The Research Council of Norway

Research in Earth Sciences in Norway

An evaluation

Evaluation
Division for Science

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Table of Contents

To the Research Council of Norway

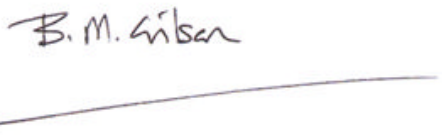
The Evaluation Committee for this review of research activities in Earth Sciences in Norwegian universities and relevant contract research institutes hereby submits the following report.

The task of making a comprehensive and objective review of the research activities undertaken over the past five years has been challenging, given the number of institutions and volume of data we were asked to consider.

The Evaluation Committee hopes that this review will be useful for the Research Council of Norway, the Ministry of Education and Research and other relevant ministries, and the individual universities and research institutes, and their component departments and research groups, which took part in the evaluation.

Our comments are offered in the spirit of constructive criticism and we sincerely hope that they will be received as such.

This report represents an agreed account of the assessments, recommendations and conclusions of our work.



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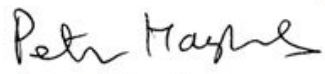

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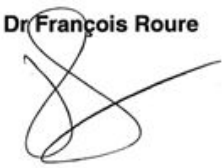

Dr François Roure

Dr Ellen Thomas

Professor Ezio Todini

1. Executive Summary

The Evaluation Committee (EC), comprised of leading international experts in a range of Earth Science disciplines, is pleased to report to the *Research Council of Norway* (RCN) that Earth Science research in Norway is generally in a state of good health. Very few truly weak research areas were observed and in a number of fields, e.g. climate science, meteorology and atmospheric science, marine science, hydrology, physics of geological processes, and sedimentary basin development in the context of petroleum systems, Norway can be considered to be internationally leading.

Norway can be proud of its many strengths in the field of Earth Sciences which have been built from a strong physical and natural science base and are of critical national importance. Maintaining these strengths is likely to serve Norway very well in the future.

The detailed evaluations presented in Sections 4 and 5 of this report were based upon written self-evaluations provided by the institutions and research groups under review, hearings with representatives from individual research groups, site visits and a bibliometric analysis of research outputs. The grading scheme adopted broadly follows that of the 2008 *Physics Review*. The general observations presented in Section 3 represent an overview of the more detailed evaluations.

For a country with a small population, such as Norway, it might be argued that there are simply too many different research organisations competing for a relatively small amount of research funding. Some rationalisation took place after the 1998 review of Earth Science research in Norwegian universities and colleges and the EC has not identified any particular need for further rationalisation, with the exception of some very small research groups which are simply not viable.

Research infrastructure is of variable quality and it is clear that some significant scientific investment in infrastructure and laboratory facilities needs to be made to ensure that Norwegian Earth Scientists continue to have access to state-of-the-art facilities in key research areas. A network of national facilities needs to be established, supported by an appropriate funding mechanism to faciliate their use.

A consistent theme in discussions with the research groups was the lack of sufficient funding to support the research base and the very low success rates in national competitions for RCN research grants. Some research groups do, however, receive significant funding from the hydrocarbon industry, which also provides access to large industry data sets.

Publication outputs are very good in a national context, but with considerable variability between different research groups. Some groups routinely publish in high-profile international journals, whereas the contributions of other groups are more modest. Publication rates in highly applied research fields are, in general, lower.

The training of Doctoral students seems to be of a high standard. There are concerns that recruitment of good Norwegian students into PhD programmes is becoming more difficult. A significant number of the Doctoral students with whom members of the EC spoke were internationally recruited.
The management of fixed-term contracts for researchers in the university sector is highlighted as an issue of some concern.

2. Introduction

2.1 Mandate and the Review Process

This report presents an evaluation of research in the Earth Sciences in Norway, with particular focus on the 5-year period 2005-2009. The mandate for this review, including its detailed objectives, long-term goals, methods to be employed and specific aspects to be considered, is provided as Appendix A. The members of the Evaluation Committee are introduced in Section 2.6.

The main objectives of this evaluation are to provide a critical review of the strengths and weaknesses of basic research in the Earth Sciences in Norway, to identify research groups that have achieved a high international quality or have the potential to do so, and to identify areas of research that need strengthening. This evaluation provides guidance for institutions and should provide the Research Council of Norway (hereafter RCN) with a sound basis for future strategic decision-making and for giving advice to government on research policy.

The evaluation was based upon a review of factual information and a self-evaluation document submitted by the units under review in June 2010, covering the period 2005-2009. It was originally intended that the review should have been completed by January 2011. Unfortunately, due to changes in Evaluation Committee membership and the appointment of a new Chairman, the review process was delayed by 7-8 months. During March 2011 hearings and site visits were held in Bergen, Oslo, Trondheim, Tromsø, Svalbard and Stavanger. A planned site visit to Sogn og Fjordane University College, Sogndal, was cancelled because of bad weather. The detailed schedule for the hearings and site visits is provided as Appendix B.

Preliminary drafts, without grades, of the individual evaluations were forwarded to university departments and research institutes in July and August 2011 for factual checking.

The Evaluation Committee was asked to provide a general overview of Earth Science Research in Norway (Section 3.1) and to make general recommendations (Section 3.2).

The grading scheme used in the evaluation is explained in detail in Section 2.5. This is based upon the scheme used in the 2008 Physics Review.

A list of acronyms and abbreviations used in this report is provided as Appendix C.

2.2 Participants in the Evaluation

The Evaluation Committee stresses that this evaluation is an evaluation of individual research groups, not of individual scientists. The constitution of these groups was proposed by the university departments and research institutes themselves. Unlike the 1998 *Review of Earth Sciences*, research institutes could choose whether or not to participate in the review process and many of them did; participation was mandatory for the universities.

The participating institutions were:

University departments:

University of Oslo
- Department of Geosciences
- Natural History Museum

The Norwegian University of Life Sciences, Ås (30km south of Oslo)
- Department of Plant and Environmental Sciences
- Department of Mathematical Sciences and Technology

University of Stavanger
- Department of Petroleum Engineering

University of Bergen
- Department of Earth Science
- Geophysical Institute

Sogn og Fjordane University College, Sogndal (140km northeast of Bergen)
- Faculty of Engineering and Science (geology and geohazards res. gr.)

The Norwegian University of Science and Technology, Trondheim
- Department of Petroleum Engineering and Applied Geophysics
- Department of Geology and Mineral Resources Engineering

University of Tromsø
- Department of Geology

The University Centre in Svalbard
- Department of Arctic Geology
- Department of Arctic Geophysics

Contract research institutes:

- Norwegian Meteorological Institute, Oslo
- Norwegian Water Resources and Energy Directorate, Oslo
- CICERO Center for International Climate and Environmental Research – Oslo
- Norwegian Institute for Air Research, Kjeller (20km north east of Oslo)
- NORSAR Norwegian Seismic Array, Kjeller
- Uni Bjerknes Centre, Bergen
- Uni Centre for Integrated Petroleum Research, Bergen
- Institute of Marine Research, Bergen
- Nansen Environmental and Remote Sensing Center, Bergen
- Geological Survey of Norway, Trondheim
- SINTEF Petroleum Research, Trondheim
- Norwegian Polar Institute, Tromsø

2.3 Key Data

The Evaluation Committee was provided with key factual information about departments/institutes and their constituent research groups. These data included the number of employees by job category and the number of Doctoral and Masters students graduated between 2007 and 2009. All staff and student numbers quoted in this report are based upon the factual data provided and have not been updated to reflect the position in 2011.

A detailed bibliometric analysis of publications in Earth Sciences in Norway for the period 2005 to 2010 was prepared for the Evaluation Committee by the Nordic Institute for Studies in Innovation, Research and Education (NIFU). The full report is provided as Appendix D.

2.4 Previous Evaluation

The last evaluation of Earth Sciences in Norway took place in 1998, resulting in the report "*Earth Sciences Research at Norwegian Universities and Colleges*" published by the RCN in 1998. Given the substantial time that has elapsed since this review, the Evaluation Committee did not consider the conclusions of this report in detail, although they were provided with a copy by the RCN. In some of the university reports in Section 4 reference is made to suggestions from the previous evaluation, but this was not done systematically.

The Earth Science research landscape in Norway has changed fundamentally in the past decade. The Evaluation Committee notes that many of the recommendations made in the 1998 report have largely been adopted, particularly:

- Better scientific integration between geophysicists and geologists/ geographers
- Combination of smaller Earth Sciences departments into larger institutes or units
- Concentration of the research effort into a smaller number of fields that are more relevant to national/societal needs
- Creating focused research groups as "*Centres of Excellence*"
- Maintaining the level of petroleum related positions
- Maintaining the total number of positions in meteorology/oceanography
- Reducing the relatively large number of positions in the fields of mineralogy/petrology/geochemistry (inorganic)
- Improving international advertising of new scientific positions

The 1998 review concluded that there was a good standard of research in the Earth Sciences in Norway, evidenced by a high level of productivity of publications with an international profile, and that much of the activity was of great importance for the Norwegian petroleum industry. The more negative aspects of its conclusions focused on the lack of strong scientific leadership, too little international mobility and research collaboration, too much internal recruitment, insufficiently strong national collaboration and the need for the RCN to play a stronger role in supporting leading scientists and investing in research infrastructure and facilities.

2.5 Grading Scheme

For the assessment of the research groups, a grading system was applied that, in keeping with the mandate, focused on the following aspects:

A: Scientific Quality and Productivity

- Published outputs, judged according to internationally applied standards for scientific quality and guided by bibliometric analysis
- The level of involvement in international research projects (e.g. EU Framework programme)
- Participation in international workshops and conferences (including convening symposia, keynote lectures etc)
- The number of PhD students supervised

B: Research Strategy, Organisation, Infrastructure and Research Cooperation

- Existence of an appropriate research strategy for the subject area for the next 3-5 years; some evidence of horizon-scanning beyond 5 years
- Presence of appropriate facilities and infrastructure to support high quality research; evidence of appropriate plans for funding their renewal
- Organisation of research groups to optimise funding opportunities
- Evidence of national/international collaboration with other research groups (e.g. sharing of facilities)
- Evidence of a supportive environment within the host organisation

C: Industrial relevance, economic and societal impact

Aspects of the science that are not reflected by internationally applied scientific measures with particular relevance to Norwegian industry, economy, health, national and global environmental issues and culture.

GRADE SCALE

Grades were assigned (at the level of individual research groups) according to a 5-point scale as explained below. Mixed grades could be given. Two grades separated by a slash (/) indicates mixed grades within the group; e.g. 4/2 indicates some parts of the group activity are given grade 4, other parts grade 2. In addition, if two grades are separated by a dash (–), this indicates a grade between the two; e.g. 3–4 indicates a grade somewhere between 3 and 4.

Excellent = 5
The group has an internationally leading position, undertaking original research, and is publishing in the best international journals. It has excellent productivity and the research is highly relevant to both national and international research agendae. The number of PhD graduates (where appropriate) and their progression is very good. Clear and convincing strategic planning exists. The Evaluation Committee has an extremely positive overall impression of the research group and its leadership.

Very good = 4
The research group has a good publication profile with a substantial number of international publications in leading journals. The group has high productivity and the research is relevant to both national and international research agendae and to Norwegian society. PhD student numbers (where appropriate) and progression are good. Good strategic planning exists. The Evaluation Committee has a very positive overall impression of the research group and its leadership.

Good = 3
The group contributes to international and national research with a significant number of good quality outputs of relevance both to international research agendae and to the Norwegian economy and society. The productivity is acceptable and the number of PhDs (where appropriate) is reasonable. Strategic planning is reasonable to good. The Evaluation Committee has an overall positive impression of the research group.

Fair = 2
The quality of research is acceptable, but the international publication profile is modest. Much of the work is routine in terms of design and publications. The focus of the research is not cutting-edge. Few or marginal original contributions to scientific knowledge are produced. Strategic planning exists, but is not particularly convincing. The overall impression is positive but with a degree of scepticism from the Evaluation Committee.

Weak = 1
The research quality is below international standards and the publication profile is very weak. The group produces international publications only occasionally. No original research and little relevance to problem solving. Little thought given to strategic planning. The Evaluation Committee did not gain a good impression.

OVERVIEW

In practice, the various criteria used in the evaluation were not as clear-cut as presented above, e.g., a research group may produce very high quality publications, but their productivity is low. An explanation may be that the group is heavily burdened by other obligations apart from research, such as teaching. The Evaluation Committee tried to take such circumstances into consideration, but this was not always possible. When different criteria suggest different grades a compromise grade was set (with appropriate explanation). The overall grade awarded reflects both the historic performance and the current position.

2.6 The Evaluation Committee

The Evaluation Committee consisted of the following experts, whose CVs are provided in Appendix D:

Professor Marjorie Wilson (Chairman)
School of Earth & Environment, University of Leeds, UK

Professor Peter Haynes
University of Cambridge, UK

Professor Michael Kendall
University of Bristol, UK

Professor Johan Kleman
Stockholm University, Sweden

Professor Monika Rhein
University of Bremen, Germany

Dr François Roure
IFP-Energies nouvelles, France

Dr Ellen Thomas
Yale University, USA

Professor Ezio Todini
University of Bologna, Italy

Alastair Lumsden, Senior Lecturer (1974-2000) in Engineering Geology at the School of Earth & Environment, University of Leeds, UK, served as the Secretary to the Evaluation Committee. **Øyvind Pettersen**, Senior Adviser, Department for Medicine, Natural Sciences and Technology, Division for Science, of the Research Council of Norway, liaised with all the research groups covered by this evaluation concerning the provision of data and self-evaluation reports and coordinated the practical arrangements for the hearings and site visits.

3. General observations and recommendations

3.1 The National Situation

Earth Sciences research in Norway encompasses a wide range of subjects including bedrock geology, stratigraphy, sedimentology, paleontology, petrology, geophysics, geochemistry, structural geology, climate science, glaciology, geomorphology, hydrology and hydrogeology, natural hazards, oceanography and atmospheric science. In a number of these areas Norwegian Earth Scientists may be considered to be internationally leading, as evidenced by their participation in international research programmes, particularly those funded by the European Commission, and by the quality of their scientific publications in highly cited international journals. In other areas the research may be considered basically sound and of national importance. Few examples of weak research performance were identified by the Evaluation Committee. A significant amount of the research undertaken is of a highly applied nature; this is of considerable economic benefit to Norway (e.g. in the context of the offshore hydrocarbon industry, carbon sequestration, hydrology and natural hazards), but also has substantial, and highly valued, international impact (e.g. in oceanography, atmospheric and climate science).

According to Essential Science Indicators^{SM} from Thompson Reuters, for the period 2000 to 2010 the Geosciences (Earth Sciences) were ranked 4th in Norway for the total number number of citations to publications, with an average citation rate of 9.70 (http://sciencewatch.com/dr/cou/2011/11mayNorway/). This is an impressive indicator of the strength of Earth Science research base in Norway.

The Research Council of Norway *Centres of Excellence* (CoE) programme has clearly had a major impact on the international profile of Norwegian Earth Science research. While CoEs were not part of the formal remit of the Evaluation Committee, comments are provided within this report where they are relevant to the research groups under evaluation.

A frequent observation made by all of the research groups in this evaluation was that they lacked sufficient funding, and often time, to conduct basic research. This is a common problem throughout Europe, Canada and the USA. Interestingly this is not a problem in China, where huge sums of money are being invested in basic Earth Science research and infrastructure, reflecting the importance to their national economy of mineral and natural resource exploration and the mitigation of natural hazards.

In some research fields, particularly in climate and marine science, the Evaluation Committee observed that there are a number of different groups pursuing similar research themes. Whilst there is evidence for strong collaboration between some of these groups, in other cases there appears to be an element of internal competition; such competition is not necessarily constructive in a small country like Norway.

The Evaluation Committee was provided with anecdotal evidence that it is becoming harder to recruit Norwegian students into the Earth Sciences (and the Sciences in general), particularly at Doctoral level. Whilst most institutions have sucessfully recruited international postgraduate students to their Masters and Doctoral programmes, there are some concerns for

the future. All the university departments evaluated appear to recruit internationally to fill academic and post-doctoral positions, which is standard practice throughout most of Europe.

In the following sections (3.1.1 to 3.1.10) the Evaluation Committee highlights some of the main Earth Science research areas of particular importance for Norway. These are not intended to be comprehensive of all aspects of Earth Science research conducted within individual universities and research institutes. More detailed commentaries are provided in Sections 4 and 5 of this report.

3.1.1 Geophysics

Solid Earth Geophysics

Norway has a strong reputation in solid Earth geophysics, which goes back well over 100 years. Research in this area is primarily concentrated in Bergen and Oslo, and at NORSAR and the NGU, with specific strengths in seismology and geodynamics. The Centre of Excellence (CoE) in the Physics of Geological Processes (PGP) in Oslo has an emphasis on solid Earth geophysics and is one of the flagship CoEs in the country. Training in this field of Earth Sciences is good and produces students who are in high demand in various sectors of industry. Many students go on to careers in the petroleum industry. The incentive for them to move into the more applied areas of geophysics (because of better employment prospects) has made it somewhat difficult to retain students and postdoctoral researchers in the more theoretical areas of solid Earth geophysics.

Seismology research started in Norway in the 1880s and national capability in this area has always existed in Bergen. The Norwegian National Seismic Network is coordinated through the University of Bergen (UiB). Historically, the country has been a world leader in array seismology, especially since the formation of NORSAR in the 1960s. This has led to a long-standing international presence in seismic monitoring and nuclear test ban verification and in seismic imaging of the Earth's deep interior. However, expertise in the latter has declined noticeably in recent years, as NORSAR's interest have become more commercially oriented. In more recent years, the broad field of geodynamics has seen growth in expertise in Bergen, Oslo and at the NGU. Plate reconstructions, mantle dynamics, and basin evolution, and their role on surface features are particular strengths.

Applied Geophysics

Applied geophysics in Norway is primarily focused on the petroleum industry, where there is a very good relationship with a range of national and international exploration and production companies, and strong support from the Norwegian Research Council. In general, research in this area is innovative and plays a high-profile role internationally. International links in this area are strong and scientists from the world over often visit Norwegian institutes as visiting researchers. The research programmes in the universities in Trondheim (NTNU) and Oslo (UiO) are particularly notable in sustaining large successful groups in applied geophysics, which are well funded by industry and government. Furthermore, since privatising, NORSAR has developed more expertise in applied geophysics.

Research output from this field primarily impacts industry and consequently publication and citation rates are lower than in other fields of research, as industry-based researchers have limited incentive to publish. However, the rate of publication by Norwegian scientists is above the world average in this field.

Depending on the strict definition of applied geophysics, five universities offer postgraduate degrees in applied geophysics at Masters level or above. As a whole, the country produces a good number of well-trained researchers in applied geophysics who are in high demand from industry. This demand often leads to difficulties in attracting Norwegian students to PhD programmes. As a result, many postgraduate students studying applied geophysics in Norwegian universities are from other countries. This issue is even more acute in the recruitment of postdoctoral researchers.

Mineral exploration and mining are areas of research in applied geophysics that are somewhat lacking in Norway at present. This problem is not unique to Norway and is partially due to the strong presence of the petroleum industry in Norway. However, as international demand for base metals and Rare-Earth elements, for example, increases, action may be needed to facilitate growth in this area.

3.1.2 Earth Science for Hydrocarbon Exploration

Collaboration with the oil industry is very strong within the Earth Sciences community in Norway, especially in the domains of sedimentary basins (exploration, tectonics, stratigraphy, source-sink sedimentary processes, basin modelling, seismic imaging, geodynamics and CO_2 sequestration). Companies such as Statoil and Shell are currently supporting the cost of professorships at a number of universities, and provide regular support for Joint Industry Projects (JIPs), Masters (field work and training) and Doctoral studentships. Sponsorship by the industry has also contributed to the research infrastructure of a number of university departments, particularly in Bergen, Oslo, Trondheim (NTNU) and Stavanger.

The Norwegian Geological Survey (NGU) provides internationally leading expertise in continental shelf geophysics, including potential field (gravity and magnetics), heat flow and 3D modelling. NTNU has a strong focus on seismic imaging, 4D seismic monitoring and geomechanics in collaboration with SINTEF. The University of Oslo (UiO) is internationally recognised for its work on the conjugate North Atlantic passive continental margins and the petroleum systems of the Barents Sea. The University of Bergen (UiB) has a strong focus on the infill of sedimentary basins and reservoir characterisation; strong collaborations are maintained with UiO in the fields of organic and inorganic geochemistry and diagenesis. UiB have international leadership in the fields of basin-scale and lithosphere-scale geodynamic modelling, fluid flow and thermal modelling. The two research institutes, CIPR and SINTEF, evaluated here have very strong links with industry, both in Norway and internationally, and with the various university-based groups.

Norwegian government policy on access, for research purposes, to commercially obtained geoscience data sets (seismic profiles, well records etc.) has created a very positive environment for both pure and applied research in collaboration with industry.

After focusing on the North Sea, which is now a mature basin, Statoil and other international companies have invested in the exploration of other basins in the deep offshore of the Mediterranean (Levant), the southern Atlantic margins (i.e. offshore Brazil), as well as in the Barents Sea. Further developments are expected in the Russian Arctic. Norway is likely to play an important role in the future development of Arctic resources, because of its geographic location and expertise in Arctic exploration, and this will constitute a priority for Norwegian Earth scientists.

The current organisation of Earth Sciences research in Norway provides a wide range of opportunities for national collaboration between the various research groups in this field.

Strong collaborations exist between the universities of Bergen and Oslo, and between NGU and the University of Oslo. The recently established research group at the University of Stavanger appears somewhat isolated from the research groups in Bergen and Oslo, and is developing its own network with the local industry. Research groups at the universities of Trondheim (NTNU) and Tromsø have strong links with SINTEF and UNIS, respectively, but only limited interaction with the larger groups in Bergen and Oslo.
International collaboration exists in a number of research areas, allowing the development of new expertise (e.g., basin modelling in Bergen) and encouraging a continuous flow of foreign students and young scientists towards Norway, at a time when too few Norwegian students are choosing to study for a PhD.

3.1.3 Igneous and Metamorphic Petrology & Geochemistry

Norway has had a long tradition of research in the field of "hard rock" geology – rooted in the study of the igneous and metamorphic processes responsible for the formation of the crystalline basement of Scandinavia. This research also extends to the study of magma generation and metamorphic processes worldwide. The largest group of researchers is located at the University of Oslo, some of whom were originally based at the Museum of Natural History. With the creation of the CoE *Physics of Geological Processes* (PGP) at UiO expertise in hard-rock geology was split between PGP and the Department of Geosciences. A high-pressure high-temperature experimental petrology laboratory has recently been set up at the Museum with equipment from a previous laboratory at the University of Tromsø. More modest levels of research activity in hard-rock geology also occur at the universities of Bergen, Tromsø and Stavanger. The Geological Survey of Norway (NGU) retains core competence in hard-rock geology and geochronology, sufficient to underpin its mapping activities.

The present level of expertise in Norway in hard-rock geology is considered by the Evaluation Committee to be sub-critical; few doctoral students are being trained and post-doctoral researchers and academic staff are mostly recruited internationally. Given the present high international demand for mineral resources (e.g. Rare Earth metals) there is likely to be an increasing demand from industry for staff with a strong background in petrology and mineralogy.

The necessary infrastructure to conduct internationally-leading research in hard-rock geology (e.g. radiogenic and stable isotope mass spectrometry, electron microprobe, scanning electron microscope, ICP-MS, XRF) needs substantial investment.

3.1.4 Oceanography

Physical oceanography groups are located in Bergen, Oslo, Tromsø, and Svalbard, although the main focus of the research is in Bergen. The regional foci of research are the coastal areas and fjords of Norway, the Arctic and Antarctic oceans and the Nordic Seas. Internationally recognized research, which is embedded in a number of European programmes and research activities, is carried out in Oslo (met.no) and in Bergen, where several oceanography groups from different institutions are involved (UiB, NERSC, IMR). In Bergen, there is good collaboration with chemical oceanographers studying the carbon cycle and with groups leading the ocean and the carbon cycle part of the Norwegian climate modelling efforts.

Several groups in Norway maintain monitoring programmes in the Antarctic, Arctic and the Nordic seas and thus provide an invaluable service to the international community. To work

successfully in ice-covered areas (Antarctic and Arctic), state-of-the-art research vessels with ice-breaking capabilities are needed.

In general, many of the individual research groups are too small and too diverse to be internationally recognized. In some institutions, oceanography is mostly supported as a discipline because of the need for teaching expertise; the hiring of new personnel is thus more dictated by teaching requirements than by research opportunities. The international visibility of the oceanography research in Bergen could be further improved by better joint strategic planning. Research could be further strengthened by increasing the number of physical oceanographers affiliated to the CoE BCCR/*Centre for Climate Dynamics*.

3.1.5 Climate Science

Climate science involves the integration of atmospheric, oceanic and cryospheric science, and the paleoclimate record based on various proxies, to improve understanding of the Earth's climate system and to make predictions about its future evolution.

Norway is internationally highly visible in the field of climate science, and contributes significantly to the work of the *Intergovernmental Panel on Climate Change* (IPCC). The Lead Author team involved in writing the 5th assessment report includes 18 Norwegian researchers, of whom 7 are members of groups evaluated in this report. In the WG I part of the IPCC assessment concerned directly with the physical science of climate change, the research fields represented by Norwegian scientists are high latitude research (Norwegian Polar Institute), physical oceanography (met.no), oceanic carbon cycle (UiB, BCCR), paleoclimate archives (UiB, BCCR), as well as anthropogenic and natural radiative forcing (CICERO). Norwegian scientists from Earth Science groups evaluated here are also contributing to the WG II part of the IPCC assessment concerned with impacts, adaptation and vulnerability, specifically to the overview (UiB, BCCR), the ocean systems (IMR), and Polar oceans (CICERO).

Norway has developed a new climate model, the Norwegian Earth System Model (NorESM) which is being used for simulations required for the 5th IPCC assessment report. The development of this model has been a cooperative venture between several different Norwegian institutions (UiB, BCCR, met.no, NERSC) and has sensibly built on components from major modelling centres in other countries. Bergen leads in the model development of the ocean and the carbon cycle. The development of components for modelling of radiation, chemistry, aerosols and clouds is carried out in Oslo (UiO, CICERO, met.no). The development of this model has assured that Norway can make a full and independent contribution to the 5th IPCC assessment.

On a European level, Norwegian institutions and scientists lead and coordinate several climate-related EU programmes such as *CarboChange*. The role of Norwegian Earth Scientists could be further strengthened by additional support of EU activities from national funds, and by increased basic funding for personnel in those key groups instrumental for future success.

During their site visits, the Evaluation Committee was alerted to limitations in the computer resources available for climate model integrations and pressure on space and facilities for laboratory work. As significant resources are being put into this subject area, e.g. through the new CoE *Centre for Climate Dynamics*, it is important that these issues are not overlooked. Provision of resources for scientific personnel and for accommodation must be accompanied by the resources needed for the scientific personnel to carry out their work at an

internationally competitive level. It is also important that the strong ability and future potential of institutions across Norway to contribute to aspects of climate science is not disrupted by the concentration of new resources in Bergen. The development of NorESM has required strong collaboration across a number of Norwegian institutions; the ResCLIM summer school is example of such successful collaboration. Future investment by non-Bergen institutions in climate science and related scientific areas should not be inhibited by a perceived need to have institutional scientific priorities that are clearly distinct from those of the various Bergen-based institutions.

3.1.6 Quaternary Geology, Glaciology & Geomorphology

Quaternary geology

Quaternary geology research in Norway has, over the past 20-30 years, been on a very high international level, manifested in, for example, large paleoenvironmental reconstruction projects concerning the northerly areas of Eurasian glaciation, in addition to high-quality terrestrial work on the Norwegian mainland. The link between marine and terrestrial Quaternary geology has been notably stronger than in other countries, e.g. Sweden and Canada. Further marine-terrestrial integrative work should be encouraged. The overall picture during the evaluation was that plans and research strategies in the Quaternary field (especially the terrestrial component) were not as strong as past achievements led us to expect, and that future research strategies should preferably be developed within a larger Nordic/European context. Collaboration with groups in other Nordic countries should be strengthened. The number of groups engaged in this field is probably sustainable and relevant for a country the size of Norway, but some groups were found sub-critical in size or lacking in focused leadership.

Glaciology

Norway has a large number of glaciers, over a wide range of topographic and climatic settings, often fairly accessible, and therefore offers first-rate opportunities for glaciological research, in addition to paleoglaciology studies concerning past ice-sheet distributions. Current research is of good quality and largely focused on mass balance, response to climate change, ice cores, surging glaciers and glacier hazards. The one asset that is unique in an international context is the Svartisen subglacial laboratory (see Section 5.2). If upgraded, and with staff increases, it could provide an opportunity for internationally leading research concerning ice flow, basal glacier conditions, and erosion. There is considerable potential for an expanded and strengthened glaciology research base in Norway.

Geomorphology

The Evaluation Committee found current glacial geomorphology research in Norway to be somewhat "local" in its outlook and to largely have a supporting role in relation to Quaternary Geology. Comparisons with the UK and Sweden show that a more balanced role in terms of scientific initiatives (formulation of projects, definition of questions) between geology and geomorphology may be both possible and desirable. Either one of the larger university-based Quaternary/ Physical Geography groups in Norway (Oslo, Bergen) or the NGU could provide the focus for an expanded research group in terrestrial glacial geomorphology.

The broader field of geomorphological research that is directly relevant to Norway comprises both long-term, large-scale geomorphology and periglacial geomorphology. The former

concerns questions such as denudation rates, origin of continental shelf sediments, evolution of passive continental margins, the age of planation surfaces, and tectonic uplift and deformation. Norway has a long and strong research tradition concerning these questions, and the Scandinavian peninsula is a first-rate study area. The Evaluation Committee noted an unfortunate recent decline in Norwegian geomorphology research with focus on the above issues. The periglacial geomorphological research is of good quality, but often local in scale. Given the research opportunities offered by Svalbard, periglacial geomorphology research at the "large and long" end of the spatial and temporal scale should be encouraged, i.e periglacial landscape evolution over millions of years. In general, there is a notable and unfortunate lack of dedicated geomorphology positions at the universities.

Strategy and hiring policy

The following observations may be relevant to future strategy development and hiring policy within the fields of Quaternary Geology, Geomorphology and Glaciology:

- The emphasis is currently strongly on field-based research.
- A number of groups are sub-critical in size.
- Many groups appear to have only one person focused on each sub-field. Given the emphasis on fieldwork and basic teaching, this person is therefore, as the norm, field-oriented in approach.

These, in combination, lead to a strong bias towards field-based research, at the obvious expense of more theoretical work or "integrative research". This may in the long run be a threat to scientific development in these fields in Norway. We suggest that the issue of critical group size is taken seriously, and that the larger groups consider the possibility to actively recruit "theoretical" or "integrative" researchers.

3.1.7 Hydrology & Hydrogeology

Hydrology

Hydrology is a science with many facets. It ranges from field-based hydrology and experimental hydrology to hydrological modeling, river and floodplain hydraulic modeling, statistical hydrology, extreme events (floods and droughts) and flood/landslide risk analysis, real-time flood forecasting and water resources management. The few Norwegian university and research institutes involved in hydrology research cover only a small percentage of this broad spectrum of vastly different topics.

The Hydrology, Glaciology and Sediment research group at the Norwegian Water Resources and Energy Directorate (NVE) is the key research centre in the Norwegian hydrological community. The main focus of their research activity is on hydrological modeling and operational flood forecasting, the development of Soil Water Assessment Tools (SWAT) for climatological studies, the regionalisation of hydrological forecasts and in landslide forecasting. Their major aim is to optimize the management of Norwegian water and energy resources. Therefore, the focus of their work and resources is aimed at bridging the gap between research and practice, putting research results into practice rather than simply publishing scientific papers in international journals. The highly operational focus of their work, needed to underpin 24/7 monitoring and forecasting, necessarily limits their basic research activities. NVE has a strategic role in providing advice to government, regional and local authorities on a range of issues including: climate change and adaptation measures; ensuring the security of community critical infrastructure and for preventing damage to life,

health and property as a result of problems related to shortages of energy supply, flooding, dam breaches, avalanches and landslides. It is the executive organ of the government's overall water resource and energy policy, together with the handling of relationships with the public through reports and active communications.

The hydrological group at the University of Oslo is internationally recognised for its competence in stochastic hydrology and hydrological modeling. They have developed new methodologies and advanced tools for time-series analysis, extreme value analysis (precipitation, flood, low flow and drought), risk assessments (e.g. flood and groundwater pollution mapping), environmental flow estimation (gauged and ungauged areas), and regional studies. Currently their research focus is on climatological studies and the regionalisation of hydrological variables and model parameters, mapping of extreme events and water resources, and detection of changes in hydrological regime and low flows. In the past they developed an interesting distributed hydrological model, which is today in use at NVE. Unfortunately this group is now very small and lacks critical mass; consequently, their outputs in hydrological modelling are modest.

The Norwegian Meteorological Institute (met.no) also conducts research in hydrology. Unfortunately, its links with the other hydrological research groups in Norway are fairly weak, limited to a small number of PhD projects (for example on flood extremes and landslides). In many countries, for example Sweden, the meteorological institutes have merged with the hydrological institutes in order to allow for better understanding between the two research communities, which originate from different backgrounds: Physics vs Engineering and Geography. There is an important need to develop a common research language, which can only be reached by day-to-day joint research and development.

The proposed establishment of a joint computer centre between met.no and the Swedish Hydro-Meteorological Institute, could provide an important opportunity to set up a Centre of Excellence in hydro-meteorological forecasting in which the expertise of the Environmental Geology and Hydrology group at UiO and the Hydrology, Glaciology and Sediment Research Group at NVE could provide the necessary competence to develop an integrated hydro-meteorological forecasting system aimed at relieving flood risk and supporting optimized energy and water resources management. NVE should be the key integrator of such a joint collaboration.

Hydrogeology

This is the area of geology that deals with the distribution and movement of groundwater in the soil and rocks of the Earth’s crust. Groundwater is an important natural resource, including as a source of geothermal energy, but can also represent a major natural hazard. In Norway the majority of hydrogeological research is conducted by the Norwegian Geological Survey (NGU) and the Norwegian Geotechnical Institute (NGI). NGU’s research in groundwater was not included in their submission for this evaluation and NGI did not participate at all.

Research into groundwater contaminant transport is conducted at The Norwegian University of Life Sciences (UMB), including coordination of an EU FP7 programme SoilCAM on soil contamination. The NTNU (Trondheim) provides a component of hydrogeology training in its Geology Masters degree programme.

3.1.8 Paleontology

Macro- and micropaleontology are actively studied as such at only at few places in Norway. Micropaleontology is practiced more widely, because it is integrated in departments dedicated to stratigraphic, paleoclimatic or paleoenvironmental studies. Within Norway, there is presently insufficient critical mass for a high-profile research program in macropaleontology. Micropaleontology research has an excellent track record, but in the future a lack of critical mass may develop, even though internationally micropaleontologists are very active in studies of past climate and environments in order to evaluate the impacts of global climate change, and in the use of microfossils as a cost-effective monitoring tool in the study of anthropogenic environmental deterioration in coastal zones (including fjords).

Macropaleontology: Invertebrate and Vertebrate

The only researchers active in macro-paleontology in Norway are located at the Natural History Museum in Oslo, where the main focus of study is in vertebrate paleontology, particularly on ichthyosaur and plesiosaur fossil collections from Svalbard. Aspects of this work have attracted considerable media attention but have not yet lead to fundamental research outputs. This group may be below critical mass for internationally competitive research.

Micropaleontology

Most micropaleontological research in Norway appears to be concentrated in centers and research groups primarily interested in paleoceanography and paleoclimatology, and to a lesser extent, in petroleum geology (stratigraphy) and environmental research. Micropaleontologists are active in the Bjerknes Centre for Climate Change research (BCCR) in Bergen, the Natural History Museum and university in Oslo, the university and the Norwegian Polar Institute in Tromsø and at UNIS.
Researchers at Norwegian institutions have an excellent record of publications in high-quality journals, especially the specialists in diatoms, radiolaria and foraminifera. Norwegian scientists have been very active in international ocean drilling projects (e.g., ODP projects in the Arctic Ocean).

Expectations for the future, however, are not very optimistic because many of the more active and well-known researchers are close to retirement and some young researchers have left the country. Biostratigraphic research in Norway will continue to be supported by the major oil companies, but within the university sector there is a rapidly declining critical mass. Environmentally-based microfossil research (e.g., environmental monitoring of oxygenation in fjord environments using foraminifera) in Oslo has an excellent international reputation, but this group lacks critical mass.

Researchers in Tromsø and at Bergen (BCCR) mainly focus on paleoceanographic and paleoclimate research, with an emphasis on the high latitude Pleistocene to Recent record. They are highly productive and publish in prestigious journals, and may be expected to keep actively publishing into the future. These groups, however, centre much of their research on calcareous microfossil groups used for geochemical and trace element proxies. The Norwegian paleoceanographic research community needs to invest in additional micropaleontologists with the expertise to select monospecific samples for proxy measurements and proxy development. It is also not clear that there is sufficient critical mass within Norwegian universities for the study of siliceous and organic-walled groups, which are

important for high-latitude studies. It is also not certain whether there is sufficient expertise for an extension of research into Deep Time, as proposed by BCCR.

3.1.9 Atmospheric Sciences & Meteorology

Norway has a distinguished history of important contributions to atmospheric science, for example in establishing the basic properties of extratropical cyclones and in developing measurement and modelling frameworks to assess transboundary transport of chemical pollutants. Norwegian scientists continue to play an internationally leading role in several different areas of atmospheric science and climate science, and in particular have played a leading role in recent IPCC assessments.

Research in atmospheric science in Norway is primarily located at the Universities of Bergen (UiB) and Oslo (UiO), at the Norwegian Meteorological Institute (met.no), at the Norwegian Institute for Air Research (NILU) and at the Centre for International Climate and Environmental Research (CICERO), with additionally a small group in Svalbard (UNIS). There is generally good connectivity between the different groups (for example UiO, met.no, CICERO and NILU have established neighbouring office space at the Oslo CIENS building and the UiB group has significant collaboration with met.no and to a lesser extent with other institutions). The groups are also in general well connected to international activities, ranging from individual collaboration with scientists outside Norway to participation in and leadership of large EU projects.

A broad area of activity (carried on at UiO, met.no, NILU and CICERO) in which Norwegian scientists are internationally leading includes chemical transport modelling, effects of chemistry on climate (including through aerosols and clouds), and measures of climate forcing (due to long-lived and short-lived species and due to emissions from specific sources such as transport) which can, perhaps via incorporation in simplified models, be used as a basis for policy discussions and agreements. This broad area is not only a 'scientific flagship' for Norwegian atmospheric science but it will continue to be of significant scientific importance. In the short-term the strength of this area of activity depends on the recruitment of talented students and postdocs and the availability of funding for specific projects. The scientists working in this area have an excellent record of obtaining such project funding. In the longer term what is needed are conditions that allow a small number of talented early career researchers to develop into research leaders, in doing so identifying new and important lines of research. These conditions might be in the Universities or in Research Institutes (there are pros and cons to both).

A second broad area (carried on at UiB, UiO and met.no) in which Norwegian scientists are generally very strong is in dynamical meteorology with a particular emphasis on high-latitude phenomena and small-scale flows. This includes measurement and modelling. Again this area has significant practical importance, to forecasting and to other areas such as wind energy where connections between research groups and industry have recently been developed. Numbers of researchers involved, particularly at Universities, are small, but there has been recent recruitment and it certainly makes sense to maintain and develop this area further since it combines national interest (including the broader interest of Norway in the Arctic) and leading-edge science that is naturally studied in both an academic and an operational context. Resources for implementing or participating in observational campaigns and access to state-of-the-art models (plus the computing resources needed to use them) will continue to be important.

The basic strength in the above two areas of atmospheric science in Norway offers strong connections to other scientific areas such as climate science, oceanography, cryospheric science and hydrology. Thus atmospheric scientists are in many cases involved in joint projects or in ongoing joint applications with other areas.

The strength of atmospheric science in Norway as outlined above is an important national resource and self-reinforcing since the scientific environment allows talented researchers at both junior and senior level to be attracted from elsewhere. If this position is to be maintained then it is important that the right opportunities are provided to talented researchers. In Universities it is crucial that new faculty positions are opened and that the best possible people are recruited to these. In the externally funded Institutes it is important that opportunities for such positions remain sufficiently favourable that their advantages of flexibility, research focus and independence outweigh funding uncertainty.

3.2 General Recommendations

3.2.1 Organisational structures

The Evaluation Committee notes that some of the university departments and research institutes evaluated have unnecessarily complex internal organisational structures, which have the capacity to become overly bureaucratic. In some cases the organisation of research into individual groups appeared rather contrived; this is not helpful from an external perspective, particularly for potential international research collaborators. The creation of *Centres of Excellence* has, in general, created an additional level of complexity. This is discussed in further detail in Sections 4 and 5.

RECOMMENDATION 1: Organisational structures should be as simple as possible to enable much better "branding" of Norwegian Earth Science research.

3.2.2 The role of the Research Council of Norway

The Evaluation Committee did not consider in any detail the role of the RCN in the management or funding of research in Norway, although committee members were provided with an overview of the current structures and financial position as background to their evaluations.

There is a general consensus amongst the Norwegian Earth Science community that success rates in competitions for funding are too low and that the RCN budget is insufficient to support the range of scientific activities needed to maintain a leading international research profile in all aspects of the Earth Sciences. In addition, there was a strength of feeling that there should be more opportunities for funding small-scale projects.

RECOMMENDATION 2: The RCN should monitor success rates in grant applications compared to those in Europe and the USA and take appropriate action. It should also develop a funding strategy which recognises those research fields in which Norway is already internationally leading – or aspires to be.

3.2.3 Centres of Excellence

The creation of *Centres of Excellence* (CoE) has generally been a very positive initiative in Norway and has raised the international profile of some areas of Norwegian Earth Science research substantially. In some cases, however, their creation has had a detrimental effect on the parent departments from which staff were drawn to build the CoE. When a CoE ends there may be particular difficulties in reintegrating the CoE staff back into their "parent" departments. Some departments have clearly thought about this problem carefully, whereas others have not.

The University of Bergen appears to have created a particularly complex organisational structure for the *Bjerknes Centre for Climate Research* (BCCR) which must have increased the administrative cost to the university significantly. *Physics of Geological Processes* (PGP) at the University of Oslo is organisationally simpler; however, because it is a joint initiative between the Departments of Physics and Earth Sciences, its staff sit outside of the normal management structure, which has created some problems.

RECOMMENDATION 3: For future Centres of Excellence greater consideration should be given to the effects of their creation on the parent departments from which staff are drawn and also to the process of reintegration at the end of a CoE.

3.2.4 Infrastructure

There is an urgent need to renew infrastructure and analytical facilities in most universities and research institutes in Norway. This requires a coordinated approach by RCN and the development of a national plan to create, update and refurbish laboratories, such that Norwegian Earth Scientists have guaranteed access to state-of-the-art research facilities. The creation of national facilities which can be easily accessed by users from across the country is important. Such facilities need to be well supported by highly skilled technical staff in order to be effective.

RECOMMENDATION 4: A review of infrastructure/facilities requirements across the Earth Science sector would be beneficial.

3.2.5 Demographics and gender balance

The Evaluation Committee noted that in some research areas the key expertise is held by staff approaching retirement. Academic staff in Norway typically retire at a much older age than in the rest of Europe; this can have the effect of creating a strongly skewed age profile in some research groups. There was a noticeable lack of succession planning in most universities and research institutes, although some groups saw impending retirements as an opportunity to change their research direction. More consideration needs to be given to the career development of future research leaders.

The need to achieve gender balance in all aspects of professional life is a basic tenet of Norwegian society. All of the universities and research institutes which participated in this evaluation appeared to take this issue very seriously in their hiring policies. Nevertheless it is clear that in some fields of the Earth Sciences suitably qualified female candidates for positions are hard to find, particularly for senior positions.

RECOMMENDATION 5: All research groups should consider succession planning as a part of their strategic planning process.

3.2.6 Publications

According to the NIFU report on Earth Sciences publication outputs (Appendix E), in 2009 Norwegian scientists published 770 articles in journals classified within the field *Geosciences*. During the five-year period 2005–2009, approximately 3000 articles were published.

The four traditional universities in Norway (Oslo, Bergen, Trondheim and Tromsø) together account for almost half (46%) of the Norwegian scientific journal publishing within the Geosciences. While the University of Oslo by far is the largest university in Norway, this is not reflected in the publication metrics. Here, the University of Bergen is the largest contributor in the Geosciences with 17 % of the national total, followed by the University of Oslo with 15 %. The Institute sector (private and public research institutes) is also a major contributor, accounting for 36% of the national output. The incidence of journal publishing in this sector is typically lower than for the universities due to the particular applied research profile of these units, often with a focus on contract research published as reports rather than

as publications in peer-reviewed journals. Industry accounts for 11 % of the Norwegian scientific journal production in the Geosciences. Similar to the Institute sector, only a limited amount of the research carried out by industry is ever published. This, in part, reflects the commercial confidentiality of the research results, but also that scientific publishing is not a significant part of their research culture. In the Institute sector, the Geological Survey of Norway is the largest contributor with 6 % of the national total.

RECOMMENDATION 6: The strongest research groups in this evaluation had well-developed publication strategies, targeting the leading international journals, whereas the weakest did not. Publications are one of the most important ways of demonstrating research strength and these should be encouraged throughout all stages of a research career.

3.2.7 Research strategy and leadership

Norway is a very democratic country and in many departments and research groups there seemed to be a great reluctance to encourage research leadership, but rather a preference for decision-making by consensus. Whilst the latter is clearly appropriate for small research groups, at department or institute level strong leadership is essential. It was evident to the Evaluation Committee that those groups that had strong leadership also had better developed strategic plans. The roles of leadership and management were often confused. In large organisations such as the Geological Survey of Norway (NGU) a matrix type of management structure has been adopted; this can be highly effective in project-based research organisations.

RECOMMENDATION 7: The RCN might consider developing a training programme for future research leaders

3.2.8 National and international collaboration

In general, the Evaluation Committee observed a high level of national and international collaboration within the Earth Science community. International collaboration has strengthened the Norwegian Earth Science research base considerably and has resulted in a good national success rate in EU funding competitions. Inevitably there is some rivalry between different universities within Norway, which has historic roots; this is not necessarily unhealthy. Research links with other Nordic countries are strong. There was abundant evidence of a willingness to share facilities and many examples of good practice.

Norway receives a large inflow of international research visitors each year. Most research groups, however, reported that there was a reluctance on the part of many Norwegian Earth Scientists to spend significant periods of time abroad, even when they were financially supported to do so.

RECOMMENDATION 8: International mobility should be encouraged more

3.2.9 Funding of Personnel

Many research groups claimed to suffer from a lack of permanent positions, and from the inherent difficulties in recruiting to short, fixed-term contracts. Different universities appear to have sought solutions to the problem of hiring staff on short-term contracts in different ways e.g. the creation of *Uni Research* at the University of Bergen. Research groups with a high number of staff on fixed-term contracts inevitably feel that they have to spend too much

time writing research proposals in order to secure funding to support their staff. Younger researchers can become discouraged if they see their peers working in such uncertain conditions without solid, long-term career prospects.

A solution to this problem has to be reached at national level as it is inextricably linked with Norwegian employment laws. Longer fixed-term contracts would clearly make such positions more attractive to the very best scientists, who might otherwise leave the country.

RECOMMENDATION 9: The hiring of research staff on fixed-term contracts has to be addressed at national level; at present these are too short-term, which is detrimental to the Norwegian science base.

3.2.10 Doctoral Training

Most of the research groups considered in this evaluation participate to some degree in the training of Doctoral students. Inevitably such training is concentrated within university departments, although most of the research institutes evaluated provided some support and training in collaboration with university partners. Most of the research institutes expressed a wish for a greater level of involvement in Doctoral training.

The most common concerns were the lack of funding to support students and a shortage of suitably qualified Norwegian applicants. Many departments appear to maintain their Doctoral training programmes by recruiting well-qualified international students. The Evaluation Committee noted that in Norway Doctoral students are generously funded compared to other European countries and the USA. More students could be taken on if they were given more modest grants rather than paid salaries. However, this may not actually improve recruitment, as many Masters students are attracted away from further academic study by the high salaries offered by Norwegian industry.

RECOMMENDATION 10: A review of Doctoral training in the Earth Sciences would be helpful in order to understand the future staffing requirements of Norwegian industry and the Higher Education sector. This should include an evaluation of the funding model in a European context.

4. Evaluation of University Departments

4.1 University of Bergen

4.1.1 Department of Earth Science

KEY METRICS	
No. of Professors	24
No. of Associate Professors	11
No. of Professor II	13
No. of Emeritus Professors	4
No. of Doctoral students: current	55
No. of PhD students graduated 2007-2009	25
No. of MSc Students graduated 2007-2009	94
No. of Postdoctoral Research Fellows	16
No. of Non-tenured Researchers	7
No. of Technical/Admin. Staff members	31
Research Groups	**GRADE**
1. Quaternary Geology and Palaeoclimate	**4/5**
2. Marine Geology & Geophysics	**4**
3. Geobiology	**4/5**
4. Petroleum Geosciences	**3-4**
5. Geodynamics	**3/4**

The Department of Earth Sciences was established in 2003 by merging the former Department of Geology and the Institute of Solid Earth Physics. It is a partner in three Centres of Excellence (CoEs: BCCR, CIPR, Geobiology). The Geophysical Institute (GFI) within the University conducts complementary research in meteorology and oceanography.

The Department hosts an extensive range of research facilities and analytical laboratories, including 3 research ships. As a consequence there are high annual operating costs to sustain these facilities. In addition the Department runs the Norwegian seismic network. Analytical facilities include: stable isotope (O,N,C), cosmogenic isotope and U-series mass spectrometry; an XRF scanner for cores; LA-ICP-MS dating and Raman spectroscopy. The overall level of the infrastructure and facilities is excellent and a number of laboratories are state-of-the-art, reflecting recent investments.

The Department has an excellent management structure and very strong leadership. Research strategy seems to be well developed at departmental level, based on a 5-year planning cycle, but appears more uneven at research group level. The research atmosphere is dynamic and extremely supportive of the early-career researchers (PhDs and post-doctoral research fellows) and there is a strong vision for the future. Their plans involve closer collaboration with the BCCR and CIPR CoEs when their funding comes to an end; this seems to have been thought through very carefully as part of the long-term strategic planning process. A new CoE in *Earth System Dynamics* is proposed.

Following the 1998 Review of Earth Sciences two research areas (organic geochemistry and hydrology) were cut. The current research focus is on energy (petroleum, renewables,

geothermal), carbon storage and sequestration, palaeoclimate, geobiology, Earth dynamics, marine and polar research.
Whilst there has been recent recruitment to all research groups there is some concern about the age profile of the academic staff; 7 members of staff will reach the age of 70 in the next 5 years and there is an evident lack of staff under the age of 40. The Department is confident that it will be able to renew these posts and views this as an opportunity to refocus its research profile. A common problem in all Norwegian universities is the difficulty in hiring good Norwegian researchers because of competition from industry. Consequently an increasing proportion of the scientific staff are foreign nationals.

Relationships with the central University Administration are generally good, although rather bureaucratic management systems and procedures can be an impediment. For example, the lack of systems to enable the Department to roll-over surplus funding from one financial year to the next prevents them building up an infrastructure fund for new equipment purchases. The Evaluation Committee found the relationship between the Department and staff employed by the University research company *Uni Research* difficult to understand; this appears to add additional administrative complexity.

The Department appears to have good research links with national and international partner organisations and in a number of areas can be considered internationally leading. Their research agenda appears to be based upon fundamental research questions and ”grand challenges”, although they also have strong links (including joint industry projects -JIPs) with a number of major hydrocarbon companies (e.g. Statoil, Shell, Total), facilitated by Professor II positions.

Publication outputs are rather variable between the different research groups. It is clear that not everyone is publishing at an acceptable rate or in sufficiently high impact journals. It is recognised, however, that very applied publications (e.g., in petroleum geoscience) may have low numbers of citations but nevertheless a high impact on the industry.

Five research groups were considered in this evaluation:
Quaternary Geology & Paleoclimate, Marine Geology & Geophysics, Geobiology, Petroleum Geosciences and Geodynamics. The boundaries between the groups are not rigid and extensive collaboration occurs between the different groups.

4.1.1.1 Quaternary Geology and Palaeoclimate

The group currently consists of 4 Professors, 1 Emeritus Professor, 1 Associate Professor, 2 Professor II, 2 Postdoctoral fellows, 1 Researcher and 4 PhD students. 4 PhD students and 11 Masters students have graduated since 2007.

The main research focus is on Quaternary climate and environmental change, involving glacier and ice sheet studies, cave and karst science, landscape and landform evolution and geochronology.

ASSESSMENT & GRADING

This has been an extremely strong research group for the past 20 years with an excellent record of high quality publications in the top journals. There appears to be a good level of collaboration with BCCR. The Group has interesting future plans for partnership in a Nordic CoE in climate-cryosphere interactions. However the Evaluation Committee has concerns

that the group lacks a strong vision for the future and has an unbalanced age profile. Speleology will be under threat when the present professor retires.

OVERALL GRADE : 4/5

Recommendations

This is a relatively small group with 4 out of 5 staff over the age of 55. There is an urgent need for the development of a much more strongly focused research strategy. If paleo ice-sheet reconstruction is to be pursued seriously in the future then research in regional glacial geomorphology and glaciological modelling needs to be strengthened. There are good opportunities to develop their expertise in the lacustrine environment to complement those of BCCR (which are more marine oriented) and in the development of high-resolution paleoclimate proxies in cooperation with researchers studying marine proxies at BCCR; integration of the magnetic susceptibility core-scanner facilities with the XRF-MST track could facilitate world class research in this area.

4.1.1.2 Marine Geology & Geophysics

The group currently consists of 5 Professors, 1 Emeritus Professor, 3 Associate Professors, 1 Emeritus Associate Professor, 1 Professor II, 3 Postdoctoral fellows and 15 PhD students. 2 PhD students and 18 Masters students have graduated since 2007.

The main research focus is on marine geology, marine geophysics and paleoclimate studies of passive continental margins and their adjacent ocean basins. Paleoclimate studies are, to some extent, integrated with those of BCCR.

ASSESSMENT & GRADING

This group has a good track record of research and a strong international network of collaborators. Collaboration with the hydrocarbon industry is also good, providing access to large seismic datasets and funding for research infrastructure. Nevertheless it appears to be somewhat heterogeneous without strong leadership or an integrated and well-formulated vision for the future; many research projects will end soon without clear plans for follow-on work. The group has a reasonable publication record, although a little light in terms of numbers of outputs; nevertheless their publications are of excellent quality and published in well-regarded, high impact journals including *Science* and *Nature*. Some of the more internationally known Antarctic research revolves around one faculty member who is close to retirement; thus continuation of this line of research seems unlikely. Several researchers in this group have been active within the International Ocean Drilling Program – IODP.

OVERALL GRADE: 4

RECOMMENDATIONS

There is an urgent need to develop a strategic plan to underpin the future research direction of the group with a greater emphasis on collaboration within the group, with other research groups in Earth Sciences (e.g. Geodynamics), the Geophysical Institute and BCCR.

4.1.1.3 Geobiology

The group currently consists of 3 Professors, 1 Associate Professors, 3 Professor II, 5 Postdoctoral fellows, 4 Researchers and 6 PhD students. 1 PhD student and 1 Masters student have graduated since 2007.

This multidisciplinary group was established in 2007 as part of the CoE in Geobiology. Its main research focus is on life in extreme environments, the early Earth, the origins of life and the deep biosphere of the oceanic crust.

ASSESSMENT & GRADING

The Evaluation Committee found this group somewhat difficult to evaluate because it is relatively small, sitting within a much larger (and relatively recently established) CoE which has a large biological component that we were not required to evaluate. The researchers clearly benefit from the excellent research facilities provided within the CoE. The group appears to be highly integrated.

The publications by this group are excellent and are in the top international journals with high visibility and citation rankings; the overall publication rate is slightly below average, but this is partly due to the fact that the group has not been established for many years. The vision and main activities of this group appear to be excellent. There is strong collaboration with other leading international groups in this field of research, including the ICDP, IODP and Interridge programmes.

OVERALL GRADE: 4-5

RECOMMENDATIONS

This group has many opportunities for future development. They should, however, take care to retain a strategic focus and critical mass for their research and not spread their activities across too many different themes.

Their plan to develop a ROV (Remotely Operated Vehicle) capability in collaboration with the University and other marine research institutions is an excellent one and essential for this type of research. This should be fully supported.

4.1.1.4 Petroleum Geosciences

The group currently consists of 6 Professors, 3 Associate Professors, 7 Professor II, 1 Postdoctoral fellow, 1 Researcher and 22 PhD students. 12 PhD students and 52 Masters students have graduated since 2007.

The main research focus is on the origin, architecture and properties of sedimentary rocks with an emphasis on the research needs of the petroleum industry (both exploration and production). The group has a broad range of expertise in sedimentology, stratigraphy, seismology, reservoir geophysics.

ASSESSMENT & GRADING

This group has a strong industry focus which, to some degree, may have compromised their strategic research vision. They have a good level of industry funding and are active members

of the CoE CIPR (Centre for Integrated Petroleum Research). There are good research links with the Geodynamics group and with the BCCR CoE; however internal collaboration within the group could be improved. There is a high level of expertise in polar research. International collaborations are quite strong but could be developed further. There is strong national collaboration with the University of Oslo within the field of petroleum geophysics. Facilities are excellent, including a new, state-of-the-art laboratory for seismic data processing and interpretation.

Publications are not particularly strong with average numbers of publications and low rates of citation; this is, in part, a consequence of the highly applied nature of their research.

The Evaluation Committee recognise the high number of PhD and Masters students supervised by group members; this is clearly a time intensive activity.

OVERALL GRADE: 3-4

RECOMMENDATIONS

With the recent appointment of a new Professor in the field of tectonics and sedimentation the group has an opportunity to sharpen its strategic focus whilst still maintaining an active dialogue with industry. Internal collaboration within the group needs to be strengthened. They need to improve their publication strategy. New research opportunities in the field of CO_2 sequestration and shale gas should be followed up.

4.1.1.5 Geodynamics

The group currently consists of 6 Professors, 1 Emeritus Professor, 5 Associate Professors, 5 Postdoctoral fellows, 1 Researcher and 8 PhD students. 6 PhD students and 12 Masters students have graduated since 2007.

The main research focus is on understanding the dynamics of the Earth's lithosphere and deep mantle over a range of spatial and temporal scales by linking observations at the surface and at depth to the underlying physical processes. Research is multi-disciplinary and involves both observation and modelling; there is expertise in structural geology, tectonics, tectonophysics, geochronology, earthquake seismology and igneous petrology. This group is also responsible for the operation of the Norwegian Seismic Network together with NORSAR.

ASSESSMENT & GRADING

In the past this group has had a patchy track record. However following some excellent new staff appointments they appear to be much more dynamic with a clear vision for their future research trajectory. The Evaluation Committee considers that they show excellent promise for the future. Given the research focus there appears to be insufficient expertise in igneous and metamorphic petrology, although this is partly compensated by collaboration with the *Geobiology* group. They have good national (e.g. University of Oslo, NORSAR, NGU) and international (France, Canada) collaborations and excellent facilities for computer-based modelling. Publications are in general average, with below average citations; however there are some highlights e.g. 2011 *Nature* paper. They have internationally recognised expertise in basin and geodynamic modelling and a growing seismology group.

OVERALL GRADE: 3-4

RECOMMENDATIONS

The group needs to focus on developing its next 5-year strategic plan; this should be a collaborative effort. The group needs to be better integrated, perhaps with an emphasis on fewer, but better executed, projects. Better technical support is needed to support the computer modelling. Given that they run the Norwegian seismic network they should take steps to better utilise these data. The new research initiative in geothermal energy research is an important development; this reinforces the need to strengthen their expertise in ”hard rock” petrology.

4.1.2 Geophysical Institute (GFI)

KEY METRICS		
No. of Professors	10	
No. of Associate Professors	8	
No. of Professor II/AssociateProfessor II	14	
No. of Emeritus Professors	0	
No. of Doctoral students: current	44	
No. of PhD students graduated 2007-2009	19	
No. of MSc Students graduated 2007-2009	35	
No. of Postdoctoral Research Fellows	8	
No. of Non-tenured Researchers	2	
No. of Technical/Admin. Staff members	9	
Research Groups	**GRADE**	
1. Meteorology	**3-4**	
2. Climate Dynamics	**4**	
3. Dynamical & large-scale oceanography	**3-4**	
4. Coastal & small-scale oceanography	**3**	
5. Chemical oceanography	**4-5**	

GFI was established in 1917 and has a long tradition of research in meteorology and oceanography. The present research group structure was set up in 2003/4; previously the department was divided into meteorology and oceanography. GFI forms a core part of the BCCR CoE (*Bjerknes Centre for Climate Research*) and is a partner in the new *Centre for Climate Dynamics at Bjerknes* (2010-2022). It includes the Bergen School of Meteorology and hosts a national research school in climate dynamics (ResClim).

Since 2003 there has been an approximately 50% turnover of staff. Unfortunately, despite some considerable effort, the balance of female academic staff remains too low. For a group of this size the number of post-doctoral research fellows seems too low.

In the 1998/9 review of Earth Sciences it was recommended that they establish a group in air-sea interaction which has not really happened. This is an important strategic research area which, unfortunately, has been difficult to fund; however, this may become a growth sector due to the increased national interest in wind energy. GFI were also encouraged to expand the group in Chemical Oceanography, which is still too small. The failure to develop these areas of research has been attributed to a lack of funding for running costs and organisational barriers to development.

The Evaluation Committee found the organisational and management structure difficult to comprehend and had concerns that the complexity of relationships with *Uni Research* and the CoEs may be acting as a barrier to effective research. *Uni Research* seems to have become a research organisation in its own right rather than a vehicle through which fixed-term contract research staff can be hired. The Head of Department reports to a Board which appears to make strategic planning more difficult. There is no clear strategic plan and it appears that their research agenda is driven largely by external funding opportunities. It is difficult to evaluate how GFI research aligns (or not) with that of BCCR or with that of the other research centres in Bergen (e.g. Nansen, IMR) with whom they collaborate.

GFI has a long-term commitment to the collection of observational data, some of which are related to specific, large-scale projects and some not. This may make it difficult for them to develop a research strategy based on science-led questions.

Numbers of publications are average with average citations. Outputs are uneven between the various research groups.

National and international collaboration is quite good but there is scope for improvement within some research groups.

Five research groups were considered in this evaluation:
Meteorology, Climate Dynamics, Dynamical & Large-scale Oceanography, Coastal & Small-scale Oceanography and Chemical Oceanography.

4.1.2.1 Meteorology

The group currently consists of 2 Professors, 2 Associate Professors, 3 Professor II, 0 Postdoctoral fellows and 11 PhD students. 1 PhD student and 17 Masters students have graduated since 2007.

The main research focus is on dynamic meteorology, the atmospheric boundary layer and radiation (both observation and modelling).

ASSESSMENT & GRADING

Research is focused on relatively small-scale processes, particularly those relevant to high latitudes. There is strong emphasis on observation and instrumentation (e.g. novel techniques such as unmanned aerial vehicles). This type of work does not have a very high scientific profile, but it is important and it is also desirable that some of it is carried out in an academic environment rather than simply being regarded as an operational task for meteorological services. This is recognised as important in other countries such as the UK and Switzerland.

The GFI Meteorology group does not, currently, appear to have a particularly high profile and while it is engaged in international research projects it does not appear to be leading them. Recent staff recruitment should help to improve the visibility of the group in the future.

OVERALL GRADE: 3-4

RECOMMENDATIONS
Continuing connections with international research programmes and with the Norwegian Meteorological Institute are important and should be strengthened. There are important opportunities for research into offshore energy which should be pursued.

4.1.2.2 Climate Dynamics

The group currently consists of 3 Professors, 2 Associate Professors, 4 Professor II, 0 Postdoctoral fellows and 12 PhD students. 5 PhD students and 2 Masters students have graduated since 2007.

The main research focus is on understanding climate variability in northern mid- and high-latitudes with particular emphasis on the role of the ocean.

ASSESSMENT & GRADING

Following the recommendation from the 1998 evaluation of Earth Sciences, the group has very successfully fused its competence in meteorology and oceanography focusing on climate dynamics and numerical modelling. They have been a key contributor to relevant national coordinated climate research projects since 2003. The group has been instrumental in the development, implementation and evaluation of the Bergen Climate Model (BCM), one of the models used in IPCC AR4, as a central research tool. The BCM is also part of the current IPCC AR5 report which should be published in 2013. There are strong research collaborations with the BCCR CoE. The group is involved in national activities including the Norwegian Research School for Climate Dynamics and the development of the Norwegian Earth System models. Their outreach activities are commendable.

Numbers of publications are good, and in the leading journals, with a slightly below-average citation rate. The impact of their work over the last 5 years has been variable with some excellent contributions.

The group is very well connected, both nationally and internationally, and has recognised expertise in dynamics and numerical modelling. Their research focuses on the processes behind the observed variability in ocean circulation and hydrography, such as the effects of the mechanical (wind) and buoyancy (heat and freshwater) forcing of the ocean. They have begun to explore new methodologies for calculating the pathways of water vapour in the atmosphere. The scientific research of the group is internationally recognised as important and their future research strategy seems sound.

To strengthen their competence on tropical climate processes, and interactions between the tropics and higher latitudes, a number of new projects have been started and a new professor in tropical meteorology has been appointed.

OVERALL GRADE: 4

RECOMMENDATIONS

The international and national visibility of this research group would be substantially enhanced if all the researchers sat under the BCCR “umbrella” within the new *Centre for Climate Dynamics* and were physically co-located with BCCR colleagues. The multiplicity of organisational structures ”dilutes” the quality of the research being undertaken and the affiliation of the researchers is not clear to the external scientific community. The Evaluation Committee strongly recommends that a much simpler organisational structure is developed.

4.1.2.3 Dynamical & large-scale oceanography

The group currently consists of 2 Professors, 1 Associate Professors, 1 Associate Professor II, 2 Postdoctoral fellows and 8 PhD students. 7 PhD students and 14 Masters (in Physical Oceanography) students have graduated since 2007.

The main research focus is on large-scale oceanographic processes in the oceans based on a combination of observational (ship-based fieldwork and remote sensing) and modelling studies. Oceanographic technology development is conducted in collaboration with BCCR and industrial partners

ASSESSMENT & GRADING

The group appears to have a strong commitment to making observations and monitoring. Members of the group have been involved in (but are not leading) a number of major EU research programmes (e.g. DAMOCLES, THOR) and maintain time series observations that are very important for the international scientific community in the polar oceans (northern and southern hemisphere). These observations are incorporated into the European project EUROSITES. This Norwegian contribution to the oceanic time series database is highly recognized internationally because the polar oceans are key areas to understand the climate relevant oceanic large-scale circulation. The group also coordinated the IPY project BIAC (Bipolar Atlantic Thermohaline Circulation).

Their publication activities are slightly below average, while the impact of the papers is slightly above average. The large volume of data they have collected does not appear to have been converted into a sufficient number of high quality publications.

This is a small research group and their research activities may have been spread too thinly across too many projects e.g. the educational project NOMA in Mozambique may have strained resources.

OVERALL GRADE: 3-4

RECOMMENDATIONS

The work of the group is based on observational data which requires access to research ships and expensive new technologies. It is important to maintain the capacity of the group to develop new methods for monitoring and to ensure that they have the technical and scientific capability to take advantage of the most recent technology developments. To maintain their international position they will need a high level of support from the University. The relationship between their monitoring and research programmes needs to be considered carefully; new models for funding the monitoring work need to be explored. The Institute for Marine Research (IMR) is also involved in time series observations and the potential for closer collaboration should be explored.

Scientific outputs (both number and impact of publications) need to be improved.

4.1.2.4 Coastal & small-scale oceanography

The group currently consists of 1 Professor, 3 Associate Professors, 2 Professors II, 1 Associate Professor II, 3 Postdoctoral fellows, 1 Researcher and 7 PhD students. 4 PhD students and 14 Masters (in Physical Oceanography) students have graduated since 2007.

The main research focus is on ocean mixing, turbulence and exchange processes, and on coupled physical-biological modelling in the marine environment. Significant contributions have also been made in the field of marine ecosystem research.

ASSESSMENT & GRADING

Some high quality research is being done in small-scale oceanography (with particular relevance to coastal and high-latitude processes). There is also important work on coupled physical-biological processes, including the development of a model (ECOSMO) that is being used by several other groups. They have also made contributions to several bi-national and EU projects (e.g. DAMOCLES). This is a small group whose membership has largely been renewed since 2006/7; the Evaluation Committee have taken this into consideration when evaluating their publications and citations, which are about average. Because of its small size the group lacks visibility outside of GFI. There are strong research connections with BCCR.

OVERALL GRADE: 3

RECOMMENDATIONS

This group needs to be better integrated into BCCR/Centre for Climate Dynamics. They lack expertise in certain areas (e.g. waves, sea ice) and probably need more academic positions to provide critical mass.

4.1.2.5 Chemical oceanography

The group currently consists of 2 Professors, 3 Associate Professors II, 3 Postdoctoral fellows, 1 Researcher and 6 PhD students. 2 PhD students and 2 Masters students have graduated since 2007.

The research group is closely integrated with the Biogeochemical Cycles research group at BCCR. The main focus of its research is to combine observations with modelling in order to understand the key biogeochemical processes in the marine carbon cycle.

ASSESSMENT & GRADING

The group is internationally well recognized and well connected. They are involved in international research programmes such as SOLAS (Surface Ocean – Lower Atmosphere Studies) and their work is relevant for the next IPCC report. Together with Resarch Group 3 (Carbon Biogeochemistry and ecosystems) of BCCR they are nationally leading the observations and the modelling of the marine carbon cycle. The group includes the coordinator of a large EU programme (CarboChange) which started in 2011; this is a continuation of the EU IP CARBOOCEAN, which was also led by the group. The group is active in experimental work on the carbon system in various ways (for instance maintaining measurements on Volunteer Observing Ships (VOS)), thus contributing to the global data base); they also do mesocosm experiments.

The numbers of publications are below average, but they have a good number of citations.

As in many of the GFI groups, the number of permanent scientists and technical staff (both laboratory and programming) are very low and the group does not appear to have critical mass. The Norway-specific problem of how to employ scientists on a temporary basis longer

than 4 years inevitably leads to a high rate of loss of skilled personnel, which could threaten the future success of the group.

OVERALL GRADE: 4-5

RECOMMENDATIONS

The cooperation between the group and BCCR is very strong, and it would make sense to integrate both groups into a single, co-located unit. Such integration is very important on the scientific side, so that from outside of Bergen, only one group is visible. This would increase the potential for external collaboration, making the working environment more attractive to international scientists, and enhance both their national and international profile. The laboratory equipment needs to be updated to maintain international standards. They should establish links with the new carbon analysis laboratory that IMR is building in Tromsø.

4.2 University of Oslo

4.2.1 Department of Geosciences

KEY METRICS		
No. of Professors	33	
No. of Associate Professors	6	
No. of Professor II	18	
No. of Emeritus Professors		
No. of Doctoral students: current	60	
No. of PhD students graduated 2007-2009	36	
No. of MSc Students graduated 2007-2009	106	
No. of Postdoctoral Research Fellows	23	
No. of Non-tenured Researchers	15	
No. of Technical/Admin. Staff members	3	
Research Groups	**GRADE**	
1. Meteorology & Oceanography	**5/3-4**	
2. Cryosphere	**3-4**	
3. Tectonics, Petrology & Geochemistry	**4**	
4. Petroleum Geology & Geophysics	**4-5**	
5. Environmental Geology & Hydrology	**3/4**	
6. Physics of Geological Processes	**5**	

The Department of Geosciences was formed in 2003 by the merger of three pre-existing departments – Geology, Physical Geography and Geophysics. At the time a clear delineation was made between the geoscience activities within the Faculty of Mathematics and Natural Sciences and those of the Geological Museum, which became a part of the Museum of Natural History. This reorganisation stemmed from the previous Evaluation of Basic Research in Earth Sciences in 1998. In 2003 four Geosciences staff became part of the CoE *Physics of Geological Processes* (PGP) which is not formally part of the Department, although most of the tenured PGP positions in geoscience are on the departmental payroll. PGP recruited a significant number of new staff subsequently. The CoE ends in 2013 and the staff will thereafter be reintegrated into the Department, or a new CoE will emerge. The Department is also a partner in the CoE *International Centre for Geohazards* and a node of the Research Centre for Environmentally Friendly Energy (SUCCESS).

This is a large department. When viewed from the outside its management structure appears rather complex with a mixture of thematic- and discipline-based subdivisions, the PGP CoE, and various 'emerging top tier research groups', as well as other groups to which some individuals contribute (e.g., 'Nordic center of Excellence: *Stability and Variations of Arctic Land Ice* SVALI'). This complex structure does not appear to facilitate development of a clear vision for the future. Consequently the overall leadership does not appear to be particularly strong. Nevertheless, despite the complex structure, the academic staff appear to be able to function well.

The publication rates of all groups are above the national average, with some (but not all) groups considered excellent. Publications are, in general, in high-visibility - high-quality, well-cited journals. Numbers of outputs have doubled since 2005.
The research infrastructure is generally good although substantial investment in laboratory facilities is required in the near future to ensure that these remain state-of-the-art. The LA-ICPMS facility for Zr dating is particularly impressive. The evaluation committee was made aware of plans for construction of a new building supported by industry funding which have currently stalled. A single group of technicians runs all the laboratories and other research infrastructure, and there is a joint administration. Most of the Department is located in the Geology Building; however the Meteorology and Oceanography Group are based in CIENS (*Oslo Centre for Interdisciplinary Environmental and Social Research),* located nearby at Forskningsparken (Oslo Innovation Centre).

Gender balance (only ~ 10% female) amongst the academic staff remains an issue; this is a common problem in all Norwegian universities.

The Evaluation Committee had some concerns that the success of PGP may have weakened other parts of the Department, leaving some groups (e.g. Tectonics, Petrology & Geochemistry) of sub-optimal size. Sensitive re-integration of staff, accompanied by a reorganisation of research groups, will be required when PGP ends in 2013. There needs to be a better balance between the teaching and research functions of the department. The size of research groups and their focus should be determined as part of a coherent strategic plan, preferably with a 5-year planning cycle. The present research groups appear to have grown somewhat opportunistically depending upon the availability of funding.

The department has a strong international reputation and in a number of areas may be considered to be internationally leading. There are good links with industry with potential for these to be increased; Petroleum Geology & Geophysics appear to be particularly well funded in this respect. The increased international focus on the shortage of Rare Earth Elements (REE) provides an opportunity for a renewal of interest in basement geology, petrology and geochemistry.

Six research groups were considered in this evaluation:
Meteorology & Oceanography; Cryosphere; Tectonics, Petrology & Geochemistry; Petroleum Geology & Geophysics; Environmental Geology & Hydrology and the CoE Physics of Geological Processes (PGP).

4.2.1.1 Meteorology & Oceanography

The group currently consists of 6 Professors, 1 Associate Professors, 4 Professor II, 5 Postdoctoral fellows, 1 active Emeritus Professor and 9 PhD students. 8 PhD students and 27 Masters students have graduated since 2007.

The main focus of its research activities include air-sea interactions, ocean dynamics, atmospheric chemistry, oceanic and atmospheric transport and the role of aerosols and clouds in climate change.

ASSESSMENT & GRADING

This group seems to be going through a transition period. The academic staff are generally doing very good research and are active in their subject areas both nationally and internationally. There is a very strong tradition in atmospheric chemistry and climate science.

This group is relatively small but covers a wide range of research topics. The strongest area of research is in atmospheric chemistry and aerosols and their links to climate change. This work is highly regarded internationally. Several members of the group are members of a strategic research group "*Water as a Regulator in Biogeochemical Cycles*" within the Faculty of Mathematics & Natural Sciences. There are plans to develop a CoE bid on this theme. Cooperation with the Norwegian Meteorological Institute and with other groups within CIENS is an important part of the group's activities.

Publications are good with a high number of citations.

A number of retirements in the next few years provide opportunities to bring greater coherence to the main research activities of the group

OVERALL GRADE: 5 (Meteorology) / 3-4 (Oceanography)

RECOMMENDATIONS

The Research Group's current major strengths appear to be in the atmospheric aspects of climate science and in meteorology. There are impending retirements in oceanography and in recruiting replacements careful consideration should be given to increasing the overall strength and coherence of the group. Their aim should be to cooperate, rather than to compete, with BCCR in Bergen and a more coherent research strategy would facilitate this, consistent with the recommendations of the 1998 *Review of Earth Sciences*.

4.2.1.2 Cryosphere

The group currently consists of 4 Professors, 2 Associate Professors, 1 Professor II, 2 Postdoctoral fellows and 10 PhD students. 7 PhD students and 17 Masters students have graduated since 2007. Two senior engineers are employed as technical staff.

The Cryosphere research group comprises the majority of the Physical Geography Section in the Department of Geosciences. It is the largest cryosphere research group in Norway. The main focus of its research is on past and present impacts of climate change on glaciers, permafrost, geomorphological processes and landscape development in cold climates, with expertise in GIS and terrain analysis, remote sensing and numerical modelling. The group revised its strategy after the last evaluation of Earth Sciences (1998), focusing its research activities more on the present-day cryosphere and remote sensing. In addition to its main focus on glaciers and permafrost, the group includes researchers studying geohazards, paleoglaciology, water resources, and glaciated landforms and is involved in a number of EU-sponsored projects. They are a partner in the CoE *International Centre for Geohazards.* The group coordinates the new Nordic CoE *Climate and the Cryosphere* (2011-2015) project *Stability and Variations of Arctic Land Ice – SVALI* and is also a partner in a second Nordic CoE, DEFROST.

ASSESSMENT & GRADING

The group may be considered to be leading in Norway but less so internationally. It has a very strong network of international collaborators, including a bilateral research and education exchange program with Canada, CryoEX. Aspects of their research are good to excellent, but their research activities are fragmented and sometimes lack focus. Some research areas lack critical mass.

Research is predominantly within two fairly narrow fields, mass-balance glaciology and permafrost processes, both with GIS and remote sensing as well integrated tools. Glaciology research is more advanced than permafrost studies in across-scale work. The traditional physical geography focus on glacial geomorphology and paleoglaciology, which was formerly strong at Oslo, is now notably lacking as a consequence of retirements.

Publications by the group have increased over the past year. Research outputs are above average, but citations are relatively low.

The group experienced an increase in research funding from RCN during the International Polar Year (IPY), 2007-2010, and they were involved in all the terrestrial cryosphere projects. They are involved in a number of EU projects and in three projects with the European Space Agency (ESA), including one on the calibration/validation of the new ESA satellite Cryosat.

OVERALL GRADE: 3-4

RECOMMENDATIONS

The group is vulnerable to changing funding opportunities and may find it difficult to replace the IPY funding. EU funding opportunities need to be leveraged as much as possible and opportunities for funding from industry should be explored.

The group needs to develop a more focused research strategy for the future.

The group has strong links with the *Environmental Geology and Hydrology* group and opportunities for closer collaboration or even integration should be explored.

Paleoglaciology studies appear to be declining in Norway; the need to maintain some critical mass of expertise needs to be considered.

4.2.1.3 Tectonics, Petrology & Geochemistry

The group currently consists of 3 Professors and 3 PhD students. 1 PhD students and 4 Masters students have graduated since 2007.

The research group is the smallest in the Department with just three professors whose broad focus concerns lithosphere dynamics in space and time with an emphasis on geochronology, petrology and hard-rock geochemistry. The members of the group became isolated when the PGP CoE was set up in 2003, have high teaching loads and effectively operate as independent researchers. This makes it difficult for them to obtain support for PhD students and technicians.

The group has good laboratory facilities although significant investments will be needed shortly if these are to remain state-of-the-art.

ASSESSMENT & GRADING

The group has a high productivity of articles published in leading international journals with very good citations; they have excellent international research networks and many visitors to their laboratories. The past research record of this group has been excellent; however, the Evaluation Committee has serious questions about its future unless some radical attempts are

made by the Department to inject some early career researchers into the group. At present most of the innovative research in petrology is being conducted within PGP. This CoE will terminate in its present form in 2013, providing an opportunity for some radical restructuring.

OVERALL GRADE: 4

RECOMMENDATIONS

The group lacks critical mass and its members have clearly suffered from the creation of the PGP CoE. With the renewed national and international interest in mineral resources (e.g. REE metals), combined with the cessation of PGP activities in their present form, there is an opportunity for some radical innovation in the field of "hard rock" geology and geochemistry. Oslo had an international reputation in this field and part of the forward strategic plan of the Department should be how to strengthen this area of research and by how much. There will be increasing demands from the minerals industry for skilled MSc and PhD students and new opportunities for research funding. Igneous and metamorphic petrology research is now sub-optimal within the whole of Norway and Oslo should re-establish its lead.

4.2.1.4 Petroleum Geology & Geophysics

The group currently consists of 8 Professors, 2 Associate Professors, 2 Professor II, 5 Postdoctoral fellows and 10 PhD students. In addition there are 6 non-tenured researchers. 10 PhD students and 30 Masters students have graduated since 2007.

The research group is organised as a "section" within the Department and operates a matrix-type organisational model. Given the number of large projects in which they are involved there appears to be insufficient administrative/technical support.

ASSESSMENT & GRADING

This is a cohesive, well-organised, dynamic research group with a clear vision for the future. The main focus of their research activity in sedimentary basin development and petroleum systems is recognised as a strategic research area by the Faculty and has a strong industry orientation (including Statoil, ConocoPhillips, ExxonMobil). International research networks are very strong and the group has international leadership in the study of the conjugate North Atlantic passive continental margins of Greenland and Norway. Research links with the University of Bergen (e.g. CIPR) are well established and also with other Norwegian research institutes (e.g. NORSAR, NGU, NGI).

Research outputs are average with relatively low citations, and not necessarily in the most highly-cited journals; in part this reflects the strongly applied nature of this research field. Outputs and citations have, however, been increasing in the past 5 years. They have also published 2 books, including one well-received volume on craters and impacts (Jurassic Cretaceous Mjølnir structure, Barents Sea).

OVERALL GRADE: 4-5

RECOMMENDATIONS

The group is clearly highly successful with a good level of funding from the hydrocarbon industry. Nevertheless the age profile of the permanent staff is increasing and the productivity of the group could eventually suffer as a consequence; consideration should be given to

addressing this imbalance. The staff working in the area of Solid Earth Geophysics seem a little isolated from the rest and some consideration should be given to this.

There appears to be a shortage of physical working space and laboratory facilities need upgrading. There are skills shortages in sedimentology and geophysics which need to be managed and a need for more permanent staff.

4.2.1.5 Environmental Geology & Hydrology

The group currently consists of 7 Professors, 0 Associate Professors, 3 Professor II, 3 Postdoctoral research fellows, 3 non-tenured researchers and 13 PhD students. 7 PhD students and 22 Masters students have graduated since 2007.

The research group was established as a cross-disciplinary group in 2003 following the merger of the 3 original departments. The leadership of the group is good and a commendable effort, with varying degrees of success, has been made to integrate scientists from a variety of backgrounds into three major research themes - Environmental Geology, Hydrology and Natural Hazards.

ASSESSMENT & GRADING

This is an extremely heterogeneous section, which does not appear to be a natural grouping of researchers with related interests. The Evaluation Committee had doubts that there is sufficient critical mass to perform at an international level of excellence in all three research themes.

As a group, they have a somewhat above average publication rate, in high-profile journals, but with some variability between the different themes; citation rates are good. International and national research collaborations appear to be strong.

Laboratory facilities are, in general, in rather poor condition; they are dispersed within different parts of the Department, and need to be upgraded to modern standards.

OVERALL GRADE: 3/4

RECOMMENDATIONS

The Evaluation Committee strongly encourages the Department to consider how the activities of this section might be better focused. At present resources are spread too thinly leading to sub-optimal performance. There needs to be a much stronger focus on areas of research strength and future opportunities for funding.

Specific comments relating to the individual research themes are as follows:

Environmental Geology

Research interests in this area are broad, encompassing hydrogeology, environmental geophysics, geochemistry, contaminants in geosystems (including CO_2) and environmental micropaleontology. At present research related to the geological storage of CO_2 provides the dominant source of funding (via the SUCCESS FME Center).

The micropaleontology sub-group has only one permanent position, but also an active emeritus, and a new biostratigrapher (palynologist) has been hired recently in Petroleum Geology & Geophysics (PEGG). In addition, there are two micropaleontologists at the Natural History Museum, so that this research area in the past has had critical mass to some extent outside the group itself. This may change with future retirements of the micropaleontologists at the Museum, who are not scheduled to be replaced by micropaleontologists. In view of the possibility of increased cooperation with the PEGG section, and the future potential loss of micropaleontological/stratigraphic expertise at the Museum due to retirement, the Department should consider whether more positions in this field of research might be beneficial. Micropaleontology research is in danger of falling below critical mass in Norway and the current and future needs of industry and for paleoenvironmental studies should be considered.

Hydrology

With the recent loss of a key post in statistical hydrology the Hydrology research group needs to be reinforced in the area of hydrological modelling from sub-catchment scales to the aggregated scales needed to interact with General Circulation Models. They need to develop stronger collaboration with the Norwegian Water Resources and Energy Directorate (NVE) and the Norwegian Meteorological Institute in the integration of hydrological and meteorological modelling. Consideration should be given to a CoE aimed at operational hydro-meteorological forecasting and sustainable water resources planning and management under climate change.

Natural Hazards

This group has sub-critical mass with only one permanent position. Research with a focus on landslides is primarily conducted in collaboration with the CoE *International Centre for Geohazards* (ICG) hosted by NGI. Given the strength of the research carried out at NGI in this area the Department needs to give serious consideration to its future support of this research area.

4.2.1.6 Physics of Geological Processes

The group currently consists of 5 Professors, 1 Associate Professor, 8 Professor II, 8 Postdoctoral fellows, 6 non-tenured researchers and 15 PhD students. 3 PhD students and 6 Masters students have graduated since 2007.

Physics of Geological Processes (PGP) was established as a CoE in 2003 as a collaborative venture between physicists and geologists at the University of Oslo. Its strategy has been to bring together an international team of scientists from the fields of geology, physics and applied mathematics to study fundamental problems in the Earth system. The CoE will terminate early in 2013 when some staff will join a new CoE in *Earth Evolution and Dynamics*, CEED. This evaluation does not include the physics staff of the CoE.

Since 2010 research activities have been organised into three main themes: Earth Materials, Fluid Earth and Solid Earth.

ASSESSMENT & GRADING

PGP has been a flagship CoE and has a high international profile. Leadership and research vision are exceptionally strong. PGP has developed the research careers of a dynamic cohort

of young geoscientists and has exceeded all expectations. The external Advisory Committee has clearly been a good investment.
Research outputs are excellent and there has been a strategy to target the leading academic journals in the field (e.g. *Nature, Science, Earth & Planetary Science Letters*). Citations are currently about average, but are increasing rapidly.

OVERALL GRADE: 5

RECOMMENDATIONS

The Evaluation Committee recognises the great success of PGP. It is, however, extremely concerned about what will happen after 2013. There clearly has been some substantial thinking about how staff will be re-integrated into the Department or into the new CoE CEED, but more is needed.

It is clear that the original creation of PGP in 2003 created some tensions within the Department, with some academic staff/research areas becoming isolated. The official end of PGP in its present form provides an opportunity for the Department to articulate its future research strategy (for the next 5-10 years). Having a CoE reporting directly to the Faculty (i.e. bypassing the Head of Department) does not seem a sensible strategy for the future.

The Evaluation Committee was presented with a possible model for the continuation of the "brand name" PGP (encompassing CEED, Tight Rocks and E-flows), about which members were somewhat uneasy. Why, for example, should research into "tight rocks" and CO_2 sequestration be "taken over" from their current sections? This seems likely to have a destabilising effect on the Department. Some serious consideration needs to be given about the future of Solid Earth Geophysics and "hard rock" geochemistry/petrology. These are important issues for the senior leadership team.

4.2.2 Natural History Museum

KEY METRICS		
No. of Professors	5	
No. of Associate Professors	5	
No. of Professor II		
No. of Emeritus Professors	1	
No. of Doctoral students: current	1	
No. of PhD students graduated 2007-2009	3	
No. of MSc Students graduated 2007-2009		
No. of Postdoctoral Research Fellows	1	
No. of Non-tenured Researchers		
No. of Technical/Admin. Staff members	5	
Research Groups	**GRADE**	
1. Palaeontology/Stratigraphy	**3/4**	
2. Mineralogy/Petrology	**3**	

The Natural History Museum (NHM) is part of the University of Oslo and was established as an independent unit at the University in 1999. Before 1999 there were two separate museums

of Geology and Paleontology. Since 2009 the research staff, both biologists and geologists, have been organised in a common "*Department of Research & Collections*", comprising some 45 researchers in total. The geologists (11 academic staff) are divided into two research groups in Paleontology/Stratigraphy and Mineralogy. Only the staff in these two groups were considered as part of this review.

Following the formation of the new Department of Geosciences within the University in 2003, a clear delineation was made between the geoscience activities within the Faculty of Mathematics and Natural Sciences and those of the Geological Museum. The internationally-leading petrology and isotope geology groups from the NHM moved to the Department of Geosciences. This process had a damaging effect on the morale of the Museum staff remaining in mineralogy, petrology and geochemistry. An agreement exists to maintain complementary research activities in the Museum and the Department of Geosciences.

The Museum is housed in an historical (1915) building which is in need of renovation. The Evaluation Committee was made aware of plans for refurbishment and some new construction.
There are ambitious plans to develop the Paleontology group into a National Centre of Paleontology, focusing on the Arctic. NHM currently hosts the largest paleontology research group in Norway and has unique laboratory facilities for the preparation of macrofossils. The future of micropaleontology research at the Museum is currently under discussion with the Department of Geosciences at the University.

Future research in mineralogy/petrology will be collection-based and focused on systematic mineralogy, ore geology and the interface with materials science. NHM has recently taken over an experimental high-pressure high-temperature research facility previously located at the University of Tromsø. This facility is currently the only one of its kind in the Nordic countries.

In general, staff have low teaching loads; however, this is partly compensated by responsibilities for the museum collections and outreach activities.

Publication rates are average with relatively low citations.

4.2.2.1 Paleontology/Stratigraphy

The group currently consists of 3 Professors (1 of whom is 40%), 3 Associate Professors (1 of whom is 50%), 1 Professor II, 1 Postdoctoral fellow and 1 PhD student. 2 PhD students have graduated since 2007.

The long-term vision of the group is to become a national centre in macropaleontology with a focus on studying the fossils, sedimentology and sediment chemistry from Jurassic/Cretaceous sections on Svalbard, where the group has collected many partial and some spectacular complete skeletons of ichthyosaurs and plesiosaurs during a National Geographic sponsored expedition (which will be published and shown on TV in April 2011). This locality clearly provides an exciting opportunity for scientific research of the highest quality, as well as important exhibits for the museum. This project has strong industry support (including Statoil/Hydro, ExxonMobil, NPD, Fugro).

Previously the world-class strengths of the group were in micropaleontology; this area of research is now likely to be much reduced following retirements of key staff.

ASSESSMENT & GRADING

The overall publication and citation levels of the Paleontology/Stratigraphy group are good; however, publication activity has been dominantly supported by the micropaleontologists.

The preparation of several tens of ichthyosaur and plesiosaur skeletons is a huge undertaking logistically, even after the large investment needed for the field operations (supported by National Geographic), providing full-time work for several preparators for several years. The preparation work has in part been done by volunteers, but there are limits to what volunteers can do and professional knowledge is required in order to enable later precise scientific description. In order to conform to international standards of research, expensive 3D CT scanning is required. In order to place the vertebrates within a reconstructed environment (e.g. estimates of paleotemperature, salinity), cooperation is needed with specialists in the various invertebrates present in the formations where the vertrebrates are found, as well as detailed sedimentological, biomarker, stable isotope and trace element studies of the sediments and fossils.

It is probable that although this ambitious project is well suited for museum paleontologists, there is not sufficient staff or funding to guarantee a strong set of publications, or to develop up-to-date, world class exhibits of the type presently shown in such places as the Natural History museums in London and New York and the Smithsonian Museum. Consequently more extended collaboration is required with colleagues outside of Norway, in addition to a need for more funding for the Museum.

The museum database of fossils is in good shape, but needs more work because images of all type material are not yet available. In addition, the database is not linked to the Paleobiology Database (http://www.paleodb.org), the recognised standard for international cooperation in paleontology. The researchers should aim to include the NMH collection as soon as possible to make their important historical collection accessible to international researchers, and thus gain more international visibility.

Overall Grade: 3/4

RECOMMENDATIONS

Careful consideration needs to be given to the future of micropaleontology research in general at the University of Oslo. Will the core activity in future be located in the Department of Geosciences rather than at the Museum?

The ichthyosaur research will need careful strategic planning and adequate resourcing to ensure that the preparation and preservation of key specimens does not take too many years to complete. There also needs to be increased national and international collaboration with invertebrate paleontologists and paleoclimate researchers with a geochemical background in order to provide the paleoenvironmental information needed to develop a modern, educationally and scientifically exciting, museum exhibit, as well as to publish their work in leading international journals.

The researchers should aim to attract more graduate students, possibly in cooperation with staff at other universities.

4.2.2.2 Mineralogy/Petrology

The group currently consists of 2 Professors, 2 Associate Professors and 1 Postdoctoral fellow. 1 PhD student has graduated since 2007.

ASSESSMENT & GRADING

The group underwent major reorganization in 2008 when scientific and technical personnel and equipment were transferred to the University of Oslo. According to the self-evaluation, this reorganisation was the most recent phase in a 30 year-long debate, and the Mineralogy/Petrology group has not yet recovered from it. Two professors have left, although new hires have been made.

The research strategy of the group and its vision for long-term development are unclear. Recently, a high-pressure, high-temperature experimental facility (piston-cylinder), acquired from the University of Tromsø, has been installed and there are ambitious plans to develop a program of experimental petrology research in Norway. The group proposes to collaborate with the new CoE *Centre for Earth Evolution and Dynamics* (CEED) at the University of Oslo in research in computational mineral physics, and with an international group of collaborators (Clermont-Ferrand, Grenoble, ETH Zurich). There is a proposed emphasis on the synthesis and characterisation of minerals and inorganic substances of interest for various industries. The development of this new laboratory appears to go against the latest reorganisation in which research equipment and personnel were transferred from the Museum to the Department of Geosciences. The role in the Museum of such a specialised, high-tech, high-cost laboratory facility is not evident; the rationale for its use in supporting the museum exhibits appears weak.

The publication outputs of this group as a whole is rather low, with relatively low citations.

OVERALL GRADE: 3

RECOMMENDATIONS

This group undoubtedly remains below critical mass. It needs to develop a realistic strategy for research in mineralogy and petrology in collaboration with the Department of Geosciences. Both groups lack critical mass which is of concern for the future health of the subject in Norway, particularly given the recent resurgence of interest internationally in economic mineral deposits (e.g. REE metals).

The experimental petrology laboratory will need to be adequately funded if it is to succeed, with appropriate technical support.

4.3 University of Stavanger

4.3.1 Department of Petroleum Engineering – Petroleum Geosciences Group

KEY METRICS		
No. Of Professors	1	
No. Of Associate Professors	5	
No. Of Professor II	5	
No. Of Emeritus Professors		
No. Of Doctoral students: current	6	
No. Of PhD students graduated 2007-2009		
No. Of MSc Students graduated 2007-2009	3	
No. Of Postdoctoral Research Fellows	1	
No. Of Non-tenured Researchers		
No. Of Technical/Admin. Staff members	2	
Research Groups	**GRADE**	
1. Geoscience Group	**3**	

The University of Stavanger was formally established in its present form in 2005. The Petroleum Geoscience group is one of four divisions within the Department of Petroleum Engineering and has only recently been established with generous financial support from Statoil and other industry sources; in 2007 there was only one member of staff. Currently there are 6 full-time staff and 5 Adjunct (Professor II) staff. A PhD programme was initiated in 2010. No other groups within the Department were evaluated.

The vision of the Petroleum Geosciences group is to become a focal point for industry, specialising in hydrocarbon exploration and reservoir characterisation, structural geology, seismic data processing and provenance studies, providing a bridge between the geosciences and engineering. There is a strong commitment to the study of onshore and offshore national geology and to the education of students in an atmosphere of leading-edge research.

The group is housed in a well appointed modern building with plenty of space for future expansion.

ASSESSMENT & GRADING

Because of the small size and recent establishment of the research group, the Evaluation Committee did not consider it appropriate to use the metrics (including publications and citations) used to evaluate those University departments with much longer histories. Thus the grade awarded represents a measure of the impressive progress the staff have made in setting up this new group from essentially a zero baseline. Effectively the group only began to function in 2009, building up from 1 person in 2007, 2 in 2008 and 3 in 2009.

The staff are young and extremely ambitious, with dynamic leadership. They are undoubtedly still well below critical mass and their research strategy is emerging progressively as new staff are hired. The Professor II positions are extremely important, providing an important

interface with industry. The staff and PhD students are predominantly non-Norwegian; there have been problems in recruiting staff because geoscience research at the University is only recently established, and also because of competition from the local hydrocarbon industry which offers much better paid positions. In addition, the University is not currently able to offer permanent academic positions due to its economic position, although the situation is changing.

The academic staff have made determined attempts to establish collaborations with other leading universities in Norway (e.g., Univ. Centre of Svalbard, Bergen and Oslo), with varying degrees of success. In addition they have retained their networks of international collaborators from their previous positions in other countries. They already have a number of successful joint industry projects (JIPs) on sub-basalt imaging and the regional geology of the Caribbean.

The University of Stavanger only provides financial support for teaching activities. Individual teaching loads are inevitably high, since there are insufficient staff numbers to support the undergraduate and postgraduate degree programmes and limited technical and administrative support. Lack of time limits their potential for research and also for writing competitive bids for funding from RCN. As a new group they have found it extremely challenging to secure funding from RCN.

Since Geosciences is a new subject at the University it has been necessary to build up the appropriate research infrastructure and facilities from a zero baseline.

OVERALL GRADE: 3

RECOMMENDATIONS

The group will need to develop a very clear focus for their future research that reflects their capabilities and the needs of the hydrocarbon industry in order to secure future funding. This requires a coherent strategy.

The University of Stavanger needs to recognise the importance of research in supporting the development of this group. Thus far they have received generous funding from the Norwegian hydrocarbon industry that has enabled the construction of a first rate data visualisation laboratory and the hiring of PhD students. The industry will, increasingly, wish to see some return on its investment, which goes beyond the provision of trained students. The group needs proper technical and administrative support if it is to succeed.

Laboratory facilities will need to be established progressively. There will inevitably need to be some major investment in expensive equipment if the University wishes to have state-of-the-art facilities for teaching and research.

4.4 University of Tromsø

4.4.1 Department of Geology

KEY METRICS		
No. of Professors	7	
No. of Associate Professors	5	
No. of Professor II	5	
No. of Emeritus Professors		
No. of Doctoral students: current	18	
No. of PhD students graduated 2007-2009	7	
No. of MSc Students graduated 2007-2009	28	
No. of Postdoctoral Research Fellows	10	
No. of Non-tenured Researchers		
No. of Technical/Admin. Staff members	8	
Research Groups	**GRADE**	
1. Polar Marine Geology & Geophysics	**4**	
2. Crustal Dynamics	**2/3**	
3. Coastal and Terrestrial Geology	**NOT GRADED**	

The University of Tromsø is one of the youngest of the Norwegian universities, founded in 1968. It has a strong focus on Polar research. There was a major reorganisation of the Faculty structure in 2009. The Department of Geology sits within the Faculty of Science & Technology.

There is a clear management structure with a Department Head, appointed by the University, who has executive powers and overall responsibility for research, teaching, human resources and budget issues. The Department Head is supported by a board. A 10-year (2010-2020) strategic plan exists to guide decision making; this is articulated through an annual plan for research and teaching and the work of a number of sub-committees.

The Department hosts the *Arctic Marine Geology and Geophysics* PhD trainee school in collaboration with the Geological Survey of Norway (NGU), the Norwegian Polar Institute and the University Centre of Svalbard (UNIS); this forms part of the *Norwegian Research School in Climate Dynamics* national consortium.

Infrastructure is, in general, good with access to two research vessels, a large-scale national marine infrastructure platform for 3-D seismic imaging, an experimental rock deformation laboratory and a new XRF scanner. There has been significant capital expenditure in new equipment since 2004. However, substantial new investment in infrastructure is required to maintain their research at the leading edge. The Department requires an upgrade of the existing, University-owned, ice-going research vessel RV Helmar Hanssen (formerly RV Jan Mayen), including a new positioning system (DGPS), and access to the planned new ice-breaking research vessel fully equipped with the latest technology for polar research. The *Crustal Dynamics Group* requires a field-emission scanning electron miscroscope, gas deformation apparatus, thin section polishing equipment and associated technical/support staff. The Coastal & Terrestrial Geoscience group needs a high-resolution swath bathymetry

system for shallow water operation from small boats. The buildings have been recently renovated providing a high standard of accommodation for staff and students, although more office space is required.
The average age of the academic staff is 57 years and the age profile is thus strongly skewed. There is a relatively high percentage of non-Norwegian nationals amongst the academic and research staff. Gender balance is improving and females are predominant amongst the post-doctoral fellows and PhD students. Previously the University offered a generous sabbatical system to make academic appointments in this high-latitude location more attractive; sabbatical leave is now linked to research performance.

Student numbers have increased rapidly in recent years but there has been no compensatory increase in academic staff numbers or technical support. This has inevitably put a strain on the Department's capacity to conduct leading-edge research in all areas.

In the previous evaluation of Earth Sciences (1998) there was a recommendation that the Department should focus on experimental petrology, carbonate sedimentology and marine geology and geophysics (particularly seismic imaging). This they have done, with the exception of high- pressure high-temperature experimental petrology research which has now ceased following the untimely death of a key member of staff in 2003. The associated laboratory equipment has been recently transferred to the Natural History Museum in Oslo and has been replaced by a high pressure-temperature rock deformation laboratory.

International and national collaboration is strong and participation in EU funded research programmes has provided access to the large-scale research infrastructure essential for Arctic research. The strategy here of sharing access to infrastructure, both nationally and internationally, is forward thinking.

The Department has a strong track record in raising research funding from external sources including RCN, the EU, industry and the Mohn Foundation.

The Department of Geology is organised into three research groups:

- Polar Marine Geology & Geophysics
- Coastal & Terrestrial Geology
- Crustal Dynamics

4.4.1.1 Polar Marine Geology & Geophysics

The group is the largest in the Department and currently consists of 4 Professors, 2 Associate Professors, 2 Professors II, 7 Postdoctoral fellows and 12 PhD students. 4 PhD students and 12 Masters students have graduated since 2007.

The research focus is rather broad, encompassing paleoceanography, paleoclimate studies, seismic stratigraphy, sedimentary processes from fjords to continental margins, geohazards, gas hydrates and geofluids in continental margins.

ASSESSMENT & GRADING

This is a highly active, well organised group with strong leadership and evidence of good cooperation between group members. Some group members are strongly dependent on participation in IODP (International Ocean Drilling Program) cruises for their research, and

there is concern about the future reduction in RCN funding for post-cruise activities. They have excellent research facilities by international standards.

The publication rate of the group is about average, but in leading journals with good citation records; citations overall are average. Some of their highest profile outputs (e.g., several papers in *Nature*) are based on the results of IODP drilling of the Lomonosov Ridge in the Arctic. Their work in sedimentology and micropaleontology is well known internationally; some of it is ground-breaking. The group has an internationally leading team in gas hydrate studies who make important contributions to research into Arctic unconventional energy sources, the environment, and past and future climate change.

There are close collaborations with the hydrocarbon industry, providing access to data and state-of-the-art technology. Strategic research collaborations exist with the leading international marine geoscience organisations (including IFREMER, IFM-GEOMAR, Alfred Wegener Institute, Woods Hole, NOC Southampton)

OVERALL GRADE: 4

RECOMMENDATIONS

The group is addressing major research questions of international significance and should be regarded as a flagship for the University. Some strategic focusing of research activities may be required in future to reflect changes in personnel and external funding opportunities (e.g., IODP).

4.4.1.2 Coastal & Terrestrial Geology

The group currently consists of 2 Associate Professors, 1 Professor II and 2 PhD students. 1 PhD student and 5 Masters students have graduated since 2007.

This group has a broad range of expertise in coastal depositional systems and sea level change, sedimentary petrology, basin analysis, diagenesis, stratigraphy, glacial geology and geohazards.

ASSESSMENT & GRADING

With only two full-time academic staff it is not really sensible to consider this as a stand-alone research group. The staff have heavy teaching loads and their highly heterogeneous research interests do not define a common theme. There does not appear to be a coherent research strategy or strong leadership. The group lacks access to modern equipment.

Publication outputs are weak with low citations and little international visibility.

OVERALL GRADE: NOT GRADED

RECOMMENDATIONS

This group lacks critical mass and the Evaluation Committee is not confident that it can survive in its present form. The impending retirement of the two academic staff members provides an opportunity for the Department to reconsider its research strategy in this area.

4.4.1.3 Crustal Dynamics

The group currently consists of 3 Professors, 1 Associate Professor, 2 Professors II, 3 Postdoctoral fellows and 3 PhD students. 2 PhD students and 7 Masters students have graduated since 2007.

The main research focus of this group relates to crustal dynamics focusing on deformation processes in the upper and lower crust, fluid-rock interactions, metamorphic petrology, tectonics and geo-resources. This is one of the few ”hard-rock” geology groups remaining in Norway.

ASSESSMENT & GRADING

This is an energetic research group which is clearly on a strong upward trajectory following a difficult period since 2003, before the hiring of a new professor in 2009. Their research involves a combination of process-oriented and regional studies which is attractive to PhD students. They have developed a good international network of research collaborators.

Their basic research facilities, with the exception of the recently established rock deformation laboratory, are, however, poor and members of the group have to travel to other institutions (sometimes outside of Norway) to use SEM, XRD, and electron microprobe facilities. There is very little technical support, and no support for the rock deformation laboratory. The lack of adequate basic research facilities, combined with the remote location, will continue to make it difficult to attract new academic staff, post-doctoral researchers and PhD students of the highest international calibre.

The renewed interest in mineral resources, particularly in northern Norway, is creating a need for trained people with a distinctive skill set in mineralogy, petrology and geochemistry. The ”hard-rock” research focus on regional geology and fluid-rock interaction processes should put the group in a strong position for the future with respect to recruiting PhD and Masters students and to obtaining funding from industry.

Research in this area has been heaviliy reliant on ”blue skies” funding from RCN which has, in the past, been difficult to obtain.

Publication rates are below average, with weak citations.

OVERALL GRADE: 2/3

RECOMMENDATIONS

The group has considerable potential for the future, but requires much stronger support from the Faculty and University in order to do well. There is a strategic opportunity to develop Departmental research strengths in ”hard-rock” geology, catalysed by research funding from industry. To achieve credibility, however, there needs to be significant investment in new analytical facilities (SEM, electron microprobe) and general infrastructure support for the laboratories.

Replacement positions following future retirements should be used for strategic repositioning of research activities. An increase in post-doctoral researchers and PhD students is essential to reach a critical mass and to build up the research.

Research links with the Geological Survey (NGU) and the University of Oslo (PGP CoE) could be strengthened for mutual benefit.

4.5 The Norwegian University of Science and Technology, Trondheim

4.5.1 Department of Petroleum Technology and Applied Geophysics

The Department was established in 1973. It combines petroleum engineering and applied geophysics and has a strong industry focus. The petroleum technology part of the Department was last reviewed in 2003. Consequently, this evaluation is based only on activities within the Applied Geophysics group.

Until 2000 the Department was part of the Applied Earth Sciences Faculty, together with the Geology Department. Since 2000 it has been part of the Faculty of Engineering Science and Technology.

Following the 1998 evaluation of Earth Science research in Norway, in 2005 a national strategic plan for better petroleum resource utilisation was published which forms the basis of the current research strategy of the Department.

The Department hosts the *Centre for Integrated Operations in the Petroleum Industry* in collaboration with a number of major international oil companies and Stanford, Carnegie-Mellon, Delft and Kyoto universities.

KEY METRICS (Applied Geophysics)		
No. of Professors	5	
No. of Associate Professors	1	
No. of Professor II	8	
No. of Emeritus Professors		
No. of Doctoral students: current	31	
No. of PhD students graduated 2007-2009	9	
No. of MSc Students graduated 2007-2009	31	
No. of Postdoctoral Research Fellows	2	
No. of Non-tenured Researchers		
No. of Technical/Admin. Staff members		
Research Groups	**GRADE**	
1. Applied Geophysics	**4/5**	

4.5.1.1 Applied Geophysics

The group consists of 5 Professors, 1 Associate Professor, 1 Assistant Professor, 8 Professors II, 2 Postdoctoral fellows and 31 PhD students. 9 PhD students and 31 Masters students have graduated in the period 2007-2009.

This group has nationally/internationally leading expertise in 4D seismic monitoring and reservoir geophysics, seismic imaging, electromagnetic methods and rock physics. There is

close collaboration with the hydrocarbon industry which provides some 60% of the Department's funding.

ASSESSMENT & GRADING

This is a strong research group with excellent financial and other research support from the hydrocarbon industry. Consequently the main research questions are industry led, providing both limitations on, and opportunities for basic research.

The average age of the academic staff is over 50 years and there are no females. Succession planning for future retirements should therefore form part of their 5-10 year strategic planning process, providing some opportunities for refocusing their research portfolio in response to the changing needs of industry. There are challenges in recruiting good post-doctoral researchers because of strong recruitment (and better salaries) by the hydrocarbon industry. The University system for hiring post-doctoral fellows on short, fixed-term contracts does not facilitate recruitment.

There are close collaborations with SINTEF Petroleum Research in the area of rock physics. SINTEF is located nearby and the two groups operate a shared computing cluster and joint geomechanics laboratory facilities. Nationally the group has good research links with the Universities of Oslo and Bergen. International research activities appear to be strong (USA, Brazil, Ukraine, Russia, France, Italy, Germany) and PhD students typically spend 3-6 months working with partner research groups abroad.

Laboratory facilities are, in general, excellent and include a 20 MNOK state-of-the-art visualisation laboratory. There does, however, appear to be some pressure on space for offices and laboratories which needs to be addressed.

The group organises the ROSE (Rock physics and Seismic) project, funded by RCN and 22 industrial partners. A substantial number of the PhD students are funded via ROSE. Annual ROSE project meetings provide a forum for staff and students to interact with international colleagues from academia and industry.

The group plans to apply for a CoE in 2011 which focuses on seismic monitoring and imaging but will also include Environmental Geophysics. They have thought very carefully about how a CoE might be integrated within the Department.

Publication rates are high, although with relatively low citations. Low citation rates are common in the field of Applied Geophysics where the main focus of publications is to bring research outputs to the attention of industry. The majority of their outputs are published in peer-reviewed journals (e.g. *Geophysics*, *Geophysical Prospecting*). In addition, a number of their outputs are published in industry "magazines" such as *Leading Edge* and *First Break*; this is essential to ensure that their research remains highly visible in the industry sector, but it does not enhance their academic visibility. PhD students are encouraged to publish papers as part of their PhD thesis which is an excellent strategy; they should be encouraged to publish these in scientifically high-profile journals.

OVERALL GRADE: 4/5

RECOMMENDATIONS

This is an ambitious research group with a strong vision for the future; they should be fully supported by the University to achieve their goal of becoming a world class centre for subsurface geophysical research. Some diversification of their research portfolio is sensible given the likely decline of funding from the offshore Norwegian hydrocarbon industry. They have recognised this and should be encouraged to diversify their research activities accordingly into related environmental fields (e.g. CO_2 sequestration, sub-ice imaging).

The lack of female academic staff and the strongly skewed demographic profile need to be addressed in future hiring strategies.

Whilst recognising the need to publish in industry-facing journals and magazines, the group needs to develop a better strategy for publishing in some higher profile international journals (e.g. AAPG Bulletin) in order to increase recognition of their work.

There is a need for members of the Applied Geophysics group to engage in joint research projects with colleagues in the Department of Geology and Mineral Resources Engineering who are located in a separate building. The Evaluation Committee was unclear about the University strategy for separating geology and geophysics in this way; this strategy should be reconsidered by the Faculty and the University. There could be opportunities for joint appointments in the area of onshore and offshore regional geology, structural geology, basin analysis and reservoir characterisation which could be aligned with both research and teaching programmes.

4.5.2 Department of Geology and Mineral Resources Engineering

KEY METRICS		
No. of Professors	9	
No. of Associate Professors	7	
No. of Professor II	6	
No. of Emeritus Professors		
No. of Doctoral students: current	13	
No. of PhD students graduated 2007-2009	8	
No. of MSc Students graduated 2007-2009	77	
No. of Postdoctoral Research Fellows	3	
No. of Non-tenured Researchers		
No. of Technical/Admin. Staff members	6	
Research Groups	**GRADE**	
1. Engineering Geology & Rock Mechanics	**1-2**	
2. Mineral Production & HSE	**1-2**	
3. Geology	**1-2**	

The Department of Geology and Mineral Resources Engineering is part of the Faculty of Engineering Science and Technology. For the purpose of this evaluation the scientific staff were divided into three groups, based largely on cognate disciplines and teaching collaborations: Engineering Geology & Rock Mechanics, Mineral Production & HSE and Geology. All of these research groups have sub-critical mass and there does not appear to be

a coherent research strategy or strong research leadership at either group or Departmental level. Their research is highly applied and mostly centred around individual PhD projects.

The Department has a very strong educational focus and some members of staff clearly have very high teaching loads which limits their potential for research. Since 2007 6 senior professors have retired, only 4 of which have been replaced. There has only been a limited amount of funding to support PhD students and a declining number of Norwegian and European applicants due to competition from industry. Most of the PhD projects are based on collaboration with industry. Increasing undergraduate student numbers have placed a strain on departmental resources; this increase does not appear to have been supported by increased funding from the University.

Following the 1998 review of Earth Sciences efforts were made to increase the focus on mineral resources (particularly quartz), to develop collaboration in advanced laboratory techniques with the Department of Material Science and Engineering, to enhance collaboration with the Department of Petroleum Engineering and Applied Geophysics and, in 2004, to establish a Gemini-centre in Underground Technology in collaboration with the Department of Civil & Transport Engineering and SINTEF Rock and Soil Engineering.

4.5.2.1 Engineering Geology & Rock Mechanics

The group currently consists of 3 Professors, 2 Associate Professors, 2 Professors II, 0 Post-doctoral fellows and 5 PhD students. 3 PhD students and 38 Masters students have graduated since 2007.

Their research activities encompass engineering geology, rock and soil mechanics, hydrogeology and Quaternary geology.

ASSESSMENT & GRADING

The group has good links with Norwegian industry and with SINTEF via the Gemini centre and 2 Professor II positions. They are also a partner in the CoE *International Centre for Geohazards* hosted by NGI. They have a long tradition in applied research but lack critical mass in each of the areas of research in which they are involved.

Laboratory facilities need significant investment and more technical staff are required.

Publication rates are slightly below average and in low profile journals and conference proceedings; citation rates are very low. This is, in part, a consequence of the highly applied focus of their research.

OVERALL GRADE: 1-2

RECOMMENDATIONS

The group needs to take a hard look at their research strategy for the next 5 to 10 years in the context of their research strengths, whilst also considering the range of expertise needed to support their teaching portfolio. Their research strategy should take optimum advantage of their role in the CoE and the Gemini centre. Their research activities seem to be spread too thinly and to need much more focus. An external advisory board with representatives from industry might be helpful in developing a new strategy.

4.5.2.2 Mineral Production & HSE (Health, Safety and Environment)

The group currently consists of 1 Professor, 3 Associate Professors, 2 Professors II, 2 Post-doctoral fellows and 4 PhD students. 3 PhD students and 10 Masters students have graduated since 2007.

The main focus of their research is on problems related to mineral extraction and mineral processing, including associated environmental issues. They have unique (in Norway) laboratory facilities for conducting industrial-scale experiments for mineral dressing.

ASSESSMENT & GRADING

Currently the research activities of the group lack scientific focus and an obvious agenda. Much of their work in rock crushing and mineral separation may be considered more in the context of experimental testing rather than research.

Publication rates are very low and in low profile journals with low citations. This is, in part, a consequence of the highly applied focus of their research.

OVERALL GRADE: 1-2

RECOMMENDATIONS

The group needs to develop a much better focused research strategy for the next 5 to 10 years, reflecting their current strengths, opportunities for hiring new academic staff following retirements and the requirements of the undergraduate and Masters teaching programmes.

There are potentially important opportunities for research funding from the mining industry reflecting the worldwide renewed interest in economic minerals (e.g. via the SINTEF Mineral 21 project in which they are playing an active role). They need to consider carefully to what extent they will get involved in conducting research into the processes of ore deposit formation; this should be done in collaboration with the Geology group and with NGU. An external advisory board with representatives from industry might be helpful in developing a new strategy.

4.5.2.3 Geology

The group currently consists of 5 Professors, 2 Associate Professors, 2 Professors II, 1 Postdoctoral fellow and 4 PhD students. 2 PhD students and 29 Masters students have graduated since 2007.

The research interests of this group are extremely diverse; these include mineral deposits, petrology/geochemistry, petroleum geology, Arctic geology and stratigraphy, and resource evaluation.

ASSESSMENT & GRADING

This group lacks critical mass in all of its research areas and there does not appear to be a coherent research strategy. Academic appointments seem to have been made more on the basis of teaching needs.

They appear to have excellent analytical facilities, including access to SEM and microprobe facilities in the Department of Material Science and Engineering. However they lack

expertise in some of the more advanced SEM techniques to utilise these fully. Publication rates are very low and mostly in not particularly high profile journals; citations are below average.

OVERALL GRADE: 1-2

RECOMMENDATIONS

In the area of mineralogy, petrology and geochemistry it would seem sensible to develop a greater strategic focus on ore geology and mineral deposits to align with their existing strengths in mineral production and new possibilities for funding from industry. There is an important need for greater integration and research collaboration with the Applied Geophysics group in the Department of Petroleum Technology and Applied Geophysics. There are considerable opportunities for joint research in the area of onshore and offshore regional geology, structural geology, basin analysis and reservoir characterisation which could be aligned with both research and teaching programmes. Contingent upon future retirements, and teaching needs, consideration should be given either to establishing joint positions between the two departments or to reduce the emphasis on petroleum geology.

4.6 The University Centre in Svalbard

This evaluation includes two departments from the University Centre in Svalbard (Universitetssenteret på Svalbard, UNIS), *Arctic Geology* and *Arctic Geophysics*. UNIS acts as an international hub for high Arctic research, delivering specific modules for the curricula of other Norwegian universities. It does not award its own degrees. UNIS used to be a foundation, but is now run as a limited company. Non-evaluated departments are Arctic Biology and Arctic Technology.

Until 2009 there were only temporary faculty positions resulting in a high turnover of staff. At present, academic staff are expected to focus 60% on research and 40% on education. The two departments are actively trying to build up their own research programmes now that they have permanent staff, rather than being a service and logistics field station for others. Typically, they educate 20 undergraduate students per semester and up to 20-25 graduate students on several courses per semester. Research has always been part of the scientific positions at UNIS, but now that permanent faculty positions exist development of a longer-term research strategy is possible. There is excellent logistical field support which is essential to allow the significant numbers of undergraduate and graduate students, and visiting researchers, to work in the field safely under rather extreme environmental conditions. The number of students has almost doubled since 2001, and there are many (up to 50%) international student visitors, including some from India on a mutual PhD agreement. Of importance for future development will be the renegotiation later in 2011 of the original agreements with the 4 founding Norwegian universities which are represented on the Board of UNIS. These agreements were signed in 1994 when UNIS was established, and need to be renegotiated now that UNIS has matured and wants to be a more equal partner.

The Evaluation Committee considers these departments as a unique case, because they have had permanent faculty only for the last two years, and not all research groups are fully mature. They have considerable potential to develop distinctive strengths in Arctic research in collaboration with Norwegian Universities and other national/international partners. The academic staff are ambitious and have strong leadership. They already have a significant international profile as organisers of international workshops and conferences and involvement in EU projects.

4.6.1 Department of Arctic Geology

KEY METRICS		
No. of Professors	4	
No. of Associate Professors	3	
No. of Professor II	5.75	
No. of Doctoral students: current	4	
No. of PhD students graduated 2007-2009	4	
No. of MSc Students graduated 2007-2009	15	
No. of Postdoctoral Research Fellows	1	
No. of Non-tenured Researchers		
No. of Technical/Admin. Staff members		
Research Groups	**GRADE**	
1. Sedimentary Bedrock Geology	**2-3**	
2. Quaternary and Marine Geology	**2-3**	
3. Cryosphere	**4**	

This is a small department with only 7 permanent academic staff members; 6 of whom were appointed in the period 2005-2009. There is a good gender balance amongst the academic staff. More than 50% of the staff are international. Management is very democratic and decisions are made at department level by consensus. UNIS has an excellent sabbatical system which guarantees 3 months leave per year of full-time employment. From 2009-2011 at least 3 staff members will be on sabbatical at collaborating universities in Norway, USA, Canada and Denmark.

The previous review of Earth Sciences in 1998 took place when UNIS was in the early stages of its development. Recommendations at that time about the need for permanent positions, adjunct professorships and the strengthening of glaciology research have all been followed.

The Department consists of three research groups: sedimentary bedrock geology, Quaternary and marine geology, and cryosphere research; these were established in 2006.

Major investments in research infrastructure, particularly logistical support for field research, were made in 2006 when the department moved into the Svalbard Research Park. Significant further investment will be required in the near future. Excellent logistical support is provided by UNIS to support fieldwork; however, skilled technical support for field and laboratory work is lacking. Marine geological research is currently limited by the need to charter external research vessels or to hire instruments to be deployed from the UNIS-owned small fishing trawler.

The Department will contribute to the EU ESFRI research infrastructure project *Svalbard Integrated Arctic Earth Observing System* (SIOS) and there are plans to establish an *International Centre for Cryosphere Research*. Involvement in *International Polar Year* (IPY) projects has provided significant momentum for these initiatives. The Department is also participating in two Nordic *Centres of Excellence* projects - SVALI and DEFROST. A number of internationally outstanding field research laboratories have been developed, including the Longyearbyen CO_2 storage facility, which are used by all 3 research groups. Their future development will form part of the SIOS project in collaboration with national and international partners.

Publication and citation rates vary within the different research groups reflecting the stage in their development. The Cryosphere group is very strong, with an above average number of publications in good journals, whereas the other two groups are proportionately weaker.

4.6.1.1 Sedimentary Bedrock

The group currently consists of 2 Professors, 1 Associate Professor, 2.5 Professors II, 0 Postdoctoral fellow and 1 PhD student. 1 PhD student and 5 Masters students have graduated since 2007.

The main research focus of this group is on the High Arctic sedimentary basins including their tectonic setting and mode of formation, fluid flow characteristics and sequence stratigraphy of the basin fill. The Longyearbyen CO_2 laboratory is coordinated by this group, facilitated by support from industry (e.g. ConocoPhillips, Statoil) and other research partners (e.g., SINTEF, NGI, IFE, NORSAR). Research activities fall mainly under the headings of structural geology/tectonics and sedimentology/petroleum geology. A high-profile project to excavate complete skeletons of Jurassic marine reptiles has been underway since 2004 in collaboration with the Natural History Museum, Oslo, facilitated by an adjunct professor.

ASSESSMENT & GRADING

This group is still relatively immature and they need to work actively to develop their long-term strategy and vision for the future. Their current range of research projects is rather diverse (ranging from CO_2 storage to Mesozoic vertebrate fossils) so that they may not have sufficient critical mass to develop all of these fully. They have a good mix of funding from industry and RCN. There are good national collaborations with the universities of Bergen (CoE CIPR) and Oslo and with the Natural History Museum, Oslo. International collaboration is growing and important research links exist with the UK, Netherlands, USA, Canada, Sweden and Egypt.

Publication rates are very low with low-average citations. However this may not necessarily be a good performance metric given that staff have not been in their posts for very long.

OVERALL GRADE: 2-3

RECOMMENDATIONS

Strategic planning for the future needs to be undertaken on a 5-year cycle with an emphasis on the major research questions to be addressed. This will require strong leadership.

A solid earth geophysicist and a scientific technician are required to support the group.

4.6.1.2 Quaternary and marine geology

The group currently consists of 0 Professors, 2 Associate Professors, 2 Professors II, 0 Postdoctoral fellow and 1 PhD student. 1 PhD student and 1 Masters student have graduated since 2007.

The research interests of this group mainly concern the reconstruction of Quaternary glaciations and Holocene environmental change.

ASSESSMENT & GRADING

This group essentially consists of only two permanent members of staff, who focus on the terrestrial and marine record respectively; they are the most recently established, and smallest, research group in the department. Considerable progress has been made in planning an impressive range of research projects with collaborators and preparing funding applications; however, this research is only in its start-up phase and therefore difficult to evaluate.

Publication rates are very low with average citations. Given that the group is small and newly established, the Evaluation Committee does not consider this a particularly relevant performance metric.

OVERALL GRADE: 2-3

RECOMMENDATIONS

This group is very much at the developmental stage and clearly has sub-critical mass with only two permanent academic staff. They are involved in a challenging number of research projects and will need to focus on a sub-set of the most important ones to avoid becoming overwhelmed. They should perhaps emphasise those projects which have a Svalbard focus and plan their collaboration with outside researchers very carefully.

4.6.1.3 Cryosphere

The group currently consists of 2 Professors, 0 Associate Professors, 1.25 Professors II, 1 Postdoctoral fellow and 2 PhD students. 2 PhD students and 9 Masters students have graduated since 2007.

The research interests of this group focus on modern-day High Arctic and High Altitude earth surface processes and their climatic controls.

ASSESSMENT & GRADING

The group is highly productive with a dynamic leader and a long-term strategic vision. They have focused their efforts on fully exploiting the scientific opportunities offered by Svalbard as a field laboratory; this strategy has clearly paid off. They have established a good network of national (Oslo, Tromsø, NGU) and international (UK, Denmark, Spain, Finland, USA, Canada, Poland, Nepal, Japan) research collaborators.

Publication numbers are well above average, though citations are perhaps slightly low.

OVERALL GRADE: 4

RECOMMENDATIONS

This group is definitely on a steep upward trajectory towards an internationally leading position in this field of research. They are not limited by their ambition - only by their lack of critical mass. Consideration should be given by UNIS to hiring some new Associate Professors. A lack of appropriate administrative support for research has made it difficult for them to coordinate EU and other large projects. UNIS needs to address this issue and also the general lack of skilled technical support. UNIS should consider whether there are merits in

having an integrated Department of Arctic Earth Sciences, rather than two smaller departments of Geology and Geophysics. Such a strategy could provide economies of scale in the provision of administrative and technical support, and improve the critical mass in some groups.

4.6.2 Department of Arctic Geophysics

KEY METRICS		
No. of Professors	3	
No. of Associate Professors	3	
No. of Professor II	6	
No. of Emeritus Professors		
No. of Doctoral students: current	5	
No. of PhD students graduated 2007-2009	1	
No. of MSc Students graduated 2007-2009	7	
No. of Postdoctoral Research Fellows	1	
No. of Non-tenured Researchers		
No. of Technical/Admin. Staff members		
Research Groups	**GRADE**	
1. Air-Cryosphere-Sea Interaction & Modelling	**2-3**	

Research in the Department of Arctic Geophysics ranges from the study of the deep oceans to the study of the Earth's atmosphere and the solar wind. The Department was established in 1993 when UNIS was founded. Since then it has grown gradually in size, but with a frequently changing staff until 2009 when permanent positions became available.

Research activities are divided into two groups. The upper/middle atmosphere group was evaluated in 2009 as part of the RCN Physics Review. The Earth Sciences evaluation is, therefore, based only on the Air-Cryosphere-Sea Interaction Observation and Modelling group (ACSO). This group also includes one professor from the Department of Arctic Technology.

The Head of Department is elected on a bi-annual basis and this is mainly a functional/administrative role. There is no formal leadership structure within the individual research groups because of their small size.

None of the current academic staff were present at UNIS during the last evaluation of Earth Sciences in 1998. In the national strategic plan which was based upon this evaluation the recommendation was made that research activities within meteorology and oceanography with a polar focus should be maintained.

4.6.2.1 Air-Cryosphere-Sea Interaction Observation and Modelling group

The group currently consists of 1 Professor, 3 Associate Professors, 3 Professors II, 1 Postdoctoral fellow and 5 PhD students. 1 PhD student and 7 Masters students have graduated since 2007.

The stated research ambition of the group is to improve the parameterisation of air-sea-ice interaction processes for use in climate modelling based upon field measurements both on

land and offshore. Their expertise includes meteorology, oceanography and snow and ice physics.

ASSESSMENT & GRADING

The group has been involved in a number of International Polar Year (IPY) projects and is an attractive partner in international research projects because of their unique location and ability to provide logistical support for fieldwork. Because of this there is a danger that they can easily become viewed as a provider of field infrastructure rather than as independent research partners.

Nationally they have links with the *Bjerknes Centre for Climate Research* (BCCR), Bergen, the University of Oslo and the Norwegian Polar Institute. They have a growing number of connections with universities overseas (e.g. in Denmark and the USA).

Members of the group have an impressive range of research interests and are addressing some of the critical questions in their field of research. However they lack sufficient critical mass to gain a leadership position in any particular research area. Consequently they tend to react to opportunities rather than driving their own science agenda. Nevertheless opportunities for collaboration appear to be plentiful and thus they can be selective about which projects to join.

The group has a reasonably well-articulated research goal ”to perform research related to improving the parameterisation of near-surface processes specifically suited for climate models”; however, they need to establish much stronger links with climate modellers to get their work recognised. Their research ambitions are compromised to some degree by the need to support a broad range of teaching programmes. For example, their recent decision to hire a chemical oceanographer seems to have been driven by teaching needs rather than by their research agenda. Future plans to develop capability in remote sensing seem sensible; however, critical mass will be difficult to achieve. A significant proportion of their time seems to be taken up with monitoring activities and the maintenance of time-series of data. Although such data underpin their research and are of value in facilitating international research collaborations, they need to be carefully balanced within the overall research strategy.

Publication rates are slightly below average with growing citations. These are improving as the group becomes better established and are not considered by the Evaluation Committee as a defining metric of performance at this stage.

OVERALL GRADE: 2-3

RECOMMENDATIONS

To raise the visibility of the group, both nationally and internationally, it is essential that they maintain active partnerships with other internationally-leading institutions, particularly BCCR, in the field of climate modelling. The generous UNIS system of sabbatical leave should be used strategically to strengthen such partnerships.

Given the small size of the group, consideration should be given to a more focused research strategy. They are clearly spreading themselves too thinly.

UNIS should consider whether there are merits in having an integrated Department of Arctic Earth Sciences, rather than two smaller departments of Geology and Geophysics. Such a strategy could provide economies of scale in the provision of administrative and technical support.

4.7 Sogn og Fjordane University College, Sogndal

4.7.1 Faculty of Engineering and Science

The Sogn og Fjordane University College was the only regional college to be evaluated in the 1998 review of Earth Science research in Norway. No particular recommendations were made at that time about future developments in the area of geosciences.

The University College has an ambitious plan to establish an *International Centre of Environmental Science* in strategic partnership with a number of European universities and the University of Bergen. This will offer European Masters programmes in Geohazards, Renewable Energy, Restoration Ecology and Landscape Planning. The rationale is based on its location in an area of outstanding natural beauty with steep mountains, glaciers and fjords which provide a perfect natural laboratory in which to study the effects of climate change on landslide activity, flooding and biodiversity.

4.7.1.1 Geology & Geohazards research group

KEY METRICS		
No. of Professors	1	
No. of Associate Professors	4	
No. of Assistant Professors	1	
No. of Professor II	1	
No. of Emeritus Professors		
No. of Doctoral students: current	0	
No. of PhD students graduated 2007-2009		
No. of MSc Students graduated 2007-2009		
No. of Postdoctoral Research Fellows	0	
No. of Non-tenured Researchers		
No. of Technical/Admin. Staff members	0	
Research Groups	**GRADE**	
1. Geology & Geohazards	**2-3**	

This research group is one of four research groups in the Faculty of Engineering and Science. It has a long history, spanning over 30 years, of research on landslides, glacial geology, hydrogeology and marine environmental geology.

A significant reorganisation occurred in 2007 reflecting a change in the nature of the Bachelor degree programme to focus on geology and geohazards. This is gradually resulting in increasing student numbers. Research on geohazards, particularly landslides, has developed into a high priority area for the University College following receipt of funding from a western Norwegian bank and establishment of strategic partnerships with the Norwegian Public Roads Administration (NPRA) and the Norwegian Water Resources and Energy Directorate (NVE). Recent retirements have allowed new staff to be recruited.

The group has a strong and dynamic leadership and they have ambitious plans for expansion. Unfortunately, the general conditions for doing research at the University College are not good. The academic staff all have extremely heavy teaching loads, reflecting the educational focus of the institution. Associate and Assistant professors only have about 15% of their time available for research. Additionally, the head of the group has a 20% Professor II position at the University of Tromsø. The University College does not have a PhD programme.

Apart from a microscopy laboratory the research group has no scientific laboratory equipment at their disposal or indeed any technical support. Much of their research is field-based. They are reasonably well equipped with a range of portable equipment for field sampling of soils and water and for monitoring slope stability. They have recently acquired a georadar system with advanced software. The academic staff have only limited access to scientific journals and advanced library facilities.

ASSESSMENT & GRADING

The Evaluation Committee found it extremely difficult to evaluate this group, as they have only recently started to work together and thus have no real history. They are full of energy, enthusiasm and ambition for the future and have a strong commitment to student education which should be valued. They appreciate that the economic position of the University College is a difficult one and have identified a niche research area that aligns with their academic skills and can make best use of the natural resources that surround them.

Their publication rate is very low, with relatively low citations. Given that a number of the staff are newly appointed, the Evaluation Committee did not consider this a useful performance metric.

OVERALL GRADE: 2-3

RECOMMENDATIONS

It would make sense for the University College to establish a stronger strategic partnership with the University of Bergen to provide academic staff with a greater range of research collaborators and access to laboratory and library facilities. In return, the University College could provide the University of Bergen with facilities and local expertise for field training and field-based research in their outstanding natural laboratory and also offer joint supervision of PhD students. Such opportunities could also be made available to other national and international partners. The research group needs to develop stronger collaborative links with the Norwegian Geotechnical Institute (NGI) and other leading institutions internationally with expertise in landslide research.

The vision of the University College to establish an *International Centre of Environmental Science* is an appealing one which could substantially improve the economy of the local region. The idea seems to have been around for a long time. Unfortunately, without a substantial financial investment this project is not likely to get off the ground. Success will require action from the top level of the University College, local and national government. The Geology & Geohazards group could have an important role to play in such an initiative.

With more modest investments, including new academic posts to increase critical mass, the Geology & Geohazards group could make a useful research contribution which addresses a local/national need. There is a considerable potential to establish a *natural landslide laboratory* (possibly in partnership with NVE, NGI and the Norwegian Meteorological Institute) and to run a range of ”summer schools” for other universities, both in Norway and internationally.

4.8 The Norwegian University of Life Sciences (UMB), Ås

The Norwegian University of Life Sciences, established in 2005 has its roots in an agricultural college established in 1859, which became the Agricultural University of Norway in 1898. The University focuses specifically on biology, food, the environment, land and natural resource management. In the next few years there are plans for the Norwegian School of Veterinary Sciences to be merged with UMB to create a new University.

Two separate research groups, based in different departments, were evaluated as part of this review.

4.8.1 Department of Plant and Environmental Sciences

4.8.1.1 Geology research group

KEY METRICS (Geology Research Group)		
No. of Professors	1	
No. of Associate Professors	3	
No. of Professor II		
No. of Emeritus Professors	2	
No. of Doctoral students: current	1	
No. of PhD students graduated 2007-2009	1	
No. of MSc Students graduated 2007-2009	5	
No. of Postdoctoral Research Fellows	1	
No. of Non-tenured Researchers		
No. of Technical/Admin. Staff members	1	
Research Groups	**GRADE**	
1. Geology	**2**	

The Geology group is the smallest of 9 research groups in the Department of Plant and Environmental Sciences which is the largest department at UMB. The Department has a wide range of teaching and research interests, including the use and conservation of nature, the environment and climate change, food production and food safety and bioproduction. The main research activities of the Geology group are focused on paleoclimate and paleoenvironmental studies and geological resources.

The Head of Department is employed on a 4-year contract which can be renewed twice and is supported by a Board. There is a separate Departmental scientific committee which deals with research.

Financial support to research groups from the Department and University is extremely limited and is based on the number of permanent staff. Research activities are, therefore, dependent on grants from external sources. There does not appear to be a high level of support for the Geology group from either the Department or the University.

The gender balance within the Geology group is very good with 50% of the tenured positions held by women. The postdoctoral research fellow and PhD student are both female. There has been some volatility in group membership, with new appointments in 2007 and 2010 and movement of one professor to another group. During the evaluation period there were, on average, only 3.3 full-time equivalent academic staff in the group.

In the Earth Sciences Review of 1998 the Department was praised for its teaching programme in hydrogeology, considered to be the most comprehensive in Norway at that time. In the 1999 national strategic plan for Earth Sciences the Department was advised to focus its research activities in geology on national georesources and to strengthen collaborations in Quaternary geology and paleoclimate studies with the Universities of Oslo and Bergen, respectively. A recommendation was made that hydrogeology should be integrated into hydrology and research activities sustained in collaboration with the University of Oslo. The Geology group have attempted to follow these recommendations in their strategic planning, but they do not appear to have been particularly strongly supported by the Department.

The Department has well equipped laboratories for soil physics, environmental chemistry, geochemistry and microbial analysis, and has its own electron microscope. It also runs a field site for studies of water and solute transport in the unsaturated zone at Gardermoen airport, in collaboration with the University of Oslo and Bioforsk. The Geology group has a range of geophysical instrumentation for near-surface characterisation, including electrical resistivity and ground penetrating radar; these are, however, in need of upgrading.

The Geology group appears to have a wide range of international research connections, including the USA, Canada, Russia, Germany, Netherlands, UK, Sweden, Denmark, Finland, Iceland and Italy. Nationally they collaborate with the universities of Oslo, Bergen and Tromsø, UNIS, the Norwegian Geotechnical Institute (NGI), the Norwegian Geological Survey (NGU) and the Norwegian Polar Institute.

ASSESSMENT & GRADING

The Geology group clearly lacks critical mass. They lack the strong leadership required to develop a coherent strategic plan which will better align their existing strengths (in hydrogeology, paleoclimate studies and Quaternary geology, and mineral resources) with the rest of the Department.

The academic staff have very high teaching loads which reduces the amount of time they have for research. Their publication records are rather variable, but include outputs in some high-profile journals; given the small size of the group and the number of recent appointments, the analysis of metrics is not particularly useful. The Evaluation Committee has taken this into consideration in their evaluation.

OVERALL GRADE: 2

RECOMMENDATIONS

In order to flourish, this group urgently needs to align its strategy more closely with that of the rest of the Department; a greater level of support from the Department is needed. There are some obvious areas which could be developed, including studies of contaminant transport in soils and groundwater in collaboration with the environmental chemistry and hydrology groups in the Department. The concept of using crushed rock as a soil fertilizer has potential and could be used to establish stronger links with the soil science group and plant biologists.

It does not seem appropriate to attempt to build more expertise in the sustainable use of mineral resources. This research theme is being picked up by the Norwegian Geological Survey (NGU) and groups at other Norwegian universities with greater critical mass.

There appear to be opportunities for greater collaboration with colleagues in the Geomatics Section of the Department of Mathematical Sciences and Technology who have expertise in satellite-based remote sensing. The Evaluation Committee questions the logic of having two separate, small geoscience groups in the University.

4.8.2 Department of Mathematical Sciences and Technology

The Department, established in 2003, is organised into six sections mostly reflecting the nature of the undergraduate and Masters teaching programmes.

The Department is led by a Professor, supported by a Board elected from various groups of employees. There is a departmental committee for research led by a professor who is the appointed research leader of the department. A strategic plan for research exists for the period 2010-2013; this emphasises the need for state-of-the-art equipment, improved national and international collaboration and an increase in publications. Each section has a Section Head, with a largely administrative role, and a research coordinator.

4.8.2.1 Geosciences research group

KEY METRICS	**Geosciences Group**	**Geomatics Section**
No. of Professors	3	5
No. of Associate Professors	1	4
No. of Professor II	1	4
No. of Emeritus Professors		
No. of Doctoral students: current	4	5
No. of PhD students graduated 2007-2009	2	
No. of MSc Students graduated 2007-2009	6	
No. of Postdoctoral Research Fellows	1	1
No. of Non-tenured Researchers		
No. of Technical/Admin. Staff members		
Research Groups	**GRADE**	
1. Geosciences	2/**3**	

The research group in Geosciences is part of the Section of Geomatics within the Department. The Section has 9 permanent and 5 fixed-term fulltime positions and 4 Professor II positions; the staff have a wide range of expertise in geodesy, surveying, photogrammetry, satellite-based remote sensing, GIS and cartography. In the past decade there has been an increasing focus on monitoring changes in the Earth's surface and understanding the processes involved. Geomatics research is an integral part of the Environmental and Climate Change component of the University research strategy.

The Geosciences research group, comprising 4 permanent academic staff and one Professor II, has a wide range of research interests in glaciology, geodynamics, ocean tide loading at

high latitudes, and remote sensing. There are three major research themes: the gravity field and its geophysical implications, ice sheet and glacier evolution and remote sensing for land surface mapping. The three professorships have all been relatively recent promotions, although two of them are approaching retirement. One of the professors is female.

The research environment is not strong, with declining student numbers and a lack of financial resources from the University for equipment and fieldwork. The last major investment in infrastructure (3.5 million NOK) was in 2004 for a gravimetry laboratory. However, the Geomatics section has a good record of obtaining PhD fellowships which contributes to the dynamics of the research group. In addition the group has a good level of engagement in European research programmes, including International Polar Year projects which are now coming to an end.

Glaciology research is conducted in collaboration with the Norwegian Polar Institute, the Norwegian Water Resources and Energy Administration, the Norwegian Meteorological Institute, the Norwegian Institute for Air Research, UNIS and Oslo University, and research groups in Canada and France. In the field of satellite remote sensing the group has collaborated with a number of national partners including the Norwegian Defence Research Establishment and the Norwegian Military Geographic Service. Gravimetric research is conducted in collaboration with a number of European universities and the Nordic mapping authorities.

The group was not previously evaluated as part of the 1998 *Review of Earth Sciences*.

ASSESSMENT & GRADING

Overall this is a worthy group who have carved out a niche for themselves in rather unpromising surroundings. Unfortunately, there appears to be very little interaction with the people working on landscape development and ice sheet dynamics in the Department of Plant and Environmental Sciences. This seems to be an opportunity for the future.

Their publication rates are slightly above average and increasing; however citations are low.

OVERALL GRADE: 2/3

RECOMMENDATIONS

Improved collaboration with the geoscientists working in the Department of Plant and Environmental Sciences would be beneficial. The University should take the opportunity provided by the planned merger with Veterinary Sciences to reorganise geoscience-related research into a single unit.

Future retirements should be seen as an opportunity to refocus their strategy into areas of strength and greatest opportunity for research funding.

5. Evaluation of Research Institutes

5.1 Norwegian Meteorological Institute

KEY METRICS		
No. of Researchers	29	
Research Groups	**GRADE**	
1. Climate Change & Variability research	**4-5**	
2. Environmental research	**4-5**	
3. Atmosphere and ocean modelling	**3-4**	

The Norwegian Meteorological Institute (hereafter met.no), founded in 1866, is a government agency under the Ministry of Education and Research which incorporates the national weather forecasting service. It has 430 employees of whom approximately 80 are scientists. Its main mandate is to address the forecasting of weather and weather-related risks for the Norwegian public and various governmental agencies. Their mission as weather forecasters and climate modelers is to help protect life and property, safeguard the environment, contribute to sustainable development, and promote the long-term observation of meteorological, hydrological, and climatological data, including related environmental data.

The organisational structure has recently been reviewed, in line with the development of their 2011-2015 strategic plan. In the context of this evaluation, three groups focusing on research and development (R&D) in climate and environmental research, and atmosphere and ocean modelling are considered. Some researchers participate in more than one group. Met.no operates a matrix management system for its research activities, with a very flat management structure.

The goal of the majority of the R&D activities (~ 80%) is to ensure that all the operational services are robust and state-of-the-art. Such underpinning research is not considered as part of this evaluation. Because of the operational focus, much of the research is highly applied and, therefore, there are limited opportunities for fundamental or ”blue skies” research. Nevertheless, the research infrastructure and international networks of collaborators provide an important foundation for basic research from which operational benefits may arise in the medium- to long-term. Such research is often co-funded by the RCN, the EU or by major national companies. Commissioned research is also undertaken on a selective basis for a range of Norwegian and European public sector organisations.

The research staff are co-located with the meteorologists and oceanographers of the Department of Geosciences, University of Oslo, in the *Centre for Interdisciplinary Environmental and Social Research* (CIENS). Four scientists at met.no hold Professor II positions in the MetOs group at University of Oslo. There are also strong national collaborative research links with the *Norwegian Climate Centre*, particularly the *Bjerknes Centre for Climate Research* (BCCR) at the University of Bergen. Research staff are encouraged to move between the met.no offices in Oslo, Bergen and Tromsø, but this does not often happen. There is also no formal programme within met.no to allow researchers to spend time at other institutions, both in Norway or overseas. A small number of PhD and Masters projects are co-supervised with colleagues in universities, particularly the University of Oslo. Most staff are employed on permanent contracts.

There seem to be no difficulties in recruiting good scientists to longer-term contracts (greater than 4 years); it is, however, more difficult to recruit to short-term contracts. Recruitment is international and there are declining numbers of Norwegian applicants for posts.
Met.no has an excellent infrastructure for research. It has a good strategy to upgrade its super-computing facilities in collaboration with the Swedish Met Office; this removes any dependency on facilities shared with universities.

Publication of results in international scientific journals is currently encouraged much more explicitly than it used to be; however, outputs are variable in the different research groups.

OVERVIEW ASSESSMENT

Met.no is an impressive organisation with a clear applied research focus. It is small compared with other national weather services, e.g., in the UK, France and USA. There appears to be a sensible balance between active research on topics where staff have a high level of experience (e.g., wave research, statistical downscaling, fine-scale gridded maps, aerosol-cloud interactions, limited-area prediction and data assimilation with high-resolution products) or where there is a particular Norwegian motivation (e.g., high-resolution, local numerical weather prediction (NWP) including strong topographic effects) and entering into cooperative agreements with other institutions (e.g., NCAR in the USA) in areas where it is not feasible to have an independent research effort. There seems to be a strong sense of institutional purpose and good science is clearly valued. Some staff have the same sort of publication record and activity profile as successful academic researchers, whereas others have a more operational/project focus and participate in, and sometime lead, cooperative ventures between different weather services. Some staff are technical specialists who do not have much impact outside met.no, but presumably have a clearly defined role as part of research teams within the organisation. All this looks comparable to other weather services such as the UK Met Office.

Research based on particular Norwegian problems (e.g., acid rain in the 1970s, pollution of the Arctic in the 1990s) has put met.no, and Norwegian atmospheric sciences research more generally, in a very strong position internationally with regard to chemical transport modelling, continental-scale air quality and chemical and aerosol effects on climate. Addressing the requirements of local forecasting, including sea-state (e.g., to meet the needs of the oil industry and fisheries), plus the availability of high quality scientific staff, has allowed met.no to achieve a high profile relative to other, larger, national weather services, for example, in data assimilation for small-scale forecasting. They have developed a number of in-house modelling tools; these are not as widely used outside of met.no as they might be.

Unlike the Swedish Meteorological and Hydrological Institute (SMHI), met.no does not include a hydrological group. Its links with the University of Oslo and NVE hydrology research groups do not seem strong enough to allow improved modelling aimed at operational hydro-meteorological forecasting and sustainable water resources planning and management in a changing climate.

RECOMMENDATIONS

Met.no should consider how to provide incentives for researchers in the academic sector to use their modelling tools; for example, by providing modest funding or coordinated technical assistance. Experience elsewhere has shown that such an approach will be to the mutual benefit of the meteorological institute and the academic researchers.

5.1.1 Climate Change & Variability Research

Climate research has been mainly funded by RCN through the NORKLIMA and International Polar Year (IPY) projects. The main focus is on the analysis and modelling of past, present and future climate states and the development and application of the Norwegian Earth System Model (NorESM). There are 12 researchers involved in this group with backgrounds in meteorology, oceanography, hydrology and statistics. The Climate research work is required for the preparation of climate change adaptation services in Norway.

The group works closely with other Norwegian climate research groups in the Norwegian Climate Centre (Norsk Klimasenter), which is a strategic collaboration between partners in Bergen, Oslo and Tromsø, and contributes to a national climate research project NorClim. They are also involved in a number of international research projects and networks. The group has contributed to various chapters of IPCC reports.

The group has an average publication record in high profile journals, with high citations, and has a good international standing.

OVERALL GRADE: 4-5

RECOMMENDATIONS

The competence of the group with respect to NorESM is linked to a few key people. This makes the group vulnerable to staff losses and the situation should be monitored carefully.

5.1.2 Environmental Research

This research group has a focus on atmospheric chemistry modelling, with an emphasis on the biogeochemical cycling of sulphur, reactive nitrogen, volatile organic compounds and particulate matter, and their impact on ecosystems, health and the Earth's climate. The major emphasis of their work is to analyse the transboundary transmission of air pollution in Europe. There are 7 researchers involved in this group. Their work is mainly focused around the EMEP programme (European Monitoring and Evaluation Programme) under the UNECE *Convention for Long Range Transmission of Air Pollutants in Europe* (CLRTAP); they are also involved in a number of other projects funded by the EU, the Nordic Council of Ministers and other international organisations.

The group has an average to slightly below average publication record in high profile journals with high citation rates, and has a good international standing.

Nationally there are good collaborative links with the atmospheric research group at NILU, with the MetOs group at the University of Oslo and with CICERO (*Centre for International Climate & Environmental Research*) which are also co-located in CIENS.

OVERALL GRADE: 4-5

RECOMMENDATIONS

Members of the group might benefit from periods of sabbatical leave in other European institutions.

5.1.3 Atmosphere and ocean modelling

There are 11 researchers involved in this group with backgrounds in meteorology, oceanography and statistics. Their main emphasis is to improve the quality of the weather forecasts delivered by met.no with an emphasis on data assimilation, ensemble prediction and atmosphere-ocean interaction. They make a valuable contribution to local forecasting, particularly with respect to wave modelling and work in close collaboration with the offshore oil industry.

The group has a below average publication rate in average journals with regard to citations and profile; citations are relatively low. This may, in part, reflect the more operational focus of their research.

There are good research collaborations with the University of Bergen and with the Nansen Environmental and Remote Sensing Centre (NERSC) and the Institute of Marine Research (IMR) in Bergen. Within atmospheric modelling, met.no is a partner in the international research programme HIRLAM (High Resolution Limited Area Model), which is a research cooperation of European meteorological institutes. The aim of the HIRLAM program is to develop and maintain a numerical short-range weather forecasting system for operational use by the participating meteorological institutes. The programme was initiated in 1985 and has gone through numerous phases in the past two decades. There is a formal agreement with the UK Met Office in relation to the development and use of the Unified Model (UM) at met.no.

OVERALL GRADE: 3-4

RECOMMENDATIONS

There could be an opportunity for stronger links with specialists in hydrology that would link to natural hazards research on landslides and flooding. In particular the group should take the opportunity provided by the establishment of a new super-computer centre in cooperation with SMHI to establish stronger research collaborations with the hydrological groups at the University of Oslo and NVE.

5.2 Norwegian Water Resources and Energy Directorate (NVE)

KEY METRICS		
No. of Researchers	11	
No. of Technical/Admin. positions	9	
Research Groups	GRADE	
1. Hydrology, glaciology and sediment research	3/5	

The Norwegian Water Resources and Energy Directorate (NVE) is a directorate under the Ministry of Petroleum and Energy and is responsible for the management of Norway's water and energy resources. It is organised into five departments of which only the Hydrology Department is considered in this evaluation.

The NVE 2010-2014 strategic plan emphasises research which is relevant to society in the areas of energy, water resources, floods, avalanches and the effects of climate change. NVE has a mandate to ensure that the utilisation of water resources in Norway is both environmentally friendly and beneficial to Norwegian society.

NVE has framework agreements with the Norwegian Meteorological Institute and with the Geological Survey of Norway (NGU). It is an associated partner in the Oslo CIENS centre (*Centre for Interdisciplinary Environmental and Social Research*). There are strong links with similar institutions in Sweden, Finland, Iceland, and Denmark, and a wide range of national collaborations with the universities of Oslo, Bergen, UNIS, NTNU, Norwegian University of Life Sciences and NGU, CICERO (Centre for International and Climate Research), the Norwegian Polar Institute and the Norwegian Computing Centre. Internationally they have a good network of collaborations within the Netherlands, USA, UK, Germany, Sweden, Switzerland, China and Russia.

Through its hydrological observation network NVE is responsible for climate change monitoring and provides advice on the measures required for adaptation to climate change and the reduction of greenhouse gas emissions. They participate in the Climate21 programme established by RCN to develop a climate research strategy in Norway.

5.2.1 Department of Hydrology

The Department of Hydrology has a history going back more than 200 years. It maintains long time-series of hydrological data and is the national centre for hydrological and glaciological monitoring.

The main focus of their research is on understanding processes in the hydrological cycle with an emphasis on water balance, the cryosphere and erosion/sedimentation, based on observations, experiments and modelling.

OVERVIEW ASSESSMENT

As the national centre for hydrology, the Department benefits from a strong base funding from the government; consequently, its infrastructure is good. By virtue of the nature of the organisation, much of the research conducted has a highly operational focus in which high quality monitoring and data analysis inevitably have a greater priority than basic research. The day-to-day demands for producing data and information clearly have the potential to undermine longer-term research goals.

5.1.1.1 Hydrology, Glaciology and Sediment research group

The Hydrology, Glaciology and Sediment research group, evaluated here, comprises 11 scientists from three different sections in the Hydrology Department, supported by 28 technical staff and administrative staff members from the other sections. Each section has a Head of Section who, together with the Director of the Hydrology Department, are members of the Department management team. The Head of Section role is largely administrative. All research projects have individual project managers.

Research scientist positions were first introduced in the 1990s. Research activity accounts for between 20 and 90% of their time. There is a good balance of female staff in the group (more than 50%). As with many scientific organisations in Norway, it is becoming difficult to recruit Norwegian scientists.

Research staff are provided with opportunities to spend time in other national/international organisations; however, not many staff take advantage of these. The Department does, however, host a number of international visitors and also Masters and PhD students from the universities of Oslo and Freiburg (Germany). Currently, staff are contributing to the supervision of 8 doctoral students.

Research funding is obtained directly from the Ministry of Petroleum and Energy and therefore external funding is not a prerequisite. Applications are, however, encouraged for research grants from RCN, the EU, the European Space Agency (ESA) and other Nordic programmes; NVE have several projects with such funding.

Infrastructure is generally very good. Since the early 1990s NVE has owned and operated the Svartisen Subglacial Laboratory – a unique facility worldwide, capable of enabling leading-edge research into processes operating at the base of glaciers. This appears to be significantly under-utilised at present but has the potential to be developed into a world-class facility for Norway.

NVE has established a useful web portal to provide public access to the results of their research and to historical data on climate and snow.

Although the quality of their hydrological research work is of a high standard, publication rates are low, in relatively low profile journals, and citation rates are also low; outputs have, however, recently started to improve. There does not seem to be a strong culture of publishing their research in international journals and the work of the Department does not obviously have a strong academic focus. The Evaluation Committee notes that although the bibliometric analysis was presented for the research group as a whole, the quality of the outputs appears to be very uneven, with much of the hydrological modeling at international levels of excellence, whereas research outputs in other areas are significantly weaker. This is reflected in the final grading.

OVERALL GRADE: 3/5

RECOMMENDATIONS

It seems clear that the researchers in the group would like to participate in more externally funded projects and to increase their involvement in PhD student training in collaboration with university partners. This should be encouraged within the overall strategic framework of NVE. Improving their publications is an important part of this process, in order to raise their profile, both nationally and internationally. In addition, it is recommended that the NVE hydrology group strengthens its collaboration with the met.no and the University of Oslo hydrology research groups, to improve modelling aimed at operational hydro-meteorological forecasting and sustainable water resources planning and management under climate change.

The Svartisen laboratory is, from an international perspective, a truly unique facility. Logistically and safety-wise it is a very challenging operation. It has, thus far, been run in a fairly low-key mode, on a minimum budget. The facility offers unparalleled possibilities to directly study and measure processes in the subglacial environment, e.g., flow velocity, basal drag, water pressure etc., on artificial purpose-built bed sections of relevant geological materials. They have good collaborations with some leading US glaciologists, but mostly with the NVE scientists in a supportive role. The Svartisen laboratory is a 5-star national asset, but if NVE is to scientifically gain maximum benefit from having it, they need to strengthen the glaciology staff. In the self-evaluation only one scientist was listed as performing Svartisen-related research.

Work at the Svartisen laboratory has the potential to change the current knowledge base on the controls on glacier flow. This would have significant implications for ice-sheet modeling and the whole issue of ice-sheet stability under a changing climate. There is thus a potential for considerable scientific breakthroughs. If NVE wants to be part of this development, it has to go far beyond the role of supplying the infrastructure. A secure base-level of funding for the laboratory, a permanent laboratory manager, and two additional glaciologists (in theoretical ice dynamics and basal interface processes, respectively) are probably the minimum requirements for NVE to fully utilize the scientific potential of the laboratory.

5.3 Center for International Climate & Environmental Research

KEY METRICS		
No. of Researchers	7	
No. of Adjunct Researchers	3	
No. of Doctoral students: current	4	
No. of PhD students graduated 2007-2009	1	
No. of Technical/Admin. Staff members	1	
Research Groups	**GRADE**	
1. Group 1 plus aspects of Group 3	**4-5**	

CICERO, the '*Centre for International Climate and Environmental Research'*, was established as a private foundation, associated with the University of Oslo, by the Norwegian government in 1990. Its staff conduct research and provide information and expert advice about national and international issues related to climate change and climate policies. Researchers are divided into 4 groups: Group 1 consists mainly of natural scientists in the area of atmospheric chemistry, meteorology and environmental chemistry; Group 2 studies climate policies for mitigation and has a predominance of economists; Group 3 specialises in adaptation and has a mixture of economists and social anthropologists, and Group 4 consists of political scientists and sociologists. The Earth scientists included in this assessment are based primarily within Group 1 and to a lesser extent in Group 3. For the purposes of this evaluation they have been considered as a single group.

CICERO staff are co-located with research staff of the Norwegian Meteorological Institute (met.no) and with the meteorologists and oceanographers of the Department of Geosciences, University of Oslo, in the *Centre for Interdisciplinary Environmental and Social Research* (CIENS).

The prime focus of the research at CICERO is on calculating the effects on global climate of different types of atmospheric emissions, and presenting the relationship between emissions and their effects in simple quantitative terms that can be presented to policy-makers and included in policy-focused models. Most of the senior staff have a strong atmospheric science background; some have a focus on physical/chemical modellling whilst others have oriented their research towards more policy-related aspects of climate research.

Funding for research is primarily from the Research Council of Norway (RCN); however, CICERO staff also undertake commissioned research for a range of national and international organisations (e.g., World Bank) and actively participate in the EU Framework programme.

Overview Assessment

CICERO staff conduct high quality research of significant importance to policy-makers. Over the past 5 years they have made important contributions to the quantification of emissions from different transport sectors and their implications for climate change; this research

activity has been conducted throughout Europe, with CICERO staff and their associates playing a leading role. They have also contributed to fundamental discussions regarding how the impact of different types of emissions should be measured. Staff from CICERO have made important contributions to IPCC assessments and have participated in a number of major European research projects (e.g. ACCESS, Quantify, ATTICA and ECLIPSE).

Overall CICERO seems to provide an excellent complement to the scientific research going on in Norwegian universities and at *met.no*, extending that body of research towards the policy arena. The strengths of CICERO reflect the strengths of Norwegian atmospheric science at the University of Oslo and *met.no,* and complement the work undertaken in Bergen at the *Bjerknes Centre for Climate Research* (BCCR). Their approach may become increasingly important in the future as governments perceive that the basic climate science questions have been answered and that the outstanding research questions are in climate change mitigation and adaptation.

CICERO relies on short-term project funding to support its staff and is therefore vulnerable to changes in Government funding for climate change research. However, this funding model provides a degree of agility to respond to changing research agendas which is to their advantage.

Publication rates are excellent overall, with high numbers of publications in high impact journals.

OVERALL GRADE: 4-5

RECOMMENDATIONS

Stronger links should be developed with BCCR to avoid the development of two silos of climate change research in Norway. At present, the research interests of BCCR and CICERO are complementary, with the emphasis in Bergen on the ocean and cryosphere and in Oslo on the atmosphere, the drivers of climate change and radative forcing. It would be advantageous for Norwegian science to have some cross-over projects, particularly in the area of Earth System modelling.

5.4 Norwegian Institute for Air Research (NILU)

KEY METRICS		
No. of Researchers	7.7	
No. of Professor II	0.3	
No. of Doctoral students: current	4	
No. of Postdoctoral Research Fellows	2	
Research Groups	**GRADE**	
1. Atmospheric Transport Processes (ATP)	**5**	

The Norwegian Institute for Air Research (NILU) was established in 1969 as an institute under the Royal Norwegian Council for Scientific and Industrial Research. In 1986 it became a private foundation. The main location of NILU is outside of Oslo at Kjeller; they also have some office space at the *Centre for Interdisciplinary Environmental and Social Research* (CIENS) in Oslo.

The main emphasis of NILU activities is on air pollution/air quality; they have a remit to provide research and advice for the Norwegian government and local authorities, businesses and industry. NILU has a long-established international reputation for the study of trans-boundary fluxes of air pollutants. Its main source of funding for research is the *Research Council of Norway* (RCN). NILU receives a small basic grant from the Ministry of Environment, but has to raise project funding (e.g. from RCN, the European Commission) to cover all of its research costs, including salaries.

NILU has a 10 year strategic plan (2010-2020) to become world-leading in the field of climate change research, focusing on the anthropogenic and natural drivers and the geochemical, physical, meteorological, hydrological and biological processes involved in climate change, through the development of multidisciplinary models, new measurement methods and monitoring networks and databases for climate change gases and particles.

NILU is organised into six departments: Urban Environment and Industry, Centre for Ecology and Economics, Monitoring and Information Technology, Environmental Chemistry, NILU UAE and Atmospheric and Climate Research. The focus of this evaluation is on the Atmospheric Transport Processes (ATP) research group within the Atmospheric and Climate Research department, which was established in 2005.

Overview Assessment

The ATP research group is an informal cluster of 10 people within the Department for Atmospheric and Climate Research; the department overall comprises some 30 scientific staff. The group has only been established for a little over 5 years and most of the researchers have been recruited to NILU more recently.

The research activities of the ATP group are focused around the development and use of an in-house Lagrangian particle dispersion model, FLEXPART. First developed by the ATP group leader in 1997, FLEXPART is an open-source computer program made freely available to the international research community. It is based on the simple principle of calculating air parcel trajectories using information from global meteorological datasets which are now made available routinely by major weather forecasting centres such as the ECMWF (European Centre for Medium Range Weather Forecasting). Such trajectories provide useful information about the transport of chemical species on scales from 10s of km to global. FLEXPART is not the only trajectory-modelling tool of this type, but NILU has been very effective in presenting it in a form where it can be used by any member of the atmospheric science community. It is therefore the modelling tool of choice for many research groups worldwide.

NILU presents its modus operandi as project-based, with individual scientists identifying and, with management approval pursuing, scientific and funding opportunities. When funding applications are successful, the necessary personnel for the project are drawn together from the NILU staff. The basic grant to NILU covers only about 10% of the operating budget; therefore, there is significant pressure to apply for funds and there are the usual frustrations of working in this manner, i.e., a large fraction of scientists' time spent writing research proposals and little opportunity to follow interesting scientific leads beyond the definition of the project. Overall, however, the funding situation at NILU appears to be very good.

Whilst highly focused around the FLEXPART model, the ATP group is by no means a research silo. They have recently demonstrated a number of novel applications of the model, ranging from understanding the water vapour budget in cyclonic systems along the west coast of Norway, through predicting the transport of ash from Icelandic volcanoes, to the dispersion of radioactive particles from the damaged Fukushima nuclear reactor in Japan. These applications reflect the ability of the group to respond rapidly to societal needs in response to extreme events.

The ATP group has an extremely strong publication record in high-profile journals. Their research is of international significance and consequently they have a very good international network of collaborators.

OVERALL GRADE: 5

RECOMMENDATIONS

Given the very strong focus of the Group's research activities around the FLEXPART software, which originated with the group leader, they are vulnerable should he ever decide to leave NILU. Some consideration should, therefore, be given to developing future group leaders and to diversifying research activities beyond FLEXPART.

Although NILU has office space at CIENS on the University of Oslo campus, it was not clear to the Evaluation Committee that sufficient use was being made of this to strengthen research collaborations with other CIENS partners. This may help with some of their recruitment problems (e.g. recruitment of suitably qualified Norwegian researchers and PhD students).

5.5 NORSAR

KEY METRICS	Total Staff	
No. of Researchers	12	
No. of Doctoral students: current	1	
No. of Postdoctoral Research Fellows	3	
Research Groups	**GRADE**	
1. Seismology and nuclear test-ban treaty monitoring	3	
2. Earthquakes and the Environment	3	

NORSAR is an Earth Science research institute which receives ~ 10% of its base level funding from the Norwegian Government, administered by the Norwegian Research Council (RCN). It was initiated in 1968 under a bilateral agreement between the USA and Norway to fund seismological research to monitor nuclear tests. In July 1999 NORSAR became an independent foundation. It is the designated Norwegian National Data Centre for Comprehensive Nuclear Test-ban Treaty (CTBT) matters. NORSAR is a partner in the RCN funded Centre of Excellence "*The International Centre for Geohazards*".

NORSAR has a Board of Directors, the majority of whom are appointed by RCN; the Board is the formal owner of the foundation. There is also a wholly-owned subsidiary company, NORSAR Innovation AS, established in 2005, set up to commercialise NORSAR's innovation activities, including software development for the international petroleum industry.

Since 2005 the organisational structure has included 5 research programmes, two of which are considered as part of this evaluation: *Seismology and nuclear test-ban treaty monitoring* and *Earthquakes and the Environment*. All research is conducted within well-defined projects led by a project manager. Formal leadership of research is at the programme management level. NORSAR has a unique infrastructure comprising field-based geophysical monitoring equipment (both seismic arrays and single stations) and a 40-year time series archive of digital seismic data.

Over 60% of the research staff are not Norwegian nationals, reflecting some difficulty in recruiting well qualified Norwegian seismologists.

Overview Assessment

NORSAR has a long and proud tradition of seismology research in Norway and is known throughout the world for its test-ban treaty monitoring and expertise in array-based seismology. In the past it was well funded by the US Government. Such funding is now in decline and the organisation is in the process of re-focusing its activities, with an emphasis on the more environmental aspects of seismic hazard and risk, whilst retaining its CTBT role. Their aim is to create a financially independent, professionally and socially attractive, and internationally oriented research institute. Given the extremely competitive nature of the market, the Evaluation Committee considered that this could be challenging.

NORSAR appears to lack critical mass based on the scope of its stated ambitions. They need to articulate their research strategy much more clearly. It is not clear whether they wish to be

a research-oriented organisation or a consultancy. At present they have elements of both and are not evidently being highly successful at either. They need to ensure that they remain at the forefront of the research agenda in order to fulfil their ambitions.

5.5.1 Seismology and nuclear test-ban treaty monitoring

The group currently consists of 5 researchers and 1 post-doctoral fellow, all of whom are full-time employees.

The main focus is on research in seismology related to test-ban treaty monitoring. The group appears to have relatively limited interaction with the university sector in Norway, with the exception of the University of Bergen (operators of the Norwegian National Seismic Network). They led an International Polar Year project in the high Arctic in collaboration with the universities of Bergen and Oslo and research groups in Germany and Poland, and have collaborated on a number of European Commission and European Science Foundation funded projects. Group members have leadership roles within the international seismological community (e.g. ISC, ORFEUS, IASPEI).

Their publication record is average, with average numbers of citations; publications are in journals of average scientific impact.

OVERALL GRADE: 3

RECOMMENDATIONS

This group carries expertise in solid Earth geophysics which is, overall, declining in Norway. Opportunities to strengthen research links with the University of Bergen/ Norwegian National Seismic Network should be pursued. There appears to be considerable potential to utilise NORSAR's huge 40-year time series, array-based data set for seismic tomography studies of the crust and upper mantle beneath southern Norway. This should be explored in collaboration with researchers in the university sector, including those outside of Norway.

5.5.2 Earthquakes and the Environment

The group currently consists of 7 researchers (of whom only 4 are permanent employees), 2 post-doctoral fellows and 1 Doctoral student.

The main research focus is on earthquake hazard, structural vulnerability and risk, and microseismic monitoring of man-made (induced) and naturally occurring seismicity (e.g., in hydrocarbon fields, mines, geothermal power plants, CO_2 storage facilities, fault zones, unstable rock slopes). There is an emphasis on deriving economic benefit from their research results. The Group's project portfolio is characterised by large number of small projects, reflecting the broad nature of their research activities. This is not necessarily conducive to generating results of publication quality, or to establishing distinctive track records in particular fields of research. In many respects the Group is operating more like a consultancy than a research organisation. Their publication record is average, with average numbers of citations; publications are in journals of average scientific impact.

OVERALL GRADE: 3

RECOMMENDATIONS

It is difficult to see how this group can develop a distinct research identity. The range of projects they are currently taking on is pulling them in too many different directions. They need to focus their attention on projects which align better with their research strengths and for which they can secure longer-term research funding.

5.6 Uni Bjerknes Centre, Bergen

KEY METRICS	Total	
No. of Researchers	22	
No. of Professors	1	
No. of Adjunct Scientists	10	
No. of Doctoral students: current	5	
No. of PhD students graduated 2007-2009	4	
No. of Postdoctoral Research Fellows	6	
No. of Technical/Admin. Staff members	6	
Research Groups	**GRADE**	
1. Palaeoclimate processes and past climate sensitivity	**5**	
2. Climate variability and dynamics	**4-5**	
3. Carbon biogeochemistry and marine ecosystems	**5**	
4. Global and regional climate projections	**4**	

The Uni Bjerknes Centre is a unit of *Uni Research* Ltd, an independent not-for-profit research company owned by the University of Bergen (85%) and the Foundation for University Research in Bergen (15%). *Uni Research,* created in 1986 as a foundation and changed to a limited company in 2003, was established to accommodate the University's growing portfolio of externally funded research projects, specifically to create more flexibility in the hiring of fixed-term contract researchers.

The Uni Bjerknes Centre staff are part of the Norwegian Centre of Excellence (CoE) *Bjerknes Centre for Climate Research* (BCCR), established in 2000 and formally funded for 10 years from 2002 to 2012, along with staff from the University of Bergen (UiB) Bjerknes Centre, the Nansen Environmental and Remote Sensing Centre (NERSC) and the Institute of Marine Research (IMR). *Uni Research* delivers the core administrative support of the CoE and employs many of the key scientists. BCCR is currently in a transitional phase as the CoE funding ends in 2012 and is being replaced by support for a new *Centre for Climate Dynamics* with a direct grant (20 M NOK/year) from the Government from 2010 to 2022.

A new organisational structure was introduced in April 2010, subdividing the Uni Bjerknes Centre staff into four research groups in: *Palaeoclimate processes and Past Climate sensitivity*, *Climate variability and dynamics*, *Carbon Biogeochemistry and Marine Ecosystems* and *Global and Regional Climate projections*. These four groups form the basis of this evaluation. Individual group leaders report directly to the Director of the Uni Bjerknes Centre.

From 2012 it is planned that the staff of the Uni Bjerknes Centre and UiB Bjerknes Centre should be co-located in a re-furbished building; currently they are located in separate, though adjacent, buildings.

OVERVIEW ASSESSMENT

Uni Bjerknes Centre staff have clearly made an impressive contribution to the overall success of BCCR which can be considered to be amongst the leading international organisations in the field of Climate Change research.

The complex governance structure of BCCR, did, however, create some difficulties for the Evaluation Committee (EC) in separating the relative research contributions of Uni Bjerknes staff from those of UiB staff. Much of the work is highly collaborative, resulting in joint publications. From an external perspective it is the CoE BCCR that has gained widespread international recognition within the climate research community, albeit through the outputs and other contributions of specific individuals and teams. The EC notes that, as a CoE, BCCR has been independently reviewed as part of a separate process.

Whilst the creation of the Uni Bjerknes Centre was intended to simplify the process of hiring fixed-term contract staff within the CoE and to provide administrative support, the existence of two legal entities within BCCR (in addition to NERSC and IMR) has actually proved to be a disadvantage, financially, for the University. The research grants and publications of the Uni Bjerknes Centre do not count for the distribution of results-based funding from the Norwegian Government to UiB, resulting in the loss of several tens of millions NOK.

The EC found it difficult to see the value, in research terms, of having a separate *Uni Research* unit (Uni Bjerknes Centre) within BCCR. This structure has the potential to increase the level of bureaucracy, resulting in less efficient use of resources. By way of an example, the need to co-locate the Uni Bjerknes and UiB staff appears to have been an ongoing problem throughout the life of the CoE and is still to be resolved.

Uni Bjerknes and UiB staff in BCCR have access to shared geochemical laboratories, ship time and super-computing facilities provided by the University. Most groups appear to be adequately supported by the local facilities and by the national super-computing facility at Bergen; the technical support provided by the latter is clearly highly valued. Nevertheless, those groups running complex Earth System models reported a need for enhanced super-computing and data storage facilities. All the research groups considered that there was a need for a greater level of technical support. The laboratory facilities appear to be highly variable; some are state-of-the-art, whereas others require significant investment in laboratory refurbishment and new equipment. Better technical support is required.

Some concerns were raised that the NIFU publications analysis did not adequately recognise the contributions of Uni Bjerknes staff because of problems concerning their affiliation. The EC considered this issue but did not feel that they had been disadvantaged in any way.

In general, recruitment to positions appears to be good due to the international standing of BCCR. There are, however, problems in recruiting Norwegian PhD students and post-doctoral researchers in some of the research areas, particularly where there is competition from industry. As a consequence of the funding model for Uni Bjerknes staff, essentially ”soft money” support on a project-by-project basis, PhD students are very expensive to fund and it is considered more efficient to hire post-doctoral researchers.

Research funding appears to be good, with significant numbers of EU projects. The most common complaint from staff was a lack of funding for basic research in Norway and the large amount of time they had to spend writing research proposals. The EC notes that the Norwegian national committee on climate change research strategy, Klima 21, has, in a recent

white paper to Government, advocated a large expansion of climate research in Norway. Nevertheless, there remains some apprehension amongst the Uni Bjerknes staff about a longer-term downturn in funding for basic Climate Science research, both nationally and internationally, as attention changes to adaptation and mitigation strategies. Much of the research conducted within BCCR does not receive industrial support, with the exception of the ”Deep Time” palaeoclimate work recently funded by Statoil.

RECOMMENDATIONS

From an external perspective, *Uni Research* appears to have developed in ways that were probably not envisaged when it was first created. It appears to have become a rival research organisation to the University, which in the case of BCCR has created an extremely complex internal management and governance structure, leading to inefficiencies. The Evaluation Committee strongly recommends that the structure for the new *Centre for Climate Dynamics* is based on a more simplified model.

5.6.1 Palaeoclimate processes and past climate sensitivity

The group consists of 1 Professor, 2 Adjunct Scientists (UiB; Dept. of Earth Science), 3 researchers and 2 post-doctoral fellows. There is a good gender balance. Difficulties were reported in recruiting Norwegian Doctoral students.

The main research emphasis is on the drivers of climate change and climate sensitivity on millennial and longer timescales, with a focus on past warm periods, ice sheets and ocean dynamics and on the sensitivity of the climate system to changes in boundary conditions. They have recently decided to focus more on ”deep time” questions, attracting some support from the hydrocarbon industry (Statoil). Palaeoclimate proxy data are integrated with atmosphere and ocean general circulation models and Earth System models of intermediate complexity.

The research of this group, particularly the high-resolution palaeoclimate reconstructions for the North Atlantic for the last few million years, is internationally leading. They have established a good network of international collaborators.

Their publication record is average in terms of numbers of publications, but with much higher than average citations.

OVERALL GRADE: 5

RECOMMENDATIONS

Expanding their activities into ”deep time” will be challenging; new collaborations will need to be established in order to make this work globally competitive. Working with colleagues from UNIS (Svalbard) and Sweden they could develop a niche for deep-time research in the high Arctic. This work might benefit from developing the use of organic biomarker temperature proxies.

Members of the group are distributed over a number of different buildings which is not conducive to effective collaboration. As this is a recently-formed group, co-location of the staff should be a high priority for the University.

5.6.2 Climate variability and dynamics

The group consists of 9 researchers, 4 Adjunct Scientists (UiB; Dept. of Earth Science) and 3 Doctoral students.

Their main research focus is on centennial to multi-decadal and shorter timescale climate variability and low- to high-latitude interactions. Key topics are the Atlantic overturning circulation and modelling of external climate forcing.

Staff turnover is relatively high and staff reported that they do not feel particularly well integrated with the rest of the University. They appear to lack critical mass in some areas. Their publication record is slightly below average but with very high citation rates; outputs are in high profile journals, including *Nature* and *Science*.

OVERALL GRADE: 4-5

RECOMMENDATIONS

Members of the group are distributed over a number of different buildings which is not conducive to effective collaboration. As this is a recently-formed group, co-location of the staff should be a high priority for the University.

5.6.3 Carbon biogeochemistry and marine ecosystems

The group consists of 7 researchers, 3 Adjunct Scientists (UiB; Geophysical Institute) and 1 Doctoral student. There is a reasonably good gender balance.

Their main research focus is on the marine carbon cycle and other biogeochemical constituents in both open ocean experiments and mesocosms, combining both empirical studies and modelling. In addition they also have an active research programme on ocean acidification. Modelling activities involve the Bergen Climate Model and the Norwegian Earth System Model (NorESM). Together with colleagues in UiB, they have developed new instrumentation for marine carbon cycle measurements which is used worldwide.

They appear to be generally well-funded by the RCN and the EU; they coordinated the EU FP6 project CarboOcean, involving 47 European partners and the USA, and will lead a follow-on project CarboChange. Their research benefits from interaction with a strong network of international collaborators in the UK, France, Germany, Sweden, the USA and South Africa.

Some difficulties were reported in recruiting Norwegian Doctoral students and post-doctoral researchers, although recruitment of international researchers remains strong.

Research outputs are fairly average in number, but with very high citation rates.

OVERALL GRADE: 5

RECOMMENDATIONS

Refurbishment of their laboratory facilities should be given a high priority.

5.6.4 Global and regional climate predictions

The group currently consists of 3 researchers, 4 post-doctoral fellows, 1 Adjunct Scientist (UiB; Geophysical Institute) and 1 Doctoral student. The gender balance is reasonably good.

Their main research focus is on developing the Norwegian national Earth System Model (NorESM) and atmospheric dynamical downscaling and production of regional climate scenarios using various high resolution models. Some group members are also involved in wind energy research. They have central responsibility for model development within the RCN NorClim project (Climate of Norway and the Arctic in the 21st Century) in collaboration with the universities of Oslo and Tromsø. Climate projections and hindcasts are provided as part of the CMIP5 for the IPCC AR5 report. They have strong international research links with collaborators in the UK, USA, Germany and Canada.

Specific problems were reported concerning the availability of super-computer time and inadequate data storage facilities. The group is located in poor quality office space in an old building.

Research outputs are somewhat below average, although citation rates are high.

OVERALL GRADE: 4

RECOMMENDATIONS

Given the core modelling activities of this group, attention needs to be given to improve access to super-computer time and for improved data storage facilities. The group appears to be expanding rapidly and would benefit from relocation to better office space.

5.7 Uni Centre for Integrated Petroleum Research, Bergen

KEY METRICS (Geoscience group only)	Total	
No. of Researchers	5	
No. of Adjunct Researchers	8	
No. of Doctoral students: current	3	
No. of PhD students graduated 2007-2009	7	
No. of MSc Students graduated 2007-2009	11	
No. of Technical/Admin. Staff members	2	
Research Groups	**GRADE**	
1. Geoscience	**2-3**	

The Centre for Integrated Petroleum Research (CIPR) is one of the divisions of *Uni Research* Ltd, an independent research company owned by the University of Bergen (85%) and the Foundation for University Research in Bergen (15%). CIPR was established as a Norwegian *Centre of Excellence* (CoE) in 2003 (2003-2013) to consolidate existing applied research on improving oil recovery performed by different departments at the University of Bergen (physics, mathematics, geology, chemistry, geophysics and biology) into a single unit, and to recruit additional researchers from the petroleum industry. The aim was to improve cooperation between academia and industry via cross-disciplinary joint projects. Uni CIPR has been a division of *Uni Research* Ltd since 2003.

As a CoE CIPR receives a fixed annual grant from the Norwegian Research Council (RCN) and can apply competitively for other research funding from RCN. It also receives financial support from a number of petroleum companies and some limited EU funding.

CIPR's research is conducted by an international group of over 100 researchers and Doctoral students with diverse backgrounds in geology, geophysics, engineering, mathematics, chemistry and biology. It is structured into 3 research groups, only one of which, the Geoscience group, is considered as part of this evaluation. The main focus of the Geoscience group has been on reservoir characterisation and modelling, although they are now moving into CO_2 sequestration.

CIPR has a very flat organisational structure. The Geoscience group is organised into teams working on specific projects; each project is managed on a day-to-day basis by a project manager who reports to the Geoscience Group Research Manager. Individual researchers are commonly working on several projects in parallel. Since the group is of limited size, external specialists are co-opted, as required, to the project teams from other institutions, both national and international. PhD and Masters students form an integral part of the project teams.

Overview Assessment

This is a fairly small research group with a significant number of adjunct researchers (6 at 20%; 2 at 50%) mostly from the University of Bergen (UiB), but also from the University of

Oslo, UNIS, private consulting and industry. Turnover amongst the scientists is relatively high due to the lack of permanent positions and to strong recruitment from the hydrocarbon industry.
CIPR is an attractive environment for Masters and Doctoral students and there is a good record of student supervision, providing a link with the Department of Earth Sciences, UiB.

In addition to its core CoE funding, CIPR staff have been successful in applying for project grants from RCN, the EU and other sources; however, they have found it difficult to secure hydrocarbon industry funding since October 2008, reflecting the global financial downturn. Staff charge by the hour on projects, which makes them expensive and uncompetitive when bidding for funding in competition with university departments. In this respect being part of *Uni Research* has not helped CIPR achieve financial sustainability.

The emphasis of CIPR research is highly applied and from the inception of CIPR it was intended that this should be largely conducted in collaboration with national and international petroleum companies via a series of Joint Industry Projects (JIPs). During the evaluation period (2005-2009) industry partners in JIPs included: ConocoPhillips, Statoil, Norsk Hydro and Agip KCO. As a consequence much of their work appears to be somewhat opportunistic, led by the availability of funding rather than based upon a long-term research strategy. In many respects CIPR is structured more like a consultancy company than an academic research institute. Staff clearly have to dedicate a lot of their time to raising research funds from external sources. Whilst the funding environment has been difficult since 2008, they do, nevertheless, have some major industry partners.

CIPR is one of the leading institutions worldwide using advanced spatial information techniques in geoscience research. Their work on ”virtual outcrops” based on 3-D LIDAR, hyperspectral imaging and remote sensing is state-of-the-art. They are currently building up an ”outcrop database”, but it is not yet clear how they will use this as a research tool. Other groups within Europe are developing capability within this field and they will need to find a way of differentiating their research so that they remain competitive. They are internationally recognised for their work on fault analysis and fluid flow in fault zones.

They have established some good research collaborations internationally, both in academia and industry. They host international visitors to CIPR on a regular basis, whilst their own permanent staff seem to be much less mobile. Links with other Norwegian institutions, including the University of Oslo, SINTEF, NGU and NGI are improving, but more work needs to be done. In addition, their links with the UiB Petroleum Geoscience group in the Department of Earth Science are perhaps not as strong as they could be.

In their self-evaluation they note that they have not had a geophysics team for some three years, although steps are being taken to resolve this. They also lack an effective data management system, although they report that a programme to collate their extensive data sets is underway. Publication rates are below average with very low citation rates, in medium-level journals without very great visibility, as expected for this type of applied, petroleum-industry relevant research. They clearly need to publish in journals/magazine that will attract the attention of the hydrocarbon industry, but this costs them citations.

OVERALL GRADE: 2/3

RECOMMENDATIONS

Overall, this appears to be an active group doing interesting applied research, but it is more of a consulting-type of organisation rather than a leading-edge research group doing high visibility, international-level research. They clearly need to decide what their strategy and funding structure will be for the next 5-10 years. Will this be industry-led or driven by fundamental research questions? They appear to be overly reliant on RCN and Government funding. They need to market their skills better within the international hydrocarbon industry.

5.8 Institute of Marine Research, Bergen

KEY METRICS : Oceanography Group	Total	
No. of Researchers	20	
No. of Doctoral students: current	2	
No. of PhD students graduated 2007-2009	0	
No. of MSc Students graduated 2007-2009	4	
No. of Postdoctoral Research Fellows	1	
No. of Non-tenured Researchers		
No. of Technical/Admin. Staff members	4	
Research Groups	**GRADE**	
1. Oceanography	3-4	

The Institute of Marine Research (IMR) is a national governmental research institute, dating back to 1900, directly owned since 1989 by the Norwegian Ministry of Fisheries and Coastal Affairs. In addition to its headquarters in Bergen there are also departments located in Tromsø and Flødevigen and aquaculture research stations in Matre and Austevoll. IMR employs some 200 scientists and has almost 700 employees; it is the second largest marine research institute in Europe after IFREMER in France. Its objectives are to provide research-based advice to the governing authorities for rich and clean seas and coastal areas, and to ensure long-term sustainable fisheries and aquaculture with minimum negative impact on the ecosystem. The Norwegian Marine Data Centre is located at IMR; this is responsible for providing marine observational data on-line, in nearly real-time.

Oceanography, one of 19 discipline-based research groups within IMR, is the focus of this evaluation. The Oceanography group also includes 4 biologists (3 researchers and 1 post-doctoral fellow) whose work is not considered here. Research within the Oceanography group is cross-disciplinary, ranging from physical oceanography to marine ecology. Activities include: operational oceanography with a focus on monitoring and hydrographic observations underpinning time-series of data going back to the 1930s; regional physical modelling, mostly hindcasting using community modelling tools; biophysical and ecosystem modelling; the effects of climate change on marine ecosystems; and the transport of pollutants from petroleum operations. A new initiative, which commenced in 2010, focuses on ocean acidification. The group is also involved in research and teaching in developing countries, including the recent establishment of the Nansen-Tutu centre in South Africa.

Research projects are undertaken within 10 different research programmes and manpower is allocated according to a matrix-management type of approach. Each programme is headed by a senior scientist who acts as programme leader. Resources are allocated directly to the programmes. Each researcher may work on several projects in different programmes. They have a strategic planning process for their research activities; the next planning period runs from 2012-2017.

OVERVIEW ASSESSMENT

IMR has a strong and modern infrastructure for its research. They own three major research vessels and operate another three; in addition they also have a number of small boats for near-shore and fjord work. Working conditions are good and most researchers have permanent positions. The funding environment appears to be fairly stable at present. There are no recruitment issues; most of the researchers are of Norwegian origin. Female researchers appear to be under-represented, although a recently-established sub-group at IMR Tromsø is predominantly female. Some 25% of their senior staff will approach retirement age in the next few years which may create some skills shortages, but also provides an opportunity to invest in new staff with different research expertise. Researchers are encouraged to spend time at other research institutions but this is not often done.

There is a strong focus on operational activities in response to the needs of the Norwegian fisheries and aquaculture industries. This limits the amount of time researchers have for independent "blue skies" research and for writing publications. Their work is of high societal value and importance for Norway, particularly studies on the acidification of the ocean, modelling of the dispersion of oil spills and the dispersion of eggs and larvae of pelagic biota.

IMR staff in oceanography have established good international networks of research collaborators and have a high visibility internationally. Their most important collaborations are with the *International Council for the Exploration of the Seas* (ICES) and their sister institutes in other European countries, Russia, Canada and the USA. IMR contribute state-of-the-art data to the ICES programme, which are particularly important for climate change research; they provide some important time-series data for volume and heat transport, hydrographic measurements in the Nordic Seas and in the Norwegian coastal regions. IMR participate in the international ARGO float project.

The group is a partner in the Bjerknes Centre for Climate Change Research (BCCR) at the University of Bergen (UiB); this has strengthened climate research within the group and enabled connections with the wider climate research community. IMR also has good links with the oceanography group at the Geophysical Institute (UiB) and in operational oceanography collaborates with met.no, the Nansen Centre and the Norwegian Institute for Water Research. It is a partner in the Bergen Marine Research Cluster and in the *FRAM Centre for Climate and Environment* in Tromsø. IMR also has good industrial collaborations with manufacturers of oceanographic instrumentation and the Norwegian petroleum industry.

Publication rates are average, with average citation levels.

The research undertaken at IMR is largely driven by its major stakeholder, the Norwegian Ministry of Fisheries and Coastal Affairs. This is reflected in a recent switch in research capacity away from open-ocean to coastal oceanography, including high-resolution operational modelling of fjords, in response to the needs of the Norwegian aquaculture industry. As a consequence, the oceanography group has a strong service role, providing valuable data and their interpretation for fisheries and aquaculture management; this limits the time available to do innovative, internationally-leading research. Nevertheless, they play an important role in maintaining long-term time series of data on the marine environment and ecosystems in the Norwegian Sea, North Sea and Barents Sea which is essential for the international oceanographic and climate change community.

OVERALL GRADE: 3-4

RECOMMENDATIONS

The number and impact of their publications needs to be improved, e.g., supported by a weekly seminar programme and by including time for writing publications in their research proposals. Strengthening the research collaboration with the Geophysical Institute, UiB (both the small scale oceanography and coastal research as well as the large-scale oceanography group) could encourage more joint supervision of PhD students.

5.9 Nansen Environmental and Remote Sensing Center, Bergen

KEY METRICS	Total	
No. of Researchers	18	
No. of Professors	4	
No. of Professor II	3	
No. of Adjunct Researchers	7	
No. of Doctoral students: current	12	
No. of PhD students graduated 2007-2009	13	
No. of MSc Students graduated 2007-2009	5	
No. of Postdoctoral Research Fellows	9	
No. of Technical/Admin. Staff members	12	
Research Groups	**GRADE**	
1. Marine Remote Sensing	**3-4**	
2. Ocean & Sea Ice Modelling	**3-4**	
3. Climate Studies & Modelling	**3-4**	

The Nansen Environmental and Remote Sensing Center (NERSC) was established in 1986 as a non-profit research foundation affiliated with the University of Bergen (UiB). Its aim is to conduct interdisciplinary research and development with a focus on remote sensing and modelling with respect to scientific problems within the natural sciences. NERSC is one of the four partners in the Norwegian Centre of Excellence *Bjerknes Centre for Climate Research* (BCCR) in Bergen. It has interdisciplinary expertise in ocean, cryosphere and atmospheric research, satellite remote sensing, modelling and data assimilation, and climate research on regional to global scales.

Between 1992 and 2010 NERSC set up an international Nansen Group of research institutes in Russia, India, China and South Africa. These faciliate an international exchange programme of scientists, post-doctoral researchers and PhD students.

The research strategy of NERSC was revised and updated in 2010 with the current vision statement: ”*To serve society through advancing knowledge on the behaviour of the marine environment and climate system in the spirit of Fridtjof Nansen*”.

There is now a focus on 5 research areas:

- Climate variability and change
- Climate process research
- Marine remote sensing
- Ocean modelling, data assimilation and forecasting
- Socio-economic impact of global change

Since January 2010 the Center has been divided into 4 research Departments: Polar & Environmental Remote Sensing; the Mohn-Sverdrup Center for Global Ocean Studies and

Operational Oceanography (established in 2004); the G.C.Rieber Climate Research Institute (established in 1996) and the Nansen-Bjerknes Center Group. Each Department is led by a Research Director. The Nansen-Bjerknes Center group was established to integrate operational ocean modelling, data assimilation and satellite remote sensing with Earth System modelling for climate predictions.

For the purpose of this evaluation the scientific staff have been divided into three research groups:

1. Marine remote sensing, including physical and biological oceanography and cryosphere studies
2. Ocean and sea ice modelling and data assimilation, including physical and biological oceanography
3. Climate studies and modelling, including both oceanography and meteorology

NERSC depends completely on external project funding and some private donations for financial support; it currently does not receive any public basic funding. From 2005-2009 some 70% of its funding was from Norwegian sources (~50% RCN; 17% Norwegian industry), the other 30% was from international sources (e.g. EU Framework Programme, ESA).

NERSC makes a significant contribution to the education of Masters and PhD students in Earth Sciences, mainly in collaboration with UiB. It has also supported a large number of international Doctoral students as part of a Nansen Fellowship programme.

OVERVIEW ASSESSMENT

The Evaluation Committee (EC) found it difficult to understand the organisational structure of NERSC. It is not clear how the 5 new research areas map on to the 4 Departments and how staff within the 3 new research groups are actually deployed. The Mohn-Sverdrup Centre and G.C. Rieber Research Institute clearly have historical reasons for their establishment, but the reason for maintaining their distinct identities does not seem obvious from an external viewpoint. The EC recognises, however, that because of the project-based nature of NERSC research funding, the main function of the Departments is to allocate personnel to projects.

Their activities include both highly-valued, operational research to support the national and international scientific community, and basic and applied research. These include the development of fundamental methods in data assimilation and new remote-sensing algorithms for ocean current, improved sea ice and ocean colour retrievals. They have developed new fundamental mathematical and numerical models for atmospheric boundary layer problems, including modelling of pollution in megacities. Most of their products are made freely available to the research community. There seems to be a strong focus on data gathering and synoptic mapping, which they do extremely well. The work they are doing in many different aspects of remote sensing is extremely important to the international scientific community; however it is not clear to the EC in which areas they are actually internationally leading.

The establishment of the Nansen Centres in Russia, China, India and South Africa is highly innovative and has provided important training opportunities for a large number of

international doctoral students and early career researchers. These centres have a strong philanthropic element, but have also brought beneficial research collaborations.

The quality of their research publications is somewhat variable, and numbers of publications are on the low side; nevertheless, a number of their outputs have had high international recognition, receiving significant numbers of citations.

The international research profile of NERSC is evident in terms of the substantial number of EU grants they have coordinated (41) and participated in (~100) since 1990, in addition to over 57 ESA projects.
All three research groups are working in important national and international research fields, providing data sets from remote sensing relevant for monitoring climate change, and ocean and sea-ice forecasting. They have positioned themselves well for future EU programmes, and are actively trying, within two of the three groups, to make more focused research efforts in the Arctic and Antarctic to play more to their strengths and to their unique capabilities. They cooperate well with other partners in Bergen.

NERSC have a strong network of international partners, predominantly within Europe, but also in Russia, China, India and South Africa via the Nansen Group. Nationally there appears to be good collaborations with met.no, IMR and the Geophysical Institute and Department of Mathematics, UiB. NERSC senior scientists sit on a number of international expert and advisory bodies within the field of satellite remote sensing, climate studies and operational oceanography and play a leading role in European organisations e.g. ESA, ESF, European Climate Forum. NERSC is a major partner in EuroGOOS; this is an international organisation, with members from the major European meteorological and oceanographic institutions, whose aim is to develop and coordinate ocean monitoring and forecasting in European and Arctic waters as part of the Global Ocean Observing System (GOOS) programme.

There is a modest level of collaboration with Norwegian and international oil companies and more recently with offshore windfarm developers, resulting in some research funding; industrial endowments have supported some long-term basic research.

Until 2010, and spanning the period of this review, NERSC has had strength and continuity of leadership by the founding Director for almost a quarter of a century. The challenge for the new leadership is to develop a core group of senior leaders to drive strategy development and to lead grant proposals. The 2010-2015 strategic plan clearly identifies the key research challenges. However, since they lack core funding they have to be somewhat opportunistic about the types of funding they apply for. This may make it more difficult for them to be strategic in driving their research agenda.

The research staff of NERSC are international and ~ 36% female. There is a fairly high level of staff turnover, reflecting the lack of permanent positions, and some challenges in recruiting suitably qualified Norwegian staff. Staff are given opportunities to make research visits to other Nansen Group centres or to other institutions internationally; however, these are taken up infrequently. NERSC does, however, host a large number of international visitors each year.

RECOMMENDATIONS

NERSC needs to consider its current (2010-2015) and future strategic plans carefully, in the context of an extremely challenging external funding environment, focusing on their research strengths and those areas in which they are internationally leading.

More attention needs to be given to developing research leaders of the future in order to ensure that their activities remain at the forefront.

Some simplification of the organisational structure would be beneficial in the longer term.

More staff mobility should be encouraged.

5.9.1 Marine Remote Sensing

The group consists of 3 Professors*, 2 Professor II, 8 Researchers, 3 Adjunct Scientists, and 2 post-doctoral fellows. [*some divide their time between two research groups and are reported in both].

This is a multi-disciplinary group, with expertise in satellite remote sensing, ocean acoustics, signal processing, electromagnetic radiation physics, sea ice physics, oceanography, boundary layer meteorology, air-sea-ice interaction and information technology for the management and dissemination of satellite data. Their main focus is on the development and validation of retrieval algorithms for satellite ocean and sea ice parameters, for use in studies of upper layer mesoscale ocean processes, air-sea-ice interaction and climate change, as well as operational oceanography. The group also uses Synthetic Aperture Radar (SAR) for sea ice studies. Research on direct surface velocity retrievals from SAR is conducted in collaboration with colleagues from Nansen Russia (NIERSC) and France (IFREMER, CLS). The group has developed satellite remote sensing techniques for studying algal blooms, water quality and primary marine production in coastal, oceanic and Arctic waters. Studies have also focused on algorithm development and validation of mean dynamic topography, sea surface salinity and sea ice thickness from recently launched ESA satellites (GOCE, SMOS and Cryosat 2). Daily data products are disseminated via the web on e.g., algal blooms and Arctic sea ice extent. They have developed web-based GIS systems to integrate remote sensing and model data as open-source products.

The group has a strong interest in the changing sea-ice cover in the polar regions. They currently lead an RCN-funded infrastructure project " *Norwegian Satellite Earth observation database for marine and polar research (NORMAP)*" in collaboration with met.no, Kongsberg Satellite Service AS and the French CERSAT (IFREMER). They have also started to develop an acoustic tomography system for monitoring ocean temperature and currents in the Fram Strait which can be used to validate ocean models. NERSC is a partner in the Svalbard Integrated Arctic Earth Observing System (SIOS).

The research of this group is highly regarded internationally. They have established a good network of international collaborators.

Their publication record is not very strong in terms of numbers of publications, but their outputs are in good journals and receive slightly higher than average numbers of citations.

OVERALL GRADE: 3-4

5.9.2 Ocean/Sea Ice Modelling and data assimilation

The group consists of 2 Professors*, 5 Researchers, 2 Adjunct Scientists and 2 post-doctoral fellows. [*some divide their time between two research groups and are reported in both].

Their research supports the development of operational oceanography related to the monitoring of the marine environment, marine resources and marine safety, as well as the production of weather and seasonal climate forecasts, including sea-ice state. Their main activity relates to the development of the TOPAZ ocean forecasting system for the North Atlantic and Arctic oceans. TOPAZ is used operationally in the North Atlantic and Arctic Oceans as part of the European GMES Marine Core Services of MyOcean, and also by the European Centre for Medium Range Weather Forecasting (ECMWF). NERSC has transferred TOPAZ to met.no for exploitation in its operational suite of forecasting tools. The group is also developing a NERSC version of the advanced community ocean model HYCOM for application to different oceans.

The work of this group is internationally leading within the field of operational oceanography. They have established a good network of international collaborators.

Their publication record is slightly above average in terms of numbers of publications, but with only modest citation levels. Their publications tend to be in lower profile journals, reflecting the operational focus of much of their research.

OVERALL GRADE: 3-4

5.9.3 Climate Studies & Modelling

The group consists of 2 Professors*, 1 Professor II, 5 Researchers, 3 Adjunct Scientists and 5 post-doctoral fellows. [*some divide their time between two research groups and are reported in both].

They play a leading role in Norwegian and international high-latitude research and actively contribute to the work of BCCR. Their expertise includes climate modelling (Norwegian Earth System Model (NorESM), Bergen Climate Model (BCM) and ocean circulation models). They maintain a time series of data for surface air temperature N of 40° N from 1900 and a high quality ocean database of T, salinity and O_2 since 1900 for the Nordic Seas, North Atlantic and Arctic Oceans. Their research has contributed significantly to studies of the Atlantic Meridional Overturning Circulation, to understanding changes in oceanic circulation related to changes in atmospheric CO_2 and to changes in Arctic sea ice, the Greenland ice sheet and global sea level. The group makes extensive use of satellite Earth Observation data.

The research of this group is internationally leading.

Their publication record is average in terms of numbers of publications, but with higher than average citation rates. They publish in some of the leading international journals, including *Science* and *Nature*.

OVERALL GRADE: 3-4

5.10 Geological Survey of Norway, Trondheim

KEY METRICS	Total	
No. of Researchers	28	
No. of Senior Researchers (= Professor)	22	
No. of Doctoral students: current	0	
No. of PhD students graduated 2007-2009	4	
No. of MSc Students graduated 2007-2009	10	
No. of Postdoctoral Research Fellows	4	
Research Groups (Geoscience Division)	**GRADE**	
1. Bedrock geology and crustal processes	**3-4**	
2. Continental shelf geophysics	**3-4**	
3. Environmental Geochemistry	**3-4**	
4. Geodynamics	**5**	
5. Geohazards	**3-4**	
6. Quaternary Geology & Climate	**3-4**	
7. Tectonics & Landscape Evolution	**3**	

The Geological Survey of Norway (NGU) is a government agency under the Ministry of Trade and Industry, dedicated to the provision of knowledge about Norway's bedrock geology, mineral resources, superficial deposits, geohazards, environmental pollution and groundwater. Its major aim is to ensure that such geological knowledge is used for the efficient and sustainable management of the nation's natural resources and environment, as reflected in the NGU vision statement "*Science for Society*". NGU's remit does not include Norway's hydrocarbon-bearing strata which are under the umbrella of the Norwegian Petroleum Directorate (NPD). NGU has over 200 employees of whom 65-70% are scientists.

NGU's core activities include geological mapping and the management of geological data in the national interest; however there is also a substantial component of underpinning research activity. From the early 1990s NGU has also carried out mapping and capacity-building projects overseas, including within Africa. However since 2007 this work has been scaled back due to greater domestic demand. Mapping activities are now mostly confined to northern Norway.

NGU has an annual planning process and a longer-term strategic plan, although this was not clearly articulated in the submission.

Research projects may be funded partly or wholly by NGU, RCN, industry or other partners. Currently some 30% of the research activities are funded from non-government sources e.g., RCN, EU, ESF and industry. The NGU basic data are typically made freely available to the community for research and information purposes, unless restricted by the organisation commissioning the work. NGU also leads a number of large, high-profile projects with national and international partners.

Research is carried out within the Geoscience Division, which is organised into 13 research teams (groups). This organisational structure was established in 2004. Each team has a team leader who is responsible for the management of tasks assigned by the NGU management team and for strategy development. Individual projects may involve members from different teams. Each research team has an annual goal for outputs e.g., reports, information for the NGU web site, and peer-reviewed papers. Overall leadership for NGU's programme of research is provided by a senior management team of six Directors who determine the budgets and manpower for individual research projects proposed by the teams.

NGU is a partner in the Norwegian Centre of Excellence (CoE) *International Centre of Geohazards*, and has strong links with other CoEs e.g., *Physics of Geological Processes* (PGP), University of Oslo.

There is an internal, merit-based promotion system enabling staff to reach a grade (Code 1183) equivalent to a Norwegian university professor. A number of the senior research staff at NGU have Professor II positions at various universities in Norway, contributing to the supervision of both PhD and Masters students. Research staff have the possibility for sabbatical leave, either in Norway or internationally.

OVERVIEW ASSESSMENT

The Evaluation Committee notes that out of 13 research groups (teams) only 7 were put forward for this evaluation. These 7 groups only partly correspond to those in the NGU Organisational Chart provided; for example the chart does not include a "Tectonics and Landscape Evolution" team. The Evaluation Committee notes that NGU's research in mineral sciences, marine geology, applied geophysics, aggregates and gravel, and groundwater was not included in their submission.

The various research teams considered as part of this evaluation seem productive and highly motivated, operating to high scientific standards. They have access to well-equipped analytical and other laboratories and high-technology systems for field deployment (e.g. LIDAR scanning). The teams are of varying size and research activity is distributed somewhat unevenly between them.

NGU has good links internationally, particularly so within the group of European geological surveys (EuroGeoSurveys) and the United States Geological Survey (USGS). It has formal collaborative links with other Arctic countries, including Russia and Canada, and with China and South Korea. NGU is widely recognised as one of the leading geological surveys in the world, along with the USGS and the British Geological Survey (BGS).

They have a very active publication strategy and publish their own scientific journal (NGU Bulletin) and thematic series of papers or monographs (NGU Special Publications), in addition to geological maps. In the past the emphasis was more on reports, whereas now the emphasis is on peer-reviewed scientific publications in leading international journals. Numbers of publications have increased considerably during the last 3 years. Publication rates vary significantly between the different groups considered in this evaluation, from below average for Geohazards (though in journals with a strong profile and good citation rate), to above average for most other groups, with the highest rates for Geochemistry and Geodynamics. The Geochemistry group, however, publish in journals with fairly low citation rates and below average profiles, whereas the Geodynamics group publishes in high impact journals with a very good profile.

The NGU funding situation appears to be becoming more challenging, with decreased core funding from Government and the ending of programmes such as the International Polar Year (IPY) and Petromaks which provided a stimulus for research activity. RCN funding peaked in 2008 and is now back to 2005 levels. This reduced level of funding limits their ability to replace infrastructure and may require a scaling-down of some activities. At the same time there is an increasing demand for the expansion of activities to support mineral exploration.

The amount of time available for ”basic research” is limited because of the need to focus on specific projects required by the Survey. Much of their research is of an ”underpinning” nature, required to support the main mission of a geological survey with the exception of that of the Geodynamics group.

RECOMMENDATIONS

The Evaluation Committee strongly recommends that NGU reconsiders its organisational structure. The research groups need to be simplified and better defined. It is not clear why there are so many individual groups. There should be an alignment between the organisational structure described on the NGU web site and that used operationally. A proper matrix management system should be re-introduced.

A more transparent 4-5 year strategic planning process would be beneficial.

In recent years, internationally, there has been a trend towards reducing the focus on bedrock mapping and hard-rock geology research within national geological surveys; this strategy has recently been challenged by the upsurge in interest in mineral resource exploration, particularly for the Rare Earth elements. NGU needs to expand its capabilities in this area of research strategically and to convince both RCN and Government of the need for increased research funding. They also need to maintain their competence in geochronology (e.g., Ar-Ar, Fission-Track) as this is in decline nationally in the university sector.

5.10.1 Bedrock geology and crustal processes

The group consists of 7 Senior Researchers, 2 Researchers and 3 post-doctoral researchers. Three group members have Professor II positions at other Norwegian universities (Bergen, Trondheim, UNIS). There have been a significant number of retirements since 2005, possibly leaving the group with a sub-critical mass.

This is a multi-disciplinary group with expertise in igneous and metamorphic petrology, sedimentology, structural geology, geochemistry and geochronology. A substantial proportion of their work involves bedrock mapping, structural mapping and GIS based map production; such activities are the core business of a geological survey. The group includes the editors of the two main geoscience journals in Norway: the *Norwegian Journal of Geology* and the *NGU Bulletin*.

They have a diverse research programme, including the evolution of mountain belts and tectonic and metamorphic processes in the deep crust, with a focus on the Arctic. This is one of the few groups in Norway that still does this kind of research. Nationally, there are good collaborations with the universities of Oslo, Bergen, Trondheim and UNIS. International collaborators include the USA, Australia, Belgium, Czech Republic, Estonia, Russia, France and Germany. High profile international projects include a FRINAT-ICDP project (FAR-DEEP) on the emergence of an aerobic Earth and a project on Re-Os isotopic tracing of

hydrocarbon systems in the Arctic, in collaboration with Colorado State University in the USA and SINTEF.

Their publication record is good, with a high number of publications in leading journals, although with relatively modest citations.

OVERALL GRADE: 3-4

5.10.2 Continental shelf geophysics

The group consists of 2 Senior Researchers, 4 Researchers, 1 post-doctoral researcher and 4 Doctoral students. The PhD students are supported via a Professor II position at NTNU.

This group may be considered to be at the fore-front of their field of research in Norway. Operationally their main role within NGU is to maintain the national gravity, aeromagnetic and heat flow databases; consequently, much of their research has a strong focus on improving data quality and on the interpretation of these data. They integrate data from various geophysical methods, including potential field, seismic reflection and heatflow, to provide the petroleum industry with an improved assessment of the most favourable parts of the Norwegian continental shelf for exploration. Projects include: numerical modelling of the thermal structure on the continental shelf and onshore mainland Norway, sub-basalt imaging, studies of intra-cratonic basins (e.g., Barents Sea, West Siberian Basin), the nature of the Jan Mayen microcontinent and the impact of neotectonic deformation on offshore sedimentary basin evolution and hydrocarbon maturation.

Nationally they have good collaborations with the universities of Tromsø and Trondheim, and also with NORSAR and SINTEF. Internationally they collaborate with a wide range of European partners in the Netherlands, Germany, Denmark, Sweden, UK, Switzerland, France, Italy and the USA.

Their research projects are funded by a number of international petroleum companies, including BP, ConocoPhillips, Chevron, Shell, Statoil, Total, and Wintershall, and also by RCN (Petromaks programme) and the NPD. The group participates in the ESF funded project *Topo-Europe* and is involved in the development of drilling proposals for the IODP.

Their publication rates are relatively high, but with lower than average citations and in fairly low profile journals

OVERALL GRADE: 3-4

5.10.3 Environmental Geochemisty

The group consists of 2 Senior Researchers and 5 Researchers.

This is a well known group within the field of environmental geochemistry, working on a wide range of projects related to the geochemistry of soils, stream and marine sediments; their research includes the distribution of toxic chemicals (e.g. PCBs) in the environment and their impact on human health. They have been studying the geochemistry of urban soils in

collaboration with the Norwegian Institute for Public Health and this project, led by NGU, has now been extended to 13 major European cities. The group is also involved in a national project (Mareano) to map polluted marine sediments in offshore Norway, in collaboration with the Institute for Marine Research (IMR) in Bergen. They also co-lead a project to study overbank sediments from the 26 largest rivers in the world.

The group has established an extensive network of collaborators within other European geological surveys and the USGS, and also with research institutes in Austria and the Czech Republic, by participating in multi-national soil mapping projects. It also has research links with groups in Russia, Australia, China, India and Germany. Nationally they have strong links with NTNU, NILU, NVE and IMR.

Their work is highly applied with a strong focus on data collection and synthesis to produce maps of environmental pollution. This kind of high quality applied research and monitoring is exactly what would be expected of a leading geological survey and the Evaluation Committee recognises its importance.

Publication outputs are fairly high, but mainly in low impact journals; citations are relatively low, reflecting their rather specialised, and highly applied, field of research.

OVERALL GRADE: 3-4

5.10.4 Geodynamics

The group consists of 6 Senior Researchers (3 of whom hold Professor II positions at the University of Oslo and 1 is a full Professor at UiO with a 20% Senior Researcher role at NGU), 5 post-doctoral fellows and 2 Doctoral students.

The Geodynamics group is one of the leading groups in the world in this research field. They study the dynamics of the Earth's crust and mantle at various scales, mapping past plate motions and attempting to understand the fundamental underlying processes that drive plate motions. Members have a diverse range of expertise including paleomagnetism, mantle flow and lithosphere, deformation modeling, marine geophysics, structural geology, geochronology, plate tectonics modeling and data visualisation. Members of the group have a long track record in the field of plate tectonic reconstructions, made with visualisation software developed in collaboration with the California Institute of Technology (Caltech, USA) and the University of Sydney (Gplates) and with the hydrocarbon industry (Splates). The Gplates visualisation tool has brought them widespread international recognition.

Within Norway they have strong research collaborations with the CoE *Physics of Geological Processes* (PGP) in Oslo; indeed, following a recent unsuccessful attempt to establish their own CoE within NGU, some research staff have recently left NGU to join the University of Oslo. The Evaluation Committee has some concerns that this might weaken the current research group within NGU. They have a very strong network of international academic collaborators including Caltech, Sydney, Massachusetts Institute of Technology (MIT), Utrecht, GFZ Potsdam, Bern and Michigan.

The publication record of the group is extremely impressive, with a high number of outputs and high numbers of citations. Publications are in high impact journals, including *Science* and *Nature.*

OVERALL GRADE: 5

5.10.5 Geohazards

The group consists of 4 Senior Researchers, 9 Researchers and 1 post-doctoral researcher. They appear to sit outside of the formal NGU organisational team structure and their research is conducted within projects managed by the *Landslide* team, the *Marine Geology* team and the *Bedrock Excavation and Applied Geophysics* team.

This is a large, multi-disciplinary research group whose main focus is on the societally relevant problem of predicting where and when hazardous landslides and rock avalanches will occur, including those into fjords which may subsequently trigger tsunamis. They combine skills in onshore and offshore engineering geology, geophysics, sedimentology, structural geology, geomorphology, Quaternary geology, and geochronology. Their emphasis is on the production of local and regional hazard maps, and associated underpinning research, based on the most up-to-date scientific knowledge and monitoring technology. The methods they use include electrical resistivity profiling and satellite-based InSAR for rapid mapping, monitoring of active slide locations, and cosmogenic nuclide dating of rock surfaces. They are well equipped with the latest technologies for 3-D mapping (e.g. LIDAR, differential GPS). Whilst some of their work relates to the relationship between seismic hazards and landslide hazards, the group lacks significant expertise in seismology. They also lack expertise in geomechanical modelling.

NGU is a member of the CoE *International Centre for Geohazards* (ICG), focusing on the stability of rock slopes. The research of the geohazards group is mainly carried out through the activities of the ICG. Within Norway, the Norwegian Water and Energy Directorate (NVE) has the national responsibility for landslide hazard mapping and the two organisations work closely together. NGU leads the *GeoExtreme* project focusing on future changes in landslide and avalanche frequencies in Norway linked to climate change. The group has a good network of national collaborators including NGI, SINTEF, met.no, CICERO, and the universities of Bergen, Tromsø, Oslo and UNIS. They work closely with the Norwegian offshore hydrocarbon industry on projects related to the safe development of oil and gas fields. Internationally, there are fairly extensive collaborations with other landslide hazards groups within Europe (e.g. Lausanne, ETH Zurich and the UK) and the Geological Survey of Chile/University of Chile. They participate in the EU funded *SafeLand* project on landslide risk in Europe in collaboration with 25 institutions from 13 European countries.

Research outputs are significantly below average with relatively low citations. In part, this is a reflection of the highly applied nature of their research.

OVERALL GRADE: 3-4

5.10.6 Quaternary geology & climate

The group consists of 3 Senior Researchers and 4 Researchers. Two group members have Professor II positions at NTNU and the University of Bergen.

This group is responsible for the Quaternary mapping programme in Norway. Their approach is holistic and they employ state-of-the-art techniques for 3-D mapping (georadar, seismics and resistivity). The group includes specialists in Quaternary geology, physical geography, geomorphology, sedimentology and marine geology. Their research focuses on surface processes, landscape development (both glacial and non-glacial) and the sedimentary record of climate change, mainly within northern Europe and Russia, including Svalbard and Greenland. There is a strong emphasis on understanding high-latitude landscape and climate development from the study of both onshore and offshore Quaternary deposits. They also work on the relationship between glaciation and the uplift history of the petroleum systems in the Barents Sea and North Sea.

Their long-term vision is to become a leading national/international group in Quaternary Geology, with the goal of understanding northern hemisphere pre-glacial, glacial and post-glacial landscapes, both on and offshore, through space and time. They propose to combine surface geological mapping, remote sensing, lake and shallow marine drilling, and 3-D seismic mapping in an integrated approach. Whilst the group has the necessary broad range of expertise, the Evaluation Committee notes that their strongest publications are in marine geology and has some concern that, without strategic investment in new positions, their vision for the future might be overly ambitious.

Group members have lead a number of research projects funded by RCN, the ESF, the EU and various industry partners, including Statoil. They were a partner in the RCN International Polar Year (IPY) project *SciencePub,* aimed at advancing knowledge on climate and environmental change in the Arctic. They have established good national collaborations with the universities of Tromsø, Bergen, Trondheim and UNIS, and internationally with groups in the USA, Canada, Russia and a number of European countries (e.g. UK, France, Netherlands, Germany)

Their research outputs are average with relatively modest citations.

OVERALL GRADE: 3-4

5.10.7 Tectonics and landscape evolution

The group consists of 5 Senior Researchers, all of whom are also affiliated with other groups, 3 PhD and 3 Masters students. They describe themselves as an independent group which is not part of the formal NGU team structure.

Their research is cross-disciplinary, combining skills in onshore and offshore tectonics and structural geology, geochronology, geomorphology, bedrock geology, seismic interpretation and landslide research. This is predominantly field based, complemented by the use of leading-edge technologies such as InSAR and LIDAR scanning. Their main emphasis is on the long-term evolution of passive continental margins, with a focus on the onshore and offshore parts of the Scandinavian continental margin as an integrated system. They address fundamental questions related to the uplift of passive margins, the influence of extensional

faulting on erosion and landscape formation and the effects of inherited structure on the distribution of geohazards. Their work has important applications within the hydrocarbon industry and in geohazards evaluation and local planning.

The scientific questions addressed by the group are interesting. However, it was unclear to the Evaluation Committee what the rationale was for setting up another group outside of the formal NGU structure. Many of their research activities overlap with those of other NGU groups.

Their research outputs are slightly below average in terms of numbers of publications, with average citations; publications are in relatively low profile journals.

OVERALL GRADE: 3

5.11 SINTEF Petroleum Research, Trondheim

KEY METRICS		
No. of Senior Researchers	6	
No. of Researchers	6	
No. of Doctoral students: current	6	
No. of PhD students graduated 2007-2009	4	
No. of MSc Students graduated 2007-2009	9	
No. of Technical/Admin. Staff members	3	
Research Groups	**GRADE**	
1. Formation Physics Department	**3-4**	

The SINTEF Group is a non-profit research foundation performing contract research and development for industry and the public sector. It is the largest independent research organisation in Scandinavia. SINTEF is structured into several research divisions, of which only part of the work of SINTEF Petroleum Research AS is considered here; this is a limited company (since 1985) which is wholly owned by the SINTEF foundation.

SINTEF Petroleum Research AS is sub-divided into 6 departments, of which only the *Formation Physics* department is considered as part of this evaluation. The Evaluation Committee notes that two other departments, *Basin Modelling* and *Seismic and Reservoir Technology*, could also have been submitted for evaluation and indeed appear to conduct more geoscience research than *Formation Physics*. These departments chose not to be evaluated.

SINTEF is a project-based organisation; projects can be of variable size from 100 kNOK to tens of millions of NOK, funded by end user ”clients”, the majority of whom are from industry. Individual projects are managed according to standard industry practices. Their main customers are national and international oil companies.

5.11.1 Formation Physics

The group consists of 1 Research Director, 1 Chief Scientist, 6 Senior Scientists, 6 Research Scientists, 2 Senior Project Managers, 1 Civil Engineer and 6 Doctoral students. Two of the senior scientists have 50% positions in universities (NTNU and the Aristotle University of Thessaloniki, Greece) and another has a Professor II position at NTNU.

Research within *Formation Physics* mostly concerns petroleum-related rock mechanics, involving both experimental studies and numerical simulation and modelling. Their goal is to make a major contribution to solving the exploration and field development challenges encountered by the petroleum industry. Emerging research areas include CO_2 sequestration, shale gas production and enhanced oil recovery.

Their research is highly applied and involves both single sponsor projects (10-20%) and Joint Industry Projects (JIPs) in which there is active collaboration with the industrial partner(s).

The latter allow more fundamental, long-term research. JIPs account for some 60-70% of their funding. Some base-level funding is provided by RCN (4-5% of budget).

Research is conducted in close cooperation with the Departments of *Petroleum Technology and Applied Geophysics* and *Physics* at NTNU, which are co-located on the same campus. The close links with NTNU provide opportunities for both Doctoral and Masters students to work in the SINTEF laboratories, and to gain useful experience of working at the interface with industry.

Recruitment to new positions is generally good, although there are some difficulties in finding good Norwegian candidates because of the opportunities for better paid jobs in the hydrocarbon industry. Researchers are provided with opportunities to spend sabbatical time in other laboratories, both nationally and overseas.

OVERVIEW ASSESSMENT

Overall this appears to be a well-funded group with a good working environment. They have excellent laboratory facilities, equipped to the best international standards, although some facilities do need upgrading. They are clearly doing internationally-leading applied research of high relevance to the hydrocarbon industry; their great strength is in the combination of observational data, from both field and laboratory, with theory, modelling and simulation.

Their national and international collaborations with other universities and research organisations are, unfortunately, not particularly strong. Existing high-profile links include those with TNO (Netherlands), IFP-EN (France) and the Aristotle University of Thessaloniki (Greece).

Publication rates are very low, with low numbers of citations; they tend to publish in below-average impact journals. Their main outputs are confidential contract reports for industry. The number of journals in which they can publish is limited, to a significant extent, by the highly applied hydrocarbon industry focus of their work. In addition, their opportunities to publish are constrained by the confidential contract research nature of much of the work which they undertake.

OVERALL GRADE: 3-4

RECOMMENDATIONS

Formation Physics clearly wish to have more time for more basic ”blue-skies” research, which would enable them to be more competitive for RCN and EU funding. To do this they need a strategy to create a more balanced funding portfolio, whilst maintaining the fundamental applied nature of their research mission. In order to do this they have to improve their publication strategy, which will require a major culture shift in the department. Staff need to be given appropriate incentives to publish.

Given that some 60-70% of their current funding comes from JIPs, it appears that they probably have much material which could form the basis of leading-edge publications, without the restrictions of confidentiality agreements. They need to evaluate what new data/ideas/models they already have and to provide their researchers with the necessary time to write papers within their workloads.
Improving their national and international networks of collaborators is essential if they wish to raise their academic profile.

5.12 Norwegian Polar Institute, Tromsø

KEY METRICS	Total	
No. of Senior Researchers	4	
No. of Researchers	14	
No. of Professor II	1	
No. of Doctoral students: current	5	
No. of PhD students graduated 2007-2009	5	
No. of MSc Students graduated 2007-2009	4	
No. of Postdoctoral Research Fellows	11	
No. of Technical/Admin. Staff members	4	
Research Groups	**GRADE**	
1. Geomapping	**NOT GRADED**	
2. Polar Climate		
2.1 Marine Geology sub-group	**4**	
2.2 Oceanography sub-group	**1-2**	
2.3 Atmospheric Science sub-group	**NOT GRADED**	
2.4 Glaciology sub-group	**3-4**	
2.5 Sea-Ice Physics sub-group	**1-2**	

The Norwegian Polar Institute (NPI), established in 1928, is dedicated to scientific research, mapping and environmental monitoring in the Arctic and the Antarctic regions. The institute advises various Norwegian authorities on matters concerning polar issues, and is Norway's competent environmental authority in Antarctica. It is a directorate under the Ministry of the Environment. The Ministry defines the scope of its research activities.

NPI has grown rapidly in recent years as part of the Government's strategic initiatives in the High North. Its Head Office in Tromsø is located in the new FRAM Centre – the *High North Research Centre for Climate and the Environment*. The Fram Centre hosts some 500 scientists from 19 institutions (including NPI) involved in interdisciplinary research in the fields of natural science, technology and social sciences.

The main research activities of NPI include monitoring of climate change, environmental pollutants and biodiversity, and geological and topographic mapping. There is a strong emphasis on fieldwork and data collection e.g., ice core drilling in the Arctic and Antarctica, and measurements of sea ice thickness in the Arctic Sea. The Institute equips and organises major expeditions and owns a research vessel, the RV *Lance*.
NPI is divided into four departments, one of which is the Research Department. The Research Department has, since 1998, been divided into 4 sections: *Polar climate* (including discipline-based sub-groups in marine geology, oceanography, atmospheric science, glaciology and sea-ice physics), *Biodiversity*, *Ecotoxicology* and *Geomapping*. Only the *Polar Climate* and *Geomapping* sections are included within this evaluation. A *Centre for Ice, Climate and Ecosystems (ICE)* has recently (2009) been created as part of the Institute to intensify research on climate and ecosystems in the polar regions, especially in the north. One of the aims of ICE is to strengthen NPI's position as a stakeholder in climate-related research,

including ice, sea-ice, alpine glaciers and the effects of climate change on high-latitude ecosystems.
As a Government institution NPI receives substantial base-level funding to support its research activities. This funding supports a large environmental monitoring programme, involving long time-series of observational data. NPI has recently been given a substantial increase in its permanent funding associated with the creation of the new ICE Centre.

OVERVIEW ASSESSMENT

The Evaluation Committee (EC) found the written submission from NPI extremely confusing and disappointing, particularly given the long history of the Institute and the high level of Government funding it receives annually. The organisational structure is far from clear. Most of the research groups submitted for evaluation are actually discipline based sub-groups which do not have their own coherent research strategy. The bibliometric analysis provided data for 7 research groups, 5 of which actually appear to be sub-groups of *Polar Climate*. Few of these sub-groups have critical mass.

There does not appear to be any kind of coherent strategic planning process in the organisation; if there is, it was not adequately described. This is surprising given that they are in a growth phase, with optimum funding. The leadership does not appear to be particularly strong. Because of the nature of their mandate from Government they need to maintain a wide range of expertise. As a consequence there are some disciplines resting in the hands of a single individual; this makes them vulnerable to staff losses.

The publication records of the various groups are very uneven, ranging from far below average to above average. Marine Geology and Glaciology are strong sub-groups with fairly high rates of publication in journals with high citation and profile; the remaining sub-groups are weak.

Collaboration with the University of Tromsø appears to be good in those research disciplines that are represented at the University (e.g., Marine Geology).

NPI staff have access to excellent resources and infrastructure, although they clearly need a new ice-breaking research ship.

Currently there seems to be limited expertise in climate modelling and staff are spread too thinly across too many different research areas. The EC was given minimal information about the new ICE Centre in the written submission, particularly concerning its staffing. It is assumed that ICE is outside of this evaluation, as it was initiated after the evaluation period, but that its creation will address some of these concerns.

As a whole, NPI has a good network of national and international collaborators. They lead the ESFRI project ”Svalbard Integrated Earth Observing System” (SIOS) and propose to use SIOS to develop new monitoring techniques.

RECOMMENDATIONS

NPI needs to look carefully at its organisational structure. Individual research groups need to have a coherent strategy, with a 4-5 year strategic plan, and must have critical mass. They should avoid creating research groups which are too small.

The role of ICE within the overall structure of NPI needs to be clearly articulated.

Research links with the University of Tromsø could be significantly strengthened in those areas in which there is a mutual research interest. The future of Atmospheric Sciences research at NPI needs careful consideration.

5.12.1 Geomapping

This group comprises 3 researchers.

The emphasis of their work is on geological mapping, data collection and storage, map production and provision of advice to various ministries. All of their funding is internal.

Within Norway they have research links with the University of Tromsø, NGU, the Natural History Museum in Oslo and SINTEF. They cite some international collaborators, mostly within Europe, including the Russian Polar Marine Geological Expedition and the German Federal Institute for Geoscience and Natural Resources (BGR).

Publication rates are very low with only modest citations. This is to be expected because of the small size of the group and the emphasis on map production.

OVERALL GRADE: NOT GRADED

5.12.2 Polar Climate

Polar Climate is introduced in the NPI written submission as a separate research section which was split into two research groups (GEO and CRYO) in 2009. However, in the subsequent presentation these two groups are never mentioned again. *Polar Climate* is instead sub-divided into 6 sub-groups (see below) which are used for evaluation purposes here.

5.12.2.1 Marine Geology sub-group

This sub-group comprises 2 researchers, 3 post-doctoral researchers and 3 Doctoral students. It appears to have existed as a formal sub-group only since 2005, although research in this area has a much longer history, dating back to 1998. The sub-group has an uncertain future because of the recent loss of research staff.

The main focus of their research is on tracing the flow of warm Atlantic surface water to the Nordic seas and Arctic Ocean and the return flow of cold water (East Greenland current) and its relation to the thermohaline circulation in the North Atlantic ocean, the atmospheric circulation (North Atlantic Oscillation) and changes in on-land ice sheets for the past 17,000 years.

They have good national research collaborations with the universities of Tromsø and Bergen, NGU and IMR. Internationally they have a good network of research links with institutions in the USA, UK, Netherlands, Russia, Sweden and Japan.

Publication rates are average, but with very high citations; their outputs are in good journals.

OVERALL GRADE: 4

5.12.2.2 Oceanography sub-group

This sub-group comprises 1 Senior researcher, 3 researchers and 4 post-doctoral researchers.

Their research focuses on the dynamics of large-scale ocean circulation in the Arctic Ocean and Weddell Sea, changes in sea ice, sea level variability in the Nordic Seas and the export of fresh water from the Arctic Ocean via the Fram Strait.
They have a good range of national collaborators including BCCR, UNIS, NERSC, met.no, IMR and the universities of Tromsø, Oslo and Bergen. Internationally they have links with the British Antarctic Survey, the Alfred Wegener Institute, Hamburg, and the universities of Washington (USA) and Stockholm.

Publication rates are very low, with average numbers of citations.

OVERALL GRADE: 1-2

5.12.2.3 Atmospheric Science sub-group

This sub-group comprises 1 senior researcher, 1 post-doctoral researcher and 1 PhD student. The group did not exist before the end of 2007 and following the recent resignation of the senior researcher cannot really be considered to exist as a group.

Research activity focuses on a time-series of measurements of broadband radiation, plus daily meteorological observations, on Ny-Ålesund, Svalbard, and also a study of the effects of black carbon on ice albedo.

They appear to have an extensive network of international research collaborators in Germany, Japan, Sweden, Switzerland, Finland, Denmark and South Korea; nationally they collaborate with NILU and the University of Oslo.

Publication rates are very low but with high citations.

OVERALL GRADE: NOT GRADED

5.12.2.4 Glaciology sub-group

This sub-group comprises 1 senior researcher, 3 researchers and 3 post-doctoral researchers. Until 2009 there were only 2 permanent staff members, but the sub-group has expanded in size recently. One of the researchers acts as the station manager for the NPI station in Ny-Ålesund.

The main emphasis of their research is on glacier mass balance and ice core studies in Svalbard and Antarctica. The Svalbard ice cores have provided an important historical archive of anthropogenic atmospheric contaminants. Their ice core work has led to a good network of international collaborators (Netherlands, Finland, Sweden, Canada, UK, Germany, USA, Austria). Nationally they have research links with the universities of Oslo, Tromsø, the Norwegian University of Life Sciences, and IMR.
The group has received research funding from RCN, the EU, ESA and NSF. They are involved in the multi-national EU-funded EPICA project (European Project for Ice Coring in Antarctica) which has led to publications in *Nature* in 2005 and 2007.

Publication rates are good with fairly high citations.

OVERALL GRADE: 3-4

5.12.2.5 Sea Ice Physics sub-group

This sub-group comprises 4 researchers and 2 post-doctoral researchers.

The main focus of the work of this sub-group is on sea ice monitoring, sea ice process studies and climate modelling in the vicinity of Svalbard and the Fram Strait and to a limited extent in Antarctica. Sea ice processes research forms a significant part of their activities. The group is involved in a number of national (iAOOS, VAUUAV, FRINAT, NorClim) and international (e.g. DAMOCLES, AMORA) collaborative projects. They are involved in the calibration and validation of data from the ESA Cryosat-2 satellite. Since 2005 they have been studying the effects of black carbon on the albedo of snow. They participate in the new ICE-Fluxes project in the ICE Centre.

Members of the sub-group have a good network of collaborators nationally (Universities of Bergen, Oslo and UNIS, NERSC, CICERO, met.no, and NILU) and internationally (Canada, China, Finland, France, Germany, Russia, USA, Japan). They have a good potential for the future if they can maintain critical mass.

Publication rates are very low, with average citations, but in leading international journals.

OVERALL GRADE: 1-2

Appendix A: Mandate for the Review

Review of research in Earth Sciences in Norway
Mandate for the evaluation committee

I INTRODUCTION

The Board of the Division for Science, The Research Council of Norway, has decided that an evaluation of research activities in Earth Sciences in Norwegian universities and relevant contract research institutes should be conducted. The report of the evaluation committee will become a part of the basis for the future strategy of the Research Council within the area. It is furthermore intended to point out strategic directions for the institutions being the objective for the evaluation.

The objective of the evaluation:

The objective is to review the overall state of basic research in Earth Sciences in Norwegian universities and relevant contract research institutes.

More specifically, the evaluation process should:

- Provide a critical review of the strengths and weaknesses of basic research in Earth Sciences in Norway, both nationally and at the level of individual research groups and academic departments. The scientific quality shall be reviewed in an international context and related to internationally accepted benchmarks.

- Identify research groups that have achieved a high international quality level or have the potential to reach such a level.

- Identify fields of research that need to be strengthened in order to establish the necessary competences in strategic fields of importance for the nation. An assessment of the impending situation regarding recruitment in important fields of Earth Science should be included.

The long-term purpose of the review:

The evaluation should provide the involved institutions with the knowledge, advice and recommendations they need to enhance their own research standards.

The evaluation should improve the knowledge base for strategic decision-making by the Research Council, constitute a platform for future work on developing the basic research in Earth Sciences, and represent a basis for determining future priorities, including funding priorities, within and between individual fields of research.

The evaluation should improve the knowledge base needed for the Research Council's advice on research policies to the Norwegian Government and ministries.

Methods
An international Evaluation Committee will be appointed. The Evaluation Committee should base its assessments on self-evaluations provided by the departments/research groups, as well as on meetings with the involved departments/research groups giving oral presentations. The Evaluation Committee may also perform selected site visits to the institutions. Facts on the organisation and resources will be included in the self-evaluations, as well as future plans, CVs, and publication lists of the scientific staff. The Committee should address both the scientific quality of the research and quantitative aspects based on bibliometric analyses of the scientific publications. The Committee is requested to write a report with a set of specific recommendations. A preliminary report will be sent to the departments/research groups to check the factual information. The Committee's final report will be submitted to the Board of the Division for Science for final approval.

II MANDATE

Based on the self-evaluations provided by the involved institutions, meetings with representatives from these institutions, and site visits, the Evaluation Committee is requested to present the evaluation in a written report. This report should include a set of specific recommendations for the future development of the area, as well as suggestions of means for improvement when required. The Committee is requested to evaluate scientific activities with respect to their quality, relevance and international and national collaboration. The Committee is also requested to evaluate the way in which Earth Science research is organised and managed.

The conclusions of the committee's report should lead to a set of recommendations and possible scenarios concerning the future development and prioritization of Earth Science research in Norwegian universities and relevant contract research institutes, including challenges related to recruitment and possible reductions in the number of permanent scientific positions.

Specific aspects to be considered and described:

1. General aspects

- Which fields of research in Earth Sciences have a strong scientific position in Norway and which have a weak position? Is Norwegian research in Earth Sciences being carried out in fields that are regarded as important and relevant by the international research community? Is Norwegian research in Earth Sciences leading the scientific developments internationally within specific fields?

- Is there a reasonable balance between the various fields of Earth Science research in Norway, or is research absent or underrepresented in any particular field? Are any fields overrepresented, in view of the scientific quality or relevance of the research being carried out?

- Is there a reasonable degree of division of research activities at the national level, or should this aspect be improved?

- Is there an adequate degree of national and international mobility?

- Are there any particular differences between Norwegian research in Earth Sciences and research carried out in other countries?

- Is there a reasonable balance between field based research and theoretical research?

- Is the Earth Science research of today in Norway relevant to the needs of industry and society? Do research groups maintain sufficient contact with industry and/or the public sector?

2. Academic departments

- Are the academic departments adequately organised?

- Is scientific leadership being exercised in an appropriate way?

- Do individual departments carry out their research as part of an overall research strategy?

- Is there sufficient collaboration between research groups within individual departments?

- Are there satisfactory policies in place guiding the recruitment and handling of employees?

- Are the efforts to increase gender balance in academic positions satisfactory?

- How has the previous evaluation of research in Earth Sciences (1997/1998) and the associated national strategic plan been used by the departments in their own strategic planning?

3. Research groups (all institutions)

3.1. Strategy, organization and research leadership

- Have research groups developed satisfactory strategies for their research, and are these implemented?
- Is the size and organisation of the research groups reasonable?
- Is research leadership being performed in an appropriate way (e.g. in execution of project management), and is there in place an effective distribution of tasks and responsibilities within the research group?

3.2. Research activities, staff and scientific production

- Do the research groups represent a high scientific quality judged by the significance of contributions to their field, prominence of the leader and team members, and scientific impact of their research?
- Is the scientific production, e.g. the number of scientific publications and Ph.D. theses awarded, reasonable in terms of the resources available?
- How is the long term viability of the staff and facilities evaluated in view of future plans and ideas, staff age, facilities, research profile, and new impulses through recruitment of researchers?
- Do they play an active role in dissemination of their own research and new international developments in their field to industry and/or public sector?

3.3. Research collaboration (national, international, industry)

- Is there sufficient contact and co-operation among research groups nationally, in particular, how is the co-operation between the academic departments and the contract research institutes?

- Do the research groups have contracts and joint projects with external partners at a satisfactory level?
- Do the research groups take part in interdisciplinary/multidisciplinary research activities at a satisfactory level?
- Do they play a satisfactory role in creating and establishing new industrial activity? What roles do Norwegian research groups play in international co-operation in individual subfields of Earth Science?
- Is the international network satisfactory, e.g. in terms of contact with leading international research groups, number of guest researchers, and number of joint publications with foreign colleagues?
- Do research groups take satisfactorily part in international programmes?
- Is their participation in international professional committees, peer review, work on standardization, and other professional activities satisfactory?

4. Research infrastructure (RI)

- How is the current situation and the future needs with regard to modern RI?
- Is there sufficient national co-operation related to the use of expensive equipment?
- Is the use of facilities abroad satisfactory, or should utilisation be improved by introducing special measures?
- Is there sufficient awareness of new RI opportunities in Europe and globally, and are there plans for active participation in such RI projects?

5. Training

- Does the scientific staff play an active role in stimulating the interest for their field of research among young people?
- Is recruitment to doctoral training programmes satisfactory, or should greater emphasis be put on recruitment in the future, including strategies aimed at improving the gender balance?
- Are there sufficient educational and training opportunities for Ph.D. students?

The Committee's written report is expected to be based on the questions above. The assessments and recommendations should be at research group, departmental, institutional (universities only) and national level.

Please feel free to address any other aspects of Norwegian research in Earth Sciences that you mean deserve consideration.

Appendix B: Schedule for the Hearings and Site Visits

Evaluation of Norwegian research in Earth Sciences
Time schedule for the hearings and site visits

Colour codes: **Hearings** **Site Visits**
Committee Meetings

BERGEN (Day 1)

Location of meetings: Hotel Neptun

Date	Time	Institution/department	Research group
Monday March 21	0815-0830	*Committee Meeting*	
	0830-1030	*Geophysical Institute, UoB*	• Meteorology • Climate dynamics • Dynamical and large-scale oceanography • Coastal and small scale oceanography • Chemical oceanography
	1030-1045	*Committee Meeting*	
	1045-1100	Break	
	1100-1200	**UNI Bjerknes Centre for Climate Research**	• Palaeoclimate processes and sensitivity • Climate variability and dynamics • Carbon biogeochemistry and marine ecosystems • Global and regional climate projections
	1200-1300	Lunch	
	1300-1400	**UNI Bjerknes Centre for Climate Research (cont.)**	
	1400-1415	*Committee Meeting*	
	1415-1615	**Nansen Environmental and Remote Sensing Center**	• Marine Remote Sensing • Ocean and sea ice modelling and data assimilation • Climate studies and modelling
	1615-1630	*Committee Meeting*	
	1630-1645	Break	
	1645-1730	**Faculty of Engineering and Science, Sogn og Fjordane University College**	• Geology and Geohazards
	1730-1800	*Committee Meeting*	

BERGEN (Day 2)

Location of meetings: Hotel Neptun

Date	Time	Institution/department	Research group
Tuesday March 22	0815-0830	*Committee Meeting*	
	0830-1130	*Department of Earth Science, UoB*	• Quaternary Geology and Palaeoclimate • Marine Geology and Geophysics • Geobiology research group • Petroleum Geosciences Group • Geodynamics Group
	1130-1200	*Committee Meeting*	
	1200-1300	Lunch	
	1300-1400	**UNI Centre for Integrated Petroleum Research**	• Geoscience
	1400-1415	*Committee Meeting*	
	1415-1545	**Institute of Marine Research**	• Oceanography
	1545-1600	*Committee Meeting*	
	1600-1615	Break	
	1615-1715	**Department of Petroleum Engineering, UoS**	• Petroleum Geosciences
	1715-1800	*Committee Meeting*	

Site visits in Bergen, Sogndal and Oslo (Day 3)

Date	Time	Institution/department	Committee members
Wednesday March 23	0800-0810	*Committee Meeting*	
	0830-0930 0930-1015 1030-1115 1115-1200 1315-1415 1435-1535	*Bergen:* *Department of Earth Science, UoB* **UNI Centre for Integrated Petroleum Research** **Geophysical Institute, UoB** **UNI Bjerknes Centre for Climate Research** **Nansen Environmental and Remote Sensing Center** **Institute of Marine Research**	Peter Haynes Michael Kendall Monika Rhein François Roure Ellen Thomas Marjorie Wilson
	1730	**Plane to Oslo, arrival at 1820**	
	0910	*Plane to Sogndal, arrival at 0948*	Johan Kleman Ezio Todini
	1030-1300	**Sogndal:** **Faculty of Engineering and Science, Sogn og Fjordane University College**	
	1358	*Plane to Oslo, arrival at 1445*	
	1600-1700	**Oslo:** **Norwegian Water Resources and Energy Directorate**	

Oslo (Day 4)

Location of meetings: The Research Council's main office

Date	Time	Institution/department	Research group
Thursday March 24	0815-0830	*Committee Meeting*	
	0830-1145	*Department of Geosciences, UiO*	• Meteorology and Oceanography • Physical Geography • Tectonics, Petrology and Geochemistry • Petroleum Geology and Geophysics • Environmental Geology and Hydrology • Physics of Geological Processes
	1145-1200	*Committee Meeting*	
	1200-1300	Lunch	
	1300-1400	**Natural History Museum, UoO**	• Paleontology /Stratigraphy • Mineralogy
	1400-1415	*Committee Meeting*	
	1415-1545	**NORSAR**	• Seismology and nuclear-test-ban treaty monitoring • Earthquake and the Environment
	1545-1600	*Committee Meeting*	
	1600-1615	Break	
	1615-1700	**Dept. of Mathematical Sciences and Technology, The Norwegian Univ. of Life Sciences**	• Geosciences
	1700-1730	*Committee Meeting*	

Site visits in the Oslo area (Day 5)

Date	Time	Institution/department	Committee members
Friday March 25	0800-0810	*Committee Meeting*	
	0830-1000	*Oslo:* *Department of Geosciences, UoO*	The entire committee
	1100-1200	**Ås:** **Department of Mathematical Sciences and Technology,** **Department of Plant and Environmental Sciences,** *The Norwegian Univ. of Life Sciences*	
	1400-1500	**Kjeller:** **NORSAR**	Michael Kendall François Roure Marjorie Wilson Johan Kleman (?)
		Norwegian Institute for Air Research	Peter Haynes Monika Rhein Ellen Thomas (?) Ezio Todini
	1540-1640	**Oslo:** **Natural History Museum**	Michael Kendall François Roure Marjorie Wilson Ellen Thomas
	1550-1630 1630-1730	**CICERO Center for International Climate and Environmental Research – Oslo**	Peter Haynes Johan Kleman Monika Rhein Ezio Todini

Oslo (Day 6)

Location of meetings: The Research Council's main office

Date	Time	Institution/department	Research group
Saturday March 26	0815-0830	*Committee Meeting*	
	0830-1030	*Norwegian Meteorological Institute*	• Climate Change and Variability • Environmental research • Atmosphere and ocean modelling
	1030-1045	*Committee Meeting*	
	1045-1100	Break	
	1100-1145	**Department of Plant and Environmental Sciences, The Norwegian Univ. of Life Sciences**	• Geology
	1145-1200	*Committee Meeting*	
	1200-1320	Lunch	
	1320-1420	**Norwegian Institute for Air Research**	• Atmospheric Transport Processes
	1420-1435	*Committee Meeting*	
	1435-1550	**Norwegian Water Resources and Energy Directorate**	
	1550-1605	*Committee Meeting*	
	1605-1705	**CICERO Center for International Climate and Environmental Research – Oslo**	
	1705-1735	*Committee Meeting*	

Trondheim (Day 8)

Location of meetings: Royal Garden Hotel

Date	Time	Institution/department	Research group/ Committee members
Monday March 28	0815-0830	*Committee Meeting*	
	0830-1000	**SINTEF Petroleum Research**	• Formation Physics
	1000-1015	*Committee Meeting*	
	1015-1200	**Visit at SINTEF Petroleum Research**	Michael Kendall François Roure Marjorie Wilson Ezio Todini (?)
	1200-1300	Lunch	
	1300-1500	**Dept. of Petroleum Engineering and Applied Geophysics, The Norwegian Univ. of Science and Technology**	• Applied geophysics
	1500-1515	*Committee Meeting*	
	1515-1530	Break	
	1530-1715	*Dept. of Geology and Mineral Resources Engineering,* **The Norwegian Univ. of Science and Technology**	• Engineering Geology • Mineral Production and HSE • Geology
	1715-1745	*Committee Meeting*	

Trondheim (Day 9)

Location of meeting: Royal Garden Hotel

Date	Time	Institution/department	Research group/ Committee members
Tuesday March 29	0815-0830	*Committee Meeting*	
	0830-1100	**Geological Survey of Norway**	• Geodynamics • Bedrock and crustal processes • Quaternary Geology and Climate • Continental shelf geophysics • Geohazards • Environmental Geochemistry • Tectonics and landscape evolution
	1100-1115	*Committee Meeting*	
	1115-1200	Lunch	
	1230-1315 1320-1405 1430-1530	**Trondheim:** **Dept. of Petroleum Engineering and Applied Geophysics,** *Dept. of Geology and Mineral Resources Engineering,* **The Norwegian Univ. of Science and Technology** **Geological Survey of Norway**	Michael Kendall François Roure Marjorie Wilson Ezio Todini
	1705	*Plane to Tromsø, arrival 1915*	
	1355	*Plane to Tromsø, arrival 1605*	Peter Haynes Johan Kleman Monika Rhein Ellen Thomas
	1700-1800	**Tromsø:** **Norwegian Polar Institute**	

Tromsø (Day 10)

Location of meetings: Rica Ishavshotel

Date	Time	Institution/department	Research group/ Committee members
Wednesday March 30	0815-0830	*Committee Meeting*	
	0830-0930	**Dept. of Arctic Geology, University Centre in Svalbard**	• Sedimentary bedrock geology • Quaternary geology • Cryosphere
	0930-0945	*Committee Meeting*	
	0945-1030	**Dept. of Arctic Geophysics, Univ. Centre in Svalbard**	• Air-Chryosphere-Sea Interaction Observation and Modelling
	1030-1045	*Committee Meeting*	
	1045-1100	Break	
	1100-1245	**Department of Geology, UoT**	• Polar Marine Geology and Geophysics • Coastal and Terrestrial Geosciences • Crustal Dynamics
	1245-1300	*Committee Meeting*	
	1300-1345	Lunch	
	1345-1530	**Visit at Dept. of Geology, UoT**	The entire committee
	1530-1730	**Norwegian Polar Institute**	• Geology • Marine Geology • Oceanography • Atmospheric science • Glaciology • Sea ice Physics
	1730-	*Committee Meeting*	

Site visits in Stavanger and Longyearbyen (Day 11 and 12)

Date	Time	Institution/department	Committee members
Thursday March 31	0645	*Plane from Tromsø to Stavanger via Oslo, arrival in Stavanger 1030*	Michael Kendall François Roure Marjorie Wilson Ezio Todini
	1130-1230	**Visit at Department of Petroleum Engineering, University of Stavanger**	
		END	
	1215	*Plane from Tromsø to Longyearbyen, arrival at 1355*	Peter Haynes Johan Kleman Monika Rhein Ellen Thomas
	1355-	**Site visit in Longyearbyen**	
Friday April 1	-1445		
	1445	*Plane to Oslo, arrival at 1900*	
		END	

Appendix C: List of Acronyms and abbreviations

BCCR	Bjerknes Centre for Climate Research
BCM	Bergen Climate Model
BGS	British Geological Survey
BIAC	Bipolar Atlantic Thermohaline Circulation
CEED	Centre for Earth Evolution and Dynamics
CICERO	Center for International Climate and Environmental Research
CIENS	Oslo Centre for Intergrated Environmental and Social Research
CIPR	Centre for Integrated Petroleum Research, Bergen
CoE	Centre of Excellence
CTBT	Comprehensive Nuclear Test-ban Treaty
EC	Evaluation Committee
ECMWF	European Centre for Medium Range Weather Forecasting
EMEP	European Monitoring and Evaluation Programme
EPICA	European Project for Ice Coring in Antarctica
ESA	European Space Agency
ESF	European Science Foundation
EU	European Union
EU	European Union
GFI	Geophysical Institute, University of Bergen
GOOS	Global Ocean Observing System
HIRLAM	HIgh Resolution Limited Area Model
IASPEI	International Association of Seismology & Physics of the Earth's Interior
ICDP	International Continental Drilling Program
ICE	Centre for Ice, Climate and Ecosystems
ICES	International Council for the Exploration of the Seas
ICG	International Centre for Geohazards
ICP-MS	Inductively-coupled plasma mass spectrometry
IMR	Institute of Marine Research, Bergen
InSAR	Interferometric synthetic aperture radar
IODP	International Ocean Drilling Program
IPCC	Intergovernmental Panel on Climate Change
IPY	International Polar Year
ISC	International Seismological Centre
JIP	Joint Industry Project
LIDAR	Light Detection and Ranging
met.no	Norwegian Meterological Institute
NCAR	National Centre for Atmospheric Research, USA
NERSC	Nansen Environmental and Remote Sensing Center, Bergen
NGI	Norwegian Geotechnical Institute
NGU	Geological Survey of Norway
NHM	Natural History Museum, Oslo University
NIFU	Nordic Institute for Studies in Innovation, Research and Education
NILU	Norwegian Institute for Air Research
NMB	Norwegian University of Life Sciences
NorESM	Norwegian Earth System Model

NORSAR	Norwegian Sismic Array
NPD	Norwegian Petroleum Directorate
NPI	Norwegian Polar Institute
NTNU	Norwegian University of Science & Technology, Trondheim
NVE	Norwegian Water Resources and Energy Directorate
ODP	Ocean Drilling Program
PGP	Physics of Geological Processes Centre of Excellence
RCN	Research Council of Norway
REE	Rare Earth Elements
ROV	Remotely Operated Vehicle
SAR	Synthetic Aperture Radar
SEM	Scanning electron microscope
SIOS	Svalbard Integrated Arctic Earth Observing System
SMHI	Swedish Meteorological and Hydrological Institute
SVALI	Stability and Variations of Arctic Land Ice, Nordic CoE
UiB	University of Bergen
UiO	University of Oslo
UM	Unified Model
UNIS	The University Centre in Svalbard
VOS	Volunteer Observing Ships
XRD	X-ray Diffraction
XRF	X-ray Fluoresence

Appendix D: Curriculum Vitae of the Evaluation Committee Members

MARJORIE WILSON (Chairman of the Evaluation Committee)
School of Earth & Environment, Leeds University, UK

Marjorie Wilson is Professor of *Igneous Petrogenesis* (since 1998) in the School of Earth & Environment and Pro-Dean for Research in the Faculty of Environment (since 2006). She has been a member of the academic staff at Leeds University since 1978. She is a Foreign Member of the Norwegian Academy of Science & Letters (1998) and was awarded an Honorary Doctorate of Philosophy by Uppsala University, Sweden in January 2000. She obtained her PhD degree from Leeds University in 1976. Marjorie has been a member of the Council of the Natural Environment Research Council (NERC) in the UK since 2007, having previously served for five years on the NERC Science and Innovation Strategy Board. She has been the Executive Editor of the Journal of Petrology since 1994. Her research focuses on the petrogenesis of within-plate and subduction-related magmatism. She is internationally recognized for her ability to integrate geochemical and geophysical data in the development of geodynamic models to explain the processes responsible for magma generation. She has worked with the Norwegian hydrocarbon industry on the interpretation of 3-D seismic data from the Atlantic continental margins to deduce the volcanic architecture. Since 2007 she has been involved in a collaborative project with the Chinese Academy of Sciences in Beijing to study the magmatism associated with the India-Asia collision zone and the evolution of the Tibetan Plateau.

PETER HAYNES
DAMPT, University of Cambridge, UK

Peter Haynes is currently Head of Department at DAMPT (Department of Applied Mathematics and Theoretical Physics) at the University of Cambridge, UK. He has been at Cambridge University since 1986 and has been Professor of Applied Mathematics since 2001. His research focuses on the large-scale fluid dynamics of the atmosphere and oceans, and related topics, particularly in the context of climate science. In fluid dynamics he is interested in wave propagation and breaking and its implication for the background flow, and in transport and mixing of trace species, including reacting chemical and biological species. These topics are relevant to both atmosphere and ocean. In atmospheric science, he is interested in the dynamics of the global circulation, in interactions between dynamics, chemistry and radiation, and in the various physical and dynamical processes controlling the distributions of chemical species, including water vapour.

MICHAEL KENDALL
Department of Earth Sciences, Bristol University, UK

Michael Kendall is Professor of Seismology, at the University of Bristol, UK; he is currently Head of Department. He obtained his PhD in Geophysics at Queen's University, Kingston, Ontario, Canada in 1991. From 1995 – 2005 he was a Research Fellow, Reader and Professor of Seismology at the University of Leeds. His research interests span global, exploration and theoretical seismology, with an emphasis on seismic anisotropy. His current research in global geophysics concentrates on the structure of the lowermost mantle, cratons, mid-ocean ridges and subduction zones. This research involves concurrent data analysis and waveform modelling. In exploration seismology his interests lie in microseismicity, rock-fracture characterisation, linked seismic and geomechanical modelling, and salt anisotropy.

JOHAN KLEMAN
Department of Physical Geography & Quaternary Geology
Stockholm University, Sweden

Johan Kleman is Professor of Physical Geography at the University of Stockholm (since 2000).

He is the Research Director of the *Bert Bolin Centre for Climate Research*; Dean of Earth and Environmental Sciences; and Vice Dean of the Faculty of Science. He obtained his PhD from the University of Stockholm in 1985. His research is centered on deciphering subglacial landform systems. The approach is two-pronged, one being subglacial conditions and the functional chain of subglacial landform preservation-reshaping-destruction, the other being credible reconstruction of paleo ice-sheet evolution. Subglacial conditions, and in particular the spatial arrangement of frozen and thawed zones, including ice streams, is an important control on ice-sheet height, flow pattern and ice discharge, and the variation of these parameters over time. The exposed beds of paleo ice-sheets, which integrate information about subglacial events over a long "time window", offer a unique opportunity to gain insight into the presently crucial issue of ice sheet stability. Credible ice sheet reconstructions are of fundamental importance for global circulation modeling (GCM) experiments in the paleo-domain.

MONIKA RHEIN:
Department of Oceanography, University of Bremen, Germany

Monika Rhein is a Professor (C4) at the University of Bremen and leader of the Department of Oceanography. She obtained her PhD in Physics from the University of Heidelberg in 1986. She is coordinating lead author for the 5th IPCC report, Working Group I. Her research focuses on water mass formation rates and their variability, water mass spreading and time-scales of spreading, the strength of the meridional overturning circulation (MOC) in the North Atlantic, impacts of changes in the MOC strength on oceanic storage of anthropogenic CO_2, Mid-Atlantic Ridge hydrothermal vents and seamounts, and equatorial and coastal upwelling.

FRANÇOIS ROURE
IFP – Energies nouvelles, Rueil-Malmaison, France

François Roure is an Expert within IFP-EN's Geology-Geochemistry-Geophysics Division. IFP - Energies nouvelles is a public-sector research, innovation and training center active in the fields of energy, transport and the environment. In 2010 he was honored by the EAGE (European Association of Geoscientists and Engineers) with the 2010 Wegener Award in recognition of his contribution to geoscientific research in the field of petroleum exploration of frontier areas and the search for new reserves, particularly in mountain belts. *He is a graduate of the Ecole Normale Supérieure de St-Cloud, and holds a doctorate in Sciences (1984) from the University of Paris VI. He joined IFP-EN's Geology-Geochemistry-Geophysics Division in 1984 after four years working at the CNRS. His research focuses on the study of sedimentary basins (architecture and geodynamics, thermal evolution, oil-bearing systems, fluid/rock interactions and reservoir characterization). As an Expert, he takes part in the IFP-EN's scientific management.* François *is currently extraordinary Professor at the Free University of Amsterdam (VU). He is President (2005-2014) of the Task Force on Sedimentary Basins in the International Lithosphere Program (ILP).*

ELLEN THOMAS
Department of Geology and Geophysics, Yale University, USA

Ellen Thomas is currently (since 2005) a Senior Research Scientist at the Center for Study of Global Change, Department of Geology and Geophysics, Yale University, USA. She obtained her PhD in 1979 from the University of Utrecht in the Netherlands. Her research focuses on quantitative studies of the ecology and evolution of benthic foraminifera (deep-sea, marginal marine environments), as indicators of global, regional and local environmental change, in combination with chemical/isotopic proxies and climate modeling.

EZIO TODINI
University of Bologna, Italy

Ezio Todini is currently the President of the Italian Hydrological Society. Recently retired, he was Professor of Hydrology at the University of Bologna from 1980 to 2010. Prior to this he combined his role as a Research Scientist at the IBM Pisa Scientific Centre (1970-79) with that of Professor of Applied Hydromechanics at the University of Pisa (1973-80) and of Water Resources Planning at the University of Florence (1979-81). His background and experience includes hydrology, hydraulics, statistics, numerical methods and operations research.

Appendix E: Letter to the institutions announcing the evaluation

Vår saksbehandler/telefon	**Vår ref.**	**Oslo,**
Øyvind Pettersen, 2203 7355	2009/09294	7. januar 2010
	Deres ref.	

Evaluering av forskningen innen geofagene

Kunnskapsdepartementet (KD) har bedt Forskningsrådet om å fortsette arbeidet med å evaluere norske forskningsmiljøer og sørge for god og systematisk oppfølging. Fagevalueringene skal videreføres, utvikles og styrkes.

Det er gjennomført evalueringer og utarbeidet fagplaner for alle fagområdene innen naturvitenskap og teknologi fra 1996 og frem til 2006. Forskningsrådet gjennomførte i 2008 og 2009 en evaluering av henholdsvis kjemi- og fysikkfagene, som første ledd i en videreføring av arbeidet med fagevalueringer, der det legges opp til å evaluere de samme faglige grunndisiplinene. Grensesnittene mot andre disipliner og hvilke mer perifere fagmiljøer som skal trekkes inn vil imidlertid vurderes på nytt for hvert fag.

Det forsøkes lagt opp til at fagevalueringene foreligger rundt årsskiftet slik at tiltakene kan iverksettes over budsjettet det påfølgende året. Oppfølgingen vil bestå i utarbeidelse av en oppfølgingsplan (fagplan) i samarbeid med de evaluerte miljøene.

Evalueringen av geofagene planlegges gjennomført i år. Den skal omfatte forskning ved universitetene og høyskolene, og dessuten inviteres forskningsinstituttene til å delta med de av sine faggrupper som arbeider med grunnleggende og langsiktig forskning innen geovitenskapelige disipliner.

Spesielt for forskningsinstituttene:

Forskningsinstituttene inviteres herved til å sende en oversikt over de forskningsgruppene/ forskningsgrupperingene – innen sin virksomhet – som arbeider med grunnleggende og langsiktig forskning innenfor geovitenskapelige disipliner, og som de ønsker skal omfattes av fagevalueringen**.** For hver gruppe skal det gis en kort begrunnelse for hvorfor den bør være med, samt navnene på de personene som inngår i gruppen.

Materialet må sendes til Øyvind Pettersen (op@forskningsradet.no) **innen 5. februar 2010**.

Eventuell deltakelse innebærer en evaluering av kvaliteten på den grunnleggende forskning på samme vilkår som i UoH-sektoren. Dersom et institutt har én eller flere forskningsgrupper som de mener bør omfattes av evalueringen, må hver gruppe bestå av minst fem forskere; dette fordi evalueringsrapporten ikke skal gå inn på enkeltforskere. På grunnlag av ønskene fra forskningsinstituttene vil Forskningsrådet foreta den endelige avgjørelsen mht. hvilke forskningsgrupper som skal omfattes av evalueringen.

Formålet

Formålet med fagevalueringene er å:

- foreta en kritisk gjennomgang av forskningen i et internasjonalt perspektiv
- få internasjonal tilbakemelding på hvordan norsk forskning skal møte utfordringene framover
- fremskaffe anbefalinger om tiltak som kan fremme kvalitet og effektivitet i forskningen
- være et redskap for institusjonenes strategiske og faglige utviklingsarbeid
- styrke Forskningsrådets grunnlag for forskningspolitiske råd til regjeringen og berørte departementer

Skisse til organisering og opplegg for evalueringen

Evalueringen vil bli gjennomført av en evalueringskomité bestående av internasjonalt anerkjente fageksperter hvis samlede kompetanse dekker bredden i geofagene.

Hvert institutt og/eller faggruppe som inngår i evalueringen vil bli bedt om å utarbeide en egenvurdering. Denne skal blant annet gi evalueringskomiteen grunnleggende informasjon om de enkelte forskergruppene. Forskningsrådet vil gjennomgå egenvurderingene for å sikre at de holder tilfredsstillende kvalitet og har en oversiktlig form. Hvert medlem i evalueringskomiteen vil få tilsendt et eksemplar av det samlede materialet.

I tillegg til å gjennomgå egenvurderingene, vil komitémedlemmene basere sine vurderinger på møter og intervjuer med representanter (primært forskere) fra institutter/faggrupper. Evalueringskomiteen utarbeider deretter en evalueringsrapport som inneholder vurderinger av fagmiljøene og kvaliteten på forskningen i en nasjonal og internasjonal sammenheng. Evalueringsrapporten vil bli offentliggjort.

Forskningsrådet vil benytte tilsvarende retningslinjer som i tidligere evalueringer for hvordan evalueringsrapporten skal utformes. Blant annet skal evalueringen begrenses til forskergruppenivå uten å gå inn på enkeltforskere; enkeltforskere eller forskergrupper vil ikke bli omtalt ved angivelse av personnavn. Forskningsrådet vil dessuten benytte prosedyrer som sørger for at de involverte instituttene/faggruppene får anledning til å kvalitetssikre de faktaopplysninger komiteen tar med i evalueringsrapportene. Disse retningslinjene vil bli gjort kjent for komiteens medlemmer ved oppnevningen.

Det skal utarbeides en plan for evalueringen av geofagene, og som ved Forskningsrådets tidligere fagevalueringer inviterer vi nå de involverte forskningsinstitusjonene til å komme med:

- synspunkter på det skisserte opplegget for gjennomføringen
- forslag til fageksperter til komiteen

Forslag og kommentarer bes sendt samlet fra hvert institutt innen 5. februar 2010.

Ekspertene må være internasjonalt anerkjente forskere som er habile med hensyn til de aktuelle norske fagmiljøene. De må bl.a. ikke ha publisert sammen med noen av miljøene de siste fem årene. Det bes spesielt om forslag til kvinnelige eksperter. Vi ber om at forslagene til eksperter inneholder navn, adresse og en kort beskrivelse av personenes forskningsområder. Presiser gjerne hvem som også vil kunne være egnet til å være leder.

Informasjonsmøte

Forskningsrådet vil med dette også invitere til felles møte for instituttledere og/eller andre representanter for institusjonene **tirsdag 2. februar kl. 12.00 – 16.00 i møterom Abel i Forskningsrådets lokaler i Oslo.** Hensikten med møtet er å diskutere prosedyre, mandat etc. for evalueringen og å lytte til eventuelle innspill fra institusjonene. Program for møtet vil bli sendt ut senere.

Kontaktpersoner

Spørsmål i tilknytning til fagevalueringen kan rettes til:

- Seniorrådgiver Øyvind Pettersen, Avdeling for naturvitenskap og teknologi, Divisjon for Vitenskap, tlf. 2203 7355, e-post: op@forskningsradet.no
- Spesialrådgiver Odd Ivar Eriksen, Avdeling for naturvitenskap og teknologi, Divisjon for Vitenskap, tlf. 2203 7023, e-post: oie@forskningsradet.no

Med vennlig hilsen
Norges forskningsråd

Asbjørn Mo
Avdelingsdirektør
Avdeling for naturvitenskap og teknologi
Divisjon for Vitenskap

Øyvind Pettersen
Seniorrådgiver
Divisjon for Vitenskap

Vedlegg: 1. Liste over UoH-institutter der forskningen i geofagene skal evalueres
2. Liste over forskningsinstitutter som tilbys å delta i geofagevalueringen

Kopi:

Vedlegg 1.

UoH-institutter der forskning innen geofagene skal evalueres:

Universitetet i Oslo (UiO)
- Institutt for geofag
- Matematisk institutt, avdeling for mekanikk
- Naturhistorisk museum (Tøyen)

Universitetet i Bergen (UiB)
- Institutt for geovitenskap
- Geofysisk institutt
- Institutt for geografi

Norges teknisk naturvitenskapelige universitet (NTNU), Trondheim
- Institutt for petroleumsteknologi og anvendt geofysikk
- Institutt for geologi og bergteknikk
- Institutt for vann- og miljøteknikk
- Geografisk institutt

Universitetet i Tromsø (UiT)
- Institutt for geologi
- Tromsø museum, seksjon naturvitenskap

Universitetet for miljø- og biovitenskap (UMB), Ås
- Institutt for plante- og miljøvitenskap
- Institutt for matematiske realfag og teknologi

Høgskolen i Sogn og Fjordane (HSF)
- Avdeling for ingeniør- og naturfag, seksjon for geologi

Høgskolen i Gjøvik (HiG)
- Avdeling for teknologi, økonomi og ledelse, seksjon for bygg, geomatikk og realfag

Universitetet i Stavanger (UiS)
- Institutt for petroleumsteknologi

Universitetssenteret på Svalbard (UNIS)
- Avdeling for arktisk geofysikk
- Avdeling for arktisk geologi

Vedlegg 2.

Forskningsinstitutter som tilbys å delta i geofagevalueringen:

- Norges geotekniske institutt (NGI)
- Norges geologiske undersøkelse (NGU)
- Norsk institutt for luftforskning (NILU)
- Norsk Polarinstitutt (NP)
- Havforskningsinstituttet
- NORSAR
- Nansen senter for miljø og fjernmåling (NERSC)
- International Research Institute of Stavanger (IRIS)
- Meteorologisk institutt
- SINTEF Petroleumsforskning AS
- Norsk institutt for vannforskning (NIVA)
- Norges vassdrags- og energidirektorat (NVE)
- Statens kartverk
- Institutt for energiteknikk (IFE)
- CICERO Senter for klimaforskning

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