The Research Council of Norway

Follow-up plan for the Evaluation of Research in Earth Sciences

Report prepared by a national committee

Division for Science

The Research Council of Norway

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Preface

The composition of the committee mandated to propose measures on the national level to follow up the recommendations from the evaluation, was specified in a letter from the Research Council dated 20 August 2013. The members of the committee were:

Professor Øystein Hov, Norwegian Meteorological Institute and University of Oslo (chair)
Professor Karin Andreassen, University of Tromsø
Professor Jon Landvik, Norwegian University of Life Sciences
Professor Gunn Mangerud, University of Bergen
Professor Brit Lisa Skjelkvåle, University of Oslo
Professor Mai Britt Mørk, Norwegian University of Science and Technology, Trondheim
Professor Arne Skauge, CIPR, UniResearch and University of Bergen

An advisor from the Research Council of Norway, Heidi Roggen, acted as a coordinator for the committee.

1 Sammendrag

1998-evalueringen av geofagene i Norge la grunnlaget for en forandring i måten vi organiserer forskning på, fra små institutter basert på en eller noen få professorer/forskere, til sentre og større institutter ("fra individer til lokale sentre"). I oppfølgingsrapporten til 2011-evalueringen tar vi det neste skrittet: "fra lokale sentre til landslag i en internasjonal kontekst". Geofaglig forskning er essensiell for verdiskapningen i store samfunnssektorer. Geofagene gir forskningsresultater som danner grunnlag for en vesentlig andel av den nasjonale økonomien gjennom forvaltning av naturressurser så vel som vurdering og håndtering av risiko. Å tilby og å administrere kunnskap og data ses i store deler av geofagene på som myndighetenes ansvar og en del av det som utgjør et velutviklet, moderne samfunn og en del av fellesgodene. Siden suksess i den geofaglige forskningen har en signifikant og direkte betydning for samfunnssikkerhet og -økonomi, har geofagene og forskerne her et spesielt ansvar for å sikre at forskningen blir tatt i bruk. Kvalitet, relevans og anvendelse er viktige forskningskriterier.

Oppfølgingsutvalget gir råd om nasjonal oppfølging av evalueringen, og har delt rådene inn i syv temaer under overskriftene "Forvaltning av naturressurser" (energikilder og forsyning, mineral-ressurser), "Håndtering av risiko" (geofarer, miljøfarer og klimaendringer) og to temaer som går på tvers av ressurser og risiko (marine geofag og polare geofag).

Å bygge sterke, lokale forskningssentre og -grupper har i løpet av de siste 10-15 årene vært vellykket og produktivt. For å kunne bidra til nasjonal dyktighet og internasjonal konkurranseevne, er det nødvendig å videreutvikle spesialisering innen disipliner. Dette er en forutsetning for å lykkes med tverrfaglighet. Det siste er sløsing uten det første. Det er også behov for å fokusere mer på anvendelse av grunnforskningsresultater.

Publikasjonsratene i de fleste delene av geofagene i Norge er gode, basert på bibliometriske analyser. Siden forskningen har så stor samfunnsmessig relevans, er det nødvendig å rette oppmerksomheten mot publisering og formidling av resultatene utover fagfellevurderte publikasjoner og H-faktorer. Dette gjelder også arven fra forskningsprosjekter (data, programvare, fysiske prøver) som nå i stor grad ivaretas av den enkelte forsker. Arven til spesialisert anvendelse eller til samfunnet generelt for å danne basis for videre innovasjon.

De fleste doktorgradsstudentene og postdoktorene i Norge tilbringer for lite tid i utenlandske forskningsmiljøer. Mer fleksible løsninger anbefales. Rekrutteringsstrategien i akademia trenger å åpne for "tenure track"-stillinger for å tiltrekke seg de beste kandidatene.

Anbefalte tiltak er gitt i kapittel fem, inkludert prioritering, institusjon som bør være ansvarlig for oppfølgingen, budsjett og varighet. Som tiltaket med høyest prioritet, foreslår vi at det etableres en sjefsforskerstilling ved statsministerens kontor for å styrke den nasjonale verdien av forsknings-innsatsen.

2 Summary

The 1998-evaluation of the Norwegian geosciences gave rise to a move of the way we organise research from small departments based on one or more senior professors/scientists, to centres and larger departments (“from individuals to local centres”). In the follow-up of the 2011-evaluation the next step is taken: “Move local centres to national teams in an international context”. The research in the geosciences is essential for the value creation in large societal sectors. Geosciences provide the research results that underpin a substantial fraction of the national economy through the management of natural resources as well as the evaluation and managing of risks. The provision and management of knowledge and data in many of the geosciences is seen as a governmental responsibility and part of what constitutes a well-developed modern society and part of the Commons. As the success of research in the geosciences has a significant and direct bearing on the safety and economy of our society, a particular responsibility rests on the geosciences and geoscientists for bringing their research results to use. Quality, relevance and impact are essential research criteria.

Advice is given for national follow-up of the evaluation, separated into seven themes under the headings “management of resources” (energy sources and supply; mineral resources), “management of risks” (geohazards, environmental risks, climate change), and two themes that cut across resources and risks (marine geosciences, polar geosciences).

The building of strong local research centres and groups during the last 10-15 years has been successful and productive. To foster national excellence and competitiveness internationally in depth disciplinary specialization needs to develop further and is a requirement for succeeding in integration across disciplines. The latter is wasteful without the former. Moving new knowledge from the results of basic science through to applications needs more attention.

The publication rates in most of the geosciences in Norway are good as judged by bibliometric analysis. As research in the geosciences is justified by its large societal relevance, publications and dissemination of results beyond peer reviewed papers and H-factors, need more attention. This also applies to moving the heritage from research projects (data, software, physical samples) from the individual researcher into specialized applications or into the Commons to form the basis for further social or economic innovation.

The doctoral and post-doctoral training in the geosciences suffer from reluctance to spend time abroad. More flexible schemes are recommended. Also the recruitment strategy in academia needs to open for tenure track positions to attract the best candidates.

Recommended measures are provided in chapter 5 including priorities, responsible institution in the follow up, budgetary implications and time horizon. As a measure of the highest priority, we propose that a Chief Scientist position is established at the Office of the Prime Minister to enhance the national value of research efforts.

3 Introduction

The report "Research in Earth Sciences in Norway. An evaluation" was submitted to the Research Council of Norway April 2011 and published in November 2011. The evaluated institutions were invited to submit comments to the evaluation and suggestions for a follow-up in May 2012, with a deadline in June the same year. The follow-up committee was first announced early March 2013, but due to unforeseen illness, alterations to the committee were necessary. The final composition of the committee mandated to propose measures on the national level to follow up the recommendations from the evaluation, was specified in a letter from the Research Council in August 2013.

The mandate (see Appendix) was to propose an advisory follow-up plan for the geosciences on the basis of the evaluation report, the views of the Research Council, and the reports from the evaluated institutions where they provided comments on the review report as well as a description of their follow-up activities. In the mandate it was explicitly stated that the committee was to propose national level measures; as the follow-up of the specific recommendations to each of the research groups was seen as the responsibility of the institution involved.

The Research Council of Norway tasked the committee with 8 different issues, all to be addressed at the national level and to be specific for the geosciences:

1. the role of the geosciences for the national strategic research areas like climate and energy research;
2. how to develop leadership skills to formulate the research strategy in the research groups and their institutions;
3. how to promote national cooperation, coordination and the sharing of the work load, including the role of international research coordination and mobility;
4. how to further develop the publication strategy, in particular in the institute sector;
5. how to improve the organization of the research institutions with special attention to the Centres of Excellence (CoEs);
6. how to develop and renew the research infrastructure at individual institutions and nationally;
7. how to align the PhD education with the future needs of Norwegian industry and higher education and research;
8. how to improve the gender balance and how to promote the recruitment of women to the geosciences in general and to tenured positions in particular.

The committee met five times. Consultations on the basis of a report of draft findings and recommendations were carried out with the relevant institutions in Trondheim on 13 January 2014, in the Oslo region 14 January, in Bergen including the Sogn og Fjordane University College and the University of Stavanger (the latter did not send any participant) 15 January, and for the institutions in Tromsø and Longyearbyen (UNIS) in Tromsø 20 January. The chairperson plus the local committee member took part in the consultations. The coordinator from RCN took part in the meetings in Trondheim, Oslo and Bergen. Because of unforeseen circumstances (illness and more) much time has elapsed between the publication of the report and the follow-up advice provided here. Several of the recommendations from the Evaluation Committee were followed up by the relevant institutions before the follow-up committee started its work. To a large extent this is accounted for in this report.

3.1 The 1998 evaluation of geosciences, and the follow-up "From individual researchers to local centres"

In 1998 an international committee formed by the Research Council of Norway (RCN) presented a review of geosciences research at Norwegian universities and colleges. The main recommendations included advice to focus the research activity into fewer areas, increase funding for well-organised research groups, establish a more focused curriculum, and be able to offer higher salaries for highly-qualified scientists. A national follow-up working group was appointed to define a strategy for organization of geosciences' research in Norwegian educational institutions for the next 10 years (Geofagplanen 1999). It concluded that there was a strong need for better scientific integration between Norwegian geophysicists and geologists/geographers; a need for geology as a science to move into more quantitative, process-oriented directions; a need for more innovative research and a better projection of the Norwegian contributions in geosciences research on the international scene. It also concluded that environmental concerns, in particular those related to possible future climate change, required better integration of topics such as meteorology, oceanography, hydrology and paleoclimatology.

Many of the recommendations from Geofagplanen 1999 have been followed up. Several of the university departments in geosciences have been restructured into larger units. Most university departments now have unified leadership and an employed head of department often with leadership experience and recruited from outside of the institution. A Centre of Excellence (CoE) system has been successfully implemented, and the geosciences have had a large share of the success in this. The international dimension of the research in the geosciences has been strengthened, not least through the Framework Programmes of DG Research of the European Commission. The number of foreign researchers, the number of co-authorships with international colleagues, in particular within Europe, has grown. The traditional turning only to North America for international research links has faded somewhat.

The recommendations from Geofagplanen 1999 suggested a move of the organisation of research from small departments based on one or more senior professors/scientists, to centres and larger departments ("from individuals to local centres").

3.2 The 2011-evaluation: From local centres to national teams in an international context – *"From local centres to national teams"*

The evaluation committee (EC) concluded that "earth science research in Norway is generally in a state of good health. Very few truly weak research areas were observed. 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 leading internationally" (p 5).[1]

Of the 59 research groups evaluated, 13 were concluded to be weak (receiving grade 2-3 or lower). Some of the smaller research groups with low grades were in a transition due to the retirement of permanent staff. Also, the evaluation criteria did not cover all research activities in applied topics. However, the low grades might also reflect a real quality problem. As the EC report is more than four years old, some of the research groups and institutions where low grades were assigned have taken steps to improve the return on research investments.

[1] In this report the term geosciences is used to denote the collection of the science disciplines dealing with non-living geo systems, while the term earth system science includes both the geosciences and living systems (ecology).

The EC said that the Norwegian geosciences add important contributions to the national welfare. The Norwegian geosciences depend on extensive, expensive infrastructure to facilitate field work including research vessels and heavy instruments for marine applications, laboratory experiments, super-computing etc.

The mandate of the current Working Group is primarily to advice on follow-up actions of the recommendations from the EC on a national level, a different mandate compared to the follow-up committee ten years ago. Many of the findings and recommendations from the EC are of a general character and not specific for the geosciences, as for instance better funding of “blue sky research” (basic science not predefined in specific programmes), or more time for research when teaching, supervision and administrative duties are accounted for. Such recommendations are therefore not further discussed in the report.

4 Discussion and overview of measures proposed

4.1 The role of the geosciences for strategic research of national importance

The geosciences provide research that underpins a substantial fraction of the national economy through the management of natural resources as well as the evaluation and managing of risks. Worth mentioning is in particular exploring and producing oil and gas (in short petroleum-related research), producing and supplying energy from renewable and non-renewable fuels, mapping and managing of mineral resources, managing the fisheries, and evaluating and managing the risks to the food supply, human health and societal infrastructures that arise from environmental pollution, storms, heavy precipitation and floods, droughts, geohazards, waves, ice, storm surges and climate variability and change.

In this sub chapter advice is given for follow-up of the evaluation on a national level, separated into seven themes under the headings “management of resources” (energy sources and supply; mineral resources) and “management of risks” (geohazards, environmental risks, climate change), in addition to two themes that cut across resources and risks (marine geosciences, polar geosciences). Figure 1 illustrates how the themes used by the EC map onto the themes of societal relevance defined here.

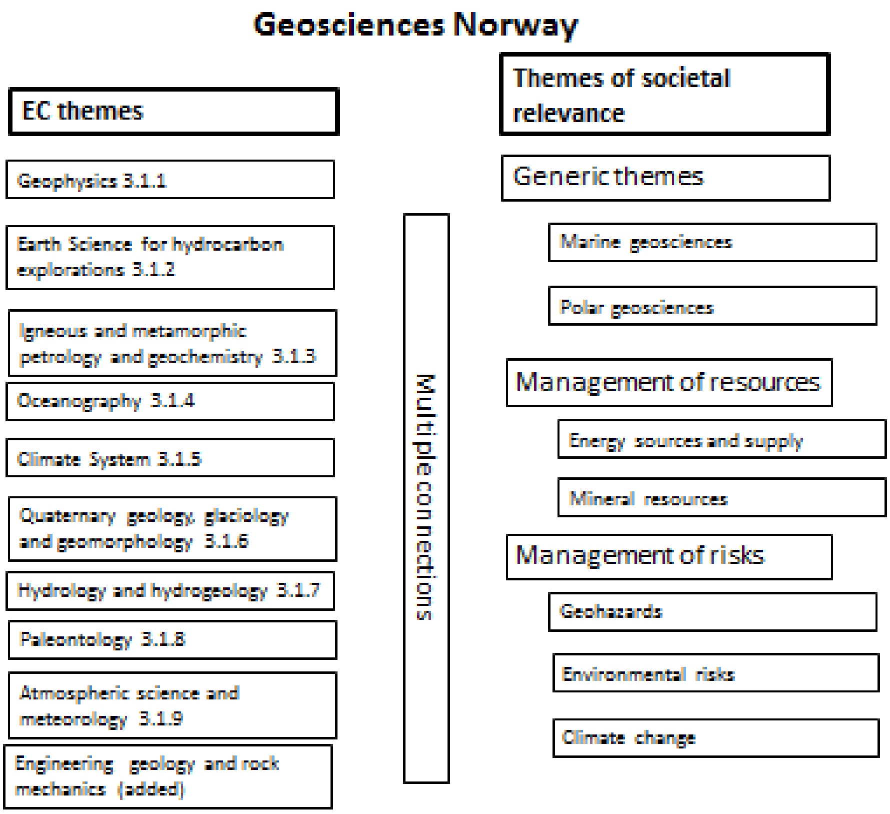

Figure 1

The provision and management of knowledge and data in many of these areas is widely seen as a governmental responsibility and part of what constitutes a well-developed modern society. For this reason industry and other commercial interests are reluctant to fund research in many of the geosciences. For the geosciences relevant for the exploitation of resources (oil and gas in particular), industry funding is very important. Private funding is presently important for research that brings basic knowledge and data into specific applications which are not society-wide and not part of the Commons. This is reflected in the statistics for Centres of Excellence (CoE) and Centres of Research Driven Innovation (SFI), where of the 34 CoEs granted up to now by RCN, at least 11 have a dominant or significant geoscience component. Of the 22 SFIs granted, about 7 involve to some (often limited) degree research in the geosciences. This reflects that knowledge and data in the geosciences are to a large extent a "public good". Market value often arises when geoscience data and knowledge are combined in an interdisciplinary setting to generate specific methods or products of industrial interest (<u>Measure M6</u>).

In the geosciences the distance between research and its application is often short, even for the more basic research issues. The success of research therefore has a significant and direct bearing on the management, safety and the economy of our society. This puts a particular responsibility on the geosciences and geoscientists for bringing their research results to use. "Science for the society" is the mission of many of the governmental and private research institutes in the geosciences, and quality, relevance and impact key criteria for success.

This role of the geosciences is reflected in the white paper from the Government in 2012-2013 (Meld. St. 18 (2012–2013)), "Long-term perspectives – knowledge provides opportunity" where the national research policy targets to a large extent overlap with those in the geosciences: environment, climate change, oceans, food safety and energy. For strategic research of national importance, the geosciences/earth system sciences are very important.

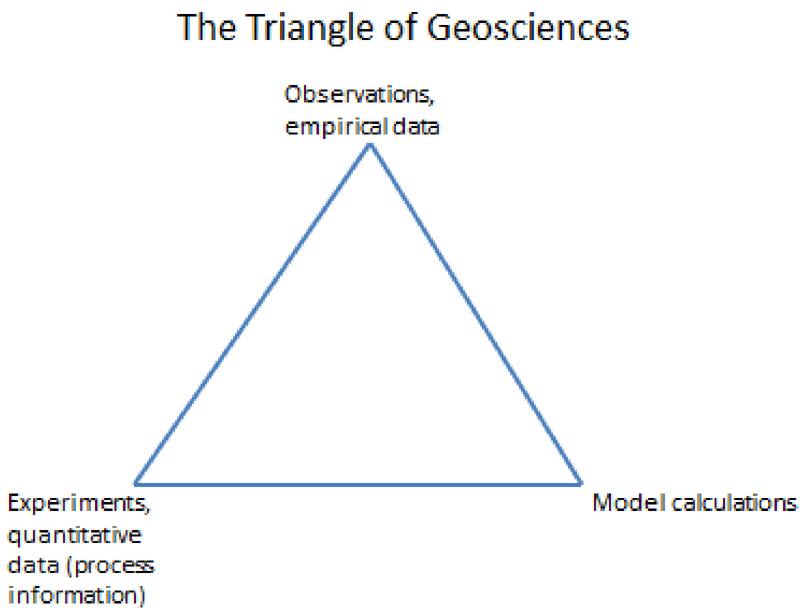

Figure 2

The geosciences rest heavily on observations and empirical data, experiments and process studies to quantify the characteristics of individual processes, and on computational mathematics and physics based on the laws of science that control the behaviour of the earth system components and the relationships between them. The different parts of the geosciences are interconnected and gradually the main focus moves towards model calculations (the lower right corner of the triangle of the geosciences in Figure 2), integrating the data and process understanding from the other two corners of the triangle. The geosciences are infrastructure-intensive disciplines. The university funding model for students does not take this properly into account (Measure M16).

4.1.1 Issues of a national character related to the individual geoscience disciplines

The EC split their discussion of the individual geoscience disciplines into nine subgroups 3.1.1-3.1.9 in its report. In addition we have added engineering geology and rock mechanics. We discuss here the disciplines in terms of seven themes of societal relevance, see Figure 1 above. Two of these, marine geosciences and polar geosciences, are overarching, representing thematic and geographical cross-cutting areas of special national importance.

Marine geosciences

Marine geoscience is strong in Norway. With our long coastline and large ocean areas under Norwegian sovereignty, it is of great importance to maintain and foster research in the marine geosciences as it underpins the exploitation and management of extensive national resources and environmental responsibilities. In addition, the deep oceans are the least explored areas on our planet. It embraces a variety of research areas in which some are dealt with under polar geosciences, climate change and energy sources and supply (see below). Marine geosciences are relevant for many other disciplines, like natural sciences including marine biology. The marine geosciences address fundamental research questions related to for example the lithosphere, geohazards like tsunamis and sub-marine slides, and the coupling to the biosphere and the atmosphere.

Oceanography is a central discipline in research related to the status of the marine environment, in safety at sea assessments including operations in sea ice, and for the mapping and exploitation of living marine resources. A range of services essential for modern society in Norway and elsewhere derive from research in oceanography.

The EC indicates that research in oceanography in Norway today is not organized in a way that provides the best value for money in terms of scientific results or services. Some of the small oceanography groups like the one at UNIS, benefit from the observational efforts at the larger institutes with national responsibilities and mandates, like IMR, and enhance the scientific value of the observations through their work (Measure M2).

An important research challenge to the geological community in Norway is related to growing international interest in the deep sea in general and more specifically to ocean mining. This is also discussed under the theme mineral resources, see below. Significant metal occurrences may be present along or near active and extinct spreading ridges that are under Norwegian jurisdiction in the North Atlantic. Some of these ridges have been investigated and sampled by the Centre of Excellence for Geobiology (UiB) in collaboration with the Norwegian Petroleum Directorate. However, documenting the potential reserves and their distribution will require novel mapping techniques adapted to great water depths. This activity must be accompanied by geodynamic modelling of the ridge system in order to understand in more detail the formation of the ridges and associated mineral deposits. This area was strengthened last year by the Research Council infrastructure funding of a remotely operated underwater vehicle (ROV) for the Norwegian Marine Robots Facility at UiB. UiB is further strengthening this field by establishing a National Centre for Deep Sea Research.

Ocean mining projects are under preparation at NTNU in ore-geology and mining, and new research in exploration methodology is being discussed.

Of equal importance is to assess the environmental impact inherent in exploiting the resources. Future surveys and research must therefore also encompass investigation of the vulnerable biosphere in the deep-water environments. If deep sea resources exploitation proves to be economically feasible, the technical infrastructure required to extract and transport the ores to the surface for further processing will be another important field for technological innovation.

Marine geosciences depend heavily on costly infrastructure and therefore the national team perspective is essential. Given the advanced level of Norwegian underwater technology, there is every reason to believe that investing in this research field will have a strong positive impact and provide new possibilities for industrial development in Norway and abroad. Research vessel based field work is another essential component. The national ice class research vessel now being built is an important step forward. Further upgrading of the remaining national research vessel fleet is needed in order to continue state-of-the-art research. Norway should also contribute to the international efforts to develop and establish novel ocean observatories (Measure M11).

Polar geosciences

The EC did not discuss polar geosciences as such in their report. It is a theme cutting across all disciplines in Norwegian geosciences, as it encompasses research over extensive sea and land areas, the cryosphere (glaciers and frozen ground) and the atmosphere. Much research within all earth science disciplines takes place in the polar areas. In particular for climate research, the polar regions present a great global research challenge. As such, most of the research disciplines within polar geosciences are also addressed under the other themes.

Norwegian research has historically had a strong polar region focus, closely related to the exploration, and later the management of Norwegian land and sea territories in both the Arctic and the Antarctic. Consequently, Norway has both a responsibility and a need to gain knowledge about the high north (see the Government's white paper on the High North (Nordområdene), Meld. St. 7/2011-2012) and the separate research strategy for the Northern Areas (Norsk polarforskning 2014-2023, RCN 2013). In the research policy document 2014-2023, the Norwegian Research Council specified six thematic priority areas: International interplay, climate and environmental change, natural resources and commercial activities, international research collaboration, research infrastructure and the communication of research outcomes. The geosciences, including the earth system perspective, are essential for all the priority areas. As for the marine geosciences, the national team perspective is particularly relevant for polar research, as the research issues as well as the infrastructural and logistical requirements are complex. The environmental, political and economic implications of research need to be closely monitored in a national and international perspective due to the fragile governance structure of the polar regions and in particular of the Arctic.

UNIS has grown to become a successful internationalized centre for field based polar research and education in geosciences. As a partner for all the Norwegian universities, UNIS provides collaboration and access to research opportunities in the Arctic. Glaciology education and research has recently been strengthened through the Nordic Center of Excellence in Cryosphere Research entitled “Stability and Variations of Arctic Land Ice” SVALI (2010-2015) coordinated by the Department of Geosciences, University of Oslo, and through the ICE-centre established at the Norwegian Polar Institute.

Geological and geophysical investigations of the extensive continental shelves of the Barents Sea and Svalbard have important implications both for energy sources (see this theme below), as well as for basic research and for building national competence of great industry value. Due to the climatic sensitivity of the Arctic, both in the present and the past, seafloor and land deposits formed during the last 1-2 million years provide archives of past climate (palaeoclimatic) and oceanographic (palaeoceanographic) changes in interplay with the changes in the cryospheric (glaciers, permafrost) system. The Svalbard archipelago provides an excellent opportunity to study the coupling of all these fields in an earth system science perspective, and maintaining and strengthening of the Norwegian research capability will very likely provide a large return on the investment. The extensive cross-disciplinary research made during e.g. the International Polar Year 2007-2008 represents an example of collective research efforts that have moved knowledge boundaries and with significant societal benefits both for the management of resources and for reducing environmental risks.

Norwegian glacial- and periglacial geomorphology has easy access to field research sites spanning from high Arctic Svalbard, to low Arctic conditions in southern Norway, and should explore this unique research potential systematically. A strategy for national terrestrial cryospheric landscape research and education should be developed. The geographical north-south and east-west extent and climatic contrasts existing within Norway, Svalbard and Antarctica can be used to enable studies of various types of landscapes and climatic zones.

(Measures M2, M12).

4.1.2 Management of resources

Energy sources and supply

Energy sources and supplies is a theme cutting across many of the disciplines addressed by the EC. It covers many forms, including nuclear energy, fossil energy (like oil, coal and natural gas), geothermal energy and renewable sources like hydropower, wind, solar and other sources.

The Norwegian oil and gas adventure has been of enormous importance for our industry and economy. The competence in the geosciences has been a key element in the successful petroleum exploration and production. The challenges are now related to exploration both in new and mature areas and also maximizing recovery by improved reservoir characterization.

If oil and gas resources in the northern region are explored and produced, there are large technological challenges in geophysical acquisition, processing, imaging and interpretation and also geo- and basin modelling that must be solved. In general the requirement for more quantitative models and crosslinks between geophysics and geology need integration with physics and mathematics in particular.

Before petroleum exploration can take place, sufficient ecosystem and ecotoxicology knowledge is required for the identification of sensitive ecological components. This is of special interest in the Barents Sea region – a highly productive and diverse marine ecosystem which also is of major global significance as it supports some of the richest fisheries in the world, as well as major parts of the global populations of marine birds and mammals. The changes in climate also require strong focus on knowledge to enable an even more energy efficient and environmentally sustainable exploitation.

Environmental risks as well as technological challenges linked e.g. to power transmission, are associated with the production of energy. The EC states that a closer integration of hydrology-meteorology-climate research could provide the necessary competence to develop integrated hydrometeorological forecasting aimed at supporting the energy production based on water, wind and solar resources under climate change (Measure M2).

The EC underscores that there is strong collaboration between the petroleum industry and the geosciences 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). These are all basic geoscience disciplines, which illustrates the petroleum industry's need to understand the subsurface in all respects. The strong links with and support from industry has facilitated cooperation and results on an academic level. The new national Research Centre for Arctic Petroleum Exploration (ARCEx), coordinated by UiT, exemplifies this – all the established petroleum research groups from the other universities in Norway are partners aiming at knowledge transfer to build up a petroleum group at UiT.

An increasing number of energy wells are drilled in Norway. These wells are mainly exploiting the heating and cooling potential of the upper 100-300 m below the surface. There is also an unexplored energy potential for deeper wells down to ca 5 km in the crust and a virtual Norwegian Center for Geothermal Energy Research (CGER) with a number of partners is established. More research is needed in Norway to be able to appreciate the future potential of these forms of renewable energy, which might have a great export potential based on knowledge transfer from the petroleum sector (Measure M2).

The production and management of groundwater for both water and geothermal energy supply are of increasing national and global importance. NMBU has a comprehensive teaching programme in hydrogeology. The University of Oslo (Department of Geosciences) has covered hydrogeology for decades, but the research and teaching capacity in the field is under pressure. Also NGI, NGU and NTNU host researchers in hydrogeology (Measure M1).

Mineral resources

The EC concluded in 2011 that the level of expertise in petrology and mineralogy is sub-critical, and that research focus in mineral exploration and mining as well as applied geophysics is rather limited. Few doctoral students were trained and postdoctoral researchers and academic staff was mostly recruited internationally.

An increasing demand for metals and other geological raw materials is related to the growing global population and higher use of raw materials in developing countries, and for a number of special metals there is a gap between availability and demand. Base metals as well as the rare earth elements are critical to the manufacture of renewable energy devices.

The Norwegian government has invested substantial funds into national geophysical and geological mapping through NGU. Improved strategy has resulted in new professorships in Norway (e.g. in ore geology at UiT, and in mineral production/flotation at NTNU). Considering the growing importance of mineral and ore-deposit characterization, there are pressing demands for increased resources in basic mineralogy and petrology at Norwegian universities. Research groups integrating ore-deposit geology, mining and environmental engineering, mineralogy, petrology, structural geology, rock mechanics and geophysics, are recommended for developing better models on the origin, distribution, and environmentally responsible exploitation of onshore as well as offshore mineral resources (e.g. NTNU, NGU, UiB, UiT). In particular, it is important to develop better methods for predicting mineral deposits deep under the surface, including sophisticated 3D/4D models of the upper crust. Moreover, knowledge of mineral resources life cycles, secondary resources and recycling of minerals is important for building a more sustainable society.

Successful exploration achievements and responsible exploitation of mineral resources will require strengthening of research and education within all of the above mentioned fields.

(Measure M10)

4.1.3 Management of risks

Geohazards

EC says that “geohazards” or “natural hazards” is an applied field of geoscience and is of national importance. Geohazards refer to rapid natural processes on or near the earth's surface which can cause large damage to people and property. Geohazards can be triggered by earthquakes and volcanic eruptions, or extreme weather events (rapid mass movements, landslides, rock-falls). Construction work can trigger landslides. In Norway, most natural hazards are associated with river floods, snow avalanches and landslides in unconsolidated material (debris flows, quick clay slides) as well as major rock slides. Steep and fractured rock faces have caused disastrous rock slides in the past. Climate change may increase the frequency of extreme weather events and trigger more landslides and influence the stability of steep rock walls and slopes.

Studies of national hazards involve hydrology, tectonics, rock physics, glaciology and meteorology. It does also include research into the dynamic processes of the earth's interior determining e.g. the understanding of the distribution and causes of earthquakes. It involves many of the institutions covered by the evaluation. National competence was developed during the CoE International Centre of Geohazard (ICG, 2003-2013) at NGI (with UiO, NGU, NORSAR and NTNU). ICG also contributed to the education of researchers and specialists in these fields, and specific master programs were initiated at UiO and NTNU. A crucial infrastructure for geohazards is the Norwegian National Seismic Network (NNSN) and the further development through the ESFRI project on European Plate Observing System (EPOS).

There is considerable political focus on geohazards. The Ministry of Oil and Energy issued a white paper on measures to mitigate flooding and landslide risks ("Hvordan leve med farene – om flom og skred", Meld. St. 15, 2011-2012). An assessment of climate adaptation was published in 2010 (NOU 2010:10) followed by a white paper – on adaptation to climate change in Norway ("Klimatilpasning i Norge", Meld. St. 33, 2012-2013) in May 2013, where it is recommended that measures to be undertaken to reduce flood and landslide damage should be evidence based, problem driven and solution oriented. NVE is appointed national agency responsible for the preparedness to all forms of natural hazards, and coordinates the national investigation, surveillance and mitigation of floods and landslides.

The white paper on floods and landslides (Meld. St. 15) emphasized the current lack of professionals and the need to increase training capacity within these themes. A specialist education is required on top of the basic geoscience disciplines, in particular the climate system and hydrological and geological processes. An education programme related to natural hazards exists at HiSF (BSc program), NTNU and UiO. UiT initiates courses related to rock slides in collaboration with other partners. UNIS is establishing a course in snow avalanches, in cooperation with UiO (Measures M1, M2).

At some stage the scientific basis for geohazards research must be reinforced through basic research programmes (observations, monitoring and modelling of landslides) as well as applied research (impact on traffic infrastructure, buildings etc.). The stakeholders should facilitate and co-fund applied research (Vegvesenet, NVE and others).

Environmental risks

The EC assigned very high grades to the research groups in atmospheric science and warns that this capacity cannot be taken for granted without providing competitive research funding to sustain it. There is not sufficient appreciation at the level of research funders of the contribution from atmospheric science including meteorology to risk reduction related to climate, environment or weather. In particular the very competent contributions from the private sector research institutes can rapidly diminish if it is taken for granted that the best groups always manage to cope even if the national funding opportunities disappear. The resource situation therefore needs attention to retain and further develop in depth disciplinary skills – a requirement to succeed in cross-cutting, interdisciplinary research which is receiving more funding attention (Measure M13).

The disciplines contributing to environmental risk research and discussed by the EC are atmospheric sciences and meteorology, oceanography and hydrology. Examples are air and water pollution and the risk to human health, ecosystems and the water supply, marine pollution and the risk to marine living resources, and extreme weather events and the societal risks they entail (Measure M13).

As also mentioned under "Marine geosciences" the EC says that for oceanography many of the individual research groups are too small and too diverse to be internationally recognized. In some institutions, oceanography is mostly a support discipline because of the need for teaching expertise; the hiring of new personnel is thus more dictated by teaching requirements than by research opportunities. Oceanography is central in research related to climate and to the status of the marine environment, in safety at sea assessments including operations in sea ice, and for the mapping and exploitation of living marine resources. A range of services essential for modern society in Norway and elsewhere derive from research in oceanography. The views of the EC indicate that research in oceanography in Norway today is not organized in a way that provide the best value for money in terms of scientific results or services (Measure M2).

EC states that there is an important need to develop a common research language in hydrology, which can only be reached by day-to-day joint research and development by MET Norway and NVE with support by UiO, UiB and NMBU to develop hydrometeorological forecasting aimed at relieving flood risk and supporting optimized energy and water resources management under climate change. (Measures M2, M13).

Climate Change

The EC states that Norwegian climate science is highly visible and contributes significantly on the international research arena. The government and the Research Council put a high priority on climate research. The disciplines contributing to climate change research and discussed by the EC are oceanography, climate system, quaternary geology and glaciology, hydrology, paleontology and atmospheric sciences and meteorology. Norwegian climate research was also evaluated in 2012 (ISBN 978-82-12-03085-5 or 2) and we quote from that evaluation "Norway has developed internationally recognized top competencies in many of the scientific disciplines that are necessary for understanding the current climate and its development. In particular the comprehensive numerical climate and earth system models are highly regarded. Norwegian climate research is in harmony with the mainstream of international climate science. However, more effort is needed to understand natural climate variability in order to better quantify the uncertainty in predicting future climate".

As said above in the environmental risks theme, the EC underlines that the strength of atmospheric science in Norway is an important national resource also for climate research. The resource situation needs attention to retain and further develop in depth disciplinary skills, which is a requirement in order to succeed in cross-cutting, interdisciplinary research which is receiving more funding attention. Climate adaptation services require a significant research effort not least within the climate predictions for the sub seasonal to seasonal and decadal time scales, as well as understanding climate-related changes in the physical environment. The national coordination of the modelling of the earth system is well established through RCN funding of NorESM development and application (Measure M13).

As also discussed in the environmental risks theme (above), the EC statement that there is an important need to develop a common research language (in hydrology) between MET Norway and NVE with support by UiO, UiB and NMBU to develop hydrometeorological forecasting aimed at relieving flood risk and supporting optimized energy and water resources management under climate change, is also important here. The EC here points to an area of very large scientific and societal importance, including risk reduction related to floods, droughts and landslides in the present and future climate, which would benefit from closer collaboration between hydrology and meteorology (Measures M1, M2).

4.2 Advice and action for development of research leadership, to strengthen the work with strategic plans for institutions and research groups

The Evaluation Committee (EC) pointed out that there is a reluctance to encourage research leadership and that there is a preference for decision-making by consensus. The EC underlined that a strong leadership is essential at the department or institute level, while consensus can be appropriate for smaller research groups. The EC pointed out that units with a strong leadership often also had developed strategic plans. It also pointed out that the roles of leadership and management often were confused. The EC pointed to the matrix type of management which e.g. can be found at the Geological Survey of Norway (NGU) as highly effective also for organising research projects.

In their feedback on the evaluation to RCN, only a few institutions have made comments here and only in general terms: The universities participating in the evaluation agreed to the comment, but some pointed to RCN or to a higher institutional level for further advice.

To change the strong research management culture in the universities, or the lack of such, action is needed both top-down and bottom-up. The universities have over the last years changed the leadership of most of the departments to a unified leadership and to employed head of department, who in several cases are externally recruited and come with experience as leader. These efforts have strengthened the productivity and competitiveness of the individual units. Training programmes on an institutional and national basis are important for fostering leadership (Measure M7).

However, there is a lack of incentives to build excellent national teams in broad fields of inter-connected disciplines. Political pressure and support, as well as new incentives on the national level, are required to build broad national teams that can address research themes of particular relevance for national economic development or for the management of environmental risks (Measure M2).

Many parts of the geosciences, other natural sciences, social sciences and economics need to be bound together when addressing the interconnectivity of the geosciences. The research challenges require research with skills in analysing the dominant aspects of the behaviour of the earth system components. At the same time the disciplinary specialization needs to be nurtured and maintained.

This implies that a balance has to be struck between disciplinary specialization and the integration across disciplines. There is a need both for traditional disciplinary research groups and groups that integrate across disciplines, the latter typically a centre with a leader that combines excellence both in science and in mobilising teams of scientists. This way of organizing has developed over the last decade. Despite the inherent challenges, the geosciences in Norway have proved remarkably resilient and capable of changes, not least illustrated by the large number of CoEs with a predominant geosciences-theme.

The science leaders – taken both as the department chairs and the leaders of individual research groups – need at the same time to foster the skills and orientation of the research group, the department/ institution, and at the national level to ensure that the research challenges are addressed at an appropriately aggregated level and based on the *international* research excellence. To meet the larger challenge for the future, which can be expressed as integration across disciplines and in depth disciplinary studies to harvest the potential of the geosciences for the national economy and the management of environmental risks, team work on a national, and even international, scale is essential. This is a complex research structure with both competition and collaboration.

To extend or develop new research methodologies across disciplines and regional and national boundaries, require predictable, long term funding and some top-down pressure in order to establish collaborative team work. Specialized, disciplinary studies and infrastructure can be reasonably short term and commissioned through competition as a mechanism for quality and relevance testing. Generic research and its infrastructures need long term, predictable funding (Measure M12 is an example).

4.3 Collaboration, division of labour and concentration (SAK)

The EC report highlighted how research in the geosciences nationally can gain from more collaboration, division of responsibility, and concentration ("SAK - samarbeid, arbeidsdeling og konsentrasjon"). The EC underlines that there is substantial collaboration among the geoscience groups in Norway, but concludes: "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".

As the evaluation comprised a part of the public institute sector research (NVE, NP, IMR, MET Norway, NGU) and the universities, the division of responsibilities among them was an important issue. The public institute sector has mission statements covering a broad range of societal knowledge and research needs. The higher education sector has in common the education of students and researchers, and meeting the societal demands for skilled labour. The public research institutes are under the auspices of specific sector ministries and their mandates reflect the sector interest in the research and its results. The sector ministries should align their funding of research in the geosciences to obtain "quality, relevance and impact" with a high return on investments (Measure M14).

The private research institute sector in Norway is large. The evaluation comprised parts of the activities of a number of them (SINTEF, UNI Research, NERSC, NILU, NORSAR, CICERO). The private sector institutes are funded over public budgets to a large extent, but almost exclusively through competition. The public research institutes also compete for research funding, but to a lesser extent. The mandates of the private research institutes are formulated to take advantage of the market opportunities. As both the private and public institute sector and the research at the universities to a large extent are funded over public budgets, the SAK perspective is relevant for all of them.

The intention of SAK is to get public institutions to define together goals that cannot be met adequately by one institution alone, and to meet the new cross-institutional challenges by restructuring own work and shifting existing resource allocation. The SAK concept was devised by the Ministry of Education and Research as a mechanism for the public sector to modernize itself "bottom up" without directives "top down". A plea can be made for additional resources if relocation of current ones is insufficient to meet the common SAK goals.

The geosciences can make very significant contributions to the national economy and the risk management, but no single institution can meet the challenges alone. The SAK perspective is therefore relevant and useful for the geosciences.

We note that at the same time as SAK is a politically driven issue, there are also strong political forces that drive new research funding outside of SAK or competition, for example related to the Norwegian geopolitical focus on the polar areas, in particularly the Arctic. This has, and will, result in the establishment of new competing research environments overlapping with already existing high quality research groups, without the focus on complementarity. This is very different from and counter-productive to the SAK perspective.

The EC mentions a similar case on p 17 in their report (chapter 3.1.5): "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." Such new measures will be more productive when their use is planned with a SAK perspective in mind.

In the university and higher education sector the SAK-mechanism has to some extent been used to develop collaborations in order to achieve a higher quality in both research and education. But it has not been easy to get the SAK perspective to function across ministerial boundaries, and the EC expresses that several research activities in the geosciences are too thinly spread across a high number of institutions, and that the quality varies too much. This was also a criticism raised in the previous evaluation. Some actions have been taken, but the culture to really address this issue on a national level is not present. This is a question of leadership and mandate on the national level. At present there is not a culture which fosters a voluntary "sit down around the table-discussion" and there is no official body with such a responsibility. The sector ministries involved have unfortunately not really taken the consequences of the SAK perspective introduced by the Ministry of Education and Research (Measure M14).

Despite this, new research areas within the earth sciences have developed mainly through multi-disciplinary approaches during the last decade, and often through collaboration between national institutions. Also national collaboration in education on the doctoral level has developed within climate and petroleum research. Examples are the national global earth system model NorESM by UiB, UNI Research, UiO and MET Norway as a contribution to IPCC and as the core of the national climate services led by MET Norway (with NVE and UniResearch), and national research schools in energy and climate.

UiT, NTNU, UiB, UNIS and UiO with IMR, NP and MET Norway have developed a national research plan "Arven etter Nansen" for parts of the geosciences and biology in the Northern Barents Sea. The planning is carried out as a SAK-project supported by the Ministry of Education and Research, and it builds on the investment done independently in the new national ice going research vessel under construction, other platforms of opportunity for observations or permanent ones, and the mobilization of the national research capacity in Norwegian universities and public research institutes (Measure M12).

Moving new knowledge from the results of basic research through to application is another challenge that requires a SAK-approach. When research findings and methodologies are mature and can provide information of societal relevance and importance, mechanisms need to be put in place to allow and encourage this to happen. In this way the societal return from the investment is secured. This can require the set-up of delivery and interdependence mechanisms between research groups and public as well as private institutions that deliver services, like NVE, MET Norway, IMR, NGU and NP. The success of for example oil companies and shipping/fishery enterprises depend on a first class knowledge base in the geosciences. Functioning delivery mechanisms of this kind can be found in the geosciences (e.g. weather forecasting). But many opportunities are probably not pursued or are immature because this way of thinking has not prevailed, leaving the return on research investments more modest than it could have been (Measures M2, M4, M14).

Competition is required to enhance quality and productivity. Collaboration is needed to ensure good coordination and a sufficiently long time horizon to develop in fundamentally new directions, requiring time and opportunity to rethink and redirect the research process as knowledge and experience are advancing. The funding horizon should be determined by the character of the effort.

The Research Council is at the moment to our opinion not distinguishing properly between items that are needed on a national and long term basis (10 years) with competition as a sub optimal mechanism for selection, and items where a reasonable level of competition is productive. The sector ministries should align their funding of research in the geosciences to obtain "quality, relevance and impact" with a higher return on investments (Measure M14).

4.4 Advice and action for (further) development of strategy for publication, in particular in the institute sector

The EC wrote in recommendation 6 (chapter 3.2.6) that "Publications are one of the most important ways of demonstrating research strength and these should be encouraged throughout all stages of a research career." The strongest research groups in the evaluation had well-developed publication strategies, targeting the leading international journals, whereas the weakest did not.

A major part of the evaluation was based on a bibliometric analysis of all the participating institutions. Publications are used as an indirect measure of the productivity. Data on how much the publications have been referred to or cited in subsequent scientific literature can in turn be regarded as an indirect measure of the scientific impact of the research. An important change is the number of publications with co-authors from other countries – in 2009 this number was 68 % (national average 53 %). In ten years it had increased form 56%.The strive for increased publication rates and internationalisation in the geosciences has been quite successful.

The RCN and the Ministry of Education and Research and other relevant ministries should increase the base funding to the private sector research institutes with the aim to raise their publication rate in the open literature (Measure M15).

A large fraction of research in the geosciences is justified by its societal relevance and value. Therefore publications and dissemination of results are very important, and go beyond the number of peer reviewed papers and H-factors. Even results from "blue sky research" in geosciences often point towards applications for instance in environmental risk management and energy production. The current emphasis on high publication numbers needs to be complemented by other measures. Efforts to act as national teams to cover science issues that require combining efforts in several disciplines, or efforts to follow research results through to application (innovation by enhancing economic or social value creation) need to be rewarded, too. Public outreach is well developed in many fields of the geosciences. The rewards here are less systematic than for peer reviewed publications, and are made up of enhanced goodwill and visibility for the individuals and institutions involved.

Research in the geosciences is based both on observations, field and laboratory experiments, and modelling (computational mathematics based on the laws of physics, dynamics and chemistry). In many cases a research project leaves behind methods, data and physical samples which have a value beyond a peer reviewed publication and beyond the lifetime of the project. A project leaves behind a heritage which in most cases is not taken care of at the system level. This means that there are not well established and generic structures for the identification and availability or retrieval of data, methods, software or physical samples by interested users. Intellectual property rights are associated only with the publications, not with the data or methods/software themselves. It is left to the individual researcher to think about this and at best establish some best practise decided locally by himself/herself or his/her home institution.

The EC found that the 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.

The management of data and the data policy in the geosciences are key issues for subsequent research and for exploitation (innovation) purposes. Significant resources today go into the establishment of research projects, both by the applicants, in the Research Council and elsewhere. Less attention is paid to secure, and make available, the data heritage from publicly funded projects beyond the science publications. Innovation in monetary or social terms is generally not pursued in a systematic way, neither at the individual researcher's level, nor at the level of his/her institution, nor at the national level. It is required to increase the awareness of the data resulting from research in most of the geosciences as a public good, rather than a private good. If mature data arising from research are handled as a public good and made available as such, its further use can in many cases create significant economic or social value. Such value needs to be recognized when research (and research proposals) in the geosciences is evaluated and rewarded.

At the same time the intellectual property rights of the researcher who contributes to a service of societal interest in this way need to be established and protected. A researcher who creates "heritage" in terms of documenting and providing data or methods or software or physical samples in standardized ways needs an acknowledgement comparable to the merit of a peer-reviewed publication. The capability "to put research results to use" (innovation/social innovation) is a quality criterion for the geosciences (Measure M4).

4.5 Improve the organizational structure, in particularly in connection with CoE's

The EC recommends that the organizational structure of the Centres of Excellence is kept as simple as possible. The EC also say that "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". But the EC also states that "their creation has had a detrimental effect on the parent departments from which staff was drawn to build the CoE. When a CoE ends there may be particular difficulties in reintegrating the CoE staff into their "parent" departments".

The CoE organizational structures are not a specific geoscience issue; it is rather related to the increasing complexity of how research is done and to the formal structuring of academic research. However, centres focusing on infrastructure intensive disciplines, like the geosciences, will tie up resources and specialized technical staff from the host departments and we therefore believe solid agreements are important.

Most of the geoscience departments introduced unified leadership and employed head of department, at the same time as the CoE incentive was introduced. It is therefore not surprising that organizing the first centres was challenging and that there sometimes was friction between the department leaders and the centre leaders. Regardless of organization, ownership at the department level throughout the centre period is critical, balancing the autonomy of a centre with the short and long term needs of the department.

Large research projects and centres need extensive administrative support. They will also be committed to teaching and supervision, tasks closely linked with the host departments. However, much of the administrative support can be done at the department level in order to limit the administration to the tasks that are centre-specific. It is crucial that the host institution together with the CoE progressively establish exit strategies, as opportunities emerge and can be fostered and brought forward.

There are also expectations that centres will become embedded within the host departments and be sustained beyond the funding period. For such expectations to develop in a realistic direction, it is crucial to involve the relevant department heads for example as board members. This type of arrangement requires clear guidelines, however, to formalize the role of the centre leader relative to the department heads. A CoE has a strong impact on the host department and need to be an integral part of it (Measure M8).

Work in progress by the Nordic Institute for Studies in Innovation, Research and Education (NIFU) (NIFU Working Paper 10/2013) states that "Added value for host institutions includes increased ambitions in the local research environment, and enhanced ability to recruit both highly competent researchers and students. On the negative side, in some cases there was increased local competition for resources, space, personnel, and friction generated by new organizational structures and scarce resources." We believe this summarizes the situation well.

In conclusion, there are several ways to organize these centres. One size does not fit all. The organization needs to be decided by the host institutions, and we do not see this as a matter of national character.

The CoE system fosters strong research teams and institutions. The CoE system redirects the national research structure significantly. As for any pragmatic, strong and successful instrument, after a while counterproductive side effects may appear, like a weak national team building capability. To succeed in this respect, perhaps the excellence criteria of the CoE system could be applied on the national level, which requires to look beyond the current CoE-structure for agenda setting, organisation including leadership and combination of resources as was done in the research plan "Arven etter Nansen" (Measure M12).

4.6 Develop/improve plans for renewal of research infrastructure, both at each institution and for infrastructure of national character

The EC stated that there is an urgent need to renew infrastructure and analytical facilities in most universities and research institutions. Adequate funding to maintain state-of-the-art research infrastructure is a critical factor in the development of earth sciences in Norway. The earth sciences are infrastructure intensive, and both teaching and research depend on state-of-the-art laboratories, field and marine cruise instrumentation, and computing capacity and storage facilities.

A coordinated approach by RCN and the government is required to develop a national plan for new and refurbishment of existing research infrastructures to secure Norwegian geoscientists state-of-the-art facilities. This also accounts for research vessels (see marine geosciences above). The effort by RCN to create national facilities that can be accessed by users from across Norway is important. However, some, typically low- and medium cost infrastructures are also needed locally. The institutions are notoriously underfunded to meet the demands. The funding model of the Norwegian universities does not reflect the cost elements of infrastructure-intensive disciplines such as the geosciences (Measure M16).

RCN has established a funding mechanism for local infrastructure by allowing depreciation costs of infrastructure to be included in project running costs. This is very welcome. There is a political and legal motion towards a free data policy in the public sector, i.e. data collected through public funding should be freely available. These developments will provide new research opportunities.

Collaboration between university departments and research organizations in using infrastructure and laboratory equipment is beneficial to all parties. Laboratory sharing can ensure more steady use and further development of the equipment, and at the same time add applied experience to the student education. Agreements of ownership, cost and income sharing are needed, also in order to ensure that governmental grants to the university sector are not subsidising commissioned work in a research institute in unforeseen ways (Measure M16).

The EC found during their site visits, that there are 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, it is important that these issues are not overlooked (Measure M16).

In many cases research infrastructures in the geosciences need to be international in order to be effective, either because the costs involved are beyond the capacity of a single country, or because the research questions studied require a distributed system of instrumentation and field platforms beyond national or regional boundaries, or because the return on an investment is significantly enhanced.

ESFRI, the European Strategy Forum for Research Infrastructures, is potentially very important for research in the geosciences in Norway, as it opens for concentration of intellectual and financial resources not achievable otherwise in a small country. For the geosciences, it is closest to succeed in topics where a strong international network of collaborating research groups already exist like EPOS (seismology), or where there is a really strong environmental policy need (ICOS Integrated Carbon Observing System), ECCSEL (European Carbon Dioxide Capture and Storage Laboratory Infrastructure), or where there is a strong national push (SIOS (Svalbard Integrated Arctic Earth Observing System) by Norway). There is no uniform governance or funding system planned across the ESFRI infrastructures. Also a better balancing may be needed of national infrastructure priorities (like SIOS) with the winning priorities in ESFRI (EPOS, ICOS) (Measure M16).

Existing applied European infrastructures with important research components for the geosciences include ESA (European Space Agency), EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites) and ECMWF (European Centre for Medium-Range Weather Forecasts). These are organized as international conventions at the governmental level and function well for their purpose. The academic access is fairly limited. The technological evolution provides a strong incentive to broaden the access to parts of the resources these infrastructures offer. This will in turn improve and broaden the operations and services for which these infrastructures were established. IIASA is another research infrastructure which has a lot to offer in integrated assessment, important in the risk related research in many of the geosciences (Measure M16).

4.7 Doctoral Training and recruitment

The EC noted that doctoral students in Norway are generously funded compared to what is done in other European countries and the USA. It noted that “many Master students are attracted away from further academic study by the high salaries offered by Norwegian industry”. The recruitment to the more theoretical geoscience disciplines is a particular worry.

The EC noted that “Most research groups reported that there was 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”. Many doctoral students are in a two income partnership, often with young children. More flexible solutions involving also shorter stays abroad should therefore be considered (Measure M5).

The lack of a tenure track system in Norway reduces the possibilities for strategic recruitment, and exacerbates the problems with contract employment, also addressed by the EC. This is, however, not specific to earth sciences.

The quality of the doctoral training at the national level can be enhanced through increased collaboration. Some PhD schools exist; like ACDC (Advanced Climate Dynamics Courses) which is funded by the Research Council. However, there is a lack of grants and incentives to participate in courses at other universities. More national collaboration would enhance the quality of the researcher training, and improve their networks, reinforcing the institutional network of the geosciences within Norway (SAK) (Measure M3).

A knowledge-based economy can only develop if well-educated citizens and researchers enter careers in a large variety of employment sectors and occupations. The growth and renewal of the academic institutions depend on strong structures for the education of PhD students, postdoctoral training and new recruitment. The Norwegian Council for Higher Education (UHR) published a paper in 2011 saying that particularly high growth was needed in the PhD education within the natural sciences and technology (Measure M17).

4.8 Advice and action to improve gender balance and promote recruitment to geoscience; in particular recruitment of women to permanent scientific positions

The EC points out that key expertise in many areas is held by personnel which is approaching retirement, and the succession planning is very important also in a gender perspective. Retirement provides an opportunity to redirect research positions and adjust the gender balance. The EC says that the gender balance issue is taken very seriously at all the universities and institutes that participated in the evaluation.

The success varies. Several explanations apply, such as a lack of good female candidates in certain fields. None of the institutions have commented on the issue of gender balance in their responses, probably because it was not specifically asked for in the letter from the Research Council to the institutions that took part in the evaluation (letter dated 11.05.2012). Many institutions do, however, have various incentives for recruiting and keeping female staff.

The leaders of an institution must support change to improve the gender balance. The most obvious point of action is within the recruitment process. The use of search committees is therefore important. By this mechanism female scientists who otherwise would not consider themselves relevant for the position, might be encouraged to submit an application.

Female staff may be in need for specific support actions, as suggested in a recent report stating that young women scientists leave academia in greater numbers than men for three reasons which are generic and not specific to the geosciences: (i) the characteristics of academic careers are unappealing (all-consuming, solitary and unnecessarily competitive), (ii) the impediments they encounter are disproportionate, and (iii) the sacrifices they have to make are great (e.g. family life).

The gender balance among the undergraduate students in geosciences is changing rather significantly and there is a majority of women in many disciplines. The legal backing of the improvement of the gender balance is strong, as is the public as well as institutional awareness of the issue. The need for additional national actions is seen as limited (Measure M9).

5 Suggested measures

Measures are proposed, prioritised and split into “measures with a budget to be covered within the funds indicated to the follow-up of the evaluation”, “measures that can be undertaken within current budgets”, and “measures that can be undertaken assuming budget growth (X MNOK/a) beyond the follow-up allocation”.

The measures all have high priority. Low priority measures are not proposed. For each measure is given the page on which it is explained and justified (there may be several mentions of the same measure on the same page).

5.1 Measures with a budget to be covered within the funds indicated to the follow-up of the evaluation (30 MNOK)

M1 Adjunct academic positions to foster national teams

Eight adjunct positions funded each with 350 000 NOK/year over 4 years, total about 11 MNOK. Allocation managed by RCN.

Establish a national adjunct professorship system in fields of high priority (themes or disciplines) and with an obvious SAK perspective. These might be areas mentioned by the EC or with a critical national relevance, either of social relevance or within an educational perspective combined with the need in basic research. In applied research fields stakeholders are encouraged to provide co-funding. (pp. 15, **Environmental risks**16, 17)

M2 Coordination in disciplines and themes of particular national significance (SAK)

1 MNOK for 4-6 initiatives. RCN or the National geoscience council responsible to initiate the processes which must act bottom-up.

To support bottom-up-initiatives to facilitate better collaboration and coordination, relevant Norwegian research groups can apply for funding to meet, discuss (workshops) and propose how to develop the research in their discipline or theme into a national team (SAK) by covering the most important research goals, methods, experimental and operational observations and applications. This action is recommended specifically in disciplines/themes listed, but others can be proposed

- oceanography
- hydrometeorology
- cryosphere landscape research and education
- geohazards with emphasis on research driven education

(pp. 12, 14, 15, 16, 17, 18, 20)

M3 National research school “The Earth System”

Call for applications of a national research school to foster SAK in the area of The Earth System – coupling of the Earth System components. The successful applicant will have 9 MNOK over 6 years from RCN. The application must take a national initiative and the research school in climate research might act as a model. (p. 24)

M4 The heritage from research projects

The aim is to make better use of the "heritage" (data, software, methods, physical samples) from research projects, by put in place a system following international standards for the management, identification and provision of data, methods and software, and physical samples.

The RCN to allocate 3 MNOK to announce a pilot-project within a discipline or theme. (pp. 18, 19)

M5 Recruitment

To encourage Norwegian geoscientists to spend more time abroad, a short stay mobility system presents important opportunities for international collaboration and knowledge exchange for candidates who are not able to undertake an extended stay.

6 MNOK, RCN to put in place a more flexible short term outward mobility schemes for PhD students. (p. 24)

5.2 Measures that can be undertaken within current budgets

M6 SFI mechanism to include innovation with high non-monetary value

RCN responsible institution, no extra cost.

To improve the societal return from research investments in the geosciences, the SFI mechanism should allow for innovation in non-monetary terms (social innovation) in addition to proposals with a commercial market potential. Social innovation is particularly relevant for public agencies providing services considered as public goods. (p. 11)

M7 Strengthen research leadership

The individual institution should continue and strengthen ongoing research manager leadership training programmes on the institutional and national level (e.g "dekan-skolen" run by UHR or research leader courses at the individual institutions or at a national level). (p. 18)

M8 Organisation of CoE

RCN should include the line management of the host department in its follow-up of CoEs, this is particularly important in fields with a heavy demand on research infrastructure and technical staff. (p. 22)

M9 Identify female applicant for positions advertised

All institutions should continue to use search committees in recruitment to identify qualified female applicants for a position and motivate them to apply. (p. 25)

5.3 Measures that can be undertaken assuming budget growth (X MNOK/a) beyond the allocation to the follow-up

M10 Mineral resources research programme

RCN should plan and implement a new long-term research programme (50-100 MNOK/a over an extended period) related to mineral resources in Norway and their characterization, exploration, mining and landscape restoration. The fundamental research component of the program should mainly be funded by the government through RCN, and should also include a significant educational component at the PhD level. RCN and the universities should encourage strong research collaboration between industry partners and the universities by implementing appropriate measures that makes it attractive and affordable for the industry to invest in relevant R&D projects. (p. 15)

M11 Marine research vessels

The Government should plan and fund the upgrading of the national marine research vessel fleet to allow state-of-the-art marine geosciences field experiments and data collection. (p. 13)

M12 "Arven etter Nansen"

RCN and the Government should proceed with the plan and fund the implementation of the SAK-project "Arven etter Nansen" which is a national research plan for the Central and Northern Barents Sea with a marine resources perspective, developed by the national universities and the relevant public agencies (IMR, NP, MET Norway) (700 MNOK over 6 years). (pp. 14, 19, 20, 23)

M13 Support of top scoring research groups

The EC noted that "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" This aspect, also emphasizing high-risk research, was also addressed in the evaluation of the Research Council itself by Technopolis Group in 2012.

RCN to ensure that research funding programmes (50 MNOK/a, 10 years) are aimed at

- disciplines or themes with research groups with a record of top score
- reinforcing FRINATEK.

(pp. 16, 17)

M14 Establish a Chief Scientist position at the Office of the Prime Minister to enhance the national value of the research efforts

A Chief Scientist at the Office of the Prime Minister is highly recommended in order to strengthen strategic and operational advice on science and science policy issues to the government. This would aid in a better implementation of science into politics as a basis for decision and policy making and would also strengthen promoting science to the public. This would benefit all disciplines. As the geosciences are very significant for national economic growth and risk management if organised and funded properly a position like this would strengthen this aspect. (pp. 19, 20)

M15 Publication incentive in the private research institute sector – increase the base funding

RCN and the Ministry of Education and Research and other relevant ministries should increase the base funding (by 10% is suggested) to the private sector research institutes with the aim to raise their publication rate in the open literature. (p. 21)

M16 Infrastructure funding

- The government (The Ministry of Research and Education) should change the university funding model for students to account for the cost structure of infrastructure-intensive disciplines
- It is crucial that RCN maintain the system with calls for special infrastructure funding related to national research foci
- RCN and the government should allocate 50-100 MNOK/a on a continuous basis for supercomputing and large scale storage facilities, which are generic research infrastructures and which must evolve with a high degree of predictability and quality and at an ambition level which match the highest globally
- RCN should provide seed-money and related travel funds (2 MNOK over 5 years) for young scientists to exploit the opportunities provided by international research infrastructures as provided e.g. by the International Ocean Discovery Programme (IODP), or some of the ones mentioned in the text (like ECMWF)
- RCN and the government should ensure that Norway becomes a part of the EU ESFRI initiative EPOS (European Plate Observing System) which is of critical importance for the further development of the Norwegian solid earth geophysics/seismology science.

(pp. 12, 23, 24)

M17 Recruitment

- RCN should fund personal PhDs for particularly talented students to be applied for during the last semester of a master’s program. This mechanism will also increase the fraction of Norwegian PhD students (25 MNOK/a suggested)
- RCN should increase by 25 MNOK/a the funding of industry and public agency supported PhD’s (Nærings- og offentlig forvaltnings-PhD)
- RCN should provide 25 MNOK/a for PhD scholarships for joint degrees between universities (national collaboration) and/or international collaboration
- The RCN and the Government should fund postdoc positions in basic research of national importance (25 MNOK/a).

(p. 24)

Appendix

Mandat for oppfølgingsutvalget

Oppfølgingsutvalget oppnevnes av Norges forskningsråd ved Divisjon for vitenskap (DSV) og vil bestå av syv medlemmer som skal dekke hovedområdene innenfor geofag. Arbeidet skal gjennomføres i dialog med Forskningsrådet.

Utvalget skal utarbeide en rådgivende oppfølgingsplan for geofag med utgangspunkt i evaluerings-rapportens anbefalinger, Forskningsrådets vurderinger og mottatte forslag til tiltak fra fagmiljøene. Planen skal i størst mulig grad gi konkrete råd og anbefalinger til tiltak som kan utføres på nasjonalt nivå. Tiltakene kan være av faglig og/eller strukturell karakter og omfatte både kortsiktige tiltak og tiltak med en lengre tidshorisont (5 – 10 år). Foreslåtte tiltak bør fremmes i prioritert rekkefølge og med angivelse av hvem som bør ha hovedansvar for de ulike tiltakene. Tiltak som forslås skal være innenfor en realistisk budsjettramme, og det skal angis hvordan tiltakene er tenkt finansiert. Planen kan også gi råd til Kunnskapsdepartementet og andre relevante departementer om spesifikke tiltak og finansielle behov.

Planen skal gi råd/foreslå tiltak:

- for ledelsesutvikling med tanke på å styrke arbeid med forskningsstrategiske planer for institusjoner og forskningsgrupper
- for (videre-)utvikling av publiseringsstrategi, spesielt i instituttsektoren
- for å fremme nasjonalt samarbeid, koordinering og arbeidsdeling, samt internasjonalt forskningssamarbeid og mobilitet
- for å bedre organisasjonsstrukturen ved institusjonene, spesielt i forbindelse med SFF'er
- for å utvikle/forbedre planer for fornying av forskningsinfrastruktur, både ved enkeltinstitusjonene og for infrastruktur av nasjonal karakter
- knyttet til doktorgradsutdanningen med tanke på fremtidige rekrutteringsbehov innen norsk industri og høyere utdanning
- som kan forbedre kjønnsbalansen og fremme rekrutteringen til geofagene; spesielt rekruttering av kvinner til faste vitenskapelige stillinger
- om geofagenes rolle innenfor nasjonale strategiske forskningsområder, f.eks. klimaforskning og energiforskning

Utvalget bes om å ferdigstille planen innen 1. juni 2013. Planen skal være kortfattet (maks 20 sider), og skrives på engelsk.

Utvalgets plan vil bli sendt evalueringskomiteen for kommentarer og vil bli diskutert med miljøene på et felles møte i Forskningsrådet i september 2013.

This publication may be downloaded from
www.forskningsradet.no/publikasjoner

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