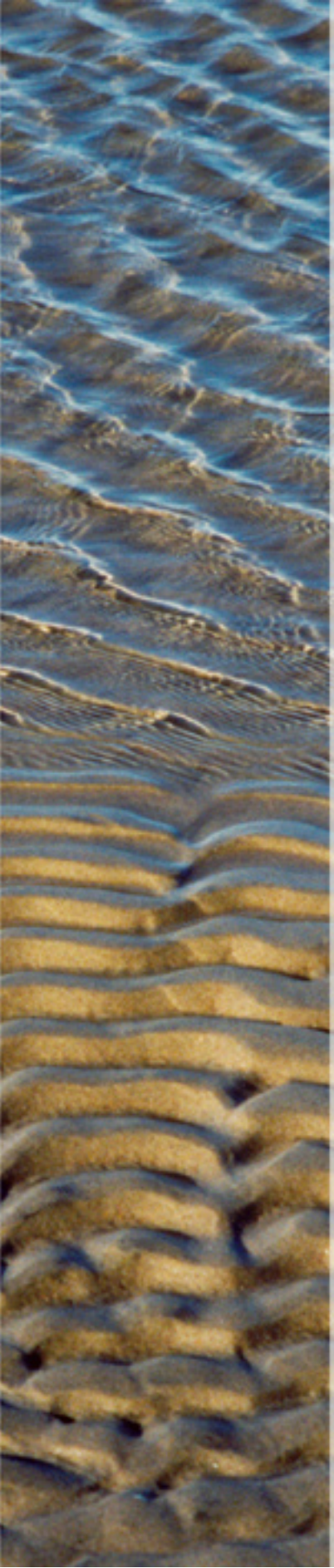

Institute of Geology
at Tallinn Technical University

INSTITUTE OF GEOLOGY 2002

Tallinn 2002

Institute of Geology
at Tallinn Technical University

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Director's 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. A new strategy is necessary to focus on commencing and further gaining excellence in teaching of selected geological disciplines in tight cooperation with Tallinn Technical University and other universities in Estonia. Our mission is 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 groups.

The Institute's research encompasses a large range of geological subjects under the investigation in Estonia. Most 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 different international sources.

In addition to the fundamental research, our scientists working within six thematic groups 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 questions 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 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 mineral sciences the main focus of coming years will be: further development of all Institute's laboratories and more active participation in applied earth sciences.

The Institute's research directions are intimately related with teaching and supervising MSc and PhD students. In 2002, two MSc and two PhD theses were defended by our researchers. Since Tartu University plays a major role in teaching undergraduate students, it is envisioned that by expanding the opportunities for postgraduate studies in the Institute of Geology the facilities will be available to meet a wide range of teaching requirements including supervision of foreign students.

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

Institute of Geology in brief

The Institute of Geology of the Estonian Academy of Sciences, presently at Tallinn Technical University, was founded on April 5, 1946 by a Decree of the Council of Ministers. The first director Prof. Artur Luha was appointed from the 1st January, but the actual work commenced in February when a group of geologists joined the Institute. Thus, in 2002 the Institute celebrated its 55th anniversary.

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 focused on stratigraphy and lithology of Palaeozoic rocks and Quaternary deposits and palaeontology. As there was no Geological Survey in Estonia at that time, the Institute was engaged in prospecting and study of mineral resources (oil shale, phosphorite and natural building materials) in addition to some hydrogeological investigations. However, 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 studies reached by the researchers of the Institute. From 1960 to 1990, the staff grew rapidly and the structure of the Institute was changed several times. The growth of the staff was partly induced by the increasing role of applied studies on phosphorite and oil shale. From the 29 people in 1947, the number of staff had increased to 193 people in the early 1990s. Shortly after Estonia regained its independence, the Institute underwent great changes. During 1992-1994, the staff was reduced by 54%. In 1996, by a 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, where 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 decade, all forms of foreign contacts have widened rapidly, including joint projects, organising scientific meetings, training of young researchers abroad, giving lectures, teaching and supervising foreign students etc.

As of December 2002, there are 73 people employed at the Institute (including part-time positions), 42 of them have doctoral degree and 9 posess master's degree.

Funding in 2002

The funding of science and research programs in Estonia is divided between Ministry of Education and Estonian Science Foundation. In addition, some monitoring and commercial projects are supported by Ministry of Environment. The Research and Development Council (www.tan.ee) is an advisory body to the government regarding research and development policy in Estonia and is lead by Prime Minister. The basics of 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) as consisting of three parts: expenditures for maintaining the infrastructure, target financing and grants. The first two parts are managed by Ministry of Education (www.hm.ee); the Science Competence Council is acting as an advisory body for the Minister of Education concerning target and infrastructure financing, which is the main funding for the research. In 2002 those sums (in millions of EEK, 1 EUR = ca 15.6 EEK) were 197 (including the expenses for post-doctoral activities and support for the Centres of Excellence in Research, and 51, respectively.

The Council of the Estonian Science Foundation (ESF), (www.etf.ee) is a decision making body responsible for grant financing. Its main goal is to support the most promising research initiatives in all fields of basic and applied research. The ESF uses state budget appropriations to award peer-reviewed research grants to individuals and research groups on a competitive basis. In 2002 the total amount of grants was 77.4 million EEK. Both, the target funding and grants are awarded on a competitive basis. The target funding and ESF grants are sufficient for salaries and consumables, but do not allow purchasing expensive research equipment. Research money from Estonian industry for applied research and innovation is a potential source for extra funding but so far it has been fairly negligible.

The annual budget of the Institute of Geology at Tallinn Technical University was approximately 9.5 million EEK (ca 0.61 million EUR) in 2002. The following illustrates how this sum divides between the major funding sources:
(1) Target funding – 6 research programmes, including 1 postdoctoral scholarship – total 5.51 million EEK (0.35 million EUR). This is about 2.8% of the total target funding in Estonia.
(2) Research grants from Estonian Science Foundation – 15 grants, in total of 1.05 million EEK (0.07 million EUR), which is ca 1.4% of total grant funding from ESF.
(3) Infrastructural expenses for the Institute are in total of 1.56 million EEK (0.1 million EUR), which includes 0.04 million EEK for expenses for management of Institute's large geological collections.
(4) Applied research contracts from Estonia, ca 0.25 million EEK (ca 0.02 million EUR).
(5) Foreign grants and contracts, ca 1.25 million EEK (0.08 million EUR).

A pie-chart illustrating the role of main different funding sources in the budget of the Institute of Geology in 2002.

Structure and staff

As of December 1, 2002; *Ph.D.*, *Cand. Sc.* and *D.Geol.* degrees can be considered equivalent; the asterisk stands for part-time positions; the phone numbers should be preceded by +372 when dialled from outside Estonia.

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Pohl, Helle	secretary
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Raukas, Anto *D.Sc.*	head of department
Molodkov, Anatoly *D.Geol.*	head of laboratory
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Veski, Siim *Ph.D.*	senior researcher
Klein, Vello *Cand. Sc.*	Geological Survey of Estonia, director
Meidla, Tõnu *Cand. Sc.*	Institute of Geology, University of Tartu, Professor
Pirrus, Enn *D.Sc.*	Department of Mining, TTU, Professor Emer.
Raudsep, Rein *Cand. Sc.*	Ministry of the Environment, head of depertment
Reinsalu, Enno *Ph.D.*	Department of Mining, TTU, Professor Emer.

Laboratories

Laboratory of Physical Investigations

The Laboratory is a structural unit, established to provide scientific staff by chemical and mineralogical research data. Methods, used in Lab are based on X-ray diffraction and X-ray fluorescence, development of which have grew to individual research topic in Lab.

The XRD have been popular in our Institute for more than 30 years. Mineralogical studies perform on rebuilt HZG4 and URD diffractometers with digitalized outlets. On the past decade, the main research topics have been study of variation of mineral structures on quantitative level (individual's lattice parameters and crystallinity). The main preference on this kind of investigations is the original software developed, allowing flexible approach to established problems, such as related to microstrains content and crystallite dimensions. Using deconvolution of XRD patterns have allowed e.g. distinguish different generations of carbonates and feldspars.

The XRF studies are based on VRA30 WDX equipment. A large-scale intercalibration for elements, heavier than Na was performed in the past decade. Based on original software, the finding of chemical composition performs through fully computerised fitting of spectrum, depending of complexity of established problem.

Micropalaeontology Laboratory

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, micro-vertebrates, 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

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 (developed by van Milligen and Bons) and MELTPOCKET (developed by Bons and Soesoo). Both programs model the formation of melt in discrete volumes that are allowed to migrate and accumulate. 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 package 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 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. Multiple fluid inlets and outlets or in situ reagents allow the percolation of fluid(s) through the system.

Students experimenting with a glass tank filled with appropriate materials and camcorder to model rock melting processes.

Laboratory of isotope-palaeoclimatology

The history of the Laboratory of Isotope-Palaeoclimatology goes back to the late 60s, when the laboratory of ^{14}C dating was established in the Department of Quaternary Geology. In the early 70s, 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 90s, 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 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 Earth Sciences research in Estonia.

Finnigan MAT Delta E mass-spectrometer is used for isotope analysis of light elements.

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), purchased in 1984 and 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;

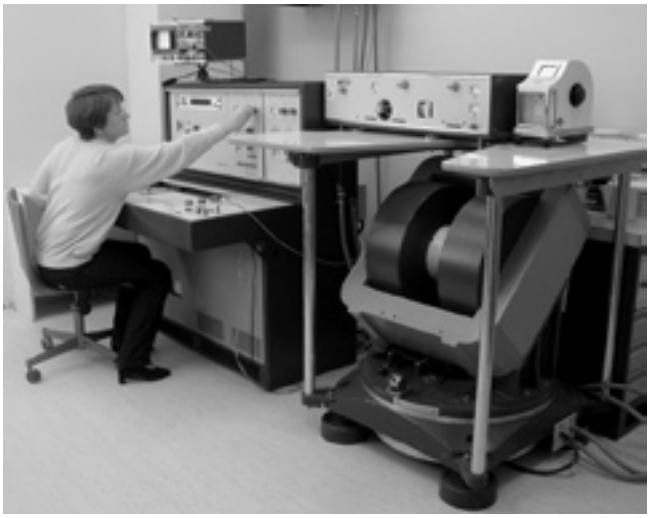
The Research Laboratory for Quaternary Geochronology

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 very few in the Western and Central European countries as well as in the former Soviet Union Republics, 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 sedimentary 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.



M. Osipova is operating the Electron-spin-resonance (ESR) ERS-221 type spectrometer – one of the main facilities in the Research Laboratory for Quaternary Geochronology

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 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

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. Time span covered is mainly 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 research program of the laboratory. As 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 that reliable reconstruction of the past shifts in the climate outside the historically documented range can be elaborated. 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. Our 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).

Collections

The Institute of Geology possesses large geological collections that comprise fossils, rocks and minerals from all over the World, emphasis being, however, on the Palaeozoic material from Estonia and the former Soviet Union. The collections include historical specimens originating already from the 1850s, but most of the material has still been collected from the 1950s until the present. The 1960s–1980s were especially productive, since in these years borehole material was extensively studied and many expeditions were organized to various regions of the former Soviet Union. The total number of individual items stretches into several hundreds of thousands, but only part of this material is properly registered.

The institute has also bedrock cores from more than 300 boreholes of Estonia and neighbouring areas. Since bedrock drilling has dramatically ceased in Estonia, the core material is especially valuable, providing samples and primary data for different studies run at the institute as well as for several joint international projects.

The collections, drill cores and rock samples are stored at the institute's building in Tallinn and at Särghaua field-station in central Estonia, but there is still general deficiency in collection storage area in Tallinn as well as in the field-station.

The collections form an integral part of the scientific work carried out at the institute. Besides, many foreign geologists visit our institute with a primary aim to study the collections, type-, figured and cited specimens in particular. Drill cores as well are frequently shown to researchers outside our institute. Every year the geology students study some drill cores during their teaching practice.

A structural unit dealing with the maintenance of the collections, the Department of Scientific Collections, was formed at the Institute in 2001. In 2002, the staff of this small department consisted of the head, keeper and three part-time curators.

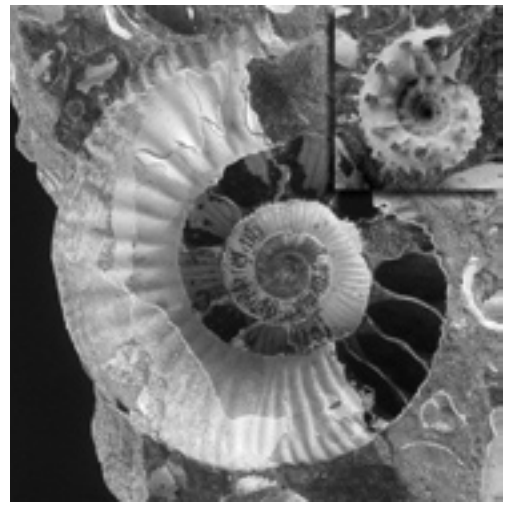
During routine cataloguing in 2002, nearly 20 000 specimens and rock samples were registered. As of December 2002, a total of 55 000 items are catalogued electronically (which is yet a relatively small part of all items deposited at the institute). Most importantly, data on the majority of the type, illustrated and cited specimens are now computerized and accessible to everyone on the Internet.

It is equally important that, alongside the registration, the material has been cleaned, re-packed if necessary and provided with new labels. These simple curatorial activities have greatly enhanced physical accessibility of Institute's collections.

In 2002, much effort was put into arrangement of various written information, e.g., descriptions of localities, hand-drawn cross-sections, photographs, and field-notebooks. The staff of the Estonian Academic Library was consulted and helped to assemble bibliographical database on Estonian geological literature.

The previous in-house MS Access-based cataloguing program was upgraded into a client-server system in 2002. In that system, MS Access is still used for the development of the main front-end, but the data is stored in open-source MySQL database server. This conversion resulted in considerably improved

These two Jurassic ammonites from North Lithuania are some of those specimens collected in 2002 to expand the collections of the Institute.



performance in the networked environment, and made it possible to access the data by different user interfaces and from any place in the world.

Parts of the database, up-to-date information on type and published specimens in particular, are now freely available via the Internet at http: //collections.gi.ee/. Plans are being made how to integrate collections' data into national or European information networks, such as, e.g., BioCASE.

In 2002, the first digital images of individual specimens, geological localities and institute's drill cores were acquired and stored along with textual information.

The software suits well the current needs, but the hardware solution cannot be considered appropriate since the system lacks dedicated server and decent backup devices. A major hardware upgrade is therefore necessary in the near future.

Dr L. Sarv working in collection storage – his contribution to the improvement of the curatorial state of Institute's collections in 2002 has been invaluable.

Schematic evolution of the database system used at the Department of Scientific Collections for routine registering of specimens as well as for more sophisticated tasks (e.g., printing catalogues and labels, enabling web access, drawing distribution maps). In 2002, an important step was made towards a scalable client-server environment.

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 the main research fields in bedrock geology of Estonia. Many researchers of the Bedrock Geology Department are also actively collaborating with foreign geologists and participate in international projectes. Therefore the bedrock studies at the Institute are not restricted to problems and material from Estonia only, but incorporate many different regions (e.g., Arctic Canada, England, Sub-Polar Urals, Scandinavia).

In 2002, the bedrock research was accomplished through three target-funded programmes, and six Estonian Science Foundation grants. Main highlights among the year's results were compilation and successful defending of two doctoral theses, one on the Ordovician scolecodonts of Estonia and neighbouring areas (Hints, O., 2002), and the other about chitinozoan biostratigraphy in the Ordovician of Baltoscandia (Nõlvak, 2002). Good progress was also achieved in the field of the late Ordovician isotope geology (Kaljo et al. 2002), but main results of these studies are still in press and in preparation. Concerning the publications, papers by T. Märss (with co-authors) describing 90 new early vertebrate taxa from different regions of the Northern Hemisphere should be emphasized. Stratigraphically important results were achieved by integrated geochemical and biostratigraphical studies (conodonts, graptolites) indicating that the Llandovery –Wenlock boundary in its type section at Leasows is evidently younger than the base of the *centrifugus* graptolite Biozone (Kiipli et al., 2002; Loydell et al., 2002; Männik et al. 2002); For the first time, 15 sedimentary cycles of nearly equal duration were revealed in the East Baltic Palaeozoic sedimentary sequence composed mainly of siliciclastics in the lower and upper parts and carbonates in the middle part of the section (Shogenova, Einasto).

In 2002, a large group of bedrock researchers, palaeontologists and stratigraphers in particular, participated the Fifth Baltic Stratigraphical Conference in Vilnius, Lithuania, where most of the new achievements, including those noted above were presented.

R. Einasto studying a Middle Ordovician section in Kunda-Aru quarry. Photo by L. Hints.

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: R. Einasto, T. Märss, V. Nestor, H. Nestor, T. Martma, M. Mõtus
Duration: 2001–2005

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 studying 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. Results of the project will be used in applied and theoretical geology, university curriculae in particular.

In 2002 studies were continued in the fields noted below together with main results achieved (in more detail under corresponding ESF grants):

(1) Main distribution patterns and diversity changes of the coral and jaw-bearing polychaete assemblages were elucidated, several new and little-known taxa were described (M.-A. Mõtus, O. Hints).

(2) Rich new analytical material about carbon isotopes was obtained from several drill cores for environmental interpretations. These data allow compiling a general trend of the isotope changes taken place during the late Ordovician and Silurian (D. Kaljo, T. Martma with colleagues).

(3) Integrated graptolite, conodont and chitinozoan biozonation was suggested for East Baltic Wenlock, which allows more precise correlation of the sections of different facies origin.

(4) In the field of the early vertebrate studies good progress was achieved in publishing of taxonomic results of the research. In all 90 new taxa were established, among them 56 thelodonts, 5 possible chondrichthyans and 29 anaspids.

Wenlock limestones containing organic buildups at Pulli Cliff, northern part of Saaremaa Island, were sampled for microfossils during the fieldwork in August 2002. Photo by T. Märss.

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

Main task of the project is elucidation of patterns of evolution of communities of corals (rugosans and tabulates) and jawed polychaetes and finding out the role of biotic and abiotic agents in evolution processes. Very important is 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) A revision of assemblage content of rugose and tabulate corals, modernization of 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 palaeo-oceanic conclusions on the evolution of the Baltic Basin.

2002 was the first work year of the new project, which continued studies commenced within the previous project. Main attention was paid to three topics as follows:

Taxonomy, biodiversity dynamics and distribution pattern of the late Ordovician and Silurian corals. Several taxa of tabulate corals were descibed from Llandovery of Jämtland. Coral assemblages from three localities of the Berge Limestone show great similarity with Estonian corals and this allows more detailed correlation of the corresponding sections and interpretation of facies distribution. Taxonomy of studied species was revised. M.-A. Mõtus took part in the field course "Coral Reef Dynamics" organized by Macquaire University, Australia on the Heron Island.

In the field of the scolecodont studies a PhD dissertation was compiled and successfully defended (Olle Hints). The thesis summarized results of several published papers on the taxonomy of the Ordovician jaw-bearing polychaetes, temporal and spatial distribution of scolecodonts, their stratigraphical usefulness, diversification, facies dependance and palaeoecology. Silurian scolecodonts show some differences in taxonomical content compared with Ordovician assemblages, but great similarity with Gotland faunas. In co-operation with C. Bergman (Kristianstad, Sweden) scolecodonts from the Viirelaid core were described.

Rich new analytic material about carbon isotopes was obtained from the Kõrgessaare, Orjaku, Rooküla, Saku, Vasalemma and Viljandi core sections. Based on these and earlier data it was possible to suggest a genaral trend of carbon isotope changes for the late Ordovician and Silurian. Positive excursions of the curve are usually connected with cooler climatic episodes, which are accompanied by sea level lowerings and certain extinction events. Several glaciations identified on Gondwana were reflected in the Baltica sections by clear carbon isotope events. High potential of the carbon isotope curve for stratigraphy and geological correlation was demonstrated.

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 2002:

Biostratigraphical investigation of graptolites (D. Loydell), conodonts (P. Männik) and chitinozoans (V. Nestor) from the Aizpute drill core in western Latvia, made possible a more precise correlation of sequences of different facies in other regions.

The presence of stratigraphical gaps at both boundaries of the Adavere Regional Stage was prooved (H. Nestor, V. Nestor) and their stratigraphical range was established. The gaps reflect global glacio-eustatic lowerings of sea level corresponding to the glaciations in South America at the end of the Aeronian and Telychian.

Lithological and biostratigraphical changes at the boundary of the Lower and Upper Visby formations have been described (V. Nestor, R. Einasto, D. Loydell) in the Ireviken section of the Gotland Island, which is a type section of the Ireviken event. It contributes to the determination of the Llandovery and Wenlock boundary in carbonate sequences.

Early vertebrates (conodonts, agnathans, fishes) of Paadla age in the Palaeobaltic

Estonian Science Foundation Grant No. 4160
Project leader: **T. Märss**
Team: J. Nemliher, V. Viira, T. Klaos
Duration: 2000–2002

The Paadla age in Palaeobaltic Silurian comprises a very distinct faunal turnover within different groups of fossils including conodonts, agnathans and fishes. Phosphatic exoskeletons of thelodonts, osteostracans and anaspids are very well preserved in the sediments of that age. Moreover, the actinopterygians first appear in Paadla time and the largest conodonts in Europe are also known from this interval. The project specifies the taxonomy of these animals, their living conditions, and the taphonomy of their skeletons.

In 2002 following studies were carried out:

Conodont distribution in the Rootsiküla and Paadla Stages, Estonia. The study was focused to the distribution of conodonts in the shallow water deposits of Soeginina Beds of Rootsiküla Stage and Sauvere Beds of Paadla Stage (Viira & Einasto, in prep.). New results in conodont taxonomy and biostratigraphy were obtained from the material of Soeginina, Anikaitse and Hülge localities. In Soeginina cliff, the type locality of the Soeginina Beds, Rootsiküla Formation, the same conodont taxa occur as in the Paadla Formation, and, thus, should belong to Ludlow. New conodonts from the Anikaitse and Hülge cliffs have features of conodonts in-between Vesiku and Sauvere ones. *Ctenognathodus jeppssoni* sp. nov., *Ozarkodina anika* sp. nov., *Ozarkodina soegina* sp. nov.,

Ctenognathodus sp. S, *Ctenognathodus* sp. C ja *Ctenognathodus* sp. P. were described.

Investigations on early agnathans and fishes. (1). Appearances of thelodonts in connection of fluctuations of the seas were studied (Märss 2002). In the Silurian the new fauna came in in the sea level high stands while in the Devonian it seemingly happened in the regressive phases of basins. It can be explained by the extended gaps in the sections. (2). *Paralogania* Karatajūte-Talimaa species from the Himmiste Beds of the Paadla Stage were described (Märss, 2003). *P. kaarmisensis* Märss occurs in the narrow interval in the *Phlebolepis elegans* Biozone (Ludlow, Upper Silurian). (3). The monographic paper on the Silurian vertebrates of Britain was submitted (Märss & Miller); its aim was to find the criteria for the correlation of British sections with the Baltic ones based on agnathans, fishes and conodonts. In the taxonomical part, thelodonts of Welsh Borderland were re-described, two new taxa, *Loganellia*? *unispinata* sp. nov. and *Nethertonodus prodigialis* gen. et sp. nov. were described, and two possible subspecies of *Paralogania kummerowi* (Gross) were treated. In the biostratigraphical part of the paper, the following biozones (and an assemblage) in the Upper Ludlow to Lower Lochkov were established: *Paralogania martinssoni* (Gross), *Par. kaarmisensis* Märss, *Phlebolepis elegans* Pander, *Thelodus parvidens* Agassiz assemblage, *Par. ludlowiensis* (Gross), *Par. kummerowi* ssp.1, *Par. kummerowi* ssp. 2 and *Turinia pagei* (Powrie). All these biozones occur in the Baltic as well and are useful for the correlations. (4). With the help of the grant, data of the studies on the global distribution of agnathans were published. 56 new thelodont and 5 possible chondrichthyan taxa were established in the Silurian and Lower Devonian of the Canadian and Russian Arctic islands, and 29 new anaspid taxa were described from the northern hemisphere (Blom, Märss & Miller 2002; Karatajūte-Talimaa & Märss, 2002; Märss 2002; Märss & Karatajūte-Talimaa 2002; Märss, Wilson & Thorsteinsson 2002).

Studies on the taphonomy of the Silurian agnathans in Himmiste-Kuigu, Saaremaa. Sedimentation conditions of the Himmiste Beds of Paadla Formation and taphonomy of *Phlebolepis elegans* Pander shoal in Himmiste-Kuigu are under study (Märss, Perens & Klaos).

Thin section of a thelodont scale. Ludlow Bonebed, Welsh Borderland, U.K.

Early Palaeozoic faunas: comparison, high-resolution stratigraphy and databases

Target Financed Research Programme No. 0330360s98
Project leader: **L. Hints**
Team: O. Hints, K. Mens, P. Männik, J. Nõlvak, A. Oraspõld, H. Pärnaste, V. Viira
Duration: 1998–2002

The aim of this project is to reveal the development and uniqueness of early Palaeozoic biota in the Baltic palaeobasin. In particular, Baltic associations of brachiopods, trilobites, chitinozoans, conodonts and scolecodonts are studied and compared with those of other basins, and their importance for the stratification of the Ordovician and Silurian sequence is established.

Biofacies differentiation along the onshore-offshore transect is studied using the temporal background provided by high-resolution bios-

tratigraphy, isotopic and geochemical data. Biozones, trends in the development of faunas in different facies belts, and evolutionary changes are used in the elaboration of improved stratigraphical charts. The results are incorporated into several international projects including IGCP Projects Nos 410 and 406.

The main results of the project and associated Estonian Science Foundation projects (Grants Nos 4674 and 4070) are:
(1) Revision and refinement of chitinozoan biozonation for the Ordovician of the Baltic region and incorporation of these data into the global correlation chart;
(2) Characterization of the composition and distribution of Ordovician-Silurian polychaete faunas in the Baltic area and other regions of the Earth;
(3) Revision of the taxonomy of conodonts and trilobites using new diagnostic features and critical analysis of the characteristics used earlier;

Recent additional preparation of the holotype of *Evropeites törnquisti* (Holm, 1882) has revealed the adjoining pygidium with important characters (Ar.11410-a, b, Swedish Museum of Natural History).

(4) Overview of the formation of Baltic brachiopod faunas associated with the main bioevents and the changes of isotopic data;
(5) Establishment of new correlation criteria using mineralogical and geochemical tools.

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
Duration: 2001–2003

In 2002 more attention was paid to the taxonomy of brachiopods and trilobites to characterize Baltica as a palaeobiogeographically specific region. These groups are representatives of the benthic faunas traditionally considered to be of diagnostic value for provinces. As preservation of the palaeontological material is excellent, new features important for the taxonomy were found and the features used earlier re-evaluated.

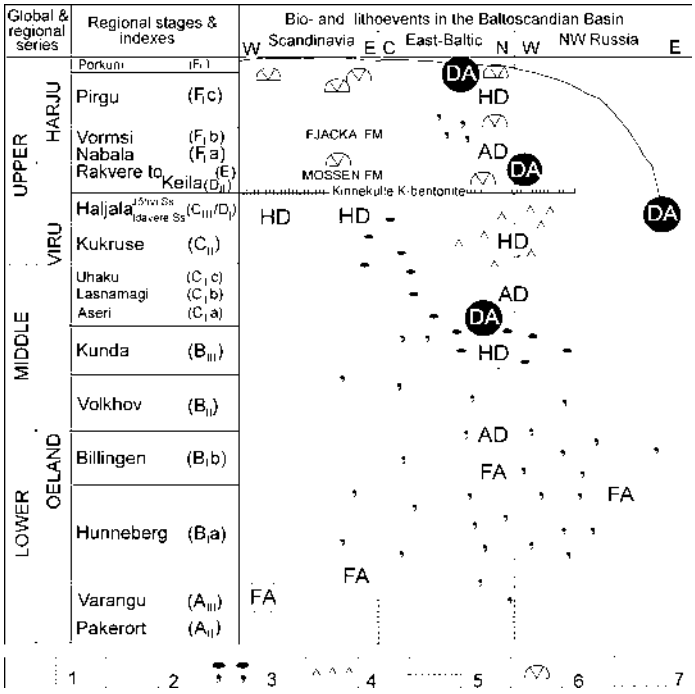
The study of the plectambonitoidean brachiopods from the Central East Baltic enabled the improvement of genus level taxonomy. The morphological study of some Baltic brachiopods Orthida revealed the features not used in taxonomy so fare but which allowing identification of a new genus and improvement the understanding of some morphological features of valves of the Rhynchonelliformean brachiopods.

The study of the trilobites Cheirurina revealed that the problems of their classification are caused mainly by the use of traditional and historically accepted diagnostic features, part of which may show ecological variation and cannot be used in taxonomy. Some important for taxonomy features were found in the marginal parts of the trilobite skeleton (sometimes these parts are not cleaned of the rock). These new features enabled us to present a new classification of the subfamily Cyrtometopinae Öpik, 1937. New species of the families Pilekiidae and Pliomeridae will be described using also some new diagnostic features.

For the Baltic faunal province, the important results were obtained by comparing the composition of chitinozoan associations in seven different regions of Baltica. These results were included on the final report of the IGCP Project 410. The study of chitinozoans in seven areas, where associations differ from each other not more that 15% of the number

of taxa, showed the high potential of these microfossils for the correlation of the Ordovician sections of the Baltic Basin. Their use in the correlation of sections from different basins is somewhat restricted.

New zones were added to the high-resolution stratigraphical scheme necessary for the timing of the geo- and bioevents. Because of completeness and wide use in the limits of the Baltic palaeobasin this scheme was incorporated into the international Ordovician stratigraphical chart as a regional scheme. New data from the Orjaku, Viljandi and Voore sections revealed new possibilities for the correlation of the sequence corresponding to the Keila and Oandu stages characterized by different facies and faunas. The correlation by chitinozoans is supported by isotope data, which shows the high reliability of biostratigraphical conclusions.



Stratigraphical chart, showing some bioevents and characteristic features of the Ordovician sequence in the different parts of the Baltoscandian Basin. The vertical scale corresponds roughtly to the time scale of Webby 1999. Lithological features: 1– shale, 2 – sandy deposits, 3 – oolites (above), glauconite (below), 4 – kukersite kerogen, 5 – K-bentonite, 6 – reefs, 7 – red coloured rocks; FA – first appearance of rhynchonelliformean brachiopods. Dynamics of rhynchonelliformean brachipods: AD – appearance of many new taxa, HD – high diversity levels, DA – disappearance of many taxa (See A/D ratio and trend of the brachiopod diversity on Fig. 3). W – West, E – East, N - North, C – Central part; Ss. – substage. The Oandu Stage (D_{III}) between the Keila and Rakevere stages is not shown in the table.

The stratigraphical background by chitinozoans was worked out for several Upper Ordovician sections, which was used together with isotope data in the overview of the geo- and bioevents in the Baltic areas. The main results of the study of chitinozoans are presented in the doctoral theses of Jaak Nõlvak.

The biofacies differentiation of the Baltic faunas has been demonstrated by the distribution of annelids (scolecodonts). Beside the biofacies differentiation in the limits of the Baltic Basin, some provincial differences occur between Baltica and Laurentia (North America). From other regions, only very sparse data are available on the Ordovician annelids. The Baltic annelid fauna differently from the American annelid fauna is often dominted by Mochtyellidae and Polychaeturidae. The North American associations are characterized by several families, which, in contrast, are missing in Baltica (Hadoprionidae) or are very rare (Paulinitidae). The summary on the Ordovician annelids is presented in the doctoral theses of Olle Hints.

Upper Llandovery K-bentonites – composition, distribution and application in high-resolution stratigraphy

Estonian Science Foundation Grant No. 4070
Project leader: **P. Männik**
Team: E. Kiipli, T. Kiipli (Geological Survey of Estonia)
Duration: 2000–2002

K-bentonites (beds of fossil volcanic ash) as possible datums for stratigraphical correlations have aroused interest among researchers for many decades. Theoretically, as each K-bentonite represents an extremely short event in the Earth's history (one volcanic eruption), these beds are perfect levels for correlations. However, due to several reasons (e.g. sorting of material during transportation, changes in chemical composition during and after sedimentation, etc.), the traditional correlations of K-bentonites, based on their geochemical composition cannot be trusted. A reliable correlation requires that all beds should be characterised in detail and distinct criteria to identify them should be found out. Also, it is essential to test the distribution (correlation) of K-bentonites using other stratigraphical, preferably biostratigraphical, methods. The main aim of the project is to work out such criteria and to test them in the correlations of Baltic sections.

In 2002, study of the Upper Llandovery bentonite layers in Estonia and Latvia gave some new criteria for the correlation of red-coloured sequences which do not comprise biostratigraphically important organic-walled fossils. Based on correlation of the three betonite beds the earlier onset of the late Llandovery red facies in the deeper part of basin (in Latvia) compared to the shallower part (in Saaremaa) is obvious. The facies shift took place in the transgressive period.

Detailed studies of composition of the O-bentonite in different sections revealed its enrichment by Nb, Zr and Ti in the off-shore regions of the basin. This can be explained by differences in chemical processes affected the settling fresh volcanic material in shallow and deep shelf environments. In shallow shelf conditions, external uptake of potassium probably promotes authigenic K-feldspar formation. In deep shelf environment, the bigger loss of silica (and other main components) during the formation of kaolinite causes the residual enrichment of bentonite by immobile chemical elements.

The succsession of volcanic beds from at least 35 individual eruptions serves as a good standard for correlating new sections based on bentonites. Bulk sediment trace elements and compositions of magmatic minerals point to at least two different volcanic sources being active at the same time.

Correlations by bentonites and faunal data (conodonts, graptolites) indicate that the Llandovery –Wenlock boundary in its type section at Leasows is evidently younger than the base of the *centrifugus* graptolite Biozone. Also, based on these data, the Ireviken Event is younger and started in early Sheinwoodian but not in late Telychian as considered up till now.

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. Bitjukova, 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 clarify the evolution of composition of the late Proterozoic and Palaeozoic sedimentary rocks and alteration of their properties in the different facies zones and in local structures using available and new geochemical, mineralogical and petrophysical data. We are going to construct the geochemical models of Baltic sedimentary basin, to reveal the distribution of chemical elements and minerals in the main stratigraphical units, variation of chemical and mineralogical composition in rocks in result of dolomitization and in the secondary alteration zones with different

nature of chemical processes. The influence of rock chemical, mineralogical composition and biomineralization on their physical properties will be interpreted using statistical correlation, spatial and multivariate (factor) analysis. As result of the project the most important processes affected rock composition and properties and quantitative geochemical, mineralogical and petrophysical models of Estonian part of the basin will be compared with the other parts of the Baltic region.

We studied 97 samples from the Baltic area of varying lithology (limestone, dolomite, marlstone and siliciclastics), geological age (Cambrian, Ordovician, Cretaceous, Paleogene, and Neogene), and thermal history as reflected in geographic location of Cambrian and Ordovician samples: weakly heated Estonian and Russian samples, more heated Lithuanian samples, and severest heated Danish and Polish samples. The relationship between Potassium content and specific surface is best defined for a given geological age and thermal history, but largely independent of lithology. The relationship between magnetic susceptibility and specific surface is best defined for specific lithologies and geological age, but is largely unaffected by thermal history. Thorium and Uranium content as measured by gamma-spectrometry did not give clear indication of specific surface.

The influence of different factors on porosity of sandstones and siltstones was studied and compared on 270 samples from shallow (Estonia – 80-800 m), central (Latvia and central Lithuania – 1-1.8 km) and western (western Lithuania, 1.8-2.3 km) parts of the Baltic Cambrian basin. Various minerals forming grains and cement of siliciclastic rocks often influence porosity in opposite to each other directions. Porosity decreases with depth owing to compaction of rocks. The factors clearly decreasing porosity are dolomite cementation in Estonia and quartz cementation in Latvia and Lithuania. The factors increasing porosity are clay minerals in the deep part and K-feldspar in the shallow part of the basin (Shogenova, Vaher et al 2002).

In result of the study of thermal conductivity and other properties of Estonian, Latvian, and Lithuanian Cambrian sediments revealed that Wiener- and mixed model and geometrical mean of components indicate best the relationship between porosity and thermal conductivity (Jõeleht et al, 2002).

Sanidine composition of 130 samples of bentonites from 12 sections of Telychian (some possibly Sheinwoodian) age was analysed by XRD for correlation purpoces. Solid solution of magmatic sanidine contained 20-40% $NaAlSi_3O_8$ molecules. The sanidine composition is very individual for many beds and can be used succesfully for correlation (Kiipli & Kallaste 2002).

Petrophysical models of Palaeozoic rocks from Pärnu borehole (55 rock samples) (Shogenova et al, 2002b) and South-Estonian rocks (335 Cambrian-Devonian samples from Ruhnu, Häädemeeste, Taagepera and Tartu 453 boreholes) were made on the base of properties studied together with their chemical composition and thin-sections. Primary porosity of carbonate rocks correlates with clay content and controlled by cyclicity of sedimentation, while secondary porosity associates with diagenetic processes from which dolomitization is the most dominant all over the studied sequence. Porosity of the siliciclastic rocks depends here on cement type and content, grain size and reworking of primary grains. Devonian mixed rocks have the most variability in the composition and properties reflected the most contrast cyclicity and great variability of the diagenetic processes in the studied sedimentary sequence. At least four different genetic types of dolomites characterised by their own sets of total iron and manganese content, magnetic susceptibility, porosity, electric resistivity, P-wave velocity and thermal conductivity were determined in these boreholes. In the studied sedimentary sequence thermal conductivity has positive correlation with dolomite and quartz content and negative correlation with clay and total iron content. Magnetic susceptibility increases with increase of iron and clay content and higher in dolomites than in limestones. Resistivity and P-wave velocity have negative correlation with clay content and is higher in carbonate rocks by comparison with siliciclastic rocks. Density, velocity and resistivity of the dolomites is higher than in the other studied

sedimentary rocks with the similar porosity, that may be explained by the higher grain density of the dolomites. (Shogenova, Jõeleht et al, 2002).

Joint systems in Devonian sandstones in southeastern Estonia were studied and described (Pirrus et al 2002). Mineralogical study of magnetic fraction from impact breccias of craters was carried out. Different mineral phases of estolites may surve as geothermo- and redox-meters for plume environments. Most likely, estolites formed due to condensation from impact vapor during rapid cooling and solidification on surfaces and in fractures of fragmented rocks (Puura, Konsa et al. 2002).

Physical properties of Palaeozoic sedimentary rocks of Estonia: complex study and systematic database

Estonian Science Foundation Grant No. 4157
Project leader: **A. Shogenova**
Team: R. Einasto, A. Kleesment, M. Konsa, K. Mens, R. Vaher
Duration: 2000–2002

During current research an approach towards the petrophysical model of the lower Palaeozioic sedimentary cover of Estonia was elaborated. Classification of geological processes and factors influenced the physical rock properties was formulated for carbonate and siliciclastic rocks. About 1300 rock samples were collected and studied during last years from 33 boreholes and 10 outcrops located all over Estonian area. Porosity, density, electrical, acoustic, reservoir, thermal and magnetic properties of carbonate and siliciclastic rocks were analysed together with bulk chemical and mineralogical composition, iron forms and typical thin-sections.

Properties of the studied sedimentary rocks depend on composition and controlled by early and late diagenetic processes. Properties of carbonate rocks significantly depend on their primary proportion of carbonate and insoluble residue content and diagenetic dolomitization. Primary porosity of Ordovician, Silurian and Devonian carbonate rocks increases with increasing of insoluble residue content. The properties of Cambrian and Devonian siliciclastic rocks are controlled by proportion between quartz content and other minerals represented by K-feldspar, clay and iron minerals. Porosity decreases with cementation represented mainly by dolomite and by clay.

The database and scientific conclusions are of great importance not only as basic knowledge, but also applicable for geophysical and geological interpretation and modelling and may be used for construction and geothermal projects.

During last 2002 year we finished the measurements of thermal properties of earlier available samples from our database in laboratory of Geological Survey of Finland (A. Jõeleht). Physical properties of new Devonian samples were measured in St. Petersburg petrophysical laboratory (A. Šogenova, V. Šogenov). Bulk chemical composition of samples were measured in St. Petersburg (VSEGEI) and iron forms were measured in TTÜ GI (T. Linkova). Thin-sections of more than 100 samples from Ruhnu, Tartu and Pärnu boreholes were prepared and pictures (photographs) are included into the database.

Porosity, wet and grain density, electric resistivity, P-wave velocity, thermal conductivity and magnetic susceptibility of 55 samples from Pärnu borehole and of 335 samples from four South-Estonian drill cores were studied together with bulk chemical composition and thin-sections. Palaeozoic sedimentary sequence, composed of siliciclastics in the down and upper parts and carbonates in the middle part of the section, accounts for about 15 sedimentary cycles of the close duration. The most widespread diagenetic processes are formation of carbonate cement in the terrigenous rocks and widespread early and late dolomitization of the carbonate rocks. Using correlation analysis it was shown that all studied physical properties are controlled by mineral composition. Wet density, electric resistivity, P-wave velocity and thermal conductivity are porosity-

dependant parameters. Primary porosity of the carbonate rocks depends on their clay content determined by cyclicity of sedimentation and secondary porosity formed during diagenetic dolomitization.

The lowest porosity, total iron content and low-field magnetic susceptibility was found in the pure limestones increasing through argillaceous limestones up to calcareous marlstones. Their wet density and P-wave velocity, resistivity and thermal conductivity had negative correlation with clay content. These rock groups have uniformed composition and properties reflected primary sedimentation processes.

Porosity, iron content and magnetic susceptibility of dolomites, argillaceous dolomites and dolomitic marlstones depend on both clay content and secondary dolomitization which may cause formation of secondary porosity and increase in iron content owing to secondary magnetisation of rock. Variability in the rock properties of dolomites is explained by their various genesis, porosity and chemical composition formed in different time.

Porosity of the siliciclastic rocks, which was the highest among the studied rock types, depends on grain size, their reworking and cementation. Dolomite cement in the Estonian siliciclastics has negative correlation with porosity. Mixed carbonate-silicicalstic rocks sampled from Devonian, Silurian and Ordovician had the most variability in the composition and properties reflected the different influence of the same mineral constituents on porosity in the siliciclastic and carbonate rocks.

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

Mineralogical study of magnetic fraction from impact breccias of craters was carried out. Suevites from breccias were sampled, photographed and studied optically using immersion method (M. Konsa). Estolites are found already in 18 structures worldwide. Estolites were located in the allochtonous breccias from the central part of the crater, and the dikes from the rim (Puura, Kirs et al. 2002). They were observed optically as silt- to sand-scale (0.1-0.5 mm) sticklet-, platelet- or blocklet-shaped aggregates among the dominating magnetic "dust" separated magnetically from crushed (<4 mm) impact breccias (Puura, Kärki et al. 2002). SEM studies at Oulu University revealed that micrometer-scale phenocryst-like inclusions in nanometer-size matrix are the main constituents of Estolites. In the welded matrix, Fe dominates together with some Si, Al, Mg, Ca, and occasionally Sn, Pb, Cu, As, W. Into the matrix, clasts of target minerals (quarts, feldspars) and clasts or blebs of native elements or intermetallides (Fe, Pb-Sn-Sb), carbides (Fe-Cr-C) and oxides (Al-O, Ti-O) are incorporated (Puura, Konsa et al. 2002). In Estolites mineral phases of meteorite impactites formed at very high (W, W-O), intermediate (e.g., the sequence from Cr-Fe-C to Fe) and low (chalcophile alloys) temperatures are presently distinguished (Puura, Kärki et al. 2002). Different mineral phases of estolites may surve as geothermo- and redox-meters for plume environments. Most likely, estolites formed due to condensation from impact vapor during rapid cooling and solidification on surfaces and in fractures of fragmented rocks (Puura, Konsa et al. 2002). The investigations will be carried on. Study of clastic dikes from Middle Devonian sandstones of the Gauja Formation in the Piusa quarry (southeastern Estonia) was carried out (A. Kleesment). The repeated transgressions and regressions of the seas and partial redeposition of older sediments took place in the Gauja Age. It was concluded that clastic dikes were developed due to rising tectonic activity soon after sedimentation when regression reached its maximum.

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. Bitjukova**
Team: J. Nõlvak, A. Teedumäe
Duration: 2002–2004

This project purposes to add new aspects into the traditional geological study of carbonate rocks in Estonia. This project's aim is to study the processes of weathering and decay of Ordovician carbonate rocks used for building of historical and culture objects in Tallinn. Damage of building stones is widely observed in Europe where the pollution situation has been for many years, and still is, quite serious. The problems of preservation of stone engaged the attention of many scientific institutions in Europe and a such kind of investigations is very actual for Tallinn as an industrial center too. Our comprehensive study includes besides the well-known lithological, geochemical, mineralogical methods also a new computerised X-ray tomography investigation of building stone. Complex analysis and careful selection of the historical objects for the study permits to determine the conditions and assess the intensity of degradation processes what are controlled by natural and anthropogenic factors. We are going to estimate the trends in variation of chemical composition and its influence on physical properties of the rocks during the time, to study the relationship between chemical and physical parameters. Previous detail studies of the composition and physical properties of the numerous samples (more than thousand) of unaltered Ordovician carbonate rocks collected from main outcrops and boreholes in Estonia by the participants of the project created the base for the interpretation of main natural geological factors that cause alteration and decay of the rocks.

On the base of the obtained data the database for the 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.

Numerical and analogue modelling of Earth's processes

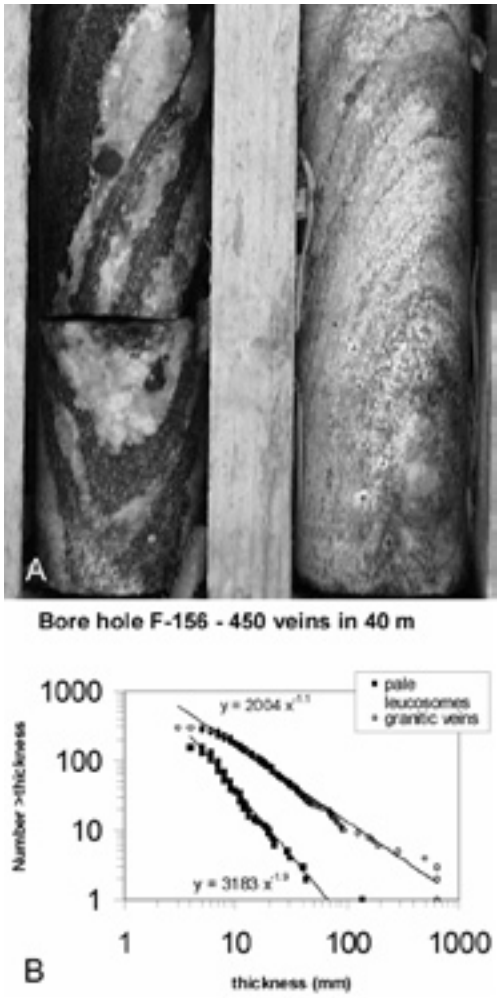
Estonian Science Foundation Grant No. 5301
Project leader: **A. Soesoo**
Team: V. Kalm (University of Tartu)
Duration: 2002–2005

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 achievements of the first year of the project are:
(1) establishment of the Earth Processes Modelling Laboratory at the Institute of Geology and building a unique experimental tank with digital recording possibilities;
(2) a combination of results from analogue experiments and field observations show that melt segregation, accumulation and migration are likely the processes that demonstrate fractal characteristics and can be described by self-organised criticality;
(3) migmatites (leucosomes) size show fractal distribution and are good objects to study self-organised criticality phenomenon in partially molten systems.



Some results from a pilot study of drill core of the Estonian Basement. (A) Photograph of typical leucosomes in drill core. (B) Thickness distribution of igneous veins in a 40 m section of drill core (shown in (a)). The logarithmic graph shows number of veins wider than a certain width against this width. The straight lines in the logarithmic graph indicate self-similarity (fractal) of the vein/leucosome population.

The age and origin of Estonian crystalline basement rocks

Estonian Science Foundation Grant No. 4615
Project leader: **A. Soesoo**
Team: V. Puura, J. Kirs (both from 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. Low abundance trace elements (REE and other incompatible elements) and Sr, Nd and Pb isotopic compositions in the whole rock and minerals will be analysed and studied for this task.

The main results of the project are: (1) the ages of different rock complexes will be determined and major magmatic events will be established within the Estonian basement. These

data will be used for the geological correlation with Fennoscandian rocks and give an answer to a major problem bothering Estonian and international geological communities - are there any older than Svecofennian (or even Archaean) rocks in the Estonian basement. These data form a base for structural geological/tectonical and economic (e.g., possibility of kimberlitic magmatism in the area) projects in the future. (2) The tectono-magmatic model of Precambrian evolution of these rock complexes and the source of mafic and felsic magmas will also be proposed and the crust-mantle relationship will be determined. This knowledge can be used in the studies of metallogeny of the basement rocks. 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).

The studies of Sm-Nd and Rb-Sr isotopic systematics have shown that the source for some granulitic mafic rocks may be in the mantle. In several cases, the chemistry of studied mafic rocks can be explained by mixing of mantle-related and crustal (lower-crust?) magmas. Nd epsilon values of most of mafic rocks varies 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. Associated charnokites also show low Sr/Sr ratios and epsilon values around 0, which indicates that these granitoids may be closely related to partial melting of mafic granulites (of igneous origin).

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. Kurik
Duration: 2002–2005

Properties of biogenic apatite varieties are studied by means of XRD and SEM/EDS. Three research foci will be based on three large subsets of samples: (1) apatite varieties from Estonian phosphorite deposit; (2) apatite varieties in Recent and fossil brachiopod shells and (3) apatite varieties in Recent and fossil vertebrates. A task of our studies is to use statistically representative data sets for testing hypothetical scenarios describing skeletal apatite formation and subsequent alteration by means of maturation and enrichment with precipitated apatite varieties. Our goal is to establish if the constraints to stability of the apatite varieties allow to use the ranges of mineralogical parameters as indicators of different processes. A wider goal is to advance representative data sets of lattice parameters that could be used as a "map" for interpreting further XRD studies of biogenic apatite varieties.

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.

Depending on natural preconditions, main attention in the Quaternary scientific research is focused on the study of the last continental glaciation, and the deposits and coastal forms of the Baltic Sea and lake basins. The palaeoshorelines of the Baltic Sea were collected into a new comprehensive database. Shorelines for the Baltic Ice Lake, Ancylus Lake and Litorina Sea were modelled.

Studies of annually laminated lake sediments present some opportunity to provide new high-resolution palaeodata for the Holocene stratigraphy. Much attention was also paid to the investigation of Kaali and Ilumetsa meteorite craters. The studies carried out last year have also contributed to elucidating the detailed history of Lake Võrtsjärv and Holocene rivers. One of our tasks has been compilation of the "Book of Primeval Nature".

Research laboratories of isotope-palaeoclimatology and Quaternary geochronology are the only complex research units in the field of isotope-geochemistry and radiometric dating in the Eastern Baltic area. 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 of the laboratories are isotope-palaeoclimatology, -palaeocryology and palaeohydrology; application of isotopic methods in geochronology, stratigraphy, climatology and oceanology; development and application of promising radiometric dating methods (ESR, OSL and OSA).

One of the main research objects is water and especially Estonian groundwater. The laboratory of isotope-palaeoclimatology is part of the ongoing EC 5th Framework Project "BASELINE" (1999–2006) and groundwater research will be an important issue also in the EC next, 6th FP. Further studies will concentrate mainly on the genesis and distribution of palaeowaters in northern Estonia, baseline geochemistry and quality of water in different water complexes.

Isotope-geochemical analyses of ice cores, permafrost and ground ice as indicators of palaeoclimate and palaeoenvironment have been and will be one of the main research trends for the laboratory. Application of isotope methods in the study of Palaeozoic stratigraphy should be of high priority in coming years, too. In further investigations to be conducted in this field much more attention should be paid on geochemical explanation of isotope variations in Palaeozoic sediments in order to find more reliable correlation between palaeoenvironmental changes and corresponding variations in the isotopic composition.

In 2002, in the Quaternary Geology Department these trends were accomplished through four target-financed projects, five Estonian Science Foundation grants and one European Commission Project. Each of these projects is briefly introduced below.

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, A. Miidel, A. Molodkov, E. Tavast
Duration: 2001–2005

Human impact on the groundwater composition in the Estonian oil-shale basin was assessed and recommendations for the improvement of the situation were given. Using factoral analysis it was proved that the chemical composition of groundwater in the Toolse and Kunda rivers is highly different and the reasons were found out. Based on the very first relation diagram ever compiled for Central Estonia, a new late- and postglacial development history of Lake Võrtsjärv was compiled. The evolution of glacial topography of western and central Estonia was reconstructed. In cooperation with the Institute of Physics of the Earth, Russia, some new sites indicating Holocene tectonic activity in N and NE Estonia were described. In the lake sediments in the lower course of the Kunda River textures indicating an earthquake in the Early Holocene were detected. Based on the precise morphological scheme of the Kaali meteorite crater, the force of the impact energy was calculated, which shows that the fall of the Kaali meteorite did not cause essential palaeogeographical changes. On the basis of new analysis data it was proved that the Kaali craters are undoubtedly older than 4000 years.

The results of comprehensive ESR study of marine deposits suggest that the sea level stand during isotope Stage 5 should be essentially higher in Eurasian north than it was predicted by the deep-sea oxygen isotope reconstructions for the Stage 5. The range of dates (145-70 ka) obtained on transgressive marine sediments and the results of palynological analysis of loess-palaeosoil and other terrestrial deposits available suggests that this palaeoenvironmental event may have been long lasting, correlating most likely with the whole of MIS 5 rather than with the period of optimum conditions in substage 5e only and should belong to the Last Interglacial (MIS 5, *sensu lato*).

New ESR-datings and palaeoclimatic records from the reference sections in the centre of the East-European Plain and other sites in the different parts of the world suggest climatic amelioration just below the MIS 6/5e boundary. It can be interpreted as an indication of a global warming and sea-level rise at the end of isotope stage 6, about, 145 ka, which is much older than the insolation maximum in the Northern Hemisphere at ca. 128 ka BP.

The time-dependent frequency distribution of all the ESR-dates obtained mostly on uplifted marine sediments along the marginal zone of the Northern Eurasia demonstrates the presence of low-frequency intervals at 130, 115, 100 and 75 ka which may be correlated with the intra-Interglacial (Eemian/Mikulinian) coolings and phases of sea regression. New findings concerning the frequency distribution of ESR-dates for northern Eurasia are in good agreement with the results of isotope and chronological analyses of speleothems from the caves of Stordalsgrotta and Okshola northern Norway. Also, in the series of sections from the eastern coast of the White Sea studied by ESR there is no interruption of marine sedimentation during the 120 – 75.5 ka interval; neither were any deposits suggestive of glaciation revealed for that period. All these data obtained suggest that the palaeoclimatic structure of the Last Interglacial was much more complicated than assumed so far.

Typical South Estonian till with Devonian clasts, eastern shore of Lake Võrtsjärv. Photo by A. Miidel.

Geologcial development of Lake Võrtsjärv

Estonian Science Foundation Grant No. 4046
Project leader: **A. Raukas**
Team: R. Karukäpp, A. Miidel, E. Tavast
Duration: 2000–2002

Owing to its central position in the territory of Estonia, Lake Võrtsjärv has played an important role in solving of many Late- and Post-Glacial palaeogeographic problems. Until recently, its earlier stages - Ice Võrtsjärv, Ancient Võrtsjärv and Big Võrtsjärv - were not precisely determined and their contours were a subject of many discussions. Based on the research results derived within this project, the distribution of these water bodies was determined in particular detail, and time limits of all the stages were presented. The heights of thresholds were measured and used in a distance diagram. The beginning of Contemporary Võrtsjärv goes back about 7500 years when an outflow from L. Võrtsjärv developed towards L. Peipsi. The great thickness of lacustrine lime (8 m) and sapropel (9 m) in the southern part of the lake basin suggests a gradual water-level rise in this part of the lake during the whole of Holocene. A map showing the carbonate content of bottom deposits was compiled.

Abrupt water level changes and the distribution of the lake during different stages of its evolution was controlled by the tectonic movements of the Earth's crust, which opened and closed the earlier outflows and inflows. The water-level fluctuations in L. Võrtsjärv have always been significant; this hampers the correlation of shorelines and river terraces. The geomorphological schemes and maps compiled on the Võrtsjärv basin furnish a basis for the reconstruction of glacial processes and allow to estimate their role in the formation of the topography.

A very first diagram of neotectonic uplift of Võrtsjärv Lowland was compiled and a new version of the lake's geological development in Late-glacial times and in the Holocene was presented. For the monograph "Lake Võrtsjärv", which will be published in March 2003, the following chapters were compiled:

- Geology of Võrtsjärv depression;
- Landforms of Võrtsjärv Lowland;
- Formation and evolution of Lake Võrtsjärv;
- Coasts of Lake Võrtsjärv;
- Bottom deposits of Lake Võrtsjärv and main outlines of geology of rivers of Lake Võrtsjärv.

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 the 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

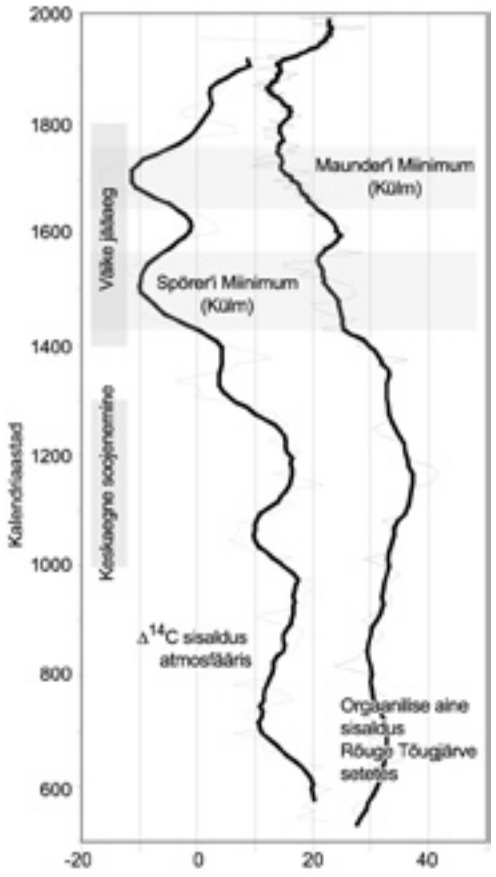
of the same period to obtain a varve-climate link, which then could be extrapolated to the past. These procedures will provide quantitative estimates of short- and long-term climate variability. Post-glacial climatic variability and environmental changes are established using diatom-inferred reconstruction. 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.

Main results in 2002:

(1) Varve counts, ^{210}Pb, biostratigraphical- and soot microsphere analyses prove the annual nature of the laminated lake sediments, correlation of the varve parameters and instrumental climate parameters (winter runoff) is 0.68. Pollen and diatom analyses show synchronity of the periods with more human impact during the last 700 years. Laminated sediments of 5 Estonian lakes register the Little Ice Age.

(2) Soot microsphere calibration curve elaborated using varve counts and/or ^{210}Pb ^{137}Cs, ^{241}Am dated sediments shows characteristic increase of fly-ash particles during the 1930s and 1940s. Mid-Finnish annually laminated lake sediments date the drainage of the Ancylus Lake to 8250–8200 BC reveals a joint investigation with Finnish Geological Survey.

(3) Palaeolimnological studies of the past 150 years of Lake Peipsi show rapid eutrophication since the 1960s and a recovery during the last 10 years. Pristine conditions existed there even as late as in the 1940s.



The content of organic matter in the annually laminated sediments of Rõuge Tõugjärv reflects climatic events such as the Little Ice Age, Medieval Warming, Spörer, Maunder etc Minima.

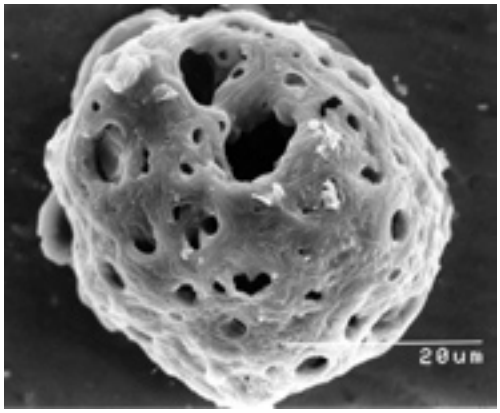
Sediment freeze coring on Lake Peipsi 01. February 2002. See Russian border further on the horizon!

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

Postdoctoral Research Programme No. 0332180s02
Project leader: **T. Alliksaar**
Duration: 2002–2003

The studies of natural historical archives such as lake sediments and peat sequences require reliable age-scale. In order to determine age for sediments accumulated during last 100–150 years the ^{210}Pb method as well as 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 changed by any chemical processes in sediments. To obtain 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 a detail independent age-scale and on the basis of that compile a calibration curve of fly-ash particles. The marker horizons of vertical distribution of fly-ash particles are accurately dated which allow applying this method to determine 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 last 100 years which can be applied for paleo-environmental studies.

A fly-ash particle.



Main results in 2002:

(1) In the homogeneous lake sediments dates obtained with ^{210}Pb method show younger ages and they are corrected using ^{137}Cs and ^{241}Am datings. At the same time results in annually laminated sediments demonstrate good accordance of age-scales of both methods - ^{210}Pb and also the distribution of artificial radionuclides. Latter confirms very good preservation of paleoinformation in sediments where bioturbation is insignificant or even missing.

(2) Spherical fly-ash particle distribution curves in analysed lake sediments have characteristic temporal trends with specific features what are found to be consistent over wide geographical areas. Comparison of particle down-core distribution with fuel combustion statistics in the region has shown that they have similar time-trends. The features in fly-ash particle concentration profile represent major changes in fuel consumption history. The results show characteristic increase of fly-ash particles during 1940s.

(3) Fly-ash particle analysing method was adapted for counting particles in lake sediments with high mineral matter content.

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, applying the retrospective studies in the north-east of Estonia, especially during the peak level of alkaline pollution 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 upgrade 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 the 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 result. The existing knowledge and the potential of young scientists and post-graduate students will be used more effectively.

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

The abrupt climate changes, volcanic eruptions, earthquakes, rapid freshwater pulses, meteoritic impacts, glacier fluctuations, etc. are short-lived occurrences or geoevents that have left some traces into the geological record, traced by geochemical, physical and biological methods. Geoevents could be of local, regional or hemispheric extension and can therefore be used in correlations and for the subdivision of the sediment sequences. Geological, as all other events, need to be characterised in time and space, i.e. to distinguish their time of occurrence, duration, order and distribution. The time-scales dating the geoevents of the Holocene should preferably be based on calendar years (annual varves, tree-rings, ice-core years, etc.) or on radiocarbon dates (also calibrated).

Which of the mentioned changes are reflected in our biostratigraphic material; what is their nature, influence on the sedimentation rate and character; are there any traces of tephra in Holocene sequences of Estonia; is it possible to establish the Holocene event stratigraphy units or improve the local stratigraphic chart - all these questions need answers and systematic treatment.

Research goals and hypotheses:

- The main goal of the project is to find, describe, date and clarify the geoevents of different temporal and spatial range. A list of Holocene geoevents traced in Estonia will be executed.
- To find the marker horizons which correspond to the geoevents.
- To establish the composition, texture, struc-

ture, geochemical and palaeomagnetic parameters, and biostratigraphy of marker units.
- To reconstruct the environmental and climate conditions, the trends of vegetation changes which correspond to the rapid events.
- To elucidate the possibilities and limitation of the Holocene event stratigraphy.
- To correlate the established events with those in the neighbouring areas.
- To sum up new material and integrate it to the data base.

Main results in 2002: 1. Climatic and environmental changes during the Little Ice Age were examined. Annually laminated lake sediments are good object to study the rapid climate cooling as their lithostratigraphy differs considerably from the sediment unit which accumulated during the Medieval Warm Period. 11-year cycle in sediment structure was observed visually and decleared statistically and could be correlated with the sunspot cycle. 2. Changes in the colonization and environmental conditions were elucidated in connection with the rapid changes in sea level. 3. Database of the transgressional shorelines of the Baltic Ice Lake, Ancylus Lake and Litorina Sea were created and isoline for the mentioned phases were simulated using the Kriging Point approach. 4. Geological investigation on the Võrtsjärv Lowland biostratigraphic key section were completed, the beginning of peat formation and increment were determined, the start and motion of forest clearances and crop cultivation were clarified. 5. Comparison and analysis of the conventional and AMS ^{14}C dates from the lake sediment of the NW carbonaceous plateau of Estonia show c 500-year difference throughout the Holocene, except the Atlantic. 6. A new version of postglacial history of the Island of Saaremaa have been presented and illustrated with several palaeogeogrpahical maps. 7. Under the leadership of Dr. Heikki Seppä (Uppsala University) the lake surface sediments from Estonian lakes were collected, palynologically analysed and correlated with the modern climate parameters to find out the transferfunction for the future palaeoclimatic reconstructions.

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. Balakhnitcheva, J. Ivask, I. Jaek, E. Kaup, T. Martma, A. Molodkov, M. Osipova, V. Raidla, H. Rajamäe, A. Marandi, L. Vallner, V. Vasilchenko
Duration: 2002–2006

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 is adjusted and associated with global climate and environmental changes. The use of isotope methods in the study of Late-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 2002: Research into the isotope composition of the groundwater on Ruhnu Island showed that at least partially it might be of glacial origin. This fact may essentially change the hitherto knowledge of the distribution area of the groundwater of glacial origin in Estonia and calls for further detailed studies. Using three independent diagnostic methods it

was found that the information about climatic changes stored in the glacier ice of Spitsbergen in the form of isotope variations is reliable. The result is important because it can be generalised for all so-called "warm glaciers", which so far had been considered as study objects of little promise.

As a result of the development of luminescence methods it was found out that the thermally highly stable defects in quartz serve as a disturbing factor on dating. The essential parameters of these defects (radiation spectra, stimulation spectra, detailed radiation kinetics) were determined. On this basis their effect in the new research devices was eliminated. The stability of the light sum stored as a result of optic stimulation and thermoluminescene in alkali feldspars was compared. It was established that the trap levels causing the ~200°C TL maximum can be used as dosimetric levels in dating.

As a result of joint use of two palaeodosimetric dating methods (ESR and OSL) the first data on the age of debatable interglacial marine deposits in the southeastern part of the Fennoscandian Shield were obtained. The luminescence method, which was essentially improved in the course of methodical studies, yielded an age about 104.0±8.3 thousand years ago and four ESR datings in the time interval ca 103.0±4.2 thousand years ago. These unambiguously show that these sediments originate from the last interglacial. Thus, the hypothesis about the third Late Pleistocene interglacial transgression in the south-eastern part of the Fennoscandian Shield has not found confirmation.

Applying isotope geological methods to the study of Palaeozoic environmental conditions the trend of changes in the isotope composition of carbon from Keila Age (Ordovician) up to the end of the Silurian (a total of 38 million years) was established. On interpreting the curve, the connection of the changes in the isotope composition of carbon with the climate cooling and warming, as well as with the changes in water level and biota was shown. It was shown that the course of isotope curve has a great potential in the correlation of geological sections, also on global scale.

Sampling for chemistry and $\delta^{18}O$ from 3.6 m snow pit in extreme conditions (Lomonossovfonna ice plateau, Svalbard. 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 is 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 are studied. It is attempted to find out whether the hypothesis basing on recent studies in Germany, the Netherlands and Scandinavian countries 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 are studied. The approximate age of these valleys will be determined by means of luminescent datings. To elucidate the conditions of subglacial meltwater discharge, the distribution and

dynamics of permafrost will be reconstructed by means of model calculations on the basis of the most recent palaeoclimatic evidence. Isotope-geochemical methods and hydrogeological models are 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 are studied and the composition of gases is determined. The possibility is 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 time up to the present.

Deep Cambrian-Vendian groundwater studies on Ruhnu Island 780 m borehole revealed interesting chemical and isotopic properties of water (E. Kaup and V. Raidla taking samples).

Energy accumulation, creation of defects and relaxation processes in solids with quartz and feldspars crystal lattice

Estonian Science Foundation Grant No. 4049
Project leader: **I. Jaek**
Team: A. Molodkov, V. Vasilchenko
Duration: 2000–2002

The further development of luminescense dating methods was continued. The high emphasis was put on perfecting optically stimulated afterglow (OSA) apparatus and dating protocols. A new reader for serial dating of quartz is being built. It was found the temperature-superstable defects in quartz (destroyed above 900°C) are disturbing factors for dating. The main parameters of these defects (spectrums of emisson and stimulation, the kinetics of afterglow) were defined. In the new reader the influence of these defects is eliminated. The stability of stored lightsum in alkaly feldspars was studied by OSA and thermoluminescense methods. It was established the traps of feldspar with TL peak at 200°C are useable for optical dating. The possibility for optical dating of natural carbonates (include mollusc shells) was investigated.

Participation in international programmes and co-operation projects

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, A. Raukas*;

Comparative Biostratigraphical Study of Cambrian and Ordovician Sequences in Polish and Estonian Part of the East-European Platform, Polish Geological Institute, participant: *J. Nõlvak*;

Comparing Upper Ordovician-Lower Silurian Carbonate Platforms in Estonia and the Great Basin: A Test of the Synchrony of Sequences and Faunal Changes, National Science Foundation (USA), co-operation partners in Estonia: *L. Hints, P. Männik, J. Nõlvak*;

Deposition conditions and evolution of sedimentation in Baltic basin during Devonian time, Committee of cooperation Sweden and Baltic states, participant: *A. Kleesment*;

Finnish Global Change Research Programme (FIGARE), Academy of Finland, participant: *A. Heinsalu*;

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

Human Impact and Geological Heritage, The Peribaltic Group of the INQUA Commission on Glaciations, participants: *R. Karukäpp, A. Molodkov, A. Raukas, E. Tavast*;

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

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, participant: *T. Martma*;

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*;

Phylogeny, Biostratigraphy, and Distribution of Psammosteids (Agnatha, Heterostraci) from the Canadian Arctic and Baltic, National Research Council, USA, participants: *E. Kurik*;

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*;

The Early Palaeozoic Northern Baltic Sea Area Based on Fossils from Åland, Finland and Hiiumaa, Estonia, Finnish Museum of Natural History, University of Helsinki, participant: *J. Nõlvak*;

The Great Ordovician Biodiversification Event, International Geological Correlation Programme (IGCP) Project 410, participants: *O. Hints, D. Kaljo, J. Nõlvak*

Baltic Heterostracans were studied in the frame of a collaborative project. A model of *Psammolepis venyukovi* from the Middle Devonian, by E. Mark-Kurik.

Applied research

Hydrogeochemical study and assessment of contamination in the areas of exploration of oil shale (Northeast Estonia), Nordic Council, 2001–2002; project leader: *L. Bitjukova*, team: *T. Metslang*;

Risk based environmental site assessment of waste from the oil shale industry, Ministry of Foreign Affairs of Norway, 2002–2003; project leader: *L. Bitjukova*, team: *L. Vallner*;

Study and protection of unique geological objects, Centre of Environmental Investments, Estonian Ministry of the Environment, 2002–2003; leader: *L. Hints*, team: *O. Hints, K. Mens, P. Männik, J. Nõlvak, H. Pärnaste*;

Nature monuments in the Estonian Nature Information System (EELIS): Saaramaa and Tallinn, Estonian Ministry of the Environment 1999–2002; project leader: *H. Kink*, team: *U. Maspuran*;

Hydrogeoecological investigation of the Kunda and Ubja mining and industrial area, Joint-Stock Company Kunda Nordic Cement, 2000–2002; project leader: *H. Kink*, team: *T. Metslang*;

Conservation Management Plan of the Pakri Landscape Reserve, Environmental Survey of the Harju County, 2001–2002; project leader: *H. Kink*, team: *J. Nõlvak, K. Erg, A. Miidel*;

Environment expertise for Paldiski landfill, A.L.A.R.A. Ltd, 2002–2002; project leader: *H. Kink*, team: *T. Metslang*;

Conservation Management Plan for Tuhala Landscape Reserve, non-profit organization "Tuhala Looduskeskus", 2002, project leader: *H. Kink*;

Expertise about the conservation management plan of Uhaku Ladscape Reserve, Environmental Survey of the Ida-Virumaa County, 2002; project leader: *H. Kink*, team: *A. Miidel*;

Monitoring of the western coast of Pakri Peninsula, Marine Systems Institute, Tallinn Technical University, 2002; project leader: *H. Kink*, team: *T. Metslang, A. Miidel*;

Compiling books "Natural Heritage of Estonia 8: Harjumaa" and "Natural Heritage of Estonia 9: Ida-Virumaa", Centre of Environmental Investments, , Estonian Ministry of the Environment, 2002; project leader: *H. Kink*;

Conservation management plans for Pae, Palamulla and Aandu landscape reserves, Environmental Survey of the Harju County, 2002; project leader: *H. Kink*;

Radiocarbon datings, various institutions in Estonia and abroad, 2002; project leader: *E. Kaup*; team: *V. Raidla, H. Rajamäe*;

Electron spin resonance (ESR) and optically stimulated luminescence (OSL) datings, various institutions in Estonia and abroad, 2002; project leader: *A. Molodkov*, team: *T. Balakhnitcheva, I. Jaek, M. Osipova, V. Vasilchenko*

Training and education

Degrees defended

O. Hints defended PhD "Ordovician scolecodonts from Estonia and neighbouring areas: taxonomy, distribution, palaeoecology, and application" on June 17, Tallinn Technical University, Department of Mining, Tallinn; supervisor: Prof. E. Pirrus (Tallinn Technical University);

J. Nõlvak defended PhD "Chitinozoan Biostratigraphy in the Ordovician of Baltoscandia" on August 27, Tallinn Technical University, Institute of Geology, Tallinn;

T. Kallaste defended MSc "Mineralogical studies of sanidine from Estonian and Latvian Palaeozoic metabentonites" on May 29, Tallinn Technical University, Institute of Geology, Tallinn; supervisor: Dr. **J. Nemliher**;

T. Metslang defended MSc "Keemilise koostise näitajate ja vooluhulkade vahelisest korrelatiivsest seosest Toolse ja kunda jõe näitel" on June 14, Tallinn Pedagogical University, Tallinn; supervisors: Dr. H. Kink, Prof. **A. Raukas**

J. Nõlvak (on the right) having a conversation with his opponent Prof. M. Rubel (University of Tartu) during the defence of his PhD thesis devoted on Ordovician chitinozoans.

PhD and MSc projects in progress

E. Kiipli PhD project "Environmental changes at the Aeronian-Telychian boundary in East Baltic", Tallinn Technical University, Institute of Geology, Tallinn, supervisor Dr. T. Kiipli;

A. Marandi PhD project "Formation of the chemical composition of the Cambrian-Vendian groundwater in Estonia", University of Tartu, Institute of Geology, Tartu, supervisor Dr. **R. Vaikmäe**;

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

M. Mõtus PhD project "Lower Silurian Tabulate corals from Baltoscandia, their taxonomy, distribution and palaeoecology", University of Tartu, Institute of Geology, 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, supervisor Prof. T. Meidla (University of Tartu), R. Vaikmäe, S. Veski;

R. Kuldkepp MSc project "Geochemistry and geochronology of Estonian granulites", University of Tartu, Institute of Geology, Tartu, supervisor Dr. **A. Soesoo**;

K. Koppel MSc project "Historical rural landscape development from 17th to 19th century in Estonia", University of Tartu, Institute of Geology, Tartu, supervisors Prof. A. Must (University of Tartu), Dr. **S. Veski**;

T. Klaos MSc project "Sedimentological and diagenetical changes in the Silurian and Devonian contact beds in Estonia", University of Tartu, Institute of Geology, Tartu, supervisors Dr. L. Ainsaar (University of Tartu), Dr. **T. Märss**;

V. Raidla MSc project "Modelling of carbon migration in the Cambrian-Vendian groundwater in Estonia", Tallinn Technical University, Institute of Mining, Tallinn, supervisor Dr. **R. Vaikmäe**

Courses and lectures given

Biomineralization, Mining Institute, TTU, lecture by *J. Nemliher*;

Early vertebrates: taxonomy and biostratigraphy, Tartu University, lecture by *T. Märss*;

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

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

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

Geology of Estonia, University of Poznan, Poland, lecture by *A. Raukas*;

Geophysics, Estonian Maritime Academy, part of course by *E. Tavast*;

Geophysics and dynamical geology, Eurouniversity, course by *A. Raukas*;

Global climate and environmetal changes, University of Tartu, part of course by *R. Vaikmäe*;

HPLC training, several institutions, lecture by *J. Ivask*;

Hydrology and hydrogeology, Eurouniversity, course by *E. Kaup*;

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

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

Meteorite craters in Estonia, University of Poznan, Poland, lecture by *A. Raukas*;

Micropalaeontology (chitinozoans), Tartu University, part of course by *J. Nõlvak*;

Micropalaeontology (scolecodonts), Tartu University, part of course by *O. Hints*;

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

Palaeoenvironment from annually laminated lake sediments, Uppsala University, lecture by *S. Veski*;

Pollen analysis and applications, University of Tartu, lecture by *A. Poska*;

Quaternary stratigraphy in Estonia, University of Poznan, Poland, lecture by *A. Raukas*;

The age of the Kaali meteorite and it's impact on the environment: new results, lecture by *A. Heinsalu*;

The protection of Antarctic Environment, The High School of Märjamaa, lecture by *E. Kaup*;

The protection of Antarctic environment, English College, lecture by *E. Kaup*;

Wetlands ecology, Eurouniversity, course by *E. Kaup*

Staff training

O. Hints took part in short course **Impact Stratigraphy** at Osservatorio Geologico di Coldigioco, Italy;

S. Veski took part in NorFA course **Pollandcal** at Växjö University, Sweden;

M. Mõtus took part in field course **Coral Reef Environment** at Macquarie University

Dr. A. Montanari teaching the participants of the ESF Short Course "Impact Stratigraphy" some basic laboratory techniques for studying impact markers. The course was held at the Osservatorio Geologico di Coldigioco in the Appennines near Ancona, Italy.

Conferences, workshops, seminars and exhibitions organised

ELLE Microstructural Modelling Workshop, July 25–28, Institute of Geology at TTU, Mainz University, Särghaua, Estonia; co-organiser: *A. Soesoo*;

Environmental changes and settling along the Baltic Sea coasts through time, October 3–6, Tartu University, Stockholm University, NorFa, Pärnu, Estonia; organisers: *A. Heinsalu, A. Poska, A. Raukas, L. Saarse, S. Veski*;

European Society for Isotope Research VI Workshop, June 29 – July 4, Institute of Geology at TTU, Tallinn, Estonia; organisers: *L. Hints, J. Ivask, D. Kaljo, E. Kaup, T. Martma, R. Vaikmäe*;

Fourth POLLANDCAL Seminar, May 23–27, NorFA, Sagadi, Estonia; organiser: *S. Veski*;

Geology of the Devonian System, July 9–12, Institute of Geology UrD RAS, Syktyvkar, Russia; co-organiser: *P. Männik*;

Modelling of Earth' processes, November 21–23, Institute of Geology at TTU and Tübingen University, Särghaua, Estonia; organiser: *A. Soesoo*;

Photo exhibition "Photos from Estonian Bedrock and Waters", January 25 – March 15, Estonian Museum of Natural History, Tallinn, Estonia; organiser: *J. Nõlvak*;

Radiocarbon dating seminar, January 22, Institute of Geology at TTU, Tallinn, Estonia; organiser: *J. Vassiljev*;

The Day of Meteoritics, May 29, Kaali School, Kaali, Estonia; organiser: *R. Tiirmaa*;

The Geology of Estonian Basement Rocks, June 5–6, Institute of Geology at TTU, Arbavere, Estonia; organiser: *A. Soesoo*

J. Nõlvak at the opening of his photo exhibition in Estonian Natural Histroy Museum

Participation in international conferences and workshops

64th EAGE Conference and Technical Exhibition, May 26–30, European Association of Geoscientists & Engineers, Florence, Italy; participants: *L. Bitjukova, A. Shogenova*;

7th Nordic Symposium on Petrophysics, August 15–16, National Energy Authority, Iceland; Nordic Energy Research Programme, Akureyri, Iceland; participant: *A. Shogenova*;

7th workshop of the EU 5th FP project BASELINE, March 2–6, University of Bern, Böningen, Switzerland; participants: *A. Marandi, R. Vaikmäe*;

8th workshop of the EU 5th FP project BASELINE, October 5–9, Aveiro University, Madeira, Portugal; participants: *A. Marandi, R. Vaikmäe*;

Academia Europaea annual meeting, October 9–13, Academia Europaea, Lissbon, Portugal; participant: *R. Vaikmäe*;

Annual meeting of the European Science Foundation Polar Board, April 21–24, European Science Foundation, Gröningen, Holland; participant: *R. Vaikmäe*;

Building bridges between archaeology and palaeoecology, March 7–8, Tartu University, NorFA, Tartu, Estonia; participants: *E. Niinemets, S. Veski*;

Contaminants in Freezing Ground, April 14–18, Australian Antarctic Division, Hobart, Tasmania, Australia; participant: *E. Kaup*;

ECO-GEOWATER EuroConference "Link Geo and Water Research", February 7–9, Genova, Italy; participant: *A. Marandi*;

Eighth International Conodont Symposium Held in Europe (ECOS VIII), June 22–25, Toulouse and Albi Universities, Toulouse, Albi, France; participants: *P. Männik, V. Viira*;

ELLE Microstructural Modelling Workshop, July 25–28, Mainz University, Tubigen University, Institute of Geology at TTU, Sarghaua, Estonia; participant: *A. Soesoo*;

Environmental Catastrophes and Recoveries in the Holocene, August 29 – September 2, Brunel University, London, UK; participant: *S. Veski*;

Environmental changes and settling along the Baltic Sea coasts through time, October 3–6, Tartu University, Stockholm University, NorFa, Pärnu, Estonia; participants: *A. Heinsalu, A. Poska, A. Raukas, L. Saarse, S. Veski*;

Estonian-German Round Table on Sustainable Development, June 12–15, Viru County Council, Narva Jõesuu, Estonia; participant: *A. Raukas*;

European Society for Isotope Research VI Workshop, June 29 – July 4, Institute of Geology at TTU, Tallinn, Estonia; participants: *L. Hints, J. Ivask, D. Kaljo, E. Kaup, T. Martma, R. Vaikmäe*;

Evolution of Devonian sedimentary basins in NW Europe, August 26 – September 1, Göteborg University, Department of Earth sciences, South-Estonia, Estonia; participant: *A. Kleesment*;

Field Symposium on Quaternary Geology and Geodynamics in Belarus, May 20–25, INQUA and National Academy of Sciences of Belarus, Grodno, Belarus; participants: *A. Molodkov, A. Raukas*;

Fourth POLLANDCAL seminar, May 23–27, NorFA, Sagadi, Estonia; participant: *S. Veski*;

Geology of the Devonian System, July 9–12, Institute of Geology UrD RAS, Syktyvkar, Russia; participant: *P. Männik*;

German-Estonian Co-operation Day - environmental technology, September 18, Tallinn Technical University, Tartu, Estonia; participant: *T. Martma*;

Global Peace Conference, December 26–30, Washington, USA; participant: *A. Raukas*;

IGS Nordic Branch Annual Meeting, November 7–9, University of Oslo, Oslo, Norway; participant: *T. Martma*;

International workshop "Industrial Heritage as a guider of development", November 29–30, Industrial Heritage Platform, Kohtla-Järve, Estonia; participant: *A. Raukas*;

Jubilee conference of Estonian Institute of Sustainable Development, November 14, SEI, Tallinn, Estonia; participant: *A. Raukas*;

Lomonosovfonna Workshop, November 6–7, Norwegian Polar Institute, Oslo, Norway; participant: *T. Martma*;

Modelling of Earth' processes, November 21–23, Institute of Geology at TTU, Sarghaua, Estonia; participant: *A. Soesoo*;

Natural and cultured landscapes: ecological and durability problems, November 28–29, Geographical Society of Russia, Pihkva Department, Pihkva, Russia; participant: *E. Tavast*;

Oil Shale Symposium, November 18–21, Tallinn Technical University, Tallinn, Estonia; participants: *L. Bitjukova, A. Raukas, A. Soesoo, A. Teedumäe*;

PAGES Meeting on High Latitude Palaeoenvironments, May 16–17, PAGES, Moscow, Russia; participants: *T. Alliksaar, L. Saarse, S. Veski*;

Perspectives in Astrobiology, September 28 – October 9, NASA NATO ASI, Creta, Greece; participant: *J. Nemliher*;

Renewing the Nation: an Exploration of Principles and Practices that Strenghten the Family Education, Our Youth and Rebuild Society, May 6, Interreligious and International Federation for World Peace, Tallinn, Estonia; participant: *A. Raukas*;

Seminar "Global Climate Change" of Alpbach Technology Forum, August 21–25, Austrian Ministry of Education and Research, Alpbach, Austria; participant: *R. Vaikmäe*;

The 3rd All-Russian Quaternary Conference, September 2–7, Russian Academy of Sciences, Smolensk, Russia; participants: *A. Molodkov, A. Raukas*;

The EU Water Framework Directive: Statistical aspects of the identification of groundwater pollution trends, and aggregation of monitoring results (WFD-GW), January 24–27, Vienna, Austria; participant: *A. Marandi*;

The Fifth Baltic Stratigraphical Conference "Basin Stratigraphy – Modern Methods and Problems", September 22–27, Geological Survey of Lithuania, Institute of Geology and Geography, Vilnius University, Vilnius, Lithuania; participants: *O. Hints, D. Kaljo, E. Kiipli, T. Klaos, E. Kurik, T. Martma, A. Molodkov, P. Männik, T. Märss, H. Nestor, A. Raukas, L. Saarse*;

The seventh marine geological conference, April 21–27, Atlantic branch of P.P. Shirsov Institute of Oceanology, Russian Academy of Sciences, Kaliningrad, Russia; participant: *J. Vassiljev*;

Third POLLANDCAL seminar, February 8–11, NorFA, Växjö, Sweden; participants: *A. Poska, S. Veski*;

Workshop "Monitoring, use and protection of Estonian-Russian boundary water bodies", July 23–24, Estonian Ministry of the Environment, Tallinn, Estonia; participant: *A. Raukas*;

The Fifth Baltic Stratigraphical Conference held in Vilnius, Lithuania, in September was attended by 12 persons from the Institute of Geology at TTU. A special session was organized for fish researchers (first row from left: I. Upeniece, Latvia; O. Rodina, Russia; T. Märss, Estonia; V. Talimaa and Ž. Žigaite, Lithuania; A. Blieck, France; J. Vergoossen, Holland; second row from the left: C.G. Miller, U.K.; I. Zupinš and E. Lukševičs Latvia; A. Ivanov, Russia; J. Šečkus and J. Valiukevičius, Lithuania. Photo by Ž. Žigaite).

Workshop of experts on Energy and Environment for the EU 6th FP, June 19–20, European Commission, Strasbourg, France; participant: *R. Vaikmäe*;

Workshop of the project leaders of EU 5th FP, February 28 – March 1, European Commission, Strasbourg, France; participant: *R. Vaikmäe*;

World Culture and Sports Festival 2002 "Toward a New World Culture of Peace - The Search and Solution to Critical Global Problems, February 13–19, , Seoul, Korea; participant: *A. Raukas*;

X All-Russian Palynological Conference, October 13–18, Moscow, Russia; participant: *A. Molodkov*;

XXV Antarctic Treaty Consultative Meeting, September 10–20, Polish Foreign Ministry, Warsaw, Poland; participant: *E. Kaup*

International travels and visits

Bitjukova, L., May 31 – June 1, Laboratorio Scientifico Scuola Vecchia della Misericordia, Venice, Italy, to work in scientific laboratory and discuss future co-operation work;

Bitjukova, L., June 16–30, University of Bristol, Bristol, United Kingdom, to analyse Middle Ordovician carbonate building stones by XRF and ACP-MS methods in the frame of EU Programm (Large Scale Geochemical Facility, IHP Programme, European Comission);

Bitjukova, L., February 1–28, University of Helsinki, Helsinki, Finland, to analyse soils and lake sediments using sequential leaching (extraction) method and ICP technique;

Bitjukova, L., July 25 – August 3, University of Helsinki, Helsinki, Finland, to study chemical composition of the samples of carbonate building stones (dissolution and microelements concentration analysis by ACP method);

Bitjukova, L., September 30 – October 9, Sank-Petersburg University, VSEGEI Institute, St. Petersburg, Russia, to study thin sections of the Ordovician carbonate rocks and analyse of the chemical composition by XRF method;

Heinsalu, A., October 21–25, Geological Survey of Finland, University of Helsinki, Otaniemi, Helsinki, Finland, to further develop collaborative research;

Hints, O., May 3–15, Osservatorio Geologico di Coldigioco, Apiro, Italy, to take part in ESF short course 'Impact Stratigraphy';

Hints, L., March 4–21, Geological Museum, Copenhagen University, Copenhagen, Denmark, to study original collections of the Ordovician brachiopods, compare the Baltic brachiopods with those from Scandinavia, and compile a manuscript on the brachiopod genera *Alwynella* and *Grorudia*;

Kaljo, D., March 15–17, European Science Foundation, Copenhagen, Denmark, to participate in discussions about the future of European Research Council;

Kaljo, D., June 8–10, European Science Foundation, Versailles, France, to participate in discussions about activities of the commission on life and environmental sciences;

Kaup, E., November 12–18, Münster University, Münster, Germany, to dismantle mass-spectrometer and transport spare parts;

Konsa, M., June 13–18, State Geological Survey, Riga, Latvia, to collect samples of the Vendian and Cambrian rocks;

Kurik, E., April 8–16, National Museum of Scotland, Edinburgh, United Kingdom, to study the collection of arthrodire *Homostius*;

Kurik, E., August 8–9, Latvian Natural History Museum, Riga, Latvia, to study Middle and Late Devonian psammosteids;

Kurik, E., September 30 – October 28, Northern Arizona University & The Academy of Natural Sciences, Flagstaff & Philadelphia, USA, to study psammosteids and placoderms from the Devonian of Canadian Arctic

Martma, T., November 12–18, University of Münster, Münster, Germany, to dismantle mass-spectrometer and transport spare parts;

Martma, T., April 17 – May 2, Norwegian Polar Institute, Svalbard, Norway, to take part in fieldwork in Lomonosovfonna;

Mõtus, M., March 2 – April 2, Macquarie University, Heron Island, Australia, to participate the Coral Reef Environment Course;

Männik, P., November 3 – December 9, Lund University, Lund, Sweden, to study taxonomy, evolution, and palaeoecology of Silurian conodonts in collaboration with Prof. L. Jeppsson;

Männik, P., July 4 – August 20, , Subpolar Urals, Russia, to participate in geological fieldwork in Subpolar Urals organised by the Geological Insitute in Syktyvkar;

Nõlvak, J., November 3–13, Geological Museum, University of Helsinki, Helsinki, Finland, to study Ordovician microfossils;

Nõlvak, J., March 20–24, Geological Museum, University of Helsinki, Helsinki, Finland, to study Ordovician microfossils from Överby;

Nõlvak, J., September 5–26, Geological Museum, University of Helsinki, Helsinki, Finland, to study Ordovician microfossils from Lumparn impact crater;

Nõlvak, J., November 14–24, Geological Museum, University of Helsinki, Department of building history of Museovirasto, Helsinki, Finland, to provide datings of different unique geological objects;

Raukas, A., June 25–29, Republic of Latvia, study of late-glacial outflows of Lake Võrtsjärv;

Raukas, A., October 6–7, University of Latvia, Riga, Republic of Latvia, to discuss joint scientific studies;

Raukas, A., October 19–25, Poznan, Poland, to give lectures on Estonian geology and study the Morasko meteorite craters;

In May 2002, O. Hints participated ESF Short Course "Impact Stratigraphy" in Italy and visited several K/T outcrops, including the famous Gubbio section shown in this photo. The Iridium-rich clay at the boundary is just where Frank points with his right hand.

Shogenova, A., March 28 – April 13, Petrophysical Laboratory of the Institute of Earth's Crust of the St.Petersburg University, St. Petersburg, Russia, to take measurements of properties of Devonian rocks;

Shogenova, A., October 26–30, VSEGEI, St.Petersburg, Russia, to prepare Devonian samples for geochemical analysis, and discuss the results of analyses;

Soesoo, A., July 30 – August 5, Turku University, Turku region, Finland, to study migmatites;

Soesoo, A., August 18–23, Southern and Central Finland, Finland, to participate in fieldwork on migmatites from amphibolite and granulite facies metamorphic rocks;

Soesoo, A., August 24–31, University of Tromso, Tromso-Lafoten, Norway, to take part in NorFa geological excursion;

Soesoo, A., September 22–28, University of Bristol, Bristol, UK, to prepare and analyse geochemical samples;

Tavast, E., April 9–13, University of Latvia, Riga, Latvia, to work in Latvian library;

Tavast, E., June 25–29, Valmiera, Latvia, to investigate the Lake Võrtsjärv outflow;

Vaikmäe, R., August 27–29, Münster University, Münster, Germany, to discuss co-operation in the field of stable isotope mass-spectrometry;

Veski, S., November 28–29, Uppsala University, Uppsala, Sweden, to give a talk, and prepare scientific co-operation;

Viira, V., October 7–18, Leicester University, Leicester, England, to finish manuscript of a joint paper

Co-operation partners

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

Arctic and Antarctic Research Institute, 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;

CNRS, Grenoble, France;

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;

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

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

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

Geoforschungs Zentrum, Potsdam, Germany;

Geological Museum of the Copenhagen University, 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, Hungary;

Indiana University, USA;

Institute of Geology, Ural Branch of the Russian Academy of Sciences, Syktyvkar, Russia;

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

Institute of Petroleum and Gas Geology, Siberian Branch of RAS, Novosibirsk, Russia;

Institute of Physics of the Earth, Moscow, Russia;

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

Krakow University of Mining and Metallurgy, Krakow, Poland;

Lithuanian Institute of Geology, 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;

National Institute of Chemical Physicss 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;

Ohio University, Athens, Ohio, USA;

Polish Institute of Geology, Warszawa, Poland;

Polytechnical University of Catalonia, Barcelona, Spain;

Pskov Pedagogical University, Pskov, Russia;

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

Smolensk Pedagogical University, Smolensk, Russia;

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

Stockholm University, Stockholm, Sweden;

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

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

Tartu Observatory, Tartu, 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 Science, Novosibirsk, Russia;

The Natural History Museum, London, UK;

Umeå University, **Deptartment of Ecology and Environmental Science**, Umeå, Sweden;

University of Alberta, Edmonton, Canada;

University of Avignon, Avignon, France;

University of Bergen, Geological Institute, Bergen, Norway;

University of Bern, Bern, Switzerland;

University of Bristol, Department of Earth Sciences, Bristol, United Kingdom;

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 Tartu, Institute of Environmental Physics, Tartu, Estonia;

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

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

University of Turku, Turku, Finland;

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

Bajnóczi, B. from Laboratory for Geochemical Research, Hungarian Academy of Sciences, Hungary, discussed about project "ESIR Network of Isotopes in Precipitation" and participated in the VI Isotope Workshop (June 28 – July 5, hosted by R. Vaikmäe);

Bergman, C.F. from Kristianstad University, Sweden, studied scolecodont type collections from Estonian and neighbouring areas (June 15–18, hosted by O. Hints);

Beznosova, T. from Institute of Geology, UrD RAS, Russia, visited Silurian outcrops in Saaremaa and discussed about the ongoing joint project on Silurian sections (September 15–21, hosted by P. Männik);

Csaba, Detre Hunor from Hungarian Geological Institute, Hungary, investigated extraterrestrial spherules (July 8–13, hosted by A. Raukas);

Derdowski, R. from University of Poznan, Poland, studied Estonian meteotite craters at Kaali and Ilumetsa impact sites, and shown different search methods of meteorite fragments and dispersed matter (August 5–13, hosted by A. Raukas and R. Tiirmaa);

Elliott, D.K. from Northern Arizona University, USA, studied psammosteid collections (August 2–20, hosted by E. Kurik);

Fórizs, I. from Laboratory for Geochemical Research, Hungarian Academy of Sciences, Hungary, discussed about project "ESIR Network of Isotopes in Precipitation" and participated in the VI Isotope Workshop (June 28 – July 5, hosted by R. Vaikmäe);

Goldman, D. from Department of Geology, the University of Dayton, Ohio, USA, studied Ordovician graptolites kept at the Institute of Geology, TTU, and made the acquaintance with the North Estonian cliff near Paldiski (July 27–31, hosted by D. Kaljo and J. Nõlvak);

Götze, H.-J. from Institut für Geologische Wissenschaften, Freie Universität Berlin, Germany, discussed future projects and teaching of geophysics for students. Organised workshop on deformation processes in high mountain areas - new data, new problems and new methods (August 2–10, hosted by A. Shogenova);

Harris, M., (Milwaukee University) **Sheehan, P.** (Milwaukee Public Museum)**, Schultz, T.** (Milwaukee University), and **Awe, J.** from USA studied Upper Ordovician and Lower Silurian sections in Estonia, particularly drill cores, to compare evolution of the Palaeobaltic basin and the Great Basin in North America (July 19 – August 12, hosted by L. Hints and J. Nõlvak);

Izokh, N. from Institute of Petroleum and Gas Geology, Siberian Branch of RAS, Russia, studied collections of Ordovician and Silurian conodonts (October 3–9, hosted by P. Männik);

Kim, R.-L. from Norwegian Geotechnical Institute, Norway, discussed aspects of the hydrogeological modelling in the frame of the project, and had a presentation in the institute's seminar (September 18–20, hosted by L. Bitjukova);

Loosli, H.H. from Geological Institute of Hungary, Hungary, discussed results of BASELINE project and participated in the VI Isotope Workshop (June 29 – July 6, hosted by R. Vaikmäe);

Lukin, V. from Institute of Geology, UrD RAS, Russia, visited Silurian outcrops in Saaremaa and discussed about the ongoing joint project on Silurian sections (September 15–21, hosted by P. Männik);

Mankki, A. from University of Turku, Finland, studied the pollen preparation techniques and pollen determination under his postgraduate programme. He analysed one section from Estonia, which refrects the Preboreal oscillation (June 1 – August 31, hosted by S. Veski);

Marshall, J.D. from Department of Earth Sciences, University of Liverpool, England, UK, participated in the VI Isotope Workshop and studied Silurian rocks in outcrops on Saaremaa (June 30 – July 9, hosted by D. Kaljo);

Motuza, V. from Institute of Geology and Geography, Lithuania, selected zircon-rich fractions of samples from Pärnu and Burtnieki

stages for absolute age determination (September 1, hosted by A. Kleesment);

Nikonov, A. from Institute of Physics of the Earth, Russian Academy of Sciences, Russia, was doing fieldwork in northeastern Estonia (hosted by A. Miidel);

Oen, A. from Norwegian Geotechnical Institute, Norway, discussed risk assessment techniques and presented a new computer program at the institute (September 22–24, hosted by L. Bitjukova);

Plink-Björklund, P. from Götebog University, Department of Earth sciences, Sweden, selected Estonian outcrops for studying sedimentation conditions of Gauja age (September 2–2, hosted by A. Kleesment);

Saether, O.M. from Geological Survey of Norway, discussed results and manuscript preparation concerning two joint projects and started preparation of a new application (May 9–15), participated fieldtrip to Kohtla-Järve region and waste sites selection for the sampling and fieldtrip to South Estonia. He also met with geologists from Tartu and Võru (August 4–14), and attended the Oil Shale Conference and discussed the fieldwork results (November 15–22, hosted by L. Bitjukova);

Schmidt, S. from Institut für Geologische Wissenschaften, Freie Universität Berlin, Germany, discussed future projects and teaching of geophysics for students. Organised workshop on deformation processes in high mountain areas - new data, new problems and new methods (August 2–10, hosted by A. Shogenova);

Seppä, H. from Stockholm University, Sweden, joined Estonian colleagues in the fieldwork for sampling surface sediments from lakes (February 3–6, hosted by S. Veski, A. Poska, L. Saarse);

Sorlie, J.-E. from Norwegian Geotechnical Institute, Norway, discussed and prepared the programme for the joint project (May 9–12), participated fieldtrip to Kohtla-Järve region and waste sites selection for the sampling (August 5–9), attended the Oil Shale Conference and discussed the fieldwork results (November 15–20, hosted by L. Bitjukova);

Valiukevicius, J. from Institute of Geology, Lithuania, studied the Devonian acantodian collection housed in the Institute of Geology at TTU and determined stratigraphic position of Estonian samples containing acanthodian scales (August 5–8, hosted by T. Märss and A. Kleesment);

Members of the American-Estonian project describing drill cores in Särghaua field station. From left to right: L. Hints, P. Sheehan (Milwaukee), J. Nõlvak, and T. Schultze (Milwaukee). Photo by G. Baranov.

Vetö, I. from Geological Institute of Hungary, Hungary, discussed aspects of the Silurian geochemistry and participated in the VI Isotope Workshop (June 29 – July 6, hosted by D. Kaljo);

Zupins, I. from Institute of Geology, Latvian University, Latvia, studied the Middle Devonian osteolepiform sarcopterygians (July 26–29, hosted by E. Kurik)

Membership and other activities

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

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

Academy of Sciences of New York, *A. Raukas* (acting 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 from September 2002); *E. Kurik, T. Märss, H. Nestor, A. Raukas* (members);

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

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);

Circumpolar Arctic Palaeoenvironment, CAPE, *R. Vaikmäe* (member of the board);

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

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

Commission on Estonian Stratigraphy, *D. Kaljo* (chairman); *J. Nõlvak* (chairman of Ordovician Working Group); *A. Raukas* (chairman of Quaternary Working Group); *H. Nestor* (chairman of Silurian working group); *K. Mens* (chairman of Vendian-Cambrian Working Group); *E. Kurik* (chairman of Devonian Working Group); *L. Hints,* (member); *O. Hints, P. Männik* (secretary);

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

Council of Estonian Academic Library, *D. Kaljo* (chairman); *R. Vaikmäe* (member);

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

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); *L. Saarse* (member up to March 2002);

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

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

EC 5th Framework Programme Subprogramme INCO-2, *R. Vaikmäe* (delegate of the programme committee);

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

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 Oceanological Studies, *A. Raukas* (member);

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* (chairman); *D. Kaljo* (deputy chairman); *A. Miidel, R. Vaikmäe* (member);

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

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

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

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

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

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 Financing of Monographic Research, *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); *A. Raukas* (member);

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

Estonian Association of Owners by Title, *A. Raukas* (chairman);

Estonian Astronomical Society, *J. Ivask* (member);

Estonian Chromatographic Society, *J. Ivask* (member of council);

Estonian Geographical Society, *A. Raukas* (deputy chairman); *R. Karukäpp, E. Kaup, A. Miidel, J. Nõlvak, L. Saarse, E. Tavast, R. Vaikmäe* (members);

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

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. Raukas* (deputy chairman);

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

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

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

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

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

Estonian Technological Agency, Advisory Board, *R. Vaikmäe* (member);

Estonian Technological Agency, Financial Board, *R. Vaikmäe* (member);

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

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

Estonian Working Group of the Joint Commission on monitoring and scientific research of water basins on the Estonian- Russian border, *A. Raukas* (member);

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

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

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

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

European Society for Isotopic Research, *R. Vaikmäe* (president); *T. Martma* (member);

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

Fulbright Visiting Scholar`s Selection Committee, *T. Alliksaar* (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);

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. Bitjukova* (member);

International Association of Geochemistry and Cosmochemistry, *L. Bitjukova* (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 Hydrological Sciences (IAHS), *K. Erg* (member);

International Association of Sedimentology, *L. Bitjukova* (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* (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. Kurik* (corresponding member);

International Union of Geological Sciences, Subcommission on Ordovician Stratigraphy, *L. 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* (chairman);

Mining Institute, Tallinn Technical University, Council on the Defence of MSc, *L. Hints* (member);

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

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

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

PALEO Club, *T. Alliksaar, A. Heinsalu, 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);

Peribaltic Group of the INQUA Comission on Glaciations, *R. Karukäpp, A. Raukas* (members);

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

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

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, *L. Saarse* (member of the master defence council);

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

The Geochemical Society, *T. Alliksaar, T. Martma* (members);

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

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

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

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Raukas, **A**., **Tartes**, **U**. 2002. Veelkord teaduse rahastamisest [Once again about financing of science]. *Äripäev* 209 (2279), 31.

Other events

On February 23, Academician Professor Dimitri Kaljo, the head of the Department of Bedrock Geology at the Institute (to the left), was awarded the White Star Orden of the 4th class by the President of Estonia.

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