Evaluation of Estonian Research

- Paleozoic Geology, Quaternary Geology, Mineralogy and Petrology -

Report to the Estonian Science Fund Council

by

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INTRODUCTION

In the present evaluation, the criteria normally used in evaluations of Swedish research have been strictly applied. Although this may be useful to show how (in the committee's opinion) Estonian science would fare in an open international evaluation, we are fully aware that the approach may be largely unfair to the talents and efforts of many Estonian scientists and research groups. Estonian science has only just broken out of the cage of an oppressive political system that has usually punished, discouraged, or barely tolerated broad international co-operation, only rarely encouraged it. Against this background, the devotion and competence that we have observed in many Estonian scientists is impressive. At the same time, we would do the Estonian scientific community a disservice if we did not try to point out the areas where the isolation and resulting lack of feedback from the international scientific community has led to the formation of substandard research traditions and organizations.

A central criterion when evaluating Swedish research projects, is whether they form part of the international research front and whether the results are readily accessible and relevant to the international community of scientists. Among other things, this means that results are to be published in English; publications in Swedish simply cannot form part of international science. With regard to Estonian science, the sooner English can become the main language of scientific communication, the better. Publications in Estonian or Russian cannot become of more than marginal importance in international science. We also need to point out that because most members of the present evaluation committee are not able to read Estonian or Russian, we have not been able to assess the intrinsic merits of most of the publications referred to in the reports from the research groups. (Furthermore, most publications were not included with the reports, which made the assessment even more difficult.)

We would like to express our deep gratitude to our Estonian colleagues for their hospitality and helpfulness during our stay in Estonia. We hope that the present report will be useful in the further development of geological sciences in Estonia, though we want to point out that a report of this type is by necessity sketchy: it cannot give a full and fair assessment of all aspects of the multifaceted activities that are going on within the wider framework of geological research in Estonia.

GENERAL COMMENTS

Geological research in Estonia is frequently directed towards practical applications and environmental monitoring. Many of the activities presented to us by the staff of the Academy of Sciences are such that in Sweden would be handled by private companies (e.g., prospectors) or non-research governmental institutes. Whereas these activities are often of great direct importance to the economy and welfare of the society, they generally do not classify as basic research, though they may range from creative endeavors to pure recording and registration. Basic research should always be creative and generate new types of knowledge, also in areas where economic or other benefits from the results may not be immediately apparent. A profitable balance between basic and applied research can only exist if a well-developed sector of basic research and education is maintained where scientific methods and knowledge can be developed and taught in a spirit of free enquiry and on a stage of broad international co-operation. Ultimately this also serves as a guarantee for the health of the practically oriented applications of science.

It should be acknowledged that many of the Academy-based activities within what we would call environmental monitoring are such that may not have been undertaken at all without the good initiative of the Academy's scientists. Nevertheless, in the long run a research organization such as the Academy should not have its resources tied up in routine registrations, except as part of a scientific research program.

Estonian science suffers from the strict division of education and research between University and Academy. Our Estonian colleagues are certainly aware of this problem, and we would like to support any efforts to involve active scientists in the university teaching at all levels and to give students the opportunity to learn in a research environment. The problem is fairly severe for geology, because almost all geological research is centered in Tallinn, whereas the educational center is in Tartu. In the long run, this split must be mended if geology in Estonia is to develop as a modern and internationally oriented science.

There is an appalling lack of proper storage space and curating facilities for fossil and rock collections. Although we did not have the opportunity to inspect existing storage spaces, we discussed the problem with some of our Estonian colleagues and were alarmed by the situation. The scientific collections appear to be scattered in offices, halls, and corridors, without being properly curated. We would like to stress the importance of finding a more suitable and permanent storage space for these valuable collections and to obtain curating help from those who have worked with the material and are still available to assist. This is an urgent matter, in view of the likely reorganization of the Academy and possible transfer of many scientists to other duties.

Geology of useful minerals

General remarks

The activities in mineralogy-petrology are largely directed towards industrial applications and geological surveys. The co-operation with the Geological Survey regarding studies of crystalline rocks is intensive and clearly of high interest to both Academy and Survey scientists. This is natural, since recruitment of staff to the Geological Institute goes via the Survey.

We were not able to visit the chemical laboratories, except at the Survey; most of the data presented to us appear to be field observations. The extensive drilling program through the sedimentary rocks into the crystalline basement gives Estonian geological research access to a unique data base, and some international co-operation with Finland and Sweden has been established to use this material in different research projects (dating, stratigraphy, geophysical measurements).

We met several groups working with geochemical environmental research and surveying. The communication between these groups is not very good and needs to be improved. Environmental research and monitoring in Estonia should have high priority.

Publications of the results are so far dominated by books and articles in Russian and Estonian. There seems, however, to be a growing interest in publishing in English, and an international contact net is being built up. This development is very important.

Section leader V. Puura seems to be a key person for the development of hard-rock and sedimentary-rock geology at the Academy of Sciences. His broad knowledge of Estonian geology and his international contacts are important for further development of a reorganized section of research in petrology and stratigraphy.

Oil shale and phosphorite deposits

Principal activities- evaluation

These deposits are of a wide economic interest to Estonia. The group earlier lead by Dr V. Kattai has produced a large number of papers (mostly in Russian) on several aspects of the commercial use of oil shales, mainly as an energy resource. The study of the oil shales has great implications for paleontology, stratigraphy, micropaleontology and organic chemistry. Obviously, international contacts have mainly been directed towards the east, but contacts now seem to build up also with western countries. Except for regional studies, few projects performed within this group could be regarded as basic research.

Recommendations

Basic research on the oil shales (stratigraphy, micropaleontology) should be separated from the engineering part and be kept within a 'basic research' geology section. Industrial and economic development has to be handled by a special division (outside the Academy) to be fully integrated into a new economic system.

Environmental research in connection with mining operations of the oil shales and phosphoritic deposits should be merged into a national organization, having full responsibility for environmental protection. Hydrochemistry and soil chemistry should be areas of focus.

Precambrian geology

Principal activities- evaluation

This research group has made good use of the drill cores to investigate the crystalline rocks of Estonia. Although small, the group has taken the opportunity to establish good contacts with geologists in Finland and Sweden. Their goal is to produce a geological map of the crystalline basement of Estonia. This has now been almost completed, thanks to co-operative work with the Geological Survey and with geophysicists. Studies of metamorphic evolution is now the main project of the Precambrian geology group.

Recommendations

The Precambrian research group has a fairly modern approach and can be considered good. Their activity and goals are so far more of a Geological Survey type but with good possibilities to attract international interest from neighboring countries. Further support is recommended.

Geophysical and structural geology

Principal activities- evaluation

Activities and research in geophysics have been reactivated after the earthquake of 1976. One seismograph (old type) is in operation in a cellar apartment. There is a growing interest for mapping neo-tectonic movement in the Baltic Shield. Use of geophysical methods has been of great help to map the Estonian Precambrian rocks, both regarding rock types and their tectonic system (faults, etc.). The need for more modern equipment is obvious. Co-operation with Finnish geodesists and geophysicists has started.

The relatively small group (led by H. Sildvee) is in the process of producing maps of tectonic, geological and geophysical interest. The group has rather well-defined goals but lacks the presence of a geodetic net.

Recommendations

Geophysics will be of importance to future developments of many branches of Estonian geo-science. This group must be kept as a nucleus for further development of geophysical methods. Future development of earth-tide movement studies should, however, have low priority.

Recent movements of the earth's crust in Estonia

Principal activities- evaluation

We were able to talk to Dr Ants Torim during our visit to Tartu. At the moment he was without funding for any meaningful activities.

Recommendations

The project should not be given further support. Dr Torim should be engaged in the new geodetic mapping of Estonia, perhaps in co-operation with the Agricultural University at Tartu, where he has been active in the education program.

Fundamentals of environmental chemistry and methods for evaluating environmental pollution

Principal activities- evaluation

Prof. Kirso and his group (Department of Environmental Chemistry; staff includes the senior scientists R. Krasnoschekova, H. Uibopouu, N. Irha and A. Bogdanov) are engaged in a project area with the general objectives of increasing the information on the kinetics and mechanisms of processes (transmission, transformation adsorption etc) of technogenic pollutants in natural systems. Specific projects are directed towards studies of carcinogenic polyaraomatic hydrocarbons (PAH). The concentration of PAH in the Baltic Sea, and particularly the distribution in the water/-sediment interface has been studied in field expeditions. The mechanisms behind the accumulation of PAH in the upper sediments as well as in marine algae have been studied. The oxidative degradation of PAH, particularly when adsorbed on solid surfaces, is presently investigated.

The general impression of the activities of the group is that the quality of the research probably is good, and some good ideas were noted. The publication record is good, and several papers appear in international journals and proceedings. However, no publications and very little results were available for the evaluation group, and no experimental facilities or scientific "high-lights" were presented at the very short meeting. The technical resources available for conducting the characterization studies of PAH and its degradation products are not known in detail, although the laboratory outfit seemed to be acceptable. The evaluation and recommendations are therefore largely based on information given in the Report for international evaluation.

Recommendations

The burning of oil shale and storing of fly ash are major sources of PAH to the environment; this makes Estonia a significant contributor to the overall release of PAH in the northern Europe. The reaction of PAH, including its degradation in the environment, constitute an important international research topic. It is recommended that studies within this field should have continued support within Estonia, at least to the extent that international progress can be followed. A major reorganization of environmental geochemistry to improve coordination between different national projects is advised. The group is certainly worth incorporating into larger laboratory in this field. It is strongly recommended that ongoing international collaboration with French groups shall continue. An even further extended contact with international groups is suggested, due to the large research efforts in the field, with the consequence that research front is rapidly advancing. This is related to the continuously improved analythical methods which allow the characterization of trace organics at environmental levels. It would also be of value for the group to establish contacts with the current Nordic projects with focus on chemical and biological processes in the Baltic, including the distribution of chlorinated organic pollutants. laboratory.

Investigation of the chemical composition of Dictyonema argillites, their behavior and possibilities of their utilization in the mining process of phosphorites.

Principal activities- evaluation

Prof Palvedre and his group are engaged in applied studies of the argillic shales of Estonia. Chemical analyses of shales from various districts (Toolse Mardu etc) have been analysed with respect to mineralogic composition as well as metals of potential commercial value (Ti, V, Mo, U and others). Extraction processes are considered or studied, aiming at full scale recovery of these elements (leaching with sulfuric acid followed by ionic exchange of solvent extraction). Some activities are devoted to studies of various procedures for the treatment of waste rock and tailings.

The quality of the analythical work appears to be fair, based on the two available published papers, although this particular work is descriptive and of minor scientific value. The technical resources available for analysis and process studied are not known to the evaluation group, and no detailed comments can be given. However, various processes for recovery of valuable metals from shales etc have been developed and tested in several international projects during the past 20-30 years; most of these projects have been closed down (e.g. in Sweden), since the conclusions generally have been that full scale recovery process would not be economically justified.

Recommendation

It is important that there is a detailed knowledge about the composition of argillites of various origin. these activities, which are descriptive in nature, should be coordinated with the ongoing studies of shale processing and shale technology. The environmental aspects of shale mining etc is also of importance, but studies of leaching of tailings and waste rock etc should best be conducted as a coordinated effort within a larger program in collaboration with other groups working in the same field. Further support for evaluation of commercial processes for the recovery of metals from agrillites and shales is not recommended.

Chemistry and geochemistry of oil shales. Fundamentals of oil shale and oil shale processing

Principal activities- evaluation

Prof. L Mölder and his group (Department of oil Shales and Shale oil; staff of ca 30, including J. Teder, K. Urov, E. Bondar and 10 more senior scientists) conduct basic and applied research with focus towards oil shale processing and recovery of shale oil derivates. The thermodynamic properties and phase equilibria of non-electrolythic solutions and polycomponent mixtures are studied, and results are applied in efforts to design extraction systems that can be used for isolation and separation of organic compounds in a technical scale. The possible use of supercritical extraction as method for liquification of oil shales beeing studied. Large efforts are put into characterization of oil shales from various sources including water soluble phenols and other organic fractions. Methods for the extraction of resorcinols and for the production of various resorcinol derivates are developed. resorcinol based selective extraction reagents have

been synthesized (e.g. for cobalt recovery). Various aspects of shale processing and the thermal decomposition of shale components are studied, including the transformation of sulphur compounds.

The group is very active, and work on oil shales and shale technology represent a sound combination of basic research and applied science. The quality of the work is generally very good, and some project appear to be excellent. There is no doubt that the group must be one of the leading ones in the world within this field. The publication record is impressing, but regrettably with few exceptions the papers are published in national journals. Much of the work is reported in the journal Oil Shale, originally started at the Institute; this is the only scientific journal entirely devoted to oil shale technology. The group seems to have little contact with geologists, which, however, does not seem to affect the scope of the research. The group has fairly modern equipment for their future research.

Recommendations

Oil shale (kukersite) is without doubt the most important natural resource in Estonia and its commercial use may be of considerable benefit for the future economy of the country. It is therefore likely that the use of oil shale for energy production as well as for synthesis of oil and gas products will increase. The requirement to optimize the reaction as well as to reduce the release of harmful waste products generated in the processes will increase. Therefore, from national point of view, a continued broad study of oil shale processing and recovery of shale oil products as well as the efforts to modify the processes to reduce the production of environmental contaminants are strongly recommended. The development of supercritical extraction processes may be a step in this direction, and a continuation of this project must be most strongly recommended. The Department already has a network of international contacts; hopefully more of their results will appear in international journals in the future.

Paleozoic geology

Principal activities- evaluation

The existence of this large research Section (more than 20 scientists) reflects the importance of the late Proterozoic and Paleozoic sedimentary sequences in Estonia, both for the economic geology of the country and as a source of data for research into the history of life and Earth. The two departments in the Section appear to be closely interconnected and may profitably be amalgamated. The following evaluation will deal with the major research programs within the whole Section.

Several of the scientists in the Section are active on the international stage. The international co-operation involves participation in the International Geological Correlation Program - an area where the head of the Section, D. Kaljo (who was abroad at the time of our visit) has put in a lot of good effort, and several of the scientists are doing periods of work and study in western countries. The percentage of publications in English is increasing, particularly among the paleontologists. However, still only a small number of articles are being published in refereed international journals.

The research on the Vendian-Cambrian sequences, mainly by K. Mens and E. Pirrus, is lithostratigraphically oriented and has lately involved international co-operation within the framework of the International Geological Correlation Program. The Estonian sequences are important for the interpretation of the development of the East European Platform. The lithostratigraphic approach appears to be rooted in classifications of rocks and structures more than in analyses of the dynamic processes of basin development, but it has resulted in valuable syntheses of the paleogeographic development of the area. Most of this work has been published in Russian, though some syntheses are available in English.

The Vendian-Cambrian work has only sporadically been done in co-operation with paleontologists within the Section; paleontological work is concentrated to the Ordovician-Devonian and involves fundamental taxonomy as well as stratigraphic, paleogeographic, and ecological studies.

The present status of taxonomic paleontology in Estonia is difficult to evaluate on the basis of the submitted reports. Some of the studies Nõlvak's work on Upper Ordovician chitinozoans) have only been put in depository and not been published except in abstract form; some of them have been carried out in collaboration with Russian specialists (L. Popov, G. Stukalina, S. Rozhnov) who appear to have been responsible for the taxonomic input; some work may not be represented because the period covered by the publication list is too short for a representative coverage of long-term monographic studies. Several of the scientists in the Section (H. Nestor, M. Rubel, L. Sarv, R. Männil, I. Puura) have been enrolled in the revision of the major international reference work *Treatise on Invertebrate Paleontology*, which testifies to their good standing in the international scientific community (such taxonomic revision work, however, is time-consuming, and results may come to be published with considerable delay). In the submitted publication list from the Section, the work by T. Märss, mainly on vertebrates, includes an important study (in an international refereed journal) on the dermal skeleton of certain Silurian jawless fish, as well as a taxonomic monograph. Other taxonomic contributions are generally of fair to good quality, though they tend to suffer from limitations imposed by Soviet publishing policies.

The taxonomic studies form a basis for other types of investigations of fossiliferous sequences. The main research directions in this regard are discussed below.

The Cambrian-Ordovician transition involves rocks of great economic importance to Estonia, the Obolus Phosphorite and Dictyonema Shale. Recent work within the Section, by K. Mens, V. Viira, I. Puura and others, has attempted to clarify the litho- and biostratigraphic context of these deposits; in this context there is also co-operation with the phosphorite group (Section of Geology of Useful Minerals). The Cambrian-Ordovician boundary studies are partly integrated with international work on the Cambrian-Ordovician boundary, and most of the recent publications are in English. The new results on cordylodontid conodonts (by V. Viira) in the boundary layers are important for global correlation as well as for evolutionary studies.

Work in the Middle-Late Ordovician and Silurian sequences involves integrated studies of faunal associations and sedimentology with the aim to identify biotic and physical events that may help to explain the pattern of occurrence of sediments and fossils and to improve stratigraphic resolution. Because the group is large, the written and oral presentations were summary, and the literature was not included in the

background material, we could not evaluate each individual project. Much of the work is carried out in connection with IGCP Project 'Global Bioevents', though it seems that only preliminary measures have been taken to include work on stable isotopes, a backbone and hallmark of the international project. The large number of cored boreholes available through the sedimentary sequence in Estonia provides an unusually beneficial background for integrated paleontological, sedimentological and geochemical studies, and if this work could be further integrated with current international research in, e.g., micropaleontology, sequence stratigraphy, and stable-isotope geochemistry, it might give the Estonian Paleozoic succession a key role in the understanding of global biological and geological events, and set the stage for a development of Estonian soft-rock geological sciences.

A further research direction within the Section concerns meteorites and impact craters. Although of definite local interest, these studies as carried out have limited relevance to international science and will not be further discussed here.

Recommendations

(1) The organization may be simplified by amalgamating the Department of Paleontology and Stratigraphy and the Department of Lithology into one research unit.

(2) The average age of scientists in the Section appears to be relatively high, and several of the senior scientists are approaching retirement age. Although the latter fact would make it easier to prune the organization (which is large in an international perspective), it is important that the experience of these senior scientists is called upon to ensure that already made investments in valuable knowledge, collections and data are not wasted. For example, available expertise should be drawn on to curate existing geological and paleontological collections before these persons leave the field altogether, and specialists involved in work on the international *Treatise on Invertebrate Paleontology* should be given opportunity to complete this work.

(3) Recruitment of young scientists is necessary to develop this field. In the current economic crisis it will be difficult to do this at a high quantitative level, which makes it even more important to keep the qualitative level sufficiently high. This is best accomplished through a close link between research and education. In the present situation, the best strategy for junior scientists and research students is to strive for exchange visits or scholarships at foreign universities, in order to sustain themselves through the economic crisis as well as to acquire the necessary international experience and qualifications for a continued scientific carrier.

Quaternary geology and geomorphology, plus dating and analytical facilities

General comments

Basically the 'Quaternary' part of the Estonian research which we were asked to evaluate can be divided into three categories:

(1) *Basic research*, of national and often international interest, in the latter case making Estonian data and interpretations available to the international research community, and evaluating problems of regional or international importance from an Estonian perspective.

(2) *Applied research,* mostly focussed on environmental impact studies which are important, sometimes very important, in an Estonian context, but usually of less regional and international consequence. Exceptions to this are various pollution studies related to the mining in northern Estonia, which have a clear regional bearing.

(3) *Back-up facilities* like dating and isotope laboratories, which also carry out methodological development research. Such facilities are necessary for Estonian science and can also be of regional and international importance.

The evaluated research teams and, where relevant, the individual researchers, will be discussed under that one of the three categories to which, according to our views, they mainly belong.

Basic research

The basic Quaternary research mainly comprises glacial history and landscape evolution (both Pleistocene and Holocene), plus marine geology. It also necessarily includes some mapping aspects. The work within these research spheres mostly falls under the Academy's 'Section of Cenozoic Geology', led by Anto Raukas. It is much thanks to Raukas' efforts that Estonian Quaternary research has managed to maintain as good links with western science as it undoubtedly has, through active participating in IGCP and other politically acceptable international projects, and through the arrangement of exchange visits of individual scientists, etc., Estonian research and Estonian data on glacial history and landscape evolution are reasonably well integrated into the international context, notably the Baltic *sensu largo* regional one.

The number of internationally seen unproductive, Soviet-style Estonian and Russian language publications within this sphere is very large, but still many of the more important results have also managed to find its way onto the international market - although then mostly into various types of conference proceedings. The number of papers published in international high-quality journals is small, but most of the main researchers have some such publications. Considering the conditions under which pre-re-independence work had to be carried out, the international publication pattern is good and when compared with overall Soviet standards it is very good.

The organization of the work into Sections, Departments and working groups is, however, not easy to understand, but probably has both historical, rational and irrational backgrounds. There is, for example, a special 'Quaternary Geology Department' (led by J. Kask) within the Raukas-led 'Section of Cenozoic Geology', regardless of the fact that there are no Tertiary deposits in Estonia. There is also,

within the same section, a special 'Geomorphology and Marine Geology Department' (led by T. Hang), working entirely with Quaternary deposits, as does the 'Landscape Ecology Department' (H. Kink; see further under 'Applied Research'). It was also unclear why the ESR-researcher A. Molodkov sorted under the 'Section of Cenozoic Geology' and not under the 'Section of Hydrospheres' 'Isotope and Paleodosimetry Laboratory(-ies)' (see under 'Back-up facilities'). A general comment here must be that the less complicated an organization is, the more flexible it becomes and the better it works!

The present knowledge of Estonian glacial history and landscape evolution, including that of the surrounding seas, is reasonably good and much new knowledge has been gained and presented in recent years - like E. Liivrands re-evaluation of the Karaküla interglacial and the oncoming Estonian-Finnish 'Marine Atlas' of the Bay of Finland. But the most modern stratigraphic, sedimentological and paleoecological concepts and working methods have not yet penetrated to the root, although the potential is there and intensified international exchange and exposure could hopefully update the system in not too many years.

This updating should preferably be done within a reduced and streamlined research group, where a small number of senior researchers are blended with fresh and swiftly internationalized junior researchers and PhD-students. As the core group for this basic research team in Quaternary science we suggest, besides A. Raukas, R. Karukäpp (glacial history, paleomagnetism, etc.), E. Liivrand (Quaternary stratigraphy, palynology, etc.) and L. Saarse (evolution of lakes and mires, etc.), plus J. Lutt for the marine niche. As to the younger members of such a group, available information is too sparse and our experience in Estonia was too short, for us to form any clear opinion on suitable persons - but generally speaking scientific competence and devotion should be paired with a certain respectlessness and a good knowledge of the English language.

As to the priorities for basic Quaternary research in Estonia during the next few years, when (if) such a reduced and streamlined organization as recommended by us should get going, it seems advisable to concentrate the efforts to within a few international projects where Estonian inputs are important. IGCP 253 'Termination of the Pleistocene' is one example.

Applied research

Some of the ongoing Quaternary studies are clearly concentrated on, although not exclusively aimed at, environmental problems - like Baltic coastal morphology and erosion (J. Kask, E. Martin, E.Mäss and K. Orviku), environmental-impact studies in Lake Peipus (A. Miidel, E. Tavast and others), and so called 'pollution sensitivity' and various geochemical studies (H. Kink and several co-workers, T. Kiipli and others, etc.). In a western system, all these subjects would normally belong under the umbrella of a governmental agency for nature protection - or the national geological survey.

Although most of them are important for Estonian environmental-protection-decisions, beyond those mirroring the spread of pollutants into the Baltic Sea, these studies do not seem to have much international relevance. Nor have the publication policy been overly aimed at the international market. Thus from a purely scientific point of view

We regard this laboratory, with its different units seen as one, and with its blend of dating and analytical facilities, reasonably good equipment, ongoing research - and with its combined staff of somewhat older and experienced scientists, and well educated devoted younger ones - as a primary asset for Estonian science. This is a place where one is likely to get something of international scientific value back for the money put in, and in fact the only sphere within the Quaternary research system evaluated by us where Estonia is really touching the international front.

However, to uphold this position will not be directly cheap. It is clear that the younger scientists there need to travel, the Finnigan Mat Delta E mass-spectrometer, which is the heart of the isotope laboratory, is from 1984, much of the other equipment is internationally seen of sub-optimal quality, etc. But the costs may well be worth taking and do not have to be paid overnight.

The Tartu ^{14}C-laboratory was founded already in 1957, that is some 15 years before the ^{14}C-facility in Tallinn. It has so far dated around 2800 samples from many parts of the world, running ca. 100 per year (Tallinn so far 1200 samples and ca. 140 per year). In general, this is a well run laboratory, supporting many important geological and archaeological projects and also doing some basic research of its own - like studying atmospheric ^{14}C-variations, e.g. due to 'bomb effects', by analyzing tree-rings. It is staffed by very dedicated people (A. Liiva, E. Ilves, H. Mäemets), but the equipment is rather out of date. We also believe that the radiation background, although probably OK for Holocene samples, is too high for the older samples 'dated' (up to 55 000 yrs BP).

As we imagine that there will forthwith only be financial room for one ^{14}C-laboratory in Estonia, it seems advisable to close the Tartu facility and concentrate resources to Tallinn - a logical action also in the light of the fact that both senior researchers in Tartu are approaching retirement.

Summary and suggestions

Within the sphere of Quaternary science the views and suggestions presented above aim at inducing both improvements in the research organization and reductions of the costs on the research budget - which, however, will probably lead to some relevant increases in other budgets. The meaning is also to concentrate available money to where the scientific payoff is best.

The general internationalization and rejuvenation of the trade with, for some important years, the concentration of Quaternary research onto a few truly international projects, is also crucial for swift progress.

It is also important, in this context, to realize that with an oppressive political system prevailing for so many years, the research community has had problems opening up in such a productive way as done in many western countries during later decades - giving younger and especially middle-level researchers much freer rein than was earlier the case. This opening-up, sharing-of-many-decisions process should be combined with as much travelling for the younger researchers as feasible which, for a start, means utilizing foreign exchange programs to the utmost. Also, the use of the Russian and Estonian languages for scientific communication should be largely abandoned and papers instead written in English (practically no Swedish geological papers or PhD-theses are in Swedish to-day!). The writing of monographs should not have

priority before the production of concentrated, well illustrated papers aimed at as international a market as their scope and level motivates!

Recommendations

(1) Form a Basic Research unit, with a small core-group of established scientists and a somewhat larger number of younger researchers - and with PhD-students and temporarily attached graduate students. Abandon the present complicated command structure with Sections, Departments and so on!

(2) Let existing governmental agencies for environmental protection, and the Geological Survey, take most of the economic and organisatorial responsibility for what has here been termed 'applied research', that is finance as much as possible of it outside the pure research budget(-s). Monitoring and basic environmental impact studies, like pollution control and coastal erosion assessment, are rarely science in the stricter sense.

(3) Invest in the people and equipment at the Tallinn multi-methods dating and isotope laboratory. Close the ^{14}C-facility in Tartu.