PUBLICATIONS OF THE ACADEMY OF FINLAND 14/03

Finnish Geosciences
EVALUATION REPORT

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Preface

On October 1, 2002 the Board of the Academy of Finland decided to implement an extended national research field evaluation of Finnish geosciences in co-operation with the Ministry of Education and the Ministry of Trade and Industry. The Board appointed a Steering Group, chaired by Professor Jorma Kangas (Research Council for Natural Sciences and Engineering, Academy of Finland), to plan and support the execution of the evaluation. Other Group members were Deputy Director General Paula Nybergh (Ministry of Trade and Industry, Vice-Chair), Special Government Advisor Mirja Arajärvi (Ministry of Education), Chief Planning Officer Esko-Olavi Seppälä (Science and Technology Policy Council of Finland) and Professor Markku Löytönen (Research Council for Biosciences and Environment, Academy of Finland). Project Manager Karl Holm from the Finnish Higher Education Evaluation Council acted as special advisor in the Group. In December 2002, Dr. Timo Huttula was appointed as external scientific expert of the evaluation. Scientific Secretary Johanna Kallio (until December 16, 2002) and Science Adviser Anu Huovinen were responsible for all administrative arrangements of the evaluation.

The goal was set to evaluate not only the quality of Finnish geoscientific research, but also the education in this field of science. The objective of the evaluation was to study:

- the scientific quality of Finnish geoscience research
- the structure of research and education as well as the role of various actors involved
- the cooperation and division of labour between universities and research institutes
- the available human and financial resources
- the national need for experts in the geosciences and the needs from the viewpoint of science, business and industries, communities, and the environment

At its meeting on February 24, 2003 the Research Council for Natural Sciences and Engineering appointed an evaluation panel whose mission was to carry out the evaluation. The members invited to serve on this Finnish Geosciences Evaluation Panel were Professor W. Richard Peltier (Department of Physics, University of Toronto, Canada; Chairman), Professor (Emeritus) Richard W. Ojakangas (Department of Geological Sciences, University of Minnesota Duluth, USA), Director Christine Weber (Laboratoire Image et Ville, Université Louis Pasteur-CNRS, France), President Tuomo Mäkelä (Outokumpu Mining Oy, Finland). The letter from the Academy of Finland to the Panel members is in Appendix A of this report and the reference information of the Panel members is in Appendix B.

For the purpose of this evaluation the Board of the Academy of Finland selected a specific set of sub-disciplines in the geosciences, respectively the areas of geology (mineralogy, geochemistry, paleontology, environmental geology, engineering geology), geophysics (geophysical geodesy, physical geodesy, seismology, geomagnetism, hydrology and hydrogeology, glaciology, oceanography) and geoinformatics (photogrammetry and remote sensing, cartography and

geoinformatics, applications of satellite technology). The units in these areas upon which the evaluation was to focus consisted of 32 different elements located at seven universities and five research institutes (Appendix D), varying in size from small research teams working in individual university departments to extremely large organizations such as the Geological Survey of Finland (GTK). This heterogeneity of scale clearly posed a significant challenge to the evaluation panel, especially as its charge included not only the issue of research quality, but also the further issues related to education, finance and the integrative structure of the research community itself.

The first meeting of the Panel was held on the afternoon of Sunday, August 24, 2003 in Helsinki, together with the members of the Steering Group. The purpose of this meeting was to provide an overview, for the sake of the Panel, of the organizational structure within which Finnish research is conducted. Also discussed were the significant efforts undertaken, since Finland joined the European Union in 1995, to increase its investment in research and development. It is an important backdrop to this geoscience evaluation that Finland currently ranks second among all OECD countries in terms of R&D investment in 2001 as a percentage of GDP, at 3.4 per cent compared with the highest Swedish investment of 4.3 per cent and the USA investment, for comparison, of 2.8 per cent.

The detailed schedule of site visits conducted by the Panel is contained in Appendix E. As well as the interviews conducted in Helsinki and environs, the Panel also traveled to Turku for discussions with units of the University of Turku and of the Swedish language Åbo Akademi University, and to Oulu for interviews with several of the geoscience-related units of the University of Oulu. A primary basis for the work of the evaluation panel consisted of extensive self-evaluation documents that were produced by each of the units that agreed to participate in the process. The self-evaluation form is in Appendix C.

0 Executive Summary of Panel Recommendations

In the body of the Report of the Finnish Geoscience Evaluation Panel to follow there appear several specific recommendations that the Panel wishes to highlight at the outset in this brief Executive Summary. These recommendations are highlighted in the text by underlining the text that contains them. The interested reader of this document will find it important to read the full text of the Report in order to appreciate the context of the recommendations.

Recommendation 1:

A first recommendation of the Panel is that the Board of the Academy of Finland reorganizes the allocation of responsibility for the totality of the Earth Science discipline to the Research Council for Natural Sciences and Engineering.

Recommendation 2:

It is the strong recommendation of the Finnish Geoscience Evaluation Panel that the Finnish higher education system be modernized so as to offer a more clearly defined career path for its young academics.

Recommendation 3:

It is a specific recommendation of the Panel that a mechanism be found to finance access to the computer systems at the Finnish IT Center for Science (CSC) by scientists whose formal appointments are not held within the university system but rather in government funded institutes whose scientists also contribute to university instruction.

Recommendation 4:

Consideration should be given to a full review of the future desirability of so strongly focusing such a large portion of the total Finnish geoscience investment in the Geological Survey of Finland (GTK) organization. (It may well be that this strong focus upon geology is amply warranted in the Finnish context but there would be real value to seriously consider what might be gained by some degree of redistribution).

Recommendation 5:

It is the recommendation of the Finnish Geoscience Evaluation Panel that a concerted effort be made to dramatically shorten the time required to complete the Ph.D. degree in geoscience disciplines.

Recommendation 6:

The Panel strongly recommends that consideration be given to reversing the strong trend towards diminishing the strength of teaching and research in the area of civil engineering.

Recommendation 7:

Given the Panel's perception that a strategic threat exists to the core strength of the GTK in research due to the increasing concentration upon developing its profile in the areas of industrial commercial and promotional endeavors we encourage the Ministry and GTK to reassess whether this increasingly large commitment to such work is truly in the nations interests.

Recommendation 8:

The Panel recommends that a geoscientist be appointed to the Research Council for Natural Sciences and Engineering so that geoscience projects might receive better informed appraisals than currently seems often to be the case.

Recommendation 9:

A set of recommendations concerned exclusively with the GTK will be found on pages 40 and 41 of this document.

Recommendation 10:

It is on strong recommendation that effort be made to take maximum possible advantage of the close proximity of all of the individual geophysical science related units that are to be collocated on the Kumpula campus of the University of Helsinki.

Recommendation 11:

Given the quality of the scientific contribution that is being made by the Department of Geodesy and Geodynamics of the Finnish Geodetic Institute, it is the recommendation of the Panel that the staffing level should be increased in order to enable the group to function at a higher level of visibility in the refereed international literature. Increased investment in the new work in space geodesy and in the level of participation in the new satellite gravity missions GOCE and GRACE would pay large dividends for Finnish science.

1 Introduction: An Era of Renaissance for the Earth Sciences

At the beginning of the 21st century, the geosciences are in the midst of a transformation driven by a number of forces that are demanding a more integrated approach to the understanding of earth processes than has previously been required. One aspect of this transformation has been a heightened recognition of the importance of the atmosphere and oceans relative to that of the solid Earth. Throughout most of the 20th century, the geosciences were entirely dominated by the resource extraction industries and by the search for economic deposits of base metals and of hydrocarbon reserves. By the beginning of the 21st century, a dramatic shift had occurred with the recognition of the impact that humankind was having upon the environment, not only concerning greenhouse gas induced global warming but also concerning the chemical contamination of the atmosphere and hydrosphere. These important problems now dominate the geoscience agendas of most OECD countries, although the mining and petroleum industries continue to be extremely important to the wealth and economic well-being of many individual nations. In many countries there has therefore been a dramatic shift of scientific focus into climate and environment-related activities and away from the strong focus upon geological mapping of the continents in the search for economic deposits of minerals that has previously dominated national concerns.

From a more general perspective this renaissance in the geosciences is occurring following an extended period of increasing specialization and is leading to a renewed appreciation of the importance of viewing the Earth as an evolving complex dynamical system. Earth is a planet whose evolution is governed by interactions among its closely coupled subsystems: the biosphere, the atmosphere, the hydrosphere, the lithosphere and Earth's deeper mantle and core. In order to appreciate the forces that control its evolution, we are faced with a problem in the science of complex systems, an emerging new science in which the focus is upon systems in their entirety rather than their isolated component parts. Earth science, or geoscience, is therefore of necessity and intrinsically an "interdiscipline" rather than being simply a subject in which interdisciplinary activity often occurs.

Earth science is also undergoing fundamental changes as a consequence of the emergence of new technologies for the acquisition, integration and interpretation of increasingly more precise and comprehensive observations of various facets of the Earth System, at all spatial and temporal scales of observation. For example the advent of global positioning satellite technology is revolutionizing the acquisition of precise geospatial data as well as the monitoring of diverse Earth processes. Once launched, the new European Galileo constellation of GPS satellites will provide further impetus for advance in this area. At the same time the continuing advance of numerical modeling methodologies is clarifying both the future evolution of the global climate system as well as the process of thermal convection in Earth's mantle that is ultimately responsible for the long timescale

drift of the continents and for the short timescale occurrence of "earthquakes". Analysis of the seismograms that record the response of the Earth to these events are similarly enabling the application of the same tomographic methods as those employed in medical imaging to construct three-dimensional images of the structure of the Earth's deep interior. Recent advances in isotope geochemistry, geochronology and paleobiology are similarly generating rapid progress in our understanding of Earth evolution. The continuing and accelerating advances in the satellite remote sensing of a variety of characteristics of the climate system, including sea level rise, ocean circulation and continental ice volume are expected to profoundly impact our understanding of Earth System processes in the coming decade.

Recognition of the strong interactions now occurring between humankind and the Earth System constitutes both an urgent research challenge as well as an important research opportunity for geoscience and for Earth Science in general. The research challenge includes the continuing need to discover new Earth resources to meet the requirements of the continuing growth in human population and perhaps especially the economic and social aspirations of the less affluent who comprise the majority. However, the challenge also includes the impetus for the development of a deeper understanding, through research, of the processes that govern the Earth's response to human influence so that the negative aspects of this influence may be mitigated. In the latter connection the requirement is not only for a response to the implications of the ongoing global warming due to increasing greenhouse gas emissions but also, as a further example, to the significant problem posed by the necessity that we properly dispose of the nuclear waste generated by the power plants being employed by Finland and other countries to provide the electrical power required to drive modern industrialized society. There is also the additional challenge to Earth Science that is posed by the increasing vulnerability of society to natural hazards such as severe weather and floods which require increasing investments to improve the "now-casts" required to provide sufficiently timely predictions to mitigate damage, both to property and to human life.

At the heart of the modern discipline of Earth Science is therefore the imperative to reconcile the need to provide the resources required for the continuing advance of society with the simultaneous necessity that the physical, chemical and biological environment that supports this advance be protected. The exploration for and utilization of Earth resources creates diverse impacts on both the local environment and upon the planet globally. The integration of research on resources with research on the environment is clearly a prerequisite for sustainable economic and social development. This requirement is clearly demonstrated by recent and ongoing international, national and even municipal-level discussions and policy initiatives concerning greenhouse gases and global climate warming.

This very brief commentary is intended to describe the current context in which geoscientific research is being conducted and is offered at the outset of this report of the Finnish Geoscience Evaluation Panel in order to provide, it is hoped, a general background to the commentary the Panel offers in the sections of this report to follow.

2 The Finnish Geoscience Milieu: Structure and Connectivity

In the light of the remarks in the preceding Introduction to the Report, it is useful at the outset to note that there is at least one impediment to providing an analysis of Finnish geoscience that does justice to the modern imperatives that are currently driving the development of the discipline. This has to do with the way in which the responsibility for Earth Science management is organized within the Academy of Finland. In particular it is clear to us that the split of atmospheric science, and the environment generally, from the Research Council for Natural Sciences and Engineering (RCNSE), mitigates strongly against our ability to produce a review of the Earth Sciences as a whole that would recognize the deeply interconnected nature of the modern research enterprise. As an example, because physical oceanography is the responsibility of the RCNSE, but atmospheric science is apparently the responsibility of both RCNSE and of the Research Council for Biosciences and Environment, the panel has been unable to assess the crucial connectivity between these subdisciplines that is driving much of modern research on the climate system of which, of course, the oceans are a fundamentally important component. The oceans and the atmosphere are both "geophysical fluids" and subjects of investigation by the "natural sciences". A second example of the difficulty caused by the way in which the geosciences have been separated from the atmospheric and environmental sciences will be clear on the basis of the increasing importance of GPS-Meteorology. It has become very clear, in particular, that observations of the occultations of the GPS signals will provide a wealth of information globally concerning the vertical variations of both atmospheric temperature and humidity, thus connecting a measurement system initially designed to produce precise geopositioning of tectonophysical significance to the problems of numerical weather prediction and climate monitoring.

A first recommendation of the Panel is therefore that the Board of the Academy of Finland reorganize the allocation of responsibility for the totality of the Earth Science discipline to the RCNSE. It would seem most natural, given modern research imperatives, that all of oceanography (physical, chemical, biological, geological), and all of atmospheric science (dynamical, chemical), should be the responsibility of the RCNSE. Given what we perceive to be this structural "irregularity", our report will hereafter deal mainly with the geosciences as defined by those under the current purview of the RCNSE, namely those upon which our site visits focused.

In general the working level structures within which Finnish geoscience is pursued mirrors that in other technologically advanced societies. This consists of a mix of university departments, government-sponsored (sectorial) research institutes such as the Finnish Geodetic Institute, the Finnish Institute of Marine Research, the Finnish Meteorological Institute, the Finnish Environment Institute and the Geological Survey of Finland. An important characteristic of a complex network of such disparate components is clearly the extent to which interactions between individuals in these different units is successfully encouraged. Although there have been useful

steps taken in Finland in this regard, for example through the establishment of country-wide "graduate schools" which are intended to bring together graduate students from all regions of the country interested in a given subject, it is unclear to the Panel how successful these "schools" have actually been in this regard, or even if this purpose of increasing the level of interaction within a given community is seen as a goal of this program beyond that of serving as a mechanism through which to finance graduate study and increase the total number of PhDs. As a general comment on the Finnish geoscience community, it seems to the Panel that much more needs to be done to encourage the development of fruitful collaborations between different elements of the system.

One significant impediment to the optimal functioning of the university component of the Finnish national effort in geoscience is that connected to the process of academic career advancement. The system that is currently in place throughout the university sector is one in which the rank of professor is a singular status rather than simply one step along an academic career path that ends with this highest rank. There appears then to be no conception in the Finnish system that promising young academics require a sense of stability (i.e., permanence) in their employment situation if they are to perform their best possible creative work. In North America, for example, new PhDs start their tenure-track careers as Assistant Professors, receive permanency through tenure in the 6th year or so if they show required productivity, are promoted to Associate Professor after some years of high productivity in both research and teaching, and after further productivity they may attain the rank of Professor. It is therefore the strong recommendation of the Finnish Geoscience Evaluation Panel that this aspect of the Finnish higher education system be modernized so as to offer a more clearly defined career path for its young academics. The Academy of Finland in a recent publication entitled "PhDs in Finland: Employment, Placement and Demand", Publications of The Academy of Finland 5/03) addressed the necessity for restructuring of academic ranks, but apparently only proposed that more postdoctoral posts be created.

A further specific problem concerning structure that the Panel has recognized concerns access to the High Performance Computing environment that is operated by the Ministry of Education -owned Finnish IT Center for Science (CSC). Although access to the facilities of this Center is provided to the universities at no charge, access is expensive for scientists working at research institutes that are not directly part of the university system. It is a specific recommendation of the Panel that a mechanism be found to finance access to the computer systems at the CSC by scientists whose formal appointments are not held within the university system even though these scientists, as we have discovered, do often teach courses for the universities in a wide range of fields. Examples of the negative impact of this policy were discovered at both the Finnish Institute of Marine Research, whose scientists provide courses at the University of Helsinki and the Finnish Geodetic Institute, whose scientists teach both at the University of Helsinki and the Helsinki University of Technology.

Probably the most apparent structural characteristic of the Finnish array of activities in the geosciences, however, is the extent to which the activity is dominated by the Geological Survey of Finland (GTK). It is instructive to consider the investment in

GTK as a fraction of the total geoscience investment represented by the suite of units that the Panel has been asked to evaluate.

Our analysis suggests that the annual budget of GTK represents approximately 63 per cent of the total (see Figure 1), by far the dominant fraction, and this clearly raises the issue as to whether an investment of this magnitude might not be more effectively employed, in spite of the fact that much of the work of the GTK is of high quality (see subsection 5.1 for detailed discussion). The Panel believes it important that a more in-depth study of this question than we have been able to perform is warranted, especially given the fact that a considerable effort in fine spatial-scale bedrock mapping appears slated to consume a significant fraction of the annual budget. A further recommendation of the Panel is therefore that consideration be given to a full review of the future desirability of so strongly focusing such a large portion of the total Finnish geoscience investment in this single organization. If some degree of funding redistribution were to occur, however, this would have to be fully justified on the basis of a clear case that a net benefit would accrue.

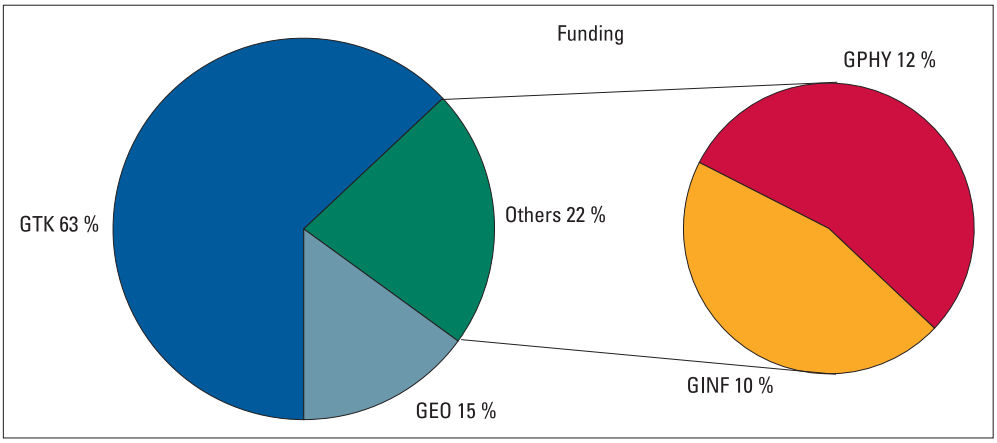

Figure 1a. *Geosciences funding profile for Finland as a whole. The total funding over all disciplines examined in this evaluation is 295 million euros during the period 2000-2003. GEO= geology, GPHY = geophysics, GINF = geoinformatics. The component denoted GTK is that of the Geological Survey of Finland.*

3 Issues in Finnish Geoscience (Higher) Education: The training of geoscientists

In the estimation of the Panel this is one of the most important areas that the Finnish community will have to address in the immediate future. It may be useful prior to discussing the specific issues in this area that have come to our attention to comment on what we perceive to be the attributes of a acceptable milieu in which the training of the next generation of geoscientists can proceed. Firstly, we think it clear that once a student has demonstrated sufficient aptitude that an investment in her/his higher education is suggested to be worthwhile, an acceptable system should ensure that the person is sufficiently well financed that focused concentration upon study and research is possible. Secondly, the system in which the student is educated should provide a clear indication of the level of accomplishment that is required to achieve the level of accreditation towards which the student is working. Thirdly, the system should seek, on average, to have students complete the required research for the advanced degree on a timescale that is reasonable and in reasonable accord with international norms.

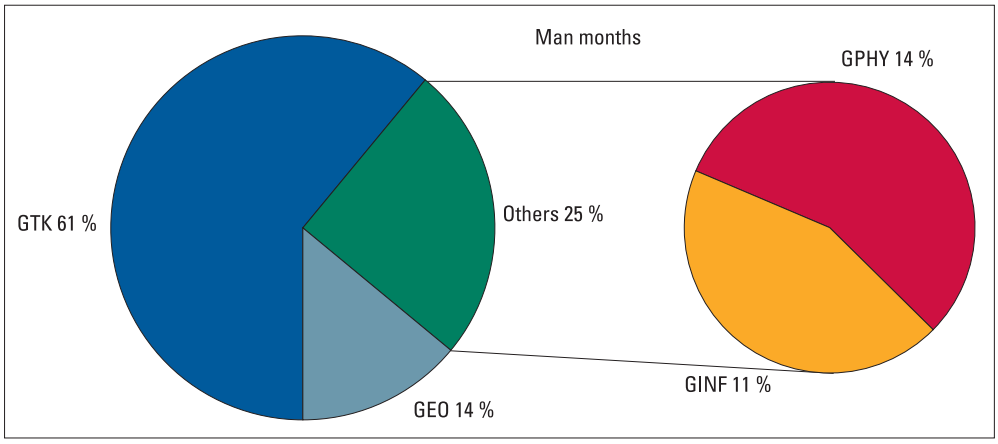

Figure 1b. *Geosciences personnel profile for Finland as a whole. The total number of man months during the period 2000-2003 was 64,122. The abbreviations are those defined for Figure 1a.*

In our opinion the Finnish system of higher education in the geosciences, and perhaps in other areas as well, although we are in no position to comment on this, is deficient in these critical respects. And, of course, these three critical characteristics of a "good" educational milieu are very tightly linked. Insofar as the first mentioned issue is concerned, that concerning the adequate financing of graduate students, it became clear to the Panel in the course of its site visits and interviews with individual scientists that there existed very large discrepancies in the funding mechanisms employed to finance graduate education and associated very large discrepancies in the level of funding individual graduate students receive. Some students, apparently the most fortunate, are funded directly through the "graduate school" mechanism,

although for a period of time that is often insufficient to allow them to complete their graduate thesis. Others, not being awarded funding through this mechanism, are obliged to seek full-time employment in government laboratories and to work towards their degrees on a part-time basis. In either event, the timescale required for them to complete a Ph.D. degree, for example, may stretch so significantly that they do not achieve this goal until they are in their late 30's. This difference in the "elapsed time to success" between the norm in Finland and that in most other OECD countries appears to the Panel to approach a decade. It is therefore the recommendation of the Finnish geoscience evaluation Panel that a concerted effort be made to dramatically shorten the time required to complete the Ph.D. degree. We realize that this is indeed one goal of graduate schools, but a considerably broader impact is clearly desirable.

One way in which this significant decrease in the "elapsed time to success" might be achieved is to fully modernize the sequence of steps that a doctoral candidate must take in order to reach this goal. Under the current system in Finland, for example, a very large fraction of university students first complete a M.Sc. degree which appears to take, on average, approximately 6.0 years of university study. Thereafter work on the doctoral degree may continue for an additional five or many more years since funding is not often available to allow the candidate to continue to work full time on the thesis until it is completed. It is unclear as to whether this excessively long time taken to success is in the best interest of either the individual student or the country as a whole. In many North American and European jurisdictions the higher education systems are designed so that the research program leading to the doctoral degree may be completed within ten years of initial entry into the university, which normally occurs at the age of 18. Doctoral degrees are therefore normally completed within six years of completion of a Bachelor of Science degree and often considerably sooner. In the British system, for example, it is reasonably common for a doctoral candidate to be awarded the degree by the age of 25. In North America, on the other hand, most candidates complete this requirement by the age of 27 or 28. In Finland, candidates are often in their mid-30's to late 30's before their degree is completed. It may well be that the best way to reduce the time to completion of a doctoral degree is either to do away with the intermediate M.Sc. degree entirely or to significantly reduce the time beyond the four-year undergraduate university degree that is required to complete it for those intending to continue towards the Ph.D. degree. This would move the system closer to the norm to which the higher education system in most European countries will be expected to conform. We are not suggesting the elimination of the M.Sc. degree entirely, but only suggesting that it might be de-emphasized for those students whose goal is to obtain doctoral qualifications. Based upon our analysis of the current situation in Finland, there is no time to lose in initiating reform in this regard.

4 Geoscience in the societal and economic development of Finland

As discussed in the Introduction, the field of geoscience has gone through a dramatic transformation in the latter part of the 20th century. In the past the roles of the "spheres" (geosphere, hydrosphere, atmosphere, cryosphere) were clearly and categorically segregated individual disciplines. Solid earth topics often played a commanding role, and were regarded as cornerstone contributors to national and global economies, and critical facilitators of the extraction of natural resources. The transformation of geoscience has not only involved the overlapping of the "spheres", but the transformation has also contributed to a fundamental change in the way society in general and the economic community in particular interacts in employing the fruits of scientific research. The integration of modern Earth Science underpins the goal of achieving responsible and sustainable economic and social development. An interesting aspect of the current community of Finnish geoscientists is captured by the age histograms displayed as Figure 2, which clearly establish the subdiscipline of geoinformatics as the younger discipline compared to the more established areas of geology and geophysics.

In the interaction of society with its economy-focused sub-community, the sustainability concept has not only become shorthand for a code of ethical conduct, it has also become a facilitator of dialogue on the past, the present and the future. The concept of sustainability has largely been adopted as a primary guideline for economic and community activities in Finland, although the dialogue rarely recognizes the substantial role played by input from the geosciences. Rather than assessing why the geosciences fail to attract the visibility and the credit they deserve in this context, the Panel considers it more relevant to consider whether the underlying strengths and competencies of the geoscience sector are properly exploited within the Finnish economy. We will also consider the challenges that lie ahead and whether the establishment is capable of coping with these challenges, fostering innovation, and receptive to extracting benefits from future development.

The greatest challenges arise in the fields in which the momentum towards transformation is strongest, and in this regard there is no denying the importance of rapidly expanding linkages of traditional geoscience, geoinformatics and Information and Communication Technology (ICT). For example, the merging of space technologies with earth science disciplines is not only serving existing activities, but is also creating totally new fields of research (see Introduction). Finland is recognized for leading-edge research and innovation in the ICT field, as well as possessing matching capability in related science and higher education. The process of linking geoscience with the huge ICT world is already on the verge of creating its own economic space, and the industrial and other business opportunities that can be foreseen are significant, either by traditional geoscience or ICT standards.

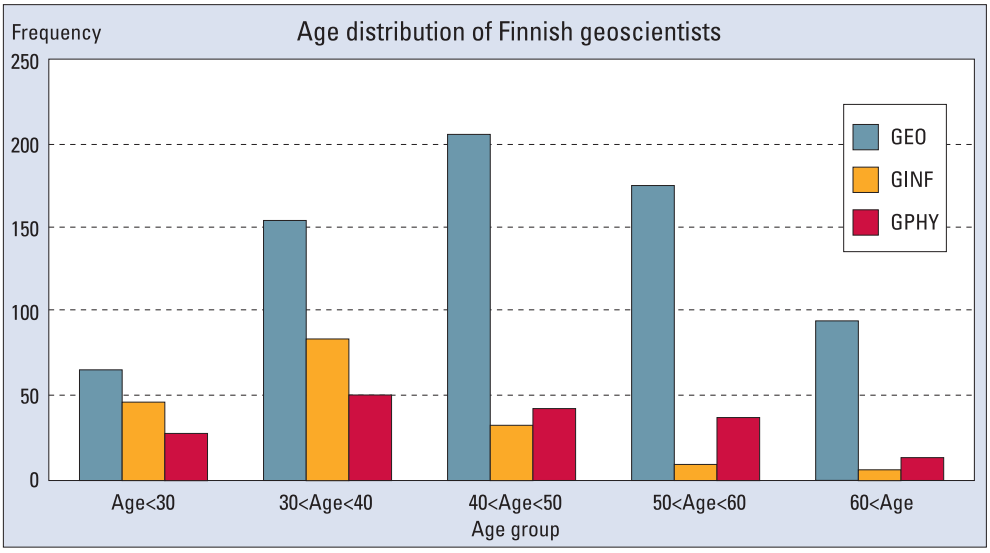

Figure 2a. *Age distribution in classes of ten years. All data. Note that the lower limits of classes are included with the class data, i.e. that the class denoted "30<Age<40" includes all persons with age in the range 30, 31,…39*

4.1 Geoscience-dependent economic space

The topics and scientific units that the Panel has evaluated have their most direct links to economic activity in relation to the subsurface of the earth. More indirect but nevertheless consequential links exist in connection with the hydrosphere.

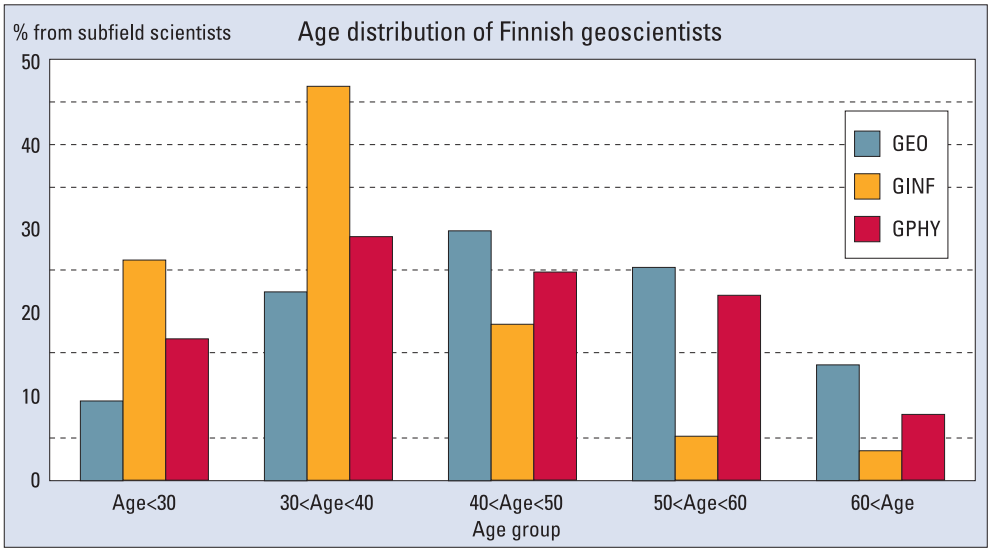

Figure 2b. *Relative age distribution in classes of ten years. The data of three subfields (geology, geoinformatics and geophysics) are shown. This figure is intended to answer the question: "What is the share of certain age groups compared to all scientists in that subfield?". Note that the definition of the classes is as in Figure 2a.*

Discussion of the economic value of the extractive industries is a somewhat complicated task, due to the inhomogeneity of the "value creation profiles" and in part to the fact that industry is less than forthcoming regarding the economic breakdown of their operations. Aggregate production included, industry directly employs some 6,000 persons in Finland and the order of magnitude of annual sales is 500 million euros. A report of the Raw Materials Group (commissioned by the Finnish Extractive Industries, 2002) estimated Economic Value Added at 350 million euros for the year 1999.

In 1992, mining legislation was modified to allow foreign companies to explore and mine in Finland. The change in the laws, combined with subsequent membership in the EU increased the interest of foreign mining circles in Finland's raw materials.

Exploitation of hard rock resources

The traditional focus of geoscience-dependent economic activity involves mining for metals and minerals and extraction of hydrocarbons. Hydrocarbons are not an issue in Finland. Mining has never been a commanding component in the economy of Finland either, although there have been a few notable base metals and ferrous alloy operations of international significance. At this time, four metals mines are in operation, a new gold mine has recently cleared the permits stage, another has been refurbished for reactivation and a number of precious metals ventures are advancing towards commercial development. The level of mining in the latter half of the 20th century was in any event sufficiently broad and diversified to serve as a crucial springboard for the birth and later diversification of the metallurgical industries. The production of base metals and steel, along with a wide range of metal transformation and fabrication industries has become large and trans-national, and the raw materials base has long since changed from local to global sourcing.

Production unit numbers in metals mining have been in decline for a considerable time, but it would be overly simplistic to assume that the geologic potential has been exhausted in any metal or mineral substance. The trend in metals partly represents the cumulative effect of three factors – the mining sector in Finland was closed to foreign capital until the 1990´s, the two Finnish major players have gradually pulled out of the upstream business due to strategic refocusing, and the more recent influx of foreign capital into exploration has focused on non-traditional substances (like precious metals and diamonds) where the long lead times characteristic of mining have not yet been worked through. The vote of confidence from international mining circles is evidenced in the fact that Finland has been one of very few countries where mineral exploration activities have not decreased. In the last few years, over 60 per cent of total Nordic area exploration outlays have been incurred in Finland, and last year alone involved an investment of over 40 million euros.

Due to the characteristics of the Finnish lithosphere (ancient shield area) the industrial minerals sector is rather narrow, but tuned to serving a multitude of product tailoring requirements of their end customers. Apatite, limestone and talc are the principal raw materials, the main clients coming from the chemical and

processing sectors, agriculture- and paper-related industries in particular. Even on a global scale, Finland is a major player in coated and specialty papers, and the volumes of filler and coating minerals consumed by the industry are very high, and presumably on a continuous uptrend. The existence of important local demand, good geologic potential and excellent infrastructure make a compelling combination in support of continued research and development of industrial mineral resources in Finland.

Natural stone has demonstrated steady advances in the last few years with turnover (5-year average 200 million euros) beating both the metals and industrial minerals sectors. The main components in the natural stone business are dimension stones and soapstone. There are already more than 75 stone quarries and 30 sites where industrial minerals are exploited, with 43 companies involved. Current success has been achieved by combining top-quality raw material with intensive product development and marketing. Research roles of the universities and the Geological Survey of Finland have been significant, as the sector is made up mostly of small- and medium-sized producers, who could not by themselves have afforded to allocate the funds required to obtain the inputs they have received from the science and research establishment.

Raw materials are an important segment of Finland's economy. In 2002, a total of 250 million euros was generated by the stone industry, 200 million euros by the metals industry, and 100-200 million euros by industrial minerals. Finland's membership in the EU is probably increasing the interest of European companies in Finland's raw materials. In 1992, mining legislation was modified to allow foreign companies to explore and mine in Finland. (Finland and Sweden supply most of the raw materials, other than fossil and nuclear fuels, for Europe's economies.)

Exploitation of other sub-surface resources

Much of the land surface of Finland is covered by unconsolidated Quaternary formations deposited and reworked in connection with the advance and retreat of the ice-sheets that advanced and retreated during the last glaciation period. Aggregate resources are abundant and easily accessible for extraction, from a purely technical point of view. Land use conservation measures, protection of groundwater reservoirs and other topics of sustainable development have gradually become guiding factors for land use planning and exploitation of Quaternary resources. Within and in the vicinity of the larger urban areas, crushed hard rock is increasingly being used instead of Quaternary material.

All kinds of construction activity provide the physical pillar for the build-up of infrastructure for societal and economic development. And one should not overlook the fact that the exploitation of natural resources is only a part of the geoscience connection to the construction activity. Construction occupies and makes use of both the surface and the sub-surface. Precise acquisition of observations and samples and comprehensive testing, modeling and application of the basic data and information derived there from are something society cannot function without. The marriage of civil and environmental engineering with the more geo-denominated disciplines

is inseparable in every large modern society, and particularly so in Finland where much of the population and a portion of the nation's Economic Value Added are physically located on top of soft clays and other unconsolidated Quaternary formations. Against this background, we are at pains to understand how the nation has allowed the teaching of civil engineering and related research to have so significantly diminished and strongly recommend that consideration be given to reversing this trend.

4.2 Geoscience-supported economic space

There is a widely circulated notion that many of the Finnish mining operations, both past and current, involve such a low grade of metals and minerals that they could not have been economically exploited unless accompanied by continuous development of ever more efficient extracting and processing methodologies and equipment, and that this has given rise to a number of successful businesses in the technology sector. Whatever the proper explanations might be, it is a fact that there is a diversified cluster of mining and mineral processing technology enterprises doing business on a global scale out of Finland. The convenience of having enjoyed close cooperation with local industrial operators certainly has gone a long way in providing a platform on which to build a wider business. For future solidity and development of this business, a continued existence of local operations may not be of paramount importance, but it certainly should be in the interests of the national economy to see such a two-way interaction maintained. In a survey undertaken by the Raw Material Group (released January 2002) for the Finnish Extractive Industries Association, the equipment manufacturers were profiled as employing 4,000 persons while producing Economic Value Added of approximately 250 million euros per annum.

The Geological Survey of Finland is a key contributor to the evaluation of peat resources in Finland. Peat is perceived as a slowly renewable natural resource and has come to occupy a reasonably significant 6 per cent in the total energy supply in Finland (source: Statistics Finland 2001). Some 40,000 ha of peat land are under production, mostly for use in combined energy production for heat and electricity. The seasonally adjusted work force in peat production was 1,500 persons in 2001, when 19 million cubic meters of peat was harvested, almost 90 per cent of the production being channelled to deliver 16 * 10^6 MWh of energy. As per the information of the Association of Finnish Peat Industries (Turveteollisuusliitto), the sales value at the clients' gate represented a sectorial turnover of approximately 125 million euros in 2001.

Space and atmospheric science should enter into an assessment of the overall economic impact of the geosciences, but we do not elaborate those linkages here. The hydrosphere instead occupies an integral part in the analysis of geoscience, groundwater in particular but "above ground" waters as well, oceanography included. Acquisition, integration and interpretation of data and system modeling have direct and very practical implications of huge economic and societal importance over temporal scales ranging from real time to geologic. The significance of the hydrosphere is obvious to almost every citizen, and the more distal parts of the

temporal scale are becoming ever more important in the assessment of risk and for the mitigation of potential hazards, both natural and man-made. Concrete examples include such topics as flood prevention, oil spill and algae bloom monitoring, and disposal of nuclear waste.

4.3 Dynamics of the science – industry interface

Most universities and science sectors in Finland have established effective linkages with industry, through an array of flexible forms of cooperation. The science - industry linkage has become an integral part of the national approach to research and the real success cases have profiles extending far beyond the pooling of resources and commissioned research into genuinely creative innovation environments. How do geosciences stand out and rank in this field is something we are not capable of measuring quantitatively, and consequently, our findings are specific to the geoscience sector and based on data extracted from the questionnaires and impressions transmitted in the interviews.

It may not be surprising that the finest examples the Panel was exposed to both in basic research and practically tuned programs combined disciplines from the traditional fields of geoscience in vanguard ways through intensive use of both precise and comprehensive geospatial and temporal data. Characteristic of these programs is the synergy that is created by engagement of either the industry or peer research units right from the stage of idea incubation. The overall impression from the entire evaluation, however, was not only that heterogeneity reigns, but that a considerable number of rather routine topics with unpretentious scientific challenge continue to survive. But we admit that to a substantial degree individual researchers are being trapped in this situation by the limitations inherent to the Finnish system of academic geoscience funding.

The observations of the Panel nevertheless suggest that the science - industry interface is well conceived both conceptually and from a practical perspective. However, most of the specific examples we have encountered, even the better ones, reflect either one time projects or rather sharply circumscribed engineering exercises. The mentality and the environment are mostly tuned to problem solving rather than to innovation as one would expect to be the primary product of “knowledge clusters”.

4.4 Knowledge cluster challenges

There are research institutes that stand out on the basis of their internal scientific strength and the excellence of their research, along with their networking with peers and disciplines in related fields, such as the Finnish Geodetic Institute, the Finnish Institute of Marine Research and the Geological Survey of Finland. These institutes possess the critical mass and display the required dynamics to act as motors and promoters in both basic and applied science and research. Their profiles of interaction with the academic world and with industry and other institutions are indicators of a process that is characteristic of synergistic clusters. To adopt the word “cluster” may yet be premature, but most of the building blocks are in existence. It is just that the “transmitting fluid” needs to become less viscous so that synergies have a chance

to emerge so as to move the system more aggressively towards a knowledge-based innovation environment, what we would be prepared to call a "cluster".

An exhaustive assessment of the "transmitting fluid" concept as a means of discussing the ability of a system to innovate is well beyond the present mandate. However, we wish to stress the importance of adopting a holistic view of the converging spheres and sub-disciplines within the geosciences as necessary for innovation. The integration and interaction of modern sciences is a continuous process presenting an ever widening array of research and development opportunities. The topics become increasingly interlinked and crossdisciplinary, and the synergies are not realized unless both the environment and the establishment are receptive and responsive. The incubatory innovation mentality that is evident in the better parts of the ICT and biosciences sectors in Finland is visible in too few corners of geoscience. The bright spots are found at the space / atmospheric / oceanographic / geodetic interfaces and are characterized by strong ICT and geoinformatics components.

In the areas related to the lithosphere and surface materials, the overriding impression of the Panel is of traditionalism. This does not mean that research is anything other than of high quality and often excellent. The impression of traditionalism emerges from the broad direction of research. Admittedly this group contains a substantial portion of topics related to such basic and traditional needs and activities of industry and society where the pace of change is far less than at the more exotic fronts. Still, the impression is that the convergence of the geosciences has not been fully acknowledged as evidenced by the fact that the fields of research represent a very conventional palette, tending to have a carry-over stamp from traditional lines and areas of research of each of the units.

The Panel suspects that to an extent the situation referred to above is a fallout that has accumulated over a period of time as a by-product from the distribution of geology and geophysics departments to so many different universities in the country. The distribution as such serves a number of purposes well, and each of the departments can be commended for having worked on synergistic integration within their own environment. The main drawbacks are lack of critical mass and insufficient lateral movement of researchers, professors and students between the departments. Virtual critical mass diversity for teaching has more or less been achieved through visiting lectures, and here the role of the Geological Survey of Finland is essential. The "cross-fertilization" mobility of scientific personnel has seen some positive development in the last few years but is still deemed unsatisfactory and should be further encouraged.

Decentralization of the geology and geophysics disciplines may be a contributing factor in the research field beyond the repercussions in teaching and career development. The impression of there being more research than expected on the safe and traditional topics of geoscience possibly reflects that the formal and informal structures which provide advanced level scientists and researchers their forums for networking and idea exchange, may not serve the purpose sufficiently well. We have no instant medicine to prescribe, but this is a topic the RCNSE of the Academy of Finland might wish to gauge.

4.5 The role of the Geological Survey of Finland

The Geological Survey of Finland (GTK) has been the provider of data and much of the research relating to sub-surface materials. Therefore, the role of the GTK is addressed here separately in the societal and economic development context.

In 1996 an evaluation of GTK was undertaken by an international team under the auspices of the Ministry of Trade and Industry. In broad terms we concur with the findings of the 1996 evaluation regarding the strengths of GTK and the profile of challenges, specifically those relating to the needs of the society. The organization has responded to the expanding quest for research and data serving to meet the requirements of sustainable development of both society and industry. The Panel compliments GTK for successfully coping with this challenge while still managing to maintain and advance research of high scientific merit.

Subsequent to the field interviews, the Ministry of Trade and Industry announced in September 2003 the decision that the Mineral Processing Research facilities of VTT shall become part of GTK. These facilities, formerly located in Espoo but relocated in about 1980 to east-central Finland, initially serviced Finland's mining industry. This unit, with about 40 employees and annual expenditures of a few million euros, will thus be a sizeable addition to the GTK. The integration of this mineral processing research unit to GTK and further development of it means new chances but also challenges to GTK and to the unit. The metal cluster, along with the ICT cluster and the forest cluster, has been cited as a strength of Finnish business and industry. We are not in a position to express a functional view on this interface; however, the issue contains elements that have organic links to the Natural Resources Bureau concept discussed in what follows.

The duties imposed upon GTK by the Acts and Degree of the Law are more than duly covered and fulfilled. From the societal and economic point of view the real issues to be assessed are not only the quality and relevance of current and planned lines of research and the core strengths required of leading edge geoscience. One also needs to address the scope and relevance of material and nonmaterial input and output, internal processes, interaction with society and industry, and justification of the activities that possibly go beyond the hard core of science and research.

As discussed under the respective unit report (section 5.1), GTK is a dynamic and qualified organization of the highest international standards. The needs of society are well served both in the traditional sectors of geology as well as in the newer emerging areas such as environment and community land use issues. Interaction with society at large and with particular targeted end user groups is deemed efficient and responsive and the networking and partnering concepts appear to be widely and productively applied both in science and research and in service functions.

Among the Geological Surveys of the EU, the Finnish GTK is remarkably well endowed regarding both human and material resources. The Survey is well known and highly regarded by other actors of the geoscience community and within the resource industries. A solid national budget allocation has been available and

the organization has built a stream of additional income through commissioned services. In the services business, GTK is not only collecting commercial benefits from its core strengths as a science and research organization, but has also ventured into technical contracting and product development in the geoscience arena.

We regard the external services business of GTK to be by and large conceptually and economically sound. However, external business is not only an opportunity but to an extent a necessity that supports part of the overall infrastructure. Infrastructure and function-wise one must actually ask whether GTK might have grown beyond an efficiently manageable palette of functions characteristic of a research and survey institution? Is GTK possibly engaged in activities it does not need to be involved in? Is GTK carrying out tasks and internal routines that external service providers could efficiently provide with acceptable quality and with flexible costing?

Evaluation of internal vs. external functions of basic tasks such as sampling and mapping was taken up by GTK management during the Panel interview. The issues appear to have surfaced more due to a skewed age distribution of personnel (see the previously discussed Figure 2) rather than arising from an efficiency analysis. The Panel wishes to encourage GTK to move swiftly towards external sourcing of tasks where scientific knowledge is not a paramount issue and also on more demanding tasks and projects when satisfactory quality can be assured by expert GTK monitoring.

In the evaluation forms, all units under review were requested "to describe how they are related to the strategies of the main organization". The response of GTK reflects the main duties of a research institute, and additionally states that "*in accordance with the strategies of the Ministry of Trade and Industry, they also engage the survey actively in producing and providing information for decision-making across the full range of economic, environmental and social issues affected by the extractive industry*". As Finland does not possess a proper Natural Resources Bureau, the Geological Survey of Finland seems to have adopted a number of duties that venture into the concepts of mining industry services, mining activity promotion and a kind of related "invest in Finland" lobbyist role. We interpret these lines and roles as having been partly mandated by the Ministry, and partly proactively assumed by GTK.

Modern extractive industries are intensely knowledge-based and linked to sophisticated technologies in ways that call for both highly specific and broad-based exposure to the economics of industrial businesses. We do not regard it appropriate to burden a geological survey institution to cover this field unless the institution is adequately endowed with expert knowledge on related topics. Quite obviously GTK meets the qualifications and competencies tests over only small segments of the industrial-economic spectrum. There is therefore an overhanging strategic threat that the challenges of resource allocation (survey vs. service) may erode the existing core strength of excellence in research. A threat of strategic proportions is unacceptable, and consequently, we encourage the Ministry and GTK to assess whether the current arrangement of allocating a wide industrial-commercial-promotional profile to a research and survey institution really serves the interests of the nation in an efficient and a balanced way.

5 Reports on the Individual Geoscience Units

The scope of the present evaluation of geosciences in Finland is indeed broad, covering 32 units in three categories – Geology, Geophysics, and Geoinformatics. Because of time restrictions, most units were allocated only a one half-hour meeting with the evaluating panel. The evaluation of the Geological Survey of Finland (GTK), by far the largest unit, was conducted over a three-hour period, and the evaluation of the Finnish Geodetic Institute was afforded two hours. The Departments of Geology at the University of Helsinki, the University of Turku and the University of Oulu each had a one-hour time slot, because each includes smaller subdivisions of petrology-mineralogy and Quaternary-environmental geology.

Although the meetings with the delegations from each unit took place at ten different sites (Helsinki University of Technology, Geological Survey of Finland, Finnish Geodetic Institute, University of Turku, University of Oulu, University of Helsinki, Finnish Institute of Marine Research, Finnish Environment Institute, and at the Academy of Finland for units from Tampere University of Technology and University of Joensuu), there was no opportunity to tour any of the geoscience units. Therefore, our evaluations are largely based on the short meetings with one or a few members of each of the units and on the information, including a 45-part questionnaire, provided by each evaluated unit in advance of the meetings.

5.1 Geological Units

The eight units classified as geological include the Geological Survey of Finland (GTK), the Departments of Geology at four universities (Universities of Helsinki, Turku, and Oulu, and Åbo Akademi University) and three laboratories or institutes within engineering departments at the Helsinki University of Technology and Tampere University of Technology, laboratories that emphasize engineering geology or rock, foundation and soil engineering. These evaluated geological units range in size from the very large Geological Survey of Finland with a total staff of more than 800 and annual expenditures of more than 47 million euros to units with less than ten total staff members.

Introduction to the Departments of Geology at the Universities

The nation's 20 universities have the roles of research, teaching and service to society, and these roles are obviously the primary roles of the four geology departments of the universities. Because the bedrock geology of Finland is essentially all Precambrian, between 3,600 million years and 1,400 million years in age, Precambrian studies have been the focus of petrological, mineralogical, and ore deposit research and teaching. The bedrock was glaciated during the Pleistocene ice age, and glacial deposits blanketed most of the bedrock during the disappearance of the glaciers. Therefore, the study of these glacial (Quaternary) deposits has long been the other geological focus. Much more recently, in the past two decades or so, environmental

geology (including groundwater studies) has become very important, and commonly interfaces with surficial (Quaternary) studies.

The production of M.Sc. degrees and Ph.D. degrees since 1980 is tabulated in Table 1. Because the four universities started their geology programs at different times (University of Helsinki in 1852, Åbo Akademi in 1918, University of Turku in 1958, and University of Oulu in 1961), total production figures since inception would not be fully comparable. The production of B.Sc. degrees is very minimal and is not tabulated, as the education system in Finland is such that students are expected to obtain their M.Sc. degrees. This will change in the near future under the European Bologna Process, wherein all the participating countries will offer B.Sc., M.Sc., and Ph.D. degrees. Finland's post-graduate educational system also has a unique peculiarity, the Ph.Lic. (Licentiate) degree, which requires less research than the Ph.D. degree. This has evidently become less important in recent years and is being phased out. However, Licentiate degrees are included in the Ph.D. figures for 1980-1999, but we have excluded them in the 2000-2002 figures.

Table 1. *Geology Graduates*

	1980-2002		2000-2002	
	M.Sc.	Ph.D.	M.Sc.	Ph.D.
University of Helsinki	204	74	27	12
University of Turku	179	39	45	7
University of Oulu	182	35	29	7
Åbo Akademi	101	8	23	1
TOTAL	666	156	124	27

It is clear that all four departments are making very significant contributions to the production of geologists.

The numbers of Ph.D. students in 2002 were as follows: Helsinki, 46; Oulu, 32; Turku, 22, and Åbo Akademi, 12. Geology majors are selected and restricted in number. In 2002, Helsinki accepted 26, Oulu 23, Turku 15, and Åbo Akademi 12 geology major students.

All four universities have emphases on different aspects of Precambrian geology, including mineralogy, petrology, and economic mineral deposits. All except Åbo Akademi University also concentrate on Quaternary studies. All give some emphasis to aspects of environmental geology, including hydrogeology, as that has been a major worldwide trend in the past two decades. Thus there are major similarities there are, however, complementary differences as well. Each department has other specializations, including the following: Helsinki in geochemistry, dendrochronology, and mammalian evolutionary paleobiology; Oulu in technical mineralogy, soil behavior in cold climates, climate change, and pollen studies; Turku in developmental methods, paleoecology, environmental geochemistry, and lake restoration; and Åbo Akademi in geochemical methods in prospecting and acidifaction problems related to sulfide-bearing clays.

We attempted to compare the expenditures of the four departments for the year 2002 from the data provided. Our numbers, which are not strictly comparable and which exclude special funds for equipment purchases, are in Table 2.

Table 2. *Expenditures, 2002*

Helsinki	1.32 million euros (not including Geophysics)
Oulu	2.23 million euros (including Geophysics)
Turku	1.33 million euros
Åbo Akademi	0.28 million euros

University of Helsinki, Department of Geology

This was the first geology department in Finland, founded in 1852. Many geologists of international stature have graduated from and have taught here.

The permanent academic staff appears to consist of five Professors and five Assistants, plus 41 Docents and ten part-time teachers who come from outside of the university to teach in their specialties. There are three support personnel.

Current fields of specialization are (1) petrology and bedrock geology (rapakivi granites), (2) economic geology (gold and platinum group elements), (3) geochemistry and hydrology, (4) environmental geology (Holocene and Quaternary studies), and (5) geology and paleontology (mammalian evolution and dendrochronology. There is an increased emphasis on applied research in environmental geology and isotope geochemistry, but basic research remains the main emphasis. . New research facilities are well equipped and faculty members have good access to facilities at the GTK.

There are 22 ongoing research projects within the Department and all involve cooperation with other national or international entities. The Department has been participating in the Finnish Antarctic Research Program since 1989. There is a notable amount of international exchange of faculty.

The faculty is extremely active with national and international organizations The publication record is excellent; for the period 2000-2002, there were 75 publications in Finland (with 11 more currently in press), and 160 publications abroad (with 25 more refereed articles currently in press). In addition, 17 popular articles were published.

University of Oulu, Department of Geosciences

The Department specializes in studies of northern Finland, especially on Paleoproterozoic bedrock and Quaternary deposits. However, this regional emphasis has not diminished the Department's role in basic research or in international geological projects.

The Department is divided into two divisions (Geology and Geophysics) and into four main subjects areas – Geology and Mineralogy, Geochemistry, Geophysics, and Surficial (Quaternary) Geology. Each subject has two professors, a senior assistant,

and an assistant, except for Geochemistry with one professor. In addition, there is a head of the excellent Geological Museum. GTK personnel teach, as Docents, specialty courses within the department. Students in any of the above subjects can specialize in geoenvironmental studies. Related courses are available in the Faculty of Technology on the same campus, and in fact, under the same large roof. This proximity stimulates interdisciplinary types of applied research.

A unique feature of the Department is the MinNet Service Unit, a service concept organized to provide comprehensive expertise in raw materials, products, and processes for the extractive industry. Research is both basic and applied topics in bedrock studies include mafic-ultramafic magmatism and PGE-Ni-Cu mineralization, gold mineralization and impact structures. Quaternary projects include deglaciation, peat profiling, pollen studies, ground penetrating radar studies of glacial deposits, and climatic changes in Arctic areas.

Research has taken staff members to the Arctic Ocean, Poland, central Europe, Norway, Russia, India, Bangladesh, China, Antarctica, and the plate tectonic spread-center off western North America. International contacts are numerous. The Department will host the 10th International Platinum Symposium in 2005.

Publications for the years 2000-2002 total 18 published in Finland and 51 published abroad. Six more refereed articles are in press. In addition, 133 abstracts were published. These are impressive numbers.

University of Turku, Department of Geology

The Department concentrates on two disciplines – Geology-Mineralogy and Quaternary Geology. Research in Geology-Mineralogy, including ore-forming processes and the development of new methods, is focused on Finland (especially southern Finland), Sweden, Norway, and Karelia, Russia (i.e. the Fennoscandian Shield). Research in Quaternary Geology (including sedimentological and stratigraphic research, paleoecology, hydrology and hydrogeological modeling, environmental geochemistry, nuclear waste sites and the next glaciation, and lake restoration) has been done in these same regions. In addition, there has been long-term, major interdisciplinary research in Brazil and Peru. There has also been work on gold deposits in Kyrgystan.

The Department's initial focus when created in 1958 was related to mining, and it prides itself on being the leading university geoscience department in Finland in applied geology. Interdisciplinary environmental sciences are stressed. The Department is active in the development of teaching curricula in environmental sciences through the Center for Environmental Research of the University of Turku, and teaches basic geology courses to other natural science disciplines. This is an important contribution, in that it increases overall awareness of geology in related fields.

The Department has two staff members in Geology and Mineralogy (i.e., Precambrian studies) and three in Quaternary Geology, plus assistants. There has been a major turnover in personnel due to retirements and departures for other

positions, so now there is an opportunity to fine-tune the rebuilding and further develop major strengths.

There is much networking with Åbo Akademi University in the Geocentre Turku, soon with University of Oulu via the Internet, and also with University of Helsinki. Advanced courses are taught in English, so foreign students also enroll. The Department has access to the GIS laboratory in the Geography Department, to Chemistry Department laboratories, and to field stations.

There is extensive networking with Finnish organizations and with international groups from around the world. There is appreciable traveling abroad and hosting of foreign specialists.

The publication record is solid, with between 39 and 53 publications for each of the last three years; about half were published abroad, many in top journals.

Only 46 per cent of funding is from the government budget. Funding is a problem – the amount of budget funds from the government is less than the total for salaries, so some positions remain open. The Department lacks funds for equipment maintenance and for hiring permanent laboratory personnel to maintain and run equipment.

Åbo Akademi University, Department of Geology and Mineralogy

This Department in Turku logically concentrates its teaching and research on the geology of SW Finland, and has long had a pronounced Precambrian geology field emphasis. In recent years the environmental geology program has experienced strong growth. The number of geology students is very large, 105-110, and there are at present 12 funded Ph.D. students. Thus there is a heavy teaching schedule (the highest in the University) for the small academic faculty of four or five and a support staff of two. There is also close cooperation with the University of Helsinki.

Some departmental research is unique – C 14 dating of mortars in old churches, sulfide-rich clay soils and sulfur geochemistry, granites in shear zones, and migmatites. Gold mineralization in SW Finland is also a research topic, and other economic deposit research has been done in conjunction with the GTK and mining companies. Bedrock mapping projects in the vicinity of Turku, with GTK sponsorship, follow earlier mapping in the Archipelago.

Equipment is between minimal and reasonable for a small department. The production of publications is reasonable for a department that is so heavily involved in teaching. Several publications are in international, peer-reviewed journals; more has been published abroad than in Finland.

The Department actively cooperates in research with many organizations in Finland and in Sweden, as well as other countries.

As Åbo Akademi University is the Swedish-speaking university in Finland for Finland's 200,000 Swedish-speaking citizens, there is much contact with Sweden on

student employment, permanent positions in industry and academia, and even on funding for Finnish Ph.D. students in Swedish universities.

In another five years, the faculty will have a large turnover because of full retirements, and the transition from many temporary staff members to more permanency should be advantageous. , Funding is a continuing concern. Foundations and corporations support much of the research.

Perspectives and Concerns of the University Geological Departments

1. The Research Council for Natural Sciences and Engineering of the Academy of Finland, which awards research grants, does not include a geoscientist. The departments think this affects the awarding of funds for geological projects. The Panel therefore recommends that a geoscientist be appointed to the Research Council for Natural Sciences and Engineering so that geoscience projects be given better informed appraisals.

2. The bulk of budget funding for the universities is determined by the volume of education and research, which are measured by the number of new students and Master's and Doctor's degrees awarded and expected in three-year periods, as agreed upon between the Ministry of Education and the University. In addition, there is funding for infrastructure, for graduate schools, for the open university, and also some bonus funding for excellence in education and research. In general, the funding of the universities is increasing, but the numbers of students and the volume of research has been increasing even more. About 36 per cent of the university funding comes from outside sources, e.g., from the Academy of Finland. Departments are finding it more and more difficult to meet all expenses, including salaries. It seems that some structural modification of the system or modification of the funding formula may be necessary (see comments on the Introduction to this Report).

3. The science teachers in secondary schools usually teach two or three subjects, either Biology and Geography or some combination of Mathematics, Physics, and Chemistry. A subject teacher has to have earned a M.Sc. in one of these subjects as a major and the others as minors. The geography curriculum also contains basic geoscience. Natural science teachers in the public schools receive some training in geography departments, but not in geophysics or geology departments. Some of the interesting geoscience they learn there is really geology and even geophysics (e.g., plate tectonics) but the students think it is geography. If interested, they thus become geography majors rather than geophysics or geology majors. This cuts down on the pool of students wanting to study geology/geophysics. If the teaching requirements were to change, this could help geophysics and geology enrollments, or at least increase the size of the pool from which to pick the new university students. The Department of Geology at the University of Turku is now participating in teacher education, and the other university departments should consider doing the same. A societal benefit would be that more students would learn more about geophysics and geology.

4. Financing for Ph.D. students in the geosciences evidently has long been a problem (see comments in the Introduction). A total of 1,426 full-time research post-graduate student positions are funded by the Ministry of Education. Some are in the geosciences, but evidently many Ph.D. students in geosciences remain unfunded. We were told that at this time, there are 157 students studying for the Ph.D. degree in geology, and that only 65 are fully funded for four years at 150,000 euros each. This financial problem should be a major concern of the Ministry of Education.

5. The Science and Technology Policy Council of Finland, which is chaired by the Prime Minister, has recommended (among other recommendations) more cooperation between the GTK and the geological departments of the four universities. The GTK, for example, has the only radiometric isotope laboratory in the country, and the age-dating of rocks must be done there. However, there should be agreements on the costs to the universities of using that facility. There evidently are no charges at present, but it would make good business sense for the GTK to impose charges that could then be included in research proposals to the Academy of Finland. Also, GTK personnel supervise, or at least co-supervise, a large number of theses being done at the universities. In summary, there should be an increased synergy between the GTK and the universities on research and on the hiring of new graduates.

Universities of Technology

Helsinki University of Technology (HUT), Department of Materials Science and Rock Engineering: Laboratory of Rock Engineering

One of seven laboratories within the Department of Materials Science and Rock Engineering, the Laboratory of Rock Engineering provides university-wide education in the utilization of bedrock, especially underground space. It was founded in 1937 as the Laboratory of Mining Engineering, and this mission continues to a much lesser degree. In recent decades, teaching and research have emphasized engineering geology, environmental geology, and geomathematics within three key areas – rock engineering, engineering geology, and applied geophysics. The unit offers a unique combination of Earth Sciences and Technology.

The Laboratory has three professors, two Senior Lecturers, three Assistants, a total academic staff of 10-12 people, and three support staff. Docents from GTK and the Universities of Helsinki and Oulu teach specific courses, and there are other courses that can be taken within HUT. The senior faculty members are very active nationally and internationally, and two teach as Docents at the Universities of Helsinki, Oulu, and Turku. Student exchanges with other countries, especially EU countries, are encouraging.

The Laboratory, the best in the Nordic countries, is well equipped for rock mechanics and rock engineering testing and modeling.

The staff has produced several of their own textbooks and handout sets in the Finnish language. The total number of publications is good for a small unit. They are also attuned to providing information for the general public.

The unit is one of four European universities that collectively offer an eight-month European mining course. Students spend two months at each university. This also leads to international contacts and employment opportunities for graduates. Employment possibilities are diverse in both the public and private sectors.

For the three-year period of 2000-2002, the Laboratory graduated 26 M.Sc. (Tech), one Lic.Sc. (Tech), and one D.Sc. (Tech). However, in the 1997-1999 period, eight doctoral degrees were awarded. The total number of degrees, including mining engineering, since the unit's inception in 1937 are 427 M.Sc. (Tech.), 64 Lic.Sc. (Tech.), and 30 D.Sc. (Tech.) degrees.

Cooperation with Finnish companies is very extensive, as are relationships with Finnish universities, GTK and other organizations. The unit plans to increase cooperation with other universities in Finland, and to increase activity in profitable international research projects.

There are funding problems. Many external lecturers must be funded by project revenues. The lack of funding affects research, too, for money easily guides the research directions. A suggestion for consideration – because of funding problems, could students take the required basic geology courses such as mineralogy, structural geology, economic geology, hydrogeology, and environmental geology at the University of Helsinki? The applied aspects of these courses could then be incorporated into advanced courses. This would avoid duplication and would perhaps eliminate the costs of an academic position.

Helsinki University of Technology (HUT), Department of Civil and Environmental Engineering: Laboratory of Soil Mechanics and Foundation Engineering

This Laboratory is central to the Department of Civil and Environmental Engineering. Main foci of research are in theoretical soil mechanics, numerical methods in geotechnics (i.e. roads, railroads, earth dams, municipal engineering), mechanical modeling of clays, deep stabilization of clay, frost research, and foundation engineering. An over-riding emphasis is environmental engineering.

The Laboratory has seven academic staff (4 funded by budget and 3 from projects) and five support staff (3 funded by budget and 2 from projects). Docents are all paid by outside funds.

Post-graduate courses are taught in cooperation with Tampere University of Technology, which concentrates more on structural engineering rather than environmental engineering. The Laboratory is developing continuing education courses.

For the years 2000–2002, the Laboratory awarded nine M.Sc. degrees and one Ph.D. degree.

The publication record is modest, but a stated goal of the Laboratory is to increase the number of publications when long-term research projects reach completion and publishable results are complete.

The Laboratory participates in a EU network of six universities in research on Soft Clay Modeling for Engineering Practice. There is considerable cooperation with foreign institutions.

Funding remains a problem. There are no funding available for renovation of equipment. Budget funding is decreasing. There is a need for more permanent staff, rather than funding temporary staff by project income.

Tampere University of Technology (TUT), Institute of Structural Engineering: Laboratories of Engineering Geology and Foundation and Earth Structures

The Department of Civil Engineering is a significant unit in Finland in the field of Civil Engineering. The Institute of Structural Engineering, within the Department, is composed of five laboratories. Two laboratories, (1) Engineering Geology and (2) Foundation and Earth Structures, focus on technical construction. The Engineering Geology Laboratory teaches the fundamentals about soils and bedrock. The Laboratory of Foundation and Earth Structures teaches the fundamentals of the geotechnical properties of soil and soil mechanics, the dimensioning and construction of foundation structures and earth works, and foundation engineering solutions that prevent groundwater pollution.

The academic staff of the Laboratory of Engineering Geology includes one Professor, one Assistant, and eight Research Scientists. The staff of the Laboratory of Foundation and Earth Structures has two Professors, one Senior Assistant, one Assistant, and seven Research Scientists. Support personnel for the entire Institute include 20 assisting research scientists, 13 laboratory employees, and five office employees. Five Docents teach specific courses.

The laboratories are well equipped. The staff has constructed most of the test equipment.

Much of the teaching is problem-oriented. Computer-aided teaching is being developed. Interdisciplinary courses are facilitated by proximity to ten departments within the University. The institute participates in three graduate schools. The staff has written textbooks for their courses. Continuing education courses are provided for industrial personnel.

There is much applied research interaction with Finnish companies, governmental agencies, cities and smaller municipalities, 300 in all internationally, the Institute networks with more than 200 customers and cooperating units, including many universities. Some representatives of foreign universities act as thesis supervisors, evaluators, and opponents at public examinations of doctoral dissertations. Two of the institute's five Docents are from Turkey and Poland.

Annually, more than 60 publications are published in Finland (including many in the university's publication series), and 35-55 are published abroad. In addition, the Department publishes "hundreds" of articles in popular magazines and papers.

Degree data available to the Panel were for the entire Institute of Structural Engineering, which includes the five laboratories mentioned above, and are thus not comparable to the figures of the two geoscience-oriented laboratories of the Helsinki University of Technology. These figures for 2000-2002 are 46 Master's degrees, 17 Lic.Sc. (Tech.) degrees, and four D.Sc. (Tech.) degrees.

M.Sc. theses are nearly always commissioned by companies or other organizations. Since 2000, seven Master's theses in foreign countries were supervised by the staff. However, foreign students do not study at the Institute, because all courses are taught in Finnish. (The reason given for teaching in Finnish is that the Finnish Building Code requires that technical documents must be drawn up in Finnish. This seems like a bit of a rationalization – certainly the words should be easily converted to Finnish where necessary.) Funding is a problem. The government budget does not even cover undergraduate education, and the institute has to use surplus research funding for this purpose. All research funding is external. New equipment is purchased with non-budget funds. Needed expensive equipment cannot be purchased without more budget money.

Summary Statement on the Three Geoscience-Related Engineering Laboratories

The three laboratories specialize in different aspects of engineering, and appear to complement each other quite well. Evidently some duplication was eliminated when civil engineering at the University of Oulu was discontinued in 1996.

There is, and should continue to be, a demand for engineering graduates in geosciences. The numbers of graduates are presumably small because of the economic depression in the 1990's, coupled with the rapid growth in information technology (e.g. Nokia). Because of a favorable job market, most M.Sc. graduates accept jobs rather than pursue post-graduate studies. The EU has created more mobility for graduates.

There also is a shortage of students entering the Civil Engineering programs. This is somewhat inexplicable, because all graduates get jobs and it is estimated that the market could utilize three times as many graduates as are available. An economic slowdown in the early 1990's resulted in a threat of closure at TUT, students left; and this may be a factor. Also, environmentally oriented programs are more attractive to prospective students. The engineering profession will soon have an aging problem, with perhaps 200 new engineers needed each year, whereas only 100 are being educated annually. Several M.Sc. (Tech) graduates from TUT found jobs in Russia and in other foreign countries.

The laboratories are evidently having difficulty competing with industrial salaries when recruiting staff members.

Geological Survey of Finland (GTK)

We have concluded that the GTK is a large, dynamic and efficient organization with excellent facilities and a great diversity of capabilities deliverable by a highly educated and talented staff. It is indeed the premier geological organization in the country, is one of the largest geological surveys in Europe, and likely is one of the best. It is a most valuable asset for Finland for several reasons, including both basic and applied research, the search for raw materials, environmental studies, other services, and as a source of general geological information for society as a whole. Nationally, it maintains close relationships with the universities, research institutes, and industry and commerce. Internationally, it has a very wide network of contacts with agencies and organizations, and is a leader in several geoscience research areas.

The GTK was thoroughly evaluated in 1996 by a three-person International Review Committee that spent 12 days in Finland during three separate months and interviewed 85 individuals, with more than one-third of them from outside of the GTK. Their report included 33 recommendations. A majority of the recommendations have been enacted and/or are in progress.

One of the major recommendations of the 1996 evaluation was a restructuring of the GTK. This was accomplished in 2002 with the major changes as follows: the Regional Office for Southern Finland, the Research and Development Unit, and GIS services of the Communications Unit were merged into the Espoo unit; the Regional Office for northern Finland became the Rovaniemi Unit; and the Regional Office for Mid-Finland became the Kuopio Unit. This restructuring was an excellent development, one that will make the excellent GTK even more efficient and productive.

GTK has three core programs 1) Mapping, 2) Minerals and Bedrock (Precambrian) Geology, and 3) Environmental and Surficial (Quaternary) Geology – they are evaluated below.

Mapping Program

Mapping includes as major categories, bedrock mapping, surficial (Quaternary) mapping, and aeromagnetic (geophysical) mapping. The utilization of geologic maps is a part of most GTK projects. It is a given that all types of maps are needed in planning for the exploitation of raw materials in a sustainable and environmentally sound manner.

One of the long-standing primary objectives of bedrock mapping has been the discovery of metallic ore deposits and other raw materials. The large Outokumpu copper deposit was discovered in 1910 and Petsamo, a world class nickel deposit, was discovered in northeastern Finland in 1921. This region belongs to Russia now. New bedrock mapping, combined with airborne geophysics and exploration geochemistry, led to the discovery of numerous metallic deposits and mines in the decades after the Second World War.

Whereas bedrock mapping of the entire country has been essentially completed at a broad scale, much more detailed mapping remains to be done, especially in northern Finland where many of the searches for metallic mineral deposits are now concentrated.

The mapping of surficial (Quaternary) deposits appears to have lagged far behind the bedrock mapping. The Mozambique project, which involves bedrock mapping of an area of Precambrian rocks the size of Finland over a four-year period, should result in some additional field training for 50 project personnel. This project is funded by the World Bank and Nordic Development Fund. Two projects in Tanzania involve mapping mineral resources in 1/4 to 1/2 of the country.

Aerogeophysical mapping of Finland is nearly complete. The availability of this expertise for contracting by the private sector and by international projects can be financially rewarding for the GTK and is clearly valuable for customers. In 2002, 20 per cent of airborne geophysics projects were commissioned by parties outside of the GTK. Magnetic, electromagnetic, and gamma-radiation surveys can be done simultaneously. Airplanes are hired by the GTK. There are also capabilities in ground geophysics mapping.

Finland has been instrumental in the production of recent maps of the Fennoscandian Shield, in conjunction with Norway, Sweden, and Russia. Ametallogenic map of the same shield is in preparation.

Soil maps of the entire country are being prepared in conjunction with other governmental agencies. The GTK is also working with the EU on soil maps for all of Europe.

Mineral and Bedrock (Precambrian) Geology Program

Bedrock studies have long been the mainstay of the GTK. Finland's location in the center of the Fennoscandian Shield has resulted in much world-class research on these old rocks. Important studies on the development of the earth's crust have been produced by Finnish geologists. The names of Sederholm and Eskola, for example, are known the world over in petrologic circles.

The GTK has long had the capacity to undertake comprehensive multidisciplinary investigations of Finnish bedrock. It appears that this capability has been maintained and even improved. Research is continuing in the quest for base metals, gold, platinum group elements, ilmenite, calcareous rocks, and diamonds. Basic research on metals, including the modeling of ore deposits, is ongoing.

The GTK has plans to hire a new professor for noble metals (gold and platinum group elements) to be based in Rovaniemi. Some of this research is international in scope. Thus, basic research is providing a framework upon which to build applied research in exploration and mining. For example, basic research on volcanic rocks is relevant to applied research for nickel and platinum group elements (PGEs); a low PGE content may indicate that nickel ore bodies formed somewhere in the local rock system.

Another example of basic research leading to applied research and commercial involvement is in diamond exploration. Recent basic GTK research in the field and in the laboratory on diamond-bearing kimberlite pipes and dikes and on heavy mineral indicator minerals derived from the kimberlites and now present in glacial tills, have resulted in data that have interested several companies to contract with the GTK for services as part of their exploration and development programs. Such companies would probably have had no interest if the enticing data had not been available. Thus the GTK's role in diamond exploration is indeed complementary to that of industry. The diamond projects also show the importance of understanding the distributions of both bedrock types and glacial surficial deposits, both based on good geologic mapping.

A further example of how basic research can lead to interest by industry is provided by GTK research on Early Proterozoic (ca 2,300 million-year-old) glaciogenic rocks and deeply weathered rocks in North Karelia, eastern Finland. The 1993 publication is being reprinted because of the demand by basic researchers elsewhere in the world as well as by industry. Industry is interested in alumina-silica rocks that meet certain chemical requirements such as low alkali and iron content.

An increased emphasis on industrial minerals, including dimension stone, has been strengthened by the addition of a professorship in stone research, to be located in the Kuopio Unit. The GTK has also provided guidance for the new Finnish Stone Centre at Juuka in east-central Finland, the establishment of which will be a further stimulus to the stone industry. The market for stone appears to be growing in nearby St. Petersburg and elsewhere in Europe.

The Finnish Reflection Experiment FIRE, carried out with Universities of Helsinki and Oulu as a Russian debt conversion project, has generated data on the bedrock of central and southern Finland to a depth of 50-60 km. The long-term practical benefits of this basic approach are as yet unknown, but undoubtedly will surface.

A map showing areas of suitability for construction has been developed for the Helsinki region, utilizing geologic and geophysical information. Such a map has numerous environmental uses. The production of such a map for other urban areas should be considered.

Environmental and Surficial (Quaternary) Geology Program

By virtue of its past location beneath Pleistocene glaciers, Finland has long been in the forefront in the studies of surficial (Quaternary) deposits. Three-dimensional modeling of glacial stratigraphic units is essential to both the extractive industries and to groundwater distribution. In addition, these studies provide background data for climatic change.

Important strengthening of activities in several land use and environmental aspects has occurred, including in hydrogeology, peat and lake investigations, marine geoscience), soils, and urban studies. A new professorship in environmental

geochemistry, a joint arrangement with the University of Kuopio, emphasizes an increased interest in environmental problems.

Mapping of groundwater resources, especially esker aquifers near population centers, is in progress. Studies of seepage waters from mines are ongoing, with the objective of developing economic remediation measures. The GTK participates in the Barents Ecogeochemistry project that pertains to chemical pollution in northwestern Russia, northeastern Finland, and Norway. Other environmental projects have also been initiated, some only in Finland and some involving other European countries.

Survey personnel are active participants on research in paleoclimates and global change. This relates to peatland studies, for greenhouse gases, especially methane, are produced from peatlands situated above the water table. Arctic research, including permafrost studies, is an integral part of this cold-climate research.

A number of personnel are involved with the nuclear waste disposal issue, in cooperation with other governmental agencies and institutes.

International Activities

The GTK is very active in international circles, cooperating with several dozen foreign organizations. The Barents Ecogeochemistry project with Russia and Norway, and the Finnish Reflection Experiment FIRE are two of the largest ongoing projects. The geological map of the Fennoscandian Shield was completed in cooperation with Norway, Sweden, and Russia. Fennoscandian magnetic and Bouguer gravity anomaly maps were done in collaboration with Russia, Denmark, and the Baltic countries.

Several diverse environmentally oriented projects are in progress with other European countries. Research on rocks and minerals is being accomplished in conjunction with Sweden, Norway, Russia, Estonia, Canada, Australia, South Africa, U.S.A., and many other nations including most European nations.

Over the years, the GTK has had projects in 40 countries on all continents. It has an international reputation that it should strive to maintain in this global society. Whereas it could be argued that the GTK should be concerned with only Finnish projects, the international experience is educational to personnel, helps many third-world countries, and constitutes a portion of GTK income.

Geoservice Centre

The GTK laboratories offer chemical, mineralogical, and isotopic analyses. Most of these are applied applications for customers, some are for basic research, and others are free for amateur rock hunters and prospectors.

The GTK airborne geophysics group has a reputation for obtaining geophysical data wherever it is required. The Nordic, the EU, Russia, and the eastern European countries may in the future be a large market for such geophysical investigations.

A new vessel, to be ready for full service by 2005, will likely result in additional marine geology contracts.

Information Management

The GTK is the nation's prime repository for geoscience data, It has the largest geoscience library, with 1,164 periodicals (393 purchased and the remainder exchanged). More than 1,300 books and 362 maps were acquired in 2002 alone. The loan service is very active, averaging more than 30 a day. Archives are maintained and these materials are available on photocopy.

The National Drill Core Depot at Loppi about 60 km north of Helsinki has seven warehouses as a repository for drill cores from the entire country. This is a most valuable asset – literally a rock library – and must be maintained.

The excellent Mineralogical Museum is of value to both laypersons and to scientists. A Geology Day is held annually at each of the three GTK locations.

Most maps have already been digitized, and the digitization of research data is nearly complete. There are 16 GTK databases on the Internet. Maps are available to everyone on the Internet.

Publications by GTK staff in 2002 included 74 published in Finland, 31 published internationally, and 34 articles in Finnish magazines and newspapers. The Bulletin series and the Special Paper Series are excellent, allowing for in-house publication of in-depth projects. We think it is a good sign that the greatest portion of research is published in Finland. All too often, in geoscience circles, publication in an international journal is a presumed indication of the quality of the research, even when a local outlet would be a better venue for the information. Obviously, however, when the research is of international importance, it must be published in peer-reviewed international journals. This adds to the international perception of the GTK. Overall, the publication record seems to be adequate to good.

The Annual Report 2002, Special Paper 36 on Current Research 2001-2002, and a brochure entitled "Exploring the Earth" that describes the various business/ consultancy capabilities of GTK, are impressive, multicolored publications that cannot be improved. These were excellent sources of information for the Panel.

The academic staff teaches training courses within the GTK via short courses, and also offers courses for laypersons and high-school teachers. There is an amazingly broad array of information designed especially for laypersons, and personnel commonly give lectures to groups or the media. Ecotourism, including an exhibition at the new Koli National Park, is an important new area. This maintenance of the public image is good for the GTK as well as for society as a whole.

In 2002, a total of 29 staff members were Docents in the universities. The staff supervised 37 Master's theses and 30 Ph.D. dissertations, with most of the research related to GTK projects.

Personnel

The GTK has 806 personnel, including 394 academic staff and 412 support staff. It has been estimated that there are 470 geologists in the Finnish labor market; of these, some 335, or around 70 per cent are geoscientists employed by the GTK. (Definitions of "geologist" and "geoscientist" vary, but nevertheless the GTK is the major employer.)

The staff is well educated, with more than 21 per cent of the academic staff (more than 10% of the total staff) having earned Ph.D. degrees. Nearly all of the remaining academic staff possess M.Sc. degrees, and a few have Licentiate's degrees.

Recommendations for GTK

It seems that because the mission of the GTK is becoming more oriented toward applied research, the main burdens of basic research will increasingly become the obligation of the university departments. While there are four university departments, they are all relatively small compared to the GTK, and Finland's production of basic research would likely decrease without input from the GTK. Therefore, continued and even expanded cooperation with the GTK, the largest geological organization in the country, seems necessary in order to maintain a satisfactory production of basic research. Furthermore, even the university departments are, because of the necessity to seek research funds, being increasingly diverted into applied research projects.

It is imperative that the mapping be expanded while there are still GTK geologists with mapping experience available to impart their knowledge to young geologists. For the last few decades, there has been a worldwide decrease of emphasis on mapping in favor of laboratory studies. While this trend has its positive aspects, it has resulted in a generation of young geologists who commonly lack sufficient field training. This problem was also emphasized by Geology Departments in the universities. They urged even more hiring of geology students for summer positions with the GTK. The survey seems to be responding to this appeal, having sponsored a two-week field-mapping course and by hiring 60 students last summer.

The percentage of the budget spent on mapping may have increased since the 1996 evaluation, which recommended such an increase, but the breakdown of expenditures made available to us did not enable us to verify this. There are some indications that mapping has slowed in the last few years. If so, this must be rectified, for mapping is a main charge of the GTK.

One educational question that the Panel wondered about, without relevant data, is where the graduate degrees were earned. We sense that nearly all degrees were earned at Finnish universities, and indeed, that is to be expected. However, we think that this can cause excessive "inbreeding", which does not lend itself to new ideas from the outside. We would urge that the GTK make a concerted effort to have a percentage of sharp young geoscientists, whom they hope to retain as permanent employees, obtain their Ph.D. degrees from foreign universities. Perhaps a fellowship program could be developed to assist students to go abroad for at least part of their

graduate work. We understand that under the Bologna Declaration of the EU, soon to be in effect, B.Sc., M.Sc., and Ph.D. degrees will be somewhat standardized. Therefore, earning the M.Sc. or the Ph.D. degree elsewhere would be facilitated. Perhaps this could be part of the plan to replace personnel as they retire.

The aging of the GTK staff is another concern (see Figure 2). While a problem, this can also be a timely blessing. Advance strategic planning on the future expansion and/or downsizing of various departments should be accomplished now, so that staff adjustments can be accomplished by some combination of retirements and new hires. Such strategic thinking now will be very important in determining the future look and continued success of the GTK.

5.2 Geophysics in Finnish Universities and Government Laboratories

The geophysical sciences, which for the purpose of this Report are defined to include geodesy (both physical and geophysical), geomagnetism, glaciology, hydrology and hydrogeology, oceanography and seismology, constitute a very diverse array of Earth scientific sub-disciplines. In each of these areas of investigation the tools employed are unique to the endeavor and the issues which are the focus of modern research vary from global to regional. As pointed out in the Introduction to this Report, it is unfortunate that the Board of the Academy of Finland chose not to include Meteorology and Atmospheric Science within the purview of this evaluation as the linkages between this area and the others, especially hydrology, oceanography and glaciology are extremely close in modern research on the climate system and climate variability. Even in geodesy, the interpretation of modern space geodetic observations such as those delivered by the new gravity field missions GOCE and GRACE requires careful attention to the influence of atmospheric loading and of continental hydrology. In the following comments upon the individual geophysical units from which the Panel heard presentations, special attention will be paid to the issue of the integration of the individual units into the Finnish geoscience milieu as a whole. These individual units will be discussed in the same order in which they were visited.

Helsinki University of Technology (HUT), Department of Surveying: Institute of Geodesy

This unit is in the process of being revitalized as the Professor of the unit has been in his position for only three years and is working to re-orient the efforts of the unit towards geophysical geodesy from the sharply focused traditional orientation towards surveying. There is a clear recognition that in order for this process of re-orientation to be successful, it will be very important to maintain the closely collaborative relationship with the Finnish Geodetic Institute that currently exists. At present there appears to exist a serious problem in the recruitment of graduate students although it is claimed that ample employment opportunities exist for students who complete the M.Sc. degree. It does not appear that there are any students currently working towards the doctoral degree in this unit of the Department of Surveying.

From the perspective of research, on the basis of the documents provided this appears to be primarily focused on practical projects to do with urban surveying rather than

upon the work in geophysical geodesy which it is the stated goal of the Professor of the unit to pursue. Only in the context of the joint Finnish-Swedish-American BIFROST project is there any evidence of focused effort in a geophysically relevant area of research and it is unclear as to the nature of the role that the unit has actively played in project execution. The project itself has delivered excellent data clearly demonstrating the expected outwards radial motion away from the centre of postglacial rebound in the Gulf of Bothnia. Overall, the number and quality of the publications that have been produced by the unit over the past three years have been very modest. In order for the nascent Institute of Geodesy to improve it must clearly develop an energetic program to attract more graduate students to the field, perhaps by emphasizing the opportunities that might be developed through the Finnish Geodetic Institute to work on the new gravity field missions GOCE and GRACE.

Helsinki University of Technology (HUT), Department of Civil and Environmental Engineering: Laboratory of Water Resources

This is a very well established and active unit which attracts a good complement of students although it is unclear how many of the M.Sc. students continue to the more advanced Ph.D. degree (very few according to the documentation). The focus of the instruction and research in the unit is on the influence of land use upon surface hydrology and the nutrient cycle, on issues concerning the use and availability of water at a global scale and upon issues in water resource management. The group consists of approximately 20 personnel, half of whom hold only the M.Sc. degree. Equipment available to the group consists of a hydraulics laboratory for physical hydrological experiments, a water laboratory for chemical analyses and simple measurements of soil properties and several experimental sites for in-the-field measurement of different hydraulogical variables. Teaching methods employed in delivering the curriculum to students appear to be varied and modern, including the use of web-based materials and the setting of computer-based exercises, the organization of student seminars and group excursions to visit illustrative sites in the field.

Research productivity of this unit appears to be reasonable although given the number of active researchers, the number of publications in the internationally refereed literature is very modest, averaging only about seven per year for the past three years. Rather than focusing upon issues that lie at the heart of modern academic hydrological research, the group purposely chooses to focus its efforts upon practical projects which can be of more immediate benefit to Finnish society. In this regard the connection of this group to the Finnish Environment Institute (SYKE) is important and appears to be strong. The group's estimates of its own strengths and weaknesses broadly agree with those identified by the Panel. Funding levels are an issue but the field is one of growing importance internationally, and the group is well placed with its strong emphasis upon quantitative modeling of hydrological processes to train the next generation of practitioners as well as the next generation of academic researchers. It is only in the latter connection that effort will be required in the future to elevate the quality and intellectual depth of the research program so that it will be possible to attract the best young minds to the modern discipline of hydrological

science. It would appear that the linkage to the Finnish Meteorological Institute is rather poor and this would have to be rectified if the field of hydrology at HUT is to truly blossom. If this connection could be developed it would lead to a capability within the group to contribute in the area of global water cycle modeling, an area of intensive growth at the international level. For example, it is in the contract of the WCRP program GEWEX (the Global Energy and Water Cycle Experiment). We found it surprising that the group seemed to be entirely disconnected from this enterprise.

University of Oulu, Department of Geosciences: Geophysics Division

This Division of the Department of Geosciences is a small, high-quality group working in traditional areas of solid Earth geophysics, namely electromagnetic induction related methods as well as seismic sounding. These techniques are applied in the general area of lithospheric geophysics and supported by work on inverse theory to develop rigorous methods by which to infer the sub-surface electrical and mechanical properties of the Earth. The group is also engaged in a number of topics in Applied Geophysics associated with the search for mineral deposits located in the Precambrian lithosphere of the Fennoscandian shield and with the application of methods designed for the solution of environmental problems (AMT = audio magneto telluric method, GPR=ground penetrating radar). Although small in size, the group appears to be very well connected internationally as evidenced by the large number of international collaborative projects in which it is involved. Many of these connect the research of the group to pan-European projects, especially in deep seismic sounding (e.g. EUROPROBE, SVEKALAPKO, BEAR, FIRE). Several of the members of the group are active in the committee structures of the International Union of Geodesy and Geophysics, a further clear indication of engagement in the global network of geophysical scientists.

Insofar as the postgraduate teaching contributions of the group are concerned, there does appear to be some problem with the recruitment of graduate students, unsurprising perhaps as the undergraduate enrollment is also very small with only 4-5 students majoring in the subject in any given year. Approximately the same number of doctoral students is also active in any given year, with one such degree being granted in each of 2000 and 2001 and none in 2002. During the period 2000 – 2002 altogether five Lic.Sc. degrees have been awarded. No M.Sc.'s have been awarded since 2001. Although the group has effectively only three Ph.D. level faculty, though it also lists all of its students as "academic personnel", it is still surprising that so few students are attracted to the subject.

Concerning the research productivity of this unit, the group lists approximately eight refereed publications in the refereed international literature each year. This is not outstanding but it is a very solid performance, even considering that several of the journals in which the publications appear are not those that have highest impact in the field. The co-authorships evidenced in the cited papers provide a clear demonstration of the highly collaborative nature of the projects in which members of the group are involved. The linkage of the group to other units in Finnish geophysics is also evident in the ongoing co-operations in geophysical education with the Helsinki University of Technology, the University of Helsinki and the Finnish

Meteorological Institute. The list of institutes with which members of the unit are collaborating is also very impressive although it has been difficult for the Panel to determine the depth of these interactions.

The SWOT analysis provided by the group of its own strengths, weaknesses, opportunities and threats is especially consistent with the findings of the Panel. It will be important for the funding agencies to recognize that this group is potentially entering a period of instability due especially to the difficulty of recruiting graduate students. The latter circumstance is recognized as being connected to the difficulty graduating students have finding appropriate employment.

University of Oulu, Sodankylä Geophysical Observatory (SGO)

This observatory in Sodankylä was founded in 1913, initially for the purpose of conducting measurements of the Earth's magnetic field. Later, especially since the time of the International Geophysical Year in 1958, SGO has been developed as a very versatile geophysical observatory in the worldwide network of observatories, which is now responsible for measurements of the main magnetic field, auroras, magnetic pulsations, ionosphere, magnetosphere, cosmic rays and seismic events. The observatory runs many field stations in Northern Finland and Scandinavia in close collaboration with the Geomagnetism group at Finnish Meteorological Institute and the Institute of Seismology, University of Helsinki. It also participates in many international projects (SVEKALAPKO, FIRE, EUROBRIDGE, TESZ, POLONAISE, CELEBRATION 2000, ALP2002). At present there are two units of SGO, which are under the present evaluation, namely the Magnetic Unit in Sodankylä and the unit in Oulu. The Magnetic Unit is responsible for monitoring variations in the main magnetic field. It has only two academic personnel, the most senior being an M.Sc. level person, who will be reaching retirement age in the next five years or so. The Oulu unit, being responsible for seismic observations, similarly has only a single academic staff member, who will also be reaching retirement age within one year.

The two units of the observatory appear to be modestly productive of scientific results with two papers listed for 2000, six for 2001 and seven for 2002. This speaks moderately well for the level of activity and engagement of SGO scientists in creative research. In order for this element of the Oulu geoscience community to continue to prosper will require that the University of Oulu carefully consider the funding that will be required to stabilize the operation with the imminent retirement of staff members.

University of Oulu, Department of Process and Environmental Engineering: Water Resources and Environmental Engineering Laboratory

This is a new unit established in 2000 as a consequence of the decision to terminate the teaching of civil engineering at Oulu in the period 1998-2001. The foci of current research in the unit include the remediation of contaminated soils, contaminant transport, the hydrology of eskers and peatlands, water quality at both specific sites and at the catchment scale, lake and wetland treatment systems and numerical modeling and design. The unit has two Professors plus one Emeritus Professor, a chief

engineer and two permanent assistants working in the area of applied hydrology and two researchers funded through specific projects. In addition it has 10-15 Ph.D. researchers and 15-20 M.Sc. students. The group appears to deliver a comprehensive basic module of courses to its students as well as an advanced module including a research seminar, a course in advanced geoenvironmental engineering, a course on contaminant transport and modelling in water courses, Environmental assessment in water resource engineering and a course in Environmental management structures. It operates laboratories for soil and environmental engineering, hydraulics, and water quality measurement. Its plans for the future include the pursuit of work in surface water hydrology and hydraulics, the application of isotopic tracers in surface and subsurface hydraulogy, ground water and soil and peat properties engineering, remediation of contaminated soils and cold climate studies.

Insofar as research connectivity of the group is concerned, both within Finland and internationally, several projects have been pursued in the period 2000-2003 with a variety of collaborating institutes and organizations. Unfortunately, the documentation describing the detailed objectives of these projects was extremely thin and so it is difficult for the Panel to comment upon them. The cause for considerable concern regarding this unit is the very small number of publications that has been produced in the four-year period 2000-2003. Only two refereed papers have been published in the Finnish literature in this period, and none internationally. The majority of the published items, either in Finland or internationally, have appeared as unrefereed Conference Proceedings. This is clearly an area that requires serious attention.

University of Helsinki, Department of Physical Sciences: Division of Geophysics

This unit forms one component of the Department of Physical Sciences that recently relocated to the new Kumpula Campus of the University. It consists of two subdivisions, respectively of Hydrosphere Geophysics and Solid Earth Geophysics. In the former area there are two Professors and in the latter area, one. In the area of Hydrosphere related research there is effort ongoing in continental hydrology, glaciology and oceanography. In the area of solid Earth geophysics there exists research streams on supercontinent formation and dispersal, on impact cratering, and on meteorite petrophysics. The unit appears to be very well organized and managed. Although the group is small it has chosen its foci of effort well, areas that are of significant interest from an international perspective. It is able to provide a comprehensive education in geophysics to its students by drawing upon the talents of docents recruited from the more specialized institutes active in the areas of geodesy (FGI), oceanography (FIMR), geology (GTK) and seismology (Institute of Seismology, and SYKE).

Insofar as internal and international linkages and partnerships are concerned, the group appears to have a number of collaborative activities underway in all of the research areas in which it is active. In the hydrosphere area most projects are focused upon the Baltic Sea and issues connected to sea ice and/or coastal oceanography or upon the impacts of climate change upon the dynamics of lakes. In the solid Earth Geophysics area the main project appears to be that involving the application

of paleomagnetic and rock magnetic measurements to the understanding of supercontinent formation since the Archean epoch of Earth history. The international connectivity of this unit is also expressed in its memberships in the ERASMUS, SOCRATES, ESF and NorFa training programs.

The contributions of the group to the literature in its field are quite respectable, both in terms of editorial responsibilities and in the production of individual research publications. In terms of refereed publications in the international refereed literature the group has averaged approximately eight papers per year for the past four years with large numbers of conference papers both in the Finnish and international literature. Generally speaking the papers are appearing in journals of reasonable quality although only a small number have been published in the highest impact journals (e.g. JGR, GJI, JWR, etc.).

There is a clear danger facing this group in that the Division of Physical Sciences within which it functions has reduced its annual budget. This appears to be extremely ill advised as the existing group provides the nucleus that could be developed into a first-rate Geophysical Sciences Institute. The opportunity for building an enhanced Finnish presence in this area is clear by the fact that the FIMR, the Institute of Seismology, and the Finnish Meteorological Institute are all to be or have been relocated to the Kumpula campus area. It is the collective opinion of the Geoscience Evaluation Panel that the union of these elements would provide Finland with an extremely powerful earth science conglomerate that would be highly significant even from a larger European perspective. It is our strong recommendation that effort be made to take maximum possible advantage of the close proximity of these individual units from both a teaching and research perspective.

University of Helsinki, Institute of Seismology

The Institute of Seismology operates directly under the Senate of the University, a special status related to its responsibilities in seismic monitoring in support of the Comprehensive (Nuclear) Test Ban Treaty, and in other observatory activities as well as in seismological research. Its scientists participate actively in the education program in geophysics of the University of Helsinki. The roster of personnel includes 14 academic staff and approximately 16 analysis and technical personnel. There are also a number of M.Sc. students (5) currently working as research assistants. An important component of the monitoring activity involves the operation of the FINES small operative array that is used for CTBT verification for the CTBTO. The Institute has also contributed importantly to the understanding of lithospheric structure through its leadership role in the FIRE deep seismic reflection profiling project, a project very similar in intent to the recently completed Canadian LITHOPROBE project. Several of its academic personnel continue to be active in international professional organizations.

Insofar as the number and quality of ongoing and recently completed research projects is concerned, the Institute continues to maintain a reasonably high profile. It has worked actively with European and other partners in projects as diverse as FIRE, which has provided baseline data of importance for the understanding of the

structure and evolution of the crust of the Fennoscandian Shield, and SVEKALAPKO. One subproject of the latter was a deep seismic array tomography experiment conducted in Europe in the period 1998-1999. The additional seismic refraction based CELEBRATION 2000 project was the largest deep seismic sounding experiment ever performed in Europe and is proving to be helpful in the construction of geodynamic models of the central European lithosphere, whereas the follow-on project ALP 2002 has been designed to continue the coverage of the CELEBRATION 2000 Project southwards into the eastern Alps and neighboring areas. Additional projects such as POLONAISE and EUROBRIDGE are adding further coverage of the European crust and lithosphere.

Insofar as the scientific productivity of this group is concerned, it has averaged some five papers per year in the refereed international literature. This is not especially high level of publication for such a large group and many of the items listed as "important scientific publications since 2000" have appeared in relatively low impact journals. This relatively low productivity is in part related to the fact that no Ph.D. dissertations in seismology were completed at the University of Helsinki in the period 1999-2003. This decline in interest in this core discipline of the geophysical sciences is of course not restricted to Finland but is rather widespread internationally.

In its own SWOT analysis the Institute noted that it feels threatened by the possibility of upcoming administrative changes. In the opinion of the Panel it may well be, however, that such "administrative changes" will be required in order to revitalize the Institute, particularly as a number of experienced support staff are approaching retirement age. The Ministry of Education might consider this an opportune time to consider uniting the Institute of Seismology within a larger geophysical sciences complex.

Finnish Institute of Marine Research (FIMR), Department of Physical Oceanography

This is an excellent unit focused upon the delivery of important observational data and model predictions that are crucial in the areas of navigation and marine security, coastal construction and marine technology, and environmental protection. Operational groups are active in the areas of sea ice observation/prediction and wind waves and sea level. Although the primary reason for these operational programs is to support the safety of commercial shipping activity, the data collected is also of importance from the perspective of climate monitoring. The data obtained from the Finnish network of tide gauges, for example, is reported to the Permanent Service for Mean Sea Level in Bidston, data which is employed to monitor the ongoing rise of global sea level due, in part, to the ongoing global warming of surface temperature. Since the landmass of Finland is currently rising out of the sea as a consequence of the ongoing isostatic adjustment of the solid Earth in response to the removal of the Fennoscandian ice sheet that covered the region at Last Glacial maximum 21,000 calendar years ago, the relative sea level data are also important for the analysis of the isostatic adjustment process and have been employed in the context of the joint Finnish-Swedish-American BIFROST project.

Areas of active research in this unit include work on currents and hydrography, polar oceanography, air sea interaction, global and climate change and the development and utilization of remote sensing measurements. The work in the area of polar oceanography that has been undertaken by members of the group is of especially high quality from an international perspective. The issue of high latitude ocean convection and the generation of deep water that this process induces is one that lies at the heart of one of the most important issues in modern climate system research, and the papers that the group continues to produce in this area in leading scientific journals are a credit to the FIMR. Although the unit has no direct educational function, its scientists do occasionally supervise M.Sc. and Ph.D. students and many do teach courses in various aspects of oceanography at the University of Helsinki. The group also provides training in oceanographic measurement to students, both Finnish and foreign, during cruises of its research vessel the R/V Aranda in the Baltic Sea and Arctic Ocean. The group is also very well integrated with the Finnish Meteorological Institute (FMI). It is also deeply involved in a large number of international oceanographic programs in collaboration with German, Swedish, American, Italian, Norwegian and Danish colleagues.

Given the ever increasing importance of oceanography and oceanographic knowledge to our understanding of the climate system and climate variability generally, it will be important for Finnish geoscience that the country significantly increase its investment in this area so as to address the weaknesses that have been identified by the DPO scientific leadership. The group is in danger of losing several of its senior scientists to more financially competitive organizations, if a concerted effort is not made to address concerns over salary and to put in place appropriate mechanisms to ensure the further development of the careers of the younger scientists. In the view of the Panel, a significant further problem derives from the lack of a well established group in oceanography in the network of Finnish universities although the recent appointment in this area in the Division of Geophysics at the University of Helsinki should help. Careful consideration should be given to establishing a graduate school in oceanography in the very near future in order to focus the renewal process in this field, a critically necessary action as the staff complement on the DPO is aging and a concerted effort will be required to ensure continuity and the maintenance of capacity.

Finnish Environment Institute (SYKE), Hydrological Services Division

This unit, originally established in 2002, consists of three distinct groups, one working in the area of hydrological monitoring, one focusing on watershed modeling, and a third working on geoinformatics support. Of the some 30 persons involved in the work in this area, approximately 2/3 are permanent, and ten hold temporary appointments working on specific applications. The responsibilities entrusted to the unit are those of a national hydrological service, and it is strongly connected with the World Meteorological Organizations community working in the area of hydrological sciences. The activities in which members of the group are involved breakdown into four primary areas, respectively (1) basic data collection and the development of the information systems required to gather and disseminate it, (2) hydrological

modeling and the use of these models in event forecasting, efforts that require both the development and the maintenance of a national capability in this area, (3) the provision of on-demand data services and expert services in the area of hydrology, and (4) the conduct of research in specific projects and the publication of research results. Rather than being an organization primarily focused upon research, this unit is clearly focused upon a national mandate to provide hydrological services, importantly related to river discharge monitoring.

In the areas of teaching and research, the level of activity of this unit is rather modest although the monitoring work being done is of a good quality. Some members of the unit do teach or have taught in university hydrology courses, but this contribution is not viewed as significant. The productivity of the unit insofar as research is concerned is also rather low, perhaps unsurprisingly since this is not a key component of its mandate. This is a good example of a unit whose work could be elevated considerably by the presence of a single creative scientist working on the climate/hydrology interface.

Finnish Environment Institute (SYKE), Water Resources Management Division

This operational unit is involved in the area of water course regulation and water course management, including the assessment and analysis of dam safety and of the predictability of ice cover formation and breakup in rivers and the prevention of ice dams in rivers. The group is also engaged in the mapping of flood risk. It is engaged in the development of means to enhance the sustainable use and care of water resource and water supply, of sewage disposal and of ways to prevent the occurrence of damage caused by exceptional water situations. These functions are those of an operational area of government rather than of an organization focused upon education and research. This will be clear by virtue of the very small number of employees who hold academic qualifications above the level of M.Sc. Although a few students have been mentored in their M.Sc. projects at University of Helsinki, University of Oulu and HUT by employees of the unit, the numbers involved have been small. At least one member of the group has given a full course in the area of geophysics at the University of Helsinki.

Insofar as the research output of this unit is concerned, this must also be viewed as extremely modest. Even though the list provided is impressively long, few of the items listed are actually peer reviewed publications that have appeared in the open international literature. Many are simply abstracts that have been reproduced in Conference Proceedings or unrefereed professional reports. Although the work upon which this unit is focused is apparently of good quality and of considerable value to the nation, it does not have a significant academic component.

Finnish Geodetic Institute (FGI), Department of Geodesy and Geodynamics

This is a large and active unit working in an area that is of fundamental interest to the international scientific community, one that has a highly credited history of involvement in addressing the most important problems in geodetic science, especially those that reside on the geodesy/geodynamics interface. The history of

Finnish work in this area, beginning with that of Heiskanen on isostasy and Väisälä on optics and precise leveling is, in many ways the history of the science itself. The relatively recently constructed new buildings in which the Institute is now housed provides an excellent home for a truly first rate scientific organization. The Geodesy and Geodynamics Unit is the heart of the organization.

The responsibilities of the Department of Geodesy and Geodynamics include the measurement and maintenance of the national spatial and gravity networks and the connection of these to the networks of neighboring countries as well as to the International Terrestrial Reference System ITRF, and its European component EUREF. The group is also responsible for the operation of the Metsähovi research station where important work is ongoing in satellite laser ranging and gravity measurements based upon both superconducting and absolute "g" instruments, the latter of the Faller (Joint Institute for Laboratory Astrophysics in Boulder, Colorado) design. In the near future the work at Metsähovi will expand to include Very Long Baseline Interferometry. Also the responsibility of this Department is research undertaken based upon the use of data from the Finnish tide gauge network as well as the work required to maintain the FinnRef permanent GPS network that continues to play an important role in the BIFROST Project. All of these duties fall under the mandate under law to perform the fundamental geodetic, astronomic and gravimetric measurements required for the mapping of the Finnish land mass.

The data that has been collected in recent years, especially that from the array of permanent GPS receivers has played an important role in the development of increased understanding of the ongoing postglacial rebound of the crust that is centred in the Gulf of Bothnia and which therefore strongly influences the vertical datum of all of Fennoscandia.

Insofar as the international connectivity of the members of the Department of Geodesy and Geodynamics is concerned, this is very strong as approximately 2/3 of the 12 permanent personnel are so involved, especially the head of the unit. The research equipment available to researchers of the unit is modern and well maintained although the level of human resources is indeed less than appears sensible given the wide range of responsibilities that the Department carries. A special effort will also be required in the very near future to improve the software available for data processing capability, as has been pointed out in the information provided to the Panel.

Although the unit functions as a professional research institute outside of the network of Finnish universities, there is nevertheless a high level of participation by the personnel in lecturing at both the University of Helsinki and HUT. At the former, all geodesy lecturers are provided by Department personnel. A small number of students from these universities have completed their M.Sc. and Ph.D. degrees under the supervision of scientists at the Institute (2 M.Sc. degrees in 2001-2002 and 2 Ph.D. degrees in 2003). Given the quality the science that may be accomplished in the area of geodynamics using the resources of the Institute it will be important in the future to increase the number of graduate students involved. Increased

involvement of younger scientists would be expected to also have a positive impact upon the number of refereed journal publications produced by members of the unit.

Although it has been the stated goal of the Department in recent years to "increase the number of papers published in international peer reviewed journals", the impact of this commitment has yet to lead to exceptionally strong results although the productivity is respectable for an institute whose primary responsibilities are in the areas of monitoring and measurement standards. Further effort to improve this situation will clearly be required in the coming years.

Given the quality of the scientific contribution that is being made by this Department of Geodesy and Geodynamics it is the recommendation of the Panel that the staffing level should be increased in order to enable the group to function at a higher level of visibility in the refereed international literature. Increased investment in the new work in space geodesy and in the level of participation in the new satellite gravity missions GOCE and GRACE would pay large dividends for Finnish science.

Finnish Meteorological Institute (FMI), Geomagnetism group and Nurmijärvi Geophysical Observatory

This is a small sub-group of the Geophysical Research Division (GEO) of the FMI in which approximately seven persons are involved. Its work is done partly in GEO in Helsinki and partly in the Nurmijärvi Geophysical Observatory (NUR) located about 40 km to the north of Helsinki. Issues of interest (at Nurmijärvi) include studies of both the internally generated secular variation and externally generated variation of the main magnetic field in Finland and Estonia. Aside from some applied work, the Observatory is also involved in a program of long-period magneto telluric measurements in southern Finland. At Helsinki in FMI, there is a continuing program on the analysis of geomagnetically induced currents in power lines and pipelines. Data for the latter purpose are analyzed at GEO. Work is also ongoing in the construction of models of the main magnetic field and in the use of the archive of magnetic measurements from the period 1844-1912 for the analysis of space weather. Three Ph.D. level scientists are involved in the sub-group together with two persons involved in field recording, two persons involved with data processing and a secretary. Two M.Sc. and one Ph.D. in this area have been produced in the past four years (2000-2003).

Research projects in which the unit has been involved in this period include the Baltic Electromagnetic Array Research (BEAR) which involved geomagnetic and magnetotelluric surveys and the collaboration of some ten institutes, GIC analyses supported internally by Gasum Oy, the Geomagnetic Survey of Estonia in the period 1998-2000, which involved two Estonian institutes and space weather studies conducted with the University of Oulu and other groups.

The publication record of this group is modest, averaging some three papers per year in the refereed international literature. Several of these papers did appear in high-impact journals.

5.3 Geoinformatics Units

Geoinformatics: Earth observations, space-borne data (Remotely sensed images and aerial photographs), cartography and geo-information.

The Geoinformatics domain is strongly related to the emerging global concepts of Information Society (IS) and Information Communication and Technology (ICT). These notions have various scales of relevancy: on the one hand there are the dramatic changes concerning communication possibilities (networks, satellites etc.), and on the other hand a real strategic and politic position from national authorities all around the world. IS is highly technologically driven through industrial innovation and development (cell phones, computer facilities, positioning capacities etc.). The role of the European Union in this context is predominant in promoting and supporting the economic impacts of new technologies.

Finland is one of the more mature European countries in the development of the Information Society, and e-government services in particular (Accenture, 2003). The current action plan set out by the Finnish *Information Society Advisory Board* outlines actions along four strategic lines: reforming administrative activities and processes; improving access, usability and end-user competence; attaining better administrative coordination, with a named authority or organization to be responsible for the implementation and follow-up of the implementation of each action point (GINIE, 2003).

The Nature of the Geoinformatics Community

These trends have also transformed the status of Information within the economic sector. The numeric form of spatial information (from analogue to digital) has opened a wide range of possibilities for transforming the nature, the creation and the marketing of information. Digital format allows circulation, high-speed exchange, duplication and combination of information processes. In this context Geographic Information (GI) has also acquired a specific value. Indeed, more that 80 per cent of all the information used daily by decision-makers or end-users are located on the Earth's surface. GI associated with Geographic Information Systems (GIS) has initiated the rapid expansion of a new economic sector.

"The potential of GI and data to underpin a great number of governmental policies, and related implementation and evaluation agendas started to be obvious to those who understand the possibilities of GI and the associated technology" (GINIE, 2003). GI has featured for a long time as an integral part of the Finnish government's records. As an example, Finland routinely assigns x,y coordinates to every citizen and their medical record, thus enabling analysis over time and space of the potential causes of disease at the level of individual patients.

Decision-makers require reliable, adaptable up-to-date and easily usable information in the majority of planning and preservation actions: waste management, environmental protection, urban development etc. It is anticipated that a coherent, easily accessible clearing-house facility for administration and public needs is the

next step of this general trend. This trend has forced the European countries and US states to develop national initiatives in order to set up a unique spatial reference data system. It is not surprising that Finland was one of the first in the wave of European countries to develop its National Spatial Data Infrastructure (NSDI).

GI is considered to be a strategic tool to reinforce government actions over territories and beyond. There has been a massive amount of work done dealing with the environmental issue in a range of preparations for the Infrastructure of Spatial Information in Europe (INSPIRE). This initiative for co-ordinating the European effort to facilitate exchanges through reliable "clearing-house structures" corresponds to a major future issue in such context. In Finland, the Finnish Council for Geographic Information (FCGI) co-ordinates the data policy and the NSDI development. Several actors are actively involved: the FCGI, the Finnish Standards Association SFS dealing with the SDI's technical standards; the National Land Survey (NLS) is responsible for the real estate register and topographic databases; the Ministry of Agriculture and Forestry (MAF) is coordinating the development of the Land Parcel Information System, and the Ministry of Justice is supervising the land register. Among its tasks several can be pointed out: to promote wider use of GI, to foster economic efficiency in data collection and data services, and to specify any general research needs in the GI sector. The Land Information System (LIS) managed by the NLS, integrates both rural and urban information systems to provide a common service for the whole country.

The development of the Information Society has been one of the major policy goals of the EU since the Maastricht Treaty (1993). The integration of trans-European networks in transport, energy and telecommunication was a specified target of the Treaty. Thus the term IS has come "to encompass the set of policies, initiatives and investments needed to boost economic growth and competitiveness, and support the development of a society strongly based on the creation and use of information-related knowledge, products and services" (GINIE, 2003). Development of GI and ICT leads to the increase of technological disciplines (computing, electronics, physics, engineering, geoinformatics etc.). The emerging sector of GI has provided a wide range of economic opportunities for start-up enterprises, as has been the case for telecommunication sector. Technology transfers are essential for economic development. The possibility to produce numeric geographic data for various purposes has led to further growth of the GI market. Data is involved of course, but software and hardware technologies are involved as well.

In order to promote wider use of GI, the preparation of future generations is required. The high level of research and education in Finland is an important strength in this regard. There is a wide range of professionals, in all European countries involved in GI, such as specialists in surveying, geography, and information technology. It is clear, however, that there is a lack of skilled interdisciplinary generalists and experts who are able to facilitate communication between disciplines. The increasing involvement by local authorities in national programs and projects also leads to a higher demand for educated people in GIS and geoinformatics capacities in general. The challenge to universities is to both increase the production of specialists and incorporate additional interdisciplinary studies to cover the connections between them.

Environmental studies need basics in any studies of natural or earth sciences (geography, ecology, geology, hydrology, forestry, etc.). Geoinformatics may be started at the beginning of the university studies for a Geographic Information speciality, or it may appear as a complement to other environmental curriculum.

Other concepts currently in vogue, such as *sustainable development and global change,* explicitly emphasize the links between Geoinformatics and the Geosciences. In order to locate, acquire, integrate, and interpret various observations of the Earth System, geoinformatics capability is required. Spatial and temporal scales of observation, advances in numerical modelling, and developments in imaging increase the use of new technologies and support the intensification of Earth science research. Earth resource location, preservation and conservation actions, health care and a variety of other society-based issues all benefit from geoinformatics capacity. There are also situations in which GI undoubtedly provides an essential source of information (natural hazards, environmental assessment, natural inventories, etc.). But the potential of this technical capability is not fully used at present, as there is currently inadequate knowledge of it and special skill in its application.

In this context the health of the Geoinformatics units is clearly an issue of major importance. The development of this sector needs to be reinforced in order to promote knowledge and skill dissemination. Interdisciplinarity needs to be encouraged across the geosciences but with mathematics, the IT sector and the social sciences as well.

As has already been mentioned, the professors, lecturers and assistants in the GI area are typically much younger on average than their counterparts in other areas of geoscience. This can be clearly seen in Figures 2a and 2b which show that in GI the relative age distribution is strongly skewed towards the younger age categories, whereas the distribution for the other domains of geology and geophysics is close to a normal distribution ranging from 40 to 50 years of age. This property of the GI units evaluated by the Panel must clearly be taken into account in assessing their quality and potential.

The location of some of the university-based units (Joensuu, Oulu, Turku) might suggest the possibility of establishing a spatial network useful for collecting and developing the knowledge and skill base in remote areas, particularly in Lapland and the border regions. However, such remote areas often have trouble utilizing the centralized computer services based in Helsinki. The Panel has been made aware of the fact that pedagogical efforts are sometimes constrained by difficulties regarding electronic connectivity. If computer facilities and software have to be shared by all units through high-speed connections to the CSC via FUNET, the connectivity must have sufficiently high bandwidth and be also sufficiently reliable to serve all interested units. This issue of connectivity is very important to the groups located outside of the Helsinki Metropolitan Area.

Besides the difficulty faced by the Panel because of the young and limited scale of the GI units, there was also the problem of imbalance because of the strength of photogrammetry and remote sensing (RS) compared to GI. The long history of RS activities has led to the creation of a fruitful environment for the integration

of methods and technology. This is not yet the case for the younger GI units the activities of which, in the absence of a strong RS background or relationships to the geosciences, are often considerably less structured and less productive. As some of these units are embedded in geography departments, it has proven difficult for the Panel to properly assess the quality of the research being performed as well as the level of pedagogical activity and the level of financial support being received. These imbalances have contributed to the difficulty experienced by the Panel in the evaluation process.

Helsinki University of Technology (HUT), Department of Surveying: Institute of Cartography and Geoinformatics

The professorship in this area was first established in 1988 under the direction of the Geodesy Institute. The separate Cartography and Geoinformatics Institute was founded in 1999 and appears to be one of the major players in the field of Geoinformatics in Finland. Despite the rather small number of permanent faculty (1 professorship, 1 lecturer and 1 assistant), it has been able to successfully promote courses in cartography and GIS in HUT. The teaching programme in cartography and GIS currently consists of 25 courses offered over a period of several years and has proven attractive to foreign students as well as those from Finland.

The recent decision to add a second professorial position (donation professor for five years) will definitely increase the impact this unit. The relationship to natural or earth sciences will also become more effective through this additional professorship (shared with Department of Civil and Environmental Engineering). The necessary adjustment period required for the unit to absorb the growth has occurred, and the benefits of the educational involvement and the research development of the members are visible in the realm of research: Uncertainty, metadata quality, user interfaces and usability of GIS, multidimensional and multi-visualization etc. These directions are definitely important as will be clear on the basis of the interactions managed by the unit (Finnish Defence Forces, Helsinki Metropolitan Area etc). Skilled people will find employment opportunities in the development of GI in administration, local authorities, private companies etc. The networking actions, which have been initiated through the Virtual University, or Geoinformatics Graduate School, need to be followed up and supported. A concerted effort must be made to significantly increase the number of publications that appear in the refereed international literature.

Helsinki University of Technology (HUT), Department of Surveying: Institute of Photogrammetry and Remote Sensing

This unit was developed in the early 60's through the creation of a Chair of Photogrammetry. Since then it has evolved with the development of technology. In 1987 a specialized study program introduced the discipline of remote sensing. Since 1994, new digital Image processing methods have strongly influenced the character of the research work. This unit is a widely recognised centre for Photogrammetry and Remote Sensing (PRS). All of the activity in the unit is based upon images employed for both acquiring and managing geoinformation. Applications include

environmental monitoring using satellite imagery, large-scale urban mapping using aerial imagery, 3-D virtual modelling of buildings, industrial plants and the natural environment. The number of researchers currently on the payroll is approximately 20, half of whom are postgraduates. The Institute is very well known for the application of laser scanning of urban and rural environments, for 3-dimansional digitization using video-imagery and for the use of perspective transformations for analytical photogrammetry. It participates actively in international scientific co-operation through commissions (ISPRS - SDR), or international remote sensing programs funded by the EU or ESA (OMEGA, ENVISAT) or more photogrammetric ones (Mexico or Jabal Haroun). The targeted research domains are of first order interest for decision-making and environmental modelling, but the work could be enhanced by increasing its international visibility.

The impact of this unit is also apparent through the strong links it has developed with Finnish surveyors, universities and the Finnish Geodetic Institute. The Institute participates to the Remote Sensing Graduate School that has been funded by the Ministry of Education and the Academy of Finland (2003-2006). The participation in the national NAVI program has instituted co-operation with other Finnish partners in "Mobile mapping" together with the Finnish Geodetic Institute. The involvement of the unit in life-long learning possibilities will contribute to the increase of knowledge of the general population in this field. Problems of continuity may drive the future development of the unit as senior scientists occupy the major positions. This unit is without any doubt a very strong and innovative element in Finnish geoscience research.

Helsinki University of Technology (HUT), Department of Electrical and Communications Engineering: Laboratory of Space Technology

This unit was founded in late 1980's. It began as part of the Radio Laboratory of HUT in the 1970's. Separating Remote Sensing (RS) technology and application developments led to the formation of the LST. In the 70's and 80's, the work focused on microwave RS. Radiometers and radar sensors have been exploited for ice and snow applications in order to extract geophysical parameters. Theoretical research concentrates on the development of models to describe dielectric properties of soil, snow and ice. Some specific devices have been designed and built (HUTSCAT, a helicopter-borne sensor) in the late 80's to provide a reference system for the ESA ERS1 sensor. In the 1990's, the number and volume of research programs increased and led to the purchase of an aircraft in the mid 90's. Visible/IR channels for space and air-borne data observation (water quality of inland lakes and the Baltic Sea), development of airborne microwave radars and radiometers has consolidated the position of LST in worldwide RS organisations (ESA, NASA etc.). Several instruments have been designed, the last being the synthetic aperture radiometry for ESA's SMOS mission (global moisture and ocean salinity mapping). This unit is of primary importance for the Finnish remote sensing community. It has a leadership role in space education within the geoscience disciplines. The LST Coordinate the Remote Sensing Graduate School. The management of the aircraft seems to be a crucial issue, and arrangements must be made (though sharing costs with other units). Some difficulties have also appeared in connection with the recruitment of senior staff.

Finnish Environment Institute (SYKE), Geoinformatics and Land Use Division (GEO)

The SYKE is the national environmental research and development centre of the Finnish environmental administration. Research and development in the SYKE deals with changes in the environment, cause and effect relationships, means of resolving environmental problems and effects of policy measures. It is the national environmental information centre and provides expert services and takes care of certain national and international statutory tasks.

The Geoinformatics and Land Use Division was founded in 1995 and is responsible for geographic information and remote sensing activities of the Finnish Environment Administration. As such it has some mandatory tasks: to provide databases for the administrations, to buy and verify data, to prepare data for end-users which include, for instance, the EU Natura2000 program and the National Land Survey databases etc. The environmental GIS established by GEO is one of the first operational environmental spatial data infrastructures to become operational. The research areas in the unit are directly linked to the priority areas of the environmental administration in Finland and closely related to the overall tasks of the SYKE.

In the Remote sensing domain, GEO has an operational task regarding environmental monitoring. In collaboration with the universities, it is involved in snow melt forecasting, water surface temperature and quality estimation and land cover mapping (EU Corine landcover programme). The staff members participate, either on a regular basis or occasionally, in the teaching of courses at universities. The GEO Unit is also a member of the RS graduate school. The unit also has a professional impact in environmental administration through its yearly GIS days event.

GEO is a good unit, with skilled and motivated people. Its international position assures some research funds through international or ESA or EU projects(ENVISAT, Envisnow, CLC2000) in collaboration with universities (HUT, or other institutes such as FGI). It is anticipated that more partnerships would be of major interest to universities. As teaching is not the main task of this division, it is important to emphasize that future relationships between universities and the GEO Unit would be a useful means through which to further develop the fields of RS and GIS in Finland.

In the units own SWOT evaluation, it has been stressed that the requirement for permanent positions is still a critical issue for this Division. The Panel suggests that an increase in the number of permanent employees and a reduction in the number of part time employees would help this unit to increase the recognition that it receives both nationally and internationally.

University of Turku, Department of Geography: Laboratory of Computer Cartography (UTU LCC)

The Department of Geography was among the first to adopt computer cartography in the late 1980's. It very early considered GI as a key development area. The UTU

LCC was founded in 1995 with a mission to provide researchers and students of the university with top-class facilities for geographical information handling. From RS to GIS to "GI clearing house" to navigation services, a very broad range of applications developments has been investigated. The Department of Geography has established a strategic plan that includes strong links to geoinformatics. In addition, a close relationship with the Faculty of Mathematics and the Natural Sciences is under development (this will involve a further English language based program on Environmental Science). One of the primary goals of the Institute is to further cross disciplinary research and innovation.

It is a truly interdisciplinary unit shared with the Departments of Geology and Biology, offering the opportunity to geoscience students and staff to familiarize themselves with GI and to integrate GI methods into their own practises and pedagogical work. It provides a large set of facilities (computers, A3 scanner, various software etc) for the use of all interested members of the community. Thematically, the research topics pursued include environmental research, urban and regional studies and applied geoinformatics. Application of RS and GIS methods to environmental topics favours relationships with geologists or biologists. Geoinformatics research, on the other hand, focuses on principles and methods of spatial data combination and visualization. One of the goals is to stimulate cross-disciplinary research and innovation. A wide spectrum of projects, from environmental research to exploration of new cartographic solutions has been ongoing.

The participation of the unit in several European programs or national ones (NAVI, LUMOONET– biodiversity clearing house) and networks, illustrates the depth of its involvement in research and teaching. The relationships are being strengthened through the RS graduate school, and the Virtual University project. Good relationships have been built with Finnish universities and research institutes. One of the problems the faculty has to face, in common with other research and education groups, is the policy for data access through the database as well as data prices for imagery. The costs for a university unit might be prohibitive for educational use or for research being sponsored through programs.

The UTU LCC is one of the key players in GI education and research in Finland.

University of Joensuu, Department of Geography: Geoinformatics

The Department of Geography established a senior Assistant Professorship in Geoinformatics in 2002 in co-operation with the Department of Computer Science, the Faculty of Forestry and the Department of Statistics. It seems to be far too early to provide an evaluation of this unit.

It may nevertheless be observed that its activities seem remote from the actual trends in this field in Finland. Strong co-operation with other GIS units will be necessary to introduce and promote GIS and GI background in the Department of Geography and other units of the university that have proposed the establishment of an international Master's level course focused on the topic of boundaries. The development of this geoinformatics unit is considered to represent a real opportunity

to integrate GI into actual research interests and to emphasize the importance of GIS in transboundary work as this is being developed in Europe as a whole (ORATE-EU, or even in Finland within FGI). The Department is attached to the Geography Graduate School.

In order to further develop Geoinformatics within the department it will be necessary to support its initial activities in GI and to promote networking activities through Virtual teaching and the exchange of students and lecturers until such time as the unit is able to offer a complete set of Geoinformatics courses.

Tampere University of Technology (TUT), Institute of Structural Engineering: Laboratory of Geoinformatics

Tampere University of Technology has ten departments. The Department of Civil Engineering has two institutes: Structural Engineering and Construction Economics. In 1995 the Institute of Structural Engineering was established. The focus has been on technical construction know-how supported by information technology in civil engineering and in research and education. The Institute of Structural Engineering consists of the following five laboratories:

- Laboratory of Engineering Geology (road construction, aggregate and natural stone, landscaping and environmental material and construction);
- Laboratory of Foundation and Earth structures (mechanical properties, instrumentation, mechanical behaviour modelling, municipality and environmental geotechnics and pile foundation engineering;
- Laboratory of Geoinformatics (measurement technology in construction and civil engineering, modelling of structures, computer aided design, db, facility management and information networks);
- Laboratory of Structural Engineering (structures en design of structures, buildings physics and resistance).

This unit is not directly connected with geosciences and only slightly associated with common GIS work. Nevertheless, a wide range of activities has been developed in the area of data bases structure and management. The involvement in economic, local and environmental domains is dynamic through very good connections with the private sector. The expertise represented appears to be well recognized in the Nordic regions.

The Geoinformatics Unit is specialized in databases and data structures. It is involved in ICT systems in surveying and in building information technology. The main topic is the integration of information systems and ICT services via web capacity. Companies as well as cities and universities are its usual partners in research and applications development. This unit is distinctly different from the others in that it is primarily directed towards civil engineering results oriented research. It benefits from the high level of expertise within the Institute and its international networks, but it may suffer from the "old-fashioned" image of civil engineering and student disaffection.

Finnish Geodetic Institute (FGI)

The FGI was founded in 1918 as a mapping institute. The main responsibility of this organization is for fundamental geodetic, astronomic and gravimetric measurements. A restructuring of the whole organization has been accompanied by the development of both new research directions and new management rules. FGI acts as an expert authority and provides required spatial references for the entire country. The numerous collaborations and the international recognition of FGI competence are two important aspects of the integration of FGI in the international geosciences arena. Some research domains are shared between departments: Map updating, mobile cartography and data quality. One of the institutional goals is to become a centre of excellence at the Scandinavian level in various domains. Thus the impending retirement of skilled and motivated people constitutes a challenge for the future.

Department of Geoinformatics and Cartography

The Department was founded in 1987. At that time no research was being performed in this area and no professors had been appointed in this domain in all Finland!! FGI appears to have become a precursor to increased involvement in this field nationally. Kirsi Makkonen (present name: Virrantaus -HUT) and Tapani Sarjakoski have developed efforts in data collection, modelling, storage, analysis, usage, communication and visualisation of spatial information that have become especially important. The change in the name of the unit from its original form 'Department of Cartography' to its current form 'Department of Geoinformatics and Cartography' reflects how research in GIS has led to the international recognition of geographic information science (geoinformatics) as a discipline of its own.

Generalization (maps and geospatial information) is a very important issue for map design and delivery. Within the stream of mobile communication (PAD, Navigator, cell-phone etc.) there exists a huge need for real-time generalization techniques. Actually the need for interactive media for spatial information delivery has been strongly pushed by the ICT sector: e.g. web-GIS with interactive information points for mobile applications. Internet-based delivery of geospatial information, mobile cartography and small-display cartography for mobile devices are the actual research topics of the unit. Two topics illustrate the importance of these issues: The GiMoDig project (EU-Geospatial info-mobility service by real-time data integration and generalization) is an example of this innovative trend. The unit's participation in the national NAVI program (VTT, Navinova Ltd, Navi Program/Consortium) provides the unit with the possibility to highlight its research in the applied domain. The NAVImap project is one part of the department's effort to support the development of the national spatial data infrastructure (NSDI) in Finland.

Currently the increasing rate of data exchange requires that quality of data be reinforced as well as the quality of the standard-interfaces. Such standard interfaces and transfer methods for geospatial information are vital in the era of network-based data processing and delivery. Quality assessment and the handling of uncertainty of geospatial information is one component of the department's

involvement in methods development. The DEM project is a good example in this context. Mandatory tasks have also been illustrated through the SLICES land use data base that encompasses the whole of Finland.

The unit has gained in experience and competence in the geoinformatics domain and will certainly have an extremely important role to play in the future. The transfer of technical and methodological competences, as in the work with Espa System (Ltd), a young company that has been created in the field of digital photogrammetric techniques with GIS, for further development and commercial application, is an illustration of innovation capacity. The involvement of the staff in the teaching of university courses (HUT, University of Helsinki) is a necessary activity for the dissemination of knowledge and for the provision of thesis support.

Department of Remote Sensing and Photogrammetry

The Department, which was founded in 1977, is an outgrowth of the evolution of FGI from an organization focused solely upon geodesy into a national mapping research institute covering all of the mapping sciences. FGI is one of the first such organizations to develop region-based and knowledge-based approaches to the analysis of remote sensed and ancillary data, work which was developed in the 1990's.

Collaboration with other institutes is well developed and is demonstrated by the transfer of methodological prototypes, such as the snow melt monitoring system provided to the Finnish Environment Institute. The Department also has close connections within the Institute to the Department of Navigation and Positioning, the Department of Geoinformatics and Cartography and the Department of Geodesy and Geodynamics. The Department also participates in various programs linked to EU issues such as the national Integrated Agricultural Control System, the Land Parcel Identification System (LPIS), and the Finnish counterpart of the Crop Growth Monitoring System.

The Department of Remote Sensing and Photogrammetry is one of the most innovative and important in Finland. One of the objectives of the unit is to become the leader in mapping research by 2010. The involvement in teaching and disseminating knowledge through lectures in universities or placements in FGI has grown and will be further developed. International competencies are recognized in several domains (Synthetic Aperture Radar, Lidar calibration, laserscanning integration etc.) techniques and developments. In the key SAR and digital photogrammetry research area, four topics related to the CORE projects have been carefully defined. The participation in EU programs with other institutes or units (EUREKA) provides international networking and assists in building the Finnish RS research structure. The graduate school also offers the unit a good opportunity to train young researchers coming from HUT and from other Finnish universities.

University of Oulu, Department of Geography: Geoinformatics

This unit is a component of the Geography Department of Oulu. It is a rather recently established unit with a GIS and RS senior Assistant Professor position allocated

since in 2001 (until 2004) and a Professor position granted in 2002, which is to last until 2006. The professorial position was been partly sponsored (1/3 salary) by the collective contributions of 28 municipalities. This may be a partial explanation for the small number of graduate students (4) currently enrolled in the program.

The primary research areas of the unit are related to two distinct themes, namely Human geography (geodemographical grid cell research) and Physical; geography (remote sensing, geospatial modelling and northern environment projects). Other projects are also being conducted in collaboration with the Finnish Game and Fisheries Research Institute. The unit also participates in the Arctic Graduate School that is coordinated by the University of Lapland, and has collaborated in the Geoinformatics Graduate School Project with University of Helsinki, HUT, University of Turku and University of Jyväskylä. Through the mechanism of the Virtual University, students are able to take GI courses at all these universities.

It seems vital to strengthen the relationships with other GIS units in Finland in order to provide education and research support. Contacts and common undertakings have already been successful through the SCANGIS 2003 exhibition in collaboration with HUT and participation in the Virtual University. The location of Oulu should allow the Department to play a very important role in GIS education and research in the Lapland region. Other research regarding land use, sustainable use of natural resources, or reindeer pasture projects, benefit from SYKE or other administrative support.

University of Helsinki, Department of Geography: Geoinformatics

This unit was only recently established (the Professorial position was created in 2002) within the Department of Geography. Since geoinformatics has become an intrinsic part of all branches of geography in both education and research (software, hardware and methodology), it is difficult to describe it separately. Recent years have seen the strong development of geoinformatics through new course offerings as well as the funding of visiting lecturers

Geoinformatics is being developed through diverse disciplines and themes: e.g. monitoring the status and change of the environment; characterization of geomorphologic processes; description of urban space: spatio temporal GIS related data for health applications (a traditional topic for the department). RS data processing and analysis methods are also being strongly developed in collaboration with other university departments (agriculture and forestry) or other universities (HUT, UTU LCC). Several research projects have enabled the unit to expand its range of competences: e.g. the EU projects, OMEGA together with HUT, and Academy funded projects, BRDF and TAITA. GIS and remote sensing programs have increased through a wide range of collaborative projects (FGI, FMA, FFRI, FARI, SYKE, VTT, and universities).

A major role has been played in restructuring and enhancing the geoinformatics communities in recent years in collaboration with HUT and UTU LCC. The Unit has participated in the Graduate School in geoinformatics proposal and co-ordinated

the Virtual University Project entitled "GIS in teacher's education" (funded by the Ministry of Education in 2001-2004). The unit also participates in the Virtual University in geoinformatics that is co-ordinated by HUT and funded by the Ministry of Education in 2004-2005.

The geoinformatics unit must be preserved and strengthened. The wide range of environmental studies that is covered offers the possibility of active participation in the geosciences generally. The new generation of people is aware of the necessity to collaborate and to develop international programs in education and research. The involvement of these people at diverse levels of decision making in GI and NSDI actions is essential. Professorship funding initiatives are substantial advertisements of the municipality's interests that are already visible but may also provide a good means through which to guarantee success in the long term.

University of Helsinki, Department of Forest Resource Management: Geoinformatics

Regarding the Finnish interest in forestry, there is a long tradition in the teaching of this subject, which began in 1907. This domain has tracked technological progress in all of observation, inventory and management. GIS and RS are two of the most important research and teaching subjects of the Department. GIS and RS applications are integrated into the field together with statistical sampling techniques forest inventory analysis, and monitoring and modelling to describe the development and current state of forests. GIS courses were established in 1998-1999, and at the same time a graduate school entitled "Forests in Geographic Information Systems" was funded, which operated in 1998-2002 in collaboration with FFRI, NLS and VTT as well as with other organizations. This school involved 13 researchers. Prof. Tokola began in 2002 by providing GIS education for the entire faculty. The unit has developed a strategic plan to guide future developments, involving among others changing one professorship in forest technology to one in logistics GIS. A new assistant is scheduled to begin in 2003.

The high level of the unit's results guarantees the capacity for research development of both the Department and local private-sector firms. The schedule of research is clearly designed and is realistic within the existing areas of competence. The use of multiscale extraction and segmentation techniques is a major area of remote sensing research as is also the area of 3-D measurement. It is anticipated that the methodological results obtained in this research may be useful for other environmental purposes as well. Despite the relatively young age of the members of this unit it does appear to be both innovative and dynamic within the forestry sector. The contacts established with other University of Helsinki Departments, geography and computer science in particular, and with other universities, for example HUT and University of Joensuu, stress the importance of networking activities.

6 General Recommendations

In general, we rank the level of Finnish geosciences as good to very good/excellent, but note that there is room for improvement.

1. We have ascertained that much of the research in the university geology departments is quite traditional. That is not necessarily a severe criticism, for traditional lines of study undoubtedly remain important, and in fact provide the core of geologic knowledge. Understandably, most research is based upon Precambrian rocks and Quaternary deposits, which comprise virtually all of Finland's geology. Nevertheless, a great deal of attention must be paid to continuing advances in the geosciences. Obviously, no scientist should remain entrenched in his or her past activities and methodology, but should be alert to changes and be committed to a lifelong learning process.

2. In the area of the geophysical sciences several of the units which the Panel evaluated were found to be of exceptionally high caliber. The Geodetic Institute in particular is clearly in this class and is amply deserving of increased investment in both the core geodetic measurement programs in the applied areas in which it is developing leading edge technology in the area of mobile mapping. The science of geodesy has come to occupy an extremely central position in modern geophysical science and Finland is positioned to further develop its presence in this area internationally in the era of the Galileo constellation of GPS satellites.

3. Finland is similarly well placed to participate in the rapid development of geoinformatics, although many of the units active in this area have been established so recently that it has proven difficult to do them justice by way of this evaluation process. This is a young field for which there is rapidly increasing demand for well trained practitioners, not only in GIS but also in other areas of application.

4. Not only is it important to see researchers and teachers involved in lifelong learning on a personal basis, but we think much more emphasis should be given by universities to providing adult educational opportunities for former graduates and other scientists. This is much more important today than a few decades ago, for we are now aware of the negative impact that humans are imposing upon the environment. Therefore, interdisciplinary knowledge and research is of utmost importance. Not only should this knowledge be provided to scientists, but to the general public as well. An informed public makes for a better functioning society, and society today is becoming, step by step, a more global society.

5. Generally, the faculties of university geoscience departments throughout the world have included specialists in various subfields of geoscience. This has both positive and negative aspects. While covering a wide and necessary range of teaching and research topics, this has commonly also led to compartmentalization. Much of this is unavoidable because of the small size of each such department. Commonly, individual faculty members, with one or a few graduate students, constitute the

research team in a given subfield. With upcoming retirements common in the university system, there should now be opportunities to make critical strategic decisions on future hires to as to better establish research/training teams (i.e., research groups), even if such teams are to consist of only two staff members. Such situations, along with the involvement of interdisciplinary staff members, may result in "clusters" on a small informal basis and to increased productivity.

6. Internationalization. The Panel is impressed with the national emphasis on internationalization, and thinks it is very broadly applicable to the geosciences. We perceive the existence of considerable "inbreeding" of Finnish geoscientists because of the dominance of degrees earned in Finland. This is apparently not only a Finnish problem, but is endemic to European universities in general. The European Bologna Declaration (1999), reaffirmed in Prague in 2001, stated that efforts to promote mobility within European countries "must be continued to enable students, teachers, researchers, and administrative staff to benefit from the richness of the European Higher Education Area, including its democratic values, diversity of cultures and languages, and the diversity of the higher education systems. One aspect of the Declaration is a standardization of Bachelors, Masters, and Doctors degrees. Thus educational mobility (e.g., earning of a degree from elsewhere within the EU, or joint degrees, or even just a semester or two of foreign study) provides an important opportunity that could help rectify the perceived problem of provinciality and expand both knowledge and employment opportunities. Interchange with non-European universities and governmental agencies should also be expanded. A side-effect of such exchanges could be worldwide research and employment opportunities in a global framework. We note that the Academy of Finland is promoting such international cooperation.

7. Clusters in Helsinki. We are impressed with the planning that has gone into the Kumpula campus of the University of Helsinki. This is a science complex that will in the near future include not only physics, atmospheric science, chemistry, mathematics, computer science, geology and geography, but also the Finnish Meteorological Institute and the Finnish Institute of Marine Research. The Helsinki University of Technology is near, as is the Finnish Geodetic Institute. It seems that some creative thinking in terms of the cluster concept, whether formal or informal, would greatly stimulate interdisciplinary collaboration among these units. There is a real opportunity here to create an internationally significant Centre for research in the geophysical sciences, broadly speaking.

   Clusters in Oulu. University of Oulu, located under a single roof, seems to be a perfect setting for interdisciplinary cooperation between the Department of Geosciences (geology and geophysics), geoinformatics in the Department of Geography, the Water Resources and Environmental Engineering Laboratory of the Department of Process and Environmental Engineering and various units within the Faculty of Technology.

   Clusters in Turku. The proximity of University of Turku and Åbo Akademi University has already led to cooperation by the establishment of Geocentre Turku. We were not provided information on this, but presume it is a rather

informal union. Again, it seems that there is a real potential for developing a cluster of cooperating units, including geoinformatics that is within the Department of Geography of University of Turku, and the Department of Chemistry. University of Turku already has a Center for Environmental Research but we are not sure about the viability of this center as we were not provided such information.

Clusters in Universities of Technology. It seems that cooperation between laboratories within and between the two universities of technology already exists, although we were not provided with much information in this regard. There is a considerable number of laboratories within each university. Can intra-university and interuniversity cooperation be expanded for the common good?

Related to clusters would be increased cooperation between, for example, the university geoscience departments. We presume that this goes on continually, but to what extent is the question.

8. Increased visits by foreign scientists would provide stimulation for both faculty and students in every department, and also result in better international visibility for each Finnish department. Specialties not offered within a department can thus be show-cased, or specialties within the subfields of staff members could result in joint research projects. Cooperation between departments could help minimize the costs to individual departments. For example, a visitor could fly to Finland and spend a week or two in each of three or four departments presenting short courses in each one. Similarly, funding would encourage the exchange of postdocs for durations of a year or two. The Academy of Finland is supportive of such developments.

9. We are impressed with the national strategy and the number and depth of national studies by organizations such as the Science and Technology Policy Council of Finland and the Academy of Finland. Such depth of study may be unprecedented elsewhere. Commitment to increasing Finland's research and development potential is further enhanced by general funding increases planned for universities and the Academy of Finland over the next few years (to 2007). This shows great foresight.

10. A related issue is the increased pressures on the university departments to do more applied research, thus directly benefiting society. And indeed, much outside funding seems to be related to applied research. But then where will basic geological, geophysical and geoinformatics research be accomplished? There is a danger in placing too much emphasis on applied research, thereby minimizing basic (fundamental) research. Finland's geoscientists have contributed to basic Earth Science knowledge for over a century, and should continue to do so. Furthermore, basic research is commonly the base upon which to build applied research. Large American universities receive appreciable funding for fundamental research from industry. Applied research spin-offs from the basic research can ultimately benefit industry.

11. It seems that there should be more cooperation between university departments and the GTK, the FGI and the FIMR. Universities are logical places to conduct basic research, thus advancing the boundaries of knowledge. However, the four geoscience departments in Finnish universities are very small compared to the institutes, and the total output of basic research can never compare to the potential from these larger structures, especially the GTK. The GTK evidently has been given a mandate to concentrate on applied research, but a large number of staff members are well qualified to do basic research and want to do some, as they have done over the past decades. Cooperation would thus be of benefit to all parties in Finland, and also to the global context of geoscience.

12. Drilling is an expensive part of mineral exploration, and so the preservation of drill cores for future study and mineral assessment is both prudent and wise. Present Finnish regulations require that mineral exploration conducted under a claim has to be reported, including supplying representative drill core samples to the Loppi Core Depot within a certain period after the expiry date of the claim. However, if a company has explored without filing a claim and beyond the area covered by proper claims, there are no obligations, and valuable information may become lost or remain unrecognised. This is of concern in other countries, too. For example, laws requiring the saving of drill core exist in Minnesota, Wisconsin, Michigan, Alberta, and in several other states and provinces. In Ontario, it is not required, but enlightened companies are cooperating because they realize it is in their own best interests for future exploration. Ontario provides a financial credit for drilling a hole if the company furnishes a drill log, and further credits are given for the expense of moving the core to storage facilities. The core storage program must be continuously supported and regulatory deposition of other kinds of exploration data should be given added emphasis in Finland.

Appendix A

Letter to the Evaluators (28.5.2003)

Dear Evaluator,

At its meeting on February 24, 2003 the Research Council for Natural Sciences and Engineering appointed an evaluation panel whose mission is to carry out the national evaluation of geosciences in Finland. The panel consists of the following members:

- Professor W. Richard Peltier, University of Toronto, Canada
- Professor (Emeritus) Richard W. Ojakangas, University of Minnesota Duluth, USA
- Director Christiane Weber, Laboratoire Image et Ville, France
- President Tuomo Mäkelä, Outokumpu Mining Oy, Finland

Professor Peltier will act as the chairman of the evaluation panel. Contact information is enclosed to this letter.

Dr Timo Huttula will act as the secretary of the evaluation panel.

The evaluation panel work in Helsinki is based on the self-evaluations and other material delivered by the geoscience units. Info meeting and dinner is arranged on August 24 afternoon (17:00). The idea is that the panel meets for the first time and there will be some general information about research and education in Finland. The site visits to units in Helsinki, Turku and Oulu will take place between August 25 and 29. The site visits are quite short. If there is half an hour reserved for a unit then the unit can use 10 minutes to present some issues and the rest 20 minutes are reserved for questions of the panel. On August 30 the panel will draft the evaluation report. The schedule of the site visits is enclosed to this letter.

The Academy will pay your travel and accommodation costs as well as a honorary reward for your service. Concerning your travel and accommodation arrangements you are recommended to contact directly the Travel Agency Area at the Academy (e-mail akatemia@area.fi, tel. + 358 9 7748 8322 or +358 9 7748 8329), or scientific secretary Anu Huovinen (anu.huovinen@aka.fi).

We send you with this letter the filled self-evaluation forms and the other material delivered by the units. All the evaluation material is sent to every panellist. We enclose a list where the primary responsible panellists are suggested for each unit. To help your work we enclose also some information about the evaluation, the updated list of the research units, three example evaluation reports and a panellist's evaluation form. You can use the evaluation form as a checklist of the important topics considered. You can either photocopy more of them or obtain the forms by e-mail from us. There is also enclosed an annual report 2002 of the Academy of Finland, Academy in Brief –brochure, Research in Finland –brochure and Finnish Universities 2002 -brochure.

Please contact us if you need some more material or information.

With kind regards,

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Enclosures:

- Contact information
- Site visit schedule
- Information about the evaluation
- Updated unit list
- Unit list with primary responsible panellists
- Three example evaluation reports
- Panellist's evaluation form
- Self-evaluation forms and other material delivered by the units
- Annual report of the Academy of Finland 2002
- Academy in brief –brochure
- Research in Finland –brochure
- Finnish Universities 2002 -brochure

Appendix B

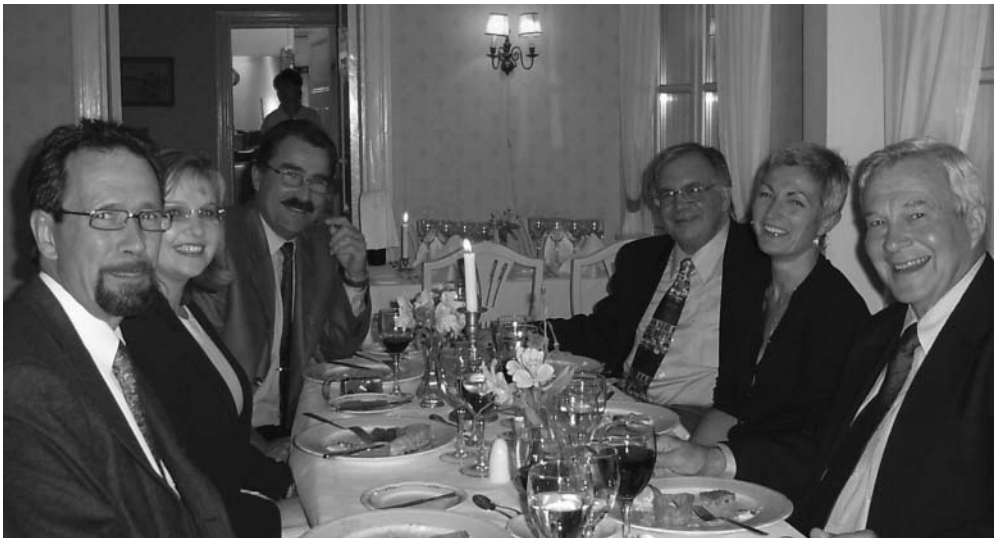
Geoscience Evaluation Panel

Professor W. Richard Peltier (chairman)
Department of Physics
University of Toronto

Professor Richard W. Ojakangas (Emeritus)
Department of Geological Sciences
University of Minnesota Duluth

Dr Christiane Weber
Laboratoire Image et Ville / Director
Université Louis Pasteur

Mr Tuomo Mäkelä
Outokumpu Mining Oy / President



Panel members and assisting Academy staff, from the left Mr Tuomo Mäkelä, Science Adviser Anu Huovinen, Dr. Timo Huttula, Professor Richard Peltier, Dr. Christiane Weber and Professor Richard Ojakangas

Appendix C

A) GENERAL INFORMATION

Table 1. General information

University, research institute or other organisation	**Department or equivalent**	
Address	**Postal code**	
Research Unit	**www / internet**	
Head of the Unit	**Phone**	**Email**
Contact person in self assessment	**Phone**	**Email**

1. Describe the administrative position and role of your Geoscience Unit within your main organisation.

2. How are the steering functions organised for your Unit?

3. Give a short history of your Geoscience Unit. Also indicate which fields your Unit has developed in relation to Finnish geoscientific research in general. Maximum length one page.

4. At the present, what are the focus research areas at your Unit and reasons for selecting them?

5. Describe and evaluate briefly the objectives and strategies of your Unit. Describe how they are related to the strategies of the main organisation.

6. Use Table 2 to indicate the funding of your Unit since 2000.

Table 2. Funding of the Unit since 2000

Financier	Purpose of use	Funding period	Amount (kEUR)	Working months

B) ACADEMIC AND SUPPORT PERSONNEL

7. Use Table 3 to indicate the academic personnel of the Unit during 2000 - 2003.

Table 3. Academic personnel of the Unit during 2000 - 2003

Name	Position and degree	Period of employment	Age & gender	Source of funding	Field of research	Nationality

8. Give statistics of the support personnel during 2000 – 2003.

9. Give information about the development of human resources and employment at your Unit since 2000. What plans do you have for the personnel development in the future?

10. Give information about additional scientific activities of the personnel since 2000 (memberships on boards of scientific associations or other bodies, evaluation tasks within the scientific community, opponent of doctoral dissertations etc.).

C) RESEARCH FACILITIES AND EQUIPMENT

11. Use Table 4 to indicate the main research facilities of your Unit and possible sub units.

Table 4. Main research facilities of the Unit and possible sub units

Unit / sub unit	Number of personnel	Task of the sub unit	Main research equipment

12. Use Table 5 to indicate the resource development done since 2000 at your Unit. List the major changes in research facilities, including field research equipment.

Table 5. Resource development since 2000

Year	Major changes in research facilities

13. What are the main strengths of your present research facilities? Are you satisfied with the present situation and what are the major development needs?

D) TEACHING, RESEARCH TRAINING AND SUPERVISION

14. Use Table 6 to indicate the number of students and degrees (for universities only).

Table 6. Education

	2000	2001	2002
Students enrolled at the department with geoscience as major subject, specify the subject:			
Bachelor's degrees			
Master's degrees			
Doctoral students			
PhLic degrees			
PhD degrees			

15. Use Table 7 to indicate the Master's, Licentiate's and Doctor's theses supervised by the Unit personnel since 2000.

Table 7. Master's, Licentiate's and Doctor's theses supervised by the Unit personnel since 2000

Name of the student	University	Year of Master's Degree	Year of PhLic Degree	Year of PhD Degree	Supervisor	Placement (employer) of the student after graduation

16. How are teaching activities arranged at your Unit? How does your Unit benefit from these activities?

17. Use Table 8 to indicate the teaching activities of the personnel since 2000.

Table 8. Teaching activities of the personnel since 2000

Name	Position	Degree	Teaching activities	Time spent in teaching / month (%)

18. Describe the teaching methods at your Unit and evaluate their effectiveness.

19. How are the quality assurance aspects organised, monitored and developed at your Unit?

20. Describe the participation of your Unit (students, supervisors) in graduate schools.

21. Give information about other forms of training that your Unit provides in the field of geosciences.

22. In your opinion, what is the role of your Unit in the national geoscientific education?

E) RESEARCH

23. Use Table 9 to indicate research projects of your Unit during 2000 - 2003.

Table 9. Research projects during 2000 - 2003

Name of project	Field of geosciences	Duration of project	Number of personnel employed	Working months	Partners

24. Describe briefly main research projects and their objectives at your Unit since 2000.

F) PUBLICATIONS AND PRESENTATIONS

25. Describe the objectives of your Unit in publishing scientific, professional and popular articles.

26. Assess the scientific quality and impact of the publications produced by your Unit.

27. Use Table 10 to indicate publications and presentations since 2000.

Table 10. Publications and presentations since 2000

	2000	2001	2002	2003	In press
Published in Finland:					
- Articles (with referee practice)					
- Articles, reviews, conference papers					
- Monographs, books and edited volumes					
- University's/institute's publication series					
- Invited presentations					
In total					

Published abroad: **- Articles (with referee practice)**					
- Articles, reviews, conference papers					
- Monographs, books and edited volumes					
- Invited presentations					
In total					
Articles in popular magazines or papers					
Other products:					

28. Use Table 11 to indicate the editorial tasks or memberships in editorial boards of scientific journals during 2000 - 2003.

Table 11. Editorial tasks or memberships in editorial boards of scientific journals during 2000 - 2003

Name	Scientific journal	Task	Years

29. Use Table 12 to indicate the most important scientific publications since 2000 and papers accepted to be published.

Table 12. Scientific publications since 2000 and papers accepted to be published

Publications

G) COOPERATION IN FINLAND

30. Identify your Unit's national research cooperation partners in geosciences.

31. Give information about the results and productivity of this research cooperation. Give some concrete examples.

32. How do you cooperate and coordinate geoscientific education between your Unit and other Units? Do you find the present practice satisfactory?

H) INTERNATIONAL COOPERATION

33. Describe the cooperation (in research, teaching and researcher training) between your Unit and international partners. Give list of institutional partners and projects.

34. Give information about the amount of working time the personnel of your Unit has spent abroad since 2000. Also give information about the amount of foreign visits to your Unit since 2000.

35. Describe and evaluate the impact and results of international cooperation.

I) SOCIETAL IMPACT

36. In what ways have the needs of Finnish society and industry related to geosciences been taken into account in your Unit's teaching and research?

37. Give information about the societal impact of your Unit. Describe the cooperation of your Unit with bodies of public administration and other organisations.

38. Give some concrete examples of your activities in popularising your field of geosciences (*studia generalia* lecture series, activities within the Open University, adult education etc.).

39. Identify the IPRs (patents, patent applications, copyrights etc.) and other commercialised products at your Unit since 2000.

40. Assess the labour market in Finland and abroad. Describe and evaluate the employment situation of the graduated (bachelor and master) and post-graduated (PhD) students of your Unit and generally in your field of geosciences. In your opinion, what is the competence level of geoscience graduates in the labour market?

41. List some of the main employers where your students have found a long-term employment.

42. According to your estimate, what proportion of graduates leave Finland to work abroad and what are the main reasons for this (researcher training, to obtain professional experience etc.)?

J) SWOT – STRENGTHS, WEAKNESSES, OPPORTUNITIES AND THREATS

43. Use table 15 to evaluate your Unit's strengths, weaknesses, opportunities and threats.

Table 13. SWOT

Strengths	**Weaknesses**
Opportunities	**Threats**

44. Visions of your Unit's activities by 2008.

K) ADDITIONAL INFORMATION

45. You can add any relevant information for the help of the evaluators. Note that the basis of the evaluation is this questionnaire.

Appendix D

List of the Geoscience Units and Contanct Persons

Universities

University of Helsinki – Department of Geology
Professor Juha Karhu

University of Helsinki – Department of Physical Sciences – Division of Geophysics
Professor Lauri Pesonen

University of Helsinki – Institute of Seismology
Director Pekka Heikkinen

University of Helsinki – Department of Geography: Geoinformatics
Professor Petri Pellikka

University of Helsinki – Department of Forest Resource Management: Geoinformatics
Professor Timo Tokola

Helsinki University of Technology – Department of Surveying – Institute of Geodesy
Professor Martin Vermeer

Helsinki University of Technology – Department of Surveying – Institute of Cartography and Geoinformatics
Professor Kirsi Virrantaus

Helsinki University of Technology – Department of Surveying – Institute of Photogrammetry and Remote Sensing
Professor Henrik Haggrén (contact secretary Marika Junttila)

Helsinki University of Technology – Department of Materials Science and Rock Engineering – Laboratory of Rock Engineering
Professor Pekka Särkkä

Helsinki University of Technology – Electrical and Communications Engineering – Laboratory of Space Technology
Professor Jouni Pulliainen

Helsinki University of Technology – Department of Civil and Environmental Engineering – Laboratory of Soil Mechanics and Foundation Engineering
Professor Olli Ravaska

Helsinki University of Technology – Department of Civil and Environmental Engineering – Laboratory of Water Resources
Professor Pertti Vakkilainen

University of Oulu – Department of Geosciences
Professor Tuomo Alapieti

University of Oulu – Sodankylä Geophysical Observatory
Director Tauno Turunen

University of Oulu – Department of Geography: Geoinformatics
Professor Jarmo Rusanen

University of Oulu – Department of Process and Environmental Engineering – Water Resources and Environmental Engineering Laboratory
Professor Bjørn Kløve

University of Turku – Department of Geology
Professor Matti Räsänen

University of Turku – Department of Geography: Geoinformatics
Professor Risto Kalliola

Åbo Akademi – Department of Geology and Mineralogy
Professor Carl Ehlers

University of Joensuu – Department of Geography: Geoinformatics
Dr. Jaakko Suvantola (M.Sc. Mika Pirinen)

Tampere University of Technology – Department of Construction Engineering – Institute of Structural Engineering
Professor Hannu Salmenperä
- Laboratory of Foundation and Earth Structures
- Laboratory of Geoinformatics
- Laboratory of Engineering Geology

Research Institutes

Geological Survey of Finland, GTK
Communications Director Caj Kortman

Finnish Geodetic Institute
Director General Risto Kuittinen
- Department of Geodesy and Geodynamics
- Department of Geoinformatics and Cartography
- Department of Remote Sensing and Photogrammetry

Finnish Institute of Marine Research – Department of Physical Oceanography
Head of department Jouko Launiainen

The Finnish Environment Institute SYKE
- Geoinformatics and Land Use Division: Division manager Yrjö Sucksdorff
- Hydrological Services Division: Division manager Markku Puupponen
- Water Resources Management Division: Division manager Ilkka Manni

Finnish Meteorological Institute FMI – Geomagnetism group and Nurmijärvi Geophysical Observatory
Group Manager Heikki Nevanlinna

Appendix E

Sun 24.8.2003 **INFO MEETING 17:00, Scandic Hotel Simonkenttä, TAPIOLA room**
DINNER 19:30, Restaurant Bellevue

Mon 25.8.2003 **Helsinki University of Technology,**
Department of Civil and Environmental Engineering, meeting room K1

8:00 – 8:30
Helsinki University of Technology – Department of Surveying – Institute of Geodesy
Professor Martin Vermeer

8:45 – 9:15
Helsinki University of Technology – Department of Materials Science and Rock Engineering – Laboratory of Rock Engineering
Professor Pekka Särkkä

9:30 – 10:00
Helsinki University of Technology – Department of Surveying – Institute of Cartography and Geoinformatics
Professor Kirsi Virrantaus

10:15 – 10:45
Helsinki University of Technology – Department of Surveying – Institute of Photogrammetry and Remote Sensing
Professor Henrik Haggrén (contact secretary Marika Junttila)

11:00 – 11:30
Helsinki University of Technology - Electrical and Communications Engineering - Laboratory of Space Technology
Professor Jouni Pulliainen

11:45 – 12:30 LUNCH, university restaurant Dipoli

12:45 – 13:15
Helsinki University of Technology – Department of Civil and Environmental Engineering – Laboratory of Water Resources
Professor Pertti Vakkilainen

13:30 – 14:00
Helsinki University of Technology – Department of Civil and Environmental Engineering – Laboratory of Soil Mechanics and Foundation Engineering
Professor Olli Ravaska

Finnish Institute of Marine Research

15:00 – 16:00
Finnish Institute of Marine Research - Department of Physical Oceanography
Head of department Jouko Launiainen

Tue 26.8.2003 **The Finnish Environment Institute SYKE, meeting room Apollo**

9:00 – 10:30
The Finnish Environment Institute SYKE
* Geoinformatics and Land Use Division: Division manager Yrjö Sucksdorff
* Hydrological Services Division: Division manager Markku Puupponen
* Water Resources Management Division: Division manager Ilkka Manni

11:00 – 11:45 LUNCH, Restaurant Omenapuu

Helsinki – Turku 12:03 – 14:00 (train)

University of Turku, main building, blue meeting room (2nd floor)

14:30 – 15:30
University of Turku – Department of Geology
Professor Matti Räsänen

15:45 – 16:15
University of Turku – Department of Geography: Geoinformatics
Professor Risto Kalliola

16:30 – 17:00
Åbo Akademi – Department of Geology and Mineralogy
Professor Carl Ehlers

Turku – Helsinki 18:00 – 19:57 (train)

Wed 27.8.2003 **Geological Survey of Finland, GTK**

9:00 – 12:00
Geological Survey of Finland, GTK
Communications Director Caj Kortman

12:00 – 13:00 LUNCH, Geological Survey of Finland

Academy of Finland, meeting room 240 (2nd floor)

14:00 – 14:30
University of Joensuu – Department of Geography: Geoinformatics
Dr. Jaakko Suvantola

14:45 – 15:45
Tampere University of Technology – Department of Construction Engineering – Institute of Structural Engineering
Professor Hannu Salmenperä
* Laboratory of Foundation and Earth Structures
* Laboratory of Geoinformatics
* Laboratory of Engineering Geology

Thu 28.8.2003 **Finnish Geodetic Institute**

9:00 – 11:00
Finnish Geodetic Institute
Director General Risto Kuittinen
* Department of Geodesy and Geodynamics
* Department of Geoinformatics and Cartography
* Department of Remote Sensing and Photogrammetry

11:00 – 11:30 LUNCH, Finnish Geodetic Institute

Helsinki – Oulu 12:40 – 13:45 (flight)

University of Oulu,
Department of Geosciences, seminar room G0236 (2. floor)

14:30 – 15:30
University of Oulu – Department of Geosciences
Professor Tuomo Alapieti

15:45 – 16:15
University of Oulu – Department of Process and Environmental Engineering - Water Resources and Environmental Engineering Laboratory
Professor Bjørn Kløve

16:30 – 17:00
University of Oulu – Sodankylä Geophysical Observatory
Director Tauno Turunen

17:15 – 17:45
University of Oulu – Department of Geography: Geoinformatics
Professor Jarmo Rusanen

DINNER 18:30 – 20:30, Oulu University's Restaurant

Oulu – Helsinki 21:35 – 22:35 (flight)

Fri 29.8.2003 **University of Helsinki, Physicum, room E204 (2. floor)**

9:00 – 10:00
University of Helsinki – Department of Geology
Professor Juha Karhu

10:15 – 10:45
University of Helsinki – Department of Physical Sciences – Division of Geophysics
Professor Lauri Pesonen

11:00 – 11:30
University of Helsinki – Institute of Seismology
Director Pekka Heikkinen

11:45 – 12:30 LUNCH, Physicum, university restaurant

12:45 – 13:15
University of Helsinki – Department of Geography: Geoinformatics
Professor Petri Pellikka

13:30 – 14:00
University of Helsinki – Department of Forest Resource Management: Geoinformatics
Professor Timo Tokola

14:15 – 14:45
Finnish Meteorological Institute FMI - Geomagnetism group and Nurmijärvi Geophysical Observatory
Group Manager Heikki Nevanlinna

CULTURAL PROGRAM 16:00 – 18:30 Tuusula, artistic community
- **16:00 Ainola, home of composer Jean Sibelius (1865-1957)**
- **16:30 Ahola, home of writer Juhani Aho (1861-1921)**
- **17:15 Halosenniemi, home of painter Pekka Halonen (1865-1933)**

DINNER 19:00 Tuusula, Krapihovi

Sat 30.8.2003 **Hotel's Meeting Room ROBA (Scandic Hotel Simonkenttä)**

10:00 – 16:00
Drafting the evaluation report

12:00 – 13:00 LUNCH, Restaurant Simonkatu

The scientific level, the structure of education and research and the role of various organisations within the geoscience field in Finland has been evaluated by an international panel. Three subfields of geosciences are discussed in detail : geology, geophysics and geoinformatics.

The evaluation was conducted jointly by the Academy of Finland, the Ministry of Education and the Ministry of Trade and Industry. In the report the panel sets out a number of recommendations both to academic organisations and to sectorial research institutes.

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