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Prolific decades of marine geology at the Geological Survey of Finland : a historical review

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Abstract The article presents a short historical review of development of marine geology at the Geological Survey of Finland (GTK). The founder of the marine geology unit at GTK, Dr. Heikki Ignatius, established at an early stage good relations with the Baltic Sea researchers of neighbouring countries. This resulted in joint research cruises, exchange of ideas and close cooperation. The purpose of this article is to highlight some of the important steps taken at GTK and to show how cooperation has resulted in the investigations of the Baltic Sea becoming one of the best studied sea areas in the World Ocean.

***Keywords** • marine geology • marine survey technique • history of oceanography*

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INTRODUCTION

Marine geology as an independent line of research evolved at a rather late stage in the 1950s, although serious pioneering work had been undertaken much earlier. The best example of successful ocean going scientific research was the Challenger expedition, that during four years (1872–1876) of sailing the World oceans collected troves of oceanographic data and including sea floor sediment samples thus paving the road for an escalating interest in the oceans and the geology of the ocean floor. Other expeditions followed, but the real boom in sea floor research followed in the wake of World War II thanks to the development of echo-sounding and positioning techniques including inventive equipment for sea-floor coring and sampling.

This new discipline, we call **marine geology** (incl. geophysics), was quickly picked up by enthusiastic innovative geologists around our *Mare Nostrum*, the Baltic Sea. There were two major advancements in sampling equipment in the 1940–1950s; 1) the Dutch van Veen grab, quickly adopted by marine biologists and geologists, and 2) the development of the piston corer by Börje Kullenberg (Kullenberg 1949) who initially showed its usefulness in sediment studies in the Mediterranean Sea.

THE FINNISH APPROACH

The Finnish Institute of Marine Research (FIMR) was founded in 1918 to conduct physical, chemical and biological oceanographic research in the Baltic Sea. Due to the early interest in chemical oceanography, including sea floor sediments, the FIMR chemist Stina Gripenberg devised a short glass-tube sediment corer which she used in her extensive study of sea floor sediments (Gripenberg 1934). She did, however, complain about the patchy nature of the seabed which made accurate mapping very difficult, but we should remember that GPS had not yet been invented and dead-reckoning (compass and speed log) was not accurate enough for map making.

Because sea floor geology was not officially included in the duties bestowed the FIMR, the Director, Professor Ilmo Hela, suggested in 1955 that Dr. Heikki Ignatius, a young Quaternary geologist just returned from the United States and employed by the Geological survey of Finland (GTK), could take on the responsibility to develop Finnish marine geological research. This began a long-lasting cooperation between the two institutes allowing geologists and geophysicists to participate on FIMR-cruises on board the “old” *R/V Aranda* together with chemists and biologists often in a symbiotic manner. Built in 1953 she was used as a passenger ship in winter traffic in the Archipelago Sea and as a research vessel during the summer season. After many decades of very fruitful oceanographic work *Aranda* was decommissioned in 1990 and substituted with a sophisticated purpose-built research vessel with the inherited name of *R/V Aranda*.

Like in many other countries around the Baltic Sea marine geology was quickly assimilated with the traditional geological community and had by mid 1960s gained a firm foothold also at GTK. This included a slow but steady increase in personnel and research funds. The following decades saw a rapid development in equipment and methodology in the study of the underwater realm of the Baltic Sea. Despite a general loss in political interest regarding geology, marine geology had special luster to it and has beheld to this day a rather high priority at the Geological Survey of Finland.

Apprenticeship in marine geology

As a young geologist and enthusiastic SCUBA diver studying at the University of Helsinki this author was invited in 1962 by Heikki Ignatius to participate, at "own cost", in a Baltic Sea geological cruise that would also be attended by Professor Ivar Hessland and his two assistants Bo Brännström and Tom Flodén from the Stockholm University. The joint cruise was a great success. A firm everlasting friendship with our Swedish neighbours was established when using standard SCUBA diving equipment I succeeded to retrieve for them, from a depth of 54 m, *in situ* Ordovician bedrock samples from a submarine outcrop half way between Gotland and mainland Sweden. This was one of the first in a long series of international cooperative cruises in the Baltic Sea during coming decades.

In 1966 after serving my compulsory military service in the Finnish Navy I was permanently employed at GTK as a geologist with the sole duty to build up a task force in marine geology. I can proudly state that years of hard work, luck and innovative thinking with a wonderful team, produced a marine group at GTK qualified to attack virtually any sea floor research job in the Baltic Sea and abroad including lake and river studies.

Early activities in marine geology

The first Finnish copy of the 10 m long Kullenberg-piston corer (Kullenberg 1947) was acquired in 1955 by Heikki Ignatius (Fig. 1) and used under his leadership for decades on many *Aranda*-cruises. It should be mentioned that the corer was also used to collect long sediment cores from the Barents Sea by Ignatius on the *R/V Aranda* cruise to Spitsbergen during the 1957 International Geophysical Year and some of the sediment samples were given to the Polish Geological Institute for analysis.

During the following years systematic coring of Holocene and Lateglacial sediments and their study based on microfossils (pollen and diatoms), grain size analysis and radiocarbon dating, made it possible to accurately outline the various stages in the development of the Baltic Sea over the past 10 000 years. A major outcome of several years of coring and detailed varve studies resulted in a publication (Ignatius 1958) on the rate of sedimentation in the deep basins of the Baltic Sea (Fig. 2). Later he elaborated on the time transgressive nature (Fig. 3) of the late glacial Quaternary sedi-

Fig. 1 The complexity of the original Kullenberg piston corer with 60 cm long brass core liners was already in 1964 exchanged into a more realistic easy to use version with 5 metre long PVC-plastic core liners and a simplified release mechanism. On board *Aranda* bearded FIMR chemist Svante Nordström watching in the background and observers crowding young geologist Esa Kukkonen working while Dr. Heikki Ignatius oversees the assembly of the corer (above) and demonstrates the new release mechanism (right)

ments found in the Baltic Sea and which he displayed in his lecture during the First Marine Geological Colloquium held in Parainen, Finland, 27–29 May 1987. The fact that the retreat of the Fennoscandian ice sheet from the Polish and German coast to the Bothnian Bay in the far north lasted over several thousand years, led to a discrepancy in terminology as noted by Ignatius in his lecture - i.e. the Baltic Sea Holocene sediments are generally considered to be postglacial in nature. However, in the Bothnian Bay the sediments are typical glacial varved clays due to the proximity of the melting glacier (see also Winterhalter 1992).

It should be noted that the quality of the sea floor sediment cores taken with the piston corer far surpassed any sediment cores acquired on land. Furthermore, thanks to the rapid development in high resolution echo-sounding techniques sequential coring of outcropping strata was used to procure sediment cores several times the length of the corer.

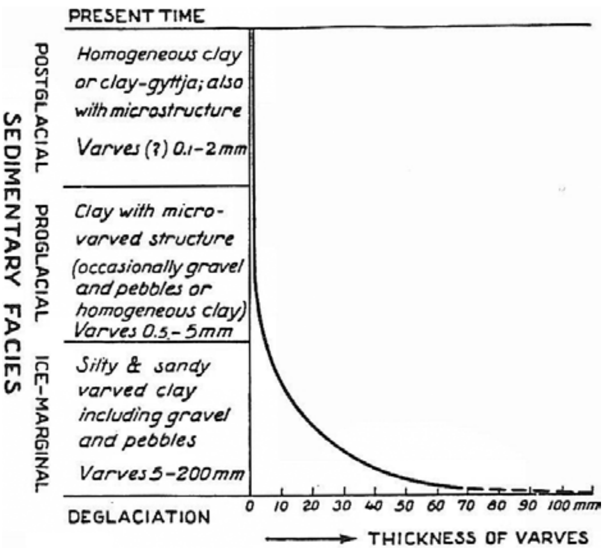

Fig. 2 A generalized curve showing the succession of changes in the character and rate of sedimentation in the deep basins of the Baltic Sea from the time of deglaciation to the present

The first attempts to map the bedrock underlying the Bothnian Sea (Veltheim 1962) and Bay of Bothnia (Veltheim 1969) were made by the GTK hard rock geologist, Valto Veltheim, using the pebble count method. The material was sampled using a van Veen grab.

Technological development

Compared to a land geologist who can attain excellent results even with just a hammer or shovel, a compass and a notebook, the marine geologist is first of all confronted with a hostile environment. The need for reliable means of transport just to reach the study site is obvious and suitable equipment are needed to "see and feel" the study target, i.e. the underwater world. Especially in the early days commercially available equipment was scarce or very expensive, so that much had to be improvised or designed and built *in-house*.

Underwater operations: SCUBA-diving was one line of approach for work in shallow waters. To this author it came naturally being myself an avid diver and underwater photographer (Fig. 4) already during my last school years. Developing the technique of underwater photography in poor visibility had an important place in the overall technological development at GTK in the early 1960ies.

Most of the Baltic Sea being deeper than the depth reachable by standard compressed air diving, photographic images of the sea floor were acquired with a "home-made" automatic deep sea camera (Fig. 5) and later augmented with CCTV (closed circuit television - nowadays simply called video). Our line of optical

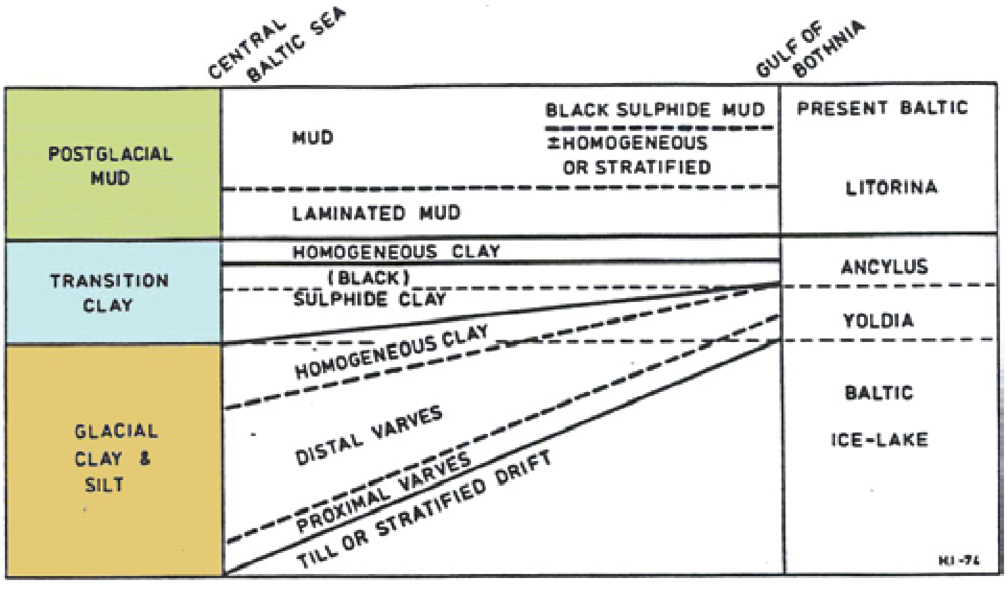

Fig. 3 The graph shows the transgressive nature of Baltic Sea sediments typically seen when comparing varved clays from the southern Baltic Sea with those from the Bothnian Bay (Copyright H. Ignatius)

sea floor observation methods eventually culminated in a cable-tethered remotely operated video and photographic vehicle (Fig. 6) pressure tested to a depth of 500 m. Later on similar mobile platforms became commercially available and currently known as ROV (remotely operated vehicle) even at reasonable prices.

Seabed coring

A newer stainless steel redesign of the piston corer was made for easier handling from smaller vessels and even from an ice covered lake. Reliable core retrieval using an automatic piston (Winterhalter 1970) was tested successfully in a lake study (Fig. 7). Upon retrieval the piston breaks automatically in half. The actual seal part of the piston is locked at the level of penetration while leaving the piston cable to be used for lifting without causing additional sediment to be sucked in with the piston.

The piston corer is excellent for coring in clayey and to some extent in somewhat silty sediments, but sand and gravel deposits are virtually impenetrable. However, various Finnish interest groups had contacted GTK in the mid seventies requesting reliable information on offshore sand and gravel reserves. We had already excellent seismic profiling hardware and suitable software for mapping exercises but we were now only in need of heavier coring equipment. Based on an earlier Swedish SGU design a powerful electric vibro-hammer corer standing upright on the sea floor was built at GTK with the help of a commercial contractor.

Initially a 10 by 5 metres outboard powered pontoon raft with a suitable derrick and winch was built for sand and gravel coring in the sheltered archipelago (Fig. 8). It was later substituted with a decommissioned 40 m long car ferry equipped (Fig. 9) with a two story living and laboratory container and a 10 ton winch and crane for handling our long sediment corers. This vessel, *R/V Geola* was used extensively in sea floor surveys both in estimating sand and gravel (Fig. 10) reserves and regular mapping surveys along the entire Finnish coastal stretch from the northernmost Bay of Bothnia to the easternmost parts of the Gulf of Finland.

Fig. 4 The author (on the left) being taken to the next diving site with *Aranda´s* work launch by the boatswain in 1962 while assistant Henrik Cronström is enjoying (?) his "smoke" prior to diving. Note the homemade underwater camera housing and the use of flash bulbs

Systematic sea floor mapping

Geological sea floor sampling with grabs and even dredges together with various corers were initially used in reconnaissance type of studies to form a general idea of the geological nature of the Baltic Sea, and particularly related to the glacial and postglacial development of the entire Baltic basin. However, it soon became clear that national interests demand systematic mapping of the sea floor within the area of national jurisdiction (EEZ).

Because of the very variable topography and the heterogenic character of the sea floor geology in the Finnish EEZ (Exclusive Economic Zone as defined in the Law of the Seas Treaty), and specially in the south-western archipelago all interpretation of acoustic survey data, (incl. echo-sounding, seismic profiling and side scan sonar recordings) had to be verified by sampling. With increasing public concern over the

Fig. 5 Automatic sea floor camera images taken down a gentle slope from a drifting ship in the Fårö Deep, Northern Baltic Sea. The depth varies from 101 m (a), 102 m (b) and 109 m (c) showing from left to right increasing level of anoxia. Pictures like these are excellent indicators of the distribution of anoxia in this case loss of anoxia following a slow dissipation of oxygen and deposition of oxidized (brown) fluffy sediment from overlying waters (See Niemistö, Winterhalter 1977)

Fig. 6 The remotely operated underwater vehicle (ROV) constructed in 1967 at GTK being carefully deployed overboard by electronics engineer Leevi Koponen while geologist Esa Kukkonen is paying out the tether cable. The video camera is used for navigation and general observation (yellow casing) and the still camera (white casing) located low on the vehicle to allow good quality photography even in very poor visibility

Fig. 8 Above photo of the first "vessel" built for rapid sand/gravel coring in the sheltered waters of our archipelago. The 6 m corer was lowered through the central "moonpool" while twin anchors steadied the operation. The actual site was chosen based on previous acoustic profiling

Fig. 7 Although the piston corer was originally designed for marine sediment sampling it is just as suitable for wintertime coring in deep lakes or even coastal lagoons not reachable by boat. Heikki Ignatius in the background with icepick in his hands although the hole in the ice was made with a long chainsaw. Technician Pauli Kaijola is checking the lead weights. Photo taken by B.Winterhalter 50 years ago in Finnish Lapland

Fig. 9 (Above photo) shows the retrieval of the 12 m long vibro-hammer corer for sampling sand and gravel under a sufficiently thick layer of silt or clay to keep the corer vertical. The attitude and penetration of the corer was controlled with an echosounder transducer located under the bow of *Geola.* On deck the plastic core liner was extracted, split, described and sub sampled

Fig. 10 Example of typical diamicton (till) sampled with the vibro-hammer corer (scale in centimeters)

marine environment not only geological parameters were important, but also environmental pollutants became new targets. This issue is addressed by Henry Vallius in this number of *Baltica* (Vallius 2016).

Soft sediments have been regularly sampled with small gravity corers, e.g. the well known *Niemistö* corer and its twins *Gemini* and *Gemax* corers (GEMAX 2001) as well as the AWI-type multi-corers (Multi-Corer 2015). However, pollutants are also deposited in sandy sediments which have so far been sampled with various grabs providing only bulk samples. Because there was a definite need for short undisturbed core samples, a new type of small semiautomatic battery operated corer (Fig. 11) for undisturbed sampling of sandy surface sediments was designed at GKT and called the *OSCOR* based on the oscillating rotation of its core barrel (OSCOR 2001) . The acquired sediment cores 20–30 cm in length were retrieved and used to study distribution of pollutants in estuaries and ports.

Hydrocarbon detection

When traces of oil were found on the island of Gotland in 1969 the Finnish oil company NESTE approached GTK asking whether any hydrocarbons could be found in the Finnish Baltic Sea EEZ. GTK responded: "probably not, but we cannot be sure because our EEZ has not been properly mapped yet". The short reply from NESTE was: "start mapping, whilst money should not be a problem". This sent this author on a month-long "fact-finding" mission to the United States. I came back with a long wishing list of equipment to be acquired, including: various acoustic profiling equipment (air guns, hydrophone streamers, sonobuoys), towed proton magnetometer, automatic positioning and data acquisition and even a water jet propelled shallow going 14 m long research vessel *Kaita* for near shore surveys. In fact, almost "over the night" (a year later) a complete survey system was built up and running. After three summer seasons of surveys and data processing, the simple result was that no commercially viable hydrocarbon structures were detected in the sedimentary bedrock sequences of the Gulf of Bothnia. However, as an academic endeavour the work provided additional insight into the geology of the Bothnian Sea (Winterhalter 1972).

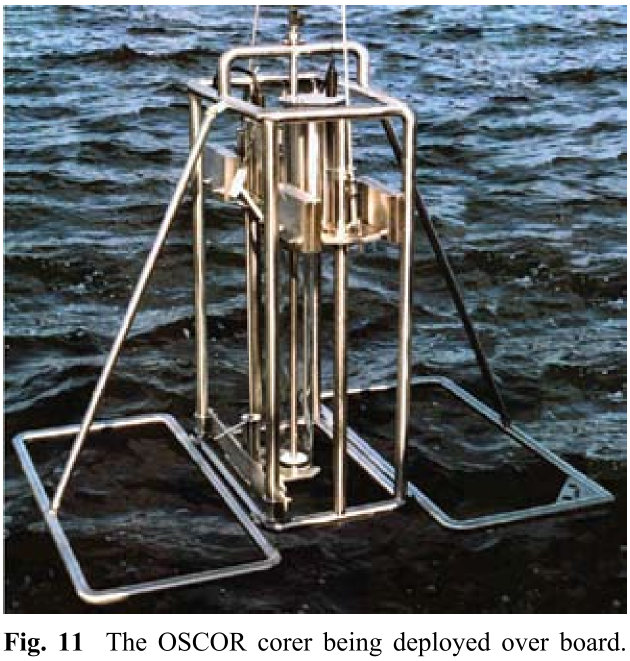

Fig. 11 The OSCOR corer being deployed over board. Upon contact with the bottom a battery driven electric motor causes the core barrel to quickly rotate (oscillate) back and forth aiding the clear plastic core barrel to penetrate into sandy sediment. Photo courtesy by Cees Laban

After the Neste project and the large scale mapping of the Finnish EEZ it became obvious that there was a definite demand for more detailed mapping of our near shore areas. We now had the versatile research launch *Kaita* for coastal work and in the 1983 the *R/V Geola* was added to the research fleet including a water-jet powered 5-metre long hard-top motorboat (Fig. 12) for really shallow water work mainly in rivers and lakes.

Development in survey methodology

In the early days of marine surveys the official *Decca* system covered many of our needs. When detailed coastal mapping demanded higher positioning accuracy the need was solved with a Motorola *MiniRanger III* system that provided metre-scale accuracy. Together with the acquisition of sidescan sonar and an array of different seismo-acoustic profiler systems it became clear that the large amount of data coming in computerisation became a necessity. This was solved with the help of *Hewlett-Packard* desktop computers, graphic digitizing equipment and a large 8-pen colour plotter for printing maps and geological cross-sections.

Cooperation with a local company (Meridata 2016), specialized in underwater acoustics led to the development of a very versatile seismo-acoustic acquisition and processing system. A side line in the cooperation was the development of a deep-tow pinger/chirp sound source (Winterhalter 1999) which provided excellent resolution in soft sediments (Winterhalter 2001b, Fig. 4).

Antarctic research

The Antarctic Treaty System (ATS) is defined to cover all of the land and ice shelves south of 60°S latitude. The treaty, entered into force in 1961 and as of 2016 has 53 parties, sets aside Antarctica as a scientific preserve, establishes freedom of scientific investigation and bans military activity on that continent. Finland joined ATS in 1984 and acquired a consultative status in 1989, requiring active scientific participation.

Abiding to the requirement of active research on Antarctica in 1990 Finland decided to establish a seasonally inhabited automatic environmental research station on Queen Maud land not far from a similar

Swedish station. Late in the year the newly commissioned *Aranda* was loaded with material to raise a modest station for meteorological, gravimetric and magnetometric measurements. While the station was erected and ground surveys of the surroundings were conducted, the marine science crew, including marine geologists from GTK and the Swedish Geological Survey (SGU) conducted early in 1991 preliminary seismic, and sidescan sonar surveys and vibrohammer coring on the Antarctic shelf.

Fig. 12 The *Kaiku* (=Echo) motorboat was fully equipped with Meridata's MDPS-integrated GPS-positioning, echo-sounder, side scan sonar and single channel low frequency towed profiler with hydrophone streamer for wide band acoustics with excellent penetration in sand, gravel and till. Electronics engineer Matti Tuhkanen is the main operator of the boat and its data acquisition equipment

During the next Aranda expedition to Antarctica in 1995–1996 a small marine geological crew with geologist both from GTK and the University of Bergen conducted an airgun survey across the Weddell Sea shelf off Queen Maud land which provided data on the structure of the continental shelf of the region (Kristoffersen *et al.* 2000). The programme included geological drilling on the continental shelf in 200 m of water while moored to the edge of the ice.

As a by-product of the initial drilling exercise an interesting observation was made. The high-frequency echo-sounder on board *Aranda* was continuously recording the water depth under the hull and in reality recording the spectrum of the local tide. First of all we noted how the tide impacted on the adjacent ice front of the partly stranded edge of the Kvitkuven ice rise causing a minor collapse of the vertical ice wall forcing a termination of the drilling operation and rapid escape.

These events helped to formulate an explanation to why ice shelves often broke down into record sized "icebergs" instead of showing continuous small breakups at the seaward edge. The simple answer could be that the entire floating ice shelf is in continuous up and down movement with the tide. Thus most of the flexing occurs naturally along the line where the ice shelf loses contact with the bottom allowing the detachment of the entire floating ice shelf to form the gigantic icebergs making headline news.

INTERNATIONAL COLLABORATION

International cooperation was at a very early stage an incremental part of the activities bestowed the marine group at GTK. This cooperation included invitation of researchers from all circum-Baltic countries to participate in GTK-cruises and the participation of GTK personnel on research vessels operated by other institutions from our neighbouring countries (cf. Vallius 2016). Some of the joint cruises were based on bilateral agreements between individual countries while some with multinational participation were the result of international agreements, e.g. SCOR (Scientific Commission on Ocean Research), HELCOM, EU funded projects.

Finnish-(Soviet)-Russian cooperation

Thanks to the close cooperation with the Soviet/Russian VSEGEI (All-Russian Geological Institute) in St. Petersburg some of the Russian research vessels used in joint cruises were equipped with various underwater manned vehicles (submersibles) that provided excellent underwater observations beyond the depth rating of SCUBA-diving. In 1995 a tethered (wire suspended) Russian two-man small submersible *Thetis* was used to study the surface texture of the recent sediment surface in the deepest part of the central Gotland basin. Previously cored sediments exhibited a laminated texture indicative of prolonged anoxia and thus no bioturbation. Prior to the dive near-bottom water samples indicated complete anoxia. Despite this I could see through the porthole of *Thetis* flat worms 3–4 cm in length of the family *Harmotoe* swimming down from higher located oxygenated water levels to the bottom for quick feeding and swimming back up for oxygen uptake. This meant that some non-burrowing macro-life forms could survive for short periods in anoxic conditions.

In another dive with the Russian 60-ton manned submersible *Bravo* to study a narrow over 10 km long channel in the west-central Gulf of Finland (Fig. 13). Diving down to the bottom at an average depth of about 80–85 metres the sea floor consisting of thick beds of recent muddy (black) sediment was found to be sporadically littered with partly buried dead fish. Actually, this was not very odd, because deeper parts of the Gulf of Finland have been known to be oc-

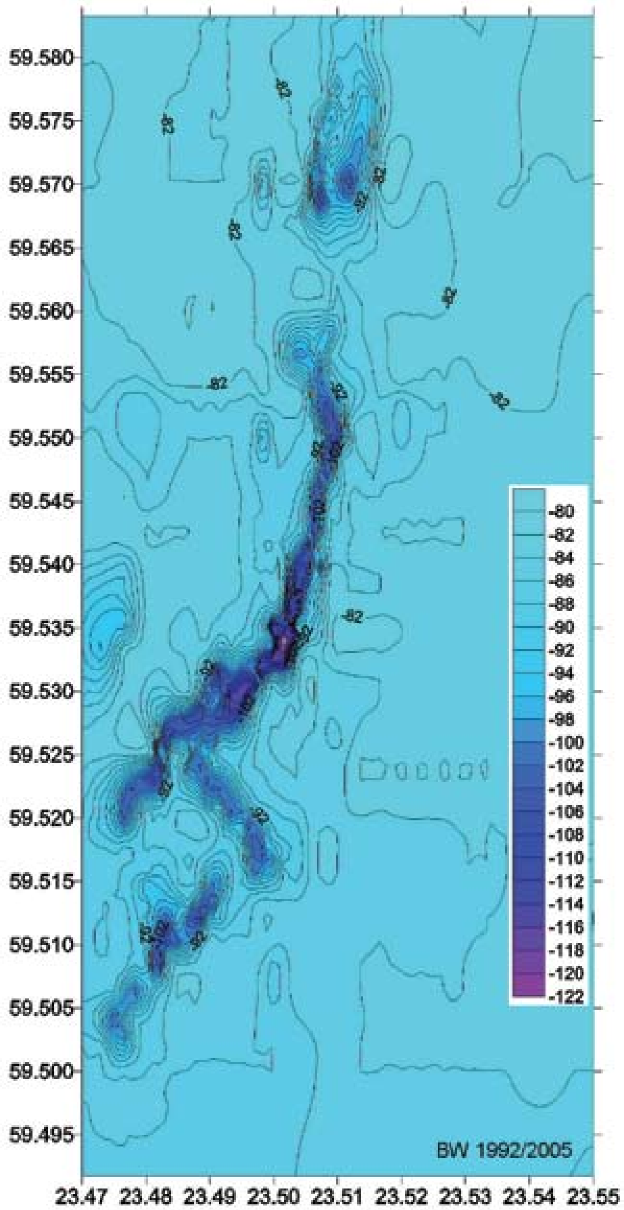

Fig. 13 Bathymetry of the 10 km long meandering Jontka-channel following fractures in the Precambrian basement rock. It is probable that the channel was incised by sub-glacial meltwater from the retreating glacier and subsequently kept free by the observed near-bottom current

casionally anoxic. Thus it was assumed that also the waters in the eroded steep sided channel reaching a depth of 120 metres would be anoxic. What astonished us in the submersible observing the inside of the channel was to find the water slowly flowing at 20 cm/s southward was teeming with macro life forms including numerous individuals of the benthic invertebrate *Pontoporeia affinis,* indicative of waters rich in oxygen. The conclusion was that these waters flowing in the channel like a river originated from a shallower area further north saturated with oxygen. This just goes to show that near-bottom currents in the Baltic Sea can behave in curious ways.

Finnish-Swedish cooperation

As mentioned previously cooperation with Professor Hessland and his team at the Geology Department of the University of Stockholm had a very early start. Later on a similar close relationship formed with like-minded geologists at the Geological Survey of Sweden (SGU) and even with those of Norway (NGU) in the form of joint cruises and useful information exchange

The EU BASYS project

Probably one of the most successful international ventures within the Baltic Sea realm was the Baltic Sea System Study (BASYS 2008) funded to a large part by the European Union Marine Science and Technology Programme MAST III. It involved 75 principal investigators from 50 partner institutions and 13 partner countries. Of the many separate interconnected projects (Winterhalter 2001a) *Subproject 7 Paleoenvironment* with GTK as the responsible institute covered a wide range of geological disciplines beginning with a detailed acoustic mapping of sediment distribution in the Bornholm Basin and two more centrally located basins, the Gotland Basin (Winterhalter 2001c) and the North Central Basin (Winterhalter 2001b) over 800 km further north. As already decades earlier Stina Gripenberg (1934) had noted that the sea floor geology is very patchy, the many long sediment cores taken just within the length of the ship in the tranquil central part of the Gotland Deep, showed astonishing variability.

Sediment samples from the many cores taken at each locality were distributed to partner institutes for detailed chemical, physical and biological analyses including mineralogical peculiarities. The ultimate goal was to get a better understanding of past and present sedimentation processes and whether the observed variations in time and space could be ascribed to specific environmental conditions (Alvi, Winterhalter 2001). One of the goals set by the project was to see how well micro-probe, x-ray and optical (Fig.14) methods in a very detailed study of the deposited sediments (actually on a sub-millimetre scale) could be used to decipher past climate variability. The cores were dated by a combination of radiocarbon and palaeomagnetic dating methods (Kotilainen *et al.* 2000, 2001)

Related to the present day strong summertime cyanobacterial blooms in the Baltic Sea causing anxiety and concern among the general public today the project showed that similar massive algal blooms were just as common during the Holocene climatic optimum and even during the Medieval warm period (Kowalewska *et al.* 1999). Thus most of the intensive algal blooms seem to correlate well with warm climates, e.g. the Roman Climate Optimum period dated between 300 BC and 400 AD (Hass 1996), followed by a minimum (lack of algal blooms) corresponding to colder climate (400–

900 AD), then a maximum during the Medieval Warm Period (1100–1400 AD) and again a minimum during the colder time period between 1400 AD and 1900 AD. According to Grazyna Kowalewska (*pers. comm.*) climate may have an equal or even greater influence on eutrophication and/or organic preservation than do anthropogenic nutrient factors. The chloro-pigment maxima in sediments are formed during warm periods and are preserved due to favourable post-depositional conditions, i.e. lack of mixing, anoxia, low light intensities and low temperatures (severe winters).

Gas-charged sediments

A gravity corer was designed by Per Söderberg (Stockholm University) for sampling gas charged sediments (Söderberg 1988) in the Stockholm archipelago to determine the nature of sea floor gas seeps forming pockmarks in the seabed. The sampled gas exhibited a thermogenic signature thus having a deep-seated bedrock origin (Söderberg, Flodén 1992).

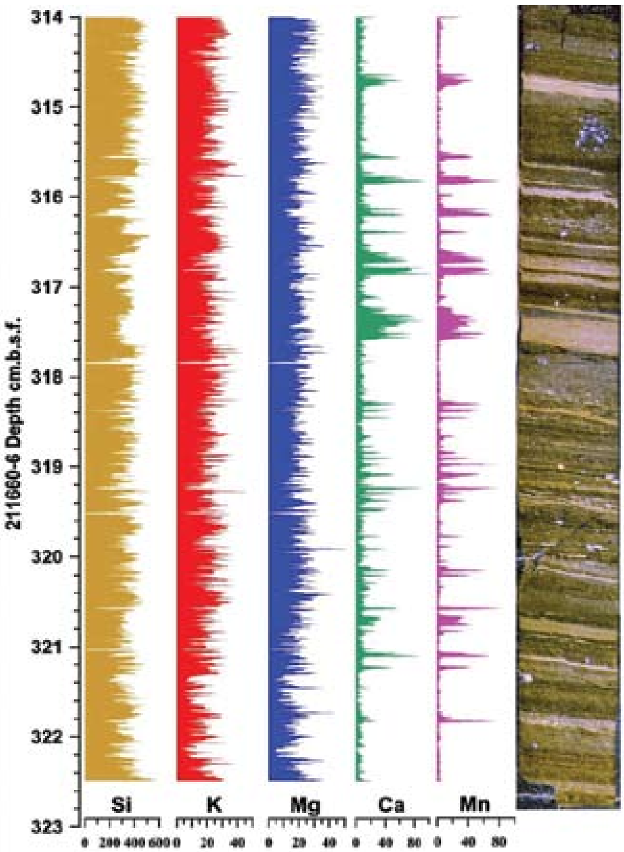

Fig.14 SEM image in cross polarized light of a thin section from core 211660-6 (Gotland Basin) between 314.0 and 322.5 mm down the core. A microprobe scan down the resin impregnated surface-polished section shows the relative content of the elements Si (silica), K (potasium), Mg (magnesium), Ca (calcium) and Mn (manganese). The correlation between calcium and manganese in the light-coloured carbonate bands is very striking and is typical of the laminated Litorina sequence deposited in the deep basins of the Baltic Sea

As a further example of Nordic cooperation *the Söderberg* corer (Fig. 15) was borrowed from Stockholm University and used for gas sampling (methane) in a study near the Finnish Olkiluoto nuclear power station on the south-eastern shore of the Bothnian Sea. The goal was to determine the origin of the gas; if thermogenic then deep-seated and indicative of bedrock fractures. Unfortunately the results were inconclusive although indicative of a biogenic origin (Hutri *et al*. 2006).

CONCLUSIONS

Despite the general diminishing trend in government funding of research institutions in Finland and also hitting GTK the marine geology task force has retained and even seen a small increase in personnel during the past years. Also available hardware and software has seen continuous improvements through the years. A twin hulled water-jet-powered research vessel, *R/V Geomari* (GEOMARI 2003) was built and fitted out as a cooperative venture with the Finnish navy. Continuous improvements in data acquisition and interpretation techniques have also been diligently employed in a joint project (VELMU 2013) with the Finnish Environment Institute (SYKE) and the Finnish Ministry of the Environment.

Fig. 15 The Söderberg gas-corer being used on *Geola* for sampling gas-charged sediments near the Olkiluoto nuclear power plant

Although the main aim of The Finnish Inventory Programme for the Underwater Marine Environmnet, VELMU is to acquire data on the occurrence of underwater marine biotopes, species and communities in Finland's marine waters, GTK is involved in the project to provide proper background information on the abiotic (geological, physical and chemical) environment. The final product based on GIS will include background information on bathymetry, seabed geological characteristics, etc on an easily accessible map portal.

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