposits and their exploitability.

The results of these investigations, the bathymetry, morphology, distribution, thickness and structure of Quaternary seafloor deposits are presented on seafloor geological maps and profiles.

The Pleistocene continental glaciation about 10.000 years ago formed various glaciofluvial sand and gravel deposits, eskers and ridges on Precambrian crystalline basement.

Submarine eskers in shallow waters have been found to protrude above the surrounding seafloor, while they often are covered by thick clay beds in deeper water. In the Archipelago Sea the eskers and the Salpausselkä formations are in places covered by thick layers of glacial and postglacial sediments.

The investigations showed that it is possible to satisfy both practical requirements of the community and scientific aims of research work simultaneously. As a result of these investigations the cities Kotka and Helsinki have exploited together about 3 million cubic metres of sand and gravel with a profit of 10 - 20 FMk/m^3 until today.

EFFECTS OF OTTER-TRAWL FISHERY ON SURFACE SEDIMENTS IN KIEL BAY (WESTERN BALTIC SEA)

Gerd Hoffmann, Friedrich Werner (Geological-Paleontological Institute, University of Kiel, Germany), Michael Bernhard (Wasser- und Schiffahrtsamt Hamburg, Germany), Klas Vikgren (Chalmers University of Technology, Gothenburg, Sweden)

The impact of trawl-fishing operations on surface sediments are little investigated compared to the resulting biological consequences. The objectives of our study concern the distribution and the reworking induced by the ploughing effects of trawl-net otter boards as processes which strongly influence the interpretation of chemical gradients and the chronology of surface layers.
The distribution of trawl-net tracks on the sea floor and their morphology were investigated by high resolving side-scan sonar, video instruments (ROV) and SCUBA diving. The mechanical effects of trawl fishery gears were studied on x-radiographs obtained from video-controlled box-core samples. These methods were applied on older trawl-net tracks of an intensely fished area as well as on trawl-net tracks specially produced in a field experiment in a region, where fishery is prohibited.

Examination of the side-scan sonar records reveal that a considerable portion of Kiel Bay sediment surface is completely covered by trawl-net tracks. Morphological analyses show that different kinds of tracks with differing effects on the sediment surface exist. The most frequent track types are ploughing tracks generating a marginal sediment wall, which are produced by continuous motion of otter boards, and jumping tracks leaving a sequence of depressions due to a jumping motion of the boards.

Three processes have been found to exert the main influences on the sediments: production and extension of a suspension cloud, generation of a marginal wall, and deformation of the overrun sediments. While the suspension cloud is spreading out only in limited areas, the marginal wall is preferredly eroded by bottom currents during storm conditions, thus leading to a wide redistribution of sediments. Sediment deformation within the tracks has been observed down to a sub-bottom depth of about 25 cm. Surprisingly, besides of folding and shearing structures also laminated structures owing to smearing processes of the otter boards are generated. This may explain the fact that no-reversed (although modified) age sequences occasionally can be obtained within fished areas.

The project was supported by the German Federal Ministry of Research and Technology.

IN-SITU MEASUREMENTS OF WET-BULK DENSITY IN THE SOUTHERN ARKONA-BASIN (RESULTS OF R/V "POSEIDON" CRUISES 179/180

Peter Holler (Geological-Paleontological Institute, University of Kiel, Germany)

During r/v "POSEIDON" cruises 179/180 (1991) geological and geophysical investigations were carried out in the southern Arkona-Basin. One goal of this cruise was the testing of a prototype of a geophysical in-situ probe (GISPSEA), funded by the MAST-Programme of the European Communities.

Measurements of wet-bulk density were performed using a slim-line borehole Gamma Ray Instrument. A radioactive source (Cs^{137}, 0.9 Gbq) was inserted into the lower part of the instrument. The radioactive source emits gamma-rays into the sediment. A detector measures scattered gamma radiations. The intensity of the scattered radiations depends on and is used to derive the wet-bulk density of sediments.

In-situ measurements of wet-bulk density were performed on 26 stations in the southern Arkona-Basin. On each station three runs were performed and the density profiles were stacked to minimize statistical variations.

In order to compare the wet-bulk densities gathered by the in-situ tool with those from sediment cores, determined by standard gravimetric laboratory techniques, four sediment cores were taken.

A comparison of the wet bulk density profiles from in-situ and laboratory measurements shows, that both profiles are in good agreement.

THE JURASSIC OF THE OSTHOLSTEIN TROUGH (BALTIC SEA): SEDIMENTOLOGICAL INTERPRETATION OF THE ENVIRONMENT OF DEPOSITION OF THE DOGGER-BETA-MAINSANDSTONE

H.-W. Holzapfel (RWE-DEA AG, Wietze, Germany)

The Dogger-beta-Mainsandstone within the northern part of the Ostholstein Trough was deposited during a regression phase of the middle Jurassic sea. The sediments generally represent four main facies types:

- massive sandstone facies
- sand-dominated sandstone claystone alternating facies
- clay-dominated sandstone claystone alternating facies
- silty claystone facies.

The vertical succession of these facies types reflects sediment deposition within distributary mouth bar, distributary channel, tidal channel and barrier bar subenvironments.

The Dogger-beta-Mainsandstone was deposited in a marine shallow water environment at the front of small prograding fluvial dominated deltas. Three deltaic depocenters were identified. The delta front is affected by micro- to mesotidal conditions as well as longshore coastal currents which redistributed the mouth bar sediments and form barrier bars interrupted by tidal channels.

INITIAL BALTIC ICE LAKE DEVELOPMENT IN FAKSE BUGT - HJELM BUGT, DENMARK. SOUTHWESTERN BALTIC SEA

Jørn Bo Jensen (Geological Survey of Denmark, Copenhagen, Denmark)

Detailed shallow seismic and lithological information have been collected in the shallow waters close to the island of Møn.
A seismic sequence stratigraphy is established in the Fakse Bugt area as basis for interpretation of vibrocore data.
Special attention is paid to sequence E.3. showing an erosional upper bounding surface, an onlaping lower bounding surface and a parallel to subparallel internal reflection configuration in an external basinal depression east of Møn.
Sequence E.3. consists of characteristic varvic glaciolacustrine deposits showing an evolution from lowest diffuse proximal varves interfingering with flow diamict to uppermost distal varves interbedded with an increasing portion of wave dominated sand layers.
The northwestern margin of sequence E.3. is observed close to Møn with an uppermost limit 20 m below present sea-level, while the southern and eastern margins are not observed.
Additional seismic and lithological data reveal that sequence E.3. covers the deeper parts of Hjelm Bugt (below level -20 m) and most of Arkona Basin with a part of Kriegers Flak as a fossil island.
In the central parts of Arkona Basin about 20 m of glaciolacustrine bottomset deposits are observed, while the area between the eastern part of Kadetrenden and Hjelm Bugt reveals 30 - 40 m glaciolacustrine sediments consisting of about 15 m bottomset deposits overlayered by sandy distal delta deposits presumably outbuilded from the Rügen area.
A plausible interpretation is that sequence E.3. consists of initial Baltic Ice Lake sediments deposited in front of the retreating glacier.

RESERVOIR PROPERTIES OF LOWER CAMBRIAN SANDSTONE IN THE BALTIC AREA

Ulf H. Johansson (Dept. of Geology, CTH/GU, Gothenburg, Sweden)

Since the mid sixties a certain amount of exploration for hydrocarbons has taken place in the Baltic. Recently the interest for exploration has increased mainly because the border between Sweden and the USSR in the Baltic Proper has been (finally) established. Both Germany, Sweden, Poland and Latvia are actually producing oil and/or gas from reservoirs in the Baltic.

In 1987 a literature survey of published material concerning petrophysical properties of sandstones was carried out at Dept. of Geology CTH/GU Gothenburg. It could be concluded that not many full data sets of porosity, permeability and capillary pressure are published. Some existing data sets are the ones given by GAIDA et al. (1973) and BLATT et al. (1980). The data available are mostly porosity/permeability plots. The only Swedish data are from aquifers in poorly consolidated sands; exceptions are the Cambrian sandstone of the Ranstad area and a few boreholes on Öland and Gotland.

Cambrian sandstones have been sampled from outcrops in Sweden. The sampled sandstones have been investigated concerning petrophysical properties. The samples from the area around Mount Billingen and Mount Kinnekulle in western Sweden have shown the closest similarities to the Cambrian sandstones of the Baltic proper.

In the south and southeast of the Baltic Proper, hydrocarbon reservoirs are known to be sited in the Lower Cambrian sandstones.

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GEOLOGICAL HISTORY OF THE BALTIC SEA BOTTOM DURING PHANEROZOIC

G.S. Kharin (Institute of Oceanology, Kaliningrad, USSR)

The geological structure and bottom deposits of the Baltic Sea were formed mainly during the Phanerozoic stage of the East-European platform. This platform has undergone many changes in the Phanerozoic. Its drift from the southern hemisphere to the northern one, crossing the equator during Ordovician-Silurian (SMITH et al. 1981) was accompanied by not unidirectional tectonic movements, which were especially intensive at the platform margins. Processes of interaction with the adjacent plateau and the uneven shape of the platform basement were obviously the main factors leading to the formation of local platform structures. In such a way the Danish-Polish Trough occupying the southwestern area of the Baltic Sea was formed. A depression of the western platform part, which had started with Japetus oceanic crust subduction below the east-European continent, resulted in the development of the Baltic syneclise as the main bottom structure of the Baltic Sea during Early Ordovician. The maximum depression amplitude of the syneclise occured in Silurian during the final stage of the Japetus closure. In Cambrian-Silurian the Baltic syneclise was occupied by a marginal sea, well connected to the ocean. The inflow of oceanic water from the Japetus into the syneclise area explains the high biological productivity of the sea, which led to the formation of kuckersite, kerogenic rocks (*dyctionema* shales) and phosphorites (Fig. 1). Productive deposits accumulated under different environmental conditions with predominating biogenic carbonate accumulation including reef formation. The Devonian and later Phanerozoic development of the Baltic syneclise was characterized by uplifting and eastward migration of the major depression. During Late Phanerozoic the major part of the Baltic syneclise obviously was an area undergoing denudation and accumulation of salt, terrigeneous sediments and shallow lagoon deposits corresponding to its transit (on the supercontinent Pangea) through the northern arid zone.

It was only in the Mesozoic (Jurassic, Cretaceous), when the sedimentation type changed in context with the migration of the East-European platform into the humid climatic zone, the development of Pangea and the Thetys Ocean as well as with the formation of the Atlantic.

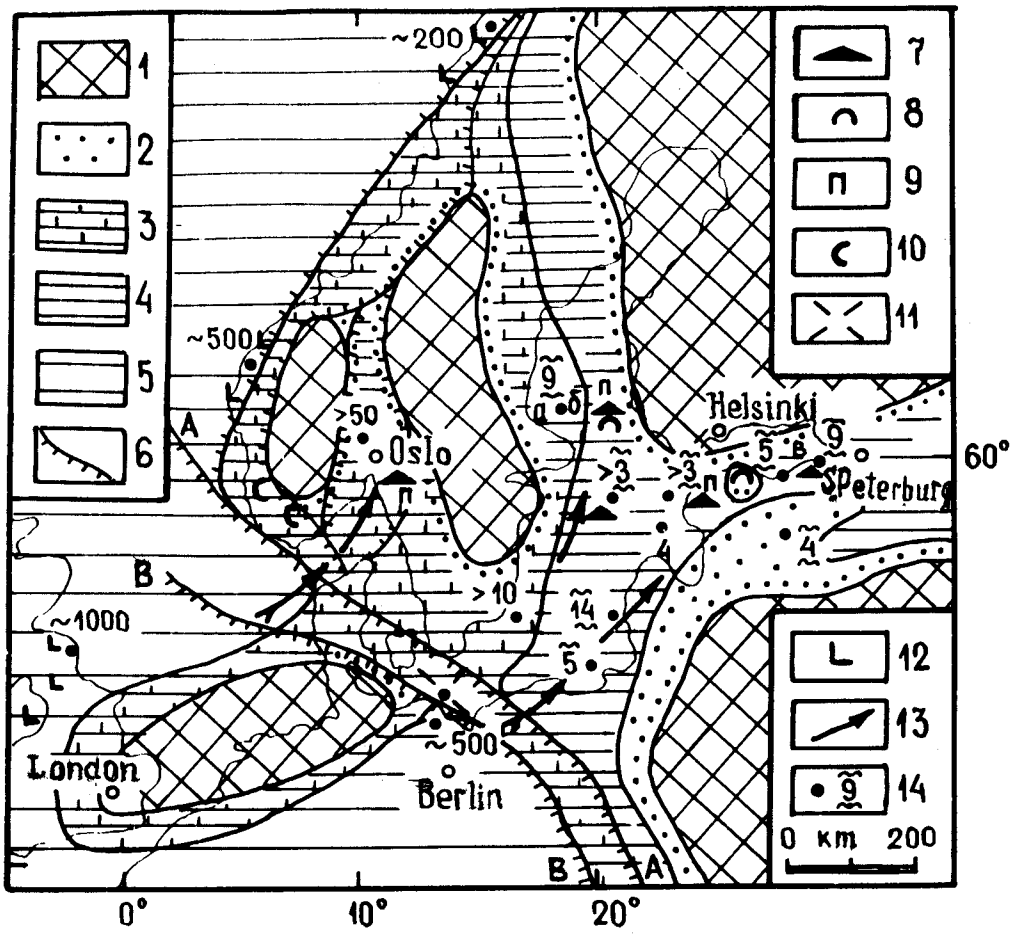

Fig 1: Lithological-paleogeographical scheme of the Baltic Sea region in Early Ordovician:
1-mainland; 2-shallow water shelf, coquina and sand accumulation zone; 3-deep water shelf, zone of stagnation and kerogenic mud accumulation; 4-the same, but with interlayers of calcareous mud; 5-ocean floor, volcanic-terrigenous flysch and volcanites accumulation zone; 6-tectonic lines (A-A - Tornquist, B-B - Varta), thrusts and subduction zones; 7-kerogenic rocks; 8-coquina phosphorites; 9-sulphides in sediments; 10-serpentinite pebbles in sediments; 11- volcanic tuffs and ashes; 12-subaqeous basaltic lava and volcanites; 13- directions of upwelling; 14-sections through drilling holes and exposures indicating thickness (in m) and hiatus

ORDOVICIAN KEROGENIC ROCKS AT THE BALTIC SEA FLOOR

G.S. Kharin (Institute of Oceanology, Kaliningrad, Russia)

During geological investigations in the Northern Baltic kerogen-bearing Ordovician rocks were found by dredging (Fig. 1). Analogous rocks were found in the southern part of the Gulf of Bothnia before. Onshore, kerogenic rocks (kuckersite, *dyctionema* shale, alum shale, etc.) are well-developed in the Upper Cambrian and Middle Ordovician. Lithological and geochemical comparison of the Baltic kerogenic rocks allowed to correlate them to the *dyctionema* shales of the Tremadocian (Lower Ordovician).

Characteristic features of the Baltic kerogenic rocks and Estonian *dyctionema* shales are their low content of organic matter (12-15%) and an increased concentration of some metals Pb, As, Mo, Au, Ag, etc.). The Baltic samples contain almost no bituminous extract, resins and gaseous petrol compared to the similar rocks onshore. Our explanation is that these components are lost as a result of halmyrolysis processes. An increase of phosphorus content along with calcium carbonate is observed in the western direction.

The data obtained enable us to draw the following conclusions: There existed an enormous shallow water basin on the Balto-Scandinavian territory during the Early Ordovician, which was a marginal shelf of the extinct Japetus Ocean. Abyssal waters from the ocean transported phosphorus and other elements to the shelf while humified waters from the peneplanized Baltic shield delivered microelements. Thus, the conditions for a mass development of organisms and the accumulation of muds enriched in organic matter, phosphorus and other elements have been established.

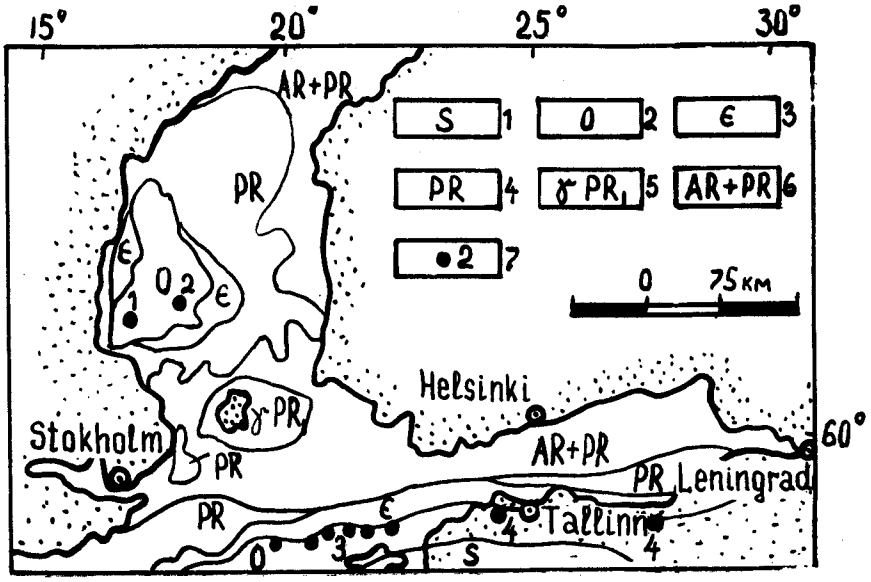

Fig. 1: Distribution of Ordovician kerogenic rocks on the Baltic Sea bottom
1-Silurian carbonaceous rocks; 2-Ordovician carbonaceous rocks; 3-Cambrian terrigenous rocks; 4-Proterozoic quartzites and sandstones; 5-Granite; 6-Archean and Proterozoic granite-gneiss; 7-Ordovician kerogenic (bituminiferous) rocks, exposed on the sea floor (1,2,3) and onshore (4)

PALEOECOLOGY OF THE BALTIC IN THE HOLOCENE

G.I. Kleimenova, E.M. Vishnevskaya (Department of Geography, University of St. Petersburg, Russia)

The authors investigated material obtained from cores of the Baltic and from cross-sections through near-coastal lake and marsh areas.

The considerably desalinated Yoldia Sea existed in the Baltic region during the Pre-Boreal period. In its final stage - the Echeneis phase - it was characterized by some more salinity.

Later on during the Boreal time the Baltic area was covered by the cool oligotrophic fresh waters of the Ancylus Lake. In its final stage - the Mastogloia phase - it was characterized by higher salinities.

According to our data there were different degrees of salinity and water temperature in the different regions of the Litorina Sea during the Atlanticum. In sediments of the southern Baltic there were found typical marine diatoms indicating warm temperatures with a restricted number of species indicating moderate temperatures. In the Central and especially in the north-eastern Baltic cool water arctic- and boreal euryhaline species have been predominating. In all sediment cores from offshore only one transgressive phase of the Litorina Sea could be detected. Contrary to this, in the onshore cross-sections the existence of two Litorina transgressions separated by a regressive phase was discovered. The second transgression was characterized by a higher salinity and by a longer duration. The temperature regime in the Baltic region during the post-Litorina stage has been more or less identical, close to the present-day conditions.
Beginning from Sub-Boreal times one can observe a gradually progressing desalinization.

According to our methodology of palynological subdivision of sediments eight palynozones have been established in south-western and south-eastern part of the offshore area. Onshore 11 palynozones have been determined in these regions. Because of the high thickness of the Central Baltic sediments there were found only 5 palynozones. The sediments of the north-eastern offshore area are characterized by 6 palynozones, whereas onshore 12 such zones could be observed in the cross-sections of this region. The hiati in some offshore cores indicate the existence of relatively complicated paleoecological conditions during the Holocene period.

Obviously, the portion of pine pollen in Holocene pollen spectra reflects the kind of sedimentation processes in the Baltic area. Sediments with a very large portion of pine pollen may be connected to big marine paleobasins with complicated hydrodynamics resulting in more or less uniform pollen spectra

over large distances.

In cores from the Bornholm, the Arkona and the Gotland basins as well as from the Gulf of Finland there were found interlayers without any diatoms and pollen in sediments of Ancylus, Litorina and Post-Litorina ages. Moreover, chemical elements indicating a changing environmental regime in the paleobasins could be detected. An increasing quantity of these elements coincides with poorly conserved pollen in sediments from the end of the Boreal and the beginning Atlanticum. This may be explained by the fact that the sedimentation of these deposits took place during a very active transgressive phase leading to an increase of microelements and to a destruction of pollen (also by chemical processes). Furthermore, it results in considerable oscillations of taxons occuring within the cross-sections.

The change of the paleoecological conditions at the boundary between Boreal and Atlanticum is also confirmed by diatom data. The transgression of the Litorina Sea at that time is reflected by a great quantity of salt-water diatom species in the sediments of that age.

Spatial-temporal comparisons of sub- and supra-aqueous deposits of the Baltic area by palynological data show their contemporary formation. At the same time it is possible to show special features in the composition of diatom and pollen spectra, which indicate different accumulation conditions.

USE OF THE GEOMAGNETIC FIELD EXCURSIONS IN THE HOLOCENE AS STRATIGRAPHIC MARKERS

V.V. Kochegura, G.P. Borisova, Yu. G. Dobretsova (All-Union Geological Institute, St. Petersburg, Russia)

The excursions of the geomagnetic field Gothenburg (about 12.000 years ago) and Etruria (about 2.800 years ago) were detected in bottom sediments of the Baltic, Barents and White Seas. The excursion Solovki with a hypothetical age of about 6.000 years was detected in 3 sections of fauna containing sediments of Atlantic age in the White Sea (Fig. 1). Additional data are required to prove the reality of the last excursion.

The excursion Etruria was traced in Subboreal deposits of 19 sections. In the Gulf of Finland this excursion was revealed in middle-upper horizons of undivided deposits of Atlantic-Subatlantic age. In the Barents Sea the excursion Etruria was detected at the palynologically confirmed boundary of first and second lithostratigraphical divisions and in the White Sea it was revealed in lower horizons of the upper members.

The excursion Gothenburg was traced in 9 sections of Bölling age deposits. In the Gulf of Finland and in the Barents Sea it was revealed at the boundary of 4th and 5th lithostratigraphical divisions and in the White Sea it was detected in upper horizons of varved clay.

The thickness of anomalous zones is up to 30 cm, that allows to estimate the duration of the excursions as 100-300 y. In every anomalous zone there are 2-3 oscillations of the remanent magnetization vector in submeridional direction. Sometimes the vector reaches full reversals. Resedimentation experiments show a decrease of the relative geomagnetic field value before and during the excursions. But, in two sections sharp-short increases of the value were noted at the beginning of an excursion.

The relationship between revealed excursions and definite stratigraphic levels proves that these excursions are real. On the other hand this fact gives a chance to use the excursions for subdividing and correlating Holocene sediments by paleomagnetic methods. For example, the excursion Gothenburg may be used as a stratigraphic marker of the Holocene-Pleistocene boundary.

BOTTOM CURRENTS AND POSSIBILITIES FOR NEAR BOTTOM LAYER ENVIRONMENTAL INVESTIGATIONS IN THE BALTIC SEA BY MEANS OF SELF CONTAINED BOTTOM STATIONS

E.A. Kontar, T.A. Demidova (Institute of Oceanology, Moscow, Russia)

Circulation of bottom currents in the Baltic Sea is presently believed to be one of the most important components defining consequences of increasing sea pollution. Wastes of differing nature are accumulated in relatively deep depressions in the sea as well as, in different forms, in near bottom sea water and in bottom sediments. Taking into account the evident importance of the problem, pop-up self contained bottom stations designed at the Shirshov Oceanology Institute, Moscow, are equipped with one to five "Potoc" current and temperature meters which are located 2 to 25 m above the sea floor, as well as several sediment traps and hydrochemical sensor modules for recording the time variation of dissolved oxygen. On the basis of experimental data obtained synchronously from 3 to 10 stations deployed on the bottom for several months, the distances, directions and paths of mass transport will be calculated; the possible zones both of stagnation and of active oxygen exchange due to hydrodynamic peculiarities will be mapped: and the flow of suspended particles coming down from the sea-surface which defines contamination of the bottom, will be estimated. Other features of bottom currents relating to bottom pollution will be discussed.

INVESTIGATIONS ON HEAVY MINERAL ACCUMULATIONS IN THE SOUTHERN BALTIC

Regina Kramarska (State Geological Institute, Sopot, Poland)

Basing on earlier investigations and feasibility studies, in 1989 and 1990 preliminary documentation works were carried out in order to determine heavy mineral resources in the Odra Bank region. The investigations covered an area of about 450 km^2. Measurements of gamma radiation intensity of deposits were made along profiles (470 km of profiling) and sand samples were taken using short cores with foil insert, which allowed obtaining cores with an undisturbed layer structure. In laboratory, grain composition of the sands and total content of heavy minerals at 137 documentation points were determined.

Heavy mineral accumulations in the Odra Bank sands are of surface character. The rich layer is 10 to more than 50 cm thick (in many points the cores did not reach the floor of the layer). It consists of sequences of several mm thick dark (with heavy minerals) and light (mainly quartz) laminae. As a rule, at the floor of such a layer a shell horizon occurs, with well preserved *Cardium glaucum* shells. Below this horizon heavy mineral accumulations do not have resource character.

The roughly determined resource areas with the relatively highest intensity of gamma radiation cover an area of about 90 km^2, and the average thickness of the heavy mineral rich layer is 26 cm. The mean content of heavy minerals in these areas is 3.7 % by weight, maximum 22.4 %. These resources of heavy minerals may be evaluated at 1.250.000 tons. In this mass of minerals about 50 % are garnets, 35 % ilmenite, 4 % zircon and less than 2 % rutile.

PALEOGENE DEPOSITS FROM THE SOUTHERN BALTIC

Regina Kramarska (State Geological Institute, Branch of Marine Geology, Sopot, Poland)

Recent investigations of the State Geological Institute and "Petrobaltic" showed that Paleogen deposits are much more widespread in the Southern Baltic than assumed so far. The contemporary reach of these deposits, determined by results of seismoacoustics and observed in six boreholes, covers shallower areas (except Pomeranian Bay and Odra Bank) and adjacent basin slopes (Fig. 1).

In the western part of the area the Tertiary cover is not continuous. Paleocene marine deposits are present in the form of quartz-glauconitic carbonaceous sandstone with marl, gaize and limestone laminations (Fig. 2). In the deposits Foraminifera and snails, Bryozoa particles and Echinoidea needles are found. In the sediments of borehole 2 a set of Foraminifera including *Cibicidoides lectus* (Vassilenko) was found, which dates the deposits back to the lower Paleocene (Montian). Microfauna determinations were made by E. GAWOR-BIEDOWA (SGI). Paleocene deposits found in the Baltic bottom correspond with Puławy beds in north-west and north-east Poland (E. CIUK 1974), with Wülpen, Wassmannsdorf and Grünberg beds in Mecklenburg and Brandenburg (D. LOTSCH 1968) and with Lubawa formation in Sambia (A.A. KAPLAN et al. 1977).

In the remaining part of the area upper Eocene marine deposits were documented. Probably they form a continuous bed, mostly about a dozen of metres thick. The Eocene sediments are represented by quartz-glauconitic sands and silty sands, and also by carbonaceous clays with single gravel-sized quartz grains. Besides, in the deposits small amounts of phosphate and pyrite were found. In places the sediments are laminated (Fig. 3). Microfauna, found and described in samples of these deposits by E. ODRZYWOLSKA-BIENIEK (SGI), is typical for the highest Eocene (i.e. Latdorf) and represented by Foraminifera species including *Globanomalina micra*. Upper Eocene beds from the Baltic bottom correlate well with the upper part of the Kiev formation in Bielorussia and the Ukraine (W.M. KLUSZNIKOW 1975). The also correspond with with the lower Mosina beds in northern Poland (E. CIUK 1974, M. PIWOCKI et al. 1987), with beds from Schönewalde in Mecklenburg and Brandenburg (D. LOTSCH 1968) and with the Prussian formation in Sambia (A.A. KAPLAN et al. 1977).

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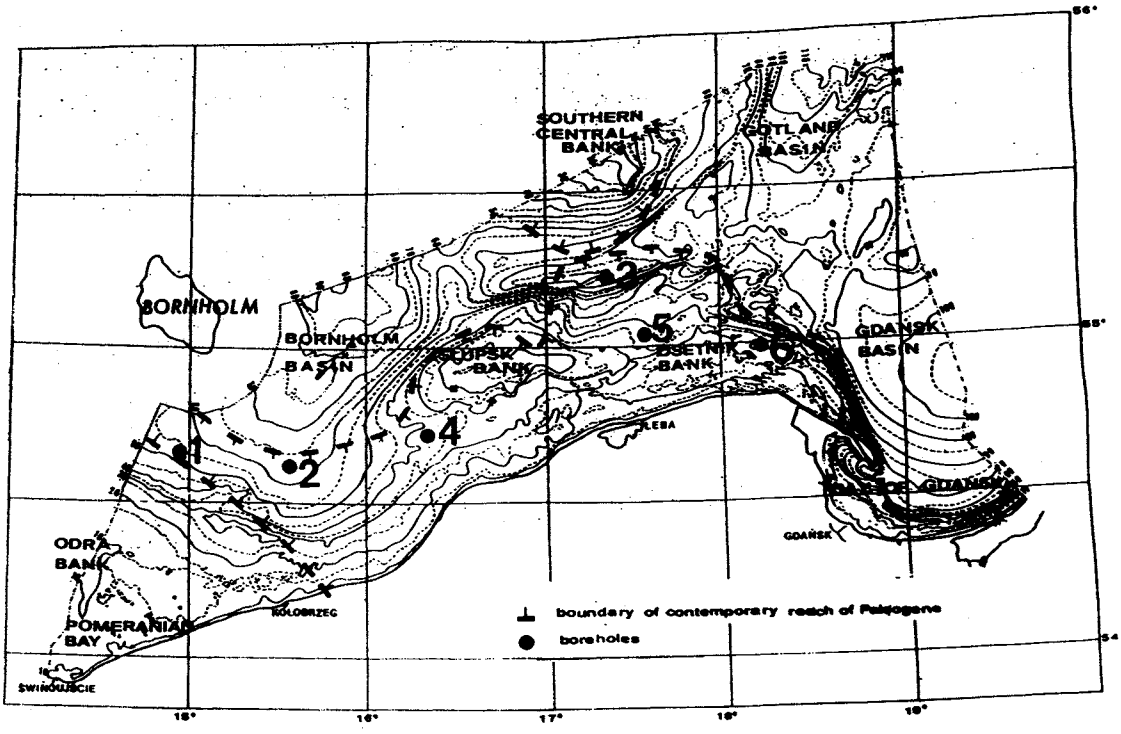
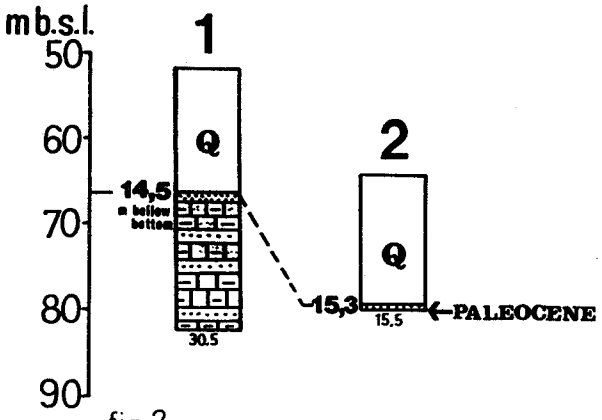


fig.1


m b.s.l.
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PALEOCENE

fig.2

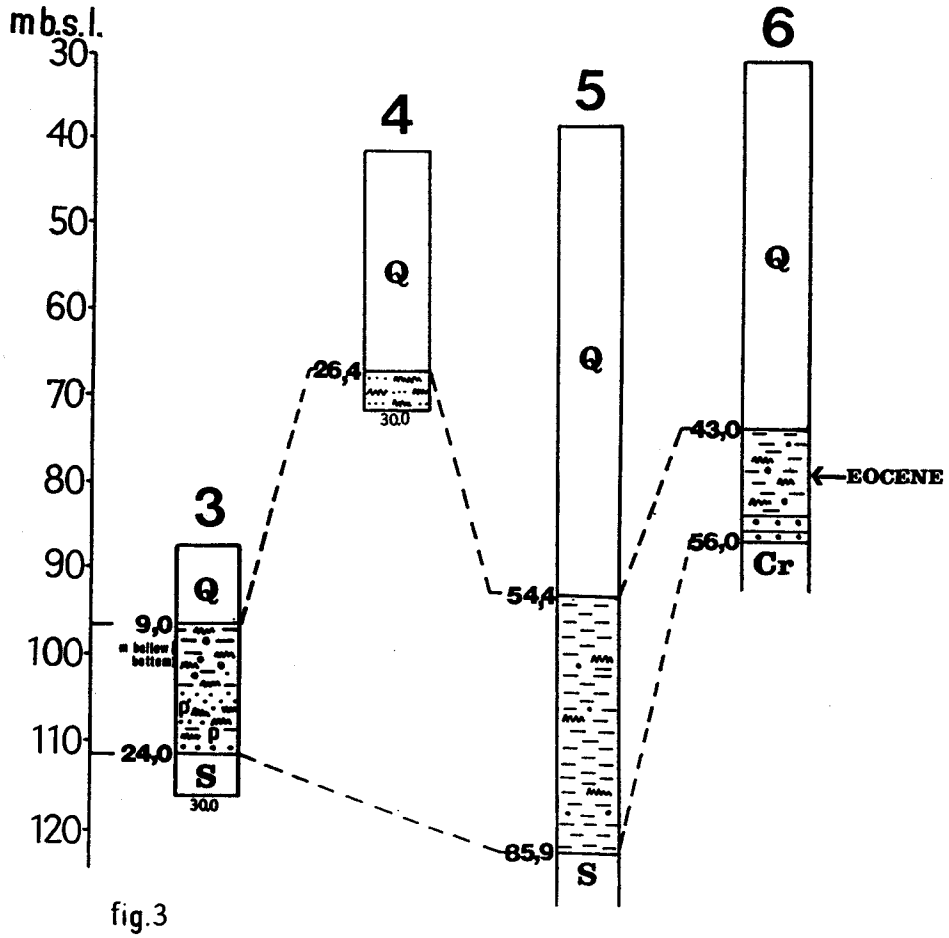
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fig.3

FORMS OF Fe, Mn, Zn, Cd, Pb AND Cu IN THE BALTIC SEA WATER

A.A. Kravtsov (Institute of Oceanology, Kaliningrad, Russia)

During the 24th cruise of r/v "Professor Shtockman" (September-October 1989) and the 22nd cruise of r/v "Akademik Mstislav Keldysh" (April 1991) detailed investigations on the hydrochemical and hydrooptical properties of the Baltic seawater were carried out in the Gotland, Landsort and Bornholm basins. Dissolved forms of Zn, Cu, Pb and Cd in the seawater and in suspension were determined by the anode inversion voltametry method. Suspended forms of Fe, Mn, Cu and Zn along with dissolved forms of Fe and Mn were investigated by the method of preliminary coprecipitation with organic disulphides and further determination of their concentration in the seawater by atomic-absorption.

At geochemical barriers and barrier zones (GB and GBZ), discovered by hydrochemical and hydrooptical methods within the water column (halocline, thermocline, oxidizing-reductive Eh barrier (layer of O_2 and H_2S coexistence)) considerable changes of the microelements' migration forms in the seawater were registered. Generally, a distinct gradient in the salinity (density) near the upper boundary of the halocline is accompanied by a sharp increase in concentrations of suspended Fe, Mn, Zn and Cu and a decrease of the concentration of dissolved Fe, Mn, Cu, Pb, Cd and Zn. This is, probably, due to the fact that the suspended particles sinking towards the bottom (especially organic detritus) with a diameter of 2-4 μm and less are usually detained at the density boundary slowing down their subsidence this way. The particles have a large specific surface stimulating active adsorption of dissolved microelements. Because of the increased time span within the boundary layer a more complete oxidation of suspended organic matter becomes possible. Thus, the concentrations of dissolved metals within the halocline are usually 2-10 times higher than in the surrounding water. The destruction of suspended organic matter leads to a transition of the metals into the dissolved form. During gradual sinking from the photosynthesis layer towards the bottom a part of suspended organic matter, which is subject to destruction, produces a considerable amount of Fe as an element, which is actively accumulated in biogenic matter.
After transition into solution Fe is hydrolized and precipitates as a hydroxide into suspension adsorbing actively dissolved Zn and Cu. Close connections between Fe, Zn and Cu can be clearly traced in all basins under investigation .

At physical-chemical Eh barriers very distinct migration form changes of the elements, which can change their valence within the existing Eh range (up to -250 mV), are observed in the water of the Gotland and Bornholm basins. These elements are Fe, Mn and in some cases Cu.

In the hydrogen sulphide zone the concentrations of dissolved metals can amount to 60-80 µg/l (Fe) and to 150-200 µg/l (Mn), respectively. Due to the sharp gradient between oxic and anoxic water, Fe^{++} and Mn^{++} diffuse towards the Eh barrier, where they are oxidized, and precipitate as hydrated oxide and dioxide, respectively. Moreover, Fe^{++} is oxidized to Fe^{+++} with lower Eh values and levels of O_2 saturation than Mn^{++}. This fact can be explained by a different oxidation velocity, which depends on pO_2 and (OH^-). Dissolved Mn (II) is oxidized and forms MnO_2 above the Eh barrier, i.e. within oxic waters. Because of oxidizing-reductive processes within very thin water layers (2-3 m), turbidity layers are formed, which disperse while hydrooptical investigations are performed. These particles (especially FeOOH) adsorb actively Zn and other microelements from the water.

Within the anoxic zone of the Gotland Deep the concentrations of dissolved microelements are usually lower than in the oxic zone. This is connected to the formation of underdissolved sulphides of these elements and to processes of adsorption and formation of hard solutions like FeS·MnS with the colloid Fe monosulphide - hydrotroilite - precipitating out of the solution. This is proved by the fact that when Eh $\leq$ -200 mV, a sharp increase of the suspended Fe and other microelements' concentrations is observed.

POSTGLACIAL SEDIMENTATION ON THE DARSS SILL, SOUTHWESTERN BALTIC

Antoon Kuijpers (Geological Survey of Denmark, Copenhagen, Denmark), Wolfram Lemke (Institute of Marine Research, Rostock-Warnemünde, Germany)

Results are presented from joint marine geological investigations of the Danish Ministry of the Environment and the Institute of Marine Research, Warnemünde. These investigations including shallow seismic surveys and sediment sampling were carried out in the years 1989 - 1991. In addition, information have been used from relevant studies previously carried out in the area by the Institute of Marine Research.
Main topographic features of the area are the Gedser Reef with a waterdepth of generally less than 10 m, and the Kadet Channel with a maximum waterdepth of 32 m. The channel has a very irregular topography. Gedser Reef is formed of glacial till, which is also the characteristic sediment type found in the Kadet Channel. The detailed sedimentation pattern in the channel, however, is very complex. A zone of glacial till and associated coarse lag sediments extends from the channel into SE direction towards the German coast (Fischland). These deposits can be related to a Late Weichselian ice marginal zone (G) known as "Velgaster Staffel". This sediment type is also widespread east of the island of Falster at waterdepths of less than 15 m. The thickness of postglacial sediments is generally less than 15 m. Thicknesses are considerably greater, i.e.up to 35 m, however, in a buried channel system southwest of Gedser Reef and southeast of the Kadet Channel.
The postglacial sediments include partly coarsegrained meltwater deposits, occasionally varved clays, fine-grained calcareous limnic deposits and peat as well as marine deposits. Small outcrops of peat occur locally in the German sector, whereas in the Danish part southwest of Gedser Reef peat is more widespread on the seafloor. Southwest of Gedser Reef the sediments are characterized by the presence of shallow gas.
Marine sediments range from muddy silt and fine sand to well-sorted fine and medium sand. Well-sorted sand is found in the area around Gedser Reef and is widespread in the German part of the area. Current-induced bedforms and grainsize trends yield evidence of active sediment transport. The bedforms include e.g. large sandwaves with a maximum height of 5 - 6 m. Sediment transport off the island of Falster can predominantly be related to strong outflow, whereas elsewhere (northeasterly) inflow is the main sediment transporting current.

MARINE GEOCHEMICAL SURVEYING OF THE OCEAN FLOOR BY A TOWED GAMMA SONDE

Helmar Kunzendorf (Risø National Laboratory, Roskilde, Denmark), Niels Schrøder (Roskilde University, Roskilde, Denmark)

The seafloor is the ultimate sink for most of the natural weathering products and for anthropogenic interventions on land and in the atmosphere. Among geochemical species to be considered and monitored on the seafloor are natural (K, U, Th) and artificially (e.g., ^{137}Cs) occurring radioisotopes. Natural accumulations that may occur on the Baltic seafloor include economic minerals. To prevent cost-extensive solutions (e.g. detailed sampling) use can be made of the physical properties of the natural or anthropogenic accumulation. Among others, gamma radiation may be emitted by these species. Natural radiation measurements on the seafloor have been conducted for mainly mineral exploration purposes in the sixties and seventies by, e. g., Russian, American and British groups. Technology is now more advanced and makes it possible to investigate the application of geochemical tools directly on the ocean floor. Also, radiation field modelling can now easily be transferred to marine applications.

For continuously monitoring the radioactivity on the floor of the Danish sea territory a prototype geochemical monitoring sonde has been constructed and tested. Construction strategies mainly were based on the availability of components in an existing laboratory. The probe, which is mounted in a sled, is towed by a small research vessel (M/S "Yoldia") along predefined survey lines. It consists of a water-tight encapsulated 6 x 4" NaI(Tl) scintillation crystal that via cable is connected to a 4-channel analyser. Data are generally collected via PC. A pressurized water-depth measuring device is coupled to the sonde to measure accurately the water depth, i.e. the distance of the sled below water surface. At present, the sled can be applied to water depths of 40 m. Being designed for application on smaller environmental research and monitoring vessels, the total weight of the sled is held at ca. 40 kg.

A systematic towing along the island Anholt onboard M/S "Gunnar Thorsson" revealed anomalously high-radioactivity in sandy surface sediments, which probably can be ascribed to heavy mineral accumulations caused by the high-energy hydrographic regime around the island. Besides the mapping of heavy minerals the probe would be efficient in outlining naturally occurring phosphorite deposits, high - and very low potassium-bearing (quartz-rich) marine deposits, and radioactively polluted areas, including locally developed anoxic basins.

THE JURASSIC OF THE OSTHOLSTEIN TROUGH (BALTIC SEA): SEISMIC INTERPRETATION IN THE NORTHERN PART OF THE TROUGH - DEVELOPMENT OF THE TROUGH AND OF THE DOGGER-BETA-MAINSANDSTONE

E. Langner (Prakla-Seismos GmbH, Hannover, Germany)

The northern part of the East Holstein Trough appears to have been active since late Triassic times; its asymmetrical configuration is emphasized by a rather steep West flank and a smoothly rising East flank. The original extension of the trough has been reduced considerably during Jurassic and the axis of subsidence moved from E to W. Subsidence and sedimentation in the trough appear to have been balanced during the existence of the trough. These conditions prevailed also in Dogger beta.

The Dogger-beta-Mainsandstone is seismically defined as horizon O, which is a rather coherent reflector changing considerably in its characteristics. Top and bottom of the Dogger-beta-Mainsandstone have been analysed by trace decomposition in well Schwedeneck See 2. Model tests with synthetic seismograms - applying thickness and facies variations - prove changes in the characteristics of the seismic signal and can be used for correlation with the actual seismic. Tentatively horizon O (Dogger-beta-Mainsandstone) of one seismic line has been transformed into its lithostratigraphic pendant.

MARINE SAND AND GRAVEL DEPOSITS ON THE SEAFLOOR WITH COMPLICATED MORPHOLOGY - EXAMPLES FROM THE DANISH STRAITS

Birger Larsen (Geological Survey of Denmark, Cøpenhagen NV, Denmark)

The Holocene trangression of a glacial landscape composed of fairly easily eroded tills and sorted melt water sediments forms the background for the deposition of a wide range of marine sand and gravel deposits. In the rather sheltered, wave or/and current dominated environments, such as the Danish Straits the following types of deposits are of importance:

- shore related deposits such as fields of beach ridges or sand accumulations at the end of beach drift paths;
- wave built terraces on the lee side of submerged till banks and lag deposits of stones or sand on the banks;
- slope deposits, in wave or current dominated environments;
- channel fills or channel lags.

Examples of the different types of Holocene - recent deposits are illustrated by bathymetry, seismic sections and drilling results and the setting, development and distribution of the types of deposits are discussed.

WHAT TO EXPECT FROM SEDIMENT MONITORING OF POLLUTANTS

Birger Larsen (Geological Survey of Denmark, Køpenhagen NV, Denmark)

The value of a sediment monitoring programme may be measured by its capability to reveal changes in the flux (e.g. mg/m^2 year) of the pollutant in question. The sensitivity of a sediment monitoring station in this respect is the interaction between the change in the net deposition rate of the pollutant, the accumulation rate of the sediment, the thickness and intensity of the zone with mixing of the bottom sediments and technical factors such as time between samplings, thickness of analysed samples, and reproduceability of the applied chemical methods. A model for these interactions is presented. It computes the response in concentration of a pollutant in the surface sample to changes in the flux of that pollutant over a period of time. It is based on sediment parameters which can be estimated by ^{210}Pb datings of the sediments on the site. The model offers a quantitative evaluation of a sediment monitoring station and may be useful in the planning and evaluation of sediment monitoring programmes.

MARINE-GEOLOGICAL INVESTIGATIONS IN THE KRIEGERS FLAK AREA

Jørgen O. Leth (Geological Survey of Denmark, Copenhagen, Denmark)

The Quaternary deposits of the Kriegers Flak area, Danish sector, have been studied. By use of shallow seismic methods (boomer, pinger, echosounder and side scan sonar) 320 km seismic profiling lines have been recorded. From the interpretation a division into seismostratigraphic units has been made. The lithological composition of these units was verified during a subsequent sampling-programme using vibrocore-equipment, gravity corer and surface samplers.

It's possible to divide the glacial deposits into 3 units: a lower glacial till, an upper glacial till and a waterlaid diamict (flowtill). Directly at the seabottom the upper till unit is seen emerging as three NW-SE striking "islands" at a level between -18 and -20 m.

In the western part a deep infilled channel is cutting into the glacial deposits. Probably it's belonging to a system of Late Pleistocene drainage channels in the Baltic. The channel is infilled with horizontal laminated sediments, draping the underlying glacial surface from levels down to -50 m.

The laminated unit can be subdivided into two different types of late-glacial deposits. The lower unit, a pinky varved silty clay ("Rosaroter Ton"), was deposited in the Baltic Icelake under calm energy-conditions, except from the lowermost transparent bottomlayer. This unit can be traced outside the channel both on the north and the south flanks of Kriegers Flak. Generally, at a level of -35 m, an unconformity marks the top of the Baltic Icelake sediments and the transition to the upper unit, a more homogeneous silty clay without any visible lamination. At this level a peat layer is found on the northern flank of Kriegers Flak, unfortunately still undated, but suggesting a decrease in the water level. From the lithology the homogeneous silty clay is deposited under more energy-rich or more turbulent conditions in the lake.

Due to the lack of exact datings no clear chrono-stratigraphical correlation can be made to other parts of the Baltic. But from the seismo-stratigraphy it is suggested that the peat layer marks the transition from the Baltic Icelake to the Ancylus Lake.

The two eastern emerging glacial "islands" seen on the seabottom, are separated by a basin infilled with fine-medium sand and gravel layers of Holocene age, covering an area of at least 60 km^2 with a thickness of up to 10 m. The sandy unit has marine indications except from the bottom layer. Late Pleistocene non-marine floodplain deposits reworked during the

Littorina transgression could be the explanation for the deposition of this unit.
A simplified composite log of the lithological units in the Kriegers Flak area, is seen in Fig. 1.

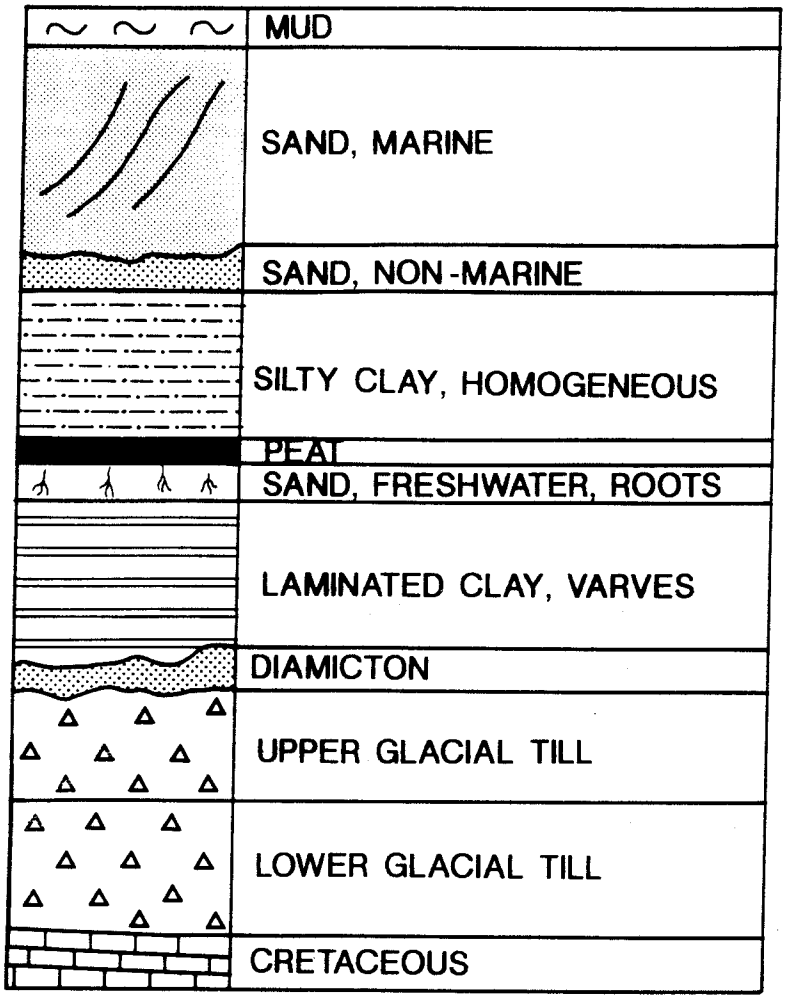


Fig. 1: Simplified composite lithological log

ENVIRONMENTAL HISTORY AND GEOECOLOGICAL CONDITIONS IN THE ESTONIAN COASTAL REGION

Ena Martin and Jüri Kask (Institute of Geology, Estonian Academy of Sciences, Tallinn, Estonia)

Estonia is a country with long traditions of sea exploration. Studies on coastal topography, deposits and shore displacement date back over a century. Owing to the intensive uplift of the Earth's crust, the ancient coastal forms are accessible at various levels. According to archaeological data the oldest known settlements on the territory of Estonia date from the Mesolithic (Pulli, Lammasmägi, Riigiküla), and during the whole history they have been mainly concentrated in the coastal zone. Recent studies on Estonian shores show that the activity of shore processes has gradually increased, and the pollution of nearshore water is extremely extensive, causing thus intensive reed vegetation growth on sandy beaches in several parts of the Estonian coastline, including some seaside resorts where the spread of this vegetation is diminishing the recreational value of beaches. The lack of a coastal management and planning system has already caused some serious environmental problems.

Muds have been used for medical treatment for over 150 years. Such agents as waste discharge of towns, fertilizers, pesticides, catastrophes on land and at the sea, and the pollutants carried via the atmosphere have badly influenced the microbiological and chemical composition of curative mud deposits in densily populated areas (Haapsalu, Käina). Serious environmental problems are connected with the military pollution caused by the activity of Soviet troups located in coastal areas. Thus it is necessary to work out as soon as possible a strategy and tactics of coastal management in Estonia.

GRAVEL ACCUMULATIONS IN THE SOUTHERN BALTIC- METHODS AND RESULTS OF EXPLORATION

Małgorzata Masłowska (State Geological Institute, Sopot, Poland)

Geological exploration carried out by the State Geological Institute on the Baltic Sea led to finding and documenting resources of natural aggregates in the areas of Słupsk Bank, Koszalin Bay and Southern Central Bank. New mining areas have also been determined. First "marine" aggregate resources have been legally approved in 1989.

Documentation was performed in two stages: preliminary investigation stage and detailed investigation stage. During the preliminary stage seismoacoustic profiling and echosounding along profiles spaced about 1.5 km apart is performed. The profiles form a regular grid. At knots of the grid cores up to 6 m length are taken and subjected to laboratory analyses with regard to grain size and physical and chemical characteristics of the sediments. In effect a preliminary determination of the resource fields is obtained. Within these fields the detailed investigation stage works are performed. In this stage, seismoacoustic measurements are done along profiles spaced 0.5 to 0.7 km apart. At knots of this denser grid cores are taken. Also boring down to 25 m is carried out.
Samples from the borings and cores are subjected to full laboratory analysis, the same as for land aggregate resources. Also test mining is performed, during which material is taken for tests on a semitechnical scale. The final report comprises a listing of investigation results and the resource documentation.

To date, in effect of investigations of the Polish part of the Baltic Sea, about 160 million tons of aggregate have been documented. The aggregate is of excellent quality, comparable with best quality land based resources.

STAGNATION PERIODS IN THE GOTLAND BASIN DEEP WATER

Wolfgang Matthäus (Institute of Marine Research, Rostock-Warnemünde, Germany)

Stagnation periods during this century are identified based on all available oceanographical observation data of the near-bottom layer in the Gotland Deep (BY 15). Special attention is given to the present stagnation period which must be regarded as one of the longest and most severe stagnation intervals recorded during this century.
Investigations in the paleoredox conditions (Ignatius et al. 1971; Niemistö and Voipio 1974) and in trace element ratios (Hallberg 1974) have shown that there has also been an alternation between oxidizing and reducing marine environment in the Gotland Deep in earlier centuries. The marine geologists of the Baltic Sea are encouraged in more sophisticated investigations of the paleoceanographical regimes in order to be able to separate clearly that part of the current environmental conditions and trends in the Baltic deep water caused by manmade impacts from the natural fluctuations.

INFLUENCE OF STORMS ON SEDIMENTATION IN KIEL BAY (WESTERN BALTIC)

Doris Milkert, Friedrich Werner (Geological-Paleontological Institute, University of Kiel, Kiel, Germany)

Storm induced sedimentation processes in a shallow marine basin without influence of tides are shown within mud sediments of Kiel Bay. For this investigation several key areas were selected within Kiel Bay: Eckernförde Bay, NW Stoller Ground, Hohwacht Bay.

Storm layers are found in surface sediments of these different areas. The samples were recovered by a video-controlled box-corer ("Reineck-Greifer"). The sedimentary structures were investigated by the study of x-radiographs.

The following types of storm layers could be distinguished:

1. Laminated silt layers:
These layers originated during a major N/NE-storm in August 1989. Samples showing this lamination were collected in Eckernförde Bay between 23 m and 28 m of waterdepth. The structures consist of a horizontal-parallel lamination with cross-stratification of clayey silt to sandy silt. It is underlain by a fine-sand layer of <1 mm thickness.

2. Homogeneous silt-layers without lamination:
They are usually 3-4 mm thick and made of sandy silt without internal structure. For the period from 1980 to 1990 three of these layers could be separated as originated by major storms in Eckernförde Bay.

3. Very fine sand ripples:
They were found in surface sediments of different parts of Hohwacht Bay and Eckernförde Bay. In Eckernförde Bay these layers ocurred during a NE-storm of winter 1978/79. The good preservation can be attributed to a) reduced biological activity and b) missing trawl net fishery in the inner part of Eckernförde Bay.

4. "Krypto"-ripples:
NW of Stoller Ground in 20 m of waterdepth we found a special form of cross-stratification. It is characterized by very fine, discordant laminae with microripples of a few millimetres height.

To get a quantitative record of sediment movement in mud sediments of Kiel Bay during storm events, we carried out erosional experiments (together with Gerd Hoffmann, Kiel). It could be shown that the N/NE storm of August 1989 induced an erosional effect of about 2 cm within a sedimentation rate of 1.2 to 2 cm.

The results show that storms induce the generation of different types of storm layers in mud sediments of Kiel Bay. Their origin depends on direction and duration of the storms. The preservation of storm layers depends on biological and anthropogenic activities in the investigation area. In general, only coarser sediment layers within mud sediments will have the chance to get preserved.

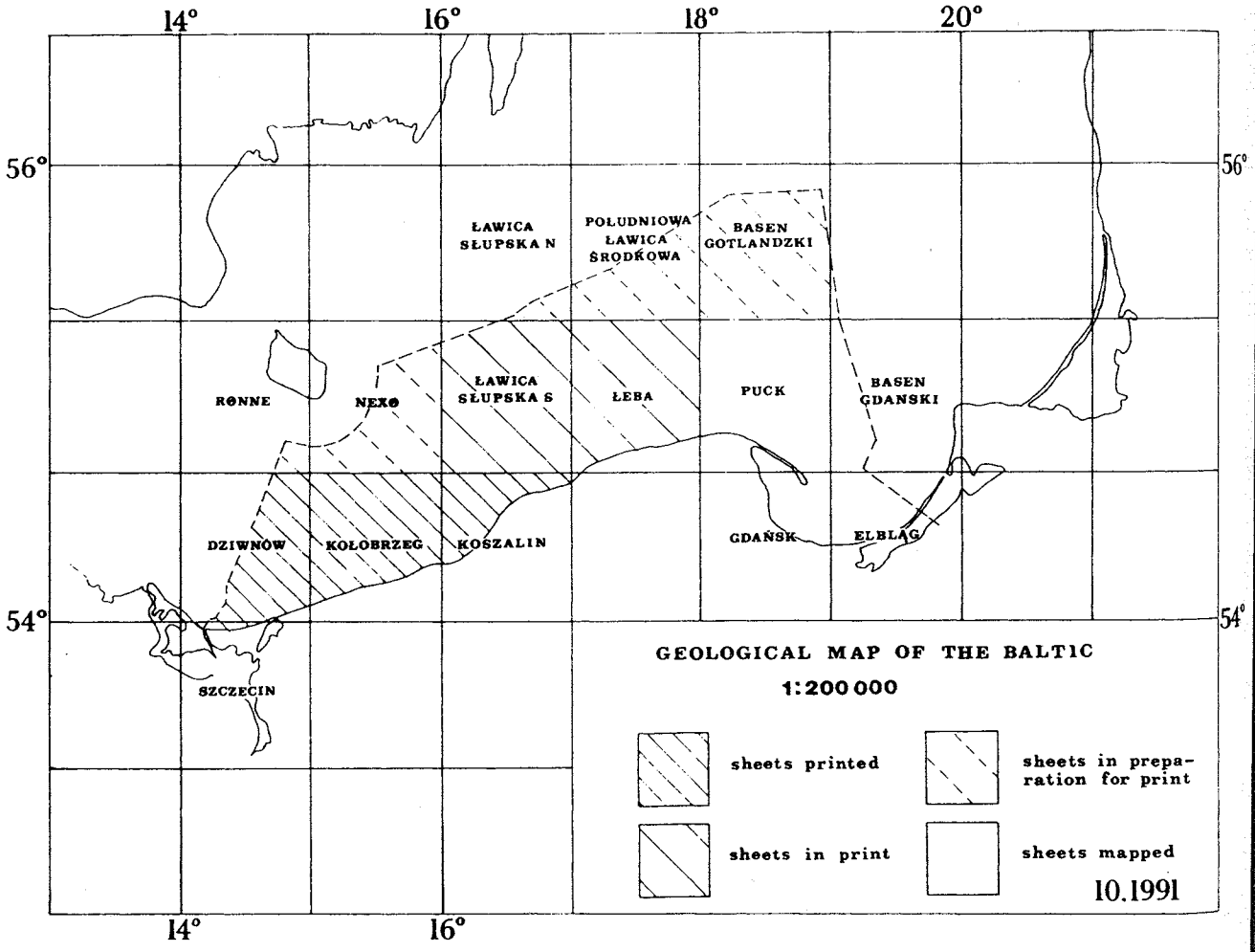
1 : 200.000 GEOLOGICAL MAP OF THE BALTIC SEA BOTTOM

Jósef Edward Mojski (State Geological Institute, Sopot, Poland)

The 1 : 200.000 Geological Map of the Baltic Sea Bottom (GMBSB) covers the Polish economic zone of the Baltic Sea and consists of 17 sheets. Each sheet has a map of bottom deposits, as well as the geological sections, main lithological profiles and four additional maps: geomorphological, lithodynamical, mineral resources and map of deposits occuring 1 m below bottom surface. For each sheet an explanatory text is printed.

The GMBSB is prepared on the basis of cruise (echosounding, collection of scoop samples, drilling cores, seismoacoustic sounding) and laboratory (grain size, mineral, petrographical, heavy minerals and chemical composition, roundness degree of quartz grains, content of organic matter and clay minerals, as well as paleobiological and datings) researches.

The symbols of deposits represent the age, grain size composition and origin. Age determination is detailed, especially for the Holocene deposits. Grain size composition is distinguished on the base of Shepard's classification.



LATE QUATERNARY EVOLUTION OF THE BOTTOM RELIEF OF THE GULF OF FINLAND

P.E. Moskalenko (All-Union Geological Institute, St. Petersburg, Russia)

The Late Quaternary history of the bottom relief development of the Gulf of Finland may be divided into three stages.
The first stage was connected with the continental glaciation activity. The influence of the Late Quaternary ice-sheets on the recent sea bottom was leading to the formation of accumulative and erosion glacial landforms. The glacial exaration was displayed mainly in the transformation of the preceding relief forms, such as structural-denudational escarps and uplands, erosional down-cuts, etc.

From the beginning of the ice-sheets degradation the glacial accumulation had been predominating. As the result of the glacial melting out of moraine material knob-and-kettle moraine plains were formed. In front of the ice-sheet borders large end-moraine ridges were built.

The approaching of the second stage was characterized by an intensive melting of the glacier and the formation of large limno-glacial basins. A highly active accumulation of terrigenous deposits took place in these fresh water basins. Their total square was bigger then the recent dimensions of the Gulf of Finland. So, the present sea bottom coincides with the deepest part of the glacial lakes. Naturally, the sedimentation processes lead to a considerable planation of the moraine relief.

The third stage of the bottom relief development coincided with the period of the marine basin existence in the recent bounds of the Gulf of Finland. The evolution of this basin began in the early Holocene. During this stage several transgressive and regressive phases were observed. The influence of marine lithodynamic processes lead to a considerable planation of the sea bottom relief, caused by the abrasion of the shallow water part of the basin, combined with the accumulation of the abraded material in the deepest parts.
So, we can state that on the first stage of the relief evolution the tendency of the contrast relief form formation was observed, on the second stage - accumulative planation with the help of abrasion and accumulation processes.

SCALES OF THE RELATIONSHIPS BETWEEN SEA LEVEL FLUCTUATIONS AND MORPHODYNAMICAL CHANGES OF THE SOUTHERN BALTIC COAST

Stanisław Musielak (Institute of Marine Sciences, University of Szczecin, Poland)

In the paper the author presents results of his thirty years research work on the coastal zone of the southern Baltic and other tideless seas (Caspian and Black).
Based on the results of his investigations the author tried to cope with the following tasks:
- determining the importance and consequences of particular factors effecting the shore zone
- selecting major and minor factors and estimating their role in a global process

In order to facilitate further predictions the dynamic processes which have been investigated and recorded needed classification in terms of time and space.
The analysis of the existing materials and the obtained results allowed to put forward the following thesis:

1) The factor that determines the intensity and direction of shore transformation processes is the sea level (water level) variation. It causes a translocation of both the main dynamic zone and the hydrodynamic barrier.

2) The sea level variation effect on the shore zone varies in terms of time and space. It may be caused by a number of different factors. The variations occur with various amplitudes and times of duration forming circulation systems of different ranks.

An analysis of relations between the coast line's shape and the geological and tectonic structure shows that the general coastline is closely connected to the tectonic structure of the area. Usually sea bays are formed in the region of syncline structures, whereas anticline structures are often accompanied by shore displacement towards the sea. Neotectonic processes can intensify or delay morphodynamic processes of sea transgression.

Neotectonic movements causing 'relative' sea level variations, measured on a scale of thousands of years and hundreds of kilometres, control the formation of shore systems and are considered to be of first rank.

In the context with relatively long-term sea level variations climate factors, besides the tectonic ones, are the reason for eustatic variations. Sea level changes, a widely accepted fact, seem to be a result of the pulsating nature of the Holocene transgression undergoing several phases of abatement and even short-term regression.

Taking time in the range of hundreds of years and space in the range of tens of kilometres shore systems of the second rank are formed this way. These systems are the origin of almost all big coastal accumulation forms, classified as spits. The sea level variations mentioned above effect the development of both cliff and dune shores.

Direct mareographical investigations enable to determine ranges of successive sea level variations effecting shore morphodynamics. These sea level variations in the range of centuries produced shore circulation systems defined as third rank ones. They act in the range of tens of years and kilometres.

Systems classified into the fourth rank refer to variations on a time scale of several years and some hundreds of metres in terms of space. The third and fourth rank systems can be recognized on aerial photographs and photointerpretation maps of the shore zone.

Circulation cells existing between the shore line and the first long-shore bar can be regarded as circulation systems of the fifth rank. They extend over a range of tens of metres and some months in terms of time.

Interstorm and intrastorm sea level variations create transitory shore systems of higher ranks. They refer to weeks, days, hours, minutes and metres, centimetres as well as millimetres, respectively. Bars and beach lagoons, internal stratification and lamination of the beach and the subshore are produced by these processes.

Variations of the last mentioned type have been registered by an equipment installed at several locations. It enabled the author to estimate the factors effecting shore dynamics qualitatively and quantitavely. The data obtained can be used for designing suitable mathematical models of these processes in particular shore regions.

THE PHOTOINTERPRETATION ATLAS OF SHORE DYNAMICS OF THE WESTERN COAST OF POLAND

S. Musielak, K. Furmanczyk, K. Osadczuk, J. Prajs (Institute of Marine Sciences, University of Sczcecin, Poland)

For an appropriate management of the coastal zone it's necessary to understand the complex physical processes involved. Research in this zone needs synoptical registrations of the same features over a large coastal area. This should be done as often as required by the coastal development. i.e., in practice, as often as possible. Most suitable is the application of remote sensing techniques like multitemporal photogrammetric aerial photographs. This way it is possible to estimate the rate of processes taking place in the coastal zone and to observe the influence of hydrotechnical constructions.

The authors present "The Photointerpretation Atlas of Shore Dynamics of the Western Coast of Poland" based upon the interpretation of multitemporal panchromatic aerial photographs taken in 1958, 1964, 1973, 1983 and 1989. A first interpretation of these photographs resulted in "The Photointerpretation Maps of the Coastal Zone for 1989" and related maps regarding dynamics on a scale of 1: 5.000 using "Kartoflex" and "Interpretoscope".
"The Photointerpretation Atlas of Shore Dynamics of the Western Coast of Poland" was made by the District Enterprise of Surveying and Cartography in Sczcecin in co-operation with and using methods proposed by the authors. The project was supported by the Maritime Office in Sczcecin.

The atlas consists of three parts:

1) Introduction - it contains a short description of the applied technology and a characterization of base materials, figures and diagrams with important coastal elements, tables with classification criteria of shore dynamics and a legend of the maps.

2) A synthetic map of coastal dynamics on a scale of of 1: 200.000, which contains:
   - spatial distribution of different types of coastal dynamics, based upon geological and geomorphological data
   - variation of the average beach width
   - other information like coverage by aerial photographs, map sections etc.

3) 21 maps on coastal dynamics on a scale of 1: 5.000. They contain:
   - the photointerpretation map for 1989 with a legend
   - many years' average of the beach width
   - maximum number of underwater long shore bars
   - geomorphological types of the coast and its dynamics (dune and cliff base lines, dunes crests and cliff ranges)

A spatial variation analysis of main morphological elements presented in the atlas allows to show many rules of the coastal zones' development. The distribution of particular types of shore dynamics and the values of their morphodynamical indicators demonstrate the very different type of processes even at neighbouring sections of the coast.

The maps show a general tendency towards coastal erosion with an average velocity of 0.35 m/year (maximum about 1.2 m/year) and the influence of hydrotechnical constructions on the coastal development. The only accumulation area is situated at the mouth of the Swina river.

The indicators presented in the atlas have proved to be very useful for the analysis of coastal dynamics.

Indicators of shore dynamics	Tendencies of development and shore dynamics	Class symbol	Numerical values of class intervals of shore dynamics for lines (m/year)		
			L_k	L_p	L_v
Vector sum of changes	accumulation	B	>0.5	>0.5	>1.0
		A	0.2÷0.5	0.2÷0.5	0.2÷1.0
	dynamic balance	O	0±0.2	0±0.2	0±0.2
Σ w	abrasion	R	-0.2÷-0.5	-0.2÷-0.5	-0.2÷-0.5
		S	<-0.5	<-0.5	<-1.0
Scalar sum of changes	dynamic stable shore	0	0÷0.2	0÷0.2	0÷0.2
	low change dynamics	1	0.2÷0.5	0.2÷0.5	0.2÷1.0
Σ s	medium change dynamics	2	0.5÷1.0	0.5÷1.0	1.0÷1.5
	high change dynamics	3	>1.0	>1.0	>1.5

Table 1: Criteria of classification of shore dynamics (1958 - 1989)

L_k - crest of avandune or top of cliff

L_p - base of dune or cliff

L_v - land-water line

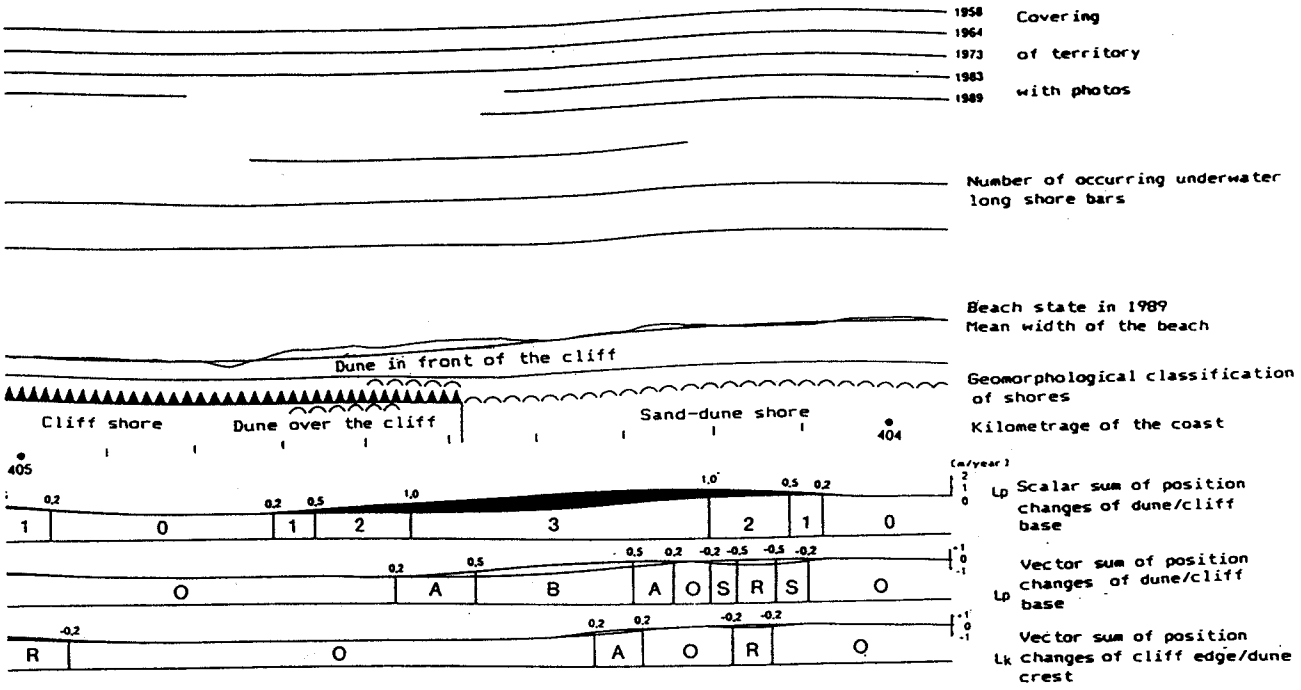


Fig. 1: Classification of shore dynamics according to Table 1

SEDIMENTATION IN THE PUCK LAGOON, NW PART OF THE GULF OF GDAŃSK

Stanisław Musielak, Andrzej Osadczuk (Institute of Marine Sciences, University of Sczcecin, Poland)

The paper presents the results of investigations carried out in the Puck Lagoon, where 98 samples of bottom deposits were taken. These samples were analysed with respect to grain-size distribution, grain roundness and mineralogical-chemical composition.

The Puck Lagoon (Little Puck Bay) is a part of the Gulf of Gdańsk. It is a shallow water area with a mean depth of 3 m. Shallow water (0-2 m) covers more than 12 %, while depths above 6 m occur only in 3 % of the area.

A detailed lithological analysis revealed, among other things, a considerable lithological differentiation of the deposits. There are macroclastic and argillaceous as well as different sediments in regard to chemical composition and genesis. Sands are the prevailing kind of sediment covering about 3/4 of the bottom area. Other parts are covered by mud and organic deposits like peat and carbon-rich limnic materials.

The grain-size distribution of the sediments is related to the bathymetry and morphology of the floor. Most frequently occurs the fraction 0.15 - 0.20 mm. In the sediments of the shore zone and at Rybitwia Mielizna the 0.25 - 0.50 mm fraction predominates, at Piaski Dziewicze 0.20 - 0.25 mm and at the Kuznice and Rzucewo deeps 0.06 - 0.10 mm and below 0.10 mm.

The sediment sorting in the study area is rather different. Best sorted are the deposits from Piaski Dziewicze, Rybitwia Mielizna and from the shore zone. Poorly and moderately sorted are the sediments from the southernmost part of the lagoon and from Kuznicka Jama, respectively.

The morphological analysis of quartz grains out of the 0.50 - 1.00 mm fraction showed the existence of genetic relations between the deposits studied and postglacial moraine material. On the other hand, no connection was found between the degree of quartz grain smoothing and either the depth of the basin or its morphology.

The mean content of heavy minerals in the deposits of the Puck Lagoon is less than 0.5 % and varies in particular samples from 0.04 % (Rewa Mew) up to 9.01 % (the region SE of Swarzewo).

According to the morphology and the character of recent sedimentation the basin is a typical example for a non-tidal sea lagoon in a temperate climate. In contradiction to other basins of this type the recent accumulation rate is rather low. There is no considerable fluvial supply. Usually the accumulation rate

is lower than 20 cm/ 1.000 years. Higher rates of about 100 cm / 1.000 years have been found only in the deepest parts of the area (Jama Kuznicka and Jama Chalupska).

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Fig. 1: Sketch map of the study area
1- morainic upland; 2- peat-bog formation; 3- cliff; 4- dunes; 5- peat in bore-holes; 6- study area; 7- localities; 8- isobaths

Fig. 2: Bottom sediments of the Puck Lagoon
1- stones and stony deposits; 2- medium-grained sands; 3- fine-grained sands; 4- poorly sorted sands; 5- fine-grained sands with organic components; 6- aleuritic-sandy sediments; 7- Aleurites (mud); 8- argillaceous and argillaceous-calcareous sediments; 9- peat; 10- peat detritus with sand and organic deposits; 11- organic deposits

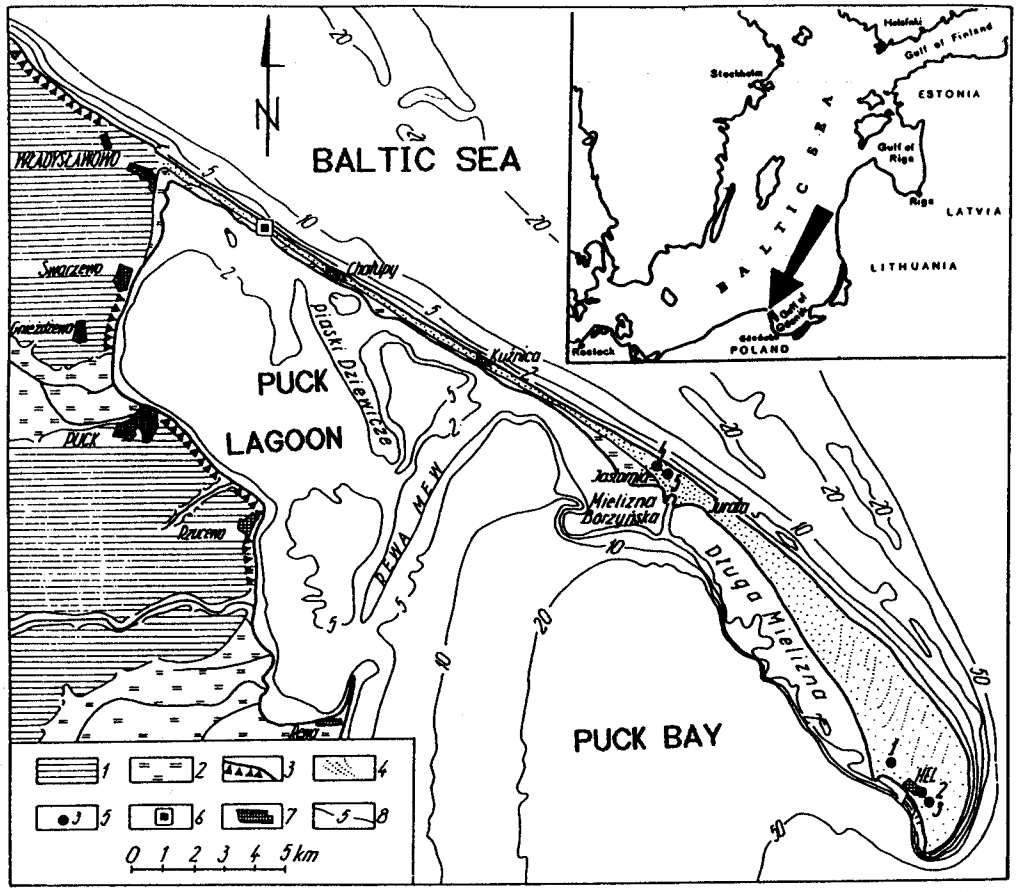
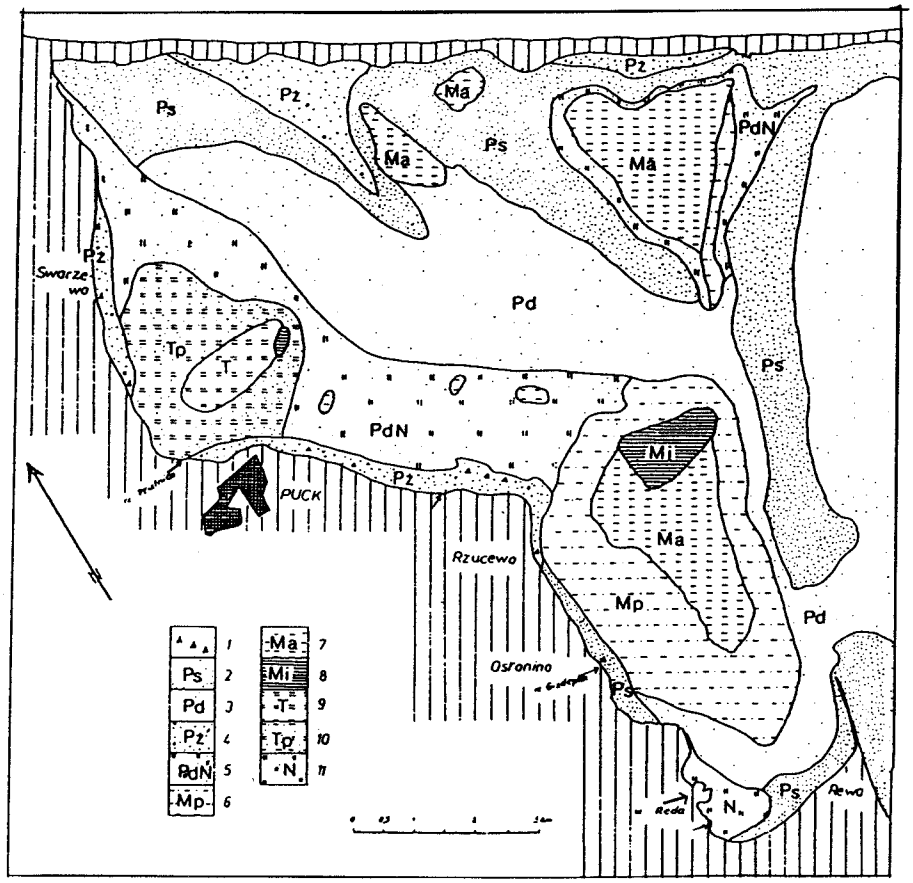

BALTIC SEA
PUCK
LAGOON
PUCK BAY
WŁADYSŁAWOWO
Swarzewo
Chałupy
Kuźnica
Jastarnia
Mielizna Borzyńska
Jurata
Długa Mielizna
Rzucewo
PUCK
REWA
Hel
Stockholm
Helsinki
Gulf of Finland
ESTONIA
Gulf of Riga
Riga
LATVIA
LITHUANIA
POLAND
Rostock
0 1 2 3 4 5km

Fig.1


Pz
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Swarzewo
PUCK
Rzucewo
Osłonino
Rewa

Fig.2

GEOLOGICAL ENGINEERING AND GEOECOLOGICAL MAPPING OF THE BALTIC SEA FLOOR CONSIDERING ITS OIL PROSPECTS

A.F. Nashestnikov, V.I. Aristov (Soyuzmorinzhgeologiya, BMGEE Kaliningrad, Russia)

The Baltic Marine Geological-Engineering Expedition (BMGEE, Soyuzmorinzhgeologiya) was founded in Kaliningrad in 1970 with the aim of oil and gas prospection. During the time of its existence it became the only performer of seismic oil prospecting and preparation of the discovered structures for drilling in the Soviet economic sector of the Baltic Sea. Moreover, geological mapping was done at scales from 1: 500.000 up to 1: 25.000. A mapping survey at a scale of 1: 500.000 was performed in the area between 57° N and the Soviet-Polish frontier in the south by 1980. The further development of oil prospection showed the need for special investigations on the natural environment in prospective areas. First of all this have been engineering-geological and geoecological mapping programmes to estimate the oil stock development and possible ecological consequences of oil exploitation.
The investigations have been done by r/v "Izyskatel-1" employing the following methods:

- echo-sounding and side looking radar (about 25.000 profile kilometres) in order to detect geomorphological characteristics and details of the sea floor
- continuous digital analogue one-channel seismoacoustic profiling and multichannel digital seismoacoustical profiling (also approximately 25.000 profile kilometres) to find and to track seismoacoustic complexes in Quaternary and older sediments and to develop a velocity model for a forecast of a number of physico-mechanical parameters (porosity, space density, modulus of deformation, specific coalescense, internal friction angle)
- electrometric observations in order to locate and specify metallic objects on the sea floor
- dredging of surface sediments to investigate its hydrochemical composition, anthropogenic contamination and to characterize the benthos
- drilling of (approximately 3.000) shallow boreholes (5-6 m in the sediment) to study its mineralogical composition and physico-mechanical parameters

Furthermore, there were drilled about 80 boreholes from 10 to 70 m depth in the sediment. Also hydrobiological and hydrochemical investigations as well as lithodynamic studies were carried out in prospective areas.

All the field work was done by employing a precision navigational system of the "Syledis" type.

Based on the obtained data an engineering-geological map of the Soviet economic zone in the area between 56°40' N and 55°20' N at a scale of 1: 200.000 was assembled. Similar maps at a scale of 1: 25.000 - 1: 50.000 were made for the southward adjacent region.

Besides exploration purposes the maps are used for feasability studies regarding the construction of oil pipelines, ports and other hydrotechnical constructions.

The present ecological situation of main oil prospective areas and the anthropogenic influence on the sediments in some ports have been investigated. In this respect the example of a small part of the Klaipeda harbour may be illustrative. Here the amount of petroleum derivates in the uppermost 50 cm of the sediment exceeds the natural background by 19 times; the value for phenoles is 28 times higher than the natural background and the values for other substances are: 4 times for synthetic surface-active substances (SSAS), 37 times for copper, 40 times for cadmium and 27 times for lead.

EVALUATION OF THE HYDRODYNAMIC ENVIRONMENT OF PELAGIC CARBONATE SEDIMENTS: EFFECT OF PARTICLE DENSITY (g/ccm) ON THEIR ENTRAINMENT

Reinhard Oehmig (GEOMAR, Research Centre for Marine Geosciences, Kiel, Germany)

Bottom current regimes determine the parameters of sediment transport and accumulation as well as diversity and ecology of benthic communities. To infer limiting hydrodynamics for deposition of pelagic deep-sea sediments, their textural characteristics and a SHIELDS-curve were used.

As an important parameter of the empirical curve for the threshold of sediment movement, the density of planktonic foraminifera, which are the main sand-sized constituents have been determined.

The effective density of the empty tests renders to be size dependent, and is for the most frequent test sizes nearly half of that valid for massive quartz or carbonate particles. The evaluation of friction velocity for sand-sized foraminifera, using these data reveals that it is in the same range as for quartz and carbonate silt.

The examination of textural characteristics of topographically exposed surface sediments of the Norwegian Sea suggests an equivalent transport and deposition of fine fraction and foraminifera tests of a distinct size. The observed correlation of foraminifera test size and the portion of fine fraction indicates that these sediments are transport associations.

Other depositional processes like the effect of bottom roughness, predepositional winnowing and selective deposition also contribute to the textural patterns found in this study.

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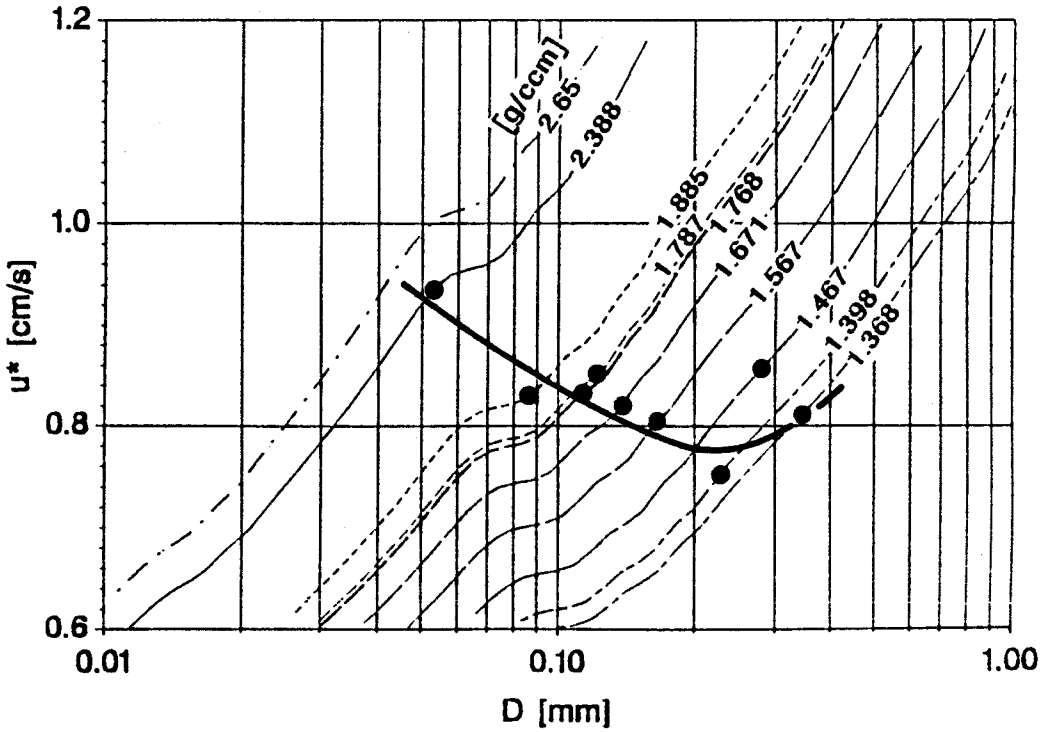

Fig. 1: Friction velocities as a function of intermediate foraminifera test diameter and effective density

PHYSICAL CHARACTERISTICS OF THE BALTIC SEA BOTTOM SEDIMENTS

V.V. Orlenok, M.I. Lindin (University of Kaliningrad, Kaliningrad, Russia)

The recent submarine relief and sediments of the Baltic Sea were formed as a result of exaration activity of the Würm glacier and the Holocene sedimentogenesis. Glacial moraine mild clays and terrigeneous muds formed during this process are at a time the main petrophysical types of the Quaternary sediments of the Baltic Sea bottom.

According to data of 280 stations on which we have been working since 1975 up to 1990 the physical characteristics of sediments mostly depend on the grain-size texture and the lithology. Thus, according to physical property changes among the Holocene sediments, there can be distinguished between sands, silty muds, and muds (see the table). There are moraine mild clays and ribbon clays in the Upper Pleistocene sediments. Wide range measurements of physical sediment characteristics enable us to obtain information about their compaction and the degree of postdepositional changes, their practical use in seismic, bottom profiling, engineering works and so on. The interrelations between different physical characteristics, lithology and grain-size texture of different sediment types are established with the help of statistical analyses. Most important is the quadratic relationship between the acoustic impedance and the reflection coefficient with the high correlation coefficient 0.96:

$$Z=1.5 +4.086K + 0.3115K^2$$

Therefore, this relation provides to work out methods of distance distinguishing between five types of sediments including their lithology and prevailing grain-size texture.

Strong correlation dependencies ($R > 0.9$) were obtained within different lithological types of sediments for such petrophysical couples as ρ and Z, W and n, V and Z, V and K, Z and K, V and ρ. For example, regressions for silty muds:

$\rho = 1.834 - 0.010\ W$; $\quad Z = 2.964 - 0.014\ W$

for mild clays:

$Z = 8.313 - 0.080\ n$; $\quad \rho = 0.337\ Z - 0.804$

for muds:

$\rho = 0.612\ Z - 0.135$; $\quad Z = 3.316\ K - 1.453$

and so on.

Table: Petrophysical model of Quaternary sediments of the Baltic Sea

Sediments	Moraine mild clays	Ribbon clays	Sands	Silty muds	Muds
Age	Q_3	Q_3	Q_4	Q_4	Q_4
V [km/s]	1.64	1.45	1.68	1.48	1.45
A [%]	4.30	2.30	0.80	3.60	3.80
ρ [g/cm^3]	1.78	1.37	1.68	1.33	1.21
K	0.30	0.15	0.33	0.15	0.09
β [cm^{-1}]	0.18	0.15	-	0.18	0.16
γ [g/cm^3]	2.71	2.74	-	2.65	2.67
W [%]	29	53	32	59	67
n [%]	70	82	71	82	88
$\varkappa$ [10^{-6} CGS]	37	-	39	36	11
<0.01 mm	42.5	53.7	21.4	27.4	62.9
0.01-0.1 mm	40.4	42.8	24.0	68.8	32.8
0.1-1.0 mm	13.5	1.4	52.0	3.8	0.6
>1.0 mm	7.9	1.7	16.4	3.9	-

Note: V - sound velocity; A - anisotropy; ρ - wet-bulk density

K - reflection coefficient; β - coefficient of absorption

γ - grain density; W - water content; n - porosity

$\varkappa$ - magnetic susceptibility

GDAŃSK BASIN-LITHOLOGY AND STRATIGRAPHY OF LATE GLACIAL AND POSTGLACIAL (HOLOCENE) SEDIMENTS

Feliks Bronisław Pieczka (Gdańsk, Poland)

The Gdańsk Basin is situated in the south eastern part of the southern Baltic sea. It consists of: The Gdańsk Deep, the Gdańsk Bay, the Vistulian Lagoon. From the east and south it is limited by the Baltic shoreline, in the north-west part by the Gdańsk - Gotlands Threshold, the rest of the border is signed contractually (F.B. PIECZKA, 1980).

The main geomorphological elements are:

1. The Littoral shallow water zone (up to 40 - 50 m water depth), covered with sandy sediments, muds and also boulders and gravels.

2. South Baltic slope (from 40 - 50 to 60 - 80/90 m water depth).

3. Deepwater zone (below 60 - 80 m) usually covered with organic muds and silts (gyttja), sporadic incrops of grey and greengrey coloured boulder clays.

4. Gdańsk-Gotlands Threshold (depth from 75 to 90 m) covered with red and chocolate coloured loams (F.B. PIECZKA).

Clays from the Gdańsk's Deep bottom are dated back to about 45 thousand years b.p. (R. KRAMARSKA et. al., 1990).
In the following there is shown a typical sediment profile from the deepwater zone (F. B. PIECZKA, 1980; L. STOCH; K. GOERLICH; F.B. PIECZKA, 1980; F.-C. KÖGLER et. al., 1985; F.B. PIECZKA; K. ZABOROWSKA, 1989):

1. Postlitorina (recent) deposits (Mya Sea, Limnaea Sea)-muds and organic muds, clayey silts, very fine laminated, gelatineous, from olivegrey up to black, very strong irrigated (65 - 75 % dm.), C_{org} = 2; 0 - 2 %; pH = 7,21 bis 7,45; Eh = - 390 to - 415 mV.

2. Litorina Sea deposits (Atlanticum period) - clayey silts and muds at the top: olivegrey, spongy with distinct cycles of laminated muds with thin layers (5 cm) of silty-clayey sand, natural water content = 55 - 66 %; C_{org} = 1,95 - 3,00 %; pH = 7,14 - 7,29; Eh = - 340 to - 400 mV.

3. Boreal deposits of Ancylus Lake at the top: clay, greyblue, bluish grey, at the bottom: clay with dark and black laminae and trails of monosulphides (small pyrite and marcasite microconcretions) Fe, homogeneous, cryptolaminated (microstructures), n.w.c. = 47 - 60 %; C_{org} = 1,45 - 21,5 %; pH = 7,13 - 7,22; Eh = - 230 to - 330 mV.

4. Preboreal Yoldia Sea deposits (Y II) - olivegrey clay, with dark grey and black laminae and concretions of iron monosulphides. The content of the sand fraction increases from the top to the bottom (2,0 to 14,0 %). Upper part = second maximum of carbonate contents (up to 1,68 % CaO = 3,82 % $CaCO_3$), n.w.c. = 49 - 55 %; C_{org} = 0,5 - 1,2 %; pH = 7,17 - 7,30; Eh = - 115 to - 320 mV.

5. Deposits of the Second Baltic Ice-Lake (DR-3) - clay homogeneous, sandy, olive grey with dark iron monosulphide concretions, in the bottom of the layer - a thin sandy layer. Sand fraction content 16 - 18 %; n.w.c. = 45 - 55 %; C_{org} = 1,2 %; pH = 7,05; Eh = - 150 to - 175 mV.

6. Late Pleistocene Yoldia Sea (YI) deposits (Alleröd). Upper part: homogeneous clay, cryptolaminated, with laminae of iron monosulphides and sand. Middle part: olivegrey clay with microlaminae and concretions of iron monosulphides (hydrotroilite), with a thin sand layer at the top. Lower part: olivebrown up to brown clay, cryptolaminated with thick darkgrey and black laminae of iron monosulphides. From the top to the bottom: high sand fraction content /up to 18 %/, very low carbonate content (CaO = 0,1 - 0,4 % = 0,23 - 0,91 % $CaCO_3$), n.w.c. = 42 - 52 %; C_{org} = 1,2 - 2,0 %D; pH = 7,00 - 7,15; Eh = - 100 to - 350 mV.

7. First Baltic Ice-Lake deposits (DR-2, BO, DR-1) - laminated clay, varved clay, very sticky, carbonated. Upper part: brown and brownish clay with pink spots to brown and brownisholive clay, with fine (delicate) laminae, lower part: microlaminated and crytpolaminated, brown up to reddishbrown clay, with lenses of blue silt (mud) and clay. First (lower) maximum of carbonates content (up to 5,9 % CaO = 13,4 % $CaCO_3$), n.w.c. = 40,0 to 50,0 %; C_{org} = 0,18 - 0,20 %; pH = 6,9; Eh = - 90 to - 135 mV.

8. Glacial clay-age = F5 (?) after Mörner=Gardno stage in North Poland (Vistulian glaciation) or older: Pleistocene glacial clay, reddishbrown, with small pebbles (calcareous).

THE RESOURCES OF CHEMICAL COMPONENTS IN SHELLS OF *DREISSENA POLYMORPHA (PALL.)* IN THE DABIE LAKE (WESTERN POMERANIA, POLAND)

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Material collected in the Dabie Lake (near Sczcecin, Western Pomerania, Poland) in 1988 is the base for the interpretation presented here. The presence of *Dreissena polymorpha* was recorded in 33 out of 71 stations. The population occurence area was estimated to be 18.5 km^2. Basic statistical parameters have been calculated regarding distribution of population sizes, the surface mass density of shells, the mass of $CaCO_3$ and of organic matter (=conchiline + periostracum): arithmetic mean (x), median (Me) and geometric mean (x_g). Furthermore there were calculated: standard deviation (s), coefficient of variation (v) and the 95 % confidence interval (PU). The amounts of $CaCO_3$ and organic matter were estimated considering changes of the chemism depending on the length of the shells (PIOTROWSKI & OCHMAN 1991). Considering a distinct correlation between population size and shell mass density as well as a direct correlation between the shell mass and $CaCO_3$ and organic matter contents, the distributions of these values are exponential and approximate each other. The highest average values were calculated for arithmetic mean, a much lower one for median and the lowest one for geometric mean (PIOTROWSKI 1991). Population sizes and contents of each component accumulated in living shell individuals with regard to different measuring positions are:

Population size:

$L_x = 31.654 \pm 10.138 \times 10^9$ individuals
$L_{Me} = 21.645 \pm 10.712 \times 10^9$ individuals
$L_{xg} = 16.965 \pm 11.341 \times 10^9$ individuals

Shell mass resources:

$Z_x = 13.871 \pm 4.342 \times 10^3$ tons
$Z_{Me} = 10.869 \pm 4.464 \times 10^3$ tons
$Z_{xg} = 7.522 \pm 4.867 \times 10^3$ tons

$CaCO_3$ resources:

$Z_x = 12.991 \pm 4.055 \times 10^3$ tons
$Z_{Me} = 9.803 \pm 4.203 \times 10^3$ tons
$Z_{xg} = 7.067 \pm 4.545 \times 10^3$ tons

Organic matter resources:

$Z_x = 0.331 \pm 0.104 \times 10^3$ tons
$Z_{Me} = 0.255 \pm 0.107 \times 10^3$ tons
$Z_{xg} = 0.181 \pm 0.115 \times 10^3$ tons

The resources of 16 elements, which occur in shells, were estimated for the arithmetic mean of shell resources. They amount to 83.884 ± 26.257 tons:

Fe	28.159 ± 8.814 tons	S	2.219 ± 0.695 tons
Al	9.849 ± 3.083 tons	Co	1.803 ± 0.564 tons
P	8.913 ± 2.790 tons	Zn	1.387 ± 0.434 tons
Sr	7.887 ± 2.469 tons	F	1.075 ± 0.337 tons
Mg	7.768 ± 2.431 tons	Pb	0.555 ± 0.174 tons
Mn	7.491 ± 2.345 tons	Cr	0.510 ± 0.160 tons
Cu	3.329 ± 1.042 tons	Ag	0.153 ± 0.048 tons
Ba	2.647 ± 0.828 tons	Ni	0.139 ± 0.043 tons

The use of different calculation techniques for the population area and the average values results in a more difficult comparison of the values for different water regions. The total resources of the various chemical components occuring also in other mollusc species and their shells at the bottom of the Dabie Lake are much higher without any doubt.

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SEDIMENTARY RECORD OF SEASONAL PRODUCTION AND GEOCHEMICAL FLUXES IN THE NORTHERN BALTIC PROPER

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The algal and chemical composition of alternating black and light coloured laminae were studied in multi-laminated sediment cores from the northern Baltic Proper. The results seem to indicate that the black layers contain abundant amounts of algae and organic material corresponding to periods of high phytoplankton production, usually the vernal diatom bloom. The light layers contain much mineral particles, little algal remains and old organic material corresponding to low production stages and/or as a result of resuspension. There is a sesonally modulated supply of phytoplankton to the sediments directly related to periods of high primary production, the vernal diatom bloom being the major source of this geochemical flux.

It is postulated that the sequences of laminae may be used as a long-term record of productivity cycles. The laminae formed during the last marine stage of the Baltic are discussed.

NATURAL AND ANTHROPOGENIC COMPONENTS IN THE PROCESS OF SEDIMENTATION IN THE BALTIC SEA

Olegas Pustelnikovas (Institute of Geography, Lithuanian Academy of Sciences, Vilnius, Lithuania)

Biogeochemical analysis of sedimentation processes in space and time allows to investigate hydrogeochemical and lithological factors by looking at the activities of microorganisms and hydrobionts. In order to decide if natural or anthropogenic processes are prevailing at present it is necessary to investigate sedimentation and element flux processes under the influence of microorganisms.

The presented results are based on complex investigations carried out in 1978-1990.

The analysis of hydrocarbons show that 11 genetic groups of hydrocarbons can be distinguished (ZARECKAS & SURVILA 1988). Hydrocarbons in water and sediments contain biogenic, petrogenic, technogenic and mixed genetical components. The data obtained indicate the low level of human background in different parts of the marine ecosystem. The investigated bottom samples have a mean composition of 63 % biogenic hydrocarbons, 32 % of the detected hydrocarbons arising from different kinds of oil pollution and 5 % of the hydrocarbons are of petrogenic origin.

The most recent sediments of the uppermost (0-30 cm) layer are enriched in Mn, Zn, Pb, Cu, Ni, Co and Cd by 1.5 - 3.5 times compared to the older ones. These differences are connected to the different roles of the elements in the sedimentation cycle. They are largest at the boundary between the phases of sedimentogenesis and early diagenesis, i.e. they are related to the phases of natural sedimentation processes.

After disintegration of sediments with concentrated nitrogen acid the element contents is lower compared to the complete disintegration by a mixture of hydrofluoric and sulphur acid, which destructed the crystal grid of silicates (e.g. Pb 1.9 - 4.9 times; Cd 1.3 - 27.5 times and Cu 1.5 - 2.6 times).
The highest amount of the investigated elements in fine dispersed aleuritic-pelitic and pelitic silts, and the fact that there is no excess of these elements in corresponding natural objects of the lithosphere indicate a predominance of natural origin for these elements. The same is evident in gas-turbidity areas indicating substance migration by deep flow or submarine discharge of ground water (Gdansk and southern Gotland basins). Investigations on the uppermost (0-12 cm) layer of the bottom sediments in the Gulf of Finland have shown the absence of distinct changes during three phases of sedimentogenesis and early diagenesis. A stability of the relationship between the lithogenic and reactable form and the prevailing natural character of elements in Gdansk Bay and in the lagoon Kuršių Marios has been actually existing during the whole geological

history (LUKASHOV et al. 1986).

Often the very high content of certain elements in the uppermost (up to 50 cm) layer of bottom sediments is connected to the beginning of industrialisation and the development of rural econmy in the 19th century and its intensive development today. In our opinion it should be defined rather as the end of the active phase of sedimentogenesis and diagenesis in sediments of that age.

At the present time the Baltic Sea begins a new cycle of desalinisation with all the resulting geochemical and ecological consequences.

SEDIMENTATION IN THE KURŠIŲ MARIOS LAGOON DURING THE LAST 200 YEARS

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The lagoon Kuršių Marios is a basin of huge sedimentation (2,9 - 3,6 m/1000 years) the area of which has decreased during the last 50 years by 35 km^2 as a result of natural processes and human activities.

Data on C_{org}, $CaCO_3$, Fe, Mn, Ti, Al, K, Na, Ca, Mg, Cu, Pb, Zn, Cr, Co, Ni, Li and Rb distribution in the upper (1 m) part of the sediment column are presented. The determined peculiarities of sedimentation rates and the distribution of elements as well as the interrelation between these compounds show that during the last 200 years no considerable change of sedimentation took place. The observed variety is due in most cases to natural processes and to microclimatic oscillations of the environment. The high amounts of certain elements in the upper (0-30 cm) layer is due to the processes of sedimentogenesis and early diagenesis under human influence. The role of the latter increases only in the areas: r. Nemunas-Kuršių Marios lagoon and Klaipeda port - Baltic Sea - as zones of geochemical barriers.

According to ^{210}Pb results the sedimentation rates are 2.9 - 3.6 m/1000 years. That means that the Kuršių Marios lagoon with a mean depth of 3.8 m will exist only for 1.000-1.500 years more in the recent form.

LATE QUATERNARY DEVELOPMENT OF THE EASTERN BALTIC AREA

Anto Raukas (Institute of Geology, Estonian Academy of Sciences, Tallinn, Estonia)

In several places in the Eastern Baltic area (Prangli, Mga a.o.) the record of the transgression cycle of the Eemian interglacial period is rather complete. Fauna and flora of marine beds suggest a melioration of climate from Arctic and Subarctic towards considerably higher temperatures than nowadays. There are two basically different standpoints on the contours of the Eemian Sea and the sounds connecting it with the ocean. According to the first concept the Eemian Sea contours more or less coincided with those of the present Baltic Sea, but according to the more reliable concept they were much wider.

In Weichselian time, two independent glaciations or big stadials (Early and Late Weichselian) and numerous rapid ice margin's fluctuations occurred in the course of deglaciation. The Baltic Sea's Late Pleistocene and Early Holocene history was, in principle, the history of a big ice-dammed or ice-influenced lake with complicated water-level fluctuations which due to uneven tectonic movements and poor biostratigraphic material available, have not been reliably correlated all over the Baltic so far.

A short (100 - 150 years) connection with the ocean in the Preboreal at the Yoldia time did not change the salinity conditions in the fresh-water basin. Brackish-water conditions appeared only 8.000 years ago in the west and about 7.000 years ago in the east. All the Baltic Sea stages have never been properly defined as stratigraphical units and they have no stratotypes. Many topical problems of the Baltic Sea history have remained unsolved so far.

QUATERNARY DEPOSITS, DISTRIBUTION AND MAPPING OF THE BALTIC SEA BOTTOM: SCALE 1 : 500.000

Marijonas Repečka (Lithuanian Geological Institute, Vilnius, Lithuania)

The distribution, genesis and age of glacial deposits of the Middle and Upper Pleistocene and Holocene deposits are shown on the Quaternary Geological Map of the Baltic Sea bottom. Such structures as the sub-Quaternary surface and incised paleovalleys are discussed. Different levels of those paleoincisions apparently correspond to the erosional base of old reservoirs which are recognized at depths of 340-320, 280-260, 160-140 and 100-80 m below the present sea level. Regular changes in thickness of the Quaternary deposits have been established. The increase in thickness of the Quaternary deposits in depressions of the pre-Quaternary surface reaches 100 m and more while the thickness of the pre-Quaternary rocks decreases in those regions, where they are locally exposed on the present sea surface .

The Geological Map for the Quaternary of the Baltic Sea and the adjacent land areas is of special interest for the development of environmental control measures. The Baltic Sea is the terminal sink for sediment load coming from the surrounding pollutant bearing drainage systems. Therefore, the distribution pattern of bottom deposits is in close connection with the distribution of pollutants associated with different sized particles.

The geological maps of the Baltic Sea can be considered as a basis for comprehensive studies of environmental conditions and the establishment of an environmental control over the Baltic region. The authors are hopeful that the maps as products of multi-year studies can serve as a reference for advanced research work both in the Baltic offshore areas and on the adjacent land regions.

LATE QUATERNARY SEDIMENTOLOGY AND SEISMIC STRATIGRAPHY OF THE NORTHERN STORE BELT, DENMARK

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In the strait of Store Bælt shallow seismic records reveal a regional succession of Late Weichselian and Early Holocene sedimentary units located in the deep channel system. Interpretation of a number of seismic sections shows that the units have a well defined lateral extension and a characteristic seismic reflection configuration. These seismic stratigraphic units are correlated to a large number of sediment cores and the succession of depositional environments and macrofaunal ecology are described.

On top of the glacial deposits the following sedimentary facies are recognized in the main channel, all situated below 25 m below M.S.L: Lacustrine laminated silty sand with a sparse freshwater fauna and elements of an arctic vegetation, 9 m. Woody peat of *Pinus* (Y. Dryas/Preboreal). Fluvial or nearshore poorly sorted sand and gravel carrying scattered shells of an arctic-boreal fauna, 1 m. Lacustrine sandy and peaty gyttja containing a freshwater fauna dominated by the bivalve *Pisidium*, 5 m (Preboreal). Peat, diverse in species (Boreal). Rhythmic bedded and finely laminated sand and detritus gyttja with a sparse brackish tolerant fauna or barren (anoxic), 4 m (Boreal/Atlantic). Marine silty sand, bioturbated by a diverse fauna, 6 m (Atlantic-Subboreal).

The first transgressive phase is the late-glacial lake system, which probably has been connected to and functioned as an outlet for the Baltic Ice Lake. The Preboreal lowering of base level caused a major draining and growth of forrest in the deep valley down to -40 m below M.S.L. The following Preboreal transgression may be connected to the general Ancylus transgression. The marine fauna elements in the bottom deposits points to a marine influx in the initial phase. The second lowering of base level in Early Boreal caused once again a terrestric regime in the valley. Later, in Boreal time the Ancylus system again extended into the Store Bælt, and the continued transgression of the Early Atlanticum resulted in a brackish environment and at last in fully marine conditions.

PALAEOMAGNETISM OF QUATERNARY SEDIMENTS OF THE BALTIC SEA AND GEOLOGICAL IMPLICATIONS

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With the aim of establishing new time marks for the existing correlation scheme eight cores extracted by vibrocorers in the Mecklenburg Bay and in the Arkona Basin were investigated paleo- and petromagnetically. The determined inclination variation records can be correlated both with each other and with the reference curves from Great Britain and Sweden for the last 12.400 years. In order to verify the paleomagnetic data detailed mineralogical investigations were carried out. The main carrier of the NRM is titanomagnetite. The character of the stable part of the NRM corresponds to a depositional remanent magnetization (DRM). The interpretation of the susceptibility variation records show that $\varkappa$ is a very sensitive and effective parameter supporting the lithostratigraphical correlation. Measurements of the anisotropy of the susceptibility revealed an undisturbed fabric in the sediments.

MODERN SEDIMENTOGENESIS AND TECHNOGENIC ATTACK ON NATURAL SEDIMENTATION SETTINGS IN THE EASTERN PART OF THE GULF OF FINLAND

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The character of modern sedimentogenesis in the eastern part of the Gulf of Finland is controlled both by dynamic factors (sea-ways, currents, etc.) and variations of the sea-level through the Late Pleistocene/Holocene. The former is responsible for a facial zonation of sediments within areas of present sedimentation, the latter controls distribution of modern and relict deposits. The sea-floor relief and neotectonic processes significantly affect the distribution of sea-floor formations. This resulted in a complicated facial alternation of various sediment lithotypes and their stepwise distribution.

The technogenic attack on the modern sedimentogenesis results in:
- a disturbance of the natural facies zonation;
- a change of the sea-floor landscapes, primarily because of hydrotechnical and mining works;
- the emergence of accumulations of detrimental impurities (such as heavy metals, oil products, nitrates, pesticides, surfactants, radionucleids) in sea-floor sediments.

The agricultural complex, large urban agglomerations, hydrotechnical engineering, the mining industry and navigation are the main sources of technogenic pollution.

Theoretical und practical conclusions are the following:
- The local influence of pollution is aggravated by the character of present processes of sedimentation, promoting wider distribution of detrimental impurities and their displacement to depth;
- Alongside intensively polluted parts, which approach to zones of ecological calamity, changes in the environment of the most part of the Gulf of Finland are not irreversible;
- Zones of natural geochemical barriers (river-sea, halocline etc.), which are the natural absorbents of most of the polluting components, are most dangerous from an ecological point of view;
- Processes of coast destruction, accompanied by emergence of local zones of modern accumulation, recently began to predominate in the coastal zone of the eastern part of the Gulf.

CRUST-FREEZE SAMPLER CORES FROM TWO BALTIC STATIONS

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Crust-freezing is a technique for sampling undisturbed cores of unconsolidated sediments up to a length of about 150 cm. The method provides samples for detailed description of sedimentary structures, sub-sampling, varve-counting etc. We sampled surface sediments from two Baltic stations: the Gotland Deep (F-81) and the Sea of Bothnia (SR-5) by r/v "Aranda" and analysed the cores for Cladocerans, diatoms and geochemistry. The sampler was modified from that presented by RENBERG (1981).

The sediments were dated by ^{210}Pb- and ^{137}Cs-methods. The ^{210}Pb profile shows an exponential decrease in concentration with depth to a constant value at a depth of 18 cm. This indicates an annual sedimentation rate of about 1.3 mm. The 1963 fall-out peak can possibly be placed to a sediment depth of 4-6 cm. However, ^{137}Cs-activity is very low, and its constant activity indicates surficial mixing. Soot particle distribution (ROSE 1990) from the SR-5 station gives 2.6 mm for the average annual sedimentation rate. This is in agreement with the datings by NIEMISTÖ & VOIPIO (1981).

The F-81 core from the depth of 231 m demonstrates a major change in the chemical environment of the deep water/sediment interface. Laminated structures caused by the precipitation of $CaCO_3$ indicate that anoxic bottom conditions have prevailed during the last 600 years (Fig. 1). However, in the uppermost 40 - 50 cm of the surface sediment, decomposition of organic material led to the reduction of sulfate and further CO_2. Production of hydrogen sulfide and methanogenesis can be interpreted from the sedimentary structures and as a net loss of carbon and sulfur from the sediment. During this process the contents of Mn, Sr, Ni, Fe, V, Ba, Mo and Cu decrease because of remobilization. Zn and Pb remain in the interstitial water.

Analyses of microfossil taxa indicate a continuous trend of eutrophication, especially in the increased amounts of *Thalassiosira hyperborea* var. *pelagica* (NIEMI 1971) in sediments above a depth of 20 cm. However, interpretation of fossil assemblages is difficult because of heavy corrosion of frustules.

It can be further noted that ebullition of gases from sediment homogenises it almost in a manner similar to that of bioturbation. Since they are accompanied by lowered contents of many elements, the properties of surface sediments may easily be misinterpreted to indicate improved oxygen conditions. The

change in the Gotland Deep basin commenced in the 13th century and all properties of the sediment studied indicate a continuous trend of increased production.

The Bothnian core (SR-5) shows accumulation and enrichment of carbon, phosphorus, arsenic and lead starting from 1950's.

Sampling of gas-charged surface sediments from deep water is a problem (SÖDERBERG 1988). The crust-freeze method yields undisturbed samples where the escape of gases is not prevented, but the primary structures of the sediments are preserved for detailed description. What is perhaps more important, subsampling can be made with great accuracy.

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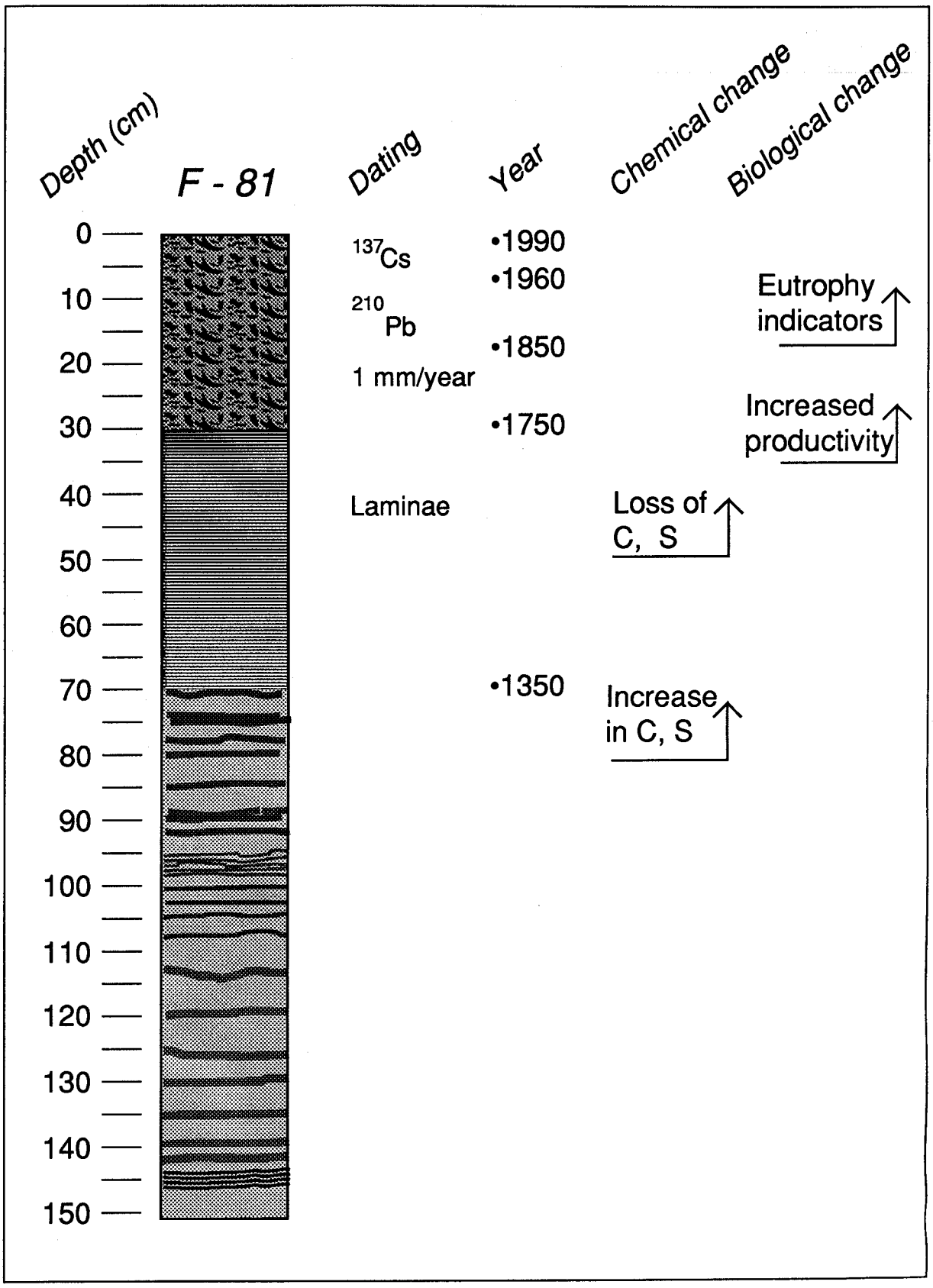

Fig. 1: Description of selected properties of the Gotland Deep (F-81) sediment profile

DISTRIBUTION OF POLLEN IN AIR, WATER AND SOIL SAMPLES OF THE BALTIC SEA

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During an expedition on the r/v "A. v. Humboldt" in the Baltic Sea a methodical work was carried out with the aim to find out patterns of the sporen-pollen grain input, its spatial differentiation and the burial of pollen in the marine sediments. It was shown that the total amount of pollen grains over the aquatory of the Baltic Sea depends on the strength and direction of wind. The species composition of pollen is a function of the floristic composition of the nearest beach, of the wind direction and of the blooming period. The pattern of the input spectrum changes with the sampling depth. The total amount of pollen grains in the superficial water layer is a bit larger than in deeper ones, whereas the composition of species is almost the same.

The distribution of species in the water depends, on the one hand, on the morphological peculiarities, the specific weight and the buoyence of pollen and on the hydrodynamics, on the other. Changes of water mass density act as a barrier on the way of fall-out of pollen grains creating one or two (depending on the water depth) peaks of their concentration. A comparison of pollen in air, water and soil samples has shown a direct ratio among them. The species composition of pollen and spores in the superficial water layer corresponds to that of the sediments. But the content of different pollen and spores suspended in the water is considerably higher. It is related to the depth of the basin, to the falling velocity of the grains and to the hydrodynamics.

NEW TOOLS IN MARINE MAPPING

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For some years we have worked with the development of resistivity, surveys and towed gamma sonde as a supplement to standard sea floor mapping methods.

Resistivity at sea

Resistivity measurements have for long been used onshore in solving hydrogeological and engineering problems, offshore resistivity measurements are in principle not different from onshore resistivity surveys.
However, there are a number of practical difficulties which necessitate to modify the method for offshore use. This difficulties have been studied in the last decade in France, and in Denmark at Århus University and at Roskilde University Center. The present examples refer mainly to the practical investigations at Roskilde.

The difficulties of offshore resistivity measurement, are mostly connected to suitable electrode configurations for salt water, electrode materials and, above all, a high signal to noise ratio. On the other hand the advantage of utilizing a moving vessel makes it possible to obtain continuous recordings, to build up an integrated multi-sensor system and to provide a continuous processing by a data-logger computer system.

Radiometric instrumentation

Water absorbs gamma rays. However, by the use of large scintillation crystals, originally developed for airborne exploration, placed near the sea-bottom, it is possible to map the natural radioactivity and hence the contents of uranium, thorium, potassium etc. in the sea-bottom sediment.

ORGANIC CARBON AND HEAVY METAL CONCENTRATIONS IN UPPER QUATERNARY BALTIC SEA SEDIMENTS

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Detailed sedimentological investigations have been performed on two cores from the Baltic Sea (Fig. 1; SCHUBERT 1991). Total organic carbon (TOC), carbonate, sulfur, and nitrogen contents as well as heavy metal concentrations have been determined to reconstruct the depositional history (Figs. 2-4).

Based on TOC and carbonate contents, Core 14971-1 (Arkona Basin) can be separated into three lithological units (Fig. 2). In the lower units (Boreal and older) TOC contents reach values of about 0.5 %, and carbonate contents vary between 10 and 20 %. High C/N ratios (Fig. 2) suggest increased amounts of terrigenous organic matter. The upper unit is composed of marine mud (Atlantikum) with TOC contents of about 3-4 % and carbonate contents of about 0 %. Low C/N ratios indicate the dominance of marine organic matter. Accumulation rates of organic carbon vary between 0.4 and 1.9 gC cm^{-2} ky^{-1}. The concentrations of Cu, Pb, Zn, and Cd reach values of 20 ppm, 10 ppm, 55 ppm, and 0.2 ppm, respectively, and show no long-term change (SCHUBERT 1991).

Sediments from Core 14969-1 (Eckernförde Bight) are only composed of marine mud; thus, they are probably not older than the Atlantikum. These sediments are characterized by high TOC values (about 4-7 %) and very low carbonate contents of about 2 % (Fig. 3) indicating the dominantly marine origin of the organic matter. Accumulation rates of (marine) organic carbon vary between 2.1 and 5.7 gC cm^{-2} ky^{-1} which implies - from comparison with recent surface-water productivity data -that about 15 % of the primary production is preserved in the sediments (for details and method see SCHUBERT 1991; STEIN 1991). The heavy metal concentrations increase in the upper 23 cm (Cu: 35 ppm, Pb: 55 ppm, Zn: 246 ppm, Cd: 1.6 ppm; Fig. 4) which may be interpreted as the beginning of industrialization about 150 years ago. Maximum heavy metal contents of this interval are higher in comparison to the natural background by a factor of 1.8 for Cu, 4.2 for Pb, 3.7 for Zn, and 4.0 for Cd.

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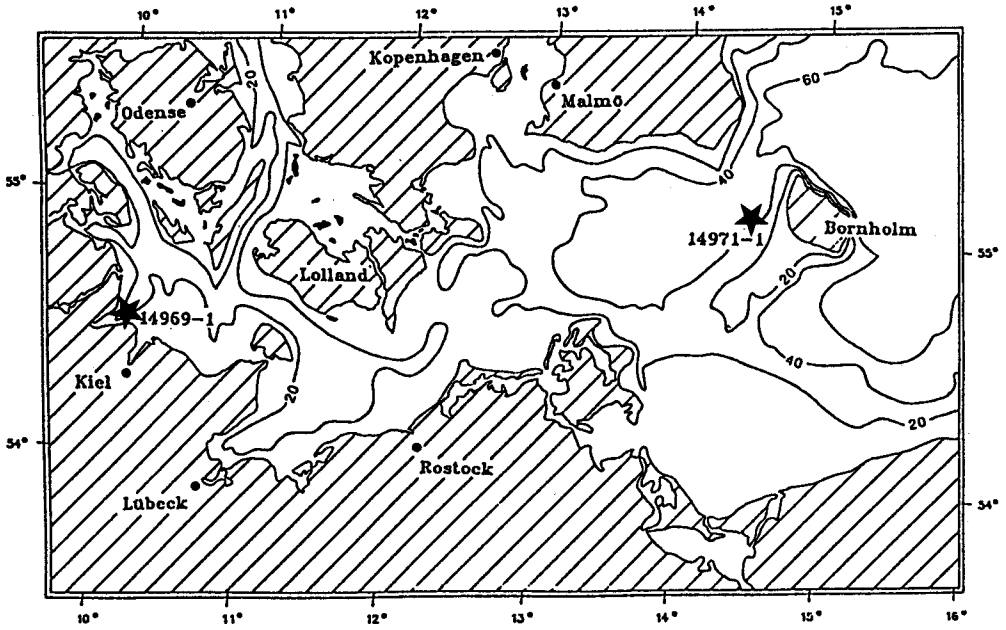

Fig. 1

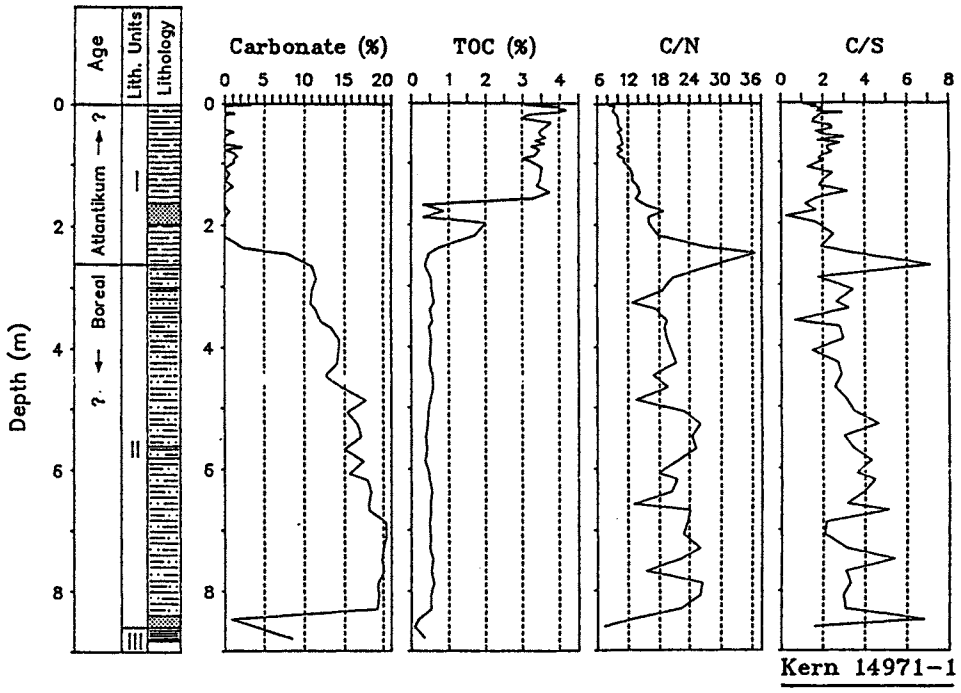

Fig. 2

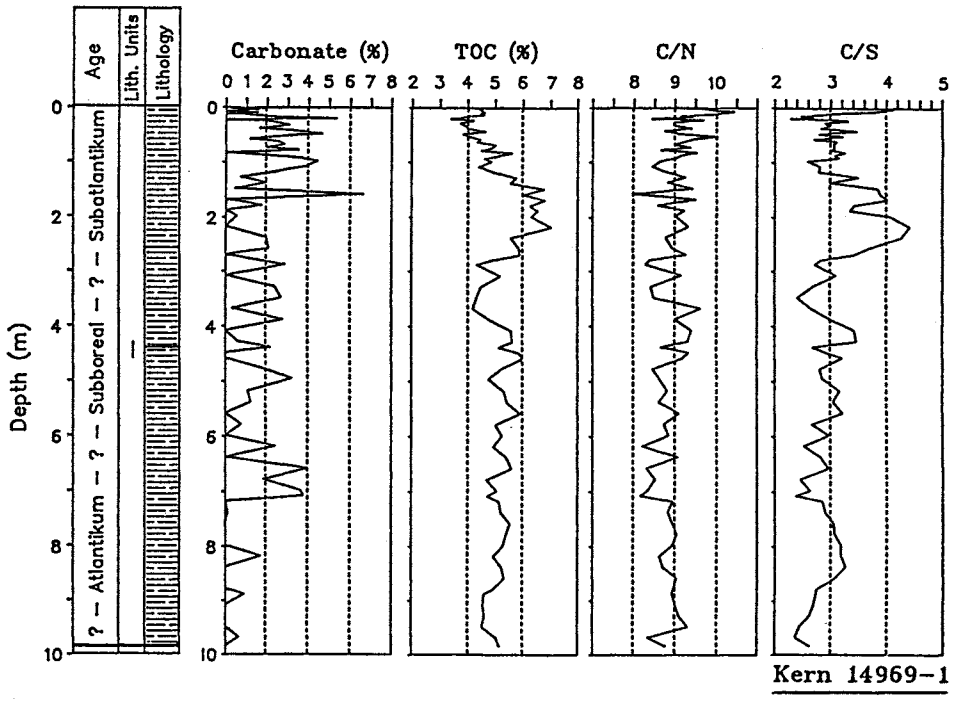

Fig. 3

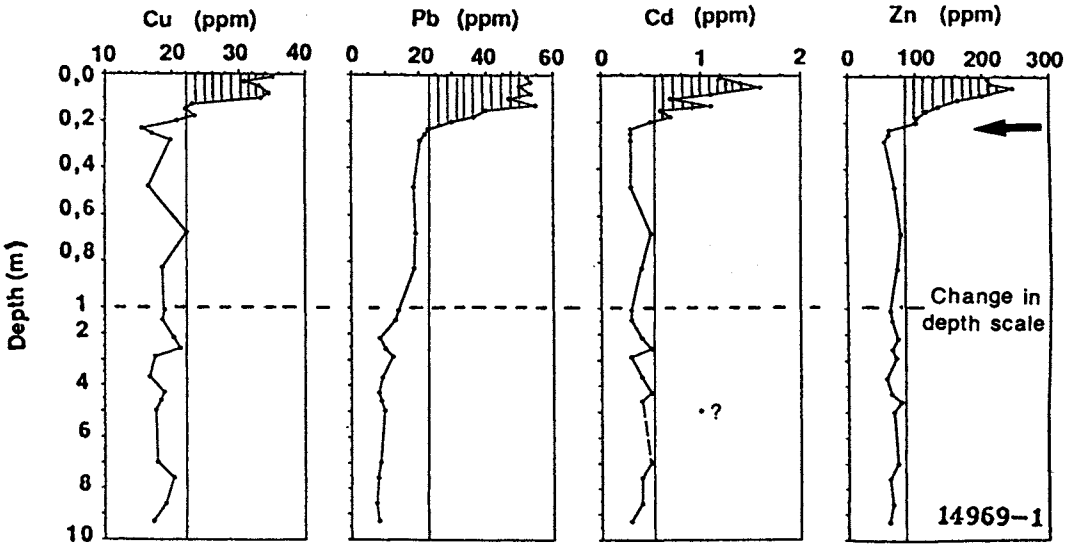

Fig. 4

DEVELOPMENT AND STRUCTURE OF SANDBAR SYSTEMS IN THE EASTERN PART OF KIEL-FJORD

Klaus Schwarzer (Geological-Paleontological Institute, University of Kiel, Germany)

Bar and trough systems along sandy coastlines represent an equilibrium between the energy input by wind, the resultant waves and currents and the qualitative and quantitative sediment supply. Changes of only one of these boundary conditions always lead to reactions of the other parameters.

Along the coastline of the eastern part of Kiel-Fjord a shore parallel sandbar system extends over a distance of about 8 km (*Kalifornien* to the harbour entrance *Marina Wendtorf*). It can be divided from east to west into an erosion area with only one sandbar, an area of passing sediment consisting of three sandbars and an accumulation area with up to ten sandbars. From east to west the extension of each of these sandbars increases. The shore normal extension of this whole sandbar system differs between approximately 100 m in the erosion area and approximately 700 m in the accumulation area (KÖSTER 1979).

This bar and trough system is both strongly affected by natural processes (geological set-up, seasonal variations (summer/winter) and anthropogenic influences. Along the coastline of the erosion and sediment passing areas a dyke together with a T-groyne system supported by beach nourishments was constructed between 1975 and 1990. The accumulation area is uneffected by anthropogenic influences.

In the eastern part the existing erosion front is progressing westward (KÖSTER 1979). Restitution from air photographs (SCHWARZER 1989) and geological mapping (DIETHELM & PITZKA 1987) showed that in the recent past the resultant sediment transport was from east to west. By grain size distributions and size parameters including the application of multivariate statistics KACHHOLZ (1984) concluded that for the modern sediments (the recent bars) it is not possible to clearly identify an east-west transport. As opposed to this he found that a shore normal differentiation only depending on the energy input by waves exists between the particular bars.

Nevertheless it was confirmed by observations and underwater mapping of scuba divers as well as by artificial tracer (luminophores) measurements that there still is a resultant sediment transport from the east to the west, which takes place mainly on the outer bars while the sand movement is vice versa on the inner bars. Shore normal sediment transport by rip currents plays an important role in these processes (SCHWARZER 1989).

Restitutions from air photographs and bathymetric surveying show

a regular distance of 1.4 km - 1.6 km between these rip currents. During storms from northeast this distance is reduced to the half (700 - 800 m). Apart from these "natural" rip currents we see another kind of rip currents induced by the T-groins.

Several measurements with tracers were carried out to determine the sediment exchange between the beach, the bar - trough system and the seabottom of the nearshore environment and the role of rip currents in these processes.

It could be shown that on the one hand "natural" rip currents are active nearly in all weather conditions whereas the rip currents effected by groins are only active during storm conditions. In all cases sediment is moving offshore from the beach and the sandbars to the luvside of the bars. Simultaneously a sediment transport into the bar system from the seaward direction is possible; a moving of tracers across the bars and further on in direction to the beach has never been recognized during the experiments. During this sand transport grain size dependent sediment-differentiation-processes partly occur (SCHWARZER 1989).

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NEPHELOID LAYERS IN THE BALTIC SEA DEEPS

V.V. Sivkov, V.L. Stryuk (Institute of Oceanology, Kaliningrad, Russia)

Nepheloid layers (NL) were studied in the Bornholm, Gdańsk, Gotland and Landsort Deeps using sinking-probe nephelometers (the light dispersion has been registered at angles of 90° and 120° within a spectrum range of 400-500 nm and 580-700 nm), Coulter Counter (size range of studied suspended particles 2-16 μm), water filtration and sediment traps. In samples of suspended matter the chemical composition was determined. The sedimentary environment was characterized by considering water temperature and salinity, dissolved oxygen, hydrogen sulphide and biogenic elements, current velocities, bottom relief and mechanical properties of subjacent sediments. The great variability and complexity of suspension formation processes and the changeability of the suspension field in the Baltic require investigations on the NL origin in each particular case.

Nepheloid layers can be subdivided into three types according to their origin. The near-bottom NL appears to be a result of the sedimentary and diffusive balance in the dispersion system of the sea. It acquires distinct features by an intensification of near-bottom currents, which produces increased turbulence of the near-bottom layer. In these cases the concentration of suspended matter may be two orders of magnitude higher than the background values.

The deep-sea NL (above the bottom, but not touching it) is formed firstly as a result of complex interaction between near-bottom currents, relief, sediments and water density stratification and then, secondly, in the course of a transition of dissolved Fe, Mn and other microelements into their suspended forms at the geochemical barrier between oxygen and hydrogen sulphide. The halocline plays a decisive role in the first process and, besides, it acts as a kind of horizontal "suspension supplier", by which sedimentary matter is delivered from the slopes into the deeps. During the processes of the second type geochemical reactions lead to an accumulation of fine suspension looking like milky "clouds" with sharp horizontal boundaries and a laminated structure, as has been observed from "Mir" submersibles (V.T. Paka).

PHYSICAL CHARACTERISTICS OF DIFFERENT LITHOTYPES OF BALTIC SEA SEDIMENTS

V.M. Slobodyanik, E.S. Trimonis, E.F. Kondratyev (Institute of Oceanology, Kaliningrad, Russia)

One of the important features of marine bottom sediments are their physical properties formed under the influence of electromagnetic, gravitational, hydrodynamic and other fields.

According to density the following layers could be distinguished within the vertical profile of Late Quaternary sediments of the Baltic Sea: 1) Holocene muds, enriched in organic matter, density from 1.40 up to 1.50 g/cm^3; 2) clays, density from 1.40 up to 1.90 g/cm^3; 3) varved clays, density between 1.50 and 2.00 g/cm^3; 4) morainic deposits, density from 1.80 up to 2.20 g/cm^3. The density of deposits increases with depth of burial, naturally.

The moisture of sediments is usually inversely proportional to their density. The maximum water content in Holocene muds is 40-80 % and more, while the Late Quaternary clays (microvarved ones as well) are characterized by 35-60 % and morainic deposits by 10-20 % moisture.

During recent expeditions moisture measurements were performed with a new superhigh frequency moisturemeter designed at the Department of Radiophysics (Kaliningrad University) in co-operation with the Atlantic Department of the Institute of Oceanology, USSR Academy of Sciences (Kaliningrad). The great measurement precision during the primary core description on board, obtained by the superhigh frequency moisturemeter, allows to trace latent structural variations in the lithologial compositions of the cores investigated.

According to sound velocity the Baltic bottom sediments can be subdivided as follows: Holocene muds and clays - 1.35-1.50 km/s; morainic loams - 1.50-1.80 km/s. In the Late Quaternary sediments the sound velocity varies vertically. These variations can be both smooth and sharp.

The magnetic susceptibility, which depends on the concentration of ferro- and paramagnetic minerals in the sediment, varies between 2 and 4 x 10^{-6} CGS and more. These changes correlate with the lithological type of the sediments: the magnetic susceptibility of muds saturated with hydrogen sulphide is the minimum one - (2-4) x 10^{-6} CGS; in clays it is (20-30) x 10^{-6} CGS and in morainic deposits (20-40) x 10^{-6} CGS and more. Increased values of magnetic susceptibility (up to 200 x 10^{-6} CGS, (70-80) x 10^{-6} CGS at average) are characteristic for hydrotroilite-enriched clays.

QUATERNARY GEOLOGY OF THE NORTH BALTIC IS A KEY TO THE UNDERSTANDING OF LATE POST-GLACIAL HISTORY OF THE REGION

M.A. Spiridonov, A.E. Rybalko, G.M. Romm (All-Union Geological Institute, St. Petersburg, Russia)

In the Late Quaternary, the present floor of the northern part of the Baltic Sea was an arena of alternating or composite interacting glacial, water-glacial, lacustrine and morainic processes. A picture especially characteristical for the young paleogeography is that of the Gulf of Finland. Available well records evidence the complex structure of the Late Pleistocene section of the Gulf's floor. For example, strata of argillaceous deposits of marine genesis are stripped in lower parts of the section at levels about -30 m. According to preliminary data, these sediments can be regarded as formed by the Mga (Eemian) transgression.

In most cases, the basement of the Quaternary strata consists of the late Valdai (Würm) moraine. Distinct marginal complexes associated with stages of Neva (Pandivere), Palivere and other younger stages are isolated in the Gulf.

The contact between the moraine and underlying Vendian formations is exposed by a quarry near the island Kotlin. This contact zone is saturated by glacigenous dislocations.

Glacial-lacustrine deposits, overlying the moraine are the thickest horizon in the Upper Pleistocene - Holocene section. There are distal and proximal facies in their composition. The formation of glacial-lacustrine deposits in the eastern part of the Gulf began approximately 14.000 b.p.

Complex geomorphological and lithological analyses permitted to interprete the genesis of the classical "varved clays" in a somewhat different way.

The analysis of the lithostratigraphical material showed the complicated character of the change from the glacial-lacustrine regime to the marine one. The presence of a single lacustrine phase of the basin development in the Preboreal/Boreal indicates a shifting of the coastal line at the Boreal/Atlantic boundary towards lower than modern zero.

SEDIMENTARY MATTER SUPPLY AND TRANSFORMATION IN GEOCHEMICAL BARRIER ZONES OF THE BALTIC SEA

V.L. Stryuk (Institute of Oceanology, Kaliningrad, Russia)

While studying sedimentogenesis it is valuable to include the concept of geochemical barrier zones. It has been shown that the most essential transformations of sedimentary matter take place within these zones (EMELYANOV 1982).

A complex approach in sedimentary matter sampling was applied including direct measurements of sedimentary flux by means of sediment traps. Investigations were made in polygon areas and along standard profiles and stations.

Updated values on sedimentary flux into the Baltic per year (the total value of 140.8 x 10^6 t was given) are: river run off - 5.4 x 10^6 t; North Sea supply - 0.7 x 10^6 t; shore and bottom abrasion - 17 x 10^6 t; atmospheric fall out - 2.7 x 10^6 t; organogenic matter - 115 x 10^6 t. The amount of chemical elements supplied into the Baltic was also estimated and compared with literature data (BRÜGMANN 1988).

The following barrier zones were distinguished and studied in the Baltic: river-sea; shore-sea; air-sea (including surface microlayer); water-bottom; photosynthesis layer; pycnocline layer; oxic-anoxic waters; the boundary between psammitic and clayey sediments and submarine seeps of ground water.

MARINE SEISMIC INVESTIGATIONS OF THE TORNQUIST ZONE AT BORNHOLM GAT

Stefan A. Thomas (Institute of Geophysics, University of Kiel, Germany), Richard Scott-Robinson (Dept. of Geol. Sci., University of Durham, Great Britain)

In 1989 the BABEL marine deep seismic survey investigated among others the structure of the crust and upper mantle of the NW Tornquist Zone for the first time by means of deep reaching reflection seismics. The normal incidence data were recorded between Scania and Bornholm on a NE-SW running line using a tuned airgun array (120.0 l) and a 3.000 m, 60-channel streamer. The record length was 18 s TWT allowing a 30-fold stack per 25 m CMP trace.

The survey shows the Tornquist Zone to be a complex inversion structure with tilted and uplifted blocks manifesting typical characteristics of tectonic evolution such as transtensional and/or transpressional stress fields. A band of subhorizontal reflections marks the top of the lower crust at 9 s TWT. The reflections peter out at about 11 s TWT and indicate a 'reflection' Moho-depth of 32-35 km.

Additional data from a commercial seismic network, recorded down to 5 s TWT by JEBCO Seismic Ltd. around Bornholm in 1988, were integrated into our studies and allow a 3D control of tectonic features encountered in and around the Tornquist Zone.

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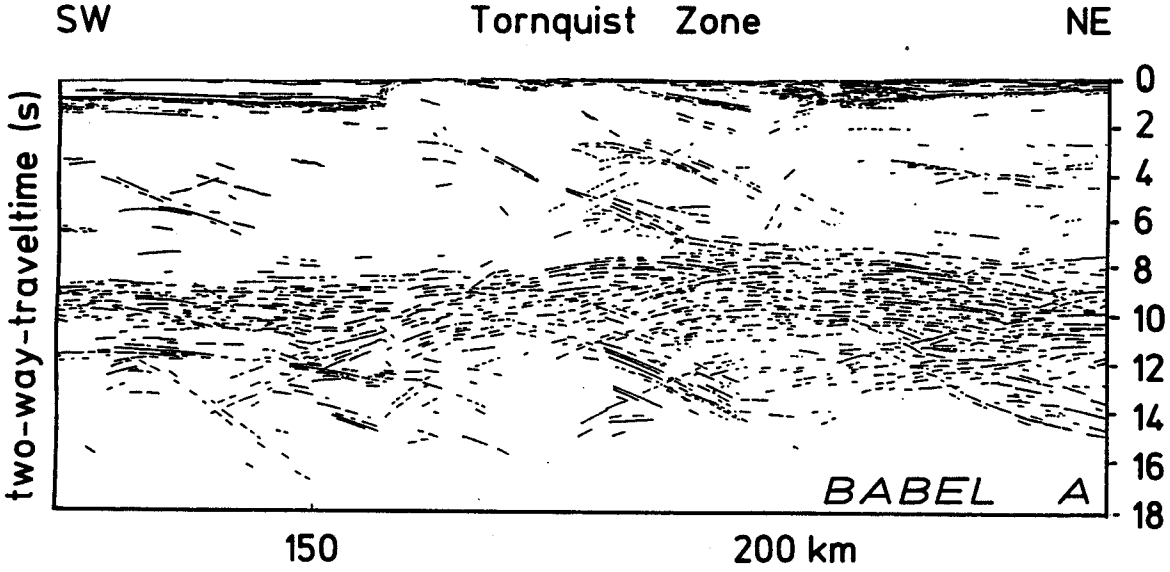

SW
Tornquist Zone
NE
two-way-traveltime (s)
0
2
4
6
8
10
12
14
16
18
BABEL A
150
200 km

DIFFERENCES OF SEDIMENTARY CHARACTERISTICS ALONG BABEL LINE A

Stefan A. Thomas, Rolf Meissner and Thomas Wever* (Institute of Geophysics, University of Kiel, Germany)

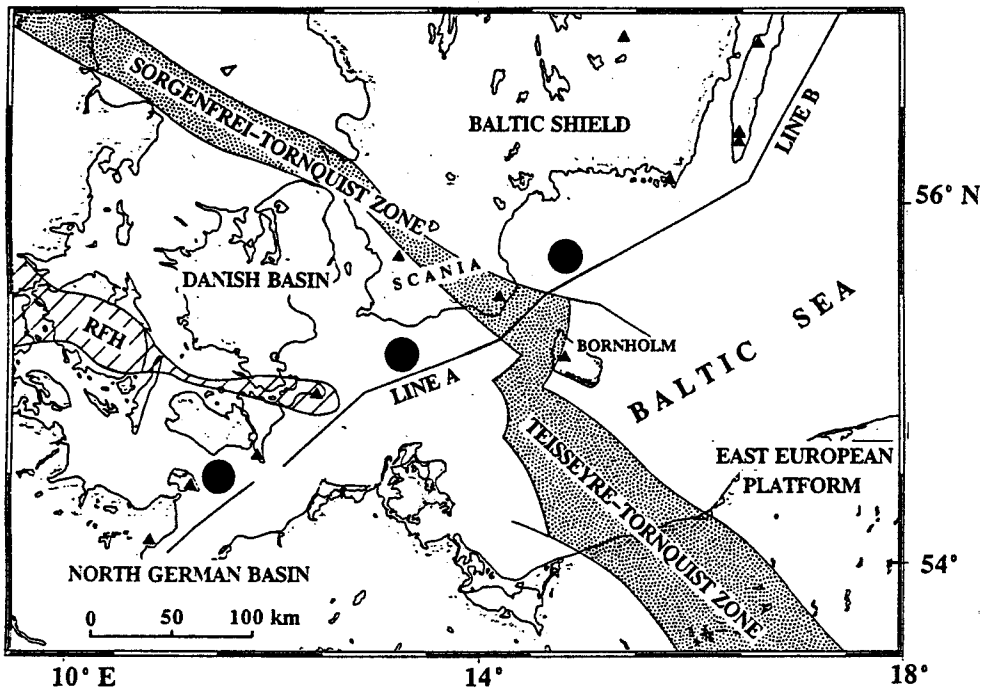
During the BABEL survey (Baltic & Bothnian Echoes from the Lithosphere) of 1989, vertical deep seismic data were recorded as a long quasi-continuous profile in the Gulf of Bothnia and Baltic Sea. The course of line A is shown in Fig. 1, the dots indicate the position of the seismic sections (Fig. 2-4). Although the main objectives of the BABEL survey were intra- and deep crustal structures we will focus on the variable sedimentary characteristics along line A.

Fig. 2 displays a part of the N-German Basin with the Zechstein marker horizon at 2.8 s TWT in the SE rising to the NE towards the Ringkøbing-Fyn High (RFH). Imaging of underlying sediments is poor - in agreement with other data from this basin. The variety of stratigraphic styles encountered along this SW part of profile A will allow a detailed interpretation in the future.

The Danish Basin is characterized by a strong reflection marking probably the base of Mesozoic sediments and its multiple deepening towards the Tornquist Zone (Fig. 4). The strata above reveals not many internal structures, indicating calm conditions during deposition. An abrupt termination of sedimentary layers at an uplifted block (shot point 6.700) by the youngest strata corresponds to the SW shoulder of the Tornquist Zone.

On the Fennoscandian Platform a relatively thin and smooth sedimentation is observed in the Hanö Bay overlying the clearly identfyable rough sediment/basement contact (Fig. 4). This is in contradiction to the previous discussed section. It is known from earlier work, that Cambrian sandstones, deposited on the basement result in a smoothing of wheathered crystalline topography. Frequently, the sediment/basement contact is also marked by diffractions.

*now at FWG, Kiel, Germany


SORGENFREI-TORNQUIST ZONE
BALTIC SHIELD
LINE B
56° N
DANISH BASIN
SCANIA
RFH
BORNHOLM
LINE A
BALTIC SEA
TEISSEYRE-TORNQUIST ZONE
EAST EUROPEAN PLATFORM
NORTH GERMAN BASIN
54°
0 50 100 km
10° E
14°
18°

SW

BABEL Line A1/I

NE

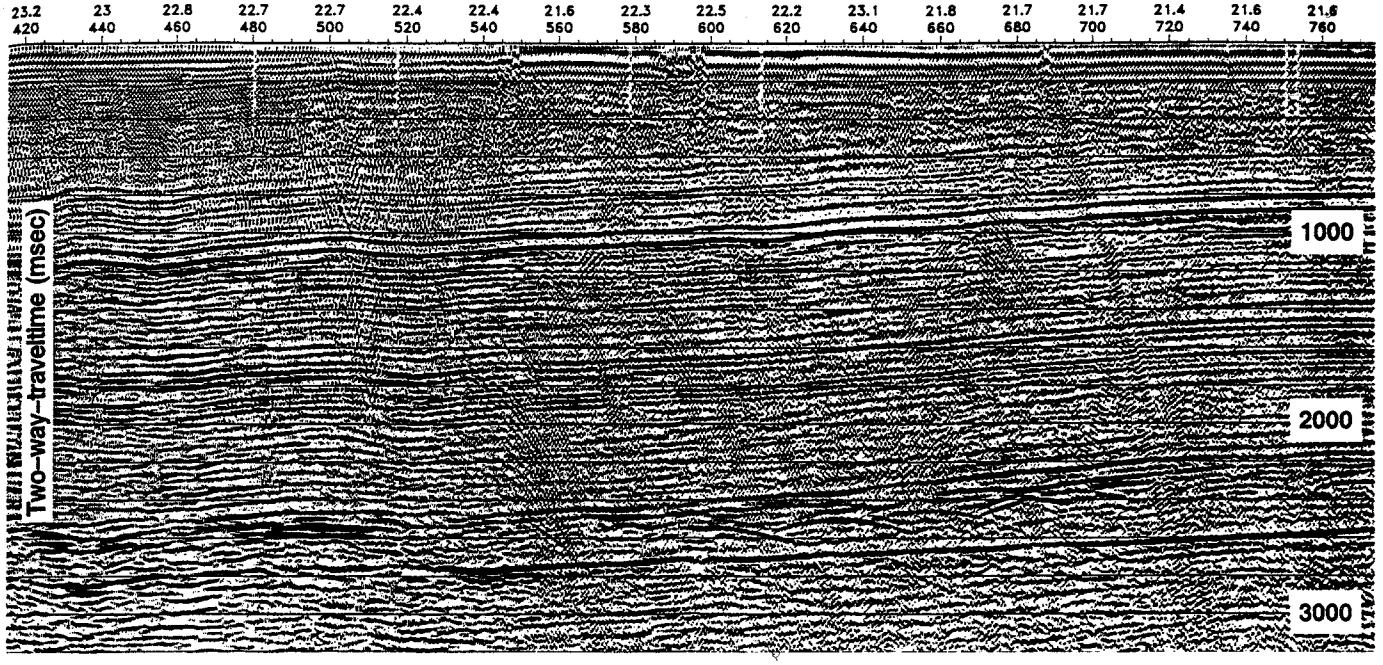


Fig. 2

SW

BABEL Line AC/I

NE

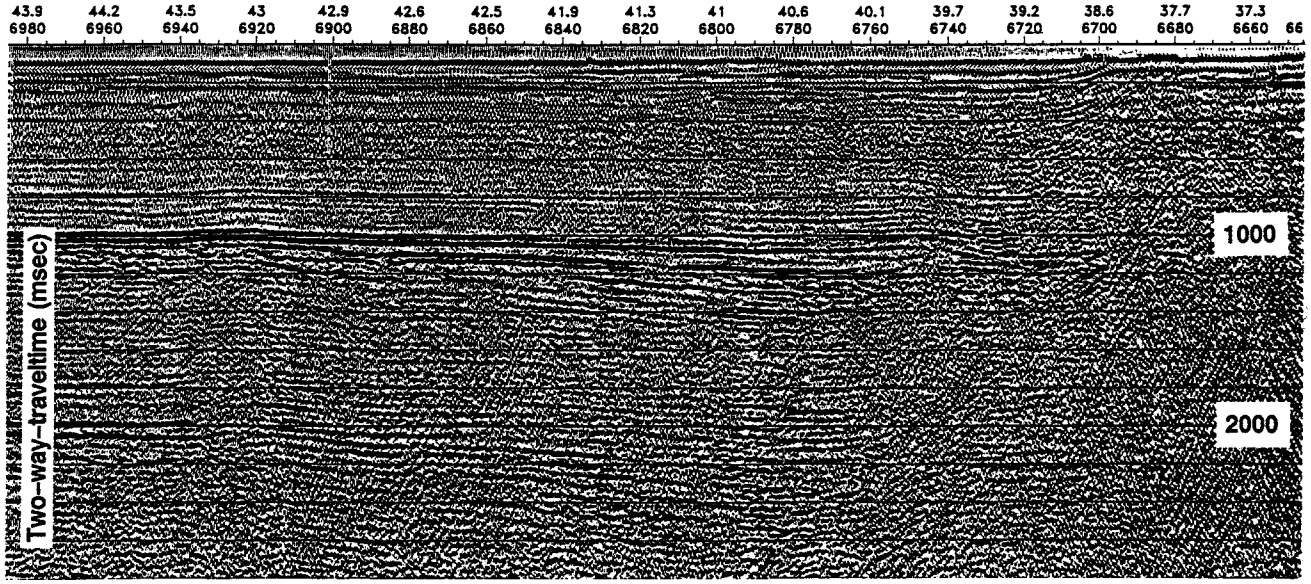


Fig. 3

WSW

BABEL Line AB/I

ENE

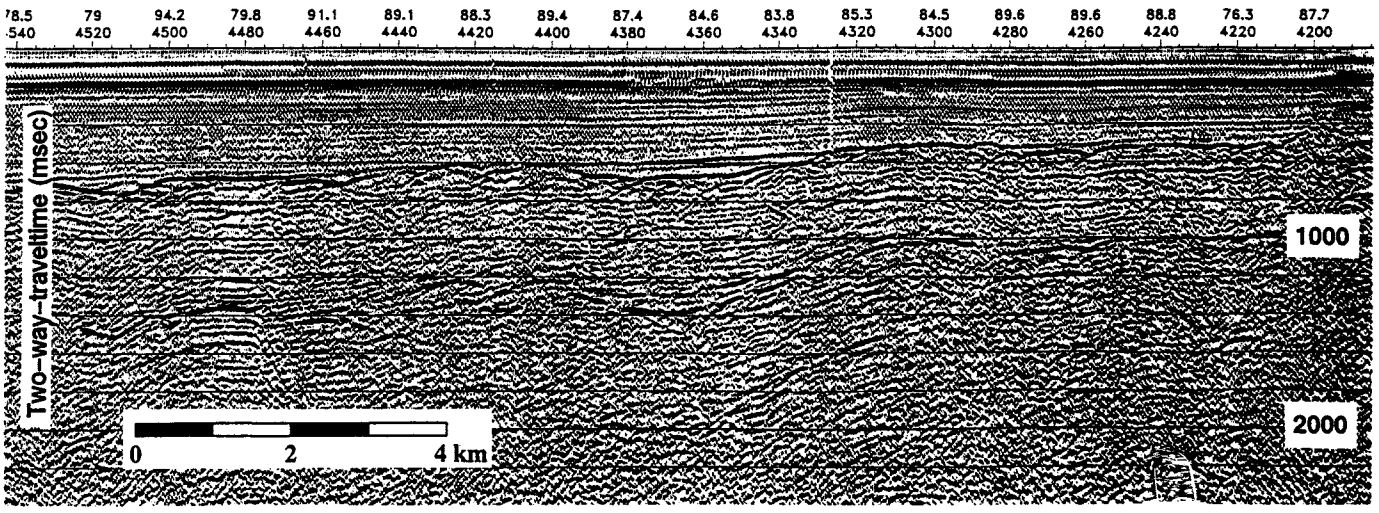


Fig. 4

HOLOCENE EVOLUTION OF THE POLISH COASTAL ZONE

Anna Tomczak (State Geological Institute, Sopot, Poland)

Field research along the whole Polish coastline and laboratory investigations, including more than 100 ^{14}C datings, and also the analysis of literature and older data indicate:

1. High interdependence between the configuration and shape of the Quaternary substratum and the thickness and lithofacial development of Quaternary deposits. In the geological structure of the Cenozoic a large role is played by the Teisseyre - Tornquist tectonic zone.

2. The coastal zone became stabilized in nearly present form about 5.5 ka B.P. From that time it is modelled by the same set of morphodynamical processes as today.

3. The Holocene evolution of the coastal zone should be divided into four periods: pre-transgressive, transgressive, post- transgressive and contemporary. In the pre-transgressive period (10.2 - 8.0 ka B.P.), down to the present depth of about 30 m, the Southern Baltic area was firm land with some lakes. In the transgressive period (8.0 - 6.3 ka B.P.), the coastline moved 5 to 60 km southwards in the result of a sea level rise by about 30 m. However, at maximum transgression the sea level at no location did exceed today's state. In the coastal zone three regions with wider than today extension of the sea came into being, i.e. in the Vistula delta, on the Gardno - Leba Lowland and at the Odra outlet. Maximum transgression occured between 6.3 and 5.5 ka B.P. (data from Vistula Bar and Hel Peninsula). Later, today's coastal zone started forming. Dunes, and in depressions between them, peat and soil were formed. In the post-transgressive period, at a relatively stable sea level, twice occured more intense inflow of sea water into lakes (beginning of Subboreal and beginning of the 10th century). The younger process was caused by an increase of the sea level by about 1.5 m (archeological data and fossil soils). The contemporary period encompasses the last thousand years. During that time the sea level was relatively stable. Recently processes leading to a degradation of the coast have gained marked significance. These processes result from anthropogenic and most probably climatic influences.

QUATERNARY SEDIMENTS IN THE NORTHERN BALTIC

E.S. Trimonis, N.I. Sviridov (Institute of Oceanology, Kaliningrad, Russia)

The distribution, composition and structure of Quaternary sediments in the Northern Baltic are reviewed considering recently obtained data by seismoprofiling (CSP), echo-sounding and sampling by corers and grabs (expeditions of r/v "Shelf", 1988 and r/v "Akademik Mstislav Keldysh", 1991).

Quaternary sediments are spread practically all over the investigated region (from 58°40' to 59°45' N and from 20°05' to 23°10' E) with the exception of steep slopes and separate elevations. Superposing the sharply rugged surface of crystalline bedrock and filling in the depressions they smooth the bottom relief. Over the major part of the area the Quaternary sediments have a thickness of 0-20 m (usually 5-10 m) increasing to 30-90 m in the depressions.

Lithologically, the Quaternary sediments are represented by morainic deposits, (partly varved) clays, and terrigenous muds (hydrotroilitic, sapropelitic) corresponding to the main stages of the Baltic history. The different sediment types are separated from each other by strong reflectors or unconformity surfaces in the seismo-acoustic profiles. Morainic deposits (sandy loams and loams with a considerable admixture of coarse-clastic material) are found in the form of lenses (20-40 m thick) at the foot of scarps and at the slopes of deep valleys (fiords). The major part of Quaternary strata comprises Late Pleistocene clays, which cover the rough surface beneath. Their thickness is relatively stable (2-6 m), but increases to 40-60 m in the depressions and in downcutting valleys. Terrigenous muds are represented by bluish-grey and dark-grey (hydrotroilitic) layers underlying greenish-grey and grey muds. Usually they are 3-4 m thick. Sometimes muds and silts form gentle bar-like elevations. They strike parallel to glints and can be related to near bottom contour currents in the Northern Baltic.

ENVIRONMENTAL ASPECTS OF MINING CLASTIC MATERIAL FROM THE SEA BOTTOM

Szymon Uścinowicz (State Geological Institute, Sopot, Poland)

Investigations carried out during the years 1988, 1989 on the Słupsk Bank gave first data on the scale of marine environment changes caused by gravel mining. Within a 1 x 1 km test field, detailed observations and oceanographical, sedimentological and biological measurements were made.

Sedimentological investigations included:

- determination of the content and variability of suspension in water
- determination of concentration and grain size of mineral suspensions in water flowing from the dredger and falling onto the sea bottom
- repeated observations of sedimentary structures around datum point markers installed in the sea bottom
- repeated measurements of bottom elevation changes at the datum points
- repeated observations and measurements of troughs left by the mining operations.

Measurements of suspension concentrations in sea water, made during mining and 1 hour after stopping operations, showed that the material falls very quickly to sea bottom and does not propagate further than 50 m to both sides of the dredger's course (sea state 1, surface current 17 cm/s, 130 deg., bottom current 6 cm/s, 310 deg.).

The thickness of the layer of sand settling on the bottom of the mined troughs was 0.5 to 1.0 cm (ca. 7500 to 15000 g/m^2). In traps placed at a distance of 50 m from the dredger's course, settlement of 1.29 to 1221.52 g/m^2 was recorded. At distances exceeding 50 m the amount of suspended material falling to the bottom decreased very quickly.
The initial depth of troughs left after the mining was 0.2 to 0.7 m. After 2.5 months the depth of partly filled up troughs was 0.1 to 0.15 m. Traces of the troughs were visible also after 9 months and their depth was 0.04 to 0.12 m.
Observations of bench marks driven into the troughs and analyses of grain size distribution of sediments indicate that the troughs have been filled up partly by material sliding down from trough edges and partly by fine sand migrating along the bottom surface.

LITHOFACIES OF THE RECENT SEDIMENTS OF THE SOUTHERN BORNHOLM BASIN

Szymon Uścinowicz (State Geological Institute, Sopot, Poland)

The paper presents the lithofacial analysis of recent sediments (i.e. from sedimentation in the Litorina and post-Litorina sea during the last ca. 7.500 years) present in the southern part of Bornholm Basin and on adjacent coastal shallow areas.
Using cluster analysis (by Q and R method), the following lithofacies have been defined:
A (gravel, sandy gravel, gravelly sand, coarse and medium sand),
B (fine sand),
C (muddy sand),
D (sandy mud, mud, clayey mud, muddy clay).

Surface trend analysis showed that lithofacies A dominates in the depth zone between 8 - 10 m and 26 - 28 m, dividing sediments of lithofacies B present in zones between 0 and 8 - 10 m, and 26 - 28 m and 44 - 46 m depths. Sediments of lithofacies C prevail in water depths between 44 - 46 m and 58 - 60 m, passing with increasing water depth into lithofacies D.
Vertical sequences of the lithofacies were investigated using the Markov chain method. In the northern part of the investigated area, Litorina and post-Litorina Sea sediments, lying on sediments of earlier evolution phases of the Baltic, do not show a vertical lithofacial differentiation. Directly on the substratum sediments of only a single lithofacies occur. In the southern part, where in the substratum Pleistocene glacial and fluvioglacial sediments are present, a vertical lithofacial sequence A → B occurs.
Regularities of horizontal and vertical lithofacial sequences are conditioned by hydrodynamic factors.
Departures from the model lithofacies sequence in horizontal and vertical result both from the paleogeography of the area in which sea transgression occured, and from regional and local or momentary differences in intensity of lithodynamic processes.

THE TECTONIC UNITS IN THE SOUTHERN BALTIC SEA OUTLINED IN THE MARINE GEOID

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The area studied, is in a broad sense a part of the major tectonic zone in the Baltic Sea, the Tornquist-Teisseyre (T-T) Zone, which has been active since Precambrian and reactivated during several tectonic phases. The margin of the Baltic Shield corresponds to a complex block-faulted zone with a Precambrian basement and Early Paleozoic, Mesozoic and Paleogene sediments. Tectonic activity has occurred recurrently from Paleozoic into Early Tertiary, although different segments have moved independently. The tectonic framework are derived from seismic data, carried out by University of Stockholm, Swedish Oljeprospektering AB (OPAB) and by the Danish Underground Consortium (DUC). Satellite radar altimetry data, from the three satellites GEOSAT, SEASAT, GEOS-3 have been integrated, to compute maps of the marine geoid. The main topics in this study are the tectonic framework and to examine the use of the satellite altimetry for interpretations of structural elements in the southern Baltic Sea. A very strong gradient in the marine geoid is observed across the T-T Zone, with a positive anomaly over the Baltic Shield in the northeast, dipping towards a gravity low over the Danish-Polish Through. Within the T-T Zone several short wavelength anomalies can be seen in the detailed maps of the marine geoid. These correlate well with those tectonic units established from seismic data, where sedimentary basins produce negative anomalies, as well as structural highs correspond to positive anomalies. Possible extensions of known tectonic features, detected in the marine geoid will also be discussed.

IDENTIFICATION OF SEISMIC REFLECTORS IN THE ARKONA BASIN, BY MEANS OF BIOSTRATIGRAPHICAL METHODS AND ANALYSIS OF PHYSICAL PROPERTIES

Per Westman (Department of Quaternary Geology, Stockholm University, Sweden)

Seismic and acoustic investigations have been carried out in the Arkona Basin since 1985. The seismic stratigraphy encompasses more than 10 Quaternary reflectors including at least one interglacial land surface. The aim of the present work is to identify the Quaternary seismic reflectors by means of biostratigraphical methods (diatom and pollen analyses) and to analyse the physical properties of the sediment from cores.

The project will focus on two sub-moraine seismic reflectors (E and F in the seismic stratigraphy) which are provisionally interpreted as possible pre-Weichselian land surfaces. These reflectors are especially distinct above scour structures, which trend NE-SW across the central parts of the basin. The scours are interpreted as glacial drainage channels or tunnel grabens of Saalean, or pre-Saalean age.

DIATOM ANALYSIS OF CORE AB 1151/91. A first 6 m long core AB 1151/91 was taken at 54°55.24'N, 13°09.93'E from the German r/v "A.v. Humboldt". Quantitative diatom analysis has been carried out between 380 cm and 30 cm sediment depth (Fig. 1), representing the time from late (?) Ancylus Lake stage to subrecent. Except for 290-190 cm the concentrations of diatoms were sufficient for quantitative analysis (200 valves counted/level). In the lowermost part of the core (600-382 cm) the concentration of diatoms was too low for counting, except for a few levels (520, 490, 480, 470 cm) which will be counted in connection with pollen analysis of the core. The sedimentological description of the core, made by W. LEMKE (Warnemünde), shows a distinct transition from Ancylus clay to Littorina clay-gyttja, separated by a 4 cm thick silt layer, at 355-351 cm. The contact between the Ancylus clay and the silt layer is very sharp, indicating an erosional episode predating deposition of the silt layer. From 380 to 340 cm the flora is dominated by benthic freshwater species, such as *Epithemia adnata, E. turgida, Amphora ovalis* + *var.* and small *Navicula* and *Fragilaria* species, with a peak at 352 cm (91,1 %). In contrast to AB 3 (LANGE & WULFF 1980) the planktonic flora in AB 1151/91 is almost absent in the Ancylus clay in spite of the greater water depth at AB 1151/91 (44.7 m) as compared to AB 3 (43 m). The transition from freshwater to marine-brackish flora begins in the lowermost part of the Littorina sediment. The freshwater flora represents 85 % of the total assemblage at 349 cm and 62.7 % at 340 cm. Although the percentages of freshwater diatoms continues to decrease upwards they constitute more than 10 % of the total assemblage except at 150 cm (8.2 %) and 70 cm (4.9 %). The high percentages are probably due to the limited

size of the basin and hence influence of the surrounding land areas. The Littorina flora is dominated by the planktonic species *Paralia sulcata* with a frequency peak at 70 cm (59.2 %). Together with 5 other species (*Dimerogramma minor, Grammatophora oceanica, G. marina, Rhizosolenia calcar-avis* and *Rhabdonema arcuatum*), it constitutes between 20.3 % (315 cm) and 78.1 % (70 cm). The Littorina assemblage resembles that of AB 3 with the exception of absence of *Rhizosolenia calcar-avis* in AB 3.

Reference

LANGE, D., WULFF, B. (1980): Diatomeen-Untersuchungen am Stechrohrkern AB 3 vom Westrand des Arkonabeckens.- Beiträge zur Meereskunde, 44,45, 75-88.

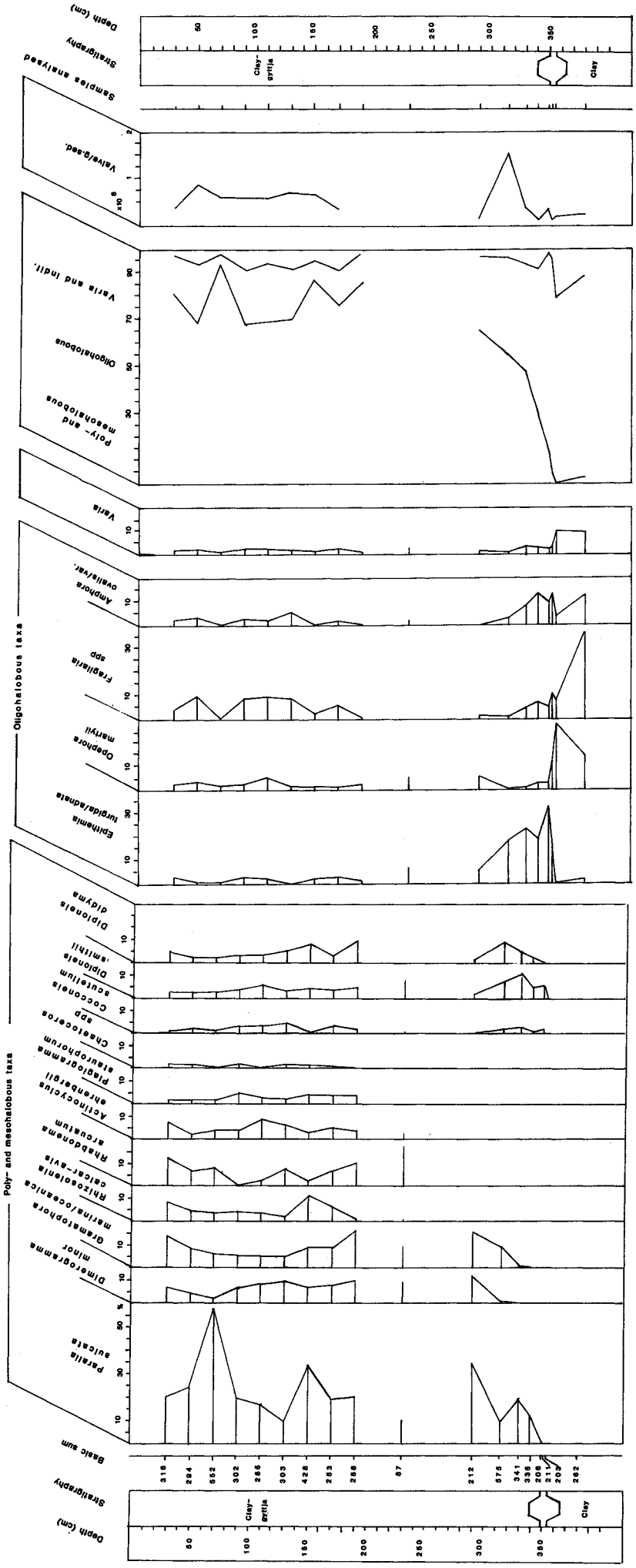

Fig. 1: Diagram showing seleted diatom taxa from AB1151/91.

AUTHIGENIC VIVIANITE IN LOWER ANCYLUS SEDIMENTS IN THE WESTERN GULF OF FINLAND

Boris Winterhalter (Geological Survey of Finland, Espoo, Finland)

Vivianite ($Fe_3(PO_4)^2*8H_2O$) occurs in lacustrine and brackish marine clayey sediments (e.g. NRIAGU & DELL 1974, ROSENQVIST 1970) normally as micro- or cryptocrystalline nodular aggregates. Core 11/89 (59°32'49.24"N, 23°07'38.84"E), taken with a large diameter piston-corer in 78 m of water in the western part of the Gulf of Finland, contained large lamellar crystals of vivianite, forming spheroidal bundles 2-3 mm in diameter. The spheroids have coalesced to form a single to double layer with an even upper surface and an irregular underside, obviously representing the main direction of crystal growth. The vivianite layer occurs on top of a black ferrous monosulphide band 350 cm b.s.f. in clay strata identified as upper Yoldia or lower Ancylus. The size of the crystals and their coalescense to form a single thin layer suggests that rather special conditions prevailed during their formation.

Spheroidal crystal aggregates of vivianite are readily formed in a gel or gel-like medium typical of anoxic sapropels (ZELIBOR et al. 1988). The crystallization process can be fast enough to account for the occurence of aggregates just below the water-sediment interface. Furthermore the pH and Eh in the sediment might be conducive to the stability of vivianite even during deep burial in the sediment. In e.g. Åsrum Lake, vivianite occurs in sediments with an Eh value between -350 mV to -410 mV and with a pH value between 7.2 and 7.6 (ROSENQVIST 1970). The limiting factor is the availability of ferrous ions and phosphorus $(HPO_4)^-$. However, also the amount of Ca^{++} (apatite) on one hand and $(HCO_3)^-$ (siderite) on the other hand does influence the formation and existence of the system ferrous monosulphide-(pyrite-hydrotroilite)-siderite-apatite-vivianite (cf. e.g. EMERSON & WIDMER 1978). The possibility of late post-depositionary formation of vivianite can not be dismissed either. It should be pointed out that no vivianite was observed in core 10/89 taken only 110 m further southeast through the same stratigraphic sequence.

A plausible explanation for the occurence of the vivianite layer in core 11/89, is that influx of oxygen depleted saline water into an area with sufficent biogenic productivity has caused a rapid accumulation of organic debris, maybe even dead fish, on the bottom. Anaerobic bacterial breakdown of this material has liberated large amounts of phosphorus which diffuses into the sediment. Ferrous oxyhydrates, buried in a reducing environment will alter to black grains and bands of ferrous monosulphide. Burial, compaction and migration of interstitial pore water has increased the availability of Fe^{++}. Where the diffusion front of the phosphate anion meets a suitable concentration of Fe^{++} and

the pH and redox are suitable, vivianite is formed. The well developed crystal structure indicates a uniform flux of Fe and P over a substantial span of time and the existence of a gel matrix, that has disintegrated upon sedimentary compaction.

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EMERSON, S. & WIDMER, G. (1978): Early diagenesis in anaerobic lake sediments - II. Thermodynamic and kinetic factors controlling the formation of iron phosphate.- Geochim. Cosmochim. Acta, 42, 1307-1316.

NRIAGU, J.O. & DELL, C.I. (1974): Diagenetic formation of iron phosphates in recent lake sediments.- Am. Mineral., 59, 934-946.

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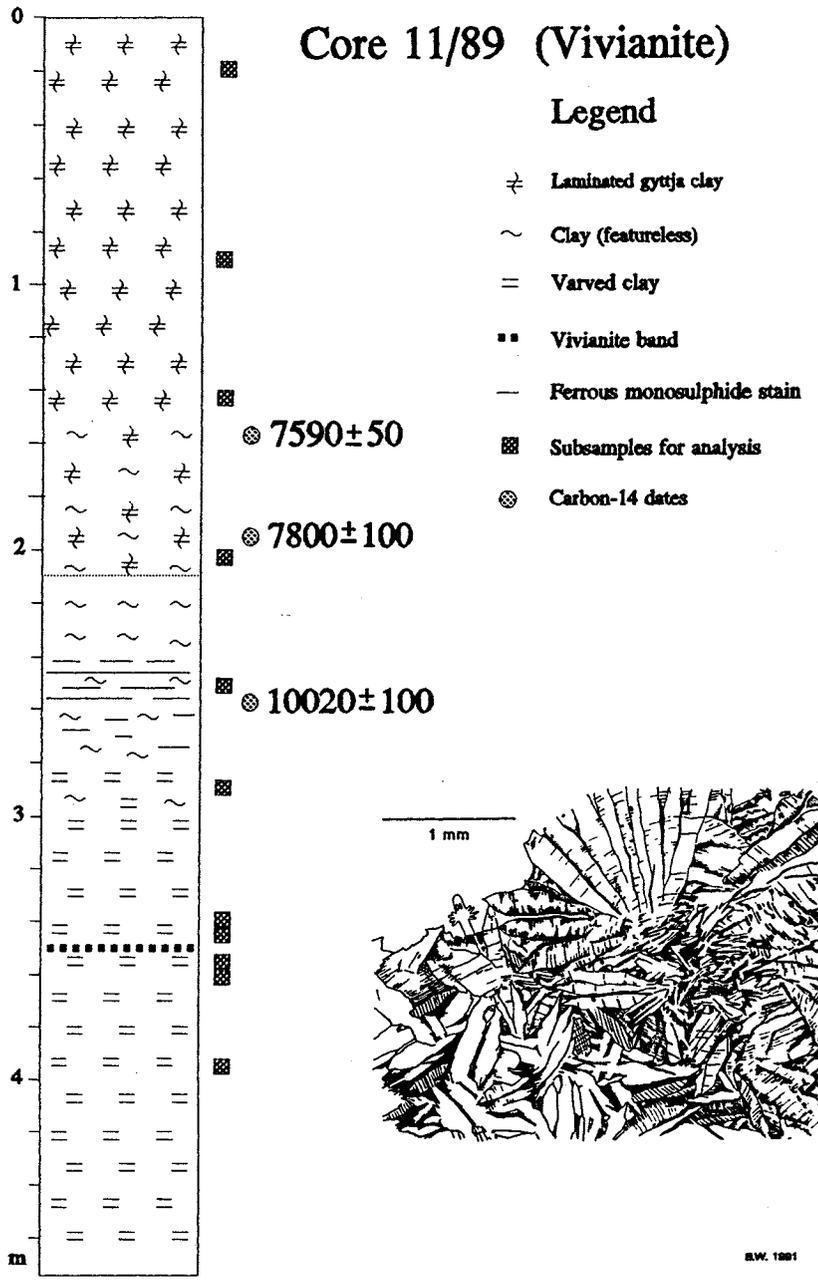


Fig.: Sketch of core 11/89, showing the stratigraphic position of the vivianite band, position of subsamples for chemical analysis and radiocarbon dating. The transition from featureless clay to laminated gyttja clay (210 cm b.s.f.) represents the end of the Ancylus Lake stage and the onset of the Litorina Sea.
Inset: Sketch of the microscopic view of a thin section prepared from the vivianite aggregates showing the lamellar character of the crystals.

Core depth cm	Al %	Si %	Ca %	Na %	K %	Mg %	Fe %	P ppm	Mn ppm
15	2.44	0.05	0.42	0.69	0.94	1.44	4.27	779	573
90	2.35	0.04	0.42	0.59	0.89	1.36	4.28	742	589
145	2.26	0.05	0.70	0.59	0.84	1.43	4.12	714	761
205	2.37	0.05	0.68	0.59	0.87	1.50	4.12	726	772
250	2.05	0.05	0.67	0.51	0.73	1.33	4.20	681	510
290	2.19	0.05	1.48	0.49	0.75	1.57	3.97	678	695
340	2.33	0.04	0.61	0.44	0.79	1.37	4.24	870	750
345	2.37	0.05	0.45	0.46	0.79	1.31	4.30	741	508
355	2.35	0.05	0.45	0.44	0.78	1.28	4.26	803	494
360	2.39	0.05	0.45	0.42	0.79	1.30	4.24	738	475
395	2.28	0.05	0.44	0.39	0.73	1.26	4.14	724	445

Core depth cm	Co ppm	Cr ppm	Cu ppm	Li ppm	Ni ppm	Sc ppm	Sr ppm	Ti ppm	V ppm	Y ppm	Zn ppm	Zr ppm
15	21.3	60.5	39.1	44.6	48.1	9.4	33.9	1620	81.5	22.0	115	21.1
90	20.1	57.7	36.8	42.1	42.8	9.0	31.6	1560	79.3	20.8	110	21.3
145	19.7	54.8	34.5	41.1	43.2	8.5	31.7	1440	75.4	20.3	105	19.6
205	21.0	56.7	38.6	42.3	44.0	9.0	31.6	1460	74.3	21.2	111	21.9
250	21.4	48.2	39.3	36.4	52.3	8.0	29.3	1290	63.7	22.0	102	18.0
290	19.9	50.9	37.0	38.9	42.0	8.4	32.3	1380	66.3	21.7	103	23.1
340	21.3	50.0	38.3	40.5	47.9	9.0	28.1	1460	70.0	22.3	109	26.1
345	21.7	55.9	39.4	40.9	46.5	9.1	28.1	1500	71.9	22.6	111	27.8
355	20.6	55.8	38.3	39.5	42.8	9.1	27.7	1520	71.7	22.1	109	28.6
360	23.0	57.0	39.7	40.1	52.2	9.2	27.2	1550	73.4	22.2	111	30.6
395	20.3	53.8	37.4	40.3	42.1	8.6	26.8	1450	69.4	21.5	108	29.6

Table 1: Aqua regia soluble components in subsamples from core 11/89. Water depth 76 m
59° 32'49.24" N 23° 07'38.84" E

SEDIMENTARY PROCESSES IN THE GULF OF FINLAND - CURRENT INDUCED SEA FLOOR CHANNELS

Boris Winterhalter (Geological Survey of Finland, Espoo, Finland)

Deep narrow channels across flat expanses of sea floor in the west central Gulf of Finland have been known for quite some time, but their origin has not been clear. Thus, the chance, in August 1991, to use the manned submersible "Bravo" on board the r/v "Akad. A. Krylov" to observe such a feature was accepted with gratitude.

The area chosen for a detailed study was a flat expanse of sea floor, formed as a result of combined erosion and postglacial deposition. The acoustic survey was conducted by r/v "Krylov", across a typical area (59°32'N, 23°30'E), previously located by the Finnish r/v "Aranda". A well developed channel, several kilometres in length, 100-200 m wide and 20-25 m deep, incised in late glacial and obviously postglacial silts, clays and muds, was found to run through the chosen study area in an almost north-south direction.

Despite the new set of acoustic profiles the origin of the channel, whether tectonic, or due to prolonged non-deposition or even semirecent erosion, is still a matter open to discussion. Although no sediment cores were acquired from the bottom of the channel, the observations made from the submersible and the doppler current profiling data gave a hint of a process not previously described from the area.

While the submersible "Bravo" was being prepared for the dive, the ship conducted, whilst adrift, an acoustic doppler current profile (ADCP) traverse (Fig. 2) almost perpendicularly across the channel. A strikingly persistent, narrow, jet-like current running south was observed to coincide exactly with the channel axis. What was even more astonishing, was that this current (20-30 cm/s) was persistent through the entire water column, even above and below the thermocline, down to the maximum depth attainable with the ADCP (measuring depth is limited to 85 % of water depth). Furthermore, the currents on both sides of this stream were in directions perpendicular or even opposite to the direction of the "jet stream" itself.

In anticipation of further measurements, I believe that the jet-like current is a rather stable phenomenon formed as a result of two colliding slowly (5-15 cm/s) moving water masses. It is obvious that this current has been active over a considerable time period. The observed deep channel would thus be the result of recent and sub-recent erosion and non-deposition.

The 6 hour dive with the submersible commenced across a flat stretch of sea bottom, with a very inhomogeneous appearance. It was caused by partial exposure of sub-recent sediments and a

patchy occurence of whitish "mats" of sulphur bacteria colonies. The dive, skimming the bottom, continued down the side of the channel, then running north along the channel axis and finally climbing up the opposite channel wall. Observations made through the front portholes of the submersible showed that the main part of the channel floor consisted of partially exposed light grayish clayey sediment (possibly late glacial silty clay), with sporadic thin "snow" driftlike deposits of loose detrital sediment.

An abundance of small animals, including crustaceans (*Mysis*) was observed near and on the bottom of the channel at depths over 110 m, while the bottom and near bottom water layer across wide stretches of sea floor on both sides of the channel at depths of 82-85 m was virtually devoid of fauna. In fact, besides being littered with patchy colonies of sulphur bacteria, partially or completely decayed fish remains could be observed. This must be related to temporary oxygen depletion and very weak currents. The fact that life was abundant within the channel absent on both sides is indicative of the "jet-stream" being clearly separated from the surrounding water mass.

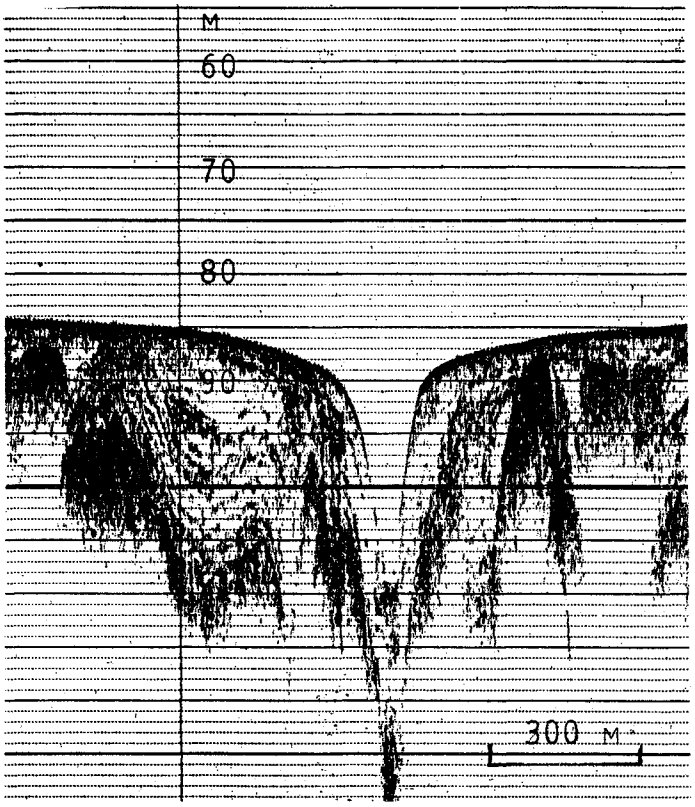


Fig. 1: Echo profile across an erosional channel incised in late-glacial silty clay sediments

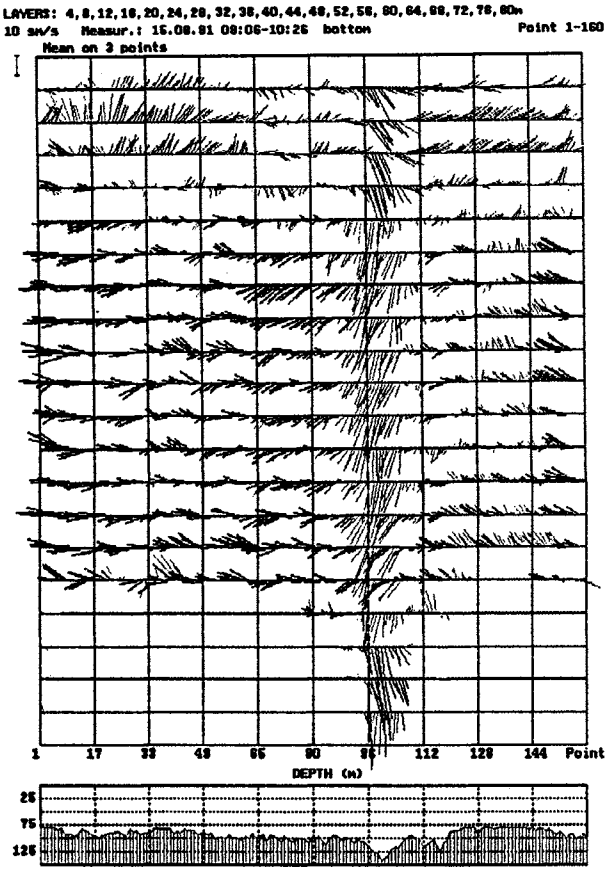


Fig. 2: Acoustic Doppler Current Profile across the channel whilst adrift. Max. measured current velocities were 20-30 cm/s coinciding with the channel axis

DIATOMS CHARACTERISTIC OF LITORINA STAGE FROM SURFACE AND SUBSURFACE DEPOSITS OF PUCK BAY (POLAND)

Andrzej Witkowski (University of Gdansk, Gdynia, Poland)

The subject of the study were diatoms from surface and subsurface sediments of Puck Bay (Poland). Sediment samples were taken by means of gravity corer of ca. 6 cm in diameter. The length of sediment cores amounted up to 70 cm. Diatoms of surface sediments (0-1 cm) were studied in fresh (water preparations) and in material cleaned by heating in hydrogen peroxide (permanent slides).

Studies of diatom microflora revealed the presence of numerous taxa. The most interesting of them were diatoms which are thought to be typical of Litorina stage. Of particular significance, however, is the presence of living *Terpsinoe americana* (Bailey) Ralfs in the surface sediments which is considered to be a leitfossil of Litorina deposits in the Baltic Sea. Numerous complete frustules of this diatom with cellular content were found in sediment samples taken from the water depth of ca. 5 m. Its cells usually formed short chain-like colonies composed of 2 to 3 specimens.

The occurence of *T. americana* in the Puck Bay surface sediments is of important significance for diatom based stratigraphy of the Baltic marine deposits. It means that this diatom can not be straightforward used as a leitfossil of Litorina stage of the Baltic Sea.

EVOLUTION OF THE SOUTHERN BALTIC AREA IN QUATERNARY - NEW DATA

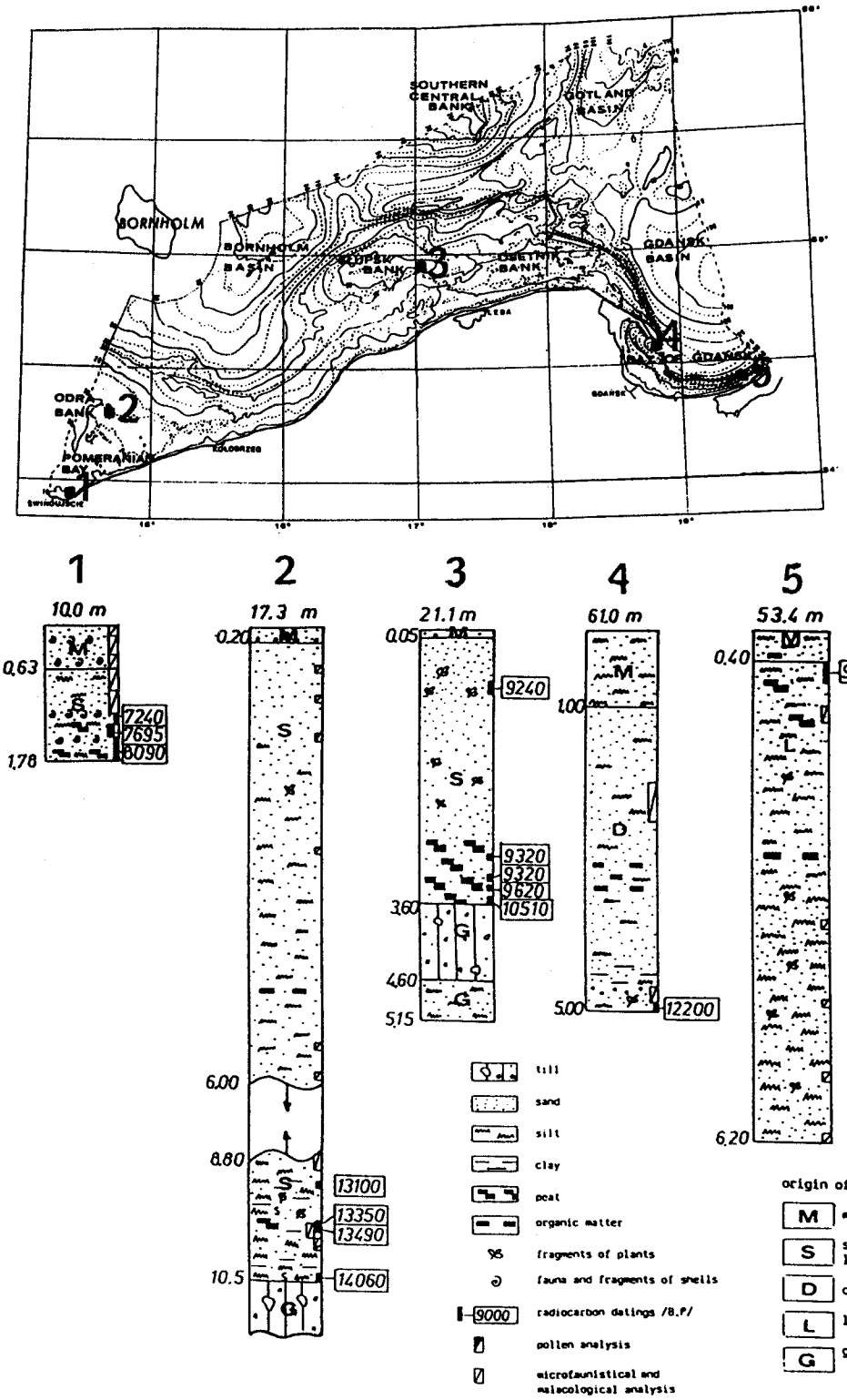
Joanna Zachowicz, Regina Kramarska, Szymon Uścinowicz (State Geological Institute, Sopot, Poland)

Cartographical and exploratory investigations of gravel and heavy mineral resources have been carried out for the last 23 years by the Branch of Marine Geology of the State Geological Institute, and have supplied many new data on the evolution of the Southern Baltic area.

Investigations of the thermoluminescent age of tills of the Southern Baltic bottom showed that all TL dates between the coastline and the 40 - 50 m depth are older than 43 ka, and most of them are older than 120 ka. This indicates that forms and sediments originated during the last deglaciation, have been destroyed by erosion processes, which occured during the late glaciation and the Lower Holocene under land conditions, and especially by marine erosion during the Litorina transgression. Tills younger than 30 ka occur in depths larger than 50 - 60 m, on the bottom of deepwater basins.

Sediments of river, lake, marsh and lagoon environments occuring presently on Southern Baltic bottom were dated using the ^{14}C method.
In the Pomeranian Bay lake and marsh sediments originating from the period 14.060 ± 220 to 7.240 ± 150 BP have been documented. The age of peat found on the Słupsk Bank was determined to be 10.510 ± 170 to 8.950 ± 70 BP.
Dates of deltaic sediments from the Bay of Gdańsk have been determined at 12.200 ± 240 BP and of lagoon sediments at 9.000 ± 260 BP.
The above ^{14}C datings document the paleogeographic evolution of the shallow-water zone of the Southern Baltic, between the end of the glacial period and the early Atlantic period, under land conditions.

Dates of marine sediments present in Southern Baltic deeps also were determined. The floor of the grey-olive organic mud layer was dated to be 8.800 ± 150 BP (Bornholm Basin) and 8.750 ± 170 BP (Gdańsk Basin).


SOUTHERN CENTRAL BANK
GOTLAND BASIN
BORNHOLM
BORNHOLM BASIN
SLUPSK BANK
SLUPSK FURROW
GDANSK BASIN
ODRA BANK
POMERANIAN BAY
1
2
3
4
5
m
1
10.0 m
0.63
1.78
7240
7695
8090
2
17.3 m
0.20
6.00
8.80
10.5
13100
13350
13490
14060
3
21.1 m
0.05
3.60
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5.15
9240
9320
9320
9620
10510
4
61.0 m
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12200
5
53.4 m
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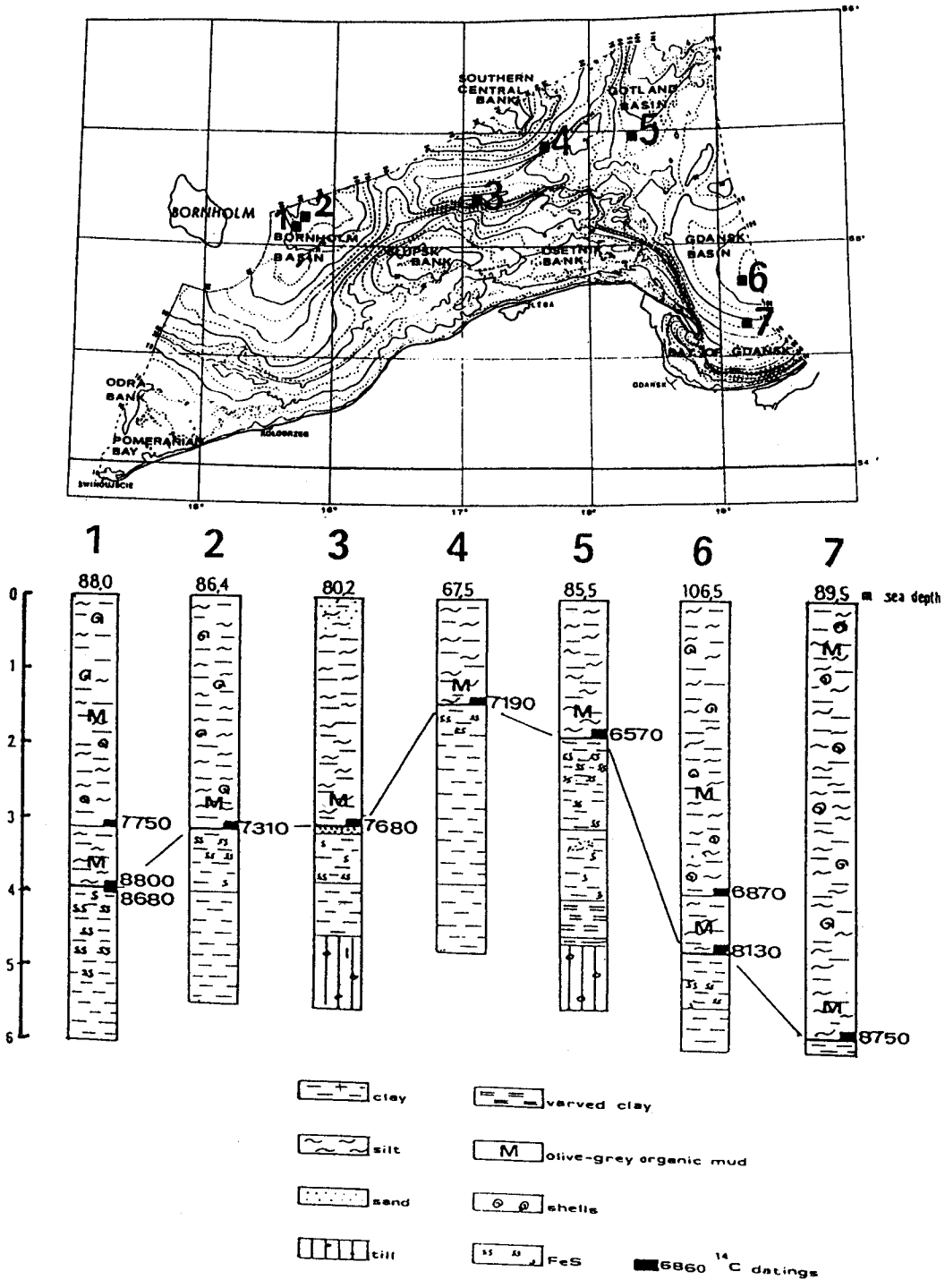
6.20
9000
till
sand
silt
clay
peat
organic matter
fragments of plants
fauna and fragments of shells
radiocarbon datings /B.P./
pollen analysis
microfaunistical and malacological analysis
origin of sediments
M marine
S swampy lacustrine
D deltaic
L lagoon
G glacial


SOUTHERN CENTRAL BANK
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ODRA BANK
POMERANIAN BAY
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ŁEBA
GDAŃSK BASIN
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88,0
86,4
80,2
67,5
85,5
106,5
89,5
m sea depth
7750
8800
8680
7310
7680
7190
6570
6870
8130
8750
clay
silt
sand
till
varved clay
olive-grey organic mud
shells
FeS
6860 14C datings

CHARACTERISTICAL FEATURES OF MORPHO- AND LITHODYNAMICS OF THE COASTAL ZONE IN THE NARVA BAY (BALTIC SEA) UNDER THE INFLUENCE OF TECHNOGENIC FACTORS

M.S. Zakharov, E.I. Staritsina, A.I. Vaseha (Mining Institute, University of St. Petersburg, Russia)

The coastal zone of the Narva Bay, which is a typical part of the glacial shelf at the contact between the Baltic Shield and the Russian Platform, is composed of gently tilted or subhorizontally overlapping layers. The layers can be (upwards) attributed to several bathymetric stages: The I. stage comprises depths between 65 and 75 m, the II. 50-65 m, the III. 37-50 m, the IV. 25-37 m, the V. 5-25 m, and the VI depths smaller than 5 m. According to Prof. LASTOCHKIN it can be affirmed that subaqueous self-organizing natural geomorphosystems should include definite series of these stages. Distinguishing of such geosystems and tracing of their boundaries is a subject of regional sea bottom studies in order to apply this knowledge to economical and ecological problems.

The central Narva Basin, considered as an independent geomorphosystem, is formed by subhorizontal layers of straight and convex cross-section, attributed to 3-6 stages with depths down to 40 m. It occupies the highest hypsometric position relative to its neighbours; hydrodynamic connections with them are realized by a series of discharge saddles in its external boundary.

During the Holocene development, the coastal zones both of the mentioned geosystem and the whole Narva Bay have been controlled by two major factors. Their interaction resulted in specific, balanced coastal forms characteristic only for the Bay. The first of the factors is connected with the general change of the Baltic Sea level during Holocene and is controlled by the irregular wave character of the tectonic-glacioisostatic elevation of the area. The clint and accumulative forms of the Kurgalsky peninsula indicate a rather moderate rate of elevation, balanced by wash-out processes in the post-Litorina time. There is no evidence of changing movement marks along the coast under study. An exception is the Narva arc in the internal part of the Bay, located at the contact between the clint and the Kurgalsky peninsula. The arc has been formed in a specific hydrodynamic regime, which is still governed by detrital flows of contrary bottom currents and a powerful discharge of the Narova river. A 23 km long sandy beach has accumulated in this location, where different coastal flows join, over a long period. Only a part of fine material was able to pass the zone of coastal shallow water into larger depths. As mentioned elsewhere, such balanced setting in connection with the geological structure, the tectonic regime and the position of the sea level results in the formation of a circular arc, which

can advance or retreat, but which always remains parallel to itself. The baseline of the arc is normal to the predominant wave fronts, providing energy for coastal transformation processes. The Narva arc, situated between 59°38' N, 28°02' E in the north and 59°25' N, 27°42' E in the south, was obviously formed in post-Litorina time in several steps, although migration tracks of supporting points (residual capes, islands or banks) could not be traced yet. It can be assumed that by the 1950's the process gradually became more stable with maximum wash out about 4 km away from its original position. The stabilization of the whole Narva Bay coastal zone is demonstrated both by the balanced form of the Narva arc and by the stable character of coastal sand bars, formed there under the influence of rip currents, normally oriented to the coast line.

The damming of the Narva river in 1956 and the subsequent decrease of run-off changed this balance dramatically. Today, the erosion of the arc's central part is enhanced to the north and south of the Narva mouth; erosional processes at the southern original reference point near Sillamyae became more active, too. Insignificant accumulation occurs in a pocket at the northern margin of the arc. These facts support the idea that anthropogenic influence destroyed the geometrical balance of the arc. Supporting points of the arc were shifted southeastward, and many areas have been eroded and transformed. Therefore, an attempt of local beach consolidation was undertaken. Obviously, all these actions can be succesful only, however, if the natural balance, i.e. the original run-off of the Narova river, is reestablished. On the other hand it is necessary to estimate the change of sediment dynamics, connected with the damming of the Neva inlet, which apparently decreased the sediment transport capacity of the eastern section of bottom currents near the head of the Kurgalsky peninsula. Within a short time span these changes can effect the state of the coast near the Narva arc.

DISTRIBUTION OF Fe-Mn NODULES FIELDS AT THE BOTTOM OF THE GULF OF FINLAND, AND THE VARIETY OF NODULES

V.A. Zhamoida , V.P. Butylin, (All-Union Geological Institute, St. Petersburg, Russia)

A sedimentological survey carried out in the Gulf of Finland in 1980 - 1990 allowed to study fields of Fe-Mn nodules. The intensity of the nodules formation and their variety in the Gulf of Finland have no analogies in the other shelf marine basins of the world. That's why the Fe-Mn nodules of the Gulf of Finland may be regarded as the best example of subaqueous ore-formation.

The distribution of the nodules fields and the nodules themselves (a structure and enrichment of the nodules stratum, morphology and composition of the nodules) inside these fields are in strict conformity to natural laws.

The distance from the Baltic shield is the main factor controlling the distribution and productivity of the nodules fields on the regional scale.
The next local level of the nodules diversity is connected with the facial and depth positions of the fields. The mostly enriched fields are situated on the border line of the recent silty-clay accumulation zones. The total weight of the nodules stratum can reach 60 kg/m^2; that depends mainly on the thickness of the silty-clay deposits, which are the secondary sources of the dissolved ore-material.

The third level of the nodules differentiation is associated with the inter-facial position of the nodules stratum inside the field. We can conditionally distinguish early, mature and aged stratums.

The last level of the nodules diversity is determined by their position inside the stratum.
Some changes in the distribution of the nodules and their chemistry features are occuring nowadays due to the anthropogenic impact.

THE MAIN PRINCIPLES OF GEOECOLOGY MONITORING, AS A METHOD OF THE EVALUATION OF MARINE BASIN EVOLUTION TENDENCIES

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The geological substratum is the basis for the development of practically all natural processes in the aquatories. The geological objects themselves are to a large extent exposed to the anthropogenic impact and their state determines the integral quality of the environments.

In spite of the great experience of the different geoecological investigations, presently there exists no unified methodology and conception of a geoecological research and monitoring.

The main idea of the geoecological monitoring is based upon the statement, that the greater part of the pollutants and their derivatives are transferred, transformed and accumulated like their natural twins, otherwise in accordance with the natural sedimentation processes in the subaqueous environments.

The present report is an account of the certain attempt of the area geoecological monitoring elaboration based upon a sedimentological survey. This type of the survey means studying and mapping of the litho-petrographic composition of the deposits exposed on the recent bottom surface. The potential opportunity of the lithological method permits not only to determine the state of the anthropogenical impact to the bottom sediments and the contamination in the concrete sampling locations, but to make the whole integral sedimentation processes scheme independent from the casual fluctuation of the hydrodynamics.

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