An Evaluation of the Work of the

Nordic Volcanological Center (NORDVULK)

2004-2008

Evaluation Team

Professor Joe Cann
Professor Howard Colley
Dr J Richard Wilson

Contents

Executive Summary	**3**
Purpose of the Evaluation	**5**
Current Organization within the University of Iceland and IES	**5**
Nordic Dimension and Context of NORDVULK	**7**
Research Projects	**8**
Nordic Research Fellows	**10**
Assessment of Research and Facilities	**13**
Summer Schools	**14**
NORDVULK Collaboration and Outreach Activities	**15**
Prospects for the Future	**16**
Conclusions and Recommendations	**18**

Appendix 1 **NORDVULK self evaluation report 2004-2008**

Appendix 2 **Staff met by Evaluation Team during on-site visit**

Executive Summary

The Terms of Reference for the review requested the Evaluation Team (ET) to evaluate the Nordic dimension of the Nordic Volcanological Center (NORDVULK) and to assess the academic quality and relevance of its research, publications, research fellowship schemes and summer schools. The ET was also requested to consider the success of establishing NORDVULK within the Institute of Earth Sciences (IES) at the University of Iceland (UI), its scientific impact on the Nordic volcanological community and continued financial support for NORDVULK from the Nordic Council of Ministers (NMR) and the government of Iceland.

The IES was established on July 1st, 2004, by the merger of NORDVULK with the geology and geophysics sections of the Science Institute (SI) at the UI. The IES retains links to the SI which provides administrative and budgetary support and this includes provision of budget control for NORDVULK projects. NORDVULK staff includes six Nordic research fellows, four senior researchers and a Nordic senior researcher. In addition there are seven NORDVULK researchers supported by other sources of funding and currently ten IES staff who are closely associated with NORDVULK research projects. In theory the management of NORDVULK appears complex with inputs from the IES Board, the IES executive committee, the Science Institute of the UI, and the NORDVULK Programme Committee. In practice the ET found that management of NORDVULK was generally straightforward and efficient. Following the establishment of the IES in 2004 the ET can see very strong evidence for close collaboration between NORDVULK staff and other staff within the IES. On the one hand the NORDVULK element has allowed the IES to develop the understanding volcanoes research theme whilst on the other the availablility of staff across the IES has allowed Nordic Research Fellows access to a greater range of supervisory expertise. It is the view of the ET that this synergistic development has met the expectations arising from the 2004 merger and it has influenced the UI consideration for the creation of a Department of Earth Sciences within the Faculty of Science.

Since 2004 the main aims of NORDVULK have included: carrying out research at an internationally high level with focus on volcanology and related fields; contributing to co-operation between Nordic researchers and institutions; and introducing new topics and methods of research in the field of volcanology. NORDVULK is one of the institutions in Iceland with direct responsibility for research on eruptions and associated earthquakes in Icelandic volcanoes. Improved ability to predict volcanic eruptions and earthquakes is a central issue for NORDVULK and has widespread international implications. To achieve its aims NORDVULK has run research fellowship schemes for Nordic nationals, conducted research projects with substantial international collaboration, and organized summer schools for Nordic and other international researchers.

The great strength of NORDVULK is the group of four senior researchers. All four of them are scientists of high calibre when rated on an international scale. Between them they are authors on 35 papers that have been published in international journals of the highest quality over the last 4 years. The recognition of their work by the international scientific community is also reflected in the high quality of those who collaborate with

them and by invitations to speak at international conferences. There is no doubt that these researchers would be able to compete for high-level posts at institutions with fine international reputations. The quality of the research of the Nordic Research Fellows can be estimated by their production of scientific publications in the period 2004-2008 in which time fellows have contributed to 27 of a total of 90 publications involving NORDVULK. The Senior Research Fellow has been involved in 24 publications since 2005. This scientific production by the Nordic Research Fellows and Senior Research Fellow is impressive. It bears witness to the successful way in which the candidates are selected, the quality of the research projects in which they have been involved, the increased supervision opportunities provided by merger of NORDVULK and the IES and the high standard of international cooperation. Another important aspect of NORDVULK‘s work is the organisation and running of international summer schools. Iceland‘s unique volcanic and glacial history and setting makes it a very attractive venue for researchers and students from across the world. The running of summer schools provides NORDVULK with the opportunity to enhance both its international reputation and that of the Nordic geological community. The ET see the summer schools as a key activity of NORDVULK allowing staff to showcase cutting edge research taking place in Iceland. It is clear that the schools have enhanced the reputation of Icelandic and Nordic geosciences as well as providing inspiration for graduate and postdoctoral students some of whom have become Research Fellows with NORDVULK.

It is the opinion of the ET that NORDVULK has been highly successful in progressing its range of activities and deservedly has a very high international reputation for the quality of its research. The ET has also noted that NORDVULK has received adequate funding but with the reduction of income from the NMR that the funding regime now has a greater degree of uncertainty which makes forward planning more prone to unforeseen financial risk. The ET can confirm that, in NORDVULK, Iceland and the Nordic countries as a group have an institution in which they can be very proud. In order to help secure a successful future the ET has made a number of recommendations which include: a review of the level and balance of funding from NMR and Icelandic government sources; a more transparent system of allocating and monitoring research funding to NORDVULK; more formalised arrangements for Research Fellows undertaking a PhD programme and an increase in the number of fellows with two year tenure; a proposal to provide seedcorn funding to allow NORDVULK to expand its summer school programme; and for NORDVULK to progress its plans in raising awareness of its work, and its significance in identifying volcanic and seismic hazards, with the public in Iceland and with other Nordic countries.

Purpose of the Evaluation

This is the final report of the external Evaluation Team (ET) for the higher education external evaluation of the Nordic Volcanological Center (NORDVULK). The evaluation has followed the guidance set out in the terms of reference drawn up by the University of Iceland (UI). The terms stipulate that the principal purpose of the evaluation is to:

- evaluate whether NORDVULK plays a relevant and conducive Nordic role through its activities and services in support of the development of volcanological studies in the Nordic region
- assess the academic quality of NORDVULK's research and its academic publication activities
- assess the relevance of NORDVULK's various activities and services: specifically NORDVULK's programme for young Nordic Research Fellows and NORDVULK's summer schools.

In addition the ET was charged with assessing the:

- success of the establishment of NORDVULK within the Institute of Earth Sciences at the University of Iceland
- possibilities for NORDVULK to further strengthen the Nordic volcanological community and how to optimise its scientific impact
- realistic possibilities for continued financial support to NORDVULK from the current funders.

The Evaluation Team was appointed by the Icelandic Centre for Research (RANNIS) and consisted of the following individuals:

- Professor Joe Cann, University of Leeds UK
- Professor Howard Colley, Higher Education Academy UK (Chair)
- Dr J. Richard Wilson, Aarhus University Denmark.

Dr Lýður Skúli Erlandsson (RANNIS) was secretary to the team.

The ET received a self-evaluation document (Appendix 1) prepared by NORDVULK staff before the visit and the team was also provided with other supporting documents and directed to key areas of the NORDVULK website (www.norvol.hi.is). The site-visit encompassed meetings with NORDVULK staff, research fellows and students and key personnel from the University of Iceland and Institute of Earth Sciences (IES) (see Appendix 2). The team was also given a guided tour of NORDVULK and IES facilities.

Current Organization within the University of Iceland and IES

NORDVULK is located within the Institute of Earth Sciences in Askja, the Natural Science building on the campus of the University of Iceland. The IES has a staff of

about 60 persons within which the NORDVULK research group has 19 researchers. At the time of the evaluation visit staff funded directly by NORDVULK included six research fellows, four senior researchers and a Nordic senior researcher. In addition there are seven NORDVULK researchers supported by other sources of funding and currently ten IES staff who are closely associated with NORDVULK research projects. A list of the current staff is provided in Appendix 1.

The IES was established on July 1st, 2004, by the merger of NORDVULK with the geology and geophysics sections of the Science Institute (SI) at the UI. The IES retains links to the SI which provides administrative and budgetary support and this includes provision of budget control for NORDVULK projects. The IES provides undergraduate and graduate studies and academic research within the earth sciences. This research is strongly orientated to take advantage of the outstanding geological character of the Icelandic region and following consultation in 2007 currently is organised into three thematic groupings: environment and climate; crustal processes; and understanding volcanoes. Naturally the NORDVULK contribution is primarily to the volcanology theme, however, NORDVULK researchers also have strong links with researchers in the other thematic groups.

The IES has a Board of Directors and day-to-day leadership is provided by a Director for the IES. At the time of the review the duties of the Director of the IES were being carried out by an executive committee of six staff. NORDVULK has a Manager (one of the four senior researchers) and currently the Manager is also a member of the IES executive committee.

The other element of management of NORDVULK activities is through the NORDVULK Programme Committee. The five members are appointed by the Nordic Council of Ministers (NMR) and the committee has an advisory role to the IES Director and nominates one member of the IES Board of Directors. The responsibilities of the programme committee include maintaining a Nordic dimension through selecting candidates for the Nordic Research Fellowship (young researchers) programme and a candidate for the Nordic Senior Research Fellow position.

In theory the management of NORDVULK appears complex with inputs from the IES Board, the IES executive committee, the Science Institute of the UI, and the NORDVULK Programme Committee. In practice the ET found that management of NORDVULK was generally straightforward and efficient though the administration of budgets through the relatively remote SI appeared to cause some uncertainty about budget allocation for NORDVULK. This meant that the ET had some difficulty in understanding the funding regime for NORDVULK.

The IES is well equipped and NORVULK researchers have access to first class instrumentation which includes electron microprobe facilities, ICP-MS, ICP-AES, GPS and seismic arrays, magnetometers and gravimeters. A number of vehicles and field stations are also available to support field teams. The excellent contacts of NORDVULK

staff with the international geoscience community also allows use of equipment (e.g. mass spectrometers) at the institutions of co-researchers.

Since the establishment of the IES in 2004 the ET can see very strong evidence for close collaboration between NORDVULK staff and other staff within the IES. On the one hand the NORDVULK element has allowed the IES to develop the understanding volcanoes research theme whilst on the other the availablility of staff across the IES has allowed Nordic Research Fellows access to a greater range of supervisory expertise. It is the view of the ET that this synergistic development has met the expectations arising from the 2004 merger and it influenced the UI consideration for the creation of a Department of Earth Sciences within the Faculty of Science (formally established on July 1, 2008).

Nordic Dimension and Context of NORDVULK

The Nordic Volcanological Institute was established in 1974 and financed mostly by the Nordic Council of Ministers for about three decades. The basic idea behind NORDVULK was to strengthen the earth science community in the Nordic countries by jointly exploiting the research opportunities provided by the active volcanism and tectonics of Iceland. In 2004 NORDVULK merged with other geological and geophysical institutions to form the IES at the University of Iceland. In connection with this merger NORDVULK´s full name was changed to the Nordic Volcanological Centre. In 2006-07 the funding of NORDVULK by the Nordic Council of Ministers was reduced by ~40% and this financial responsibility was taken over by Icelandic sources.

Volcanological research on Iceland has significant Nordic relevance. Ancient volcanic rocks form a major part of the geological record in Scandinavia and Finland. To understand these requires experience of modern active volcanoes such as those of Iceland. Most of the rocks in Scandinavia and Finland were formed hundreds of millions of years ago whereas those on Iceland are all younger than 16 million years, and some are still forming today. One of the reasons for the unique geological setting of Iceland is that the Mid-Atlantic ridge, where new oceanic crust is constantly being formed, comes to the surface on Iceland. This means that features that are usually hidden on the ocean floor can be studied here. Volcanic eruptions on Iceland take place under a variety of conditions: sub-aerial, sub-aqueous, and sub-glacial. Studies of ocean ridge volcanism and other vital aspects of plate tectonics on Iceland are essential to be able to understand ancient rocks that were formed by similar process in the geological past in Scandinavia and Finland. Research into magmatic and hydrothermal (geothermal) processes that are active on Iceland are also relevant for our understanding of the formation of economic mineral deposits that occur in ancient rocks.

Volcanic eruptions in Iceland are a major hazard not only for Iceland itself, but also for the Nordic countries, since large Icelandic eruptions can spread toxic volcanic ash over the whole northern hemisphere. Any Nordic activity on natural hazards must include this as a possibility, and Iceland must be the focus for this research. Past Icelandic volcanic eruptions have greatly influenced the climate in the northern hemisphere. The Laki eruption in 1783 led to crop failure, great loss of livestock and the death by

starvation of 25% of the population of Iceland. The amount of sulphuric acid aerosol released into the atmosphere was 80 times more than the well-documented 1980 Mount St. Helens in the western USA. Following the Laki eruption the winter temperature in the eastern USA dropped by almost 3°C and the following two years were marked by cold winters as well. An eruption on this scale today would disrupt many international flights in the northern hemisphere for many months and would spread ash over the Nordic countries with major impact on agriculture and water supply.

Iceland also experiences many earthquakes, and research into their nature, distribution and risk assessment is essential for many people worldwide.

NORDVULK is extensively involved with research on eruptions and associated earthquakes in Icelandic volcanoes. Improved ability to predict volcanic eruptions and earthquakes is a central issue for NORDVULK and has widespread international implications.

A further benefit of NORDVULK research is that the history of past volcanic eruptions on Iceland is recorded in ash layers not only on Iceland itself but also in the Greenland ice cap, where they have been sampled by drilling. These not only give a record of Icelandic eruptions in the past, but also act as datum-plane markers that allow the history of climate change in the past to be determined more accurately.

Since 2004 the main aims of NORDVULK have been to:

- carry out research at an internationally high level with focus on volcanology and related fields, including contributing to a better understanding of changes in the global environment;
- contribute to co-operation between Nordic researchers and institutions;
- introduce new topics and methods of research in the field of volcanology;
- attract a permanent staff and guest researchers of high international quality and with good contacts;
- ensure that NORDVULK's staff are used as referees and consultants in relevant fields of research.

Research Projects

The research of the full NORDVULK team of research fellows, senior research fellows and senior researchers can be described broadly under four headings.

Crustal deformation associated with volcanic activity and plate tectonics

As the plates spread apart, and as magma rises below volcanoes, the Earth's crust deforms, bulging upwards or sinking and extending or compressing. When the deformation is sudden, as in an earthquake, a fault develops and the two sides of the

fault move in opposite directions. When the deformation is gradual, as when a volcano inflates, the movement may happen over months or even years. The movement of the crust can be measured by GPS observations (though these can only be made at individual places) and by INSAR, a technique that depends on comparing satellite images from different times (which gives measurements over wide areas, but only at discrete times). Records of earthquakes can be used to discover the direction of slip on a fault. The NORDVULK team uses all of these methods together, and has developed great skill in their application. The aim eventually is to discover the causes of deformation and make predictions about likely earthquakes and eruptions. The methods are not easy to use, and it will be some time before the observations can be interpreted to give predictions, but the NORDVULK team is a world leader in this field.

Origin of magmas feeding Icelandic volcanoes

The magmas that erupt at the surface in Iceland come from many kilometres down where the hot Earth's mantle melts as it rises while the tectonic plates split apart. The steps that take place during this process are very complex, and are different from volcano to volcano. Yet to understand a volcano properly and predict its activity, these steps must be evaluated. This can be done through close examination of the chemistry of the lavas of the volcano, through observations of its volcanic gases and through careful study of the crystals that have been brought up with the lava from depth. The science of petrochemistry, as this is called, is difficult, and the necessary measurements are complex. NORDVULK has excellent scientists in this field and fine instrumentation, but needs international collaboration to answer all of the questions. Fortunately their collaborators are also leaders in the field and have access to other types of instruments. This part of the programme is proceeding well.

Volcanic ashes of Iceland

To understand the volcanoes of Iceland fully, a historical record of eruptions is necessary. Already the record from the time of settlement is one of the longest volcanic records available anywhere, but a longer time sequence is needed. Fortunately the ashes from past eruptions are trapped in sediments in Iceland and those sediments can be dated. The chemistry of the ashes identifies the volcano that has erupted, and hence a record for each volcano can be established. Ashes from the largest Icelandic eruptions spread all around the northern hemisphere, and can be traced in the cores drilled into the Greenland icecap. Not only do these ash bands give time markers in the icecap cores, but they allow very precise correlation between cores, since each band formed during a single year. The ash bands are a very important component in the use of ice cores to study climate change in the past.

Volcano-icecap interactions

A recent development within NORDVULK has been research into possible interaction between volcanoes and icecaps. When an icecap forms, its weight depresses the crust beneath, and when it melts, the crust rebounds. At present the great Vatnajökull icecap is melting and thinning, and beneath it is an active volcano. Will the decrease in

pressure from the melting generate new eruptions? The INSAR technique is ideal for studying this and work is underway.

All of these project schemes have shown significant progress in the recent past, with some of the achievements representing important steps forward at the international level.

Nordic Research Fellows

One of the main funding activities of NORDVULK is a stipend programme for researchers from the Nordic countries. There are five regular stipends for young researchers and in 2007 one additional stipend was granted. At present there are four at the post-masters level and two at the postdoctoral level, but this proportion can vary from year to year. There is also a position for a Senior Research Fellow from one of the Nordic countries. All these appointments are for one year but most are renewed for a second and rarely for a third year.

Candidates that apply for a stipend are assessed by the Nordic Programme Committee for NORDVULK. This committee consists of one member from each of the five Nordic countries; the Manager of NORDVULK plays an important advisory role. They jointly decide which of the current fellows should receive continued funding, which new applicants to support, and whether the fellows should be at the post-masters or postdoctoral level. The Senior Research Fellow vacancy is also filled; the incumbent senior fellow may be given continued support or a new applicant may be appointed. This selection process appears to function in a very satisfactory manner since the research fellows have consistently been of high academic quality.

The research project on which the Nordic Research Fellow is to work is decided through interplay between the applicant, the NORDVULK Manager and other staff of NORDVULK and the IES. Some of the projects are supervised jointly together with researchers from elsewhere in the Nordic countries. Examples of the current research projects (see also Appendix 1) of the fellows are listed below.

DYNAMICE (glacier-volcano DYNAMics in ICEland)

This involves study of the influence of volcanic activity on glacial environments. The project is funded jointly by NORDVULK and the Royal Swedish Academy of Sciences. The research is in collaboration with others from Sweden and Denmark.

Transport and deposition of metals and sulphur compounds in volcanic geothermal environments

Studies of near-surface geothermal activity have great value for our understanding of similar processes at depth that have produced some of the worlds´ most important economic mineral deposits. This research involves the University of Helsinki.

Origin of the three magmatic series in Iceland

This involves study of tiny inclusions of melt that were trapped during the crystallization of minerals. Magma compositions are otherwise seldom preserved in rocks. The project is in co-operation with researchers in France and Sweden.

Crustal deformation and the state of stress along Reykjanes Peninsula, an oblique plate boundary.

This project takes advantage of the unique location of Iceland where the mid-Atlantic ridge is exposed at the surface. The relationship between surface deformation and earthquakes is being studied in co-operation with researchers in Sweden.

Magma flow directions in dykes inferred from magnetic studies.

This study uses the fact that magnetic minerals that crystallize in magmatic rocks retain information about the orientation of the magnetic field at the time of crystallization. Deciphering this information that is "frozen" into the rock can provide data on, for example, the direction of magma flow in dykes. This can indicate the source of the magma. This project is a collaboration with researchers from Sweden.

The current Nordic Senior Fellow is involved in several projects including study of the deformation over time at a number of volcanoes on Iceland. This provides information of deformation caused by magma chambers at different levels in the crust, and allows evaluation of volcanic unrest and the hazard risk. Other studies include measurement of glacial thinning over time at Vatnajökull. This is caused by a combination of volcanic activity and glacio-isostatic deformation. Since 1997 the glacier edge has been uplifting at a rate of more than 25mm/year and the influence of global warming on this system can be monitored. Collaborators include researchers from USA, France, UK, Spain and Sweden.

Some, but not all, of the post-masters research fellows are enrolled as PhD students either at the University of Iceland or at the Nordic university from which they received their graduate education. The fact that the stipends are normally given for a maximum of two years while a PhD takes 3 years means that alternative financing must be found to complete a PhD. There is, at present, no formal agreement between NORDVULK and Nordic universities or other Nordic funding agencies regarding PhD enrolment or financing for completion of the higher degree. This is an area of concern for the ET and a recommendation for action is listed later in the report.

While there has always been a positive collaboration between NORDVULK and geologists/geophysicists at the University of Iceland, including supervision of research fellows, the merger has meant that this cooperation has blossomed so that a wider range of research projects and supervisors can be offered. As a consequence of the merger, research fellows also have access to a wider range of analytical and other facilities than previously. There are now over 20 potential supervisors for research

fellows at the IES. Research fields that now can be offered include volcano-seismology and volcano-glaciology. Together with the volcano-deformation research that was already being performed at NORDVULK this provides a very solid research platform for many aspects of geophysical volcanology.

The opportunities provided by the world-class field area of Iceland and the facilities at NORDVULK (and the rest of the IES) attract researchers from many places worldwide. There are currently 6 researchers at Nordvulk with other sources of funding. Since 2004 these guest researchers have come from the Netherlands, USA, Sweden, Germany, France and Scotland. This adds to the active, international research atmosphere at NORDVULK.

Since NORDVULK was established in 1974 there have been 95 Nordic Research Fellows; 11 of these are from 2004 or later. Fellows have been fairly evenly distributed between the Nordic countries: Iceland 13 (1 since 2004); Denmark 23 (5); Norway 22 (3); Sweden 17 (1) and Finland 20 (1) (see Appendix 1). About 28% of these are female.

One of the main functions of NORDVULK is scientific training. The success of this can be assessed by analysis of the current employment of previous fellows (Appendix 1). Almost 90% are employed in earth sciences; only 10% of these are employed outside the Nordic countries. A total of 35% are employed in jobs involving academic research; 16% in governmental research agencies; 21% in private consulting companies involved with earth science; 12% are research students.

The quality of the research of the Nordic Research Fellows can be estimated by their production of scientific publications in the period 2004-2008 (see Appendix 1). During this interval, past and present research fellows have contributed to 27 of a total of 90 publications involving NORDVULK. Research fellows are the first authors of 20 of the 27 publications. Co-authors are, in many cases, NORDVULK and IES staff and/or international collaborators. Most of these articles have been published in leading international journals including the Journal of Volcanology and Geothermal Research (10 articles), Bulletin of Volcanology (4), Geophysical Journal International (2), Boreas (2), Chemical Geology (1), Contributions to Mineralogy and Petrology (1), Journal of Petrology (1) and Geology (1). The Senior Research Fellow has been involved in 24 publications since 2005; he is first author of 6 of these. Six of the 24 are currently “sub judice”. The journals include the Journal of Volcanology and Geothermal Research (4), Bulletin of Volcanology (2), Geophysiacl Journal International (2), Journal of Geophysical Research (5), and Meteoritics & Planetary Science (3). This scientific production by the Nordic Research Fellows and Senior Research Fellow is impressive. It bears witness to the successful way in which the candidates are selected, the quality of the research projects in which they have been involved, the supervision by NORDVULK and IES staff and the high standard of international cooperation.

During our brief visit to NORDVULK we met some of the current fellows who briefly presented their research projects. We were impressed by the standard of the

presentations and their enthusiasm. During our discussions with them it was evident that the fellows were dedicated, highly motivated and intelligently applied appropriate scientific methodologies.

Assessment of Research and Facilities

The backbone of NORDVULK is the group of four senior researchers. All four of them are scientists of high calibre when rated on an international scale. Between them they are authors on 35 papers that have been published in international journals of the highest quality over the last 4 years. The recognition of their work by the international scientific community is also reflected in the high quality of those who collaborate with them and by invitations to speak at international conferences. There is no doubt that these researchers would be able to compete for high-level posts at institutions with fine international reputations.

Working closely with them is the Nordic Senior Fellow. Over the last four years this post has been filled by two energetic and successful scientists who have contributed their own skills to the success of the group. But the team of scientists associated with NORDVULK is larger than that. There are the Nordic Research Fellows (at present six) who bring extra vitality to the group together with their considerable scientific abilities (see above for detail of achievements). Then there is the group of researchers who have found funding from outside NORDVULK to work as part of the team. At present there are seven people in that group, all of them following new and promising lines of research. Finally there is the group of eight associated researchers in the staff of the Institute of Earth Sciences all of whom are fine scientists too.

This team of over twenty scientists is truly excellent, when judged on a global scale, has breadth as well as depth in the subject, and has the energy and ability to push the science of volcanoes a long way further ahead.

The overall quality of the research carried out by the full NORDVULK staff team can be estimated by their production of scientific publications (Appendix 1). Since 2004 a total of 90 publications in internationally recognized scientific journals has been produced by individuals (or groups) related to NORDVULK. Of these, 13 have been submitted recently. The output includes papers published in leading journals such as Nature (3 papers), Geophysical Research Letters (7), Bulletin of Volcanology (12), Journal of Volcanological and Geothermal Research (18) and Journal of Geophysical Research (7).

The facilities available to the team are also first class. NORDVULK brought to the Institute of Earth Sciences a number of important (and expensive) pieces of equipment (see Appendix 1) that are necessary for the research programme of the group. One of these, the electron probe, has been recently upgraded. These are complemented remarkably well by the equipment contributed by the Institute for Earth Sciences. Together these (including the excellent technical staff that run them) are a formidable resource for the science that NORDVULK does so well.

Overall then, in NORDVULK, Iceland and the Nordic countries (who have privileged access to the team) have a research group that is the equal of any similar group elsewhere in the world, and a group that deserves continued full support.

The senior researchers raised one issue at our meeting. Though the amalgamation with the Institute of Earth Sciences has gone very well, the finances of NORDVULK seem to have moved one step away from the control of the senior researchers. In the past it was possible to allocate research funds to promising projects with little difficulty. Now it appears to them that the University has placed a filter in the system so that formal applications have to be made for funds that were at one time readily available.

Summer Schools

An important aspect of NORDVULK's work is the organisation and running of international summer schools. Iceland's unique volcanic and glacial history and setting makes it a very attractive venue for researchers and students from across the world. The running of summer schools provides NORDVULK with the opportunity to enhance both its international reputation and that of the Nordic geological community. Summer schools are commonly the prelude to further collaboration between NORDVULK and institutions and individuals within the Nordic countries and elsewhere in the world. Since 2000 NORDVULK has run four summer schools and a pattern of running a summer schools on a two-year interval is within the resource capabilities of the NORDVULK staff. Staff did indicate to the ET that they would like to run summer schools on a more regular basis, however, the organisation of a summer school is quite demanding. The funding for a school has to come from grant proposals submitted by NORDVULK staff and international collaborators. Sources of funding for recent schools have included Icelandic and Nordic agencies, the EU and the National Science Foundation in the USA. Following this NORDVULK staff then play a central role on an international organising committee and of course there is then the logistical requirements for running field excursions and laboratories as well as presentation and discussion sessions. This means that a member of staff taking on responsibility for a summer school inherits a substantial workload and responsibility for maintaining and enhancing the reputation of NORDVULK. In some years staff do not have the time to run a school, for example, in this year NORDVULK staff are involved with supporting field excursions and laboratories associated with the International Geological Congress and the IAVCEI (International Association of Volcanology and Chemistry of the Earth's Interior) meeting in Iceland. In meetings with staff the ET heard that logistical preparation and support for summer schools was not a major problem as NORDVULK staff had considerable experience in this respect. The key area where staff felt additional support would be useful was for the Nordic Programme Committee to identify a regular source of initial 'seedcorn' funding to get the whole process of grant application and planning underway as well as advertising of the summer school across the Nordic nations.

The current structure and content of the summer schools is designed to address the interests of experienced international researchers as well as graduate and postdoctoral students. The schools generally have broad themes and recent topics have included

geodynamics and magmatic processes and the environmental effects of large volcanic eruptions on the northern hemisphere. At this level with participation of international experts the summer school allows NORDVULK staff to discuss and disseminate their research work, often with the result of establishing further international collaboration.
The benefit for graduate students was illustrated by a number of the research fellows interviewed by the ET saying that attendance at a NORDVULK summer school had provided the inspiration to place an application to become a Nordic Research Fellow.

NORDVULK staff mentioned the possibility of the UI co-funding a summer school with UI undergraduate students participating in the school gaining academic credit. This would mirror some of the credit-bearing geological field programmes offered to students through the EU Erasmus exchange scheme. The ET sees considerable merit in this development and would recommend serious consideration of this proposal to offer academic credit to students from the UI and possibly students from other Nordic universities. NORDVULK staff suggested that an undergraduate-focused summer school could cover highly topical climate study themes related to investigation of volcanism, glaciations and Quaternary events revealed in Greenlandic ice cores.

The ET see the summer schools as a key activity of NORDVULK allowing staff to showcase cutting edge research taking place in Iceland. It is clear that the schools have enhanced the reputation of Icelandic and Nordic geosciences as well as providing inspiration for graduate and postdoctoral students. The ET would strongly recommend that NORDVULK, with the support of the Nordic Programme Committee and the UI, look at ways of providing a secure funding and resource base that will allow a regular and sustainable programme of summer schools.

NORDVULK Collaboration and Outreach Activities

In reviewing the documentation and in discussion with NORDVULK and IES staff the ET was impressed with the very strong level of international collaboration. The collaboration takes a number of forms and includes facilitating periods of study at NORDVULK for eminent researchers from prestigious institutions in Europe, the USA and elsewhere in the world, allowing research students from Nordic and other European institutions to contribute to NORDVULK research programmes, and involvement of international researchers in NORDVULK projects, frequently using funding from within their own countries (e.g. NSF in the USA) to support their involvement or providing NORDVULK researchers with access to the state-of-the-art research instrumentation (e.g. electron microprobe at Clermont Ferrand). Currently NORDVULK research programmes involve about 30 international collaborators from institutions in Sweden, Denmark, Spain, Italy, France, Switzerland, UK and the USA. NORDVULK staff reported that the number of requests for collaborative international research significantly exceeded their capacity to accommodate such requests.

Within Iceland NORDVULK is an established authority for the media in providing advice, guidance and information on volcanic and earthquake events. NORDVULK staff collaborate closely with colleagues from other Icelandic institutes, such as the

Meteorological Institute in the geophysical monitoring of seismic activity, and the Iceland GeoSurvey in the study of geothermal areas. NORDVULK staff also see a role beyond the provision of expert knowledge and will seek to advance the public understanding of volcanic and seismic hazards through a more user-friendly website. There is also an acknowledgement of the need to raise the NORDVULK profile across the Nordic countries and to make better use of the information department of the Nordic Council of Ministers.

The ET considers the collaborative and outreach activities of NORDVULK to be exemplary and a reflection of the high regard that the international geosciences community has for NORDVULK. At present the involvement of international collaborators is accommodated within the staffing and resources available and appears well managed. The ET would recommend a continuation of this careful approach which avoids stretching staffing and resources too thinly. NORDVULK staff have identified the need for raising awareness of their work with the public in Iceland and with other Nordic countries, and the ET would encourage the staff to address this aspect of their work in the next round of strategic planning.

Prospects for the Future

The ET assessment has shown that NORDVULK is performing an important role both in its science and in its monitoring of the activity of Iceland's volcanoes. This role has a specifically Nordic dimension in terms of privileged access to research opportunities and in hazard prediction. The group at present functions very well embedded within the Institute of Earth Sciences at the University of Iceland, but requires continued earmarked support if it is to progress successfully. What about its future prospects?

The strategic vision that closes the NORDVULK Report 2004-2008 (Appendix 1) is fundamentally sound. The present four research themes outlined above will continue to be important and must be maintained. Integration within the Institute of Earth Sciences allows in addition new themes to be explored. In particular the ET supports the development of links to research on the environmental consequences of eruptions and on the environmental history of Iceland through the Quaternary. These areas are of increasing importance in global earth science research, and are especially significant with the prospect of global climate change.

The Nordic Research Fellowships have a crucial role to play in the future. They allow young Nordic researchers access to the superb natural laboratory that Iceland is, and provide a vital support for the research of the senior researchers within NORDVULK. The ET recommends that the fellowships maintain the current balance between PhD students and young postdoctoral researchers, with roughly half going to each type. It is crucial to maintain the quality of intake on this programme, which is in competition with other programmes open to young Nordic researchers. One obstacle to this is that the fellowships are offered for only one year in the first instance with the possibility of renewal for one or even two further years at a later stage. Since the programme started

52 fellows have been in post for up to 1 year, 37 from 1 to 2 years and 25 beyond 2 years (some individuals have had more than one period of fellowship). The ET is clear that to attract the best candidates, fellowships should be offered for two years in the first instance. This will allow PhD students to be certain of some continuity of support (though they will need to seek additional funds to complete), and will allow postdoctoral fellows to write papers and complete a significant new project that will prepare them for employment. Other schemes have already moved in this direction and this fellowship scheme ought to follow. To allow this to happen while maintaining the same number of fellows will require additional funding to the scheme, rising from five fellowships at any one time to six.

As indicated above, the ET considers that the programme of summer schools for PhD students, postdoctoral researchers and more senior scientists must be maintained on a regular basis. This is not only important in widening Nordic participation in the work of NORDVULK, but also to publicise its work on the international stage. Some of the most significant international collaborations of NORDVULK have arisen as a result of past summer schools. The ET also considers that there would be benefits in organising regular week-long educational field trips to Iceland for undergraduates from Nordic countries. These trips would be able to teach both the volcanic activity in all its forms and the evolution of Iceland through the ice-ages up to the present day. Direct experience of active geological processes has a considerable impact on student understanding of the earth sciences. Both summer schools and field trips could be financially self-sustaining, but would need seed-corn funding from NORDVULK funds to allow for publicity, for reconnaissance, and for assistance with organisation.

The ET is concerned about the current funding of NORDVULK. As a result of the Brändström report of 2003 advocating increased national support of Nordic institutions, funding from the Nordic Council of Ministers (NMR) was reduced from 89 million ISK in 2004 to 58 million ISK in 2006. The reduction in funding was largely made up by an increase in funds from the Icelandic government. The funding structure has become somewhat unclear since the merger of NORDVULK with the Institute of Earth Sciences in the University of Iceland. Funding for NORDVULK activities comes partly through the Science Institute of the University and partly from other University sources, which cover costs such as accommodation and salaries of university professors attached indirectly to NORDVULK. Within the funding from the Science Institute for the Institute of Earth Sciences, 58 million ISK is earmarked as the NMR contribution to NORDVULK. This pays for about half of the salary costs of the senior researchers, the research fellows and the technicians who operate the instruments required by NORDVULK research, or about 30% of the total cost of NORDVULK activities excluding the salaries of the university professors attached indirectly to NORDVULK. A sum of 57 million ISK comes to NORDVULK from the Icelandic State Budget via the Science Institute of the University. The remainder of the NORDVULK income is generated through research projects. NORDVULK activities are thus vulnerable to any changes in University priorities and/or Icelandic politics. The ET considers that any further reduction in NMR funding would potentially have a serious impact on NORDVULK activities. Indeed a

modest increase in NMR funding would be necessary to implement the changes proposed in this report.

The Nordic impact of NORDVULK both scientifically and practically is sufficient to justify such a response from NMR. A modest increase of NMR funding would indicate confidence in NORDVULK activities both in terms of its considerable scientific successes in the past and in its plans for the future. It would also help to secure long-term support in the Institute of Earth Sciences, the Science Institute and the University of Iceland generally.

Another issue to take into account is the international dimension. Iceland is known around the world of the earth sciences as a unique field laboratory for research into volcanoes and spreading plate boundaries, and the interaction of these with ice sheets. NORDVULK has a considerable international reputation for research in this area of science, as do the associated scientists in the Institute of Earth Sciences. As a result of the excellence of the scientists involved together with the importance of the research into earth science that it is possible to do in Iceland, NORDVULK has perhaps the highest profile internationally of any of the Nordic institutions of earth science. Requests for partnership and collaboration from scientists internationally greatly exceed the ability of NORDVULK to fulfil them. NORDVULK is seen around the world as a remarkably successful and persuasive example of intergovernmental co-operation for the advancement of science.

Finally, it is interesting to examine the interaction between NORDVULK and the University of Iceland. In the last few years the University, with the strong encouragement of the Icelandic government, has moved on from putting almost all of its energy into teaching to become much more involved in research. Our understanding is that NORDVULK has had a considerable influence, as an internationally successful example of Nordic science, on the way in which the Science faculty has been restructured and as a model for the development of research within the university.

Conclusions and Recommendations

In the Terms of Reference for the review the Evaluation Team has been asked to evaluate the Nordic dimension of NORDVULK and to assess the academic quality and relevance of its research, publications, research fellowship schemes and summer schools. As indicated in the text above it is the opinion of the ET that NORDVULK has been highly successful in progressing its range of activities and deservedly has a very high international reputation for the quality of its research.

The Terms of Reference also requested the ET to consider the success of establishing NORDVULK within the Institute of Earth Sciences, its scientific impact on the Nordic volcanological community and continued financial support for NORDVULK. The ET has documented above the very real success of NORDVULK and IES and the impressive scientific impact it has had across the Nordic countries. The team has also noted that NORDVULK has received adequate funding but with the reduction of income from the

Nordic Council of Ministers that the funding regime now has a greater degree of uncertainty which makes forward planning more prone to unforeseen financial risk.

The ET can confirm that, in NORDVULK, Iceland and the Nordic countries as a group have an institution in which they can be very proud. We trust that the NMR continues to recognise this and that this institution deserves continuing and generous support from the Nordic lands. In order to help secure a successful future the ET would make the following recommendations.

1. The University of Iceland should carry forward the option to create a Department of Earth Sciences within the Faculty of Science and so build on the research success and leadership achieved through the formation of NORDVULK and the IES (subsequently established on July 1, 2008).

2. The University of Iceland, in consultation with the Nordic Programme Committee, and management within the IES and NORDVULK, to review the level and balance of funding from NMR and Icelandic government sources with a view to guaranteed funding at a sustainable level for a specified period (e.g. 3 years) to allow NORDVULK to plan a sustainable programme of research. The ET believes that additional funding at modest levels from the NMR would allow NORDVULK to enhance significantly its research activities and outputs, for example, by providing six research fellowships with two year tenure.

3. The University of Iceland, in consultation with the Nordic Programme Committee, and management within the IES and NORDVULK, to consider the approach to funding of research within NORDVULK to allow a greater degree of autonomy on how NORDVULK prioritises the allocation of funding and to give greater transparency to the allocation and monitoring of research funding.

4. NORDVULK, in consultation with appropriate staff within the University of Iceland and the Nordic Programme Committee, to review of arrangements for research fellows undertaking a PhD study with a view to introducing a formal agreement which sets out the NORDVULK commitment to supporting PhD study.

5. The ET recommends that the fellowships maintain the current balance between PhD students and young postdoctoral researchers, with roughly half going to each type. NORVULK should consider the merit of providing guaranteed funding for a two year period to recipients of research fellowships and increasing the number of research fellowships to six awards.

6. The ET would strongly recommend that NORDVULK, with the support of the Nordic Programme Committee and the University of Iceland, look at ways of providing a secure funding and resource base that will allow a regular and sustainable programme of summer schools.

7. Consideration should also be given to running broad themed undergraduate summer schools which would award academic credit to undergraduate participants. The University of Iceland and other Nordic institutions could seek to fund the summer school unit using their established resource allocation models for units of teaching.

8. At present the involvement of international collaborators is well managed and accommodated within the staffing and resources available. The ET would recommend a continuation of this careful approach which avoids stretching staffing and resources too thinly.

9. The ET would recommend that NORDVULK staff carry forward the proposals for raising awareness of their work, and its significance in identifying volcanic and seismic hazards, with the public in Iceland and with other Nordic countries.

Appendices

Appendix 1	NORDVULK self evaluation report 2004-2008
Appendix 2	Staff met by Evaluation Team during on-site visit

Signatures of Evaluation Team

Professor Joe Cann

Professor Howard Colley

Dr J Richard Wilson