Institute of Earth Sciences, University of Iceland (IES)

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Structure, research activities and vision

A report in preparation of strategic review
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1. Mission Statement

The Institute of Earth Sciences (IES) is dedicated to academic research and graduate studies in the Earth sciences. The institute is engaged in research in a variety of geoscientific and environmental disciplines. Our main focus is on the unique geological features of the Iceland region.

We seek to:

- Advance our understanding of physical and chemical Earth processes operating within the Iceland region by reading records of the past and recording presently active processes, thus preparing for the future.
- Maintain a flexible, multi-disciplinary and collaborative approach to research and higher education.
- Apply earth science understanding to the needs of society and the economy.
- Provide an organization that nurtures creativity and innovation, and secures the essential resources to sustain these activities.

2. Establishment of the Institute of Earth Sciences

The new institute was formed in July 2004 by merging the Nordic Volcanological Institute with the Geology and Geophysics sections of the Science Institute of the University of Iceland, along with a part of the teaching staff from the Department of Geology and Geography and the Department of Physics within the Faculties of Science of the University of Iceland.

The structure and budget composition of the merging geoscientific bodies differed somewhat. The staff of the Science Institute (SI) was divided into five categories: 9 members of the Faculty of Science with research facilities at the Science Institute; 12 senior research scientists; 4 research scientists temporarily employed either for specific projects or as post-doctoral fellows; 2 technicians and clerical staff; and 5 students.

The staff at the Nordic Volcanological Institute consisted of: 5 senior research scientists; 6 research fellows (graduate students and post-docs within the Nordvulk programme for young researchers); 2 project-funded research scientists; and 5 other staff (technicians, research assistants, office manager).

In 2003 the total budget of the Nordic Volcanological Institute was 119[#] million ISK of which 83 came from the Nordic Council of Ministers (NMR), 17 from the Icelandic Government, and 19 from research funds. The total turnover for geoscientific research at the Science Institute was approximately 192 million ISK of which 76 million ISK came from the Government budget, 55 million ISK from research funds and 61 million ISK from companies. In addition, teaching expenses for geology and geophysics at the University were about 55 million ISK, a large part of which is salaries for faculty members with facilities at the Institute. These salaries are not a part of the IES budget.

The IES moved into a new building, Askja, during 2004 together with the Department of Biology and the Biology Institute. In addition, faculty within the field of social geography work in the building, but are not affiliated with the IES. The building has a total floor space of approximately 7550 square metres, about 3600 of which are either common floor space or designated for teaching. The IES has exclusive use of about 2000 square metres, of which one third is office space and two thirds are laboratories and other workspace. The IES does not pay rent or running costs for the building from its budget. In addition, the IES rents or uses floor space of approximately 300 square metres at a number of locations in the Reykjavík area for storage of field gear and samples, and maintains two field stations in north-eastern Iceland.

3. External framework of the Institute

3.1 Position within and organization of the University of Iceland

The Science Institute, University of Iceland, is funded by the Icelandic government separately from the University of Iceland as a whole. With the formation of the IES, the Science Institute (SI) was divided into two parts, the IES and the Institute of Physics, Chemistry and Mathematics. The government funds that go to support IES are channelled through the SI. The IES remains a part of the SI, which functions as an administrative umbrella for its two sub-institutes by running a joint administrative office handling staffing and budgetary affairs. The administrative office of the SI is located in another building on the University of Iceland campus at a distance of about 500 m from Askja. The SI has a board governing the joint affairs of the two sub-institutes, with representation from the boards of each. The SI Board is responsible for the operation of SI and its two sub-institutes to the Faculty of Science and the University Council as depicted by the flow chart in Figure 1.

The SI board has been internally selected and the Institute's governance culture can be characterized as very democratic. In contrast, the Nordic Volcanological Institute has had a director responsible to an external board and so its governance tradition has been centralized. The new institute, IES, has a governance system that falls in between those two, i.e. with a director responsible to a board whose majority is internally selected, but has significant external representation. This new system must function within the overall governance structure of the University. The role and function of the new director and board of the Institute will be shaped and adapted during these initial years of the IES.

[#] 1 million ISK is equivalent to approximately 85.000 NOK, 11.000 €, 7.500 £ and $13,000

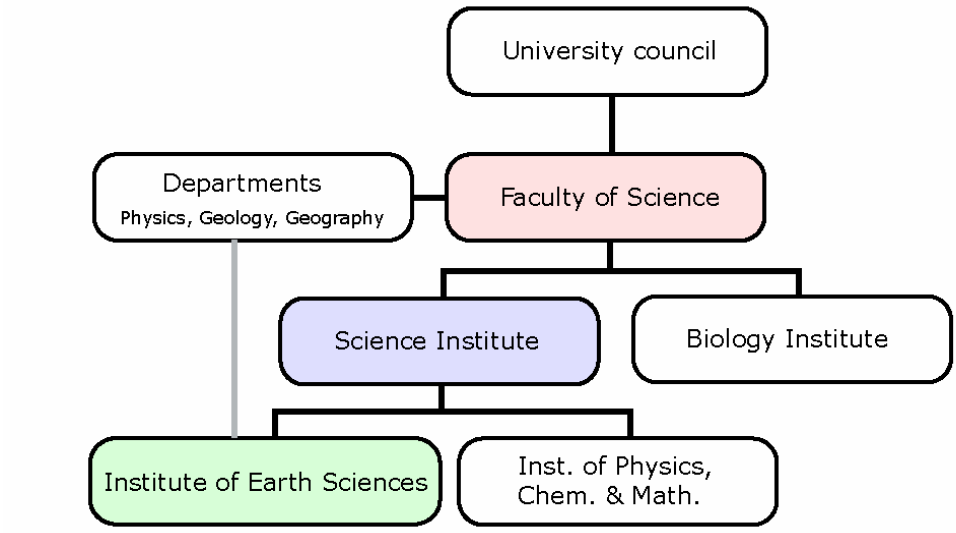

Figure 1. A schematic flowchart of the administrative structures for research at the University of Iceland under which the Institute of Earth Sciences falls. Only those parts of the administrative structure that are directly relevant to the Institute are included.

Teaching staff with research facilities at the IES and graduate students at the Institute fall within two of the six departments of the Faculty of Science as shown in Figure 2. Those are the Department of Geology and Geography and the Department of Physics. However, in neither case do all the teachers of the department work at the Institute. The Department of Physics includes experimental and theoretical physics (not at IES) in addition to the two geophysics teachers at IES. The Department of Geology and Geography includes social geography and tourism studies (not at IES) in addition to the 5 geology teachers and 2 physical geography teachers at the IES.

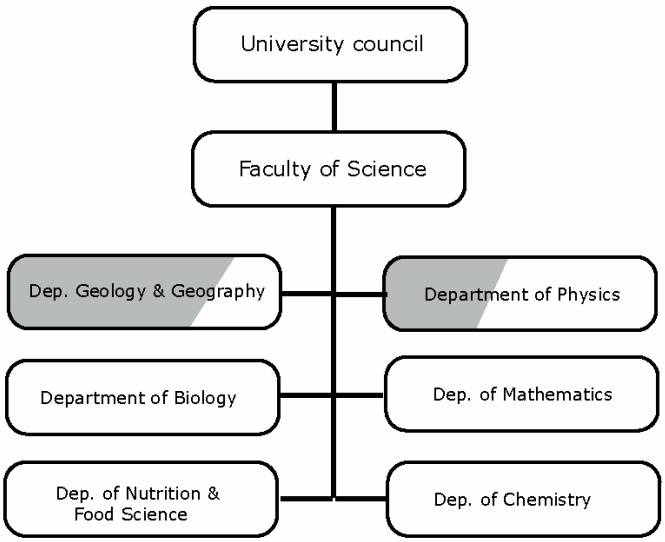

Figure 2. A schematic flowchart of the organization of teaching within the Faculty of Science at the University of Iceland. Six divisions fall under the FacultY. The Institute of Earth Sciences houses teachers from two of the divisions, in both cases only parts of each division as indicated by the shading of these divisions.

3.2 Collaboration within Iceland

The IES is the centre for earth science research in Iceland and as such collaborates with a wealth of other institutions, government agencies and companies, as shown in Figure 3. This collaboration takes the form of joint scientific research projects with other earth science institutes, access to and sharing of facilities, consulting, for example for the

Icelandic Civil Defence Department during natural disasters, and in the form of financial support for research projects. During past decades, utilization of hydropower and geothermal energy has grown considerably in Iceland and will continue to increase. This calls for both fundamental and applied research. Because of this, Icelandic energy companies have funded a significant fraction of research at the IES, as shown in Table 1. The staff members of IES can apply for funds to both the Research Fund of the University of Iceland and the Icelandic Research Fund (IRF). Over the past 3 years the IES has drawn 16% of its income from these sources.

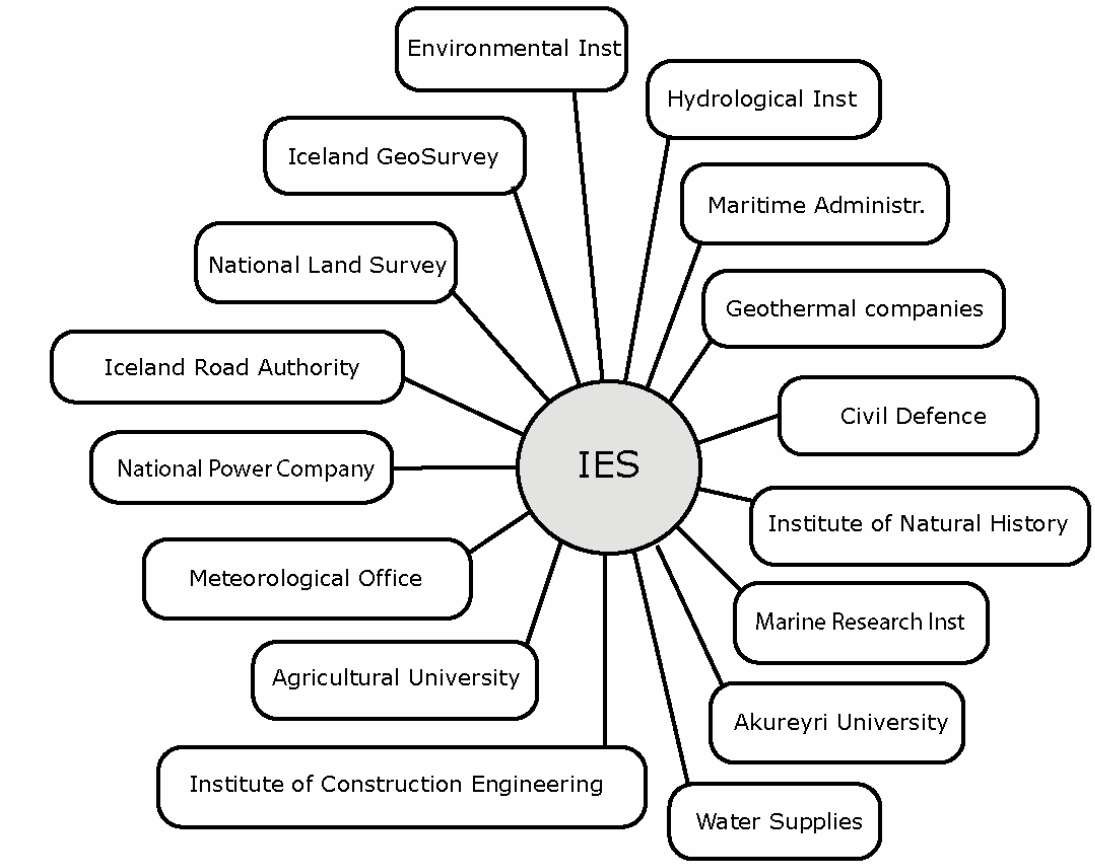

Figure 3. The IES is the largest earth science research institute in Iceland and collaborates with a wealth of other institutions, government agencies and companies.

3.3 Icelandic research funds

Over the past three years the IES has drawn about 16% of its income from Icelandic research funds. During this period IES staff were principal investigators on about 50% of grants awarded by the natural sciences branch of the IRF (Earth and Biological Sciences). Individual grants range from about 1 million ISK to 7.5 million ISK and typically cover field expenses and the salary of a student or assistant. The total amount awarded by the foundation's fund for natural sciences in 2006 was a 57 million ISK out of which 27 million ISK went to projects at the IES. The Icelandic Centre for Research has a separate fund for the health sciences (46 million ISK in 2006), for engineering and technology (38 million ISK in 2006) and for the humanities (42 million ISK in 2006). The fund also awards grants for young researchers (58 million ISK in 2005) and for scientific equipment purchases (140 million ISK in 2005). Other research grants that are available to IES staff on a competitive basis include the University of Iceland Research Fund (16.5 million ISK to IES staff out of 144 million ISK in 2006 across the whole University) and the student research fund of Eimskipafélag Íslands, which is also administered by the University of Iceland. The latter fund was opened for applications for the first time this year and offered salary grants for 27 graduate students.

3.4 Foreign research funds and cooperation

The staff of IES collaborates formally and informally with scientists all over the world, as reflected in the affiliations of the co-authors of papers shown in the publication list, and sabbaticals spent at the various research institutes. Formal collaboration is established through research contracts with entities such as NMR (Scandinavia) and EU research networks (Europe). In addition, IES staff members have been collaborators in NSF (USA) and NERC (UK) funded projects. Over the past three years the IES has drawn approximately 6% of its income on average from foreign grants. The access that international collaboration provides IES to international scientific infrastructure (e.g. ships, instrument pools) and to funds for field expenses is at least as important economically as the international funds directly awarded to IES staff.

4. Finances

In 2005 the budget contribution to IES from the Icelandic government was 118 million ISK. Also in 2005, 84 million came from the Nordic Council of Ministers (NMR), 55 million ISK from Icelandic research funds, 11 million ISK from foreign research funds and 52 million ISK from government institutions and companies, mostly power companies. In addition, teaching expenses for geology, geography and geophysics at the University were about 60 million ISK, a large part of which was salaries for faculty members with facilities at the Institute. This expenditure, while not included in the IES budget, does provide a significant part of the Institute's resources. The total turnover of the Institute was approximately 320 million ISK.

The expenditures of the IES in 2005 were divided in relative terms as follows: 67% went to salaries for long-term and short-term staff and students; 4% went to instrument purchase; 26% were general project costs; 3% were overhead costs (office, board).

Of the total budget for the IES in 2005, about 38% came from soft money, i.e. competitive funds, company grants and service contracts. If teacher salaries are included in the budget calculation, the proportion of soft money falls to approximately 31%. Approximately 6% of the total budget lies in salaries funded by competitive funds.

YEAR	I. GOV.	NMR	I. GRANTS	F. GRANTS	INST. & COMP	TOTAL
2003	93	83	50	24	61	311
2004	102	87	48	12	47	297
2005	118	84	55	11	52	320

Table 1. Evolution of the main sources of income for the IES over the past 3 years. I. Gov. refers to direct contributions from the Icelandic Government. NMR stands for the contribution from the Nordic Council of ministers. I. Grants stands for Icelandic research grants. F. Grants stands for foreign research grants. Inst & Comp stands for Icelandic institutions and companies. Numbers for 2003 and first half of 2004 are combinations from the Science Institute and the Nordic Volcanological Institute.

Table 1 shows the evolution of the main sources of income for the IES over the past three years. The contribution from the Icelandic government has increased significantly. Note that the contribution from NMR is due to be reduced by approximately 30% in 2007.

Icelandic research funds do not allow for overhead costs in project budgeting. However, the SI charges 2.5% to all external funds from which operational costs for the SI office are partially drawn. In addition, external income from sources other than research funds are charged 2.5% which goes to a fund used for common SI expenditures, 2.5% which goes to a fund for common IES expenditures and 5% paid into the University of Iceland Research Fund.

5. Internal structure of the Institute

The IES is headed by a board of 5 members selected for a 4 year period. The Institute's director is responsible for the daily administration of the Institute and is responsible to the board. The basic units of activity are projects, each led by a member of the senior staff. Project leaders carry both scientific and financial responsibilities for their projects. Individual projects form separate budget items. The Institute operates an informal group structure for internal communication and delegation. The Institute operates the Nordic Volcanological Centre which is partially funded by the Nordic Council of Ministers (NMR). Regulations for the IES are listed in Appendix III.

5.1. Board

The Board of the IES has five members selected for a four-year period. One member of the board is appointed by the provost of the Faculty of Science, three are elected by the Institute's staff, and one is chosen from the Nordvulk Programme Committee (see section 5.5. below). The Board is responsible for:

- developing a research policy for the Institute,
- the budget of the Institute,
- selecting academic staff members.

The board proposes an appointment for director of the Institute to the University's Rector.

5.2. Director

The director of the Institute is hired for a period of up to 5 years by a process identical to that used for the selection of long-term academic staff (see section 6 and Appendix III). The director is expected to be actively involved in research in addition to performing administrative duties. The director is:

- in charge of daily operation of the Institute, including finance and administration,
- responsible for preparing a budget proposal and a research strategy proposal in collaboration with the academic staff. These proposals are presented to the board which has the final responsibility.

5.3. Research groups

The Institute is informally divided into the research groups listed below. These are loosely defined based on the similar background of members and their research interests. The six groups are: 1. Physical Geology, Geography and Geophysics; 2. Glaciology; 3. Quaternary Geology and Sedimentology; 4. Deformation-Seismology; 5. Igneous Geochemistry; 6. Aquatic Geochemistry.

The role of the research groups is not formally defined. They are thought of as providing an informal structure which serves to simplify the board's and director's consultation with staff and aid the director in delegating tasks to staff.

5.4. Nordic Volcanological Centre and contract with NMR

The IES operates the Nordic Volcanological Centre (Nordvulk), which is partly financed by the Nordic Council of Ministers (NMR) according to the contract outlined in Appendix II. The centre is responsible for the following programmes:

- An interdisciplinary volcanological research programme
- Operation of instruments for volcanological research

- A programme for young researchers
- A Nordic research scientist position
- A programme for visiting scientists
- Summer schools and workshops
- A committee for the Nordic Volcanological Centre

Nordvulk has consisted of about 5 research scientists, 5 Nordic research fellows and 5 to 10 other research staff. Nordvulk´s budget at the time of amalgamation was about one third of the total budget of the IES.

5.5. Nordvulk Programme Committee

The Nordvulk Programme Committee is appointed by the NMR and includes five members, one from each of the Nordic countries, Sweden, Denmark, Finland, Norway and Iceland. Responsibilities of the committee include:

- maintaining a Nordic dimension in the volcanological programme,
- establishing and sustaining a Nordic network of contact persons,
- proposing Nordic candidates for the programme for young researchers,
- proposing a candidate for the Nordic research position.

The Nordvulk programme committee has an advisory role to the IES director and the NMR in addition to selecting one member of the IES board.

5.6. An administrative flow chart for the Institute

Figure 4 shows an administrative flow chart of the Institute. The Board is responsible for general finances, policy and recruitment. The director is responsible for daily operations within the mandate laid out by the board. The director is responsible for financial administration together with the SI administration. Leaders of research groups have an informal function, which is to channel communication between the director and the project leaders who are responsible for the science and finances of individual projects. The IES operates the Nordic Volcanological Centre, a research centre concentrating on volcanology and related active geologic processes, as a separate administrative unit with its own budget, according to a contract between the NMR and the University of Iceland.

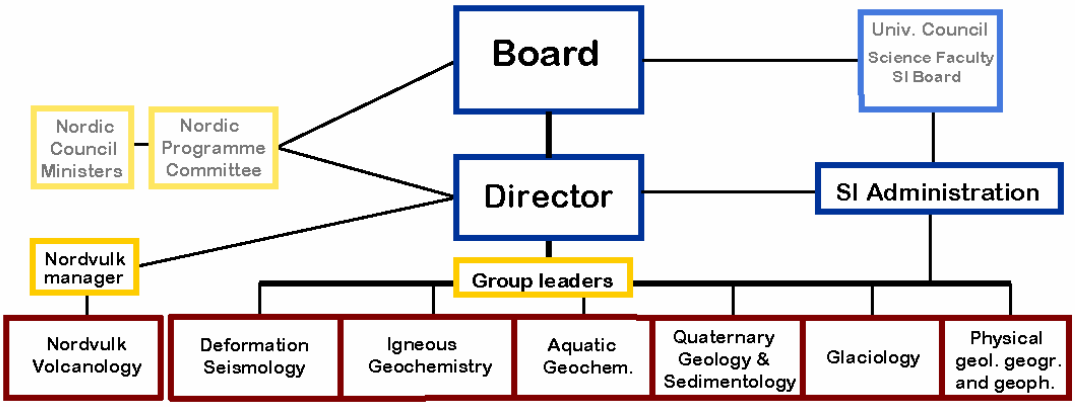

Figure 4. An administrative flow chart of the IES.

All of the research groups connect in one way or another with the research theme of volcanology. Volcano-related seismicity, structural seismology and surface deformation studies around volcanoes are conducted within the Deformation-Seismology group. Studies of source fingerprints and fractionation processes seen in volcanic products are studied by the Igneous Geochemistry group. Interactions between water and volcanic rocks in geothermal systems and environmental effects of volatile volcanic products are

studied by the Aquatic Geochemistry group. Tephra samples from sedimentary sequences and jökulhlaup deposits resulting from subglacial volcanism are studied by the Quaternary Geology and Sedimentology group. Many of the most active volcanoes in the country are subglacial and must be studied within the context of glaciology. This gives rise to a special class of eruption mechanisms studied along with physical volcanology by the Physical Geology, Geography and Geophysics group.

6. The Institute's staff

The staff of the Institute of Earth Sciences is divided into five categories according to the rules of the Institute. There are 9 members of the Faculty of Science who maintain research facilities at the Institute (7 professors and 2 lectors). They are not staff members in the sense that their salary does not come from the Institute's budget. Members of the faculty have teaching, research and administrative duties. There are 11 research professors and 7 senior research scientists employed at the Institute. They have research (80%) and administrative (20%) duties, but no teaching duties. However, many of them supervise PhD and MS students and teach undergraduate courses. Compensation for this teaching is paid for by the Faculty of Sciences. Five post-doctoral fellows are currently at the Institute, all with fixed-term appointments financed by research grants. The Institute employs nine junior researchers and research assistants and six office and technical staff. Registered PhD students are 11, 7 Icelandic and 4 foreign, but more are affiliated with the Institute. Nordic research fellows are 4 and MS students currently number 26.

Members of the faculty, research professors and senior research scientists, who constitute what are referred to as the A and B staff categories, are hired according to a peer-review process. The A and B staff members nominate an evaluation committee made up of one internal and two external scientists, with one traditionally being chosen from outside of Iceland. The evaluation committee determines which of the applicants are qualified for the advertised position and may be asked to rank them. The Board of the Institute then formulates a proposal based on the evaluation committee's report, to be presented at a staff meeting at which only category A and B staff have a right to vote. Any proposals formulated by the staff must also be considered along with the Board's proposal. The meeting then votes on the proposals presented. Finally, the Board makes a recommendation to the University rector based on the results of the staff meeting. Rector makes the appointment.

A and B level staff have a right to a one-term sabbatical after 6 terms of duty. They have a research duty, which can in principle be performed anywhere at any time at the expence of project funds. Twenty seven A and B level staff spend one to two man-years on sabbatical each year, mostly at North American and European universitites. Currently, two out of 27 are on sabbatical. Colleagues from abroad often visit the Institute, sometimes in association with field work during the summer and generally for relatively short periods, but younger researchers have visited the institute for up to one year. A formal visitor programme and affiliation status for visitors is being organised within the Institute.

Of 27 category A and B staff at the Institute, 25 have a PhD degree or equivalent. Since tertiary education at the University of Iceland is a relatively recent addition to the school's teaching, all of those 25 earned their PhD outside of Iceland. This is a strength for the Institute, as the leading research and teaching staff have all been a part of another research community for an extended period of time. This reduces the risk for intellectual inbreading. Figure 5 shows the countries where A and B staff have completed their final degree.

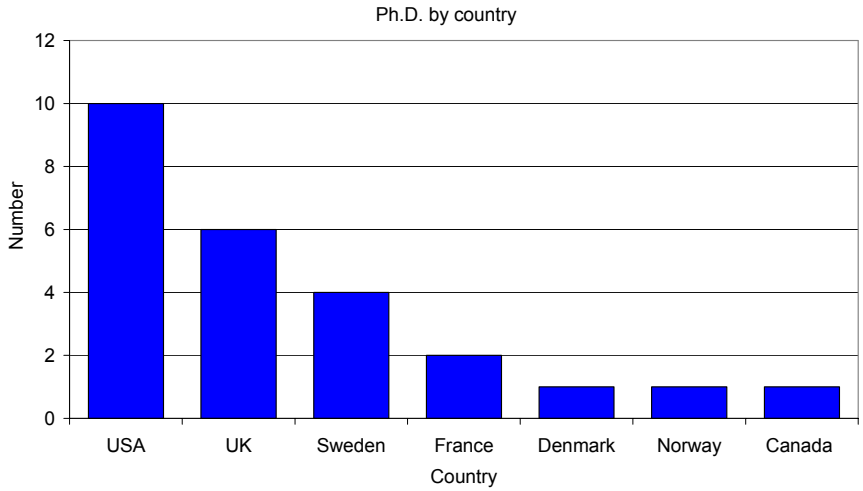

Figure 5. Frequency diagram for country of PhD of all senior research and teaching staff at the Institute (category A and B).

The Institute of Earth Science was formed by merging elements of the Science Institute, University of Iceland, and the Nordic Volcanological Institute. Those two Institutes were founded in 1966 and 1974, respectively. In both cases, growth occurred mostly during the initial years of operation and during the 1980s. Turnover of staff has been limited and original staff are now beginning to reach retirement age. This is reflected in the histogram shown in Figure 6. The distribution of staff age is clearly bimodal with peaks centered on 45-50 years and 60-70 years. Staff younger than 45 years of age constitute only 22% of the total. Clearly, considerable turnover of staff will occur during the next 5 years. The university offers a possibility of partial early retirement, releasing funds for half a position. No staff members have seen this option as attractive.

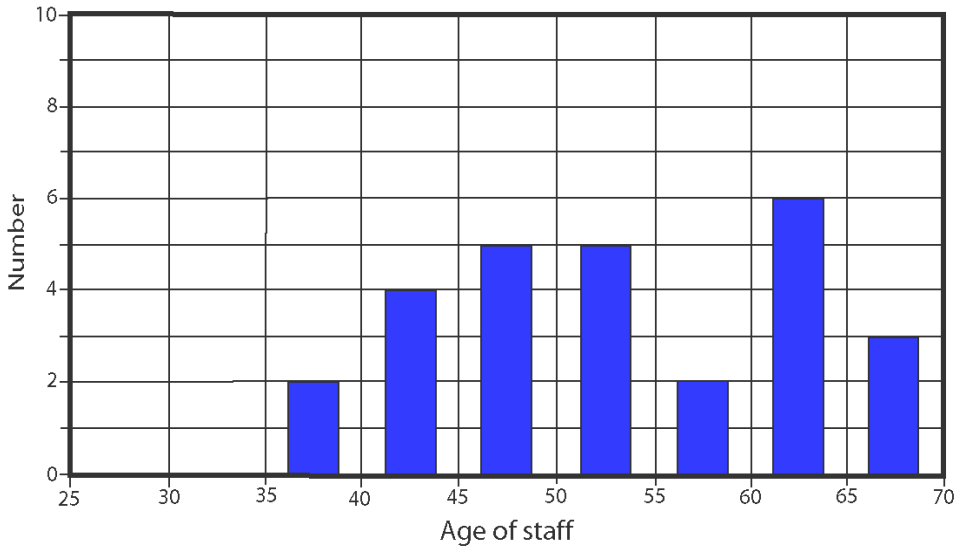

Figure 6. Frequency diagram showing the age distribution of category A and B staff at the Institute.

6.1. Salary structures

The salary and rank of A and B staff members are based on productivity. Productivity is evaluated according to a point system that counts points for teaching conducted, supervision of graduate students, articles published in journals included in the statistics of ISI web of science, articles published in other peer-reviewed journals, citations, books and book chapters, reports, other published articles, talks and posters presented at conferences and workshops, organizing of conferences, participation on committees and for administrative work. One set of rules is applied over all disciplines throughout the

university. The accumulated points determine rank, which in turn determines the basic salary. In addition, the university operates a bonus system by which staff members are awarded a bonus according to the number of points acquired over the past year.

7. The Institute's role and performance

7.1. Teaching

Teaching is not a primary duty of the IES. However, nine faculty members have research facilities at the IES and IES research staff are actively engaged in teaching at the University of Iceland. The IES has a clear role in the research training at the University of Iceland and the research students are an important element of the Institute. The educational infrastructure and role of the University of Iceland is an important element of the IES working environment.

The University of Iceland is the only university in Iceland that offers degrees in geology, physical geography and geophysics. Science education was started at the university in 1968, initially for BS only. The Science Institute was founded in 1966 and research in the earth sciences increased dramatically in the following years. Initially, the university primarily filled an educational role, but research strength has continued to grow over the past four decades and the emphasis on research and research education has increased. A two-year MS programme was introduced at the university in 1988 and a PhD programme in the year 2001. The first PhD students have recently graduated. Teaching staff has gradually increased from 3 around 1970 to 13 today in geology, geography and geophysics, combined. Research scientists at the Science Institute have also taken an active part in teaching.

Teaching at the BS level in the Earth sciences has been built up within two separate departments at the University of Iceland. A degree path in geophysics has been offered within the Department of Physics, which also offers degree paths in theoretical physics and experimental physics. Degree paths in geology and physical geography have been offered within the Department of Geology and Geography, which also offers degree paths in social geography and tourism studies. Students typically enter university at the age of 20 and the BS programme is three years of full-time study. To enter as a student in the earth sciences at the University of Iceland, the only requirement is a matriculation certificate from a natural science course of study at a junior college (Gymnasium), or equivalent. The number of students who enter Earth science studies at the university each year varies considerably from year to year but is, on average, about 20. Of this group, approximately two thirds graduate after 3 or 4 years of study. The University of Iceland charges a nominal registration fee of 40.000 ISK per student per year.

The interest shown by foreign students to study Earth sciences in Iceland has grown considerably in recent years. This has led to the development of a special programme for foreign students in the Earth sciences, which was established in 2001. The programme offers courses equivalent to a half- or a full year of study towards a BS degree. All classes in this programme are taught in English. The students are able to transfer the credits from their course work to their home university and many manage to finance their stay in Iceland through student exchange programmes. Currently, there are about 60 foreign students enrolled in the programme.

7.1.3. Research education

An MS programme was established at the University of Iceland in 1988. The first students graduated in 1990. 37 students have graduated from the program in the Earth sciences. The entry requirement is a BS degree or equivalent with a minimum grade-point average of 6.5 out of 10. An MS study consists of a minimum of 60 study units,

which is equivalent to two full years of study. Between 15 and 45 units are earned through completion of a research project. An MS committee is appointed to oversee the study. It usually has two members, one of which is the student's supervisor. The student hands in a thesis at the end of his/her studies, which is evaluated by the committee and an external evaluator nominated by the University rector.

A PhD programme was established at the University of Iceland in 2001. Three students have graduated in the earth sciences, the first in 2004. The programme is completed in either four years after a BS (120 units) or three years after an MS (90 units). The total number of units in courses for a PhD is 120, counting the 90 units required for the BS and 30 units in graduate courses. The entry requirement is an MS degree or a BS with a minimum grade-point average of 7 out of 10. A PhD committee has 3-5 members appointed by the Faculty, including the student's supervisor. At least one committee member should be from outside of the department. The student hands in a thesis at the end of his/her studies, which is evaluated by the committee and two external evaluators. The student defends his/her thesis with an oral presentation followed by cross examination by the external evaluators.

7.1.4. Nordic fellows

The Nordic Volcanological Centre operates a programme for Nordic Research Fellows. Each year five fellowships are granted for a period of one year at a time. Fellowships may be renewed up to a maximum of three years. A master's degree (or equivalent) is a minimum requirement. Those that enter with a PhD degree work independently as post-doctoral fellows, although in collaboration with long-term staff. Most of the Nordic research fellows enter with a master's degree and work on well-defined projects under the supervision of an adviser from the staff. It has become more common for the Nordic research fellows to use their stay at Nordvulk as a part of a PhD programme at the University of Iceland or another Nordic university. In 2005, nine papers were published by the Institute with Nordic research fellows as co-authors. The Nordvulk Programme Committee oversees this programme and selects fellows from the pool of applicants each year.

The programme for Nordic Research Fellows has been continuous since the foundation of Nordvulk over thirty years ago. Some 100 fellows have spent between one and three years at Nordvulk for a total of about 150 person-years. The nationalities of the fellows are approximately evenly distributed among the five Nordic countries. The majority of those are currently employed within the academic and research sectors in their home countries.

7.1.5. Earth scientists in today's community

The University of Iceland has educated Bachelors of science in geology and geography since 1968 and in geophysics since 1972. Since then, more than 260 have graduated in geology, 322 in geography (physical and otherwise) and 69 in geophysics. A masters programme was started in 1988 and 19, 8, and 10 students have graduated from that programme in the three fields, respectively. Approximately 50 of the university's BS graduates in earth sciences have completed a MS degree or equivalent. Out of all BS graduates in geology, about 45 have continued on to complete a PhD education abroad. The corresponding number for geophysicists is near 25. The majority of graduates of the University in the fields of geology, physical geography and geophysics are employed in government research institutions in Iceland, in the Icelandic energy industry and within the educational sector.

7.1.6. New opportunities in tertiary education

A PhD programme was started at the University of Iceland in 2001. Two students have graduated in geology and geophysics and 10 PhD students are currently affiliated with the Institute. The policy of the University leadership calls for growth of the PhD programme and research training in general. This, combined with improved possibilities for acquiring funds for student research from the IRF and funds such as the research student fund of Eimskipafélag Íslands, establishes a strong potential for growth. The earth sciences are well-poised to take advantage of new opportunities in research education because they are held in high regard in Iceland. This is a direct result of the field's strong academic standing within Iceland, because of the importance of the hydro- and geothermal power industries to the country's economy, and because of strong public interest in the country's geology.

7.2. Research at the Institute

The IES is a research institution. Research is its primary duty.

The earth sciences have a high profile and are held in high regard by the Icelandic community, mainly due to the population's close proximity to active geologic processes. The volcanic, geothermal, and glacial processes that shape the country are clearly visible to all. Natural hazards in the form of eruptions, earthquakes and glacial outburst-floods (jökulhlaups) increase the population's awareness of the earth sciences. The economic importance of hydro- and geothermal-power to the country further enhances our discipline's status in the minds of the Icelandic people. All of this combines to place the earth sciences in Iceland in a position of strength from which to build.

The Institute has an obligation to the community to maintain a high standard of achievement over a broad range of earth science topics in order to keep the public informed about the natural phenomena around them and ensure that they are aware of the natural hazards that may directly affect their lives. The Institute also has an important duty to train future scientists for institutions and companies related to the power industry and as consultants for government on natural hazards, economic and environmental issues related to power generation and utilization, and global change.

7.2.1. The unique geological setting of Iceland

Being the largest subaerial part of the mid-ocean rift system, Iceland provides a unique setting for research spanning many fields of the earth sciences. Integrated crust-mantle processes within the North Atlantic mantle plume and rifting at the Mid-Atlantic Ridge make Iceland a target for diverse research related to the formation and evolution of the mid-oceanic rift system and to plume-ridge interactions. Climatic conditions, topographical features and current glaciation also make Iceland an attractive study-site for glacial processes and products, present and past.

Extensive volcanism within the Iceland region is reflected in structurally and geochemically more complicated volcanic systems than those found along the oceanic ridge system. Volcanic systems outside the main rift axis are also of interest to scientists conducting volcanological research at convergent plate boundaries. Moreover, volcanic eruptions in Iceland occur under highly variable environmental conditions, including subaerial, subaqueous and subglacial environments. High-temperature geothermal energy, one of the prime natural resources of Iceland, is maintained by migration of magma forming shallow intrusions or crustal magma chambers within the central volcanoes. Monitoring of crustal deformation and seismic activity within recently active volcanic systems along the rift axis and near the centre of the Iceland hot spot has greatly advanced our understanding of how volcanoes work. Modern-day monitoring and surveying techniques draw on experience gained during seismic and volcanic crises in the

last three decades. At the same time, the Icelandic nation is still vulnerable to these natural hazards.

Use of fossil fuel results in the greenhouse effect. This calls for an increased understanding of global climatic changes. Iceland's location in the North Atlantic is ideal for various studies aimed at reconstructing the dynamics of past environmental and climatic variability in order to understand interactions between components of the global system. Iceland's glaciers are indicators of the response of the cryosphere to climate warming, ideal for the coupling of field studies and numerical modelling of the response of glaciers to climate change. The glaciers are also important analogues to warm-based Pleistocene ice sheets. Sedimentary and volcanic rock sequences on land contain a detailed record of Tertiary and Quaternary palaeo-environments including glaciation and vegetation history. Integration of records from Icelandic glaciers, lake and marine sediments and palaeontology can all be used to reconstruct past environmental changes and to identify and understand processes that may affect climate on Earth in the coming decades. High resolution, (multi-proxy) palaeo-climate records from lake and marine sediments provide information regarding natural climatic variability during the Quaternary. Whereas major eruptions in the past have had a temporary influence on global climate, their tephra layers, preserved in sediments and glaciers, provide age control on sedimentation rates.

All of the above factors make Iceland a unique natural laboratory for the study of important geological processes shaping our planet.

7.3. Research groups and their roles

The Institute is informally divided into the research groups listed below. These are loosely defined groups based on the similar discipline background of the members and their research interests. The six research groups are: 1. Physical Geology, Geography and Geophysics; 2. Glaciology; 3. Quaternary Geology and Sedimentology; 4. Deformation-Seismology; 5. Igneous Geochemistry; 6. Aquatic Geochemistry. The approximate accounts of group expenses found in tables 7.3.x.3 in the following sub-sections include salaries of faculty members affiliated with each group which are not a part of the IES budget outlined in section 4. Furthermore, some common costs are not accounted for in the below accounts of group expenses. This results in a discrepancy between the total budget of the Institute in 2005, with a turnover of 320 million ISK, and the sum of the individual group expenses listed below, which is close to 360 million ISK.

7.3.1. Physical geology, geography and geophysics

PG3 is not strictly a disciplinary research group since it is composed of three rather diverse subgroups of physical volcanologists, exploration geophysicists and physical geographers. However, a common link is an emphasis on field based studies dealing with processes and effects of volcanic eruptions, past and present, volcanic structures of various sorts, volcanic soils and volcanic stratigraphy.

The studies in physical volcanology are influenced by the wide range of eruption types occurring in Iceland: effusive to explosive eruptions, basaltic to rhyolitic eruptions, and eruptions with or without the interaction of magma and external water. Areas that have received considerable attention are flood basalt volcanism, ice-volcano interaction and the application of tephrochronology to the study of eruption histories of volcanic systems. Magma production rates during the Tertiary are studied through magneto-stratigraphic mapping. Geophysical surveying is applied to volcanic structures with the aim to complement the volcanological and stratigraphic work. Extensive palaeo-magnetic studies of the strata in Iceland have resulted in one of the largest palaeo-magnetic sample collections of basalts found in the world. The work in geography includes studies of sea-ice in the North Atlantic, soil erosion and land management, the environmental

effects of human populations on the land, and socio-economic impacts of volcanic eruptions.

Physical volcanologists apply various field mapping methods, supplemented by analyses such as grain-size distribution, microprobing, XRF, SEM and ICP. In geophysical and glacier-volcano studies, GPS surveying is applied, as well as aero- and ground-based magnetic surveying, and gravimetry. Rock samples are analysed in a palaeo-magnetic laboratory and model studies of ice flow in relation to subglacial heat sources are studied with numerical modelling in a PC-cluster. In the geography section remote sensing is used for sea-ice studies, and GIS-based analyses are performed and applied to various problems.

UNI. TEACHERS	SEN. RES. SCI.	JUN. RES. SCI.	RES. ASS.	TECHNICIAN	GRAD. STUD.
3	4	2	2	1/3	2.5 PhD+10 MS

Table 7.3.1.1. Personnel of the Physical Geology, Geography and Geophysics group. One PhD student is working on a joint project with aquatic geochemistry.

In 2005 the group consisted of seven A and B level staff, and two research assistants, one with a half-time appointment. Two junior research scientists were affiliated with the group and one technician was partially involved in group activities. One research assistant is primarily engaged in data processing in studies of ice-volcano interaction and geophysics, while the other assistant works on cartography, web-maintenance etc., and serves a considerably larger group than PG3. At present the group has 3 PhD students, one of which is working on a joint project with Aquatic Geochemistry, and 10 MS students and one graduate Fulbright Scholar (for 2005-2006).

The facilities used by the group are summarized in Table 7.3.1.2. They include instruments for various types of geophysical surveying, computers, including a PC mini-cluster and facilities for GIS-based work, vehicles for over-snow travel and access to 4WD field vehicles. A sediment laboratory and tools for chemical analyses within the IES are used by members of the group.

INSTRUMENT	OPERATED BY GROUP	YEAR PURCHASED	AVAILABLE WITHIN IES	AVAILABLE ELSEWHERE
PC-mini-cluster	X	2005		
1 DGPS submeter	X	1996		
3 GPS geodetic instr.	partly	1996, 2004	X	
Gravimeter	partly	1998		Partly
5 GIS/RS computers	X	1995-2005	X	
2 Mirror stereoscopes	X	1980?	X	
1 Interpretoscope	X	1989-1991	X	
8 Mirror field stereosc.	X	1985-2005	X	
2 GPS Garmin instr.	X	2006	X	
2 portable proton magnetometers	X	1980, 1985	X	
2 port. Fluxgate magnetometers	X	1974, 1989	X	
Susceptibility meter	X	1987-95	X	
Dr. Förster magnetom.	X	1978	X	
Molspin AF demagnetiser	X	1989	X	
2 Echo 1" drills	X	1989, 1998	X	
Microprobe			X	X
ICP			X	
XRF			X	X
SEM				X
ARL microprobe				X
Sediment lab.			X	
2 snow scooters	partly	1985	X	
3 4x4 vehicles – (2 for snow driving)		1999-2001	X	
GIS lab	partly	2004	X	
Field stations			X	

Table 7.3.1.2. Main facilities used by the Physical Geology, Geography and Geophysics group.

In 2005 the turnover of the group was 57 million ISK (Table 7.3.1.3). Permanent staff salaries account for 76%, salary for one long-term research assistant comes from project funds (about 6% of the total turnover) and 18% cover project costs, including salaries for field assistants etc. About 21% of the income came from external sources while 79% is secure funding.

	GOVERNMENT AND NMR	ICELANDIC GRANTS	FOREIGN GRANTS	COMPANIES & AGENCIES	TOTAL
Salaries	42.700.000	1.000.000	0	2.600.000	46.300.000
Instr. & oper. costs	1.800.000	3.200.000	200.000	5.000.000	10.200.000
Total	44.500.000	4.200.000	200.000	7.600.000	56.500.000

Table 7.3.1.3 Approximate annual expenses of the Physical Geology, Geography and Geophysics group in 2005 in ISK.

The main research projects in which the group participated during the past 5 years are listed in Table 7.3.1.4. together with information about the source of funding and external collaboration.

PROJECT NAME	PROJECT TYPE AND FUNDING	EXTERNAL COLLABORATION
Ice volcano interaction, explosive volcanism and jökulhlaup hazards (EU project VOLUME)	UI Research Fund, IRF, NERC-BAS, Icelandic Road Authority, Civil Defence Agency EU	British Antarctic Survey University of Wurzburgh, USGS Icelandic Meteorological Office VOLUME partners
Magma production rates in the volcanic zones	IRF, Reykjavík Energy, National Power Company	Icelandic Institute of Natural History, University of Pittsburgh
Eruption history of Icelandic volcanoes, explosive volcanism, jökulhlaup hazard assessment	IRF, IES, Jules Verne, NCIP-Civil Protection Dept.	Univ. Blaise Pascal, Univ. Edinburgh, Univ. Hawaii, Iceland Meteorol. Office, Nat. Energy Authority
Tephrochronological research and dating (EU project HOLSMEER)	IRF, IES, Jules Verne UI Research Fund, EU	Univ. Bergen, Univ. Blaise Pascal Univ. Edinburgh, HOLSMEER partners
Vestmannaeyjar, nature of volcanism, volcanic history and hazard.	Viðlagatrygging	Univ. Durham, Univ. Edinburgh, Inst. Physique de Globe, Paris
The Búrfell lava: chemical and thermodynamic properties and formation of inflated lava flows	Internal	Copenhagen Univ., Univ. Blaise Pascal.
The evolution of the Reykjanes ridge from land to 62°N.	NSF, Icelandic Parliament	University of Hawaii
Rootless cone formation	NSF	University of Hawaii
Phreatoplinian volcanism	NSF	University of Hawaii
Climatic Effects of the 1783-1784 Laki Volcanic Eruption	NSF	Rutgers University University of Hawaii
Stratigraphic studies in the Miocene lava pile	UI Research Fund	Various geologists/institutions
Long-term properties of the geomagnetic field	Internal	
Studies in history of science relevant to Iceland	Internal	
Physics of convection in the Greenland Sea (EU project CONVECTION)	EU	University of Cambridge + CONVECTION partners
Environmental changes during Holocene and in relation to land use management since settlement of Iceland (vegetation, soils, organic carbon, climate).	UI Research Fund Internal Kristnihátíðarsjóður	University of Aberdeen National Museum of Iceland, Medieval centre at Reykholt Agricultural University of Iceland
Land Degradation and Development	UI Research Fund	University of East Anglia, Norwich, UK
Natural hazards in relation to subglacial volcanoes ((socio-economic and environmental effects (vegetation, soils, cultivated land)).	UI Research Fund Macquarie University NSW	Macquarie University NSW

Table 7.3.1.4. Main projects of the Physical Geology, Geography and Geophysics group.

7.3.2. Glaciology

Glaciological research at the IES focuses on processes at present-day glaciers in Iceland, which are: (1) of general interest to glaciology (e.g. glacier flow, surges, calving, glacio-volcanic interactions, jökulhlaups, sediment production), (2) of international interest for global-change studies thanks to their climatic setting in one of the most maritime regions of the glaciated areas of the world (e.g., response to climate change, sea level rise, fresh water input to the ocean, Holocene glacier variations), and (3) of value for the Icelandic community due to their impact on regional human activities (e.g., water supply and drainage, hazards, crustal uplift).

The group is engaged in studies of the geometry, mass balance, dynamics and hydrology of ice caps in Iceland; past, present and future.

UNI. TEACHERS	SEN. RES. SCI.	JUN. RES. SCI.	RES. ASS.	TECHNICIAN	GRAD. STUD.
0	1	2	1	1/3	1 PhD

Table 7.3.2.1. Composition of the personnel of the Glaciology group.

The group consists of one senior researcher, two junior researchers and one research assistant. One PhD student is currently affiliated with the group and one technician is partially involved in group activities.

Group members use conventional field equipment for mapping surface and sub-ice topography (radio echo sounding, survey GPS), and for monitoring surface mass balance and glacier flow. Other equipment and methods used by the group include vehicles for travel on snow and glaciers, automatic weather stations, satellite optical sensing (SPOT, ASTER) and radar interferometry (InSAR), hot water drills, general process description and database compilation, numerical simulation and modelling, and time-series analysis.

INSTRUMENT	OPER. BY GROUP	YEAR PURCHASED	AVAIL. AT IES	AVAIL ELSEWHERE
Radio echo sounders	X	1980-2000		
10 automatic weather stations	X	1996-2005		
Survey GPS –instr.	X	1994-2004	X	X
Mass balance measurement instruments	X	1975-2000		
Over-snow vehicles	X	1978-2002	X	
Data processing software (ERDAS, PCI-Geomatica, MatLab, Surfer, Grapher, etc.)	X	1980-2005		
Computer hardware	X	1995-2005		
Hot water drill	X	1990		X
Field vehicles		1999	X	

Table 7.3.2.2. Main facilities used by the Glaciology group.

The group's turnover in 2005 was approximately 35 million ISK of which two-thirds went to salaries and one third to project costs. More than 77% of the group's budget in 2005 came from external funds and two-thirds of the group's salaries are paid with external funds.

	GOVERNMENT AND NMR	ICELANDIC GRANTS	FOREIGN GRANTS	COMPANIES & AGENCIES	TOTAL
Salaries	7.300.000	7.200.000	3.500.000	4.600.000	22.600.000
Instr. and oper. costs	600.000	2.600.000	2.000.000	7.300.000	12.500.000
Total	7.900.000	9.800.000	5.500.000	11.900.000	35.100.000

Table 7.3.2.3. Approximate annual expenses of the Glaciology group in ISK.

The group works in close collaboration with other groups within IES on remote sensing, volcanology, geothermal activity, chemical weathering, crustal deformation, Holocene climate, glacial and periglacial geomorphology, erosion and sediment transport. Outside IES, group members collaborate with other Institutes and government agencies on glacier hydrology, water supply, river control connected to road and bridge construction, and civil defence (National Power Authority, Icelandic Meteorologic Office, Icelandic Road Authority, Civil Defence Agency, etc). The group is also engaged in numerous international projects. The main projects in which the group has participated over the past 5 years are listed in Table 7.3.2.4. together with information about funding and external collaboration.

PROJECT NAME	PROJECT TYPE AND FUNDING	EXTERNAL COLLABORATION
GLACIODYN, SPICE, ICEMASS, TEMBA. Glacier mapping, monitoring and numerical modelling (radio echo sounding, remote sensing, mass balance, energy balance, dynamics;)	EU, National Power Comp., Governm., Road Authority, Iceland Res. Fund, Univ. Res. Fund	UBC, Univ. Calgary (UC), Simon Fraser Univ. (SFU), IMAU, Univ. Innsbruck, VAW-ETHZ, U. Swansea, SPRI, BAS, UiB, UiO, IPY,DTU, LEGOS, Hydr. Survey
Glacier hydrology (drainage characteristic, jökulhlaups, hazards, glacio-volcanic interaction). GLACIORISK	EU, National Power Comp., Governm., Road Authority, Iceland Res. Fund, Univ. Res. Fund	UBC, SFU, CEMAGRAF, LGGE-CNRS, NVE
Glacier response to future climate. Reconstruction of past glaciers.	EU, National Power Comp., Governm., Road Authority, Iceland Res. Fund, Univ. Res. Fund, Nordic Res. Fund (CWE, CE, VVO,	UBC, UC, SFU, Met. Office, IMAU, INSTAAR
Development of remote sensing in glaciology. SPOT5, ASTER, ERS.	Iceland Res. Fund, Univ. Res. Fund, OASIS	U. Innsbr., LEGOS, DTU, ESA
Tephra layers in glaciers, observations and modelling		UBC, UC
Lithosphere response to glacier variations	Road Authority	

Table 7.3.2.4. Main projects of the Glaciology group.

The group aims to continue mapping the geometry of glaciers in Iceland, to monitor mass balance, dynamics, hydrological processes, and glacio-volcanic interaction. The group also intends to carry out numerical modelling of the glacier response to future climate change, and reconstruction of glaciers in Iceland since the last glacial maximum. Emphasis will be placed on further development of remote sensing methods in glaciology and exploration of information on past mass balance, glacier dynamics and volcanic history derived from studies of tephra layers inside the glaciers (mainly by radio echo soundings and physical modelling).

7.3.3. Quaternary Geology and sedimentology

The Quaternary Geology and Sedimentology group focuses on a common research theme: Spatial and temporal patterns of climate change. The understanding of physical, chemical and biological processes are critical for the interpretation of palaeo-records on climate change, and the modern physical environment in Iceland offers many possibilities to improve the understanding and calibration of environmental proxies. Palaeo-environmental data from Iceland such as glaciation history, palaeo-oceanography, soil development as well as vegetational and faunal changes have particular value due to the geographical location of Iceland which enables monitoring of the history of the boundary between Arctic and Atlantic water and air masses.

Topics studied by group members include: Sedimentary processes related to glaciers and glacial rivers; eolian processes, soil erosion and human impact on the natural

environment; coastal processes and sea-level changes; responses of sandur plains to the degree of glaciation and sea-level changes; isostatic changes during the Holocene and last glacial-interglacial cycle; mapping of sedimentary and volcanic sequences in Tertiary and Quaternary strata; dating of volcanic, tectonic, and climate archives in the Iceland region; the shelf around Iceland and the mid-ocean ridges with respect to development of sedimentary basins; acquisition of marine palaeo-environmental data through coring and geophysical research; marine sedimentary processes in volcanic setting with special emphasis on fracture zones; land-sea correlation of climate and palaeo-oceanographic records using tephrochronology, Tertiary and Quaternary evolution of plant communities in Iceland, palaeo-ecology and sedimentology of the Tjörnes sequence as well as the sedimentary and fossil record of the Tertiary and Quaternary volcanic sequences in Iceland for the last 15 million years.

The group acquires data from seismic reflection studies and from sediment coring of both shelf and lake sediments. In order to determine glaciation history, studies of the proglacial areas of active glaciers in Iceland and elsewhere include studies of lithofacies and glaciotectonic features. Studies of soil profiles are undertaken to obtain data on the physical properties of soil, volcanic input and tephra stratigraphy. A variety of physical and geochemical methods are used for the analysis of the data, and both the macro- and micropalaeontological records form an important part of the palaeo-environmental research.

UNI. TEACHERS	SEN. RES. SCI.	JUN. RES. SCI.	RES. ASS.	TECHNICIAN	GRAD. STUD.
3	2	0	0	1/3	4 PhD + 7 MS

Table 7.3.3.1. Composition of the personnel of the Quaternary geology and Sedimentology group.

The staff of the Quaternary Geology and Sedimentology group consists of five A and B level staff (see Table 7.3.3.1). Four PhD students are enrolled in the group and six more are affiliated with the group at foreign universities. Seven MS student are attached to the group. Up to six short-term research assistants were hired in 2005.

INSTRUMENT	OPER. BY GROUP	YEAR PURCHASED	AVAIL. AT IES	AVAILABLE ELSEWHERE
CM 5014 Coulometer, CM 5200 Furnace autosampler and CM 5240 TIC autosampler	X	2002		
Freeze Dryer	X	2002		
Grain size analys.	X	2001		X (ISOR)
Microprobe			X	X Hawaii, Edinburgh, University of Bergen
Biogenic Silica	X	?		Univ. of Chicago
2 boats	X	2004		
2 Sed. corers	X	1994, 2004		
3 vehicles		1999-2001	X	
GPS	X	1998	X	
Altimeter	X	1987, 1991		
Sedimentology lab	X		X	
5 Microscopes	X	1975 - 2004	X	
Field vehicles		1999	X	

Table 7.3.3.2. Main facilities used by the Quaternary geology and sedimentology group

Equipment used by the group include project-related field equipment in addition to laboratory facilities for the study of microfossils and macrofossils, carbon and carbonate geochemistry, tephra geochemistry, facilities for grain-size analysis, and facilities for non-destructive logging of sediment cores and sampling of sediment cores. The group has access to the following analytical instruments: XRF, SEM, ICP, microprobe.

	GOVERNMENT AND NMR	ICELANDIC GRANTS	FOREIGN GRANTS	COMPANIES & AGENCIES	TOTAL
Salaries	25.000.000	6.500.000	1.100.000	0	32.600.000
Instr. and oper. costs	500.000	7.200.000	11.600.000	1.150.000	20.450.000
Total	25.500.000	13.700.000	12.700.000	1.150.000	53.050.000

Table 7.3.3.3. Approximate annual expenses of the Quaternary Geology and Sedimentology group in 2005 in ISK.

The group's turnover in 2005 was 27.6 million ISK. About 50 % of the turnover lay in salaries of permanent staff while about 15 % were used for the salary of short-term research staff. Approximately 35 % went to project related costs. The income was 50% secure and 50% came from soft money.

Table 7.3.3.4 gives an overview of the main research projects in which the group has participated over the past five years, including information about the sources of funding and the level of international collaboration.

PROJECT NAME	PROJECT TYPE AND FUNDING	EXTERNAL COLLABORATION
Warm times/Cold times: Reconstructing Iceland's climate and environment since the last glaciation to evaluate the impact of future climate change (2003-6)	IRF, NSF, University Research Fund	Univ Colorado, Univ Exeter, Univ. Alberta, Edmonton, Canada, Univ. British Columbia
Changes in the North Atlantic circulation: understanding the past –preparing for the future (2005-7)	IRF, Univ. of Iceland Research Fund	Univ Colorado, Univ Exeter, Univ Alberta, Edmonton, Univ of British Columbia
Midge inferred temperatures from Icelandic lakes (2006-8)	CSEF -Comer funds	Univ Colorado, Univ. Alaska, University Mass., Amherst
Quantitative estimates of Holocene warmth and climate variability derived from Icelandic Lake sediments (3yr) 2004-7	NSF	Univ of CO, Boulder, NCAR, Boulder, Univ Alaska, Univ Mass., Amherst, MA, Univ Calgary, Calgary, Alberta, Univ. Chicago
A synthesis of the last 2000 years of climatic variability from arctic lakes (2005-9)	NSF, ARCSS	Univ. of Arizona, Tucson, Univ. of Colorado, Univ. of Mass, Amherst, MA. Univ. of Minneapolis
Late Weichselian early Holocene Deglaciation and Relative Sea Level Changes	Internal	Icelandic Institute of Natural Sciences
Ice sheet modelling	Internal & Univ. Edinburgh	University of Edinburgh
Seal level changes in NW Iceland	Internal, Univ. Edinburgh	University of Edinburgh
Environmental changes recorded in Icelandic Shelf Sediments	IRF 2000-2002	Univ. Aarhus, Univ. Bergen
HOLSMEER Holocene Shallow Marine Environments of Europe	EU 5th Framework	14 international partner institutions
PACLIVA Patterns of palaeoclimate variability in the North Atlantic	EU 5th framework	13 international partner institutions
Millennium European Climate of the Past Millennium	EU 6th Framework	39 international partner institutions
ALDA Aldursgreining sjógerða við Norður-Atlantshaf	IRF	University of Aarhus, East China Normal University, China
Molluscan migration to and from Iceland	University Research Fund	Geological Museum, Copenhagen
Tjörnes marine faunas	University Research Fund and IRF	Univ. Copenhagen
Tertiary floras of Iceland	IRF	Aarhus University and Museum of Natural History, Stockholm
Brúarjökull – sedimentary environment of a surging glacier	Swedish Research Council, IRF, University of Iceland Research Fund, 2003-2005	Univ. Lund, Univ. Copenhagen
Glacial history of the Kara Sea area, arctic Russia.	Swedish Research Council, NSF, UNIS	UNIS (Svalbard), Univ. Lund, Univ Colorado, Boulder, Univ. Illinois Chicago
Late Quaternary glacial and environmental history of Svalbard and the Barents Sea.	Swedish Research Council. Univ. Gothenburgh, UNIS	UNIS (Svalbard) and University of Gothenburgh, Sweden

Table 7.3.3.4. Main projects of the Quaternary Geology and Sedimentology group 2001-2005

The group depends on cooperation with other groups within the IES in the fields of tephrochronology and palaeo-magnetic dating, but also interacts with groups working on surface deformation and glaciology.

The interaction between tectonic, volcanic, and geomorphological processes throughout the geological history of Iceland and the exceptionally active modern physical environment will continue to offer many research opportunities in environmental research. It is envisaged that study of the palaeo-record, which in many cases has a unique dating potential, as well as increased emphasis on the research of active processes will be valuable for the international research community.

7.3.4. Deformation – Seismology

Deformation and seismological research at the IES focuses on active processes around volcanoes, their associated fissure swarms and the tectonics of the divergent plate boundary in Iceland and surrounding regions, as well as studies of the structure and properties of the crust and mantle beneath the region. These studies take advantage of the on-shore exposure of an oceanic rift system, which is unique to Iceland, and focus on the anomalous nature of the Iceland region as an oceanic rift, striving to define and understand the transition from anomalous Iceland to a normal oceanic environment.

Members of the group are engaged in studies of seismicity and deformation around active volcanoes, studies of plate boundary deformation associated with volcanic events and larger transform earthquakes, mapping of earthquake faults and the relationships between various modes of surface faulting, seismicity studies on the Iceland shelf, studies of crustal thickness and structure in Iceland and the ocean around Iceland, studies of mantle structure and fabric beneath the region, studies of deformation responses to changes in glacial loading, studies of methods of earthquake location, and mapping of volcanic and seismic hazard.

For this purpose, group members use GPS-geodesy, satellite radar interferometry (InSAR), optical levelling, strain and tilt meters, gravity, bathymetry, and isostacy, multibeam and subscan/sidescan seafloor mapping, OBS seismometry, broadband seismometry, short-period seismometry from the SIL network operated by the Icelandic Meteorological Office, and various methods of numerical simulation and modelling.

UNI. TEACHERS	SEN. RES. SCI.	JUN. RES. SCI.	RES. ASS.	TECHNICIANS	GRAD. STUD.
1	6	2	0	2	1 PhD+1 NF+3 MS

Table 7.3.4.1. Composition of staff in the Deformation-Seismology group.

The group consists of seven A and B level staff (see Table 7.3.4.1), with two current short-term junior researchers, and two technical staff primarily engaged in field work. The group currently has one PhD student, one Nordic research fellow and 3 MS students.

INSTRUMENTS	Operated by group	Year purchased	Avail. At IES	Available elsewhere
Portable GPS instruments (10)	X	1997-2005	X	
Fixed GPS laboratories and analysis software	X	1999-2005	X	X
SP seismic network (1s), 6 stations	X	1974-90		
Intermediate period (5s) seismic network, SIL	X	1990-2005		X(IMS)
InSAR analysis lab and software	X	1995		
Portable seismic instrument pool (10sp+3 BB)		2005-6		X(in Icel)
Sp OBS instruments				X(U Hokk)
SP(0.25 s) refraction instruments (15)	X	<1985		
Broadband instruments				X(Pascal, Seis-UK)
EM300 multibeam echo sounder				X
Field stations in Krafla and Askja			X	
Gravimeters			X	X
Field vehicles (3)			X	

Table 7.3.4.2. Main resources of the Deformation-Seismology group.

The group's facilities include portable GPS instruments, permanent GPS observatories, a short-period seismograph network, access to the state-of-the art SIL network of 50 SP and BB seismographs, an InSAR analysis lab and software, access to an Icelandic portable seismic instrument pool, access to international portable seismic instrument pools, access to a multibeam echo sounder, field stations in NE Iceland and field vehicles (see Table 7.3.4.2).

	Govt & NMR	Icel. grants	Foreign grants	companies & agencies	Total
Salaries	51.700.000	2.700.000	1.600.000	3.300.000	59.300.000
Instr. & oper. costs	11.300.000	7.500.000	800.000	5.400.000	25.000.000
Total	63.000.000	10.200.000	2.400.000	8.700.000	84.300.000

Table 7.3.4.3. Approximate annual expenses of the Deformation-Seismology group in 2005 in ISK.

The group's turnover in 2005 was 84 million ISK. 61% of the turnover lay in salaries of the permanent staff while 9% were used for the salary of short-term research staff. Approximately 30% went to project-related costs and infrastructure. The income was 75% secure and 25% came from external sources.

Table 7.3.4.4 gives an idea of the main research projects in which the group participated over the past 5 years, including information about the sources of funding and level of international collaboration.

Project	Type	External collaboration
PREPARED (Improving seismic preparedness and mitigating risk, based on studies of south Iceland June 2000 earthquakes)	EU	Prepared consortium (14 partners)
VOLUME (Volcanoes – Understanding subsurface mass movement)	EU	VOLUME consortium (12 partners)
RETINA (Realistic Evaluation of Temporal Interaction of Natural hazards)	EU	RETINA consortium (11 partners)
FORESIGHT (Frequent Observation-driven Realistic Evaluation and Simulation of Interacting Geophysical Hazard Triggers)	EU	FORESIGHT consortium (16 partners)
South Iceland earthquakes: Pre-, co- and postseismic crustal deformation	IRF, NSF, internal	U. Florida
Volcano geodesy	IRF, EU, NSF, internal	Many in UK, France, USA
Glacio isostacy	Icel. Road Author., Nat. Power Comp., Internal	Icelandic groups, Lund University, CNRS, France
Bathymetry and tectonics of the Tjörnes Fracture Zone and S-Kolbeinsey Ridge	IRF, NSF, Internal	Woods Hole, Marine Research Institute
KRISE crustal structure of the Iceland Plateau	NSF, IRF, Internal	U. Oregon, U Bergen, Hokkaido
ICEMELT (crustal and mantle structure beneath Iceland)	NSF	Carnegie, Cambridge, Rhode Island
Volcano seismicity, Hekla, Torfajökull	IRF, Internal	U Helsinki, Cambridge
Volcano deformation	IRF, Internal	
Shear wave splitting across the Iceland hot spot and flow in the North Atlantic upper mantle: Results from the ICEMELT experiment.	NSF	Carnegie
Definition of the lithosphere of Iceland. Seismological and geodynamical analysis of the asthenosphere of the Iceland hot spot.	NSF, Univ Res. Fund	J.W. Goethe University in Frankfurt.

Table 7.3.4.4. Main projects of the Deformation-Seismology group in 2001-2005.

Two factors have shaped the activity of the group more than anything else: technical development and on-going geodynamic events and processes. Both have been difficult to foresee. The impact of the use of InSAR, continuous GPS and broad-band seismometry has yet to be fully appreciated and realised. Each new geodynamic event such as a volcanic eruption, magmatic intrusion or a large earthquake or faulting event has added enormously to our understanding of crustal dynamics. It is of vital importance to maintain flexibility in order to be able to react to events of this type. The following items

are at the present time seen as important areas of focus for the group's activity in the immediate future:

1. Strengthening of InSAR capabilities, by participation in new multi-national projects using satellite and airborne radar.

2. Further development of a network of continuous GPS-stations. Adding a fourth dimension to the monitoring of deformation fields has been extremely important. The possibility of 1 s positioning bridges the frequency gap between long-period seismometry and geodesy. Such a network will greatly enhance the study of deformation rate during magmatic events and "slow" earthquakes.

3. Further establishment of GPS-networks for campaign-type measurements with the aim of building a network with mesh-size not exceeding 5 km covering the entire plate boundary and all volcanic areas.

4. A pool of portable field seismographs should be further developed for use both during seismic crises and in structural studies. Very few instruments are available for such use in Iceland. We have relied on borrowed instruments for this purpose, both from the UK and US. Ocean-bottom instruments have been operated in cooperation with Japanese groups.

5. Deployment of a wide-aperture seismic network, including ocean-bottom stations around Iceland, to study the deep roots of the Iceland hotspot. It is possible that this opportunity will arise in the near future, in cooperation with groups elsewhere.

6. Use of the state-of-the-art multibeam sounder on the research vessel Árni Friðriksson (Iceland Maritime Institute) to study structures in the active areas around Iceland. This powerful research tool has been severely underused due to the lack of research funding. High-resolution structural maps of the Reykjanes Ridge, the Kolbeinsey Ridge, the Tjörnes Fracture Zone and the Vestmannaeyjar volcanic system are high-priority projects.

7. Use of broad-band seismographs to study seismic signals of local origin, e.g. local earthquakes, "slow" earthquakes, volcanic tremor, microseisms etc.

8. Mapping of active structures in the plate-boundary regions on land has been an important element in the group's activity and is by no means completed. The availability of high-resolution digital areal photography, real-time differential GPS mapping tools and use of GIS software for both mapping and analysis will greatly aid in this effort.

7.3.5. Igneous Geochemistry

Geochemical and petrological research at the IES focuses on the origin and evolution of magmas at divergent plate boundaries, particularly in Iceland where chemical, isotopic and mineralogical complexities reflect interaction between the mantle plume and the rift. Different volcano-tectonic regimes resulting from the westward drift of the rift system relative to the plume give rise to great a diversity of magma types. The resulting rocks appear in a variety of facies, from holocrystalline to glassy (e.g., Quaternary palagonite formation), allowing the study of crystal-melt relations as well as quenched melt inclusions in crystals. Processes of magma formation and evolution, dynamics of lava flows, eruptive mechanisms, and time scales of various processes are being studied by members of the group.

Isotopic studies reveal a heterogeneous mantle source whose different melt fractions and cumulative melts at different levels in the mantle and crust are being studied both experimentally and as glass inclusions in crystals. Volatiles, being of prime importance in all petrological and volcanic processes, are receiving ever-increasing attention at the Institute, from high-pressure solubility experiments to studies of degassing and water-magma interaction in volcanoes. Time scales of petrological processes, and the ages of young lava flows are studied with disequilibrium isotope chemistry. Individual projects also include the study of entire volcanic systems or special aspects of their chemistry and evolution.

Methods employed by members of the Igneous Geochemistry group include geological mapping and sampling, field studies of volcanic phenomena, ICP-spectrochemical and electron microprobe analysis, ICP-MS-analysis of isotopes and REE, high- and low-P experiments, Fourier-transform infra-red analysis of volatiles in glasses and minerals, measurements of disequililbrium isotopes, and Mössbauer-spectroscopic analysis of minerals and glasses. Where the Institute's analytical arsenal is found wanting, cooperation is sought with foreign institutions.

UNI. TEACHERS	SEN. RES. SCI.	JUN. RES. SCI.	RES. ASS.	TECHNICIANS	GRAD. STUD.
1	4	0	1	2/3	1 PhD+2 NF+4 MS

Table 7.3.5.1. Personnel of the Igneous Geochemistry group.

The group consists of one professor and 4 senior research scientists, one of whom occupies half a position, one research assistant and two technicians, one of whom is partially affiliated with the group. The group currently has one PhD student, two Nordic research fellows and 4 MS students.

INSTRUMENT	Operated by group	Year purchased	Available at IES	Available elsewhere
Chemical laboratory	X	2005		
Rock laboratory (crushing, grinding, sawing, sifting, mineral separation)	X	1970-2005		
Lapidary (polishing, thin sections)	X	1980-2005		
1-atm high-T furnaces (3) with fO_2-control	X	1975-85		
Piston-cylinder (P<40 kbar, T<2000°C)	X	1990		
Internally heated Ar-pressure vessel (P<10 kbar, T<1500°C)	X	2005		
Microscope heating stages for melt inclusions (2)	X	1990-95		
X-ray diffraction (XRD)	X	1960		
Electron microprobe (ARL/SEMQ)	X	1974-96		
petrological microscopes for incident and transmitted light (4)	X	1970-80		
Petrol. microscopes for transmitted light (15)	X	1975-85		
ICP-AES		2005	X	
ICP-MS		1998	X	
TOF-ICP-MS				X
SEM (scanning electron microscope)				X
FTIR (infra-red spectrometer)	X	2000		
Mössbauer spectrometer				X
Field vehicles (3)		1999	X	
Field stations at Krafla and Askja		1985	X	

Table 7.3.5.2. Facilities of the Igneous Geochemistry group.

The facilities of the group (Table 7.3.5.2) include wet-chemical and experimental laboratories, analytical instruments (ICP-AES, ICP-MS, XRD, FTIR), a primitive lapidary (larger tasks are relegated to a central lapidary in Reykjavik), microscope heating stages, and an array of petrological microscopes. Outside the Institute, the group has access in Reykjavik to a Mössbauer spectrometer, TOF-mass spectrometer, and a SEM. In France, a member of the group operates a laboratory in Clermont-Ferrand for analysing disequilibrium isotopes, and access to ion-probes is facilitated through cooperation with Edinburgh University (Scotland) and Brown University (U.S.A). Three field vehicles are operated jointly by the IES.

	Govt & NMR	Icel. grants	Foreign grants	companies & agencies	Total
Salaries	45.000.000	0	0	0	45.000.000
Instr. & oper. costs	6.300.000	700.000	2.100.000	0	9.100.000
Total	51.300.000	700.000	2.100.000	0	54.100.000

Table 7.3.5.3. Approximate annual expenses of the Igneous Geochemistry group

The group's turnover in 2005 was about 54 million ISK (Table 7.3.5.3). The largest item lay in salaries (83%), and most of the research was internally funded. This, however, varies highly from year to year as support from Icelandic and international grants has

varied greatly between years.

Members of the group are engaged in cooperative research with other members of the Institute as well as with foreign and Icelandic research institutions. The relationship between tectonics and petrology constitutes an interdisciplinary field of research, the analysis of tephra layers in the Greenland ice cores and elsewhere another, and the various aspects of "volcanology" a third.

The founding of the IES under one roof has opened up new scope for cooperation between the different fields of earth science within the University of Iceland — in the case of the Petrology-Geochemistry group, not least with that of geophysics. We foresee interdisciplinary cooperation in elucidating the chemical and petrological response of individual volcanic systems to regional tectonic constraints such as rifting events and crustal uplift. Here, independent geophysical evidence regarding crustal thickness and structure stimulates interdisciplinary efforts to elucidate crustal accretion in Iceland. Second, the petrological nature of dense bodies beneath central volcanoes (as shown by gravity and seismic measurements) calls for a study in suitably-eroded volcanic centres. Third, the causal relationship between petrochemistry and volcano-tectonic regime (rift vs. off-rift vs. propagating rift) is a promising field for research. And, fourth, the Quaternary Palagonite Formation remains largely to be studied petrologically, not least the role that hydration and alteration of its high-temperature phase assemblage plays in Iceland's geothermal budget. Finally, a campaign involving the radiometric age determination of Tertiary volcanic centres is in the planning.

Some on-going research projects in which members of the Petrology-Geochemistry group are engaged are listed in Table 7.3.5.4. Most of these have been running for a number of years and have received some external funding in the past (see the Table). Generally such support is called for, especially for field work, for buying external analytical work, or for paying salaries to students. However, for most of the projects, the analytical capability of the IES is sufficient for running the projects and hence they have been largely "internally funded".

Project name	Project type & funding	External collaboration
Time-scales of magmatic processes in Icelandic volcanoes	IRF, UI, French Embassy	Clermont-Ferrand, Uni. of Oregon
Magma dynamics of Katla volcano during the Holocene	UIRF	Clermont-Ferrand, Uni. California-Santa Cruz
Silicic rocks in Iceland as an analogue for the continental protocrust	Internal	
Dating older rock formations and recent alteration products	Jules Verne netw. French-Icelandic collabor.	Uni. Wisconsin, Uni. Utrecht
Phase equilibria of peridotite at high pressure and temperature.	Internal	Arizona State University
Solubility of water, carbon dioxide and sulphur in volcanic glasses.	Internal	Arizona State University.
Volatiles in magmas based on Ion-probe anal.	IRF	
Fluorine degassing of volcanic ash: implications for environmental hazard	Internal	
Modelling of magmatic evolution based on measured water content of magmas	Internal	
Ash layers in Greenland ice cores	Carlsberg Foundation	University of Copenhagen
Radium and Radon in thermal water.	Internal	ISOR, University of Florida
Holocene volcanism of the Weastern Rift	Internal	University of Hawaii, ISOR
Volcanic history and geochemistry in the Northern Rift.	Internal	University of Cambridge University of Bergen
The Selsund pumice	Internal	
Melt inclusions in crystals	UIRF, IRF, internal	U. Hannover, Brown Uni., Vestmannaeyjar Nat. Inst.
Redox processes in Icelandic and Mars rocks	Internal	Aarhus University

Table 7.3.5.4. Selected ongoing research projects of the Igneous Geochemistry group.

7.3.6. Aquatic geochemistry

Aquatic geochemical studies include focus on water-rock interaction, processes of the weathering environment, and groundwater and hydrothermal systems. Various thermodynamic and kinetic experiments constitute an important part of the activity of the group, with the intent to improve the understanding of field data. Isotope studies involve assessment of the origin of ground water and past climatic changes. All of these studies are relevant to Iceland's water resources, including its unique geothermal systems and the interaction of its basaltic crust with both fresh and sea-water. in the country and water and seawater interaction with basaltic crust. The group has strong expertise in the areas of geothermal fluid chemistry, isotope fractionation (H, O, C), chemical weathering, and experimental geochemistry.

The Aquatic geochemistry group consists of three A and B level staff, one junior research scientist and three research assistants, two of whom work largely independently on their projects (see Table 7.3.6.1.).

UNI. TEACHERS	SEN. RES. SCI.	JUN. RES. SCI.	RES. ASS.	TECHNICIANS	GRAD. STUD.
1	2	1	3	1/3	2.5 PhD+1 NF+2 MS[a]

Table 7.3.6.1. Personnel of the aquatic geochemistry group. [a]One student is doing a project which is partly in physical-geography.

The group has exclusive use of a total laboratory space of 120 m^2 and a laboratory of 80 m^2 which is partly used by others. One laboratory holds a mass spectrometer for determination of light isotopes (^{18}O, ^{2}H and ^{13}C). There are two laboratories for experimental work and two rooms for an ICP-AES and auto-analyser instruments, respectively. Facilities are good for various types of mineral-solution experiments and for analysis of light isotopes as well as major and trace elements in water and gas samples. Access to instruments for mineralogical analysis is relatively good. Table 7.3.6.2 summarizes the major instruments available to the group in Iceland.

Instrument	Operated by the group	Purchased year	Available within IES	Available elsewhere
Mass spectrom.	X	1985		
ICP-AES	X	2005		
Gas chromatograph	X	2003		
Ion chromatograph	X	2004		
Opt. spectrophotom.	X	1990		
IR spectrometer			X	
Electron microprobe			X	
XRD				X
SEM				X
Field vehicles		1999	X	

Table 7.3.6.2. Analytical instruments available for the Aquatic Geochemistry group.

Funds are presently being sought to replace the mass spectrometer and to obtain a new ion chromatograph for determination of trace quantities of cations. Preparation is also under way, in collaboration with specialists from other groups, to seek funds for an ICP-MS instrument with laser ablation and a quadropole detector, primarily for analysis of some trace elements in mineral phases.

Progress has been made with instrumental analysis and sampling techniques during the last two years, and work is under way to determine nutrient salts by IC. Carbonate carbon is determined by IC and total carbon by ICP-AES, yielding organic carbon by difference. Sulphur species in water must be determined on site or collected into resin. For amorphous silica over-saturated solution at room temperature, pH must be measured before the onset of polymerization. For analyses of 20 components in water only three 30 ml samples are needed.

The salaries of the professor, two senior research scientists, and the Nordic research fellow are from secure funds and constitute approximately 33% of all group costs. Most of the research projects and expenses of the A and B level staff, the junior research scientist, the research assistants, the technical assistant and students are covered by soft money (65% of total). About 55% of the soft money comes from energy companies in Iceland (27.4 million ISK) and 45% from Icelandic and international research funds as shown in Table 7.3.6.3.

	Govt & NMR	Icelandic grants	Foreign grants	Companies and agencies	Total
Salaries	23.500.000	11.500.000	0	13.600.000	48.600.000
Instr. & oper.costs	3.000.000	10.500.000[b]	1.200.000	13.800.000	28.500.000
Total	26.500.000	22.000.000	1.200.000	27.400.000	77.100.000

Table 7.3.6.3. Expenses of the aquatic geochemistry group in 2005 (approximate)**.** [b]A part of this income (6 million ISK) included a grant to renew the ICP-AES instrument and was common with the Nordic Volcanological Centre.

The group has been involved in many research projects over the last 5 years. Table 7.3.6.4 gives a list of the most important projects, their nature and a list of collaborators. During the last decade, aquatic geochemical studies at IES have focused on palaeoclimate, the origin of geothermal water, water-rock interaction processes, in particular chemical weathering and denudation rates and the assessment of geothermal fluid compositions.

Project	Type	External collaboration
Isotopes as tracers in groundwater hydrology		ISOR
Palaeoclimate: The Greenland Ice Cores		Niels Bohr Inst. DK, Saclay Inst, France, INSTAAR, USA
14C age determinations		Tandem Accl. Lab., Aarhus Univ., DK
Dissolution rate of volcanic glasses	Post doc. research	Univ. Toulouse France
The concentration, isotope composition and origin of sulphur in Icelandic river waters.		Univ. Stockholm
The effect of volcanic eruption on the chemistry of surface waters.	Nordic fellows	Univ. Stockholm
Experimental and theoretical study of reactive transport of arsenic through natural porous media	Ph.D. project	Univ. Aberdeen UK
Effect of climate and vegetation on chemical weathering rate	PhD and MS project	Univ. Paris and Toulouse
River concentrations and fluxes	Ph.D. project	Icelandic institutes, gov-ernment agencies Open University UK
Gases in geothermal steam	Ph.D. project	
Mg-silicate pptn. From geothermal waters	Expert project	
Kinetics of silica polymerization	Expert project	
Determination of Fe(III) hydrolysis constants	Post doc. research	
Redox reactions in geothermal systems	Post doc. research	
Chemistry of wet-steam well discharges		
Trace elements in ground- and geothermal waters		
Ground and geothermal water chemistry in basalts		ISOR, U.Akureyri
Program for chemical speciation and reaction process modelling		ISOR, U. Akureyri

Table 7.3.6.4. Main research projects over the last 5 years through mineral-solution equilibria. Experimental physical chemistry work, largely for improving interpretation of field data, has gained increased weight in the activity of the group. The writing of a new computer code for speciation and reactive transport modelling is in its final stages.

Most of the research projects of the group during the last decade or so have concentrated on various aspects of aquatic geochemistry although, through collaboration, members of the group have been quite extensively involved in palaeo-climatic, environmental and other studies. It is envisaged that the future activity of the group will have a twofold emphasis: to maintain and update geochemical facilities at IES and to

increase involvement in theme-oriented projects which require experts with varied background. Experts in the group would contribute to three of the four proposed research themes of IES (volcanic processes, global change and water and geothermal resources).

It is difficult to run almost all of the aquatic geochemistry laboratories on soft money as is the case now. It is essential to receive at least partial support from the government budget in order to employ permanent staff for this activity. This would be especially helpful for graduate student and Nordic-Fellow projects.

Field-based isotopic and chemical work will continue. It is, however, expected that experimental work will continue to increase, as it has during the last few years. Experimental data are essential to advance the interpretation of many kinds of field data. Projects of interest which are presently being discussed for the near future are:

1. CO_2 sequestration to counteract emission of CO_2 into the atmosphere by the burning of fossil fuel.
2. Further drilling into the Greenland ice-sheet to reveal palaeo-climatic changes
3. The redox, trace element and mineralogy of rocks altered by acid fluids in high-temperature geothermal fields
4. Experiments to generate general equations describing the dissolution rate of volcanic glasses and minerals
5. Studies of atmospheric moisture to improve the understanding of the isotopic characteristics of the water cycle in Iceland.

Water-rock interaction studies have progressed much during the last 1-2 decades due to the use of reaction path and reactive transport modelling. This type of work requires experts in geochemistry, hydrology and modelling. Very limited emphasis has been placed on hydrology and modelling studies at the IES. It should be seriously considered by the Board of IES whether such research should be established. Initially it would probably involve employing a hydrologist/modeller, thus linking the aqueous geochemistry and the glaciology research groups.

7.3.7. Nordvulk

Nordvulk is a research centre within the IES which is partly funded by the Nordic Council of Ministers. The centre has been operated in the same form as the former Nordic Volcanological Institute since the IES was founded. Members of the centre are integrated into the research groups of the IES. The information here is thus not an addition to the account of IES activities outlined above for the individual research groups.

The Nordvulk group consists of six senior research scientists, two research assistants and two technicians. Currently, three junior research scientists are affiliated with the group in addition to one PhD student and four Nordic fellows.

UNI. TEACHERS	SEN. RES. SCI.	JUN. RES. SCI.	RES. ASS.	TECHNICIANS	GRAD. STUD.
0	6	3	2	2	1 PhD + 4 NF

Table 7.3.7.1. Composition of Nordvulk personnel in 2005.

The centre is responsible for an interdisciplinary research programme in volcanology and related fields. The research emphasis of the centre has been on deformation studies around volcanoes and the neovolcanic zones in Iceland associated with both fissure swarms and earthquakes, studies characterizing the variable source material of Icelandic volcanism, the melting process in the mantle as well as crustal accretion and evolution, and near-surface volcanic processes through study of much of the geochemical spectrum from volatiles through major and trace elements to isotopes and their ratios. The centre

has also been active in volcano seismological projects, volcano mapping projects and technical development for monitoring volcanic and earthquake hazard.

Research collaboration between Nordvulk and the University of Iceland has been extensive through the years. However, sharing a working environment and administration makes that collaboration simpler and more natural. In this way the expertise base of the Nordvulk project has grown and the IES has moved significantly closer to the critical mass necessary to maintain a dynamic research environment.

Nordvulk operates a number of research facilities that define the foundation of the research programme. These are listed in Table 7.3.7.2 and include various instruments for chemical analyses of rock, geophysical data gathering and analysis, and geological mapping. Joining the IES in the same building and within the same administration clearly expands the centre's infrastructure base. At the same time the infrastructural base of the IES as a whole is significantly improved by incorporating Nordvulk.

Instrument	Operated by group	Purchased Year	Available within IES	Available elsewhere
Chemical laboratory	X	2005		
Rock laboratory (crushing, grinding, sawing, sifting, mineral separation)	X	1970-2005	X	
Lapidary (polishing, thin sections)	X	1980-2005		
Petrol. microscopes for transmitted light (15)	X	1975-85		
SEM (scanning electron microscope)		2003		X
X-ray diffraction (XRD)	X	1960		
Electron microprobe (ARL/SEMQ)	X	1974-96		
FTIR infra-red spectrometer	X	2000		
MC-ICP-MS	X	1998		
ICP-AES		2005	X	
TOF-ICP-MS		2003		X
GPS instr. & anal. software	X	1992-2005	X	
InSAR analysis centre		1996-2005		
Seismometers		1985-2005	X	X
Field Vehicles	X	1999	X	
Field stations (2)	X	1985		
GIS	X	2000	X	

Table 7.3.7.2. Main research infrastructure used by Nordvulk scientists.

The Nordic funding of Nordvulk is motivated by the desire to offer Nordic earth scientists access to infrastructure which allows them to study the active processes of Iceland, primarily volcanic, but also tectonic and other active processes. This experience provides Nordic researchers with insight that is useful for the interpretation of the geological history of Scandinavia and formation of natural resources such as e.g. metallic ore. The most important part of Nordvulk's activity is the programme for Nordic research fellows through which young Nordic earth scientists are funded to conduct research projects in Iceland for a period of one to three years. The scientific expertise of the centre and its research infrastructure form the backbone of the Nordic research fellow programme. Nordvulk also hires one senior Nordic researcher, with special advisory duties for the Nordic fellow programme, temporarily (2 – 4 years) and conducts summer schools and workshops for Nordic and international researchers and students.

	Govt & NMR	Icelandic grants	Foreign grants	Companies and agencies	Total
Salaries	85.000.000	2.700.000	1.200.000	2.000.000	90.900.000
Instr. & oper.costs	29.500.000	700.000	1.200.000	3.100.000	34.500.000
Total	114.500.000	3.400.000	2.400.000	5.100.000	125.400.000

Table 7.3.7.3. Approximate break down of Nordvulk´s expenses in 2005 in ISK.

During 2005, approximately 84 million ISK of Nordvulk's funding came from the Nordic Council of Ministers. In addition, Nordvulk received funds from the Icelandic government

amounting to approximately 30 million ISK. Nordvulk scientists also raised approximately 11 million ISK in research grants. Approximately 72% of the centres budget went to salaries, and 28% to project costs and operation of research infrastructure.

Project	Type	External collaboration
PREPARED (Improving seismic preparedness and mitigating risk, based on studies of south Iceland June 2000 earthquakes)	EU	Prepared consortium (14 partners)
VOLUME (Volcanoes – Understanding subsurface mass movement)	EU	VOLUME consortium (12 partners)
RETINA (Realistic Evaluation of Temporal Interaction of Natural hazards)	EU	RETINA consortium (11 partners)
FORESIGHT (Frequent Observation-driven Realistic Evaluation and Simulation of Interacting Geophysical Hazard Triggers)	EU	FORESIGHT consortium (16 partners)
Coseismic crustal deformation caused by the June 2000, south Iceland earthquakes	Internal, IRF, Uni. Icel. Res. Fund	Icel Met. Office
Pre- and postseismic crustal deformation due to the June 2000, south Iceland earthquakes	IRF, Internal, EU	Icel. Met. Office, USGS, ETHZ, CNRS
GPS measurements across eastern and western volcanic zones	NSF, Internal	Univ. Miami, Icel. Met. Office
Volcano geodesy	IRF, EU, NSF, internal	Many in UK, France, USA
Glacio isostacy	Icel. Road Author., Nat. Power Comp., Internal	Icelandic groups, Lund University, CNRS, France
Iceland Geodynamics	Book writing	Springer-Praxis
Role of water in magma fragmentation in the 1362 Öræfajökull erupton.	Internal & Iceland Parliament	University Blaise Pascal, Clermont Ferrand.
Vestmannaeyjar, nature of volcanism, volcanic history and hazard.	Internal and Viðlagatrygging	University of Durham, Inst. Physique de Globe
The Burfell lava: chemical and thermodynamic properties and the formation of inflated lava flows.	Internal	Univ. Blaise Pascal, Copenhagen Univ.
The evolution of the Reykjanes ridge from land to 62°N.	Internal, NSF	University of Hawaii Miami University
Volatiles in magmas based on Ion-probe analysis	IRF	
Fluorine degassing of volcanic ash: implications for environmental hazard	Internal	
Modelling of magmatic evolution based on measured water content of magmas	Internal	
Ash layers in Greenland ice cores	Carlsberg Found.	University of Copenhagen
Radium and Radon in thermal water.	Internal	ISOR, University of Florida
Holocene volcanism of the Weastern Rift Zone	Internal	University of Hawaii, ISOR
Volcanic history and geochemistry in the Northern Rift.	Internal	University of Cambridge University of Bergen
The Selsund pumice	Internal	

Table 7.3.7.4. Main research projects of Nordvulk researchers in the past 5 years.

The main research projects in which the Nordvulk group of scientists participated in the last 5 years or so are listed in Table 7.3.7.4. The projects include international projects with international funding from both EU and the NSF of the USA. Many of the projects involve extensive collaboration with other Icelandic and foreign institutions.

Nordvulk has functioned as a separate unit from been operated to the side of the research group structure of the IES. Nordvulk naturally interacts with all of the research groups in one way or another. Ties are strongest with the Igneous Geochemistry and Deformation-Seismology groups, but are currently also strong with the Aquatic Geochemistry and Physical Geology, Geography and Geophysics groups. Two of the current Nordic research fellows work within the latter two groups. The field of volcanology in Iceland is clearly related to quaternary geology and sedimentology on one hand and glaciology on the other through studies of subglacial volcanism and jökulhlaups. Eruptive processes is affected by the glacial environment and eruptive

history is partly stored in the quaternary sedimentary record. The record of volcanic hazard is primarily stored in Holocene sediments.

The future of Nordvulk is defined to a large extent in the current contract between the Nordic Council of Ministers and the University of Iceland (see appendix II). There the role of Nordvulk is outlined, defined by the Nordic interest in maintaining the centre. Nordvulk will remain a centre dedicated to fulfilling a Nordic interest in providing access for Nordic earth scientists to the natural laboratory of active volcanic and related processes in Iceland. An emphasis on volcanic, tectonic and other currently active processes will continue. However, it is not yet clear how Nordvulk´s structural integration into the IES can best take advantage of amalgamation with the University of Iceland. A model needs to be developed for Nordvulk which maintains its Nordic profile, but at the same time provides a clear advantage for earth-science research and education within the University of Iceland.

7.4. Research programmes

The board of the IES has suggested that instead of disciplinary research groups the Institute organize itself internally in terms of thematic research programmes. The IES has identified a set of process-related research themes, which summarize the Institute's research activity in terms of classes of research questions. These themes are defined in order to focus the research of the Institute, to encourage multidisciplinary research activity and to set a framework for development of a research strategy for the Institute. The themes are not meant to be comprehensive or exclusive. The function of the thematic research programmes is envisaged as similar to the current function of research groups with individual projects continuing to form the basic units of activity and individual project leaders carry both scientific and financial responsibilities of their project. The research themes are: 1. Volcanic and tectonic processes; 2. Mantle processes and crustal formation; 3. Climate research and cryospheric processes; 4. Water and geothermal resources.

7.4.1. Volcanic and tectonic processes

A multidisciplinary research programme in volcanology and tectonics should ideally include the study of the origin of magma, its transport towards the surface of the Earth and its evolution, as well as studies of volcano structures and behaviour, tectonic processes and surface deformation, volcanic and earthquake hazards, volcanic eruptions, and their environmental impacts. A series of research projects within the IES are dedicated to improving our understanding of magmatic, volcanic and tectonic processes.

These processes are responsible for the building of volcanoes and their associated rift zones, and determine the dynamics of volcanic systems. They shape the neo-volcanic zones in Iceland and the surrounding region, and involve the interaction of tectonic forces controlled by a passive and distant stress field, and the local or active forces related to the buoyancy of the underlying structure and ascending melts. Furthermore, they lead to volcanic hazards, earthquake hazard, and environmental effects of volcanic activity which can be catastrophic. Lava flows, pyroclastic flows, lahars and jökulhlaups are devastating consequences of volcanic activity. Airborne volcanic gas (CO_2, SO_2), halogens, and fallout from eruptions can have short-term global effects on climate and the biosphere, including direct effects on living conditions. These facts underline the importance of volcanology and tectonics in Iceland.

Iceland provides an exceptional setting for such a programme, because of frequent eruptions and a large number of volcanic systems of different types. Most types of volcanic landforms on Earth are found in Iceland, including eruptive fissure, stratovolcanoes, calderas, and both subglacial and submarine volcanic formations. At the same time, Iceland offers an exceptional exposure of the divergent plate boundary which

crosses the island. The neo-volcanic zones are uncharacteristically wide and the transform component of motion at shifting spreading centres is accommodated by a complex mode of deformation, overlapping with en-echelon sequences of small-scale rift zones or fissure swarms. The environmental effects of volcanic activity in Iceland have been dramatic and have included the release of huge amounts of toxic gases, e.g., associated with the eruption of the largest lava flow on Earth in historic times. The climatic effects on volcanoes have also been important. A major pulse in volcanic productivity has been associated with the last deglaciation in Iceland. The geological record, sedimentary profiles, Greenland ice-cores, as well as a written record since the settlement of Iceland, hold information that can be decoded to give complete information on volcanic activity in and around Iceland.

Important contributions to volcanology by Icelandic researchers include the pioneering work on tephrochronology of Sigurður Þórarinsson, studies of magma-water interaction during the Surtsey eruption, and studies of volcano-ice interaction. These have introduced to the field terms and definitions that are used internationally. Palaeo-magnetic studies of oceanic crust in the North Atlantic demonstrated plate spreading. Igneous geochemistry studies have revealed the details of magma formation and evolution. The internal structure of volcanoes and the dynamics of volcanic systems have been revealed by studies of eroded volcanic edifices, as well as by seismological and geodetic techniques applied to active volcanoes. Seismicity at sea and detailed mapping of the ocean floor extend our knowledge about tectonics and volcanism off shore. Hydro-geochemisty has been used to study magma-hydrosphere interaction. Pre-eruptive processes have been studied, and prior warnings have been issued for a number of eruptions. Studies of environmental effects of eruptions have revealed the significance of volcanic pollution and the behaviour of eruptive columns and have demonstrated the effect of eruptions on the atmosphere, e.g. for the evaluation of aviation risk.

Future advances in volcanology and tectonics will continue to be based on a multidisciplinary approach. Emphasis will be on studies of volcano-ecosystem interaction, environmental effects of magmatic and volcanic processes as well as the interaction of tectonic and volcanic processes and the effects of external environmental factors on volcanic processes. Improved geochemical and geophysical technology, satellites and remote sensing, broad band seismometry, and chemical and physical effects of volcanic products, will be used to provide measurements of these processes in detail. Improved modelling approaches applied to new data are then likely to lead us to a better understanding of the magmatic, volcanic, and tectonic elements of the Earth system.

7.4.2. Mantle processes and crustal formation

Iceland is a natural laboratory for the study of oceanic rifting, because the island constitutes by far the largest exposure of an oceanic spreading environment on earth. However, Iceland is an anomalous ridge segment. The crust is anomalously thick, the neovolcanic zones are unusually wide, the volcanism is chemically diverse, the tectonics are unusually complex. Iceland offers a unique observational platform to probe processes at depth, both chemically and physically. The region around Iceland is the prime example of ridge-plume interaction, i.e. where a plume is inferred to be nearly coincident in space with a spreading centre. At the same time Iceland is perhaps a critical setting to evaluate the plume hypothesis. A number of research projects at the IES are dedicated to elucidating structure and processes of the mantle beneath Iceland as well as crustal accretion, structure and evolution.

Isotope analyses reveal a heterogeneous mantle source beneath Iceland constraining mantle circulation processes. Detailed geochemical investigations of volcanic products show variable degrees and depths of melting in the mantle, coupled with assimilation, mixing and differentiation processes at depth. Variable extrusive production rates in the

Holocene demonstrate effects of glacial isostasy on the mantle melting process, and studies of metamorphic facies of xenoliths constrain the crustal geotherm. Palaeo-magnetic studies, coupled with radiometric age determinations, provide an important tool for mapping and dating the Tertiary volcanic products in Iceland and yield information about extrusive production rates.

Seismic studies of mantle structure reveal low seismic velocities indicative of high temperature beneath Iceland distributed along the Atlantic rift system at depth. Surface deformation due to changes in glacial loading and transients in plate-boundary deformation demonstrate low viscosities in the lower crust and mantle. Studies of crustal thickness show a thick crust of highly variable thickness indicating a high and variable production rate of the melting process and possible lower crustal flow. Upper-crustal seismic structure reveals an evolution of the crust as it drifts away from the neovolcanic zones, which is related to alteration and metamorphic processes. Deformation studies around central volcanoes indicate magma accumulation at high levels in the crust and both seismic and gravity studies at volcanoes indicate they are underlain by dense and seismically fast bodies of probable intrusives or cumulates.

All of these studies fill in a picture of the overall processes that are responsible for the existence of Iceland as an elevated ocean basin and shape the framework of the near-surface volcanic and tectonic processes.

Future progress in understanding mantle processes and oceanic crustal accretion in the Iceland region will involve a multidisciplinary approach integrating constraints from geochemistry, inversion of geophysical data and modelling of the underlying processes. Increased sampling of the oceanic region around Iceland, both chemical and physical, is envisaged to better constrain the transition from anomalous Iceland to a normal oceanic environment and to provide a wider aperture for deeper probing of the mantle. At the same time important research opportunities relating to mantle processes and crustal accretion remain unexploited on land. These include the relationship between petrology and tectonics, and volumetrically-subsidiary processes of differentiation that may throw light on the formation of Earth's earliest continental crust, and various processes surmised on the planet Mars may find more easily studied parallels in Iceland.

7.4.3. Climate research and cryospheric processes

Iceland is located at the boundary between air masses and ocean currents from tropical and Arctic regions. The climatic conditions and topographical features are conducive to high glaciation, making Iceland an attractive study-site for glacial processes and products, present and past. About 11% of Iceland (11,200 km^2) are covered by ice at present. Almost all forms of glaciers are represented, from cirque glaciers to extensive ice caps, including Vatnajökull (8,100 km^2), Europe's largest ice mass. Variations in ocean/atmospheric circulation have left a greater impact on Iceland than on other North Atlantic landmasses. The glaciers are dynamically active and responsive to climatic fluctuations, and they have greatly affected the landscape of Iceland and the adjacent sea-floor by means of erosion and deposition, both glacial and fluvial. The combination of active tectonics and volcanism, both in the terrestrial and marine environments offers exciting research opportunities to monitor and date regional environmental changes. Sedimentary and volcanic rock sequences contain a detailed record of Tertiary and Quaternary palaeo-environments including glaciation history, vegetation history and distinctive record of marine mollusc migration. Ultrahigh-resolution sediments are available in Icelandic lakes, as well as on the Icelandic shelf, containing a record of palaeo-oceanographic variability that covers at least the last glacial-interglacial cycle, and probably extends back to the Tertiary. Thus, high-resolution geological data archives from various sources make Iceland an exceptional site for studying palaeo-environmental changes.

Presently about 60% of the glaciers overlie the active volcanic zone providing unique conditions for studies of glacio-volcanic interaction, such as the exchange between magma and glaciers, the formation of hyaloclastite ridges, mounds and tuyas, the dynamic response of glaciers to subglacial eruptions, jökulhlaups due to volcanic eruptions. Such studies may also further our understanding of the impact of volcanism on other planets such as Mars. Explosive volcanism in Iceland has produced widespread deposits of air-fall tephras in the North Atlantic region. The application of tephrochronology for correlation and independent dating of marine, terrestrial, and atmospheric climate records offers outstanding opportunities for establishing reliable chronologies in the area.

Because of their profound effects upon the environment, Icelandic glaciers and the phenomena associated with them have long been subjects of human interest. The proximity of settlements to several ice caps has resulted in a rich repository of historical observations of their advance and retreat, surges, glacial floods threatening inhabited regions, damaging vegetation, and disrupting the Icelandic road system, and temporarily deterring fish from entering coastal waters. The glaciers are reservoirs of ice and melt water that feed groundwater reservoirs and the largest rivers in Iceland, many of which have been harnessed for power production.

Systematic studies of glaciers in Iceland date back to the 1930s. Over the last three decades extensive exploration has been carried out by mapping the surface and bedrock topography, subglacial landforms and geological structures, active volcanoes, geothermal areas and subglacial lakes. Glacier dynamics and sporadic surges, the regular drainage of melt water and occasional jökulhlaups have all been subjects of recent research. Due to a unique combination of natural circumstances these studies have allowed us to assess current theories about water flow beneath glaciers, surges and glacier-volcano interactions. Other studies have included comprehensive surveys of the glacier's mass balance and its relation to meteorological conditions, and numerical modelling of the response of glaciers to climate change.

In addition to work in and around Iceland, palaeo-climate research by stable isotope measurements on the Greenland ice cores has been carried out in collaboration with several international research groups, notably the glaciology group at Copenhagen University, Denmark, The Saclay Institute, France, and INSTAAR, Boulder, USA. The Greenland ice-core studies have been of major importance to the understanding of climate change during the glacial and interglacial cycles.

Future studies of climate research and cryospheric processes will be focused on the exploration of the high-resolution regional palaeo-environmental data stored in both terrestrial, englacial, lake and shelf sediments, and exploration of present-day glacial and periglacial processes and products; including glacier dynamics and hydrology, glacier-volcano interaction and crustal deformation. Emphasis will be on reconstruction of past glaciation in Iceland by glacier modelling and field-based observations, studies of glacier response to climate change, and exploration of volcanic history recorded by tephra layers in glaciers. In addition to conventional field equipment (for geophysical surveying, radio echo sounding, survey GPS, weather observation, sediment coring), satellite remote sensing, and numerical modelling will be further developed.

7.4.4. Water and geothermal resources

The most important resources of Iceland include water in some form; rivers, lakes, glaciers, ground water, geothermal fluids and the ocean around the island. Rivers and lakes are important for fishing and tourism as well as for hydropower. Glaciers constitute an important water reservoir feeding most of the countries biggest rivers and are an integral part of water as a power resource. Ground water supplies water for domestic and industrial purposes. Geothermal areas are a very important resource for Iceland, both as

an energy source and a tourist attraction. The ocean around Iceland is the nation's bread basket.

Many features of the water and geothermal resources provide unique opportunities to study many basic processes of international interest while they are at the same time applied. They include various aspects of water-rock interaction in basaltic crust, near-surface chemical weathering processes, the formation of volcanogenic metalliferous deposits and isotopes as tracers of the age and flow of groundwater. Water in its frozen form carries a record of past climate changes and glaciers constitute a large water reservoir that is sensitive to climate change through their mass balance, drainage and flow.

The chemistry of soil-, river-, and lake waters and precipitation is important because chemical weathering of Ca-Mg silicates affects long-term atmospheric CO_2 content and climate. Iceland provides a unique opportunity to study the weathering of Mg–Ca silicates in a uniform lithology, with variable rainfall, rock age and glacial/vegetative cover and high relief. Frequent volcanic eruptions provide opportunities to study the effects of volcanoes on the chemistry of natural waters. Laboratory experiments to determine dissolution rates of minerals and volcanic glasses from 0-200 °C provide an important basis for interpretation of field-based studies. The extensive multiple use of geothermal resources in Iceland has made the country a world leader in developing geothermal energy. This provides a unique opportunity to study geothermal fluid chemistry, specifically mineral-fluid equilibrium conditions in geothermal systems, development of geothermometers and assessment of the response of geothermal systems to production load. Experiments have been carried out to aid the understanding of geothermal fluid chemistry, including the kinetics of silica polymerization measurement of mineral solubilities and hydrolysis constants for ferric iron. Some of these studies are relevant to metamorphic petrology and volcanology, as they relate to degassing of intrusive magma bodies and metal transport in the crust.

Glaciers cover 11% of Iceland's surface area. Extensive exploration has been carried out on Icelandic glaciers by mapping the surface and bedrock topography, sub-glacial landforms, geothermal areas and lakes. Glacier dynamics and sporadic surges, the regular drainage of melt water and occasional jökulhlaups have been studied. Due to unique natural circumstances these studies have allowed us to assess theories for water flow beneath glaciers, surges and glacier-volcano interactions. Other studies have included comprehensive surveys of the glacier's mass balance and its relation to meteorological conditions, and numerical modelling of the response of glaciers to climate change.

Research projects under the theme of water and geothermal resources are based on geochemical and glacier data, sometimes supplemented by hydrology/hydrography. They include:

- Aqueous solution experiments involving both kinetics and equilibrium thermodynamics
- Isotopic and chemical composition of geothermal fluids, soil, river, and lake waters as well as snow and ice
- Water-rock interaction studies and weathering processes
- Carbon budget of the atmosphere and environmental impact of volcanic activity and geothermal utilization
- Origin, age, flow direction and chemistry of ground- and geothermal water
- Mapping of water reservoirs in glaciers and glacier-drainage basins for glacial rivers in Iceland and estimation of melt-water runoff to ground-water systems and glacial rivers (including jökulhlaups)
- Modelling of the response of glacier drainage to climatic changes and estimates of the heat flux from sub-glacial geothermal areas.

The studies falling under this theme are conducted in collaboration with various Icelandic and international institutes.

Future advances in water geochemistry will be based on improved analytical capacity coupled with modelling of hydro-chemical systems as well as continued field studies of precipitation, surface waters, ground water and geothermal fluids. Progress in glaciology will be based on improved remote sensing technology and other methods of monitoring glacier deformation as well as modelling. A need for a capacity in hydrology and hydrologic modelling is common to many studies on water resources.

7.5. Research productivity

Research productivity is often estimated by counting publications and citations. This is in general a crude measure which should be used for comparison with care as many factors other than research efficiency and quality affect such statistics.

	DENMARK	FINLAND	ICELAND	NORWAY	SWEDEN
Clinical medicine	1.14	1.31	1.29	1.18	1.25
Biology and biochemistry	1.59	1.14	0.67	0.93	1.32
Botany Zoology Veterany medicine	1.47	1.17	1.95	1.93	1.00
Microbiology Genetics	1.01	1.06	1.57	0.87	1.00
Chemistry	0.70	0.67	0.24	0.56	0.72
Earth Sciences	1.25	0.80	**4.37**	2.70	0.94
Physics	0.82	0.72	0.47	0.51	0.83
Mathematics	0.66	0.62	0.65	0.79	0.62

Table 2. Number of published papers in ISI journals per university-sector researcher in the period 1998-2002 by field and country. Source: National Auditor of Iceland report 2005, Institute of Scientific Information/NIFU.

Relevant National Scientific Indicators from the Institute for Scientific Information/NIFU were recently published in a report by the National Auditor of Iceland about the university sector in the country and comparing it to the university sectors of the other Nordic countries (see Appendix I). The average numbers of scientific publications (ISI listed) per university researcher during the period 1998 to 2002 are tabulated for the five Nordic countries and subdisciplines of natural sciences in Table 2 (see also Table A.I.3.6). According to the table the earth sciences have a strong standing compared to other disciplines in Iceland and also stand strong compared to earth sciences in the other Nordic countries. Note that the IES is the only university research institute in Earth sciences in Iceland of significance. The average numbers of citations per scientific publication for the same countries and disciplines are tabulated in Table 3 (see also Table A.I.3.7). The work of Earth scientists in Iceland is cited more frequently than the work of their colleagues in the other Nordic on average.

	DENMARK	FINLAND	ICELAND	NORWAY	SWEDEN
Clinical medicine	6.21	6.56	7.53	5.77	5.83
Biology and biochemistry	7.06	7.46	5.04	5.87	7.67
Botany Zoology Veterany medicine	3.59	2.74	3.11	3.08	3.59
Microbiology Genetics	11.38	12.21	9.30	10.52	11.77
Chemistry	5.59	3.43	1.80	3.66	4.70
Earth Sciences	4.19	3.55	**5.40**	3.51	3.95
Physics	5.91	3.98	1.97	4.17	3.93
Mathematics	1.69	1.54	1.58	1.79	1.76

Table 3. Number of citations per published papers by university-sector researchers in ISI listed journals in the period 1998-2002 by field and country. Source: National Auditor of Iceland report 2005, Institute of Scientific Information/NIFU.

We have gathered some publication statistics of our own. For this we have chosen to limit our count to journals included in the statistics of the ISI web of science. We have chosen to monitor the publication activity of current IES staff as a whole over five year periods as a function of time. We have also chosen to compare publication statistics for

IES to two institutions of similar scope and size in Europe and the USA. For this purpose we have chosen the Geological Institute at Copenhagen University (GICU) and the Department of Geological Sciences at Rutgers University (GSRU).

In Table 4 we show the evolution of ISI publication statistics for current IES A and B staff over 5 year periods since 1991. The numbers show a clear trend of increasing publication rate, by about 74% over the past 10 years. This may be a slight over estimate as the older numbers could be slightly incomplete. The above-mentioned report by the National Auditor finds a similar trend for the University of Iceland in general (47% between the periods 1992-1996 and 1998-2002). This may in part be explained by the age profile, namely that the youngest staff are now more established than they were 10 years ago. The introduction of a performance-related salary and rank system may have had an effect on these statistics. The trend may be either a reflection of the time it takes to establish a dynamic research environment or a cultural change that comes with an increased recognition of the need to disseminate research results, in particular within the international research community. An increased level of international collaboration and participation in international research projects has certainly contributed to the trend. The introduction and gradual growth of graduate studies over this period have likely been a significant contributor to this trend.

	Number of ISI publications
1991-1995	103
1996-2000	126
2001-2005	179

Table 4. Evolution of ISI publication statistics for current IES A and B level staff over five year periods since 1991. Note that the count of papers is subject to possible error of a few percent. Co-authored publications are counted once only.

In Table 5 we compare ISI web of science publication statistics for IES, GICU and GSRU. Note that the sizes of these institutions are similar. Under the heading of research staff we count all current long-term research staff. We list the total number of ISI publications over the past five years. The counts are then normalized by the number of staff. There is little difference between GICU and GSRU in these statistics, but IES lags somewhat behind. However, when we plot the distribution of publication rates by individuals over this period in Figure 7 we see that the difference is accounted for by a few individuals at GICU and GSRU that have achieved a very high publication rate. It should also be noted that PhD studies have only recently been introduced at the University of Iceland and at IES the PhD programme is being established. A lack of a PhD programme in the past can partially explain the somewhat lower publication statistic at the IES than at the other two institutions. Finally, the local forum for scientific dissemination for the international community, the journal Jökull, is not listed as an ISI publication despite the fact that the journal has for decades had international distribution and its many quality articles have been subject to international review. Jökull currently has a pending application to become an ISI publication. IES staff have published 20 articles in Jökull over the past 5 years.

	Institute of Earth Sciences, University of Iceland	Geological Institute, University of Copenhagen	Department of Geological Sciences, Rutgers, State University NJ
Number of research staff	27	27	24
Total ISI Pubs. 2001-2005	179	248	211
Average 2001-2005	6.7	9.2	8.8

Table 5. Overall publication statistics showing a comparison between IES, Geological Institute of Copenhagen University and Department of Geological Sciences, Rutgers University. The statistics are based on staff lists from web pages and a search in the ISI web of science. The search was done in February 2006. Note that the count of publications is subject to potential errors of a few percent. The definition of academic staff is also subject to error of similar relative size. Co-authored publications within each institute are counted only once.

The above publication statistics are difficult to compare with precision. They are perhaps more likely of use for future reference.

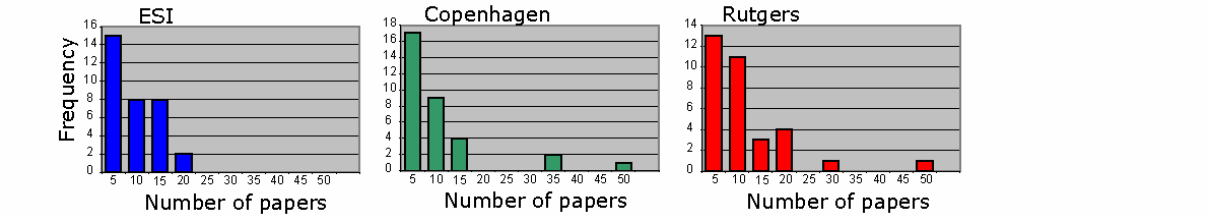

Figure 7. Histograms showing the distribution of ISI publication rates (publications 2001-2005) of individuals in the three earth science institutes compared.

7.6. International research projects

Staff at the IES have over the past decade collaborated in numerous international research projects. These projects vary in nature from EU projects with formalised collaboration with numerous international partners, to informal collaboration with colleagues at institutions abroad. An increased level of collaboration over the past decade has been a significant boost for the research activity of groups at the Institute. Tables in subsections of chapter 7.2.3 list main projects of the past five years and give a good idea about the level of international cooperation and its importance.

7.7. Outreach

Being the largest institution engaged in basic research in the earth sciences in a small community where natural phenomena play a prominent role, there is considerable demand for talks and commentaries by staff members, both for the local media and various clubs and associations. In addition several staff members actively participate in promoting science in society. These activities can be grouped into the following categories:

- Public talks on aspects of earth sciences given at various local clubs (Rotary, Lyons, Rescue groups, travellers clubs, etc.).
- Vísindavefurinn – a website hosted and maintained by UI, providing short concise answers to questions on scientific matters sent in by the public. This website has several contributions by IES staff each year.
- Articles in Icelandic popular journals and media written by staff on aspects of their research aimed at the informed layman (Náttúrufræðingurinn, Útivist, Útivera, Verpill, Fjallið).
- Articles written by staff in Nordic popular science journals promoting the wonders of Icelandic nature, primarily related to volcanism. Nordvulks Nordic staff have been especially active in this.
- Web pages maintained by staff members with geological information.
- Supervision of classes outside the normal school curriculum aimed at children with good learning abilities - held occasionally over the last few years. In this category are also adult education classes organised by UI.
- Appearances in media (local, international) in documentaries and news pieces, providing expert opinion on matters relating to the earth – notably during events in Iceland (earthquakes, jökulhlaups, volcanic eruptions, evidence of climate change, etc.).
- Leadership and participation in societies open to the public, aimed at advancing science in Iceland.

Staff at the IES have published approcimately 8 articles in popular science journals per year in the past five years including numerous articles in Nordic journals.

8. Status

The IES is the largest research institution in Iceland within the field of earth sciences, with research strength in volcanology, tectonics, magmatic processes, deformation studies, structural seismology, palaeo-magnetics, glaciology, glacier-volcano interaction, palaeo-climatic and palaeo-oceanographic studies through quaternary geology, sedimentology and isotope analyses in ice cores, tephrocronology, geothermal processes and chemical weathering. Research at the Institute takes advantage of the natural laboratory that Iceland and the surrounding region provide for the study of active earth processes and exploits the information about global change held in the geological and glacial record.

Research at the Institute of Earth Sciences is driven by senior research scientists and faculty members. The basic units of activity are projects, each led by a member of the senior staff. Project leaders carry both scientific and financial responsibilities for their projects. Individual projects form separate budget items.

The collaboration between the Nordic Council of Ministers (NMR) and earth scientists in Iceland at the Nordic Volcanological Institute has been long-standing and successful. Nordvulk has created a name for itself in the international research community and many young Nordic earth scientists have had exposure to and experience with volcanic and other active earth processes in Iceland. The IES has now inherited Nordvulk as the Nordic Volcanological Centre during a phase of structural change at NMR. It is important for the IES to find an effective model for the future of Nordvulk in order to ensure that this collaboration continues. It is equally important for the IES to convince Icelandic authorities to increase funding to the Institute so that Nordvulk will remain funded at the same overall level as before in spite of reduced funding from the NMR.

The IES was constructed by merging research elements that date from about 35 years back in time, i.e. roughly the length of one career. Consequently, the original staff are approaching retirement. Seven staff members will reach mandatory retirement within the next five years, four of them academic staff. For this reason alone the coming five years will surely be a period of renewal of staff. Any growth of the Institute will contribute to that renewal. This inevitability provides an opportunity to shape research policy and increase the research vigour of the Institute, while at the same time it presents the challenge of how to take full advantage of the experience of the retiring staff.

The Institute staff strives to disseminate their research results both internationally and locally within Iceland. The scientific productivity of the group has increased by 78% in the past decade as measured in terms of international publications. This reflects a growing emphasis on research within the group, improved conditions in which to conduct research in Iceland and increased participation in international research projects. At the same time the University of Iceland has set itself an ambitious goal to elevate its status as a research university and new opportunities have come about for the funding of research education. It is important for the IES to grab this opportunity to further grow as a research institution.

The IES is a new institution and its formation has introduced a new administrative structure and a new culture into the University of Iceland. The Institute is currently adapting to its new working environment. This exerts pressure on the IES, but also provides an opportunity to introduce change for the better. It is important that this adaptation process be successful, not only for the future of the IES, but also because this process of change may work as a precedent for the University of Iceland as a whole on its way to become a stronger research university.

9. Future

The Institute seeks to maintain a flexible, problem-oriented, multi-disciplinary approach to research and higher education, promoting creativity, innovation and international collaboration. Within the new Institute, several research programmes are envisaged, which link research projects and focus on research opportunities offered by the natural laboratory of Iceland and the North Atlantic region: 1) Volcanic and tectonic processes; 2) Mantle processes and crustal formation; 3) Climate research and cryospheric processes; 4) Water and geothermal resources.

Research output from the IES research groups has increased dramaticaly over the past decade. The Institute aims to enhance the current level of research activities, in particular by offering facilities for graduate students and post-docs. A special volcanological programme is maintained for young scientists from the Nordic countries, which is an important platform that a more vigorous research training programme can build on. Other important prerequisites for increased research output include effective administration, high-quality staff and students, good facilities and sufficient funding for improved technical support and infrastructure, e.g. in the form of more supporting staff.

It is the aim of the IES to continue cooperation with the NMR and run the Nordic Volcanological Centre for the benefit of young earth scientists in the Nordic countries and through increased collaboration with colleagues in the Nordic countries. For this purpose, it is vital to maintain facilities for research and research training in volcanology and related fields. Statements in the appendices and annexes of the contract between the University of Iceland and NMR, signed by the Rector of the University of Iceland, a representative of the NMR, and the Icelandic Minister of Education, to the extent that the funding level of the Nordvulk will not be reduced strengthens this goal. The IES sees Nordvulk as a vehicle to increasing international research cooperation, also outside the Nordic countries.

PhD training at the University of Iceland is in its infancy. The IES aims to take a leading role in the quest of the University of Iceland to strengthen research education. For this purpose, it is necessary to increase funding for graduate courses at the University of Iceland and to strengthen Icelandic research funds, but this objective also requires initiatives from university staff. At the IES we aim to build on existing experience in organizing summer schools and international courses which take advantage of research expertise at the Institute, research expertise of international research partners, and the natural earth laboratory that Iceland offers. We aim to establish a formalised visitor programme at the Institute and an affiliation status for major research partners. It is the aim of the IES to increase the number of enrolled PhD students from the current number of about 10 to 30 over the next 5 years. It is the aim of the IES that a significant part of the PhD students will be international students.

The current period of change offers an opportunity for innovation and improvement. It is the aim of the IES to utilize this opportunity to improve the administration of the Institute, e.g. by clarifying lines of command, by simplifying administration of supporting staff, by improving the flow of information within the Institute, by reorganizing to better adapt to the modern world of international research collaboration, and by improving public relations through web pages and public outreach.

The current changes have brought about administrative complications which we aim to simplify. We aim to transfer budgetary and staffing administration to our new building in Askja.

10. Publication list

The following list of publications is for the five year period from 2001 to 2005, inclusive, and is divided into six categories: 1) Articles in international reviewed journals included in the ISI web of science database; 2) Articles in other reviewed journals; 3) Book chapters; 4) Reports; 5) Extended abstracts; and 6) Articles in popular science journals. Authors that are currently working at the IES are highlighted in bold letters. The list is near complete except for published reports. Conference abstracts are not listed (except for extended abstracts), but each year Institute staff attend approximately two international conferences each and present their work there. In addition a number of smaller conferences and workshops are held in Iceland annually with wide participation by IES staff.

JOURNAL	NUMBER OF PAPERS 2001-5
Jökull	20
Journal of Geophysical Research	18
Earth & Planetary Science Letters	14
Geochimica et Cosmochimica Acta	13
Journal of Volcanology & Geothermal Research	12
Geophysical Research Letters	11
Annals of Glaciology	10
Quaternary Science Reviews	10
Journal of Quaternary Science	8
Chemical Geology	7
Bulletin of Volcanology	6
Geology	6
Geophysical Journal International	6
Journal of Glaciology	6
Polar Research	4
Aquatic Ecology	3
Arctic Antarctic & Alpine Research	3
G^3 Geochemistry, Geophysics, Geosystems	3
Global & Planetary Change	3
Holocene	3
Nature	3
Antarctic Science	2
Applied Geochemistry	2
Boreas	2
Geothermics	2
Land Degradation & Development	2
Marine Micropalaeontology	2
Meteorics & Planetary Science	2
Quaternary Research	2
Tectonophysics	2
American Journal of Science	1
Applied Spectroscopy	1
Bulletin of the Geological Society of Denmark	1
Canadian Mineralogist	1
Comptes Rendus Geoscience	1
Earth Surface Processes and Landforms	1
Geological Magazine	1
IEEE Trans. Geosc. & Remote Sensing	1
International Journal of Earth Science	1
Journal of Foraminiferal Research	1
Journal of Palaeolimnology	1
Journal of Petrology	1
Journal of Structural Geology	1
Lithos	1
Marine Geology	1
Palaeoclimate & Palaeoecology	1
Palaeogeography	1
Permafrost & Periglacial Processes	1
Physics & Chemistry of the Earth	1
Reviews of Mineralogy & Geochemistry	1
Reviews of Palaeobotany and Palynology	1
Radiocarbon	1
Science	1
Science of the Total Environment	1
Sedimentology	1

Table 6. The number of articles published by current IES staff in 2001-2005 in individual international journals.

In Table 6 we list the international journals in which articles were published by current IES staff in the period 2001-2005 ranked according to the number of articles. The journal Jökull is included in the list although it is not listed by ISI web of science. Those journals that are used most by IES staff are, besides Jökull: Journal of Geophysical Research, Earth and Planetary Science Letters, Geochimica et Cosmochimica Acta, Journal of Volcanology and Geothermal Research, Geophysical Research Letters, Quaternary Science Review and Annals of Glaciology. Three Nature papers appear on the list and one Science paper.

In Table 7 we list the number of publications by category. The number of international ISI web of science publications is 192, or 38 per year on average. Out of those current IES A and B staff account for 179. Current IES staff members are first authors on 74 of the 192 ISI publications. In addition, a number of the publications have first authors that were at the IES when the reported work was done. One hundred and seventeen other reviewed articles, book chapters and extended abstracts were published during this five year period, or 23 per year on average. Twenty of those were articles published in Jökull. Eighty seven of the 117 reviewed publications that are not ISI listed were in English and 3 in other languages than English or Icelandic.

INTERNATIONAL ISI	OTHER REVIEWED	BOOK CHAPTERS	REPORTS	EXTENDED ABSTRACTS	POPULAR SCIENCE
192	37	53	68	27	41

Table 7. Summary of publications during the period from 2001 to 2005 by category.

More than 68 reports were published, 60% of them in Icelandic. The total number of articles in popular-science journals during the period from 2001-2005 was 41 in 7 different languages.

ENGLISH	ICELANDIC	OTHER
319	79	20

Table 8. Summary of publications during the period from 2001 to 2005 by language.

International Reviewed Papers (in ISI journals)

2001

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Appendix I

The following tables appear in a recent report on a review of the University sector in Iceland published by the National Auditor (Ríkisendurskoðun, 2005). The information comes from National Scientific Indicators/Institute for Scientific Information/NIFU. The information is in Icelandic. The following table will help with translation to English.

Fræðasvið: Discipline	Danmörk: Denmark	Finnland:Finland
Noregur: Norway	Svíþjóð: Sweden	Líffræði: Biology
Lífefnafræði: Organic Chemistry	Grasafræði: Botany	Dýrafræði: Zoology
Efnafræði: Chemistry	Stærðfræði: Mathematics	Eðlisfræði: Physics
Klínísk læknisfræði: Clinical Medicine	Sameindalíffræði: Microbiology	
Erfðafræði: Genetics	Jarðvísindi: Earth Sciences	

Table 3.6. shows the number of published articles per person during the five-year period 1998-2002.
Table 3.7. shows the average number of citations per article during the same period.

Tafla 3.6. Hlutfallslegur birtingafjöldi vísindagreina 1998-2002

Fræðasvið	Danmörk	Finnland	Ísland	Noregur	Svíþjóð
Líffræði og lífefnafræði	1,59	1,14	**0,67**	0,93	1,32
Grasafræði, dýrafræði og dýralækningar	1,47	1,17	**1,95**	1,93	1,00
Eðlisfræði	0,82	0,72	**0,47**	0,51	0,83
Jarðvísindi	1,25	0,80	**4,37**	2,70	0,94
Efnafræði	0,70	0,67	**0,24**	0,56	0,72
Klínísk læknisfræði	1,14	1,31	**1,29**	1,18	1,25
Stærðfræði	0,66	0,62	**0,65**	0,79	0,62
Sameindalíffræði og erfðafræði	1,01	1,06	**1,57**	0,87	1,00
Útkoma miðað við Ísland = 1,00					
Líffræði og lífefnafræði	2,38	1,69	**1,00**	1,39	1,96
Grasafræði, dýrafræði og dýralækningar	0,75	0,60	**1,00**	0,99	0,51
Eðlisfræði	1,74	1,51	**1,00**	1,08	1,75
Jarðvísindi	0,29	0,18	**1,00**	0,62	0,22
Efnafræði	2,91	2,78	**1,00**	2,35	3,02
Klínísk læknisfræði	0,89	1,01	**1,00**	0,91	0,96
Stærðfræði	1,02	0,96	**1,00**	1,22	0,96
Sameindalíffræði og erfðafræði	0,64	0,68	**1,00**	0,55	0,64

Heimild: National Science Indicators/Institute for Scientific Information/NIFU.

Tafla 3.7. Meðalfjöldi tilvitnana í vísindagreinar 1998-2002

Fræðasvið	Danmörk	Finnland	Ísland	Noregur	Svíþjóð
Líffræði og lífefnafræði	7,06	7,46	**5,04**	5,87	7,67
Grasafræði, dýrafræði og dýralækningar	3,59	2,74	**3,11**	3,08	3,59
Eðlisfræði	5,91	3,98	**1,97**	4,17	3,93
Jarðvísindi	4,19	3,55	**5,40**	3,51	3,95
Efnafræði	5,59	3,43	**1,80**	3,66	4,70
Klínísk læknisfræði	6,21	6,56	**7,53**	5,77	5,83
Stærðfræði	1,69	1,54	**1,58**	1,79	1,76
Sameindalíffræði og erfðafræði	11,38	12,21	**9,30**	10,52	11,77
Útkoma miðað við Ísland = 1,00					
Líffræði og lífefnafræði	1,40	1,48	**1,00**	1,16	1,52
Grasafræði, dýrafræði og dýralækningar	1,15	0,88	**1,00**	0,99	1,15
Eðlisfræði	3,00	2,02	**1,00**	2,12	1,99
Jarðvísindi	0,78	0,66	**1,00**	0,65	0,73
Efnafræði	3,11	1,91	**1,00**	2,03	2,61
Klínísk læknisfræði	0,82	0,87	**1,00**	0,77	0,77
Stærðfræði	1,07	0,97	**1,00**	1,13	1,11
Sameindalíffræði og erfðafræði	1,22	1,31	**1,00**	1,13	1,27

Heimild: National Science Indicators/Institute for Scientific Information/NIFU.

It is not clear from the report how these measures are defined in detail. Therefore, we want to be cautious in interpreting them. However, the indication is that the Earth Sciences at the University of Iceland are significantly more productive than in the university sector on average in the other Nordic countries as a whole and that normalized by the corresponding field in the other Nordic countries Earth sciences stand well in comparison to other fields of the natural sciences.

Appendix II

Summary and translation of excerpts from contract between the University of Iceland and the Nordic Council of Ministers (NMR) on the formation of the Institute of Earth Sciences by merging of the Nordic Volcanological Institute and elements of the Science Institute, University of Iceland.

On July 1st, 2004, the University of Iceland and the Nordic Council of Ministers signed a contract on the formation of the Institute of Earth Sciences at the University of Iceland by joining the Nordic Volcanological Institute (Nordvulk) and the Department of Geology and Geography and the Department of Geophysics at the Science Institute, University of Iceland. The contract was worked out in consultation with the Icelandic Ministry of Education and some of the appendices of the contract signed by the minister of education. The contract period is from the 1st of July 2004 until 31st December, 2007. Nordvulk is after the formation of the IES a research centre within the Institute, Nordic Volcanological Centre.

The new institute is partly funded by a direct contribution from the Icelandic government to the Science Institute, University of Iceland. This contribution is a continuation of the past funding of those elements of the Science Institute that entered into the IES, a continuation of the past funding of the Icelandic government for the Nordic Volcanological Institute, and additional government funding to the IES of 15 million ISK/year. The new institute is also partially funded by the Nordic Council of Ministers that reduces with time according to Table A.II.1.

2005	7.819.000 DKK
2006	6.994.000 DKK
2007	4.663.000 DKK

Table A.II.1. The funding level of NMR for Nordvulk in Danish krowns during the current contract period as set in the contract. These contributions are adjusted on an annual basis according to inflation. One Danish krown is approximately equivalent to 12 Icelandic crowns.

The funding agreement in the contract is approximately equivalent to no net change of funding level. The increased contribution from the Iceland government, which is spread over three years, is approximately equivalent to the reduction of the NMR contribution in years 2006 and 2007.

The following is among other things stated (in Icelandic; Not a certified legal translation) in appendix 2 to the contract:

- The contract is made in order to merge the Nordic Volcanological Institute with the earth-science part of the Science Institute, University of Iceland, in a new research institution in the earth sciences within the Science Institute.
- Icelandic authorities will support the new institute and agree with the intention of the University of Iceland to establish an ambitious international research institution in the earth sciences.
- With the contract the Nordic Volcanological Institute is transferred from the administration of the Nordic Council of Ministers and continued in changed form under the administration of the University of Iceland. From this follows that the Nordic Volcanological Institute no longer exists as an independent Nordic institution.
- The operations of the Nordic Volcanological Institute fall under the University of Iceland where they are integrated into a new institution by the name of the Institute of Earth Sciences.

- The activities of the new institution (IES) will be coordinated in order to maximise the advantages of joining its elements in one institution. The goal is that the new institution will be strong from the onset and capable of growing with extended research tasks.
- The Nordic dimension of the IES will be maintained and other international cooperation strengthened.
- Within IES volcanological research and other volcanological activity will be incorporated into the Nordic Volcanological Centre.
- The objective is to secure the financial situation of the new institute (IES) so that its activities will be at least as extensive as they are now (at signing in 2004).
- The University of Iceland overtakes the property and commitments of the Nordic Volcanological Institute on behalf of the new institute. The administration and use of equipment and housing, made available to the Nordic Volcanological Institute by the Icelandic government, is overtaken by the University of Iceland on behalf of IES.
- The plan is that the new institute will receive, in addition to budget contributions to the Science Institute, a budget contribution from Icelandic authorities that will amount to at least the equivalent to the Icelandic government contribution to the Nordic Volcanological Institute in 2003. In addition, Icelandic authorities have decided to grant an annual contribution of 15 million ISK to the University of Iceland especially for the new institute.
- The University of Iceland is responsible for the operations, finances, book keeping and a budget overview for the new institute. Information on the budget overview will be sent to the Nordic Council of Ministers according to their working rules.
- Operations and research in IES will follow the strategy set by the IES board for which the board is responsible and build on research projects chosen by individual academics for which they are responsible.
- IES will publish an annual report with accounts of research, other tasks and progress. The annual report will be according to directions from the Nordic Council of Ministers for reporting of its cooperative institutions. The annual report shall be delivered to the offices of the Nordic Council of Ministers no later than the 15th of February each year (for the previous year). An annual coordination meeting will be held for the IES and the offices of the Nordic Council of Ministers.
- The parties to the contract will at regular intervals evaluate the progress made with the amalgamation of the new institute and will see to that an external evaluation will be undertaken of the IES when they deem that the results of the amalgamation are sufficiently clear, though no later than in 2007. The parties to the contract will discuss continued Nordic support for the Institute on the basis of this review. The Nordic Council of Ministers aims to continue financing projects according to the milestones of the contract until the results of this review are available.

The following is among other things stated (in Icelandic; Not certified legal translation) in appendix 3 to the contract, signed in April, 2004 by the rector of the University of Iceland, a representative of the Nordic Council of Ministers and the Icelandic minister of education:

- The Institute of Earth Sciences, University of Iceland, will be established by the 1st of July 2004. The new institute will be formed by joining the Nordic Volcanological Institute and the earth-sciences parts of the Science Institute University of Iceland.

- The aim of establishing the IES is to set up an ambitious, international research institution in the earth sciences that builds on the unique geological setting of Iceland and the expertise that has been built up in Iceland. The function of the two elements that make up the new institution will be coordinated to ensure maximal gain from joining them.
- The Nordic dimension of the IES will be maintained under the name "Nordic Volcanological Centre" and other international collaboration increased so that the IES will be strong from the onset and in a position to grow. The Institute will offer a research environment that attracts Nordic research fellows and scientists.
- The new institute will be an administratively independent institution within the framework of the law and rules of the University of Iceland.
- The objective is to secure the financial support for the IES so that it can grow and strengthen. Nordic support will continue and the Icelandic government will provide special support to the building of the Institute.
- On behalf of the IES the University of Iceland overtakes the properties and commitments of the Nordic Volcanological Institute as well as the administration of the housing made available to the Nordic Volcanological Institute by the Icelandic government.
- This agreement will be realised with the signing of a formal contract between the University of Iceland and the Nordic Council of Ministers.

Annex 4 to the contract states (in Danish; Not certified legal translation) among other things:

On the overall goals of Nordic Volcanological Centre.

- Nordvulk (Nordic Volcanological Centre) is a Nordic research centre within volcanology at the Institute of Earth Sciences, University of Iceland. Research on an international level and training of Nordic research fellows are the central elements of the Centre's activities. Nordic researchers who have worked at Nordvulk contribute to a broader scientific expertise within volcanology and related fields in the other Nordic countries when they return to their home country.
- Nordvulk maintains a research environment that includes expertise within: petrology, geochemistry, geophysics and tectonics with Iceland and the North Atlantic region as the main emphasis. The concentration of resources at one research centre in Iceland gives the Nordic countries a joint centre of competence with the necessary critical mass in order to take advantage of the unique possibilities to study volcanoes and surface deformation in Iceland.
- In the beginning of the contract period Nordvulk applies to the staff that were transferred from the Nordic Volcanological Institute to the University of Iceland at the signing of the contract. A special Programme committee will be assigned to the Nordic Volcanological Centre as described in annex 5 to the contract, e.g. in order to see to Nordic interests in the centre and other tasks defined in annex 5.
- Nordvulks main goals are:

  1. To operate a joint Nordic centre of competence in research within volcanology and related fields.
  2. To make advanced research facilities for volcanology available.
  3. To offer research training and summer schools to young Nordic researchers who get access to the earth science research community in Iceland as well as personal supervision through Nordvulk.

4. To offer a minimum of one position for a highly qualified Nordic senior researcher from outside of Iceland as well as to offer a general programme for guest researchers.
5. To maintain a close cooperation with other Nordic institutes and other institutes which run volcanological research over the whole world and to participate in international research programmes.
6. To function as a formal, visible entry point for researchers, students and institutions for volcanological research and related fields that are strongly represented in Iceland.

Research – a Nordic perspective. Nordvulk´s goals are:

- To do research at an international level with emphasis on volcanology and related fields, and also to contribute to a better understanding of changes in the global environment.
- To contribute to cooperation among Nordic researchers and institutions.
- To contribute to the introduction of new research fields and methods.
- To attract a core of staff and visiting researchers of high international recognition and strong contacts.
- That Nordvulk´s staff be sought after as referees and consultants on issues that relate to the centre's activities.

Nordvulk participates in an advanced volcanological research programme. In the beginning of the contract period this includes the academic and technical personnel (in addition to Nordic research fellows and project staff):

- Five academic research positions.
- One lab assistant, one electronic technician, one specialist in geographic information systems, one mechanic technician, one administrator.
- Guest researchers.

The following indicators give a quantitative measure of the scope and organisation of the research and can also be used as qualitative indicators:

- The number of scientific publications in international journals (goal: 7/year)
- The number of presentations at international conferences (goal: 7/year)
- The number of articles in popular-science journals (goal. 2/year)
- New results on Nordvulk´s web pages

Nordvulk has instruments and facilities for volcanological research that include:

- Geochemical laboratory
- Electron microprobe
- Mass Spectrometer (MC-ICP-MS)
- Geophysical laboratory including equipment for studies of surface deformation
- Field vehicles and equipment for field work
- Mechanical workshop

These joint Nordic facilities are central to volcanological research at Nordvulk. They open up for new, interesting possibilities within parts of the earth and environmental sciences. Operational and maintenance costs of these facilities will be secured during the contract period at least at the same level as in previous years at the Nordic Volcanological Institute. Nordic research fellows and their projects have a priority in using these facilities that otherwise will be used as joint resources for the IES and other Nordic researchers.

It is Nordvulk's goal that:

- Operation of Nordvulk's facilities is secured.
- Instruments and facilities will be available to Nordic researchers.
- Nordvulk's personnel will assist users with the general operations of Nordvulk's instruments and facilities.

Annex 5 to the contract defines the composition and role of the Nordvulk programme committee. The following is an uncertified translation of the annex from Icelandic. Explanations added in translation are in italics.

A special Nordvulk programme committee with five representatives will work in association with the Nordic Volcanological Centre. The committee is nominated by the Nordic Council of Ministers (NMR). The committee has a general advisory role and serves the purpose to see to that Nordic points of view will be accommodated in the activities of the IES. The composition and role of the Nordvulk Programme Committee are defined in further detail in this annex document.

1. A special programme committee of five representatives nominated by the NMR works in association with the Nordic Volcanological Centre.
   1.1. Each *Nordic* country (*Denmark, Finland, Iceland, Norway and Sweden)* nominates one representative. The autonomous regions (*Greenland, Faeroe Island, Åland Islands*) may participate in the programme committee's work, although without a voting right.
   1.2. The programme committee selects a chairman from its representatives. The chairmanship of the committee shall be rotated according to the rules of the NMR.
   1.3. The members of the committee will be earth-science specialists or specialists in Nordic research collaboration.
   1.4. The expenses of the committee will be paid by the IES.
   1.5. The programme committee can suggest working rules for Nordvulk which the board of IES would need to ratify.

2. The programme committee selects one member of the board of IES from its members.

3. The main role of the programme committee is to encourage and help the IES to strengthen cooperation with other Nordic and international institutions. The programme committee will, e.g., work toward:
   3.1. development of an international research group focusing on volcanology in Iceland.
   3.2. better possibilities for Nordic researchers and research students to study and do research in volcanology.
   3.3. joint research projects between the IES and other Nordic Universities and research institutions.
   3.4. cooperation on purchase and operation of research infrastructure.

3.5. improved access to Nordic and international research funds in order to finance research at IES.

4. The programme committee has the following role on behalf of the board of the IES:

4.1. To develop rules and a strategy for the Nordic fellows and Nordic senior scientist at Nordvulk.

4.2. To evaluate applications for Nordic fellowships and the position of Nordic senior scientist at Nordvulk and propose appointments to the director of IES.

4.3. To participate in the organisation of summer schools for young Nordic researchers as well as other training courses for earth scientists and students.

4.4. Other tasks that the board of the IES may assign to the committee.

5. The programme committee has an advisory role about strategic decisions for the IES and Nordvulk.

5.1. The purpose of this advisory role is to ensure that the IES reflects in its activities the Nordic interests and fulfils the obligations of the contract. The committee can in this regard report directly to the NMR.

5.2. The programme committee shall be involved in the development of long-term strategy, research emphases and the annual budget plans of the IES.

6. The board of the IES has the right to change these rules subject to consultation with the programme committee and NMR.

Appendix III

REGULATIONS
on the University Institute of Earth Sciences

Article 1
General

The University Institute of Earth Sciences is one of two institutes that together make up the University Science Institute. Its role is to pursue basic research in geological sciences. The objective of its operations is to make the Institute of Earth Sciences an international research institute of earth sciences reflecting on the geology of Iceland and its surroundings. Regulations on the Science Institute apply to the operations of the Institute in addition to the following rules of procedure.

Article 2
Organization and Management

The Board of the Institute defines its major objectives and decides on its internal organization. Teachers and specialists that enjoy facilities and lead research projects at the Institute are called project leaders. They are free to choose projects that comply with their employment contracts and are responsible for the operation of the projects they lead. Employees register for the Disciplinary Groups they choose to take part in, see Article 3. The Director administers the general operations of the Institute. Office management is part of the joint services provided by the Science Institute led by the Science Institute's Director. Its daily adminstration is in the hands of an Office Manager who is responsible to the Director.

Article 3
Disciplinary Groups

Disciplinary Groups constitute the realm of employees that use similar disciplinary knowledge, facilities or measuring techniques for their research. Each Disciplinary Group elects a Chairman who is the group's spokesman in relation to the Director and the Board, and who is an adviser to these parties in matters of objectives and facilities. The Disciplinary Groups are the ones specified in Article 7.2, Appendix 6, of the Contract between the Nordic Council of Ministers and the University of Iceland. These groups will be redefined when the Board of the Institute has laid down general objectives for the research conducted within the institute.

Article 4
Fields of Research

The Board of the Institute decides, upon consultation with the Director, the chairmen and the project leaders, which inter-disciplinary tasks (fields of research) the Institute puts weight upon. The fields of research are defined in Article 7.3, Appendix 6, of the Contract between the Nordic Council of Ministers and the University of Iceland. One such field entails the operation of the Nordic Centre for Volcanology according to the Contract. The fields of research will be redefined when the Board of the Institute has laid down general objectives for the research to be conducted within the institute.

Article 5
Board

Five persons are appointed to the Board of the Institute of Earth Sciences for four years at a time. One is appointed by the Project Committee of the Nordic Centre for

Volcanology, the second by the President of the Faculty of Science. This second member must be an internationally recognized geoscientist operating outside the Nordic countries. The same parties appoint reserve members for these two. Three are elected at a staff meeting of the Institute of Earth Sciences as well as three reserve members. The Board elects a Chairman and a Vice-chairman and divides other responsibilities between its members.

Article 6
Election of the Board

One month before the election, the Board of the Institute of Earth Sciences appoints an Election Committee of three to take care of the preparations and operation of the election of three Board members. At this election, employees of the Institute of Earth Sciences according to Article 11, par. a-d, of the Regulations on the University Science Institute have the right to vote. Not later than a week before the election the Board stages a primary among qualified voters to test the support of persons eligible for the Board. The Election Committee then presents a voters' register with the names of those with the right to vote, and decides on matters of uncertainty that may arise.

Employees according to Article 11, par. a and b, of the Regulations on the University Science Institute and other individuals, which have been nominated to the Election Committee by at least one fourth of the employees that have the right to vote and whose qualifications are considered by the committee to be comaparable to employees according to Article 11, par. a and b, of the Regulations, are eligible. Members of the Election Committee are ineligible. The Election Committee presents a list with the names of eligible persons not later than one week before the primary and decides on matters of uncertainty that may arise.

At a Staff Meeting the Election Committee oversees the election. Voting proceeds without any discussion on eligible persons. External votes are permitted for the election of the Board. The Election Committe establishes more detailed rules regarding the matter. To begin with, votes are cast for the three main Board members. Those three that receive the most votes are duly elected. If two or more persons receive an equal number of votes for third place, another election for those two is carried out. If the number of votes is still equal a toss-up for the seat on the Board is performed. When the Board members have been elected, a similar election is carried out for reserve members of the Board. The order of reserves is based on the number of votes they receive.

Article 7
The Tasks of the Board

The Board formulates the general objectives for the Institute. The Board deals with matters of Disciplinary Groups and scientific fields, organizes co-operation as appropriate and clarifies uncertainties. The Board presents an operational budget and a financial budget for the Institute, and has a general overview over its general activities. It divides the appropriation and other financial contributions to the joint operation of the Institute between projects. The Chairman of the Board acts as the Board's representative and is its advocate. The Board has permission to grant the Chairman of the Board, or in the Chairman's absence the Vice-chairman, power to make decisions on Board matters between Board meetings. He must give an account of his decisions at the next Board Meeting.

Article 8
Board Meetings

The chairman of the Board calls Board Meetings by e-mail, or in another manner agreed upon by the Board, with at least three weeks' notice. Telephone meetings can however be called with at least one week's notice. In the invitation to the Meeting the agenda of the meeting shall be detailed. The Chairman of the Board shall preside over Board

Meetings. A Board Meeting is mandatory if two or more Members of the Board so request. The same applies if the Chairman of the Board of the University Science Institute makes such a request, and he has the right to speak/be heard and propose a motion at the meeting. If equal votes are cast at a Board Meeting the motion is decided by a toss-up. A Board Meeting may pass a resolution if at least four Board members or their reserves take part in the meeting. The minutes of the meeting shall be written up and presented at the next Board Meeting and confirmed by the Chairman of the Board. Copies of the minutes of the meeting shall be sent to the Chairman of the Board of the University Science Institute. The minutes of meetings shall be available to all the employees of the Institute of Earth Sciences. The Chairman of the Board of the Institute of Earth Sciences and the Director of the University Science Institute attend Board Meetings and have the right to speak/be heard and propose a motion. The Director is the Secretary for the Board. The Board may announce decisions by e-mail between meetings.

Article 9
The Director

The Director is responsible for the administration of the Institute and shall, in this respect, follow the policy and instructions issued by Board Meetings and Staff Meetings. The Director attends Board Meetings where he has the right to speak/be heard and propose a motion. The Board is free to transfer the power of decision in matters of day-to-day administration provided that he accounts for his decisions at the next Board Meeting. He leads the preparation of the operational budget and the financial budget in co-operation with the project leaders and the Chairmen of the Disciplinary Groups. The Director is responsible to the Board for the operation of the institute and for contact with staff. The Director represents the Institute and is its advocate.

Article 10
The Appointment of Director

The Director shall be a respected geoscientist with a wealth of administrative experience. The appointment to the post for up to five years is effected after an advertisement has been placed in the appropriate media. The procedure shall be in accordance with the Rules of the Faculty of Science of the University of Iceland on the appointment to posts. The applicants shall hold a doctorate and have shown an aptitude for scientific work comparable to that of professors at the University of Iceland.

Article 11
Staff Meetings

The provisions of Article 8 of the Regulation No. 398/2004 on the University Science Institute shall apply to Staff Meetings of the Institute of Earth Sciences, The Chairman of the Board calls and chairs a Staff Meeting.

Article 12
Research Facilities

The Director of the Institute of Earth Sciences decides on the provision and extent of facilities for external parties according to Article 11, par. f, of the Regulation on the University Science Institute in co-operation with the Chairmen of the Disciplinary Groups as appropriate.

A decision on the provision and extent of research facilities according to Article 4, Regulation No. 398/2004 on the University Science Institute shall be guided by how well the parties'research fits the objective of the Institute of Earth Sciences, their need for facilities and their activities within the Institute. The Board shall check these factors regularly.

The Board of the Institute shall be permitted to provide a retired employee with research facilities if it deems the quality of his research sufficient. The employee in question shall, however, be required to hand in a written application regarding such facilities not later than one year before he retires. The application shall be be renewed annually.

Article 13
Annual Report

The Institute of Earth Sciences shall publish an Annual Report in which research, other projects and results are described. The Annual Report shall be prepared in accordance with the Nordic Council of Ministers' guidelines on the preparation of reports by co-operating institutions. The Report shall arrive at the Office of the Nordic Council of Ministers not later than February 15 each year. Joint consultation meetings of the Institute of Earth Sciences and the Office of the Nordic Council of Ministers shall be held every year.

Article 14
Reference

These regulations are adopted with reference to Regulation No. 398/2004 on the University Science Institute and the Contract between the Nordic Council of Ministers and the University of Iceland regarding the foundation of the University Institute of Earth Sciences and the Nordic Centre for Volcanology.

Temporary Provisions

The election of the initial Board shall take place in June 2005 and the Board shall start operating July 1 2005.