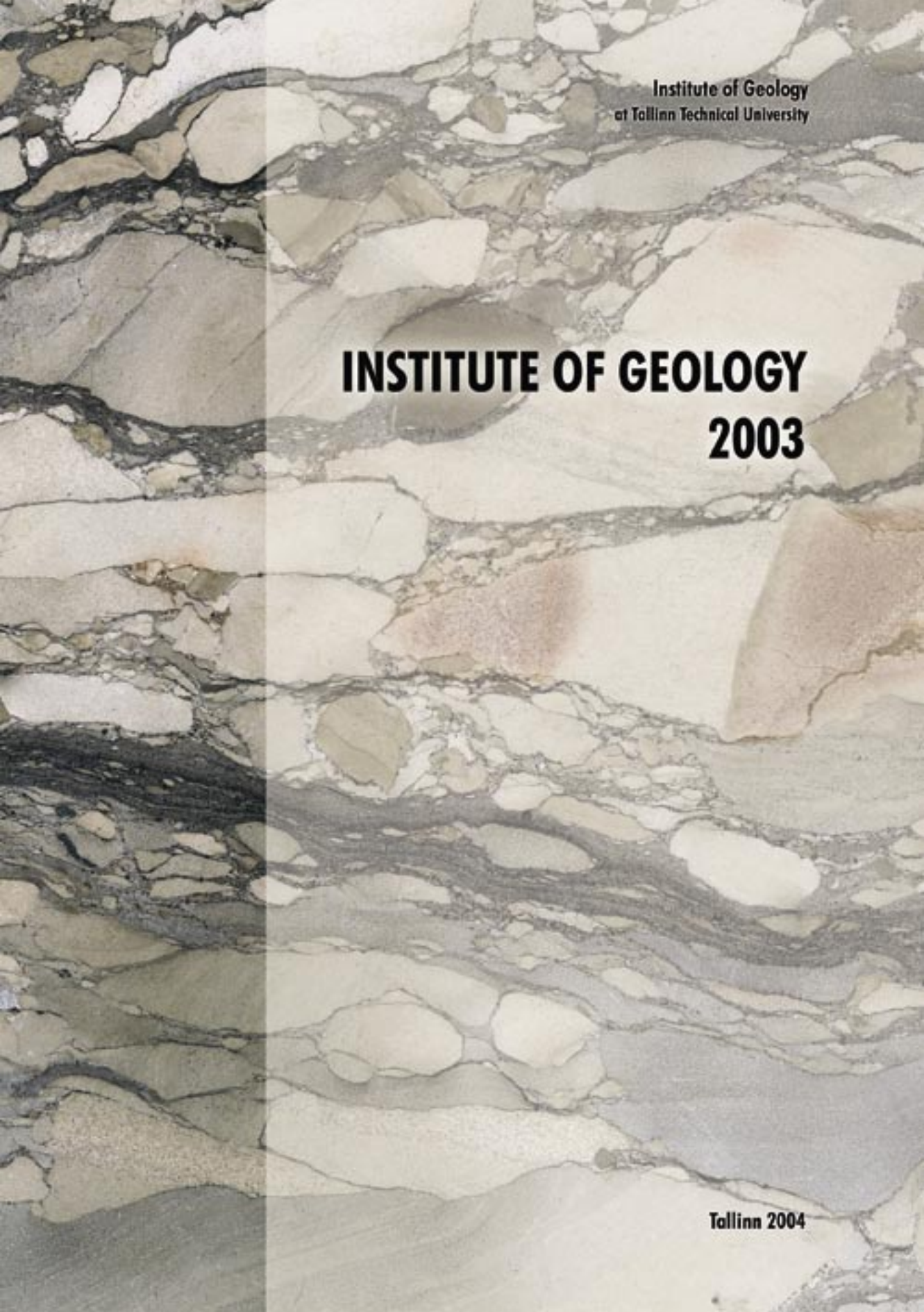

Institute of Geology
at Tallinn Technical University

INSTITUTE OF GEOLOGY 2003

Tallinn 2004

Institute of Geology
at Tallinn Technical University

Compiled by *O. Hints*

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Foreword

The mission of the Institute of Geology at Tallinn Technical University is to play a leading part in research and development of earth sciences in Estonia. The Institute of Geology maintains its reputation for internationally competitive research across broad fields represented by the existing constituent working groups. This involves intense research activity within the working groups and a constant, competitive reassessment of the balance of activities within and between them. Our mission is also to serve the wider geoscience community by fostering improved communication between academic science groups, the private sector, and government. The ultimate goals of the development program are to gain a more effective public presence for the geosciences, develop a sufficient stream of well-trained geoscientists to support industry and government projects, and to allow for the dissemination of ideas between the various geoscience sectors.

The Institute's research encompasses a large range of geological subjects under the investigation in Estonia. The majority of research topics meet international standards of science and the teams carry out their research in collaboration with the international earth sciences communities, including additional financing from international sources.

In addition to the fundamental studies, our researchers are able to (1) solve practical geological problems in Estonia and abroad; (2) consult with both private and government corporations when required; (3) raise and help solve inter-disciplinary problems both inside and outside their fundamental research topics; (4) use practical knowledge-based research to promote increased commercial activity with the earth sciences.

A great importance is placed on upgrading of the existing, and establishment and development of new laboratories in collaboration with other institutions in Estonia and abroad. Within the broad areas of lithology, palaeontology and stratigraphy, geochemistry, petrology, geological modelling and mineralogy the main focus in coming years will be in further development of all Institute's laboratories and more active participation in applied sciences.

The main research directions at the Institute are intimately related with teaching and supervising MSc and PhD students. In 2003, the Chair of Physical Geology was established at Tallinn Technical University which will considerably promote our involvement in teaching postgraduate students. For future national and international success a rejuvenation of the staff must be given a high priority. Several new appointments are planned in the institute in order to resolve the potential problem of staff retiring without replacement. In addition, an increase in the number of postgraduate positions will contribute to the overall rejuvenation trend and enhance the quality of research.

Our scientific collections of Palaeozoic rocks and fossils are the largest in the region and open for studies by Estonian and foreign researchers and students.

Institute of Geology in brief

The Institute of Geology, presently at Tallinn Technical University, was founded on April 5, 1946 by the Decree of the Council of Ministers. In February 1947, when professor Artur Luha was appointed the first director of the Institute by the President of Estonian Academy of Sciences, the actual work commenced. During the first years the staff remained small and there were three departments at the Institute – geology, applied geology and geophysics. The main research was focussed on stratigraphy and lithology of Palaeozoic and Quaternary sediments and palaeontology. As there was no Geological Survey in Estonia at that time, the Institute was engaged with prospecting and study of mineral resources (oil shale, phosphorite and natural building materials) in addition to some hydrogeological investigations. However, at this stage the foundation was also laid to fundamental research.

In the early 1960s, most of the geological research institutes all over the Soviet Union were subordinated to the USSR Ministry of Geology in Moscow. The Institute of Geology in Estonia managed to preserve its affiliation to the Academy of Sciences. This was mainly due to the high level of fundamental research conducted by the researchers of the Institute.

From 1960 to 1990, the staff grew rapidly and the structure of the Institute was changed. The growth of the staff was partly encouraged by increasing role of applied studies on phosphorite and oil shale. From the 29 people in 1947, the staff has grown up to 193 people in the early 1990s. Shortly after regained independence of Estonia, the Institute underwent great changes. During 1992-1994, the staff was reduced by 54%, mostly at the expense of applied research directions (hydrogeology, geophysics, marine geology were concentrated to the Geological Survay of Estonia). In 1996, with the Decree of the Estonian Government, the Institute was affiliated to the Ministry of Education. A year later, the Institute of Geology joined Tallinn Technical University as an independent research and development institution.

The Institute has had close contacts with all Estonian universities, particularly with Tartu University, which most of our staff has graduated from. The Institute also has contacts with other environment and education oriented government and private organisations. During the last decades, all forms of foreign contacts widened rapidly, including joint projects, organising scientific meetings, providing lectures, etc. The number of scientific publications is quite high as well as an international recognition of a number of our research teams.

As of December 2003, there are 75 people employed at the Institute, 44 of them on researcher positions.

Funding in 2003

The basics of science funding policy are described in the strategy program "Knowledge-based Estonia. Estonian R&D Strategy 2002-2006", according to which the expenses to science and development are ranging from 0.8% (2002) to 1.5% (2006) of GNP. According to the Law on Science and Development, the direct funding of fundamental science activities via state budget money (totally 80% of all science funding) consists of three parts: (1) expenditures for maintaining the infrastructure, (2) target financing and (3) research grants. The first two are managed by the Ministry of Education and Research (www.hm.ee); the Science Competence Council is acting as an advisory body for the Minister of Education and Research concerning target and infrastructure financing, which is the main funding for the research. Research grants, on the other hand, are awarded by the Estonian Science Foundation (ETF, www.etf.ee).

In 2003, the target financing, including research programmes, post-doctoral fellowships and support for the Centres of Excellence in Research was **219** million EEK (14 million EUR). Most of this amount was awarded on competitive basis to 254 different research programmes with duration of up to five years. Usually, the target financing covers most of the salaries and few other expenditures.

The infrastructure funding, totalling **61** million EEK (4 million EUR) in 2003, is proportional to the target financing that is provided for an institution and is used to keep up various parts of the infrastructure.

The Estonian Science Foundation financed 742 research initiatives in all fields of basic and applied research, totalling **77** million EEK (5 million EUR) in 2003. The research grants are mostly used for stipends, equipment purchase, international travel, consumables etc.

Applied research and innovation is also funded by the Ministry of Economic Affairs and Communication through the Enterprise Estonia, Ministry of the Environment and from few other sources. Input of the private sector to the science has so far been fairly negligible in Estonia.

In recent years, Estonian researchers have been rather successful in particupating in, and applying for European and other international funding schemes.

The annual budget of the Institute of Geology was approximately **9.6** million EEK (0.6 million EUR) in 2003. The following illustrates how this sum divides between the major funding sources:

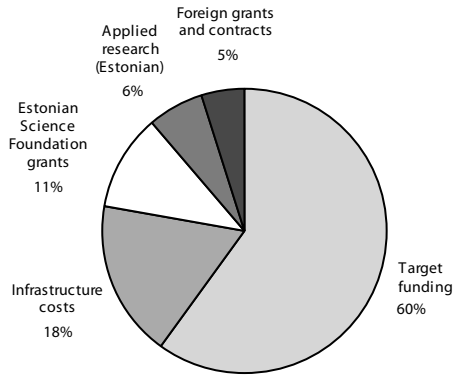
(1) Target funding consisting of 6 research programmes and 2 postdoctoral scholarships total **5.75** million EEK (0.37 million EUR).

(2) Research grants from Estonian Science Foundation – 15 grants, in total of **1.05** million EEK (0.07 million EUR).

(3) Infrastructural expenses for the Institute is in total **1.7** million EEK (0.1 million EUR), which includes **0.04** million EEK for expenses for the management of Institute's large geological collections.

(4) Applied research contracts from Estonia, ca **0.6** million EEK (0.04 million EUR).

(5) Foreign grants and contracts, ca **0.5** million EEK (0.03 million EUR).



A pie-chart illustrating the annual income and the main funding sources of the Instiute in 2003.

Structure and Staff

The Institute of Geology has administration and three departments. Departments of Bedrock Geology and Quaternary Geology also contain laboratories as sub-units. As of December 1, 2003, the Institute has **75** employees, including those with part-time load and halted contracts. During 2003, 6 new people have been employed and 4 left the Institute due to retirement or other reasons.
Ph.D., *Cand.Sc*. and *D.Geol.* degrees indicated below can be considered equivalent. Numbers in brackets indicate part-time positions (as of December 1, 2003).

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Laboratories

Laboratory of Physical Investigations

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The main research fields of the Laboratory are mineralogy and geochemistry. Mineralogical studies are based on the X-ray diffraction and carried out, using HZG-4 and URD diffractometers. All data processing is fully digitalised. In the past year the main research topics were mineralogy of diagenetically altered volcanoclastic ashes of Palaeozoic age; aragonites, constituting shells of Macoma and Cerastoderma from the Baltic Sea; and bioapatites, Recent and fossil. To study such mineralogical constants as lattice parameters, microstrains content and crystallites size, original software is developed. Basically, by whole-pattern fitting of XRD patterns by different profile-shape functions (usually, the modified Lorenzian profile used), specific solutions are constructed for such minerals, as feldspars, carbonates (hexagonal and rhombic, both) and apatites of different origin. Chemical studies are conducted, using XRF technique and VRA-30 analyser. The laboratory has joined with the international intercalibration programme (EnviPT-2), and has succeeded to pass the criterions of ISO 5725 for As, Co, Cr, Pb, V and Zn. For all other elements, heavier than Na, the intercalibration programme is still in work. Laboratory of Physical Investigations carries out a wide spectrum of activities to provide state and municipal institutions, such as environmental services, custom and police organisations with analyses, most commonly of unique character. Also, there is a certain circle of elements, which analyses in the laboratory are precise enough (Cr, Mn, Ni, Co, Sr, Ru, Ro, Pd, Os, Ir, Pt, Au, Ag) to satisfy the technological demands of private companies.

* * *

Micropalaeontology Laboratory

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Micropalaeontological investigations constitute an important part of the traditional palaeontological research at the Institute. The main groups of microfossils commonly extracted and/or studied include chitinozoans, conodonts, graptolites, vertebrates microremains, and ostracods – groups that play a major role in Lower Palaeozoic biostratigraphy.

The biostratigraphical dating methods are highly rated and frequently utilised to provide the temporal background for sedimentological, geochemical and other studies not directly related to palaeontology. Moreover, even some questions not directly related to geology can be answered on the basis of microfossil content. A good example is dating of building limestones.

Setup of the micropalaeontology laboratory is best suited for extraction of microfossils from carbonate and clayey rocks, which are prevailing in the Lower Palaeozoic strata of the Baltic region. The main methods used in this laboratory include:

(1) acid digestion, particularly with acetic- and weak hydrochloric acid, for extracting organic or phosphatic remains; (2) disintegration with hydrogen peroxide and sodium-hyposulphite, for carbonaceous as well as other fossils; (3) separation and concentration, primarily using heavy liquids and sieving.

* * *

The Earth Processes Modelling Laboratory

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Most geological processes occur on time and length scales and under conditions that are impossible or very expensive to achieve in laboratory. Significant progress in our understanding of geological processes has been achieved by simulating these processes both by numerical experiments and by physical experiments with analogue materials. Experimentation is most powerful when both numerical and physical experiments are combined. At the moment the Earth Processes Modelling Laboratory (EPML) involves both analogue and computer modelling approaches to study:

(1) Igneous processes from partial melting to crystallisation, including mantle and crustal melting, melt accumulation, emplacement and pluton formation.

(2) (a) Interaction. Melt/fluid-rock interaction, with particular attention to the microstructural factors that play a role in such processes. (b) Transport. The way in which fluids (melt, magma, acquous fluids, oil, gas) moves through a rock and accumulates over up to more than 20 orders of magnitude from source to emplacement. Migmatite and dyke formation.

(3) Chaos and scale-invariant or self-similar phenomena in fluid-rock systems, focusing at the system characteristics that follow from the mechanisms that are subject of (1) and (2). These research directions include international cooperation with scientists from a number of universities.

Numerical modelling. Numerical modelling includes both traditional geochemical modelling and novel numerical modelling techniques. The base for the modelling of transport and accumulation phenomena will be the codes PISTON, MELTPOCKET and ELLE. Although these models originally model the physics of transport and accumulation, they can incorporate chemical processes as well. For this purpose, they will be linked with the geochemical and thermodynamic modelling packages, for instance MELTS (Ghiorso & Sack, 1995). Analogue modelling. Classical chemistry and thermodynamics can usually accurately tell what reactions would occur, but experiments are needed to see how these reactions occur in a rock. “Meso-scale” experiments are aimed at the simulation of larger scale systems, ranging from dm/m-scale partial melt systems (migmatites) to km-scale ascent through the crust or mantle. These experiments are done in semi-2D (plexi-) glass tanks in which the system that is to be studied is “rebuilt”, with appropriate scaling and analogue materials such as sand or gelatine, and when possible partially molten rock analogues.

* * *

Laboratory of Isotope-Palaeoclimatology

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The history of the Laboratory of Isotope-Palaeoclimatology goes back to the late 1960s, when the laboratory of ^{14}C dating was established in the Department of Quaternary Geology. In the early 1970s, the mass-spectrometry laboratory and the laboratory of TL dating were started. On the basis of those research groups, the laboratory of isotope geology as a separate structural unit within the Institute of Geology was established in 1975. To reflect more precisely the main research trends of this group, the laboratory was renamed in 1996; its present name is the Laboratory of Isotope-Palaeoclimatology. Although since the early 1990s, the Laboratory of Radiometric Dating, has formally been a separate research unit within the Department of Quaternary Geology, since 1997 both laboratories have worked together in the frame of a target-financed project, because for both groups the main research direction has been the development and application of physical and geochemical methods in the study of the Quaternary palaeoclimate and palaeoenvironment.

The main research fields in the laboratory

are isotope-palaeoclimatology, palaeocryology and palaeohydrology; application of isotopic methods in Palaeozoic stratigraphy, climatology and oceanology. An important mission of the laboratory is to propagate the possibilities and advantages of the application of modern physical and isotope-geochemical methods in the reasearch of earth sciences in Estonia.

The laboratory is based on modern analytical technique, the most important instruments are:
(1) Finnigan MAT Delta E mass-spectrometer for isotope analyses of light elements (H, C, N, O, S), equipped with relevant sample preparation lines.
(2) ^{14}C analyser based on liquid-scintillation counter and relevant sample preparation laboratory;
(3) ion-liquid chromatograph IVK-21;

* * *

Research Laboratory for Quaternary Geochronology

Contact: **Anatoli Molodkov**, molodkov@gi.ee, (+372) 645 46 54.

Since the mid-1970s the laboratory has been engaged in research in the field of luminescence, and since the early1980s – in research in the field of ESR dating of mollusc fossils. As a result, new versions of ESR/OSL techniques have been developed in the recent years for age determinations of marine, freshwater and terrestrial mollusc shells and enclosing deposits.

Now the Tallinn Research Laboratory for Quaternary Geochronology (RLQG) is one of the very few in the Western and Central European countries as well as in the former Soviet Union , which can provide at least three up-to-date Radiation Exposure Dating Methods – Electron-Spin-Resonance (ESR), Thermally- and Optically- (infrared-light) Stimulated Luminescence (TL, OSL). A new promising optically stimulated afterglow (OSA) method is currently under development. Together they are applicable over a time range from about hundred years to almost a million years on various naturally occurring minerals: biogenic carbonates, such as terrestrial, freshwater and marine mollusc shells, corals (by ESR), and minerals (quartz and feldspar) common in aeolian (e.g., sand dunes, loess) and waterlain (e.g. fluvial, lacustrine, marine) deposits (by TL and OSL). Combined use of the above-mentioned methods is enormously valuable because it can provide an independent age estimation for Quaternary deposits and cross check often urgently needed to estimate the reliability of the dates obtained.

ESR/OSL are described as Radiation Exposure Dating Methods because each is used to determine the total radiation dose absorbed by a mineral since it was last exposed to a "clock-resetting" event. For luminescence dating of sediments the clock-resetting event is the exposure to sunlight which sediment grains undergo during transport and the process of sedimentation. The ESR signal is not affected by exposure to ordinary light. The "clock-resetting event" in ESR is the creation of a mineral, e.g. the growth of shell skeleton by molluscs.

The main trend of the research activity, the laboratory has long been engaged in, is the OSL and mollusc-based ESR-study of Quaternary sedimentary dynamics and environmental changes in the Northern Eurasia (including the high-Arctic) region. The major goal of the work is to establish the periodicity and chronology of the main Quaternary events and their relationship with changes in the level of marginal seas and inland bodies of water, to create a network of reference datings for regional, interregional and transboundary correlations and to provide the linkage between marine and terrestrial data sets.

The research in the field of Mid- Late Pleistocene ESR/OSL-geochronology combined with sedimentology, palynology, diatom analysis, etc., remains to be a highly important tool for chronostratigraphic studies on the vast territories of Eurasian north, especially when the age of the sample is greater than the 40-

50,000 year limit of radiocarbon dating.
Main facilities at the RLQG
(1) Electron-spin-resonance (ESR) ERS-221 type spectrometer (X- and Q-band);
(2) Computer-controlled Ingrid-type SLM-1 thermally- (TL) and optically stimulated luminescence (OSL) reader equipped with IR laser stimulation;
(3) Gamma-spectrometer (for measurement of uranium, thorium and potassium content in sediments);
(4) Optical high resolution spectrometers for absorption measurements in the near-IR-vis-UV ranges;
(5) X-ray-, beta- and gamma sources of irradiation.
(6) Specialised chemical laboratory for preparation of samples for ESR, OSL and TL analyses;
(7) Specialised laboratories for luminescence, resonance and radiometric measurements and irradiation;
(8) Darkroom laboratory for luminescence analysis.

* * *

Laboratory of Holocene Geology

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The main aims of the laboratory are paleoenvironmental, paleoclimatic and paleogeographic reconstructions. Changes of vegetation are recorded by means of multidisciplinary methods involving pollen and diatom analysis, geochemistry, etc. Methods are developed for quantification of proxy records and modelling vegetation changes related to climate and human impact. The time span covered is mainly the Holocene, involving prehistoric as well as historic and modern time.

The Laboratory of Holocene Geology has a long experience and is well equipped for coring and subsampling of lake and bog sediment sequences. Over 10-m long sediment cores can be obtained with the coring depth up to 30 m of water using our devices. Also for unconsolidated topmost sediments freeze crust corer and piston corer are in use. Our laboratory is equipped for preparation of biostratigraphic sediment analyses (pollen, diatoms, etc.) and with research standard microscopes for both pollen and diatom analyses and has a complete range of diatom floras for N Europe.

Both fundamental and applied research is included in the research program of the laboratory. The instrumental record of the impact of climate change on the environment is too short to capture the whole range of climatic variability. Therefore geological records should be investigated and different proxy data should be produced in order to elaborate a reliable reconstruction of the past shifts in the climate outside the historically documented range. Research priority has been given to continuous high resolution natural records with annual to decadal time resolution (annually lake sediments). Our sediment studies are timely with respect to recent initiatives of global change IGBP/PAGES programs HITE (Human Impact on Terrestrial Ecosystems), LIMPACS (Human Impact on Lake Ecosystems), PEP III (Pole-Equator-Pole Europe Africa Transect), and European Science Foundation projects HOLIVAR (Holocene Climate Variability) and European Lake Drilling Project. The research is also linked to the Nordic scientific programs, e.g. LAMSCAN (Detecting rapid environmental changes through studies of annually laminated lake sediments in northern Scandinavia) set-up under the Nordic Council of Ministers Nordic Arctic Research Programme, POLLANDCAL (POLlen LANDscape CALibration) and FIGARE (Finnish Global Change Research Programme).

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Collections

The Institute of Geology holds the largest geological collections in Estonia. Particularly well represented are Lower- and Middle Palaeozoic fossil invertebrates and vertebrates from the Baltic region and former Soviet Union areas. The total number of individual items reaches to several hundreds of thousands palaeontological, mineralogical and petrological specimens complemented with more than 300 drillcores and many rock samples collected for future study.

The main collections of fossils, minerals, rocks and meteorites are stored in the Institute's building in Tallinn, wheareas drillcores and rock samples are kept at the Särghaua field-station in Central Estonia. All of them are being used for every-day research carried out at the Institute as well as by many researchers from outside the Institute and from abroad.

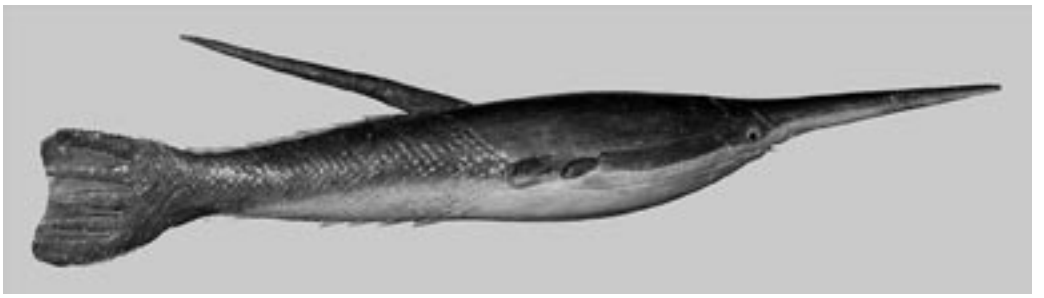
The research and development plan of Tallinn Technical University for the years 2001 to 2005 includes establishment of publicly accessible geological museum based on the rich collections of the Institute of Geology. By the end of 2003, however, the plans of movement of the Institute to a new location were still obscure, and so were the ideas about suitable display area for the collections.

The Department of Geological and Palaeontological Collections was formed at the Institute in 2001. As of 2003, it consists of full-time keeper (Ursula Toom) and a curator (Aasa Aaloe), but several other people, including some students, have also contributed to curatorial activities.

The main priorities in the collections management in 2003 were continuing re-packaging, re-labelling, ordering and electronic registration of old collections in Tallinn and at Särghaua field-station. At Särghaua, efforts were also put into enhancing the value of drill-cores by marking, photographing, ordering and re-boxing wherever necessary, and box-by-box registration in database.

Staff of the Department of Scientific Collections is trained in lifting large specimens. In this photo, curator A. Aaloe is carrying a huge brachiopod in the collection storage. *Photo by G. Baranov.*

Putting this into numbers, more than 23000



Life-size models of the Devonian fishes, made by Elga Mark-Kurik were exposed this year for 4 month in the Latvian Museum of Natural History, Riga. Figured model is that of the heterostracan *Rhinopteraspis dunensis* (more than 60 cm long).

Former Prime Minister of Estonia, Mart Laar visited the geological exhibition at the Kunda Museum organised by the Instiute's staff. *Photo by H. Pärnaste.*

records of individual items were added into the database during 2003. This takes the total number of registered items to over 76000. Also some 400 drill-core boxes were photographed and appropriately registered.

A part of the database is accessible on-line at the collections' website (http://sarv.gi.ee/), but the interface is still experimental and cannot be fully implemented due to major hardware deficiencies. The in-house developed client-server database system has proved, however, very stable and efficient since the conversion to MySQL database software in 2002.

It is noteworthy that, as the first institution in Estonia and one of the firsts in Europe, the Institute joined the all-European BioCASE (Biological Collection Access Service for Europe) network that will provide a single interface for accessing unit-level data from multiple collection holders in different locations and countries. The system works using wrappers at each data providers' site that translate data requests to SQL queries against local databases and return data in standardised XML output that in turn can be understood by the common query tool. This network will greatly facilitate usage of biological and palaeontological information by scientists and other people who might need that for their work or for personal interests.

It should also be noted that the Estonian Museum of Natural History started to implement and test the same data model and software bundle to be used in the department of geology. An agreement was signed by both institutions to further tighten collaborative efforts in the field of electronic databasing. If the test period will be successful, then a common approach will result in simplified data exchange, reduce duplicating in data entry and increase overall accessibility and usability of Estonian geological collections within the country and abroad.

After several discussions the main curatorial policies were formulated at the Institute and affirmed by director's decree in 2003. Several principles were taken over from the corresponding documents of the Natural History Museum, London. For example, ordinary loans may now be requested for one-year period and may be extended for another year if absolutely necessary; one registered loan may not contain more than five type specimens; valuable specimens have to be covered by insurance, etc.

Another important step for the Institute's collections was that a small display of common rocks and fossils in Estonia complemented with appropriate photos of geological sites, maps,

A silurian trilobite *Calymene* from the Institute's collections. *Photo by G. Baranov.*

etc. was organised at Särghaua field-station. Since the field-station is being frequently used by students and many other people without deeper knowledge in Estonian geology, this small display turns invaluable for teaching and publicising geology.

In 2003, a temporary geological exhibition was also prepared and displayed at the Kunda City Museum. It was actively visited, especially by schoolchildren, and the staff of the Department gave several lectures on the outline of Estonian geology and general palaeontology there.

As part of the Gross Symposium held in Riga, Latvia, in September, an exhibition of selected specimens from the unique collection of models of Palaeozoic fishes made by E. Kurik was opened at the Latvian Museum of Natural History. This exhibition will stay open for public access until the beginning of 2004.

A small geological display was opened in 2003 at Särghaua field-station. *Photo by G. Baranov.* ↑

The Instiute's drill cores were used to teach young geologists to describe rock successions in core sections. Photo taken at Särghaua field-station during summer meeting of the Movement of Estonian Young Geologists. *Photo by G. Baranov*. →

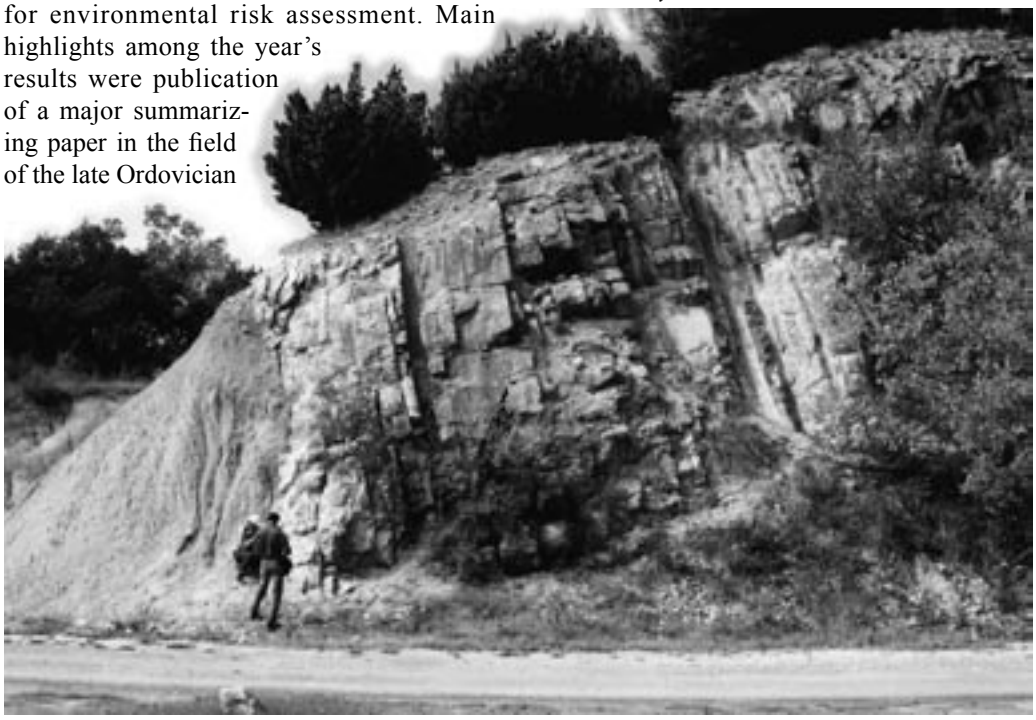
Research

Bedrock Geology

The bedrock of Estonia consists of Proterozoic crystalline basement and mainly Palaeozoic sedimentary cover (Vendian–Devonian). The latter is very weakly metamorphized and tectonized, but rich in well preserved fossils. Correspondingly, palaeontology, stratigraphy, lithology, mineralogy, petrography, partly geotectonics and geophysics, and in recent years isotope geology have been main research fields in the bedrock geology of Estonia. Many research projects in progress under the Bedrock Geology Department embrace besides the Estonian material also that of different regions of the world (e.g., Arctic Canada and USA, Poland and Scandinavia, Siberia and Sub-Poral Urals a.o.) and are carried out as bilateral joint studies with colleagues from foreign countries or as cooperation items in the framework of wider international programmes (e.g., IGCP).

In 2003 these trends were accomplished through three target-financed projects, nine Estonian Science Foundation grants and one Estonian - Norwegian co-operation grant for environmental risk assessment. Main highlights among the year's results were publication of a major summarizing paper in the field of the late Ordovician isotope geology (Brenchley *et al*., 2003), and several papers by T. Märss and by E. Mark-Kurik (both with co-authors) describing new early vertebrate taxa from different regions of the Northern Hemisphere. Good progress in trilobite studies is marked by the paper by H. Pärnaste (2003) about *Krattaspis*. An important result that improves classification and correlation of the Llandovery – lower Wenlock rocks was achieved by integrated biostratigraphical studies of chitinozoans, conodonts and graptolites (Loydell *et al*., 2003). The paper by Bons and Soesoo (2003) should be noted as the first one marking the beginning of work of the new earth processes modelling laboratory. Studies in sedimentary cyclicity (Nestor *et al*., 2003) and secondary dolomitization (Teedumäe *et al*., 2003) of the lower Silurian rocks continue to provide new interesting results.

Not just the Baltic sections, but also those on other continents are attracting our researchers. Ordovician/Silurian boundary in Turner Falls section of the Arbuckle Mountains, Oklahoma, USA, was sampled for chitinozoans in 2003. *Photo by J. Nõlvak.*



Late Ordovician and Silurian marine ecosystems in the NW part of the Baltica continent and their role in the progress of geology

Target Financed Research Programme No. 0331760s01
Project leader: **D. Kaljo**
Team: T. Märss, V. Nestor, H. Nestor, T. Martma, M. Mõtus, T. Klaos, E. Mark-Kurik
Duration: 2001–2005

The main idea of the project is to apply the ecosystem concept in studies of the geological history of the NW part of the Baltica continent, which makes possible to integrate into a whole complex different aspects of the basin evolution, including facies - palaeogeographical and palaeoecological, geological - sedimentological and oceanological - climatological. For such a many-sided research a set of lithofacies - palaeogeographical base maps (16) will be compiled, where also other data are shown. This set of maps allows to study different aspects of the basin evolution both in time and space concurrently. Sedimentary cyclicity, eustatic changes, detailed lithology of certain intervals, carbon and oxygen isotopes will be also investigated. Studies in taxonomy, evolution and distribution of corals, stromatoporoids, vertebrates, chitinozoans should give an understanding of the living component of the palaeoecosystems. The results of the project will be used in applied and theoretical geology, university curriculae in particular.

In 2003, the following most essential results were achieved (see also corresponding grants and publications):

(1) Rugose coral diversity is positively correlated with the warming of the late Ordovician climate, but this can be overshadowed by eustatic changes (D. Kaljo). Intraspecific variation of tabulates depends mostly on sea bottom conditions (M.-A. Mõtus). Taxonomic content of scolecodonts in the Wenlock, Ludlow and Pridoli in 20 outcrops on Saaremaa Island was identified (O. Hints).

(2) Late Ordovician carbon isotope data showing an alternation of arid and humid climatic episodes were summarized. Isotope stratigraphy and bioevents of the Hirnantian glaciation and the Silurian oceanic cyclicity were published (Brenchley *et al*., Kaljo et al.)

(3) Lime-mud accumulation cycles in the Raikküla Stage were found to have formed in the conditions of arid climate during an icehouse period in the latest Ordovician and earliest Silurian (H. Nestor et al.). Conodont and chitinozoan biozonations and their correlation with graptolite zones were improved (V. Nestor, P. Männik).

(4) Taxonomy and taphonomy of early vertebrates were studied. A monograph on Silurian and Early Devonian thelodonts and chondrichtyans of the Canadian Arctic was completed. Sedimentation and taphonomy of the *Phlebolepis*-bearing beds were analyzed (T. Märss et al.). A new early Devonian arthrodire genus *Uralosteus* was established (E. Mark-Kurik).

* * *

Evolution of communities of Silurian corals and jawed polychaetes of Estonia and its climatic and oceanic agents based on isotope analysis

Estonian Science Foundation Grant No. 5042
Project leader: **D. Kaljo**
Team: O. Hints, T. Martma, M. Mõtus
Duration: 2002–2004

The project is aimed at elucidating evolutionary patterns of coral communities (rugosans and tabulates) and jawed polychaetes and finding out the role of biotic and abiotic agents in evolution processes. Very important is the applied aspect of the project, i.e. accumulation of bio- and isotope stratigraphy data for solving different problems of geology. In order to achieve these goals, the following studies are planned:

(1) Revision of assemblage content of rugose and tabulate corals, modernisation of the taxonomy used earlier, filling of gaps, description of new taxa; compilation of a list of jawed polychaete taxa together with corresponding taxonomical study. Establishment of stratigraphical ranges of all taxa of both groups.

(2) Study of spatial distribution, diversity

patterns and development of rugose coral- and jawed polychaete communities; investigation of relationships between the two fossil groups and other fossil organisms.

(3) Study of changes of carbon and oxygen stable isotope content in order to estimate climatic and oceanic parameters, and to use environmental events for chronostratigraphical correlation. The same stratigraphical interval and the same sections as mentioned in items 1 & 2 will be studied. In addition, the rocks formed in relatively deep water environments and containing seldom or no corals and polychaetes will be studied to correlate coral and polychaete bearing rocks with graptolite biozonation.

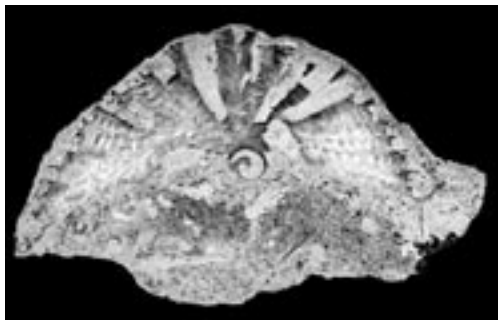
(4) Interpretation of integrated palaeontological and geochemical data, which will, on the one hand, reveal the trends of biological evolution and development of communities of both fossil groups. On the other hand, the expected results include palaeoclimatic and palaeooceanic conclusions on the evolution of the Baltic Basin.

In 2003, the following most essential results were achieved (see also the list of publications):

(1) In the study of the evolution of coral communities the dependence of their diversity pattern on environmental conditions was analysed. The first diversity maximum was reached in the mid-Caradoc and the second one in the late Ashgill. Changes in rugose coral diversity are well correlated with warming or cooling of the late Ordovician climate, but eustatic changes causing the origination of suitable habitats are also of great importance (Kaljo, 2003). Richness and intraspecific variation of tabulate corals depend mostly on water dynamics and sea bottom character. This pattern was studied on Saaremaa Island, in the reef facies outcrop of Liiva cliff where dominant species show a clear correlation in morphology and environmental parametres (Mõtus, 2003).

(2) The taxonomic composition of Silurian jawed polychaetes from 20 outcrops on Saaremaa Island was established. Among nearly 50 species recovered, representatives of genera *Kettnerites* and *Oenonites*, and at some levels also e.g., *Vistulella* dominate. As compared with the Baltic Ordovician polychaete fauna, the studied Silurian assemblages tend to be generally less diverse, though the relative abundance of scolecodonts is very high at some levels. Several typical Silurian families (Paulinitidae, Hadoprionidae and Atraktoprionidae) are very rare or missing from the Ordovician. Quantitative data show great biofacies differences in fossil distribution, especially in the Paadla Stage. Comparison of scolecodont assemblages of Saaremaa and Gotland reveals great similarities in taxonomic content and abundance, but due to several gaps in Estonian sections not all the species known in Gotland were found in Saaremaa (O. Hints).

(3) Environmental parameters of the ecosystem evolution were studied using carbon isotopes. A rich data set from the late Ordovician was summarized (Kaljo et al. accepted). A 10 Ma long period of minor isotopic shifts (2–2.5‰) and a short (2 Ma) but strong excursion (4–6‰) at the end of the Ordovician were identified. The latter is interpreted as an implication of the Gondwana glaciation. These positive shifts do not correlate with the lithologies of the corresponding rocks, which refers to more general reasons for changes. Considering different data, an alternation of arid and humid climatic episodes was suggested. Two papers on the isotope stratigraphy and bioevents of the Hirnantian glaciation (Brenchley *et al*., 2003) and on the Silurian oceanic cyclicity (Kaljo *et al*., 2003) were published.



Silurian tabulate coral *Favosites jaaniensis* from Saaremaa attached to a gastropod indicates that the planula had to find a firm substrate in muddy bottom to start growing.

Boundaries, stratotypes, and integrated stratigraphy of the Wenlock Series in the northern East Baltic, and correlation with adjacent regions

Estonian Science Foundation Grant No. 5088
Project leader: **H. Nestor**
Team: R. Einasto, P. Männik, V. Nestor, V. Viira
Duration: 2002–2004

Basing on the correlation of zonal successions of stratigraphically important groups of fossils (conodonts, chitinozoans, graptolites and others), the position of the boundaries of the Wenlock Series will be established in key sections of the northern East Baltic. This will contribute to the determination of the series boundaries in other regions and to the composition of the global integrated biozonal standard for the Wenlock time interval. Stratigraphical classification and nomenclature of the Wenlock strata will be revised on the ground of complex bio- and lithostratigraphical investigations of type sections of regional stages and formations. The investigations will contribute to stabilization of the Wenlock regional stratigraphy, which forms a temporal-spatial framework for linkage of results of different geological investigations, and for creation of data bases.

Main results in 2003:

Investigation of the distribution of conodonts (P. Männik) and chitinozoans (V. Nestor) in several drill cores (Ruhnu, Aizpute, Ikla, Heimtali, Põltsamaa) enabled to improve regional biozonal standards of conodonts and chitinozoans and their integration with graptolite zones. V. Nestor subdivided the Silurian sequence into 26 chitinozoan biozones and established four new zones. An extensive stratigraphical hiatus was established at the Llandovery/Wenlock boundary. Correlation by conodonts demonstrated that the lower limit of the Wenlock in its type section lies not at the base of the *Cyrtograptus centrifugus* graptolite zone as commonly accepted, but stratigraphically much higher, at the level of the *C. murchisoni* graptolite zone. It raises a need to revise the position of the lower boundary of the Wenlock Series in graptolite sequences of other regions.

Analysis of new and previous data (H. Nestor and V. Nestor) allowed to re-estimate the position of the Adavere Regional Stage according to the international stratigraphical standard. The analysis confirms that the Adavere Stage is limited from both sides by subregional stratigraphical gaps of glacio-eustatic origin. The boundaries of the stage roughly coincide with the limits of the Telychian Global Stage and lie at the base of the *Rastrites linnaei* and *Cyrtograptus murchisoni* graptolite zones, respectively.

Investigation of the conodont fauna (V. Viira) and cyclostratigraphic analysis (R. Einasto) of the Wenlock-Ludlow boundary beds in Saaremaa Island confirmed that the conodont fauna in the Soeginina Beds, hitherto included in the Rootsiküla Stage, is identical with the conodont fauna from the Sauvere Beds of the Paadla Stage. A remarkable stratigraphical gap was established in western Saaremaa at the base of the Soeginina Beds. It impels to displacement of the Soeginina Beds from the Rootsiküla Stage to the Paadla Stage and their correlation with the base of the Ludlow Series.

H. Nestor and R. Einasto described the sedimentary cyclicity in the Raikküla, Nurmekund and Saarde formations of the Raikküla Stage and found that pure micritic limestones, cyclically interbedding with more argillaceous bioclastic limestones or marlstones, have synchronous boundaries and probably reflect alternation of arid and humid climatic states. Such abrupt cyclical climatic changes are characteristic of a long-term global cooling or icehouse periods. Thus the sedimentary cyclicity of lime-mud accumulation confirms the existence of a longer icehouse period in the late Ordovician and early Silurian contested by a part of investigators.

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Ordovician-Silurian stratigraphical schemes: analyse and improvement of global and Baltic regional units based on high-resolution biostratigraphy, isotope geology and sequence stratigraphy

Target Financed Research Programme No. 0332524s03
Project leader: **L. Hints**
Team: O. Hints, P. Männik, J. Nõlvak, H. Pärnaste, V. Viira
Duration: 2003–2007

Recent progress in stratigraphy is best expressed through the improvement of correlation charts and introduction of new stratigraphical units or revision of the existing units based on standard principles and geochronology. The goal of this project is to employ recent achievements in regional and global geology to revise regional correlation charts using, wherever feasible, internationally recommended principles and procedures. The focus is also on conodont and chitinozoan biozonations, which will be improved using proper taxonomy and evolutionary lineages. The correlation of regional units with new global standards will also be analysed and refined.

In 2003, investigation of the boundary interval of the global Middle and Upper Ordovician series in Estonia started. Most importantly, the graptolite *Nemagraptus gracilis*, whose appearance is used globally to mark the lower boundary of the Upper Ordovician, was positively identified from 10 boreholes in Estonia and Latvia for the first time.

Also, two new outcrop sections covering the Uhaku-Kukruse boundary interval were sampled for microfossil study (chitinozoans, conodonts, scolecodonts), and a promising analysis of that material is currently in progress.

The study of lithofacies differentiation and biostratigraphy of the Pirgu and Porkuni stages (that correspond to the sixth global stage) concentrated on the improvement of the chitinozoan biozonation. The distribution of brachiopods points to the fact that the pre-Pirguan faunal change may contribute to the identification of the boundary between the fifth and sixth global stages as well as the boundary between British Caradoc and Ashgill series in Baltic sections.

With the primary aim of clarification of several biozone boundaries in relation to the boundary between Uhaku and Kukruse stages, a section was sampled in the working oil-shale mine "Kohtla". *Photo by G. Baranov.*

New data on organic-walled microfossils were acquired from the Hunneberg Stage. A rich assemblage of chitinozoans recovered may turn a useful correlation criterion for the base of the second global stage of the Ordovician, which is defined in the Diabasbrottet section in Sweden. Also, some of the oldest known scolecodonts were recovered from that interval.

The study of chitinozoans and conodonts in the Ruhnu (500) borehole section resulted

Excavation of the new Museum of Art in Tallinn provided an excellent outcrop for Ordovician research. *Photo by G. Baranov.*

in a detailed biostratigraphical subdivision of the section. For the first time, the *A. ventilatus* conodont Zone was distinguished in the East Baltic and the *A. superbus* conodont Zone was recorded with its full vertical extent.

The distribution of conodonts in the North American Barn Hills section indicated an Ordovician age of some beds included into the Silurian thus far. The isotopic data on the uppermost Ordovician of Estonia and North America have been used in the comparison of changes in the environments of two palaeocontinents.

A new conodont association in the Wenlock-Ludlow boundary interval in Saaremaa indicates the occurrence of beds that are missing in many other sections. A new unit, the Anikaitse Beds, was establised for these strata.

The taxonomic study of the conodonts *Wallserodus* in North America and Estonia showed that this characteristic Silurian genus appeared in the latter area already in the Middle Ordovician (in the Lasnamägi Stage).

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The Baltic faunal province and development of its biota in the Ordovician

Estonian Science Foundation Grant No. 4674
Project leader: **L. Hints**
Team: O. Hints, J. Nõlvak, H. Pärnaste, V. Viira
Duration: 2001–2003

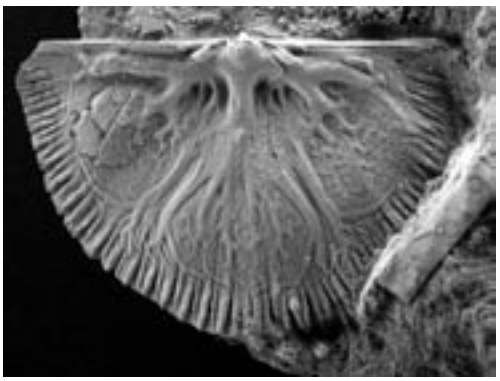
Distinctive composition of Ordovician communities of the Baltic palaeobasin, North Estonian areas in particular, has enabled establishing the Baltic faunal province as one of the main faunal provinces in the Ordovician. The aim of the present project is to study the characteristics and development of the Baltic faunas with primary stress on brachiopods, trilobites and several microfossil groups.

The main results of the project in 2003 can be summarised as follows:

Brachiopods of the family Grorudiidae were studied in collaboration with D.A.T. Harper. New Middle Ordovician specimens from Latvia and Öland were compared with the original material of *Grorudia* and *Alwynella* from Norway. This revealed that the two names cannot be considered synonymous, as proposed by some authors. Grorudiids appeared to be characteristic of the deeper water environments of the Baltic Basin, and missing in North Estonian brachiopod faunas. Other representatives of this family are known mostly from China and Australia.

Continuing study of the latest Ordovician brachiopods revealed that the *Hirnantia*-fauna in the Baltic area is most diverse in the lower half of the Porkuni Stage where isotopic data indicate a significant environmental change. The decrease in the diversity of this cosmopolitian fauna is marked by the disappearance of the most characteristic species, the youngest association being represented by lingulates and/or small rhyncholelloideans.

The revision of two trilobite genera, *Krattaspis* and *Reraspis*, of the subfamily Cyrthometopinae allowed a new interpretation of the subfamily. Also, new diagnoses for both genera were provided and two new species of *Krattaspis* described. The new opinions on the systematics of cheirurids were based on the study of juvenile specimens. Also, new methods of measurements enabled revealing new features with high diagnostic value and distinguish them from the characteristics that depend on habitats. It appears that the oldest cyrtometopid trilobites belong to the Baltic



Brachiopod genus *Cyrtonotella* constitutes a typical element of Baltic Ordovician shallow shelf faunas.

fauna, though the family spread fast to other basins as well.

The new data on the conodont composition and distribution enabled establishing the Cambrian-Ordovician boundary in the NE Estonian sections. The lowermost zonal conodont *Iapetognathus* appeared in the upper part of the Rannu Member of the Kallavere Formation.

The study of some Lower and lower Middle Ordovician sections in North Estonia (Tallinn and Pakri) revealed the occurrence of scolecodonts in the Pakerort, Varangu and Hunneberg stages. The hitherto known oldest polychaete jaws in the Baltica continent were those from the Volkhov Stage. Thus, the known stratigraphical range of the group in Baltica was extended nearly 20 million years. Being also among the oldest records on jawed polychates, these finds contribute to the understanding of global distribution and diversification of the whole group. Especially important is the Hunnebergian assemblage, which may contain a link between some families common in younger strata.

The study of North American chitinozoans from several Midcontinent sections revealed that the Laurentian chitinozoan faunas were clearly distinct from those of Baltica. At some levels, however, rapid changes in faunas seemed to take place simultaneously in both continents.

Tremadocian samples from the Museum of Art excavation in Tallinn yielded the oldest Baltic scolecodonts, whilst Hunnebergian rocks were rich also in chitinozoans Photo by G. Baranov.

There were also episodes of immigration when some Laurentian forms invaded Baltica.

Chitinozoans and graptoloids provided an important biostratigraphical background for the project and in its framework the Baltic chitinozoan zonation was also further enhanced.

Reconstruction of cyrtometopine trilobite *Krattaspis popovi* Pärnaste, 2003. The Baltic representatives of this genus are the oldest known cheirurids in the world. *Drawing by H. Pärnaste.*

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Lower Silurian conodonts — evolution, associations and palaeoecology, and application in high-resolution stratigraphy

Estonian Science Foundation Grant No. 5406
Project leader: **P. Männik**
Duration: 2003–2006

The project is planned as a palaeontological-biostratigraphical research. The studies will mainly be based on collections from Estonia but information from other regions will be essential. The success of the project will depend greatly upon cooperation with specialists working with conodonts in other regions (direct comparison of collections, discussions, consultations, joint studies and publications, use of some special laboratory equipment, etc.). Also, consultations with students of other specialities (sedimentology, geochemistry, etc.) will provide valuable additional information allowing evaluation of the stratigraphical and palaeoecological conclusions based on the distribution of faunas, finding out relations beween taxonomically different associations of faunas, interpretation of environmental conditions, etc.

The project has two main aims: 1) taxonomic revision of the Lower Silurian conodonts and monographic description of the faunas from Estonia, and 2) characterization of the evolution of selected evolutionary lineages of taxa as well as faunas in general based on the taxonomic and palaeoecological analysis of the

Lower Silurian conodont faunas, and based on these data, the evaluation and updating of the biozonal scheme.

The expected results of the project will be the revised taxonomy and detailed descriptions of Lower Silurian conodonts from Estonia; characterization and description of general and specific features in the evolution of the Lower Silurian conodont faunas; characterization of the palaeoecological associations of conodonts, their distribution in time and space, and their relations to particular environmental conditions; revised and updated biozonation and reliable criteria for regional and global correlations; evaluation of the data available, their continuity or discontinuity and the possible reasons for this.

Main results in 2003:

(1) The earlier conclusion that only two species of *Walliserodus* occur in the Telychian-Sheinwoodian interval in the Baltic was proved. (2) *Walliserodus* existed already in the Llanvirn time. (3) *A. tvaerensis* became extinct at the end of the Idavere time and, accordingly, the upper boundary of the *A. tvaerensis* Biozone in Estonia lies in the middle part of the Haljala Stage. (4) *A. superbus* appears in the lowermost Rakvere Stage. (5) The *A. tvaerensis* and *A. superbus* biozones are separated by an interval the upper part of which (the Oandu Stage) corresponds to the *A. ventilatus* Biozone. The lower part of this interval is characterized by the dominance of several simple-cone taxa and by extremely rare occurrence of *Amorphognathus*. No biozone can be recognized in this interval at the moment. (6) The 1st and 2nd datums of the Mulde Event were recognized in the Ruhnu core section. Also, the only specimen of *Oz. sagitta sagitta* known so far in Estonia was found in this section. (7) The conodont faunas in the Barn Hills section (Utah, USA) are almost identical to those known from the interval of the same age in the Baltic. (8) The Ordovician-Silurian boundary in the Barn Hills section lies about 10 m higher than considered up till now. (9) The fauna of Silurian conodonts in the Central Urals differs little from that known from the Baltic.

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Evolution of composition and properties of rocks in the Baltic sedimentary cover: geochemical, mineralogical and petrophysical aspects and modelling

Target Financed Research Programme No. 0332088s02
Project leader: **A. Shogenova**
Team: L. Bityukova, R. Einasto, T. Kallaste, E. Kiipli, A. Kleesment, M. Konsa, T. Linkova, J. Nemliher, A. Teedumäe, R. Vaher
Duration: 2002–2006

The main purpose of the project is to study the composition and properties of the late Proterozoic and Palaeozoic sedimentary rocks and to clarify their diagenetic history in the different facies zones and in local structures using the available and new geochemical, mineralogical and petrophysical data.

The results of the comparative study of Baltic glauconite-bearing rocks of different lithology from five countries and Cambrian siliciclastic rocks from three countries were published (Shogenova, *et al*., 2003; Šliaupa *et al*., 2003). The factors influencing the reservoir quality of rocks were revealed. It was found that the Cambrian rocks from East and North of the Baltic Basin (Estonia) have the highest reservoir quality; it decreases in central Latvia and is lowest in western Lithuania, while temperatures of Cambrian waters and prospective for geothermal energy recovery increase to the West (Šliaupa *et al*., 2003). The study of zircon from the lowermost sedimentary cover of Estonia and NW Latvia showed that the provenance areas for the Vendian/Cambrian clastic sedimentation on the East European Craton are located outside its present position (Konsa & Puura, 2003). The geochemical and mineralogical analyses of black shales and red-coloured rocks showed a bioproductivity rise in the mid-Llandovery and decrease in the late Llandovery.

The composition of the 95 Devonian rock samples studied from 5 southern boreholes is determined by the proportion between dolomite and insoluble residue. The properties depend on the mineral composition and either on porosity (density, electric, thermal and elastic), or/and total iron content (magnetic and thermal properties). Porosity depends on the clay content and dolomitization process, and on the cement content in the siliciclastics. Porosity-density and porosity-thermal conductivity relations different for carbonate and siliciclastic-bearing rocks permitted to discriminate between lithological rock types in the Devonian (Shogenova *et al*., 2003). The role of fractures in Devonian sandstone complexes as pathways for migration of active fluids was explained (Kleesment, Puura & Kallaste, 2003; Kleesment, 2003; Kleesment & Puura, 2003).

The petrophysical model of Ruhnu borehole was based on the studied composition and properties of 114 rock samples and 54 thin sections. Distinct correlation lines and different correlation coefficients of porosity-dependent parameters (density, P-wave velocity, electric resistivity and thermal conductivity) were found for primary sedimentary rocks (limestones, calcitic marlstones), and for dolomitized rocks (dolostones, dolomitic marlstones). Correlation coefficients of porosity with other parameters for limestones together with calcitic marlstones were higher than for dolomites and dolomitic marlstones (Shogenova, Jõeleht *et al*., 2003).

The chemical and physical parameters of dolomites of different genesis from different facies of the Devonian, Silurian and Ordovician sequences were compared with nondolomitized rocks and with each other (Shogenova, Kleesment *et al*., 2003, Shogenova, Einasto *et al*., 2003). Interpretation of the studied parameters suggested early diagenetic near surface pervasive dolomitization of Silurian and Upper Ordovician rocks, Devonian age of the late diagenetic dolomitization of Ordovician rocks from the North Estonian fracture zones, late diagenetic dolomitization of highly porous Silurian rocks, associated with Devonian early diagenetic dolomitization, late diagenetic dolomitization of the Pae Member of the Middle Ordovician Väo Formation and early diagenetic dolomitization of widespread layers from the lowermost part of the Ordovician (Shogenova, Einasto *et al*., 2003). The lattice parameter d104 of the Silurian dolomite from the Raikküla Formation was in good agreement with the genesis: the primary dolomite and dolomite in limestone or contacting limestone has expanded lattice, the most strongly altered secondary dolomite is close to stoichiometric (Teedumäe *et al*., 2003).

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Mineralization in fault zones, discontinuity layers and meteorite craters: alternative geohistorical evidence for the Baltic Sea region

Estonian Science Foundation Grant No. 4417
Project leader: **V. Puura** (University of Tartu)
Team: M. Konsa, A. Kleesment
Duration: 2001–2003

During the final year of the project, field investigations, laboratory work and data analysis were continued. Mineralogical study of magnetic fraction from impact breccias of craters was carried out. Suevites from breccias were sampled, photographed and studied optically using the immersion method (M. Konsa). The results of research on metamorphism of the Svecofennian rocks and examining of the structure of rapakivi intrusions and deep-seated faults were accepted for publishing in the Proceedings of the Estonian Academy of Sciences, Geology (V. Puura, J. Kirs, T.All, M. Konsa).

The occurrence of PDF-planes in minerals of the impact-breccia of the Avike crater (Sweden) proved the impact-origin of this structure (V. Puura, J. Kirs, M. Konsa et al.).

As a result of the petrographical, mineralogical and geochemical study of breccias of the Kärdla crater, a manuscript for printing in the

journal "Meteoritics and Planetary Science" was composed. The following main conclusions were drawn: (1) PDF-quartz-containing allochthonous breccias were formed in the stage of temporary crater. (2) K-metasomatism and decrease of Na-Ca are specific to breccias of crystalline rocks. K-metasomatism is gradually decreasing in the bedrock under the crater. (3) K-metasomatism took place with water vapour. (4) Kärdla meteorite was probably chondritic (not iron meteorite as proposed by K. Suuroja *et al*., 2002).

The study of dolomitic bodies at bedrock faults and discontinuity surfaces was continued. Specific features of the dolomite at Kurevere opencast pit were determined through the use of chemical and mineralogical analyses (optical by T. Pani and M. Konsa, XRD by K. Kirsimäe).

In consequence of the comparative study of zircon typology separated from metamorphic complexes of the basement, rock series formed from either volcanic or sedimentary protoliths were identified (V. Puura, M. Konsa et al.).

The possible provenance of clastic minerals of the lowermost parts of the Vendian and Cambrian sequence from the local underlying Precambrian rocks in Estonia was studied. It was found that Precambrian rocks of the East European Craton could not be the main source for the Vendian/Cambrian sequences in Estonia (Konsa & Puura, 2003).

* * *

Processes of decay of the Ordovician carbonate rocks and assessment of conditions of the historical objects in Tallinn

Estonian Science Foundation Grant No. 5017
Project leader: **L. Bityukova**
Team: J. Nõlvak, A. Teedumäe
Duration: 2002–2004

The problems relating to the damage of building stones have attracted many scientific institutions in Europe and are also very actual for Tallinn, the biggest industrial centre of Estonia. This project purposes to add new aspects into the traditional geological study of carbonate rocks in Estonia and complex study of weathering and decay processes of Ordovician carbonate building stones.

For the study in 2002–2003, 13 historical objects were selected. 156 samples of Ordovician limestones of these buildings were studied. The samples were taken both from building stones and from the so-called black crust formed on their surface. The study by lithological, chemical (13 major and 42 trace elements measurement by XRF-fluorescence, ICP-MS and ACP-ASP technique), mineralogical (8 parameters by XRD-technique) methods showed a wide variation of the composition of building stones. The content of silicate admixture is very variable ranging from 0.1 to 19%. S content is much higher in the black crust and increases up to 8% that is caused by calcite solution and gypsum formation. According to the mineralogical analysis, its content is up to 20%. Iron minerals (hematite and pyrite) occurred in several samples and in very limited contents (up 0.n%). To estimate the alteration of the studied building stones, the DGF (the degree of gypsum formation) coefficient was calculated. Its values are less than in the main types of the building stone used in the cities of Nordic countries. The study of 50 thin sections showed the destruction of the texture of the building stones and alteration of mineral composition (iron minerals and Fe-dolomite formation) in the zones next to the black crust.

The measurement (22 samples) of physical properties (porosity and density) showed that porosity ranges from 2.6 to 13.6% and density from 2700–2760 kg/m^3. Porosity tends to increase with the increase of the SiO_2 content. Comparison of the mechanical properties of rock samples from quarries and boreholes showed that these properties are lower in borehole samples. This may be due to destruction of rocks during drilling. There is a positive correlation between porosity and insoluble residue, and a negative correlation between porosity and

density. In the old and weathered building stones with a higher clay content, an intensive microlayering has become clearly visible. The high content of insoluble residue is a positive factor for intensive mechanical destruction and chemical decay of stones. The accumulation of As, Ba, Cd, Cu, Pb, Sb, Se, Sn and Zn in the black crust was determined; the contribution of As, Pb, Zn and Cu proved highest in the black crust. The content of As is 3–8 times, Pb 2–8 times, and Zn 2–4 times higher than in the building stones. These elements could form sulphates and sulphides and accumulate on the destructed alliterated surfaces. The observed high content of iron oxides could also promote intensive adsorption. The most intensive accumulation of trace elements is revealed in the black crust from the building stones of St. Nicholas's and St. Olaf's Churches. The determined values of elements are relatively similar to the concentrations of trace elements in Venetian monuments. The obtained data permits to reveal the conditions of carbonate building stones and assess the intensity of alteration processes, which are controlled by natural and athropogenic factors. The obtained results showed that the most intensive alteration of building stones from the studied object is observed in Great Coast and in the city wall near the Stout Margareta Tower.

The former city prison is a typical limestone building in Tallinn. It is made of Ordovician limestone of the Väo Formation. *Photo by G. Baranov.*

The palaeontological study of chitinozoans confirmed that the limestone used in the buildings of Old Tallinn is represented by rocks of the Väo Formation. Typical examples are the Middle Age gravestones in Tallinn.

In the frame of the project there was co-operation with scientists from München, Helsinki and Tartu Universities. In the project the postgraduate students T. Kespre and T. Klaos (GI TU) were involved. The data obtained in this project is used in the MSc Thesis of M. Limberg (Tallinn Academy of Arts, 2002). The results were presented at national and international meetings. Some investigations were carried out in Bristol University (UK) in the frame of EU Program (EC ARI Program). The results of the project will be used for interpretation of natural geological weathering processes and estimation of the pollution of building stones. On the basis of the obtained data, a database for future monitoring will be completed and the recommendations for selection of the optimal technique for the diagnosis and conservation of the historical objects will be suggested.

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Numerical and analogue modelling of Earth's processes

Estonian Science Foundation Grant No. 5301
Project leader: **A. Soesoo**
Team: T. Klaos, K. Urtson, V. Kalm (University of Tartu)
Duration: 2002–2005

A large proportion of the Earth's crust is composed of igneous and volcanic rocks. Because of the abundance of these rocks and their central role in major large-scale geological processes (oceanic spreading, subduction and mountain building) it is important to understand their formation. Much is known about various aspects of their formation, but there is a lack of knowledge on how these aspects are connected across different length scales, from initial melt formation on the microscopic scale to ascent in metre to kilometre scale magmatic bodies and final emplacement in sometimes 100 km scale batholiths. Furthermore, many studies have focussed on either physical-mechanical aspects or geochemical-petrological aspects. A fusion of the results from these different viewpoints is critical to the understanding of the whole process.

This project aims to investigate the formation of igneous rocks, from the initial formation of melts to the ascent and emplacement of magmas and from a combined physical and geochemical perspective. Central to the project is the integration of different methods: geochemical and numerical modelling, analogue modelling and field observations. Experiments with rock analogues will focus on the microscopic distribution and segregation of melt during progressive melting, while other experiments will investigate the larger-scale processes of transport and accumulation and the non-linear dynamics and system characteristics of transport and accumulation. Both lines of research are linked by numerical modelling, where chemical and mechanical modelling techniques will be combined to systematically investigate the physics and chemistry of magma segregation, accumulation and transport.

The main results obtained in 2003 showed that fractals can be effectively used in studies of magma mixing and mingling, mantle convection, lava flows, percolation properties of veins, ore mineralization etc. The width of migmatitic leucosomes in the Estonian basement rocks also follows the power-law distribution and shows fractal properties. Despite the differences in size and number of measured leucosomes and veins, differences in host rock types and formation conditions, the studied leucosome/vein thickness shows good power-law distributions with exponents usually between 1.0 and 1.9. The same exponents were obtained from the studies of leucosomes in different outcrops (e.g. Masku area, Southern Finland). The spacing of leucosomes/veins in a rock section is not a random feature, but shows fractal distribution (D=0.77–0.79). As a combination of the numerical model (MELTPOCKET) and natural observations, it can be mathematically shown that knowing the power-law of the size - number distribution for the melt batches, we are able to estimate the total volume of the melt phase, as well as the relative contributions of the largest batch (dominant for $m<1$), and of the smallest batches (dominant for $m>1$). The relationship between the magmatic leucosome/vein width-distribution exponent, and the melt batch size-distribution has also derived. One B.Sc. thesis has been compiled in 2003 (K. Urtson: The use of analogue experiments in the studies of partial melting).

* * *

The age and origin of Estonian crystalline basement rocks

Estonian Science Foundation Grant No. 4615
Project leader: **A. Soesoo**
Team: J. Kirs and R. Kuldkepp (University of Tartu)
Duration: 2001–2003

This project is focussed on the determination (1) of the age of the Estonian Precambrian magmatic rocks by using radioactive isotopes. The following isotopic systems are investigated in the whole rock and minerals for this task: Sm-Nd, Rb-Sr and U-Pb. (2) Secondly, the project does study the geochemical and petrological characteristics of these magmatic rocks in order to determine the origin of those magmas, the tectonic environment during the rock formation and the main fractionation processes. A compilation of both geochronological and geochemical studies allows us to model the geological history of the southern part of the Fennoscandian Shield in terms of the early (1.6 to 2.0 Ga) evolution of oceanic crust (Svecofennia) and subsequent continental accretion (Fennoscandia).

Based on recent studies, it has been elucidated that the age of the South-Estonian granulite complex is actually comparable with that of North Estonian and Southern Finish complexes (1.80–1.89 Ga). The studies have shown that Estonian granulites are enriched with light lantanoides and large ion lithophilic elements. This together with the peculiarities of Rb–Sr and Sm–Nd isotope composition indicates their possible connection with mantle related magmas which are enriched with incompatible elements (E-MORB or OIB type magmatism). Nd epsilon values of most of mafic rocks vary relatively little around 0 (BE), while chondritic model ages of those rocks vary between 1.67 and 1.94 Ga. The variation within the Rb-Sr isotopic system is larger (0.701–0.708), which may suggest higher mobility for Rb and Sr.

Studies of U-Pb isotope geochronology of the Estonian basement rocks in Charls University, Prague.

It is also noteworthy that there is no distinct difference between similar rock types from different structural-tectonic units of the Estonian basement. However, the Jõhvi zone slightly differs geochemically from the other granulitic areas. So far the connection between the Estonian granulites of deep crust origin and the evolution of the Svecofennian ocean is unclear. It should be mentioned that magmatism older than 1.91 Ga has mostly been described from eastern Finland in the marginal areas bordering the Archean rocks. More recent data on Nd and Pb is otope geology have provided a basis for the supposition that earth crust older than 1.9 Ga can also be found under the Svecofennides. However, the studies conducted in 2002–2003 have not discovered involvement of older crust in Estonian granulites in large quantities. Thus, there remains a possibility that granulites might have been related to the development of numerous island arcs in the Svecofennian ocean. In view of this, investigation of the age and composition of Estonian granulites has not only local but also global geological significance.

The charnockites, associated with granulitic rocks are possibly formed during collisional arc type of settings. The geochemistry of both rock types implies to their close relationship – the charnockitoids are possibly formed from melts derived from the mafic metaigneous rocks.

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Properties of biogenic apatite varieties as indicators of their formation and alteration

Estonian Science Foundation Grant No. 5275
Project leader: I. Puura (University of Tartu)
Team: J. Nemliher, E. Mark-Kurik
Duration: 2002–2005

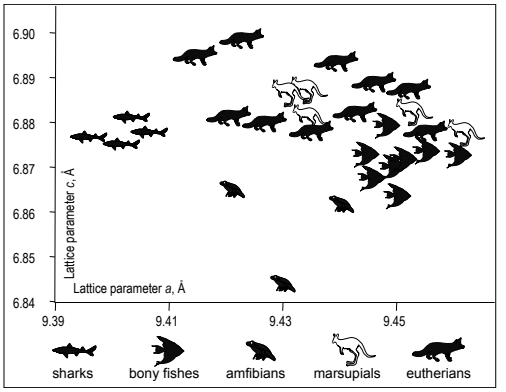
During 2003, the XRD-studies of the properties of skeletal apatites of Recent vertebrates were started. It is was found, that:

(1) it is possible to distinguish between some taxonomic groups of vertebrates that tend to have distinct lattice parameter intervals (see Figure).

(2) the differences in bioapatite lattice parameters of analogous mineralized tissues (scales and teeth of one specimen) are within the sensitivity limit of the XRD analysis. However, the variation of the apatite lattice parameters in a milk teeth of one child is lower (0.1 $Å^3$ of unit cell volume) than the variation of the apatite lattice parameters of the scales of one bony fish (0.2 $Å^3$ of unit cell volume).

A comparative study of mineralized tissues of one fish specimen revealed that lattice parameters of apatite of bones and scales are similar, while both are different from those of teeth apatite.

Additionally, a theoretical model for XRD studies of specimens, consisting of different-sized crystallites of the same composition, was developed. It was found that in case of composition of theoretical sample of particles of different magnitude, the XRD reflection in particular lattice direction would be expressed as a sum of two bell-shaped functions, both represented by modified Lorenzian profiles. The best-fit case was found when standard deviation of those theoretical samples was around 4. This model was applied to the study of vertebrate enamel, where it allowed distinguishing between two series of crystallites of different size.



A scatter plot of showing lattice parameters of skeletal apatite of studied vertebrates.

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Quaternary Geology

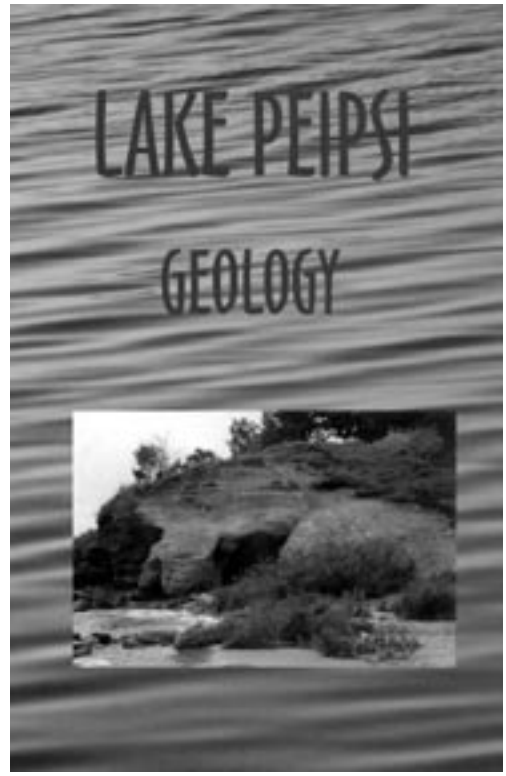
The Quaternary cover in Estonia is up to 200 m thick and has a complicated structure. Deep ancient valleys and glacial interlobate massifs, the so-called insular heights, are the most suitable objects for stratigraphical and palaeoglaciological studies. During last years stratigraphical schemes of the Pleistocene, Late-glacial and Holocene deposits have been accepted and they serve as a basis for geological mapping and applied works in the Republic.

On May 12–17, 2003, an international symposium on Human Impact and Geological Heritage, dedicated to the memory of the Academician Karl Orviku, was held in Tallinn. Karl Orviku was the founder and the first head of the Department of Quaternary Geology and director (1954–1968) of the Institute of Geology of the Estonian Academy of Sciences, member of the Executive Committee of the International Union for Quaternary Research. Four-day excursion to North-East Estonia was organised and the Excursion Guide and Abstracts Book was published. The researchers of the Quaternary Geology Department participated also in organising the International Seminar "Earth's Fields and Their Influence on Organisms" at Kloogarand on June 26–29, 2003.

A long-term cycle of the study of the Estonian big lakes was finished which culminated with a seminar in the Academy of Sciences "Science to the Society – Big Lakes of Estonia" on March 28, 2003. The Science Prize of the Republic of Estonia in bio- and geosciences was awarded to researchers of the Institute of Zoology and Botany at Estonian Agricultural University and Institute of Geology at Tallinn Technical University (Avo Miidel, Anto Raukas) for the monographs dealing with Lake Peipsi ("Lake Peipsi. Geology", Peipsi", "Lake Peipsi. Flora and Fauna" and "Lake Peipsi. Meteorology. Hydrology, Hydrochemistry"). Recently, the monograph "Võrtsjärv" was published.

In 2003, investigations in the Quaternary geology of Estonia and neighbouring countries were accomplished through three target-financed projects and five Estonian Science Foundation grants. An important task was compilation of the "Book of Primeval Nature" in the frames of which two booklets of the series "Natural Heritage of Estonia" (No. 8 Harjumaa: Harku, Keila and Padise and No. 9 Ida-Virumaa: Vaivara, Sillamäe, Toila) were published. Much attention was paid to applied geology, mainly in the field of geoecology. State monitoring of the shores of Peipsi and Võrtsjärv was provided. From her personal savings Hella Kink financed construction of the building for the non-profit society Pakri Nature Centre aimed at serving as a scientific research centre in this, one of the most highly polluted areas in Estonia.

The Quaternary geologists of the Institute have close contacts with researchers from neighbouring countries and belong to many international co-ordinative bodies.



Estonian State Prize in bio- and geosciences was awarded to a group of researches for series of monographs dealing with Lake Peipsi. The volume on geology of the lake was edited by A. Miidel and A. Raukas from the Institute of Geology.

Late Quaternary environment dynamics in the northwestern part of the East-European Platform: stratigraphy, geochronology, correlation

Target Financed Research Programme No. 0331759s01
Project leader: **A. Raukas**
Team: R. Karukäpp, H. Kink, T. Metslang, A. Miidel, A. Molodkov, E. Tavast
Duration: 2001–2005

In cooperation with scientists from the USA (P. Clark, W. Rinterknecht) for the first time in the northern Baltic erratic boulders were used for dating ice marginal formations by means of the beryllium method; the ages 11 732–16 251 were obtained.

The explosive energy of the Kaali meteorite was assessed. It was shown that the resultant emitted three-dimensional turbulent gas flow reached a height of 6.8–7.9 km and was capable of scattering fine meteoritic matter over a very large area. In cooperation with French scientists (F. Marini) the composition of the cosmic matter dispersed at Kaali was studied under a high-resolution scanning microscope and by means of an ultra-sond. Its morphogenetic classification was compiled.

At the lower reaches of the Kunda River seismogenic structures of Holocene age were identified in Kunda Lake sediments (together with N. Nikonov from Moscow). The find is the first of this kind in the Baltic States. The lower part of the lake marl of Holocene age and the underlying older lake sediments are seismotectonically disturbed. The earthquake took place in the Early Holocene 9 500–7 900 ^{14}C years ago. The direction of sediments deforming lateral pressure was SE-NW.

Together with S. Veski's working group isobases of the Baltic Ice Lake, Ancylus Lake and Litorina Sea were modelled. The results showed that the rate of uplift was higher in NW; this was explained with flexural changes of the Earth's crust uplift. During the Ancylus Lake stage, the direction of the uplift gradient was irregular, its magnitude was greater in NW Estonia and NW Latvia. In the Early Holocene, the uplift of the Earth's crust was uneven and changing.

The study of the last interglacial sediments on the southern coast of the Kola Peninsula showed that many stratotype sediments occurring there are erratics. Using two independent dating methods (ESR and OSL) it was proved that the sediments under consideration formed during the Late Pleistocene (Eemian-Boreal) transgression. The results suggest that during isotope stage 5c the level of ocean was rather high. The micro- and macrofauna and plant associations identified in sediments suggest much warmer climatic conditions than those at present. The results obtained on the east coast of the White Sea do not exclude the occurrence of cold-water Weichselian transgression some 46 000 years ago. The studies confirm that during isotope stage 5c glacial sediments did not accumulate in the White Sea area.

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The last continental glacier in Estonia: its dynamics and chronology

Estonian Science Foundation Grant No. 3452
Project leader: **A. Raukas**
Team: K. Erg, R. Karukäpp, A. Miidel, E. Tavast
Duration: 2003–2006

A concise survey of the Pleistocene sediments in Estonia was compiled and the late-glacial interval was analysed in particular detail. In Estonia, there were no significant ice margin oscillations in the late-glacial. Glacier tongues did not advance, as a rule, from the direction different from the previous one, but the direction of ice movement within it changed due to the shift of the glacier's feeding area or the increasing effect of the subglacier topography as a result of the thinning of the ice. This resulted in the formation of the so-called palimpsest-structures, where the traces of every following process shaded the previous ones. In terms of the mode and rate of glacier movement as well as the formation of sediments and relief of decisive importance is the circumstance whether the temperature in the glacier's base is below or above the freezing point. As a rule, Estonian glaciers were "warm-bottomed".

Based on all the applied methods (TL, OSL, ESR, 10Be, ^{14}C, varvometrical and palynological) and the most recent data on the ice sheet dynamics in the Baltic Sea region, the chronology of the ice sheet retreat in Estonia was summarized.

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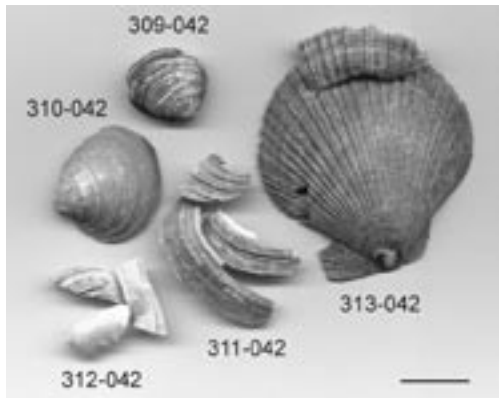
Palaeoenvironmental changes in NE Estonia during the Last Ice Age (a pilot project)

Estonian Science Foundation Grant No. 5440
Project leader: **A. Molodkov**
Team: T. Balahnitšova, I. Jaek, A. Miidel, M. Osipova, E. Tavast, N. Bolikhovskaja (Moscow State University), A. Nikonov (Institute of the Earth Physics, Russian Academy of Sciences), K. Ploom (Geological Survey of Estonia), M. Sakson (Geological Survey of Estonia)
Duration: 2003–2004

The project is dedicated to the fundamental problems of the Late Quaternary geology of the Baltic sphere: temporal extent and palaeoenvironmental structure of the Last Ice Age, interregional correlation of the events recognised with those recorded in different environments and localities. The deposits recently examined at the Voka site, NE Estonia, seem to be a unique archive of natural palaeoenvironmental changes which occurred there and left behind many sequences with a well preserved Late Pleistocene record.The palaeoenvironmental development of the study area during the past-Eemian age is still unclear in many aspects but its resolution can be achieved by a multidisciplinary study of the stratigraphic sequences of the new Lower-Middle Weichselian section at the Voka site. The proposed project concerns the most critical – chronostratigraphical and palaeoenvironmental – aspects of the Last Ice Age in Estonia.

To begin with the solving of the problems, it is important at the present stage: a) to elucidate the extent and timing of the deposits revealed in the section; b) to perform preliminary recon-

One of the Voka V3-03 section stripping showing the stratigraphy of the deposits and sampling points for pollen, diatom and luminescence (OSL) analyses. *Photo by A. Molodkov.*



Marine shells from the southern Kola Peninsula ESR dated at 103.0 ± 4.2 ka (Molodkov & Yevzerov, 2004). The result indicate that the marine deposits from which these shells were collected belong to the first Late Pleistocene Boreal transgression that, according to the materials of ESR-chronostratigraphic studies over the marginal areas of Eurasian North (see e.g., Molodkov & Bolikhovskaya, 2002) can most likely be compared with the whole OIS 5. The scale bar is 20 mm long. *Photo by A. Molodkov.* →

struction of the dynamics of palaeoenvironmental changes in Northern Estonia; c) to correlate the data obtained with the data known from deep-sea, ice-core and continental records; d) to check the hypotheses offered regarding the Weichselian age of the deposits; e) to elucidate the real age of some controversial palaeoenvironmental events in Estonia and the Baltic region. The expected result of the project is a preliminary palaeoenvironmental information that can be particularly important for a further extension of the studies and for better understanding of the Last Ice Age palaeoenvironmental system in the Baltic sphere. In case of positive results it may have a significant impact on the reconstruction of the palaeoclimatic system in Estonia as well as in the whole Baltic region.

* * *

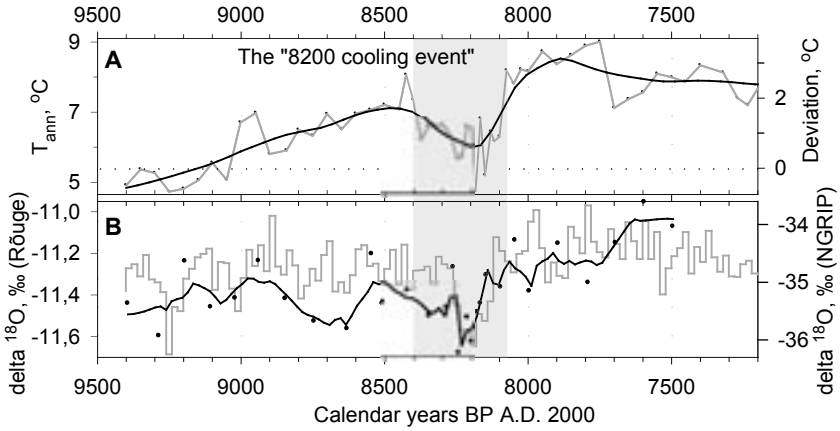
The varvo-chronological time-scale of Holocene geoevents

Target Financed Research Programme No. 0331758s01
Project leader: **S. Veski**
Team: A. Heinsalu, A. Lepland, E. Niinemets, A. Poska, L. Saarse, J. Vassiljev
Duration: 2001–2005

A major aim of the Earth Sciences is to improve the predictive power of scenarios produced by climate models. Instrumental records of the climate change are too short to elucidate the full range of climatic variability. Therefore, it is necessary to reconstruct climate from geological archives with a high-temporal resolution.

The project delivers reconstructions of lake ecosystems, climate change and environmental dynamics at seasonal to decadal resolution in Estonia during the last 10,000 years through a multidisciplinary study of annually laminated lake sediments. The network of annually laminated (varved) sediments in Europe and Estonia presents an opportunity to provide new high-resolution palaeo data from unique and precise environmental archives. The predicted temporal range of annually laminated sediments in Estonia can extend to 14,000 years. Accurate varve counts, verification of their annual nature and documentation of each individual varve thickness from Estonian sediment sequences will be made using high-resolution techniques (thin section investigation, image analysis, X-ray densitometry, scanning electron microscopy). Varve thickness variations of the last centuries will be compared to meteorological data of the same period to obtain a varve-climate link, which then could be extrapolated to the past. These procedures will provide quantitative estimates of short- and long-term climate variability. Post-glacial climatic variability and environmental changes are established using diatom-inferred reconstruction. Abrupt transitions between time periods of stable climatic conditions (e.g. the Younger Dryas-Holocene transition, the early Preboreal Oscillation, cooling events at ca. 8200 years BP and at ca. 2800–2700 years BP, the Little Ice Age) are studied at a high-temporal (an annual and possibly seasonal) resolution. An accurate calendar year chronology provided by sediment sequences enables to objectively compare variations in palaeoclimatic proxy data with each other and alternative palaeodata sets of similar resolution (e.g. ice-cores and tree-rings). The time-series data sets produced are for the benefit of global change community and can be used to validate predictive climate models.

In 2003, the 4018 year long early Holocene part of the Rõuge varve chronology was anchored to the best varve chronology in Europe - Lake Nautajärvi in Finland via palaeosecular variation of the Earth's magnetic field to minimize cumulative varve counting error. Varve studies at Tõugjärv, Estonia and Nautajärvi, Finland revealed environmental and climate changes at 8.2 cal. ka BP. The WA-PLS-modelled (r2=0.88) pollen inferred Tann dropped 1.5 ºC between 8.4 and 8.0 cal ka BP, showing that perturbations of the North Atlantic termohaline circulation (THC) by massive freshwater outflows from eastern North American glacial lakes during the collapse of the Laurentide Ice Sheet influenced the North European climate



A – The pollen-based annual mean temperature reconstruction of Lake Rõuge for 9400-7200 cal yrs. ago showing the 8200 cooling event. The red curve is the original data and the black curve is a LOESS smoother with a span 0.15.
B – $\delta^{18}O$ record of Lake Rõuge shown with a LOESS smoother with a span 0.15. The original measured values are indicated by the black dots. The NorthGRIP $\delta^{18}O$ record from Greenland (vertical bars), presented in 20 yr. averages, is shown for comparison. A quantitative annual mean temperature reconstruction from an annually laminated lake-sediment sequence in Estonia, eastern Europe, shows a distinct cold period at 8400–8080 yrs. ago, synchronously with a pulse of freshwater from the melting Laurentide Ice Sheet. The results indicate a strong teleconnection between the North-Atlantic oceanic forcing and the East-European climate at least up to 26°E longitude, mediated probably by the changing intensity of the zonal atmospheric circulation.

significantly. Modelled climate data is supported by negative excursions in the Rõuge O-18 data and sediment image analysis. The results show that the 8.2 event had a major impact on the more eastern and more continental part of Europe than shown previously, suggest that a freshwater pulse of 0.75 Sv. can cause a cooling of 1.5 ºC in Estonia and increase our understanding of the importance of the zonal flow on the climate of northern Europe at least up to the latitude of ca. 26°E, in larger context supports the model experiments in that there is a sensitive teleconnection between freshwater pulses, THC, zonal flow and North-European climate.

Several people from the institute were involved in scientific consulting of the documentary "Home of the Sun - Kaali saladus". *Snapshot courtesy to Vesilind Ltd - Vides Filmu Studija 2003*.

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Perspectives of using spherical fly-ash particles for indirect dating of recent sediments: methodical developments

Post-doctoral fellowship No. 0332180s02
Project leader: **T. Alliksaar**
Duration: 2002–2003

The studies of natural historical archives such as lake sediments and peat sequences require a reliable age-scale. In order to determine the age of sediments accumulated during the last 100–150 years the ^{210}Pb method and the distribution of several artificial radionuclides (as ^{137}Cs, ^{134}Cs, ^{90}Sr, ^{241}Am etc.) has been used in Estonia. One of the dating and correlation method, which has also been employed, is the sediment distribution of spherical fly-ash particles emitted during the high-temperature combustion of fossil fuels. The advantages of this method are simplicity and cheapness, and

also accuracy as the distribution of particles in cores is not influenced by any chemical processes in sediments. To obtain a reliable temporal distribution curve of fly-ash particles, it must be calibrated with an age-scale received by some other dating method. In the course of last years, annually laminated sediments found in several lakes of south-eastern Estonia enable to create an independent detailed age-scale and on the basis of that compile a calibration curve of fly-ash particles. The marker horizons of the vertical distribution of fly-ash particles are accurately dated; this allows to apply this method to determining the age of homogenous sediment profiles. The result is a simple alternative method for stratification and evaluation of accumulation rate of lake sediments formed in the course of the last 100 years. It can be used in for paleo-environmental studies.

The main results:

As an alternative technique for sediment dating spheroidal fly-ash particle stratigraphy was calibrated using varves, ^{210}Pb, ^{241}Am and ^{137}Cs chronology in lake sediments of different areas in Estonia.

The dates obtained with the ^{210}Pb method on homogeneous lake sediments showed younger ages and they were corrected using ^{137}Cs and ^{241}Am datings. At the same time, the results on laminated sediments demonstrate a good accordance of the age-scales obtained with both methods – ^{210}Pb and also the distribution of artificial radionuclides. The latter confirms the annual nature of the lamination and very good preservation of paleoinformation in sediments where bioturbation is insignificant or even missing. Datings of homogeneous lake sediments show also that marker horizons of artificial radionuclides, ^{137}Cs and ^{241}Am have temporal differences, whereat the distribution of ^{241}Am better agree with the age-scales obtained by other dating methods. The reason for that may be the mobility of ^{137}Cs in sediments due to diffusion processes.

Spherical fly-ash particle distribution curves in analysed lake sediments have characteristic temporal trends with specific features that are found to be consistent over wide geographical areas. Comparison of particle down-core distribution with fuel combustion and emission statistics in the region has shown that they have similar time-trends. The features in fly-ash particle concentration profile represent major changes in the fuel consumption history. According to the correlation of different dating means the characteristic increase in the fly-ash particle concentration occurs in sediment layers accumulated during the 1940s. In sediment cores also another specific change is recorded, the sub-surface peak in particle concentrations, which is caused by a decrease in fuel consumption or improvements in emission control. Dating features from the fly-ash particle profiles are in some extent subject to regional variation, especially the maximum value in particle concentrations, which is dependent on local industrial development. Despite the classical distribution of fly-ash particles in laminated sediment cores, their concentrations are very variable there because of the variations in the mineral matter content in different sediment layers. Therefore, for obtaining more detailed particle chronologies for recent sediments the combination of all available dating methods is used to calibrate the fly-ash particle cumulative profiles.

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The interaction of forest and atmospheric fly ash influx

Estonian Science Foundation Grant No. 5002
Project leader: **M. Kaasik** (Tartu Observatory)
Team: T. Alliksaar, J. Ivask
Duration: 2002–2004

The interaction between forest stands and fly ash pollution is reciprocal: (1) the fly ash affects the condition of trees through the air and soil and (2) the different aerodynamic roughness of the forested and open land induces the non-uniform distribution of ash particles in the landscape. The aim of this project is to clarify the regularities of this interaction.

(1) The systematic differences of deposition of fly ash indicators (cations, anions, heavy

metals, insoluble particles) in the landscapes of different surface roughness (flat open, flat forested, hilly) will be quantified, paying attention to the variability due to weather conditions. Based on gathered data, the dependence of the fly ash deposition flux on the landscape type will be found.

(2) The relations between the oil shale fly ash deposition fluxes and wood increment in the forest stands growing on peaty soils will be found using the retrospective studies in the north-eastern Estonia, especially during the peak level of alkaline pollution in 1970–1990, as the main method and the air pollution transport modelling as the supporting method. The results are expected to enable the forecasting of the succession of forest condition, using the development scenarios of the oil-shale-based energy production.

The results will be applied to upgrading the air pollution dispersion and deposition model AEROPOL in order to enable forecasting of fine territorial distribution of deposition fluxes of particles sized about 10 micrometers.

The project will join the two research directions grown up from solving of environmental problems in Estonia: (1) the mathematical modelling of air pollution and (2) the paleoecological studies. The synergetic effect will be achieved as a result.

Results in 2003:

Atmospheric fly ash influx causes peat accumulation to stop or being disturbed: bog becomes a source of CO_2 instead of a sink. As a result at least 17 000 excess tonnes of CO_2 will be left in the atmosphere annually. Although the carbon binding reduction effect is only a few % of CO_2 emission from power plants, it lasts for decades after emissions have reduced or stopped.

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Holocene event stratigraphy of Estonia

Estonian Science Foundation Grant No. 4963
Project leader: **L. Saarse**
Team: E. Niinemets, A. Poska, S. Veski
Duration: 2002–2005

Main results in 2003:

For the first time it was elucidated that the climate cooling at 8200 cal BP has preserved in the sedimentological and palaeobotanical record of lacustrine deposits.

Climate warming during the medieval period and cooling in the Little Ice Age have been identified in the sediment profiles analysed in detail. Organic matter, carbonate and terrigeneous fraction were determined in every 1 cm throughout the entire sequence.

Creation of the pollen/climate calibration database was started, to give an opportunity for a more reliable reconstruction of quantitative climate parameters.

The first results show a strong influence of annual mean temperature on the modern pollen composition and demonstrate the potential of pollen data for long-term climate reconstruction in Estonia. They also provide evidence against simple interpretation of fine-scale variations in a single climate reconstruction. In particular, our results highlight the importance of careful study design and implementation in the construction of pollen/climate transfer function.

Based on pollen stratigraphy from three lacustrine deposits in Estonia, the mean annual temperature was reconstructed for the last 9000 years. Sediments deposited before 9000 BP are insufficiently studied and dated, because the organic sedimentation very often started at that time or even later. The Finnish-Estonian pollen/climate reconstruction model was used in reconstructing mean annual temperatures. These are among the first quantitative climate reconstructions from Estonia -- a country located in a zonoecotone sensitive to the North-European atmospheric dynamics. The produced curves match well with Finnish studies carried out with the same methodology. Based on these reconstructions, the mean annual temperature during the Holocene thermal maximum was 2.5 °C higher than at present.

A remarkable cooling occurred at 8400 - 8000 cal BP; it has been identified in four sediment sequences. Still, higher resolution pollen data with better time control is needed for a more detailed correlation.

The database of the Litorina Sea was updated with data from southern Finland and north-western Russia. The analysis of new data demonstrates that the Litorina Sea isobases are not straight lines, especially in the eastern part of the study area. 15- and 20-m isobases are inclined to the north-west compared to those previously presented. The isobases of the eastern part of the study area are more broadly distributed due to the metachronous Litorina limit and/or due to "hinge" line. 14-C data corresponding to the Litorina I stage were also mapped using the same methodology as for coastal formations. Most of the dates are between 6750-7250 BP. Some dates, especially from the south-western Finland are older, and some dates from the north-western Russia are younger. The age difference could be explained with dating errors or dates not characterising the first Litorina stage.

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Spectrofluorometric characterisation of dissolved organic matter in pore-water of lake sediments

Estonian Science Foundation Grant No. 5582
Project leader: **A. Leeben** (Institute of Marine Systems, TTU)
Team: T. Alliksaar
Duration: 2003–2005

The proposed research is aimed at analysing dissolved organic matter (DOM) in the pore-water of lake sediments using fluorescence spectra. A set of analyses (including microbiological, size exclusion chromatographic and organic matter analyses) on sediment core samples from small Estonian lakes with different trophic status will be carried out in order to:

(1) investigate the relationship between fluorescence of pore-water DOM and lake historical productivity;

(2) study the possibilities of using fluorescence spectra of pore-water DOM for identification of precursors of accumulated organic material.

The obtained data will be processed using the principal components analysis.

Application of the fluorescence technique has advantages in comparison with the classical methods used in palaeolimnology since it is fast and requires no sample pretreatment. Characterisation of pore-water DOM can be carried out on small volumes of samples. This fluorescence method may be useful for:

(1) sorting large core sample sets to be tested by other characterisation methods or for characterisation of archived samples;

(2) augment the interpretation of dissolved organic carbon sources and alterations in sediments for understanding carbon cycling in freshwater ecosystems, determination a carbon budget in aquatic systems or human impact on lake ecosystems.

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Late Quaternary and Palaeozoic climatic and environmental changes and their isotope-geochemical records in continental and marine sediments, hydro- and cryosphere of Northern Hemisphere

Target Financed Research Programme No. 0332089s02
Project leader: **R. Vaikmäe**
Team: T. Balahnitšova, J. Ivask, I. Jaek, E. Kaup, T. Martma, A. Molodkov, M. Osipova, V. Raidla, H. Rajamäe, L. Vallner, V. Vassiltšenko
Duration: 2002–2006

The formation mechanism of glacial groundwater stored in the Cambrian-Vendian aquifer system, the present distribution limits of this palaeogroundwater and formation conditions of the chemical composition of the water are elucidated. Based on the results obtained through the analysis of the isotope-geochemical composition of glacier ice and permafrost in Eurasian Arctic, the dynamics of climate and environmental changes in this region are adjusted and associated with global climate and environmental changes. The use of isotope methods in the study of the Upper Ordovician and Silurian sections in the Baltic basin would enable to find connections between the geochemical and isotope composition of deposits, which enables to use the results of isotope analysis for reconstructing environmental conditions of the Palaeozoic. The physical basis of the luminescent and optical dating techniques is developed.

Results in 2003:

Isotope-geochemical investigations on Kopli Peninsula, Tallinn, showed that a rise in the total dissolved solid content and concentration of major ions in the Cambrian-Vendian groundwater due to overexploitation is caused, first of all, by leaching of host rock and by leakage from underlying crystalline basement, rather than by sea water intrusion. Carbon isotope analysis were used to study the environmental parameters of the Palaeozoic ecosystem evolution. A 10 Ma long period of minor isotopic shifts (2–2.5‰) and a short (2 Ma) but strong isotopic excursion (4–6‰) at the end of the Ordovician were identified. The latter is interpreted as an implication of the Gondwana glaciation. The mollusc-based ESR-proxy climate records within oxygen isotope stage 6 prove the existence of at least two intermediate interstadials during the penultimate glacial rhythm estimated at about 170 and 155 ka. These ESR-ages and pollen palaeoclimatic signals from terrestrial deposits in the centre of the East-European Plain appear to correlate reasonably well with the relatively warm events in the Arctic region recorded during the same time interval in the GRIP ice-core.

Growth of glaciers can best be measured using satellite positioning systems. In this photo, a high precision GPS is being calibrated by the "fixed point" at the top of Mount Annekammen, Svalbard (glacier Kongsvegen in the backround). *Photo by T. Martma.*

The influence of last glacial ice sheet on the formation of Estonian groundwater

Estonian Science Foundation Grant No. 4161
Project leader: **R. Vaikmäe**
Team: J. Ivask, E. Kaup, T. Martma, V. Raidla, L. Vallner
Duration: 2000–2003

The aim of the project was to elucidate to which extent the ice sheet, which covered Estonia during the last glaciation, has influenced groundwater formation in this area. The character of the influence of the ice sheet and its extent in space and time were studied. It was attempted to find out whether the hypothesis basing on recent studies in Germany, the Netherlands and Scandinavian states and suggesting subglacial meltwater discharge through aquifers and tunnel valleys (Boulton *et al*., 1995; Piotrowski, 1997) might explain, considering the geological structure of Estonia, the formation of the groundwater here during the ice age and the present distribution of palaeogroundwater. With this in view, the origin of buried valleys was studied.

To elucidate the conditions of subglacial meltwater discharge, the distribution and dynamics of permafrost were reconstructed by means of model calculations on the basis of the most recent palaeoclimatic evidence. Isotope-geochemical methods and hydrogeological models were used to determine more precisely the spread of palaeogroundwaters in Estonia and its neighbourhood. The reasons for the extraordinarily high gas content in the Cambrian-Vendian aquifer were studied and the composition of gases was determined. The possibility was checked whether it might be atmospheric air of the last glacial age which caught trapped in the continental ice, reached with subglacial meltwater discharge the aquifer system and has preserved there in several places up to the present.

The results arising from the project will serve as a basis for elucidating the mechanism of groundwater formation in Estonia during the last ice age, for determining the limits of palaeogroundwater distribution and its dynamics during the post-glacial period up to the present.

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Participation in international programmes

Biological Collection Access Service for Europe (BioCASE) network, European Union EESD Programme, participant: *O. Hints*;

Coastal environmental change during sea-level highstands – A global synthesis with implications for management of future coastal change, International Geological Correlation Programme (IGCP) Project 437, participants: *A. Molodkov*;

Global Stratotype Sections and Points (GSSP) for the Silurian System, International Subcommission on Silurian Stratigraphy project, participants: *V. Nestor*;

Human Impact on Terrestrial Ecosystems (HITE), International Geosphere-Biosphere Programme Network, participant: *S. Veski*;

Middle Palaeozoic Vertebrate Biogeography, Palaeogeography, and Climate, International Geological Correlation Programme (IGCP) Project 491, participants: *E. Mark-Kurik, T. Märss*;

Information on archipelago for travellers, Helsinki City Environment Centre, participant: *J. Nõlvak*;

NARP project: Investigating rapid climate change using Svalbard ice cores, Norwegian Polar Institute, participants: *T. Martma, R. Vaikmäe*;

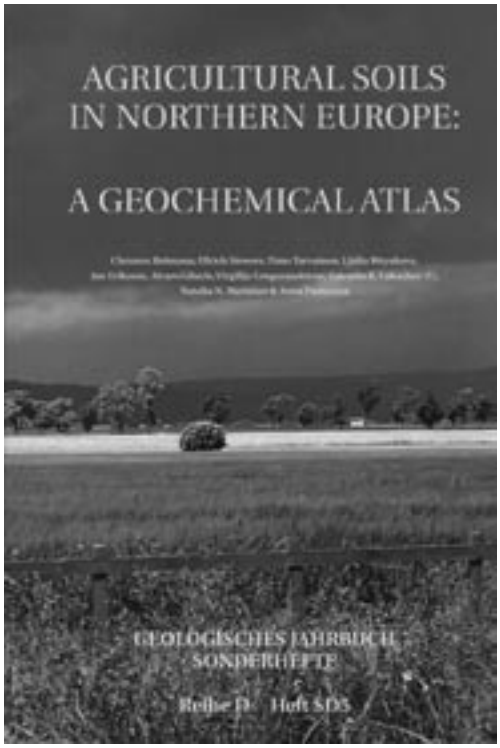
Natural Baseline Quality in European Aquifers: a Basis for Aquifer Management, EC Framework V Project EVK1-CT1999-0006, participants: *R. Vaikmäe, A. Marandi, J.Ivask, E. Kaup, T. Martma, L. Vallner*;

Quantitative reconstructions of past land-use/land-cover and floristic diversity inferred from fossil pollen data (POLLANDCAL), The Nordic Academy for Advanced Study (NorFa) Project, participants: *A. Poska, S. Veski*;

Quaternary Environment of the Eurasian North (QUEEN), European Science Foundation Research Project, participant: *A. Molodkov*;

SOMAP-UK: A combined data -modelling investigation of water isotopes and their interpretation during rapid climate-change events, participant: *T. Martma*;

Baltic Soil Survey, Bundesanstalt für Geowissenschaften und Rohstoffe, Germany, participant: *L. Bitjukova*;



As a result of collaboration research programme "Baltic Soil Survay", Geochemical Atlas of North Europe was published. L. Bitjukova was one of the authors and acted as the Estonian co-ordinator of the programme.

Applied Research

Risk based environmental site assessment of waste from the oil shale industry

Project by the Ministry of Foreign Affairs of Norway, 2002–2003.
Team: **L. Bityukova**, T. Metslang, L. Vallner.

The basic idea of the project is to use the national high priority environmental problem for training and demonstrating the EU approach to assessment and solution of such environmental projects. The main purpose of the project is the complex environmental investigation of soil and water contamination and estimation of the ecological situation in North-East Estonia.

In the framework of this study the geochemical mapping for three areas (Narva, Kohtla-Järve and Kiviõli) was carried out. The contents of 73 major and trace elements in 200 soil samples were studied and main regularities in their distribution were estimated. The groundwater of Ordovician and Ordovician-Cambrian water aquifers nearby the semi-coke waste dumps close to towns Kiviõli and Kohtla-Järve, and Narva ash plateau were studied. Inflow of polluted contaminated water leads to intensive changes of local aquifer environments and primary chemical composition of the groundwater. The obtained data allowed to characterise the level of unorganic and organic compounds in the groundwaters from different aquifers, the estimated level of contamination being dependant upon the depth and distance from the landfills.

The trace elements and organic compounds' (PAH, BTX and phenols) measurement gave a possibility to specify inorganic and organic pollutants and to determine the variation of the most harmful compounds in the studied waters. The highest impact of pollution is observed in the water near the waste dump. The studied groundwater sampled from the wells located in the suburbs of waste mounds have high values of pH, decreasing with increasing distance from the semi-coke and ash mounds. The pH values in water collected from the wells drilled through the waste heaps are very high. The waters in the channel around the landfill are characterised by high alcalinity and also by very high pH values. The highest alcalinity was determined in the water from the wells on the heaps. In the water from channels the alcalinity is lower. The phenol content in the groundwater from the upper water aquifer sampled from the wells near the waste mound exceeded Permitted Limit Values (PLV) in several times. In the deeper water aquifer it increases very quickly. The intensity and extension of groundwater contamination by organic pollutants in waste mounds depends on the depth of the water aquifer. The groundwaters at the distance of about 500m from the waste dump are characterised by the lowest concentration of organic pollutants. The groundwaters there have concentrations that do not exceed PLVs. The concentration of organic compounds was also tested in semi-coke and leaches from solid waste. The leaching was carried out at liquid to solid (L/S) ratios of 10 to 1. The study showed that leachability of fresh semi-coke is low. A 24-hour leaching test of materials from Kiviõli and Kohtla-Järve dumps showed very low concentrations of organic compounds in extracts. The semi-coke waste is therefore not expected to be the source of the observed contamination in the subsurface.

Special boreholes were drilled on and near waste mounds in NE Estonian industrial area to take groundwater samples and monitor water quality. *Photo by L. Bityukova.*

The ecotoxicological testing allowed estimating the well-known negative influence

of the contamination by toxic elements and other pollutants on the health of people. The hydrological and transport modelling of the main waste heaps (Kiviõli, Kohtla-Järve and Narva) was carried out in co-operation with Norwegian colleagues.

Natural baseline quality in European aquifers: a basis for aquifer management

European Commission Project No. EVK1-CT-1999-0006, 2000–2003.
Team: **R. Vaikmäe**, J. Ivask, E. Kaup, A. Marandi (University of Tartu), T. Martma, V. Raidla, H. Rajamäe, L. Vallner.

In Southern and Central Estonia, the Cambrian-Vendian aquifer system contains relict saline groundwater of marine origin with TDS values up to 22 g/l. Cl- and Na+ predominate over all other ions in this zone. In northern Estonia the Cambrian-Vendian aquifer system contains palaeogroundwater, which recharged during the last glaciation. This is fresh water with the total dissolved solids values mainly below 1.0 g/l. The baseline chemical composition of the water is formed through the water–rock interaction during the last more than 10 ka. Generally, the groundwater has a good quality, but in some areas the elevated Fe and Mn concentrations are causing problems. The groundwater does not always meet the requirements of drinking water standard in respect of Cl- and Na+ content. The most characteristic feature of the baseline quality of the groundwater stored in the Cambrian-Vendian aquifer system in northern Estonia is its lightest known oxygen isotopic composition ($\delta^{18}O$ values of c. -22‰) in Europe. This gives a possibility to use the isotopic composition of groundwater as an ideal tracer of possible changes in the groundwater baseline quality.

In northern Estonia the groundwater of Cambrian-Vendian aquifer system serves as high quality drinking water for communities and towns (incl. Tallinn), but important is also its industrial use. The supply is very significant, amounting to 10–13% of the Estonian groundwater consumption. Overexploitation of freshwater resources of the Cambrian-Vendian aquifer system in Tallinn and mine dewatering in north-eastern Estonia has resulted in the development of two basin-wide depression of potentiometric level. In turn, it has caused the changes in the direction and velocity of groundwater flow, which has led to 1.5 to 3.0-fold rise in the total dissolved solid content and concentration of major ions in the groundwater. The main sources of dissolved load in the Cambrian-Vendian groundwater are the leaching of host rock and the other geochemical processes that occur in the saturated zone. Leakage from the underlying crystalline basement, which comprises saline groundwater in its upper weathered and fissured portion and is hydraulically connected with the overlying Cambrian-Vendian aquifer system, is another important source of ions. An intrusion of seawater into aquifer system with consequent implications for water quality is at present time still not evident but should be considered in coming decades.

Anomalously high barium concentrations (up to 6.4 mg/l) in abstracted groundwater were found in some wells of Kunda, Rakvere and Kohtla-Järve cities. The crystalline basement and its weathering core, which are hydraulically connected with the overlying Vendian and Cambrian terrigenous rocks, are the probable sources of barium and fluorides in groundwater.

As the non-renewable resource of fresh palaeowater in the Cambrian-Vendian aquifer system is limited, special regulations for sustainable consumption of the water have to be settled.

The sand- and siltstones of the Middle Devonian (D_2) aquifer system, extending in Southern Estonia between the Gulf of Liivi and Lake Peipsi, contain good-quality groundwater. The recharge area for Middle Devonian aquifer is the South Estonian uplands, which consist mostly of Quaternary sediments. The local lower areas, such as lakebeds and buried ancient valleys act as discharge areas for D_2 aquifer. The Middle Devonian aquifer system is used for the public water supply mainly in the rural areas of South Estonia and also in several towns.

The hydrochemistry of the Middle Devonian aquifer is governed mainly by the chemistry of atmospheric precipitation percolating through

unsaturated soils, by water–rock interaction in the overlying Quaternary sediments and by seawater–groundwater interaction in coastal areas. The main control of the baseline quality is the water–rock interaction in the overlying Quaternary sediments. The chemical composition of precipitation water, which is of Cl-HCO_3-SO_4-Ca-Mg-Na type, changes already due to bioactivity in the soil into HCO_3-Ca-Mg-Na type of water. The amount of dissolved CO_2 in the water can vary within the range 20–30 mg/l. Such water dissolves carbonates in the carbonate rich Quaternary sediments. These processes result in the formation of HCO_3-Ca-Mg type of water, which usually is still undersaturated with respect to calcite.

Seawater intrusion into the Middle Devonian aquifer system is an important factor able to change the water type. This process has been detected in several wells in the coastal areas of Western Estonia.

The high concentration of Fe is one of the characteristic features for Middle Devonian groundwater in the confined zone. In more than 60% of wells the concentration of Fe is higher than 0.3 mg/l and in about 30% of wells the concentration is higher than 1.0 mg/l. It results, however, from purely natural geochemical processes. This means that according to the water quality guidelines of the EU and also according to the maximum concentration limit (MCL) of the Estonian drinking water standard, in most of water intakes iron removal should be carried out.

As the agricultural activity in Estonia has been low during the past decade and the population density is not high in South Estonia, the nitrate values below the 3 mg/l can be evaluated as baseline. In case of higher values the local situation should be evaluated case by case.

Viru-Peipsi Catchment Area Management Plan (Viru-Peipsi CAMP)

European Union, French Global Environment Fund, Estonian Goverment No. LIFE00ENV/EE/000925, 2003.
Team: **A. Heinsalu**, T. Alliksaar.

Estonian lakes have definitely been a subject to human activities and following perturbation. The instrumental record on lakes is too short (ca 50 years in Estonia) to capture the whole range of limnological changes in lake ecosystem during man-made eutrophication. Paleolimnological techniques provide means to study the past shifts in the aquatic ecosystems outside the instrumentally documented range and evaluating natural background conditions and long-term variability in lakes.

The aim of the project is to elaborate a water management plan for Viru-Peipsi region according to the requirements of the EC Water Framework Directive. In the frame of the project sediment research from four small lakes (Lake Nohipalu Valgjärv, Lake Kaiavere, Lake Rõuge Tõugjärv and Lake Otepää Pikkjärv) was initiated, in order to study the onset of the man-made eutrophication and to establish baseline conditions in these water bodies. The chronology will be established and evaluated by different independent approaches: (1) ^{210}Pb dating; (2) ^{137}Cs and ^{241}Am dating; (3) counting of annually laminated sediments; (4) fly-ash particle distribution in sediments. Sediment physical and chemical properties including water content, organic matter and carbonate content, wet and dry bulk density were determined. Environmental change in the past for these lakes was reconstructed using sediment diatom analyses.

S. Veski and A. Heinsalu coring the surface of the lake sediments on Lake Nohipalu Valgjärv. The results were used to interpret human impact on eutrophication.

Integrated Strategies for the Management of Transboundary Waters on the European fringe - the pilot study of Lake Peipsi and its drainage basin (MANTRA-East)

European Commission Project No. EVK1-CT-2000-00076, 2002–2004.
Team: **A. Heinsalu**, T. Alliksaar.

MANTRA-East is an international environmental research project launched to analyse and develop strategic planning methodologies and scientific tools for the integrated management of transboundary water basins located on the existing and future borders of the European Union. The point of departure of the MANTRA-East project is the EU Water Framework Directive. The project is funded by European Union Fifth Framework Program. The principal investigator at Intitute of Geology TTU is Atko Heinsalu. Our main task in the frame of the project is to carry out paleolimnological investigation of sediment sequences from Lake Peipsi and Lake Võrtsjärv in order to study the onset of the man-made eutrophication and to establish pre-eutrophication background conditions for those water bodies.

The current limnological monitoring programs established to determine the effects of nutrient enrichment in Lake Peipsi cover too short time-span, which narrows our perspective on when the changes in lake ecosystem started. In order to study the onset of the man-made eutrophication and to establish natural background conditions in Lake Peipsi a short sediment core was taken using a freeze corer from the central part of the lake. Recent sediments were examined by diatom analyses in a high temporal resolution. The age model developed for 40-cm sediment core was calculated using the constant rate of ^{210}Pb supply and the results were validated with independent chronological evidence, the down-core distribution of fly-ash particle abundance and regional oil-shale combustion history. Both chronologies were in good agreement and suggest that the sedimentary record covers the last 130 years. Diatom assemblages typical for large alkaline mesotrophic lake with well-illuminated water column occur in the sediment accumulated prior to mid-1950s. The lake ecosystem was stable and resistant for at least 70 years period to human activity. In mid-1950s and 1960s a modification in diatom flora is registered by an increase in the abundance of eutrophic diatom *Stephanodiscus parvus* although 'pristine associations' for Lake Peipsi were still dominating. In 1970s and 1980s high plankton abundance suggests high phytoplankton productivity and low transparency of the water. The planktonic component of the assemblage dominated by *Stephanodiscus parvus* reflects progressive nutrient enrichment. In 1990s a slight recovery of the ecosystem has taken place due to reduction of phosphorus loading. Absolute abundance of planktonic diatoms varies greatly, which implies that the ecosystem is still rather unstable. According to the preliminary dating results (^{210}Pb, ^{137}Cs, ^{241}Am, fly-ash particles) sedimentation rate in Lake Võrtsjärv was rather rapid and irregular. Sediment composition indicates rather strong eutrophication since 1960s.

Hydrogeological monitoring of the Kunda and Ubja mining and industrial area

Contract with the Joint-Stock Company Kunda Nordic Cement, 2003.
Team: **H. Kink**, T. Tubli, T. Metslang.

In 2002, the water use in 46 households in the Ubja oil-shale area was studied and the water levels were measured. In 2003, these data were processed, the results were compared with those obtained in 1988–1991. Since the studies were conducted in a water-poor year, the wells less than 10 m in depth, were dry. The situation proved most critical in the Aresi–Jäätma–Kohala area.

Preparation of submittal of new UNESCO World Heritage objects: the Baltic Klint and Soomaa National Park

Contract with the Estonian Ministry of the Environment, 2003.
Team: **H. Kink**, R. Vaher, A. Miidel.

According to the contract with the Ministry of the Environment of the Estonian Republic, relevant materials were prepared and submitted to UNESCO Estonian National Committee. The following objects relating to the Baltic Klint were proposed to be included on the World Heritage List: Osmussaar Landscape Reserve, Pakri Landscape Reserve, Türisalu Landscape

Reserve, Ülgase Landscape Reserve, Tsitre–Muuksi Klint within Lahemaa National Park, Ontika Landscape Reserve, Voka–Päite Klint, Udria Landscape Reserve. On September 29, 2003, the Baltic Klint was included in the preliminary list of UNESCO World Heritage Objects.

Soomaa peatland is one of the last bog massifs preserved in Europe. Materials justifying its inclusion on the World Heritage List were prepared. Since it is not allowed to have any kind of permanent human settlement at the site of natural heritage, Soomaa was proposed to be included on the World Heritage List as a natural and cultural heritage.

Study and protection of unique geological objects

Contract with Centre of Environmental Investments, 2002–2003.
Team: **L. Hints**, O. Hints, K. Mens, J. Nõlvak, H. Pärnaste.

The primary goal of this project was to study important and extensive but temporary geological exposures, such as those in working quarries, and collect rock and fossil material from these sites. In 2003, a lot of new data was obtained from the Vasalemma quarry, NW Estonia, especially on unique Ordovician ripple marks.

A rich geological and palaeontological material was also collected from the Kunda quarry. A proposal was made to consider a section on the Kunda river bank as the neostratotype of the Cambrian Lontova Formation and Lontova Stage; the geological sights of the excursion route in Kunda were proposed and the geological exhibition was composed in the Kunda museum.

An extensive temporary exposure in the Vasalemma quarry provided an opportunity to study unique Ordovician ripple marks. *Photo by G. Baranov.*

Study of ecological damage caused by the Frontier Guard Training Center of the former Soviet Union

Contract with Pakri Tuulepark Ltd, 2003–2003.
Team: **H. Kink**, T. Metslang, T. Tubli.

The environmental state of the area at the head of the Pakri Peninsula was studied. The results showed a weak residual pollution. Ecologically harmful waste must be stored and pollution sources eliminated.

Expertise on the conservation management plan of Avaste, Hageri, Sutlema, Varbola, Seli-Angerja landscape reserves

Contract with Environmental Survey of Rapla County, 2003.
Team: **H. Kink.**

This study was based on the Book of Primeval Nature compiled mainly in 1990s. More than 3000 springs are known in Estonia. Nearly 70 springs are proposed as candidates for Natura 2000 objects, 17 of these bearing international value, 48 are of Estonian importance and five have local meaning.

Categorisation of outcrops and erratic boulders in the Book of Primeval Nature

Contract with Estonian Ministry of the Environment, 2003.
Team: **E. Pirrus** (Department of Mining, TTU), L. Hints, A. Kleesment, K. Mens, T. Märss, H. Nestor.

This project aims to subdivide the objects recorded in the Book of Primeval Nature into different categories based on their scientific significance, aesthetic and recreational value. Objects of international-, state- and local importance are distinguished. For instance, stratotypes of regional chronostratigraphic units carry undoubtedly international meaning whilst some large erratic boulders may be of importance for local people only.

Supplementary environmental monitoring of the Pakri Peninsula and Paldiski Bay during dredging of the South Port of Paldiski

Contract with Institute of Marine Systems, Tallinn Technical University, 2003.
Team: **H. Kink**, T. Tubli, T. Metslang, A. Miidel.

The monitoring (January – June, 2003) showed

that part of the material dumped into the sea had accumulated on the shore. The abundance of birds had decreased. The sea water quality was much the same as during the dredging work in the autumn of 2002 (when it worsened).

Geophysical investigation of Paldiski wind farm area

Contract with Paldiski Tuulepark Ltd, 2003.
Team: **H. Kink**, T. Tubli, R. Vaher, T. Metslang.

Resistivity profiling was carried out along four traverses. The dipole-dipole array was used. The electrode separation of both dipoles was a = 20 m. The distance between the centres of dipoles was l = 40 m. Station spacing was 20 m. The total length of four traverses was 8 km. Attention was focused on narrow low-resistivity anomalies as indicators of possible fracture zones. Three major zones (length over 0.7 km) were located. Resistivity section of two zones was studied with deep-sounding on seven stations using the Schlumberger array.

Estimation of water quality of Lepasalu, Rõõmu- ja Varsaallika springs in Tallinn

Contract with Department of Transportation, Tallinn Technical University, 2003.
Team: **H. Kink**, T. Metslang, T. Tubli.

The data obtained through monitoring of springs opening in similar geological conditions were used for water quality assessment. Compared to this data, the Cl content in Varsaallika spring was 10 times, in Rõõmuallika spring 5 times and in Lepistiku spring 4 times higher. In the samples taken on September 6, 2003, the Cl content was 10–15 times higher.

Investigation of Leetse stream mouth area on Pakri Peninsula

Contract with Environmental Survey of Harju County, 2003.
Team: **H. Kink**, A. Miidel, T. Metslang, T. Tubli.

The bottom relief of the excavation in the mouth of Leetse stream was studied. Soil and water samples were taken. The diameter of the excavation is 36 m, depth from the water level ca 8 m. The excavation is surrounded by accumulations of sandstone and argillite overgrown with 20–30 year old pine forest. The water in the excavation is contaminated, bottom deposits are strongly polluted.

Compilation of books "Natural Heritage of Estonia 8: Harjumaa" and "Natural Heritage of Estonia 9: Ida-Virumaa"

Contract with Centre of Environmental Investments, 2002–2003.
Team: **H. Kink**, A. Miidel, A. Raukas.

The booklets dealing with the inanimate nature monuments including outcrops, erratic boulders and interesting landforms, but also providing information on mineral resources, water and greenery objects and historical monuments were published in 2003.

State Monitoring of Estonian Big Lakes Coasts

Contract with the Estonian Ministry of Environment, 2003.
Team: **A. Raukas**, E. Tavast.

Complex investigations were performed in 8 monitoring areas on the coast of Lake Peipsi and 7 areas on the coast of Lake Võrtsjärv.

Radiocarbon datings by contracts with various institutions in Estonia and abroad

Contracts with various institutions, 2003.
Team: **E. Kaup.**

Altogether ca 55 datings (18 to abroad).

Improvement of storage conditions and databasing drillcores and rock samples of the Institute of Geology

Contract with Centre of Environmental Investments, 2003.
Team: **L. Hints**, A. Aaloe, U. Toom, O. Hints, G. Baranov, M. Killing, J. Lääts.

Mineralogy, geochemistry and technical qualities of dolomites of the Kurevere deposit, Lower Silurian, Estonia

Contract with Nordkalk Ltd, 2003.
Team: **Puura, V.** (University of Tartu), M. Konsa and others.

Expert opinion on the categories of spring habitats included in the Appendix I of the EU Nature Directive

Contract with Environmental Survey of Rapla County, 2003.
Team: **H. Kink**, A. Miidel, R. Vaher.

Training and education

Degrees defended

V. Raidla defended his master's thesis "The formation of carbon content in Estonian Cambrian-Vendian groundwater and groundwater dating with radiocarbon method" on June 4, at the Department of Mining, Tallinn Technical University, Tallinn; supervisors: Prof. E. Pirrus (Department of Mining) and Dr. **R. Vaikmäe**.

Valle Raidla during the defense of his MSc thesis on June 4, 2003 at the Department of Mining, TTU. He continues research on groundwater as PhD student at Institute of Geology, University of Tartu. *Photo by Helle Pohl.* →

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PhD and MSc projects in progress

E. Kalam, MSc project "Timing and geochemistry of shoshonitic magmatism in the southern part of the Svecofennian Domain, Estonia", Tallinn Technical University, supervisor Prof. **A. Soesoo**;

E. Kiipli, PhD project "Modelling of the environmental geochemical changes in the Early Silurian Baltic Basin", Tallinn Technical University, supervisors Prof. **A. Soesoo** and T. Kiipli;

T. Martma, PhD project "Application of carbon and oxygen isotopes in the study of Baltic Ordovician and Silurian", Tallinn Technical University, supervisor Prof. **D. Kaljo**;

M.-A. Mõtus, PhD project "Lower Silurian tabulate corals from Baltoscandia, their taxonomy, distribution and palaeoecology", University of Tartu, supervisor Prof. T. Meidla (University of Tartu);

E. Niinemets, PhD project "Abrupt climactical changes in Holocene and Late-Pleistocene", University of Tartu, Institute of Geology, Tartu, supervisors Prof. T. Meidla (University of Tartu) and Dr. **S. Veski**;

H. Pärnaste, PhD "Systematics and biozonation of the Arenig trilobites of northern East Baltic", University of Tartu, Tartu, Estonia, supervisor Prof. T. Meidla (University of Tartu);

V. Raidla, PhD project "The formation of carbon content in Estonian Cambrian-Vendian groundwater", University of Tartu Institute of Geology, Tartu, supervisors Prof. K. Kirsimäe and Dr. E. Karro;

K. Urtson, MSc project "Melt migration and accumulation: an analogue modelling approach", University of Tartu, supervisor Prof. **A. Soesoo**;

K. Erg, PhD project "Water balance of closed and acting oil-shale mines", Tallinn Technical University, Tallinn, supervisors Prof. E. Reinsalu (Department of Mining) and Prof. **A. Raukas**;

K. Koppel, MSc project "The formation of historical rural landscapes during the 17th–19th centuries", University of Tartu, Faculty of Philosophy, Department of History, Tartu, supervisors Prof. A. Must (Tartu University), Dr. **S. Veski**;

A. Marandi, PhD project "Formation of the

chemical composition of the Cambrian-Vendian groundwater in Estonia", University of Tartu, supervisors Prof. V. Kalm (University of Tartu) and Dr. **R. Vaikmäe**;

R. Kuldkepp, PhD project "Geochemistry, partial melting and geochronology of Svecofennian crystalline rocks", Tallinn Technical University, supervisor Prof. **A. Soesoo**.

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Courses and lectures

Distribution of Ordovician chitinozoans in Baltoscandia, University of Dayton, Ohio, USA, guest lecture by *J. Nõlvak*;

Environmental technique and technoecology, Estonian Maritime Academy, course by *A. Raukas*;

Evolution of the Earth biosphere and global climate and environmental changes, University of Tartu, lecture course by T. Meidla and *R. Vaikmäe*;

Geology and geophysics, Estonian Maritime Academy, lecture course by *A. Raukas*;

Geology and mineral resources of Estonia, EuroUniversity, lecture course by *A. Raukas*;

Geophysics and dynamic geology, EuroUniversity, lecture course by *A. Raukas*;

Isotope geology and hydrology, University of Tartu, lecture course by *R. Vaikmäe*;

Limnology, EuroUniversity, lecture course by *E. Kaup*;

Marine geology, Estonian Maritime Academy, lecture course by *A. Raukas*;

Monitoring of surface waters, EuroUniversity, lecture course by *E. Kaup*;

On the geology of Estonia, in the Kunda Museum, mostly for the pupils of the Kunda Secondary School, series of lectures by *L. Hints*;

Palaeoclimatology, Estonian Maritime Academy, lecture course by *A. Raukas*;

The Antarctic environment and its protection, Märjamaa high school, Illuka and Mäetaguse basic schools, lectures by *E. Kaup*;

Lectures and astronomical observations, Student circle "M31", Tallinn Astronomy Observatory, by *Ü. Kestlane* and *J. Ivask*.

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Conferences, workshops and exhibitions organised

Earth Fields and their Influence on Organisms, June 26–29, Estonian Society of Geopathy, Institute of Geology at TTU, Kloogarand, Estonia; co-organiser: *A. Raukas*;

Exhibition "Photos from Estonian Outcrops and Waters", January 16 – June 1, Forest Museum, Sagadi, Estonia; organiser: *J. Nõlvak*;

Exhibition "Slices of Geology", February 14 – August 5, Museum of Kunda, Kunda, Estonia; organisers: *L. Hints, H. Pärnaste, G. Baranov*;

Exhibition of fossil fishes, September 7 – December 31, Latvian Museum of Natural History, Riga, Latvia; organiser: *E. Mark-Kurik*;

F.G. v Bellingshausen's 225th anniversary, October 2–5, EGS, Estonian Polar Foundation, Tallinn, Estonia; organiser: *E. Kaup*;

International Symposium on Human Impact and Geological Heritage, May 12–17, Institute of Geology at TTU, Institute of Ecology, TPU, Geological Survey of Estonia, Tallinn, Estonia; organisers: *R. Karukäpp, A. Miidel, A. Raukas, E. Tavast*;

International Symposium on Human Impact and Geological Heritage held in Tallinn on May 12-17 was dedicated to the 100th anniversary of famous Estonian geologist Karl Orviku. The meeting attracted many people outside geological disciplines as well. *Photo by G. Baranov.*

Geological excursion of the Gross Symposium on vertebrate palaeontology visited several famous fossil sites of Saaremaa Island. T. Märss, one of the organisers (second to the right), is demonstrating eurypterid remains in Viita Trench. *Photo courtesy to Ieva Upeniece.*

Meteorites and meteorite craters I: Are Kaali craters well studied?, February 27, Institute of Geology, University of Tartu, Tartu, Estonia; co-organiser: *S. Veski*;

The Gross Symposium 2. Advances in Palaeoichthyology, September 7–14, University of Latvia and Latvian Museum of Natural History, Riga, Latvia; co-organiser: *T. Märss*.

Participation in international conferences and workshops

200 years from the 1st Russian circumnavigation, August 8, NGO A.J. v Krusenstern, Kiltsi, Estonia; participant: *E. Kaup*;

65th EAGE Conference and Technical Exhibition, June 2–5, European Association of Geoscientists & Engineers, Stavanger, Norway; participant: *A. Shogenova*;

6th Framework Programme project proposal meeting, May 5–6, GADAM Centre, Ustron, Poland; participant: *A. Molodkov*;

6th NorFa POLLANDCAL Workshop, February 7–11, NorFa, Bern, Switzerland; participants: *A. Poska, S. Veski*;

7th Congress on the History of Oceanography, September 6–14, World Ocean Museum, Kaliningrad, Russia; participant: *A. Raukas*;

7th NorFa POLLANDCAL Workshop, May 15–19, NorFa, Exeter, England, UK; participants: *A. Poska, S. Veski*;

8th NorFa POLLANDCAL Workshop, October 16–20, University of Bergen, Bergen, Norway; participant: *A. Poska*;

9th International Paleolimnology Symposium, August 24–28, University of Helsinki, Geological Survey of Finland, Espoo, Finland; participants: *T. Alliksaar, A. Heinsalu, E. Kaup, T. Martma, J. Vassiljev, S. Veski*;

9th International Symposium on Fossil Cnidaria and Porifera, August 3–7, University of Graz, Graz, Austria; participants: *D. Kaljo, M. Mõtus*;

Academia Europaea annual meeting, September 11–14, Academia Europaea, Graz, Austria; participant: *R. Vaikmäe*;

Annual Meeting of the Russian Mineralogical Society. Mineralogy, Gemmology, Art, September 23–26, Sankt-Petersburg University, Sankt-Petersburg, Russia; participant: *L. Bityukova*;

Baltic Sea Science Congress, August 24–28, University of Helsinki, Helsinki, Finland; participant: *J. Vassiljev*;

COGEOENVIRONMENT 2003, September 13–19, Union of Geological Sciences (IUGS), Geological Survey of Lithuania, Vilnius, Lithuania; participants: *L. Bityukova, E. Tavast*;

Earth Fields and their Influence on Organisms, June 26–29, Estonian Society of Geopathy, Kloogarand, Estonia; participant: *A. Raukas*;

Estonian Nature Photo of the year 2000 (photo exhibition), January 1, Tallinn, Estonia; participant: *H. Pärnaste*;

F.G. v Bellingshausen's 225th anniversary, October 2, Estonian Geographical Society, Tallinn, Estonia; participants: *E. Kaup, A. Raukas*;

First International Paleobiology Database Symposium, March 13–15, Natural History Museum, Humboldt University, Berlin, Germany; participant: *O. Hints*;

Geological Heritage Concept, Conservation and Protection Policy in Central Europe, October 1–4, Polish Geological Institute, Centre of Exellence Research on Abiotic Environment REA, Krakov, Poland; participants: *A. Raukas, E. Tavast*;

Global ruling at transition time: Innovative proposals for gaining peace in changeable world, August 27, Interreligional Society, Tallinn, Eesti; participant: *A. Raukas*;

International Symposium on Human Impact and Geological Heritage, May 12–17, Institute of Geology at TTU, Institute of Ecology, TPU, Geological Survey of Estonia, Tallinn, Estonia; participants: *R. Karukäpp, A. Miidel, A. Raukas, A. Soesoo, E. Tavast, J. Vassiljev*;

International Symposium on Isotope Hydrology and Integrated Water Resources Management, May 19–23, International Atomic Energy Agency (IAEA), Vienna, Austria; participants: *T. Martma, R. Vaikmäe*;

JCADM-7 (Joint Committee of Antarctic Data Management), June 28 – July 5, Federal Office for Scientific, Technical and Cultural Affairs (OSTC), Brussels, Belgium; participant: *J. Ivask*;

Loess and paleoenvironment, May 26 – June 1, INQUA, Moscow, Russia; participant: *A. Molodkov*;

NARP project Meeting, October 26–27, Institute for Marine and Atmospheric Research, Utrecht, Netherlands; participant: *T. Martma*;

Polar Regions and Quaternary Climate, October 4–9, San Feliu de Guixols, Spain; participant: *A. Molodkov*;

Polarclim-2 workshop: Land-ocean links in Holocene palaeoclimatology, May 8–9, Polarclim project, Bergen, Norway; participant: *S. Veski*;

Presentation and Understanding of Dating Results, May 3, GADAM Centre, Ustron, Poland; participant: *A. Molodkov*;

Rapid transgressions into semi-enclosed basins, May 8–10, Polish Geological Institute, Gdansk-Jastarnia, Poland; participant: *J. Vassiljev*;

RiSCC (Regional Sensitivity to Climate Change in Antarctic Terrestrial and Limnetic Ecosystems), July 2–8, Insubria Varese University, Varese, Italy; participant: *E. Kaup*;

The Baltic Sea Region: Formation and Deformation of the Crust, March 4, University of Tartu, Institute of Geology, Tartu, Estonia; participants: *A. Kleesment, M. Konsa, J. Nõlvak, A. Soesoo, R. Vaher*;

The Fourth World Meeting of Estonian Geologists. Estonian Geology in the Beginning of the New Century, September 26–27, University of Tartu, Institute of Geology, Tartu, Estonia; participants: *R. Einasto, D. Kaljo, R. Karukäpp, M. Killing, A. Kleesment, E. Mark-Kurik, J. Nemliher, H. Nestor, V. Nestor, A. Poska, A. Raukas, A. Shogenova, A. Soesoo, E. Tavast, A. Teedumäe, R. Vaher, J. Vassiljev*;

The Gross Symposium 2. Advances in Palaeoichthyology, September 7–14, University of Latvia and Latvian Museum of Natural History, Riga, Latvia; participants: *E. Mark-Kurik, T. Märss*;

Workshop of the EC 5th Framework Programme projekt BASELINE, March 29 – April 2, University of Avignon, Avignon, France; participant: *R. Vaikmäe*;

Workshop of the EU 5th Framework Programme, January 22–25, European Commission, Strasbourg, France; participant: *R. Vaikmäe*;

World Water Week – 2003, August 9–16, Global International Water Assessment, Stockholm, Sweden; participant: *L. Bityukova*;

XVI INQUA Congress, July 23–30, INQUA, Reno, USA; participant: *A. Poska*;

XXVI Antarctic Treaty Consultative Meeting, June 9–20, Foreign Ministry of Spain, Madrid, Spain; participant: *E. Kaup*.

International travels and visits

Bityukova, L., March 12–28, Helsinki University, Helsinki, Finland, studied and analysed carbonate rocks by ACP;

Bityukova, L., June 22–29, Hydroisotope laboratory, Federal Institute for Geosciences and Natural Resources, Schweitenkirchen (München), Berlin, Germany, studied various research and analysis techniques;

Heinsalu, A., January 7–9 and January 22–25, Geological Survey of Finland, Turku University, Espoo and Turku, Finland, discussed collaborative research and participated in the defence of PhD thesis of T. Kauppila;

Heinsalu, A., May 26–30 and November 17–20, Geological Survey of Finland, Espoo, Finland, to use the equipment in the laboratory of paleomagnetism and discuss scientific co-operation;

Hints, O., October 5–16, Lund University, Lund, Sweden, studied Silurian scolecodonts from Gotland and Saaremaa in order to establish taxonomic composition and distribution of jawed polychaetes in Estonia and to compare the polychaete faunas of the two regions;

Hints, L., June 10–19, Swedish Natural History Museum, Stocholm, Sweden, studied collections of Ordovician brachiopods deposited in the museum, type-, figured- and illustrated specimens in particular;

Kaljo, D., March 13–14, Academy of Finland, Helsinki, Finland, participated in the meeting of Nordic representatives of the European Science Foundation;

Kleesment, A., March 28 – April 3, Institute of Geology and Geography, Vilnius, Lithuania, collected samples from Devonian drillcore sections;

Kleesment, A., September 28 – October 4, Institute of Geology, University of Latvia, Riga, Latvia, collected samples from Devonian drillcore sections;

Konsa, M., March 23–31 and September 27 – October 4, Geological Survey of Latvia, Riga, Latvia, collected rock samples;

Mark-Kurik, E., September 11–12, Latvian Museum of Natural History, Riga, Latvia, studied Devonian fishes (psammosteids) in collections and exposition of the museum;

Martma, T., April 21 – May 10, Norwegian Polar Institute, Tromsø and Svalbard, Norway, participated in fieldwork in the frame of NARP Project in Svalbard;

Martma, T., November 30 – December 7, Norwegian Polar Institute, Tromsø, Norway, participated in high resolution sampling of the Lomonosovfonna deep ice core;

Mõtus, M., September 21 – October 5, Institute of Geology of Komi Science Centre of Ural Branch of the Russian Academy of Sciences, Syktyvkar, Russia, studied tabulate collections from Subpolar Urals;

Männik, P., April 3–14, Institute of Geology

Peep Männik participated the expedition to North Urals were many Lower Palaeozoic sections were visited, described and sampled in 2003. In this photo, Silurian limestones are exposed by the Ilych River, Ambar-Kyrta. *Photo by P. Männik.*→

and Geochemistry, Ekaterinburg, Russia, studied collections of Silurian conodonts from the North- and Central Urals (Kabanka, Toguzak, SG-4 core, etc. sections);

Männik, P., June 16 – August 31, Institute of Geology of Komi Science Centre of Ural Branch of the Russian Academy of Sciences, Syktyvkar, Komi Republic, Russia, participated in the fieldwork organised by the Institute of Geology (Syktyvkar) in the North and Subpolar Urals;

Nõlvak, J., May 24–27, University of Lund, Lund, Sweden, participated in the ceremonial meeting for dedication of two Ordovician Global Stratotype Sections and Points (GSSPs) marking the base of the Second Stage at Fagelsang and the base of the Upper Ordovician and the Fifth Stage at Diabasbrottet;

Nõlvak, J., September 2 – October 31, University of Dayton, Dayton, Ohio, USA, studied Ordovician graptolite and chitinozoan evolution and biostratigraphy in the frame of collaborative project (EAR 0106844);

Raukas, A., July 20 – August 3, Nancy University, Nancy, France, studied the composition and genesis of microimpactites of the Kaali crater field in the frame of Parrot project (together with Prof. F. Marini);

Raukas, A., October 22–28, Geological Institute of Hungary, Budapest, Hungary, studied jointly the composition and distribution of fine meteorite matter;

Shogenova, A., February 6–12 and August 18–28, Petrophysical Laboratory, Institute of the Earth's Crust, St. Petersburg University, St. Petersburg, Russia, carried out laboratory analysis of physical properties of Palaeozoic sedimentary rocks of the Baltic region;

Shogenova, A., March 28 – April 3, Institute of Geology and Geography, Vilnius, Lithuania, participated in fieldwork and collected samples of sedimentary rocks;

Soesoo, A., August 31 – September 8, Lapland, Finland, Sweden, participated in the NorFa field excursion dedicated to transition from orogenic to anorogenic magmatism;

Soesoo, A., July 10–25, Charles University, Prague, Trest, Czeck Republic, participated in the summer school and the meeting, and did some laboratory research as well;

Teedumäe, A., January 29 – February 5, Institute of Geology, University of Latvia, Riga, Latvia, studied the results of physical-mechanical analysis of various carbonate rocks;

Teedumäe, A., March 28 – April 3, Institute of Geology and Geography, Vilnius, Lithuania, participated in fieldwork and collected samples of sedimentary rocks;

Teedumäe, A., September 27 – October 4, Institute of Geology, University of Latvia, Riga, Latvia, participated in fieldwork and collected samples of sedimentary rocks;

Vaher, R., March 28 – April 3, Institute of Geology and Geography, Vilnius, Lithuania, participated in fieldwork and collected samples of sedimentary rocks;

Vaher, R., September 27 – October 4, Institute of Geology, Riga, Latvia, collected rock samples;

Veski, S., May 26–30, Geological Survey of Finland, Espoo, Finland, used laboratory facilities and carried out palaeomagnetic analysis.

T. Martma sampled a glacier for $\delta^{18}O$ in Holtedahlfonna, Svalbard (May 2003, 79°N, elevation 1175 m). *Photo by O. Brandt.*

Co-operation partners

All-Russian Geological Institute (VSEGEI), St. Petersburg, Russia;

Andong University, Andong, South Korea;

Arctic and Antarctic Research Institute, Russian Academy of Sciences, St. Petersburg, Russia;

Arctic Center, Rovaniemi, Finland;

Belarus National Academy, Institute of Geological Sciences, Minsk, Belarus;

British Antarctic Survey, Cambridge, UK;

British Geological Survey, Wallinford, UK;

Centre of Isotope Research, Grøningen, Netherlands;

CSIRO Marine Research, Hobart, Australia;

Department of Environment & Resources, Technical University of Denmark, Lyngby, Denmark;

Department of Geography and Oceanography, Australian Defence Force Academy, Australian Capital Territory, Australia;

Department of Mining, Tallinn Technical University, Tallinn, Estonia;

Department of Natural Sciences, Tallinn Pedagogical University, Tallinn, Estonia;

Department of Ecology and Environmental Science, Umeå University, Umeå, Sweden;

Division of Earth Sciences, University of Glasgow, Glasgow, Scotland, UK;

Environmental Change Research Centre, University College London, London, UK;

Estonian Museum of Natural History, Tallinn, Estonia;

Federal Institute of Geosciences and Natural Resources, Berlin, Germany;

Freie Universität Berlin, Institut für Geologische Wissenschaften, Berlin, Germany;

Geoforschungs Zentrum, Potsdam, Germany;

Geological Institute, University of Bergen, Bergen, Norway;

Geological Museum of the Copenhagen University, Copenhagen, Denmark;

Geological Museum of University of Copenhagen, Copenhagen, Denmark;

Geological Museum of University of Helsinki, Helsinki, Finland;

Geological Survey of Denmark, Copenhagen, Danmark;

Geological Survey of Estonia, Tallinn, Estonia;

Geological Survey of Finland, Espoo, Finland;

Geological Survey of Lithuania, Vilnius, Lithuania;

Geological Survey of Norway, Trondheim, Norway;

Hungarian Geological Institute, Budapest, Hungary;

Hydroisotop Laboratory, Schweitenkirchen, Germany;

Indiana University, Bloomington, USA;

Institute of Ecology, Tallinn Pedagogical University, Tallinn, Estonia;

Institute of Environmental Physics, University of Tartu, Tartu, Estonia;

Institute of Experimental Physics and Technology, University of Tartu, Tartu, Estonia;

Institute of Geology and Geochemistry, Ekaterinburg, Russia;

Institute of Geology, Komi Science Centre, Ural Branch of Russian Academy of Sciences, Syktyvkar, Russia;

Institute of Geology, University of Tartu, Tartu, Estonia;

Institute of Marine Systems, Tallinn Technical University, Tallinn, Estonia;

Institute of Palaeontology of the Russian Academy of Sciences, Moscow, Russia;

Institute of Petroleum and Gas Geology, Siberian Branch of Russian Academy of Sciences, Novosibirsk, Russia;

Institute of Physics of the Earth, Russian Academy of Sciences, Moscow, Russia;

Institute of Zoology and Botany, Estonian Agricultural University, Tartu, Estonia;

Kola Science Centre, Russian Academy of Sciences, Apatity, Russia;

Krakow University of Mining and Metallurgy, Krakow, Poland;

Latvian Museum of Natural History, Riga, Latvia;

Lithuanian Institute of Geology and Geography, Vilnius, Lithuania;

Lund University, Lund, Sweden;

Mainz University, Mainz, Germany;

Memorial University of Newfoundland, St. John's, Canada;

Milwaukee Public Museum, Milwaukee, USA;

Mining Institute, St. Petersburg, Russia;

Moscow State University, Moscow, Russia;

Museum Victoria, Geology Section, Carlton, Victoria, Australia;

Nancy University, Nancy, France;

National Institute of Chemical Physics and Biophysics, Tallinn, Estonia;

National Institute of Polar Research, Tokyo, Japan;

National Museums and Galleries of Wales, Cardiff, Wales, UK;

Northern Arizona University, Flagstaff, USA;

Norwegian Geotechnical Institute, Oslo, Norway;

Norwegian Polar Institute, Tromsø, Norway;

Polish Institute of Geology, Warszawa, Poland;

Polytechnical University of Catalonia, Barcelona, Spain;

Pskov Pedagogical University, Pskov, Russia;

Research Institute of Earth Crust, St. Petersburg University, St. Petersburg, Russia;

Smolensk Pedagogical University, Smolensk, Russia;

Stockholm University, Stockholm, Sweden;

Tartu Observatory, Tõravere, Estonia;

Texas Technical University, Lubbock, USA;

The Academy of Natural Sciences, Philadelphia, USA;

The Institute of Archaeology and Ethnography of the Siberian Branch, Russian Academy of Sciences, Novosibirsk, Russia;

The Natural History Museum, London, UK;

University of Alberta, Edmonton, Canada;

University of Avignon, Avignon, France;

University of Bern, Bern, Switzerland;

University of Cambridge, Cambridge, England;

University of Dayton, Ohio, USA;

University of Exeter, Exeter, UK;

University of Gent, Gent, Belgium;

University of Helsinki, Helsinki, Finland;

University of Latvia, Riga, Latvia;

University of Leicester, Leicester, UK;

University of Liverpool, Liverpool, UK;

University of Münster, Münster, Germany;

University of Oulu, Oulu, Finland;

University of Portsmouth, Portsmouth, UK;

University of Poznan, Poznan, Poland;

University of Rennes, Rennes, France;

University of Rio de Janeiro, Rio de Janeiro, Brasil;

University of Tartu, Tartu, Estonia;

University of Tübigen, Tübigen, Germany;

University of Uppsala, Uppsala, Sweden;

University of Vilnius, Vilnius, Lithuania;

University of Wisconsin-Milwaukee, Milwaukee, USA;

Växjö University, Växjö, Sweden.

Guest scientists

15 researchers from Environmental Engineering Department from Norwegian Geotechnical Institute, Oslo, Norway, participated in the scientific excursion to North-Eastern Estonia (October 9–11, hosted by L. Bityukova);

Afanassieva, Olga from Palaeontological Institute of RAS, Russia, was interested in the osteostracan material collected from several regions of Russia (the Central Urals, Severnaya Zemlya, northern Timan), and housed in the Institute of Geology at TTU (December 11–19, hosted by T. Märss);

Bogdanova, Svetlana from Lund University, Sweden, discussed co-operation projects on the Baltic Precambrian (June 10, hosted by A. Soesoo);

Dong-Jin, Lee and Boo Young, Bae from Andong University, South Korea, collected Middle- and Upper-Ordovician tabulate corals from varius localities in Estonia (August 9–14, hosted by M. Mõtus);

Gorbatchev, Roland from Lund University, Sweden, discussed co-operation projects on the Baltic Precambrian (June 10, hosted by A. Soesoo);

6 researches lead by Hahlbrock, Klaus from Max Plank Society & GS Foundation, Germany, discussed problems of marine geology and research in Estonia (October 6, hosted by A. Soesoo, D. Kaljo and A. Raukas);

Karabanov, Aleksander from Geological Institute of Belarus National Academy, Belarus, participated in the conference "Human Impact and Geological Heritage" and coordinated the joint research in the field of Quaternary geology (May 12–17, hosted by A. Raukas);

Löfgren, Anita from Lund University, Sweden, studied Ordovician conodonts from the Pakri Cape section and prepared a joint manuscript (August 14, hosted by V. Viira);

Marini, Francois from Nancy University, France, participated in the conference "Human Impact and Geological Heritage" and discussed a joint research of Kaali meteorite crater field (May 10–15, hosted by A. Raukas);

Marini, Francois from Nancy University, France, collected cosmogenic material and microimpactites in Piila Bog during the joint expedition to Saaremaa, and technogenic spherulitic material in Estonian Oil Shale Basin (September 15–25, hosted by A. Raukas);

Nielsen, Arne Thorshøj from Geological Museum of University of Copenhagen, Denmark, studied different sections of the Volkhov Stage and took samples for the research on ecology of trilobites (July 4–17, hosted by H. Pärnaste);

Norova, Larisa from St. Petersburg Mining Institute, Russia, studied engineering geological characteristics of deposits in the Voka outcrop (August 18–22, hosted by A. Raukas);

Ojala, Antti from Geological Survey of Finland, Finland, carried out fieldwork on Lake Rõuge Tõugjärv (February 25–27, hosted by A. Heinsalu);

Rudolph-Lund Kim from Norwegian Geotechnical Institute, Oslo, Norra, coordinated the hydrogeological modelling (August 31 – September 3, hosted by L. Bityukova);

Saether, Ola. M from Geological Survey of Norway, Trondheim, Norway, discussed results of the collaborative project and prepared a joint paper (March 24–30, hosted by L. Bityukova);

Seppä, Heikki from University of Helsinki, Finland, discussed and prepared the final version of the joint paper "The 8200 yr. cold event recorded in annually laminated lake sediments in eastern Europe" and future co-operation (October 23–24, hosted by S. Veski);

Sorlie, Jan-Erik from Norwegian Geotechnical Institute, Oslo, Norra, discussed and coordinated the Norwegian-Estonian project "Risk based environmental site assessment of waste from the oil shale industry" (January 30 – February 2, hosted by L. Bityukova);

Stankowski, Wojciech and Kaczmarek, Pavel from Geological Institute of Poznan University, Poland, studied jointly the morphology and composition of fine meteorite matter at Ilumetsa and Kaali meteorite craters (May 7–18, hosted by A. Raukas);

Thorn, Paul from American Embassy, USA/ Denmark, was introduced with the institute and its development plans (February 14, hosted by A. Soesoo);

Tovmasyan, Kristine from Institute of Geology, University of Latvia, Latvia, consulted about the location of outcrops of the Pärnu Stage and investigation of this unit (May 31, hosted by A. Kleesment);

Valiukevičius, Juosas from Institute of Geology and Geography of Lithuania, Lithuania, studied Silurian acanthodians from Estonia (May 5–17, hosted by T. Märss).

* * *

Membership

Academia Europaea, *R. Vaikmäe* (member);

Academy of Sciences of New York, *A. Raukas* (acting member);

Advisory Board of the journal Baltica (Vilnius), *A. Raukas* (member);

American Geochemical Society, *A. Lepland* (member);

American Geographical Society, *A. Raukas, L. Saarse* (members);

American Geophysical Society, *A. Lepland* (member);

American Geophysical Union, *R. Vaikmäe* (member);

Archimedes Foundation, *R. Vaikmäe* (member of the board);

Association Eesti Elujõud (the Vitals of Estonia), *A. Raukas* (member);

Association Eluterve Eesti (Sound Estonia), *A. Raukas* (member);

Australian National Antarctic Research Expeditions (ANARE) Club, *E. Kaup* (member);

Baltic Stratigraphical Association, *D. Kaljo* (chairman), *A. Raukas* (member);

Board of the Estonian Encyclopedia Publishers, *A. Raukas* (chairman);

Cabardinian non-profit Society, *A. Shogenova* (co-founder);

CIMP Subcommission on Chitinozoa, *V. Nestor, J. Nõlvak* (members);

Commission of Development of Tallinn Technical University, *A. Soesoo* (member);

Commission of Estonian Mineral Resources, *D. Kaljo* (chairman); *A. Soesoo* (member);

Council and Board of Kalev Sports Society, *A. Raukas* (member);

Council of Academic Library of Tallinn Pedagogical University, *D. Kaljo* (chairman);

Council of Europe, Committee on Higher education and Research, *R. Vaikmäe* (member of the Bureau);

Council of Institute of Geology at TTU, *A. Soesoo* (chairman); *D. Kaljo* (deputy chairman); *L. Hints, J. Ivask, A. Molodkov, P. Männik, T. Märss, A. Raukas, R. Vaikmäe, S. Veski* (members);

Council of Tallinn Technical University, *A. Soesoo* (member);

Curatorium of Tallinn Pedagogical University, *A. Raukas* (chairman), *R. Vaikmäe* (member);

Curatorium of Estonian Agricultural University, *R. Vaikmäe* (member);

Editorial Advisory Board of journal Oceanological and Hydrobiological Studies (Gdansk), *A. Raukas* (member);

Editorial Board of Biographic Lexicon of Estonian Science, *H. Nestor* (member of the and editor of speciality);

Editorial Board of journal Boreas, *R. Vaikmäe* (member);

Editorial Board of journal Bulletin of the Geological Society of Finland, *A. Heinsalu* (member);

Editorial Board of journal Bulletin of the Geological Survey of Estonia, *A. Miidel* (member);

Editorial Board of journal Newsletter on Stratigraphy, *D. Kaljo* (corresponding editor);

Editorial Board of journal Oil Shale, *A. Raukas* (member);

Editorial Board of journal Paleontologicheskij Zhurnal, *D. Kaljo* (member);

Editorial Board of journal Proceedings of the Estonian Academy of Sciences. Geology, *A. Raukas, D. Kaljo*, *A. Miidel* (members), *R. Vaikmäe* (member of the advisory board);

Editorial Board of journal Quaternary International (Canada), *R. Vaikmäe* (member);

Editorial Board of journal Stratigrafiya. Geologicheskaya Korreliatsiya, *D. Kaljo* (member);

E**ditorial Board of Year Book "Research into Ancient Times"**, *A. Raukas* (member).

Encyclopaedia of Estonia, *A. Raukas* (scientific chief editor);

Encyclopaedia of Tallinn, *A. Raukas* (member of the editorial board);

Enterprise Estonia, finance committee, *R. Vaikmäe* (member);

Estonian Academy of Sciences, *D. Kaljo* (member, board member, foreign secretary); *A. Raukas* (member);

Estonian Academy of Sciences, Commission of Meteoritics, *A. Raukas* (chairman); *Ü. Kestlane* (member); *R. Tiirmaa* (secretary);

Estonian Academy of Sciences, Commission of Natural Conservation, *A. Miidel* (member);

Estonian Academy of Sciences, Commission on Science Stipends, *A. Raukas* (member);

Estonian Academy of Sciences, Council of Energetics, *A. Raukas* (member);

Estonian Academy of Sciences, Division of Biology, Geology and Chemistry, *D. Kaljo* (deputy head);

Estonian Academy of Sciences, Publishing Board, *A. Raukas* (member);

Estonian Association of Owners by Title, *A. Raukas* (chairman and head of the board);

Estonian Astronomical Society, *J. Ivask* (member); *Ü. Kestlane* (member of the board);

Estonian Commission on Stratigraphy, *D. Kaljo* (chairman); *J. Nõlvak, A. Raukas* (members); *O. Hints* (secretary);

Estonian Commission on Stratigraphy, Ordovician-Silurian-Devonian Working Group, *J. Nõlvak* (chairman); *O. Hints, L. Hints, D. Kaljo, A. Kleesment, E. Mark-Kurik, P. Männik, T. Märss, H. Nestor,* (members);

Estonian Commission on Stratigraphy, Precambrian Working Group, *A. Soesoo* (member);

Estonian Commission on Stratigraphy, Quaternary Working Group, *A. Raukas* (chairman); *E. Kaup, A. Miidel, A. Molodkov, L. Saarse, S. Veski* (members);

Estonian Commission on Stratigraphy, Vendian-Cambrian Working Group, *K. Mens* (member);

Estonian Geographical Society, *A. Raukas* (deputy chairman and member of the presidium); *A. Raukas* (honorary member); *R. Karukäpp, E. Kaup, A. Miidel, J. Nõlvak, L. Saarse, E. Tavast, R. Vaikmäe* (members); *H. Kink* (member of the board);

Estonian Geological Society, *L. Bityukova, O. Hints, R. Karukäpp, A. Marandi, K. Mens, A. Miidel, A. Shogenova, E. Tavast, R. Vaher, R. Vaikmäe* (members); *D. Kaljo, A. Raukas* (members of the council);

Estonian Jewish Society, *A. Shogenova* (member);

Estonian Malacological Society, *E. Tavast* (member);

Estonian Maritime Academy, Board of Councels, *A. Raukas* (member);

Estonian Maritime Academy, Council of Marine Department, *A. Raukas* (member);

Estonian Mining Society, *K. Erg* (member);

Estonian Ministry of Education, Board of Scientific Competence, *R. Vaikmäe* (member);

Estonian Ministry of Environment, Board, *A. Raukas* (member);

Estonian National Committee of Geologists, *D. Kaljo* (chairman); *A. Soesoo, A. Raukas* (members);

Estonian National Culture Foundation, Tiina Tamman's Subfoundation, *A. Raukas* (board member);

Estonian Naturalists' Society, *H. Nestor* (chairman of divison of palaeontology); *R. Einasto, L. Hints, D. Kaljo, H. Kink, A. Kleesment, M. Konsa, E. Mark-Kurik, K. Mens, A. Miidel, P. Männik, V. Nestor, J. Nõlvak, A. Rukas, L. Saarse, L. Sarv, E. Tavast, R. Tiirmaa, R. Vaher, V. Viira* (members);

Estonian Polar Club, *E. Kaup, T. Martma, R. Vaikmäe* (members);

Estonian Polar Foundation, *E. Kaup* (member of the board);

Estonian Rome Club, *A. Raukas* (member);

Estonian Science Foundation Bio-Geoscience expertcommission, *S. Veski* (expert);

Estonian Society for Research of Native Place, *A. Raukas* (member);

Estonian Society of Prehistoric Art, *Ü. Kestlane* (member of the board);

Estonian Union of History and Philosophy of Science, *H. Nestor* (member of the board, chairman of Tallinn division); *Raukas* (member);

Estonian Union of Scientists, *A. Raukas* (co-chairman, member of the board); *R. Vaikmäe* (member of the board); *A. Kleesment* (member of the council); *R. Einasto, D. Kaljo, R. Karukäpp, H. Kink, H. Nestor, A. Soesoo, E. Tavast, R. Vaher* (members);

Euro-Asian Geophysical Society, *A. Shogenova* (member);

European Association of Geoscientists and Engineers (EAGE), *A. Shogenova* (member);

European Geophysical Society, *L. Bityukova* (member);

European Pollen Monitoring Program, *A. Poska* (member);

European Society for Isotopic Research, *R. Vaikmäe* (member of the advisory board); *T. Martma* (member);

Finnish Society of Earth Physics, *A. Raukas* (member);

Geological Curators Group, *O. Hints* (member);

Geological Society of Finland, *A. Raukas* (corresponding member);

Geological Society of London, *D. Kaljo* (honorary member);

INQUA Comission on Continental Palaeohydrology, *L. Saarse* (corresponding member);

INTAS, *L. Bityukova, E. Kaup* (evaluators);

International Association For Mathematical Geology (IAMG), *A. Shogenova* (member);

International Association for the Study of Fossil Cnidaria and Porifera, *H. Nestor* (member of the council);

International Association of Exploration Geochemistry, *L. Bityukova* (member);

International Association of Geochemistry and Cosmochemistry, *L. Bityukova* (member);

International Association of Geomorphologists, *A. Raukas* (Estonian national representative);

International Association of Geomorphologists, Estonian National Committee, *A. Raukas* (chairman); *R. Karukäpp* (secretary);

International Association of Hydrogeologists (IAH), *A. Marandi, R. Vaikmäe* (members);

International Association of Sedimentology, *L. Bityukova* (member);

International Association of Theoretical and Applied Limnology (SIL), *E. Kaup* (member);

International EPR (ESR) Society, *A. Molodkov* (member);

International Federation of Scientists, *A. Raukas* (member);

International Glaciological Society, IGS, *R. Vaikmäe* (member);

International Palaeontological Association, *T. Märss, V. Viira* (members);

International Palaeontological Association, graptolite working group, *D. Kaljo* (member);

International Permafrost Association, IPA, *R. Vaikmäe* (member);

International Society of Vertebrate Morphology, *T. Märss* (member);

International Union for Quaternary Research (INQUA), *A. Raukas* (honorary member);

International Union for Quaternary Research (INQUA) Estonian National Committee, *R. Vaikmäe* (vice-chairman); *A. Raukas, L. Saarse* (members);

International Union of Geological Sciences,

Commission on Geological Sciences and Environmental Planning, *A. Raukas* (Estonian national representative);

International Union of Geological Sciences, Subcommission on Devonian Stratigraphy, *E. Mark-Kurik* (corresponding member);

International Union of Geological Sciences, Subcommission on Ordovician Stratigraphy, *L. Hints, O. Hints, D. Kaljo, J. Nõlvak* (corresponding members);

International Union of Geological Sciences, Subcommission on Silurian Stratigraphy, *D. Kaljo* (member); *P. Männik, T. Märss, H. Nestor* (corresponding members);

IPA Task Force for Isotope Geochemistry of Permafrost, *R. Vaikmäe* (member);

Ministry of Environment of Estonia, *A. Teedumäe* (leader of the group to draft the decree);

Non-profit Society "Museum of Konstantin Päts", *A. Raukas* (member);

Non-profit Society "Pakri Nature Centre", *A. Raukas* (chairman); *H. Kink,* (member of the board);

Non-profit Society "Archeology Center", *Ü. Kestlane* (member);

Nordic Association for Hydrology, *R. Vaikmäe* (member);

PALEO Club, *T. Alliksaar, E. Karukäpp, E. Kaup, T. Martma, A. Molodkov, V. Raidla, A. Raukas, E. Tavast, J. Vassiljev, S. Veski* (members);

Pander Society, *P. Männik, V. Viira* (members);

Past Global Changes (PAGES), *L. Saarse, S. Veski* (corresponding members);

Research Centre Free Europe, *A. Raukas* (member of the council);

Royal Geographical Society, London, *A. Raukas* (honorary member);

Scientific Society of Gdansk, *A. Raukas* (foreign member);

Society for Nature Conservation of Tallinn, *H. Kink* (member of the board);

Society of Core Analysts (SCA), *A. Shogenova* (member);

Tallinn Association of Estonian Real Estate Holders, *A. Raukas* (member of the board);

Tallinn College of Engineering, Board of Councels, *A. Raukas* (chairman);

Tallinn Pedagogical University, Council on the Defence of Doctor's Degree in Ecology, *A. Raukas* (member);

Tallinn Scientists' House, *R. Einasto, D. Kaljo, E. Kaup,K. Mens, A. Raukas, A. Soesoo, R. Vaikmäe, M. Viiul* (members);

The Geochemical Society, *T. Alliksaar* (member);

The Palaeontological Association, *D. Kaljo* (member);

The Peribaltic Group of the INQUA Commission on Glaciations, *R. Karukäpp* (member);

The World Innovation Foundation, *A. Raukas* (honorary member);

UNESCO International Hydrological Programme, Estonian National Committee, *R. Vaikmäe* (member);

Union "Alcohol-Free Estonia", *A. Raukas* (founding member).

* * *

Publications

Papers in CC and SCI listed journals

Blom, H., **Märss**, **T**., Miller, C.G. 2003. A new birkeniid anaspid from the Upper Silurian of Skåne, South Sweden. *GFF* **125**, 57–61.

Bons, P.D., **Soesoo**, **A**. 2003. Could magma transport and accumulation be a useful analogue to understand hydrocarbon extraction?. *Oil Shale* **20**(3), 412–420.

Brenchley, P.J., Carden, G.A., **Hints**, **L**., **Kaljo**, **D**., Marshall, J.D., **Martma**, **T**., Meidla, T., **Nõlvak**, **J**. 2003. High-resolution stable isotope stratigraphy of Upper Ordovician sequences: Constraints on the timing of bioevents and environmental changes associated with mass extinction and glaciation. *Geological Society of America Bulletin* **115**(1), 89–104.

Davis, B.A.S., Brewer, S., Stevenson, A.C., Guiot, J., ..., **Saarse**, **L**., ..., **Veski**, **S**. ... 2003. The temperature of Europe during the Holocene reconstructed from pollen data. *Quaternary Science Reviews* **22**, 1701–1716.

Granskog, M.A., **Martma**, **T**.**A**., **Vaikmäe**, **R**.**A**. 2003. Development, structure and composition of land-fast sea ice in the northern Baltic Sea. *Journal of Glaciology* **49**(164), 139–148.

Hints, **L**., Harper, D.A.T. 2003. Review of the Ordovician rhynchonelliformean Brachiopoda of the East Baltic: Their distribution and biofacies. *Bulletin of the Geological Society of Denmark* **50**, 29–43.

Hints, **O**., **Hints**, **L**., Meidla, T., Sohar, K. 2003. Biotic effects of the Ordovician Kinnekulle ash-fall recorded in northern Estonia. *Bulletin of the Geological Society of Denmark* **50**, 115–123.

Isaksson, E., Hermanson, M., Hicks, S., Igarashi, M., Kamiyama, K., Moore, J., Motoyama, H., Muir, D., Pohjala, V., **Vaikmäe**, **R**., van de Val, R.S.W., Watanabe, O. 2003. Ice cores from Svalbard-useful archives of past climate and pollution history. *Physics and Chemistry of the Earth* **28**, 1217–1228.

Kaljo, **D**., **Martma**, **T**., **Männik**, **P**., **Viira**, **V**. 2003. Implications of Gondwana glaciations in the Baltic late Ordovician and Silurian and a carbon isotopic test of environmental cyclicity. *Bulletin de la Societe Geologique de France* **174**(1), 59–66.

Loydell, D.K., **Männik**, **P**., **Nestor**, **V**. 2003. Integrated biostratigraphy of the lower Silurian of the Aizpute-41 core, Latvia. *Geological Magazine* **140**(2), 205–229.

Mark-Kurik, **E**., Young, G.C. 2003. A new buchanosteid arthrodire (placoderm fish) from the Early Devonian of the Ural Mountains. *Journal of Vertebrate Paleontology* **23**(1), 13–27.

Nikonov, A.A., **Miidel**, **A**.**M**. 2003. Discovery of Seismogenic Deformations in the Postglacial Deposits at the Southern Coast of the Gulf of Finland. *Doklady Earth Sciences* **391**(5), 641–646.

Pinglot, J.F., **Vaikmäe**, **R**., Kamiyama, K., Igorashi, M., Fritzsche, D., Wilhelms, F., Koerner, R., Henderson, L., Isaksson, E., Winther, J.G., Van de Wal, R.S.W., Fournier, M., Bouisset, P., Meijer, H.A.J. 2003. Ice cores from Arctic subpolar glaciers: chronology and post-depositional processes deduced from radioactivity measurements. *Journal of Glaciology* **49**(164), 149–158.

Punning, J.-M., Terasmaa, J., Koff, T., **Alliksaar**, **T**. 2003. Seasonal fluxes of particulate matter in a small closed lake in northern Estonia. *Water, Air and Soil Pollution* **149**(1-4), 77–92.

Pärnaste, **H**. 2003. The Lower Ordovician trilobite Krattaspis: the earliest cyrtometopinid (Cheiruridae) from the Arenig of the East Baltic. *Special Papers in Palaeontology* **70**, 241–257.

Saarse, **L**., **Vassiljev**, **J**., **Miidel**, **A**. 2003. Simulation of the Baltic Sea shorelines in

Estonia and neighbouring areas. *Journal of Coastal Research* **19**(2), 261–268.

Seppä, H., Birks, H.J.B., Odland, A., **Poska**, **A**., **Veski**, **S**. 2003. Modern pollen-climate training set from northern Europe: developing and testing a tool for palaeoclimatological reconstructions. *Journal of Biogeography* **30**, 1–17.

Papers in other peer-reviwed journals and books

Heinsalu, **H**., **Kaljo**, **D**., Kurvits, T., **Viira**, **V**. 2003. The stratotype of the Orasoja Member (Tremadocian, Northeast Estonia): lithology, mineralogy, and biostratigraphy. *Proceedings of the Estonian Academy of Sciences. Geology* **52**(3), 135–154.

Kaup, **E**., Burgess, J.S. 2003. Natural and human impacted stratification in the lakes of the Larsemann Hills, Antarctica. In: Huiskes, A.H.L., Gieskes, W.W.C., Rozema, J., Schorno, R.M.L., van der Vies, S.M. & Wolff, W.J. (eds). Antarctic Biology in a Global Context. Backhuys Publishers, Leiden, The Netherlands. 313–318.

Kleesment, **A**., Puura, V., **Kallaste**, **T**. 2003. Clastic dikes in Middle Devonian sandstones of the Gauja Formation, southeastern Estonia. *Proceedings of the Estonian Academy of Sciences. Geology* **52**(3), 155–178.

Mens, **K**. 2003. Early Cambrian tubular fossils of the genus *Onuphionella* from Estonia. *Proceedings of the Estonian Academy of Sciences. Geology* **52**(2), 87–97.

Märss, **T**. 2003. Paralogania from the Rootsiküla, Wenlock, and Paadla, Ludlow, stages of Estonia. *Proceedings of the Estonian Academy of Sciences. Geology* **52**(2), 98–112.

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Other events, awards, etc.

A group of researches from different institutions, including **Avo Miidel** and **Anto Raukas** from the Institute of Geology were awarded the *Estonian State Prize* in bio- and geosciences for series of monographs dealing with Lake Peipsi.

Academician Professor **Anto Raukas** was elected a honorary member of the *World Innovation Foundation.*

Mati Viiul, managing director of the Institute (to the left) is an amateur film-maker. In 2003, he produced two documentary films on geology: "The wonderful world of fossils" and "Reading the book of mud". Some of Mati's previous films have won international prizes.

Under the sponsorship of the Institute, summer meeting of the *Movement of Estonian Young Geologists* took place at Särghaua field-station where Institute's staff partly organised teaching and contests.

A. Miidel (to the right) received the Estonian State Prize in bio- and geosciences. ↑

Mati Viiul (to the left) is an amateur film-maker. In 2003, he produced two documentary films on geology: "The wonderful world of fossils" and "Reading the book of mud". Vasalemma limesone quarry was on of the scenes where fossils and their environments were filmed. *Photo by T. Tubli.* →

How to find us?

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For staff e-mail and web addresses see page 8–9.