

Resources for society



A good framework for learning through intercultural understanding – a GEUS development project

GEUS' gradual development towards greater internationalisation has revealed how cultural differences and lack of intercultural understanding can complicate the way we communicate, collaborate, match expectations, give each other feedback and share knowledge. These challenges have been evident at staff meetings, appraisal and performance interviews, during collaboration at laboratories and during trips abroad e.g. in connection with meetings. There has been a demand from GEUS' employees for tools to manage these challenges.



Idea generation at staff conference

In 2012, GEUS held a staff conference at which different aspects of cultural understanding were discussed in working groups and at plenary sessions. The output of the conference day included new ideas, as well as various proposals for internal adjustments. Furthermore, there was a widespread wish to ensure that existing competences at GEUS can be put to even better use. Therefore, as a result of the conference, an action plan for intercultural understanding was prepared. The action plan consists of a number of large and small activities to enhance and utilise GEUS' intercultural understanding in the period 2012–2015. Some of these activities have already been implemented and others are planned for the future.

Anchored in a research project

Special focus is on creating a good learning environment through intercultural understanding. This is done through a project supported with resources from the Danish Centre for Development of Human Resources. This project will moreover be anchored in a research project at Aalborg University. The objective is to examine how intercultural competency can be established, developed and implemented in an organisation through creating new practices in the workplace which support new ways of collaboration that cut across differences.



Preface

This Annual Report for 2012 provides a brief overview of some of the work that GEUS has been involved in over the year. The year 2012 is the first in GEUS' performance contract for 2012–2015, which involves new and generally higher goals. We have had a very productive 2012 and have met the majority of the goals set for our work. We have seen increasing activity as well as higher productivity in our scientific work.

The increase in activity reflects a growing demand for GEUS' expertise within all its working areas, as well as the fact that, in 2012, GEUS had considerable success in winning contracts for research projects. This is due not only to our competitiveness but also to the fact that we work in areas with considerable socio-economic interest and substantial challenges, both nationally and internationally. There is a confluence between GEUS' core business, as set out in the *GEUS Strategy 2012*, and four of the nine 'grand challenges' of the 21st century: minerals, environmental and climate change, water resources, and energy supply and storage.

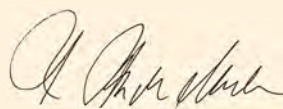
The mineral resources of Greenland attracted particular attention during 2012. GEUS took part in many meetings and workshops and received a number of foreign delegations at high political level. Furthermore, a number of cooperation agreements were signed with sister organisations in Asia.

A high point was when, as principal organiser on behalf of a wider group, GEUS hosted a much-visited conference during the Danish EU Presidency, entitled *Critical minerals for the clean energy and high technology industries 2012 and beyond – the EU perspective*. According to several of the participants, the conference was the first successful gathering of representatives from the entire value chain, from finding the minerals and mining them, to the processing and production industries, and on to reuse and recycling.

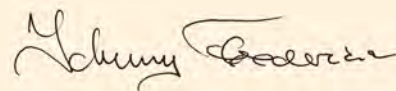
Collaboration between the various European geological surveys was stepped up considerably in 2012 and it is now approaching a form which will allow the surveys to serve jointly as a virtual geological survey for the EU. An important part of this process has been significant progress in creating a common European infrastructure for geological data.

During the year, GEUS supplied its main stakeholders with important knowledge and consulting services to help meet socio-economic challenges and provide an informed basis for political decisions. These stakeholders are: the Ministry of Climate, Energy and Building, the Ministry of the Environment, the Ministry of Foreign Affairs of Denmark and the Government of Greenland. Services included consultancy in connection with geothermal projects and shale gas in Denmark as well as pesticides and land management in Danish environmental policy, submission of a claim to the UN for an area offshore Greenland and rare-earth elements and other minerals in South Greenland. Finally, from 1 January 2013, GEUS has a new board with Professor Minik Rosing from the Natural History Museum of Denmark as the new chairman.

Contributing to society with several of its core areas, GEUS is looking forward to a challenging 2013.



Per Buch Andreasen
Chairman of the Board



Johnny Fredericia
Managing Director



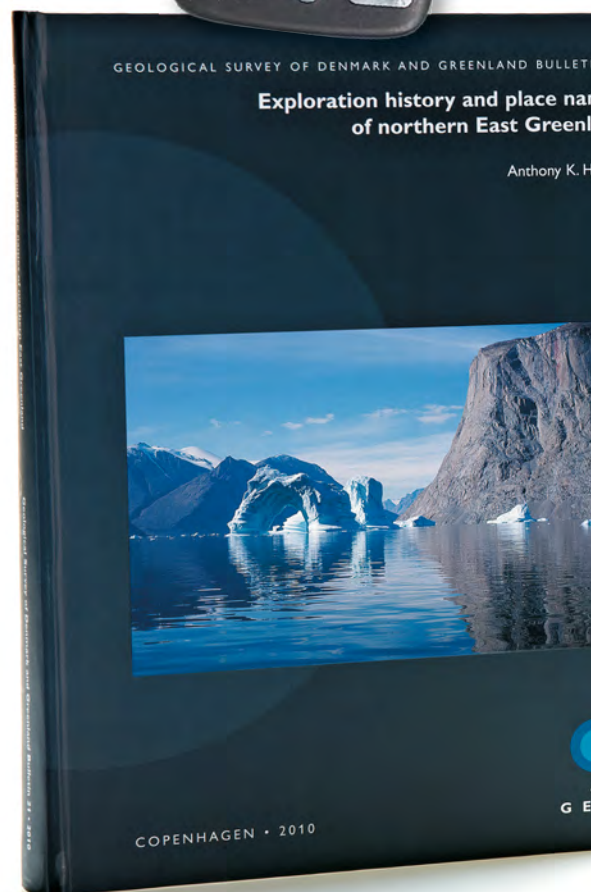
Digital access to place names in northern East Greenland

Place names such as *Jomfru Tidsfordriv Fjord* (virgin past-time) and *Trompeteren Bastion* (trumpeter) are only two examples of the wealth of exciting and extraordinary place names in northern East Greenland. They originate from the many polar expeditions, often with a geological purpose, to this remote and inaccessible part of the world. During the course of the year, GEUS launched a web-based, interactive map of northern East Greenland place names. The map provides help for field geologists, data analysts, armchair-travelers and many others to navigate and communicate about this exciting part of Greenland. Use the free-text search function, the map or the index to find a place name and its explanation or location on the map. The information is from the book, *Exploration history and place names of northern East Greenland*, which GEUS published in 2010. In addition to the catalogue of place names, the book contains a complete list of all significant expeditions to the northern part of East Greenland. By far the majority of these expeditions were geological expeditions, and this is reflected in many of the place names.

The book and the interactive map include 5650 place names, as well as coordinates and information about name-giver and the meaning of the place name. Use the digital map (<http://geuskort.geus.dk/stednavnedb>) in conjunction with the printed book or the electronic version, which can be downloaded from GEUS' website. This will give you access to both the descriptions of the many expeditions and plentiful picture material.

Common Nordic app with geological sights

GEUS published its first app in 2012. With only a few smartphone taps, GeoTreat displays descriptions of geological sights. GeoTreat covers several Nordic countries and geological attractions in Denmark, Finland, Norway and Sweden are available for rapid retrieval. Currently the app includes information about 14 sites of geological interest in Denmark; sites which reveal exciting stories about the geological origin of Denmark. More sights will be included in the future. For Greenland, the app currently includes just one sight; namely Ilulissat Icefjord in West Greenland, which was included in the UNESCO World Heritage List in 2004. GeoTreat shows the geological sights on a traditional or satellite map, from which you can tap your way to a brief description of the individual area and access to more information in the form of e.g. films, websites and articles. The brief descriptions are available in several languages, including in English, so that visitors from outside the Nordic region can join in. GeoTreat was developed in collaboration with the geological surveys in Finland, Norway and Sweden.



New online access to Greenland mineral exploration data

Interest in mineral exploration in Greenland has never been greater. In March 2012, GEUS and the Bureau of Minerals and Petroleum in Nuuk launched a new interactive service: the Greenland Mineral Resources Portal. This portal provides access to all available information about mineral resources in Greenland. The portal gives exploration companies, researchers and other stakeholders access to data, reports, maps and scientific background data on the geology of Greenland. For example, the portal contains company reports, GEUS publications, mineral deposit descriptions, geophysical data, as well as geochemical data and sample analyses from the popular mineral resources hunt, Ujarassiorit, in Greenland.

Data can be shown directly on a computer screen, or users can choose to receive packed data files via email, e.g. scanned PDF files of company reports or descriptions of an area with mineralisations. The portal will be further developed throughout 2013 and new themes will be introduced. Among the new themes being considered are original GEUS field maps and published maps, photos of important sites, mineral licences, as well as other types of data useful in a mineral exploration context in Greenland.



Common European infrastructure for geological data

Just like the rest of the world, European society increasingly needs access to data about nature, the environment and mineral resources across man-made borders in order to manage resources in the best possible way. Exchange of geodata and environmental data is important to the EU. Geological data are an essential tool when looking for water, oil and minerals, or when minimising the implications of natural disasters such as earthquakes and volcanic eruptions. In recent years, GEUS has been working on several EU-funded research projects to promote the exchange of geodata across European borders. These projects are helping implement the EU INSPIRE Directive on the establishment of a common European infrastructure for spatial information to enable easier exchange of data over national borders.

With several of its European sister organisations, GEUS is involved in two new European projects about geodata: the European Geological Data Infrastructure Scope (EGDI-Scope) project and the InGeoCloudS project. The EGDI-Scope project is working to prepare a pan-European infrastructure for geological data. The project will develop a plan for implementation of the common data structure which will also serve as the common framework for results from previous and ongoing geodata projects. These geodata projects include OneGeology Europe and EuroGeosource, which involved geological maps and mineral resources. The aim of InGeoCloudS is to demonstrate the possibilities in using cloud computing for a common infrastructure for geodata. Cloud computing provides access to almost unlimited resources for data storage and calculations at large data centres. The project will demonstrate the possibilities for using the cloud for common basic data and for sharing intelligent services which can combine data and e.g. deliver themes for managing Europe's natural resources and environment.



Water resources

Knowledge to optimise the management of Danish water resources

Bacteria in slurry can leach into the groundwater

We have known for many years that run-off and leaching of slurry from fields potentially overload the aquatic environment with nutrients. However, until now there has been no field study of whether micro-organisms and estrogens from livestock manure also leach into the groundwater. The PATHOS centre, which is financed by the *Danish Council for Strategic Research*, is examining the survival and spread of these organisms and substances, and thus their possible pollution of the groundwater. Results from PATHOS now reveal that bacteria from slurry can leach into the groundwater. In two test fields with moraine clay at Estrup and Silstrup in Jylland, slurry was applied as part of normal farming operations. On both fields, subsequent measurements revealed that micro-organisms from the slurry had leached into the shallow groundwater.

The studies focussed on tetracycline-resistant *E. coli*, as many farmers treat their livestock with tetracycline. The results show that up to 120 tetracycline-resistant *E. coli* are leached per ml water, which is a very high number. The PATHOS centre, which is managed by GEUS, is a collaboration between The University of Copenhagen, Aarhus University, the Technical University of Denmark, Grundfos New Business, Novozymes A/S, Copenhagen Biotech Supply Aps, Dianova A/S and DANVA.

Innovation for environmental improvement and climate change adaptation

Like the rest of the world, Denmark is focusing on realising knowledge and competences to benefit the environment and society. At the end of 2012, the Danish Government published its innovation strategy and GEUS is taking part in several initiatives and networks within research, innovation, training and education. In the strategic partnership *Water in Urban Areas*, which is receiving funding from the *Danish Council for Technology and Innovation*, GEUS is contributing knowledge about geology, the subsurface movement of water, and the quality of water. Jointly with industry and authorities, GEUS is moreover contributing expertise to adapting Danish cities to the future climate through the development of technologies and administrative tools. Through the partnership, GEUS is directly involved in projects to develop rainwater drainage solutions that cater for both the large volumes of surface water and the quality of water, as well as water treatment solutions.

Finally, along with 102 other enterprises and organisations, GEUS is a partner in the *Innovation Network for Environmental Technology (Inno-MT)*, which is receiving support from the *Danish Agency for Science, Technology and Innovation*. The objective of *Inno-MT* is to strengthen innovation and growth in the Danish business community. Through this network, GEUS is coupling knowledge about geology and water resources with new environment technology.



Water resources centre with innovative graduate programme

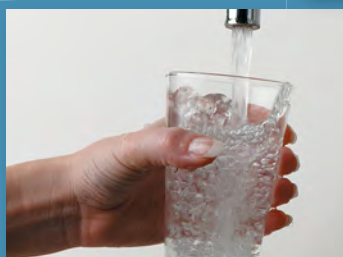
Access to clean water is vital for both people and nature. However, global water resources are limited due to population growth, pollution and climate change. Expert knowledge about water is key to being able to protect and use the world's water resources sustainably. Geocenter Denmark has carried out intense research into water resource challenges for many years in partnership with the Department of Geosciences and Natural Resource Management, the University of Copenhagen and GEUS, and 2012 saw the introduction of a new centre for water resources. Here, Geocenter Denmark is collaborating with the approved technological service provider, DHI, to enhance these research and training activities.

One objective of the centre is to establish an international and market-relevant graduate programme in water resources. This programme will comprise courses in e.g. hydrology, hydrogeology, geophysical measuring methods, groundwater chemistry, integrated hydrological modelling, and water resources management. The students will be offered *learning through research*, as they will have the opportunity to participate in the centre's many international research projects. Furthermore, the programme will give students access to state-of-the-art laboratories, field stations and modelling software at GEUS, the University of Copenhagen and DHI. The programme is receiving funds from Geocenter Denmark.

Sustainable water management

The Danish water management plans are a key element in the implementation of the EU's Water Framework Directive, which dictates that watercourses, lakes, offshore coastal areas and groundwater must achieve 'good status' before 2015. These plans contain the recipe for how Denmark will achieve the targets in the Water Framework Directive. In this context, six water utility companies have called for an improved professional basis for assessing the sustainable groundwater resource and the impact on watercourses from water abstraction. The six water utility companies are Vandcenter Syd, HOFOR, Tre-For, Aarhus Vand, Esbjerg and Aalborg Forsyning.

These companies believe that the water management plans draw an excessively bleak picture of overexploited groundwater occurrences. According to the companies they fail to describe accurately the surface water and groundwater exchange and they use antiquated targets and an inadequate professional basis for assessing the impact of water abstraction on watercourses. Last year saw the launch of collaboration efforts between the six water utility companies and GEUS. The first phase of this work will look closer at the Danish water management plans, collect international knowledge and prepare a description of current practice in other countries for the implementation of the required water management plans. The results of the first phase, which is being financed by the water utility companies, will be presented at meetings, in which the *Danish Nature Agency* will also take part, as well as in a report. The results will be included in the next base analysis at the end of 2013, which will follow up on the implementation of the Water Framework Directive. The first phase will also contain a proposal for a second phase, which will develop new criteria for sustainability as well as tools for practical use in Denmark.



Delimitation of the continental shelf around Greenland

In 2004, Denmark ratified the United Nations Convention on the Law of the Sea, which opens for opportunities to make claims for subsurface and seabed resources outside the 200-nautical-mile limit. Claims have to be documented, primarily with data on sea depths and seabed sediment thickness. Five areas are involved: one area in the Arctic Ocean, two off North-East Greenland and South Greenland, and two areas north-east and south-west of the Faroe Islands. During the first six months of 2012, GEUS completed work to document the area south of Greenland, and on 14 June the Danish Government and the Government of Greenland submitted their scientific documentation for their claim to the continental shelf in this area to the UN's Commission on the Limits of the Continental Shelf (CLCS). The area in question outside the 200-nautical-mile limit off Greenland's coast is approx. 115,000 km². It consists of two parts: a south-western part adjacent to Canada and an eastern part adjacent to Iceland. Similar documentation for claims to the continental shelf in the areas north-east and south-west of the Faroe Islands have already been submitted in 2009 and 2010.

During the summer of 2012, seismic, bathymetric and gravimetric data were acquired, and geological samples were retrieved from the seabed in the Arctic Ocean north of Greenland. This work took place from the Swedish icebreaker *Oden* during the *LOMROG III* cruise in August and September in collaboration with the Swedish Polar Research Secretariat. During the autumn, researchers began work on data documentation for the area offshore North-East Greenland. The Continental Shelf Project is being funded by the Ministry of Science, Innovation and Higher Education, with contributions from the Faroese Government, and work is being carried out in collaboration with several other institutions from Denmark, the Faroe Islands and Greenland.

Oil and gas in deep-lying Jurassic strata in the North Sea

Although the Central Graben in the North Sea is a mature oil province, there remains a lack of knowledge about the carbon potential of its Jurassic strata. In 2012, GEUS worked to close this gap in our knowledge. The work in question took place under the three-year PETSYS (PETroleum SYStem) project, which is being funded by oil companies that are active in exploration for oil and gas in Denmark. Work dealt with new interpretations and comparison of seismic and stratigraphic data from wells in order to establish a cohesive framework for the complex geological Jurassic strata. The geologists also worked on a list of the properties of the sandstone reservoirs from Jurassic, such as porosity and permeability, and they are in the process of preparing an outline of the regional variation in e.g. quality and type of source rock and hydrocarbons, as well as areas where hydrocarbon can have been formed. Finally, workshops were held in March and September at which the results were presented, and a GIS-based website is under development from which the companies can retrieve data and survey results.



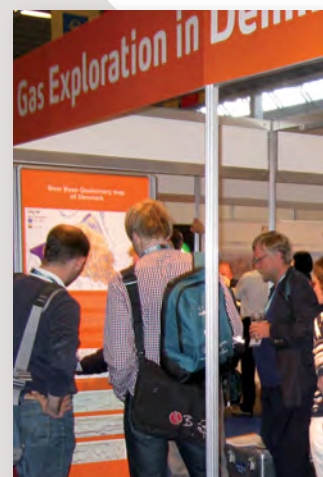
European shale gas resources

In Denmark as well as in Europe, interest in the development of unconventional energy resources is great, not least in view of recent years' significant developments within shale gas extraction in the USA and Canada. Knowledge about European shale gas resources is extremely limited, but a new initiative now aims at providing realistic estimates of the potential. Behind this initiative is the GeoEnergy Expert Group under EuroGeoSurveys, an association of European geological surveys. GEUS has the role of project manager of a pilot study to map the shale gas potential in the Baltic Sea countries. The objective is to prepare a model of the shale layers. In October, GEUS arranged a well-attended thematic meeting on shale gas in collaboration with the American Association of Petroleum Geologists, the Geological Society of Denmark and the Society of Petroleum Engineers. The topics included: shale gas in the USA, the assessments of global shale gas resources being made by the U.S. Geological Survey, and Danish surveys, including research by GEUS into Danish shale geology.

Well-attended international energy conference

In the beginning of June, thousands of geologists, engineers and geophysicists gathered at Bella Center in Copenhagen for the large international oil and gas conference, the 74th EAGE Conference and Exhibition, arranged by the European Association of Geoscientists & Engineers. The conference offered presentations, workshops and exhibition stands. Researchers from GEUS were plentiful at the conference, presenting the results of their geological studies within oil and gas exploration and subsurface carbon storage. Several GEUS employees participated in workshops at which research results and technical issues were presented and debated with international colleagues. The workshops dealt with subjects such as hydrocarbons, geothermic research, and exploitation of energy from geothermal wells.

The *Danish Energy Agency* prepares a new licensing round in the North Sea in 2013. This will be the 7th round. As part of these preparations, the Agency and GEUS had a stand at the conference, where they presented an outline of the many opportunities for exploration in the North Sea. GEUS also organised an excursion to Rømø, where the participants had a guided tour in a contemporary geological environment analogue to the type of environment that has been the source of several oil reservoirs in the deep subsurface. The excursion was organised with GEUS' partner in Geocenter Denmark, the Department of Geosciences and Natural Resource Management at the University of Copenhagen.



Knowledge for continued exploration and exploitation of energy resources in Denmark and Greenland

Energy resources

Mineral resources

Scientific basis for targeted and environment-friendly exploitation of mineral deposits in Greenland and Denmark

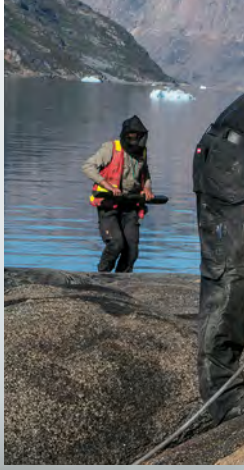
High quality of research

GEUS has completed an international evaluation of its mineral resources research. This evaluation has been presented in a report prepared by an international evaluation panel. The Minister for Climate, Energy and Building, Martin Lidegaard, has taken note of the evaluation panel's report and has expressed his content with its positive conclusion about GEUS' high-quality research in this particular research area. The Minister is also pleased about the report's recommendations for new assignments.

"With the considerable focus on the cohesion between growth strategies and resources in Greenland, Denmark and the EU, as well as in a wider international context, I believe it is very important that the Ministry of Climate, Energy and Building, in GEUS, has a strong, recognised and important research institution. GEUS' mineral resources research is important for the Ministry's focus on the vulnerability of using basic raw materials in infrastructure projects and critical minerals in green high-tech solutions. At the same time, GEUS' research can contribute to the debate about resource efficiency and similar aspects in connection with the Ministry's work with enterprises and other stakeholders," the Minister said about the evaluation.

Conference on critical minerals

In May, GEUS hosted a well-attended conference on critical minerals in green energy and high-tech industries. The conference, entitled *Critical minerals for the clean energy and high technology industries 2012 and beyond – the EU perspective*, spotlighted access to critical raw materials and minerals in Europe, as well as the solutions required to ensure the availability of these resources. Leading decision-makers and experts from the EU, industry and research discussed Europe's access to and supply of minerals and raw materials, and what defines these as critical from geological, political and economic perspectives. Thirteen talks and a subsequent panel discussion initiated the exchange of knowledge, views and ideas. The conference was organised by GEUS in collaboration with EuroGeoSurveys, the European Technology Platform on Sustainable Mineral Resources and the Confederation of Danish Industries and it was led by the Danish EU Presidency. All the presentations from the conference are available at the conference's webpage on the GEUS website: <http://critical-minerals-2012.geus.dk>





Studies of Greenland's minerals from north to south

Interest in Greenland minerals is huge and many companies are currently carrying out exploration in Greenland. There are also several ongoing surveys commissioned by the public sector, and during the summer of 2012, geologists from GEUS examined three different areas in order to assess their mineral potential. South-East Greenland saw the greatest activity in 2012. This is one of the least surveyed areas in Greenland. These activities were concentrated in the Skjoldungen area between 62°N and 64°N, where samples were collected to determine the age of the rocks and for geochemical, mineralogical and petrological analyses.

Zinc was the object of attention in North Greenland. Zinc is a metal in great demand globally. GEUS surveyed five locations in southern Peary Land which holds sedimentary occurrences of zinc. These surveys were a spin-off from an expert workshop held by GEUS in 2011 which assessed the potential for sedimentary zinc deposits in Greenland.

Finally, GEUS commenced surveys in the Gardar Province in South Greenland in order to assess and understand the formation of several deposits of critical minerals. Occurrences of rare-earth elements (REE), as well as niobium and tantalum, are in focus here, and ore-geological, petrological and mineralogical surveys are planned for the upcoming years in a number of areas near Narsaq.

Surveys to prepare for raw materials extraction and wind farms

Denmark is by and large self-sufficient in raw materials for building and construction. Raw materials such as sand, gravel and clay come primarily from onshore extraction and the increased extraction in some areas conflicts with the desire to preserve landscapes and nature. Raw materials in the seabed are therefore also in focus. In recent years, GEUS has been working to map seabed landscapes and sediments, in Danish coastal waters as well as in the North Sea.

In 2012, the Danish Nature Agency carried out marine geological surveys in three large areas of the North Sea, totalling 6,300 km², to establish a basis for invitation to tenders for exploration and extraction of raw materials. In the last six months of 2012, GEUS assisted Energinet.dk in describing the geology of the seabed at Horns Rev, the site for the new large Horns Rev 3 wind farm. GEUS has previously performed similar surveys for the two wind farms already in operation at Horns Rev. A similar project for Energinet.dk was carried out in the Baltic Sea off the coast of Møn in connection with the establishment of a wind farm at Kriegers Flak.

Changes in sea level in Denmark

Rising sea levels are a serious implication of global warming. In a memorandum to the Ministry of Climate, Energy and Building, in March, GEUS and the Danish Meteorological Institute provided their assessments of the degree to which the sea level in Danish waters could change over the next 100–200 years. The assessments are based on existing knowledge, and the memorandum concludes that the global sea-level rise will be around 3 mm annually. This increase is due to three things, each of which contributes 1 mm: melting ice in Greenland and Antarctica; melting ice from mountains; and the expansion of sea water due to an increase in sea temperatures.

The sea level around Denmark is expected to increase by between 20 cm and 140 cm up to 2100. The smallest increase will be in northern Jylland where the sea-level rise will be partially offset by the continuing land uplift since the last ice age. It is estimated that the global sea level will have increased by 0.6–4 m by around 2200. In the shorter term, over the next decades, the Danish Meteorological Institute and GEUS estimate that we can expect more powerful and more frequent storms, which may lead to more frequent flooding of low-lying coastal areas; a trend that we are already experiencing today. In the longer term, over one or more centuries, sea-level rises and changed wind conditions will together lead to increased storm-surge heights.



The environment, climate and culture in north-east Sjælland

October 2012 saw the launch of a new project to map the development of landscape and settlements in northeast Sjælland over the past 3000 years. GEUS, Hørsholm Egns Museum (a local cultural-history museum), and the Saxo Institute at the University of Copenhagen are behind the project, which has received funding from the 15. Juni Fonden. The cross-disciplinary project will provide new knowledge about the development of small settlements and built-up areas, as well as the changes in land use in north-east Sjælland from the Bronze Age up to today.

An important objective of the project is to examine the development of agriculture and the history of the forests in the area. To this end, geobotanical surveys are being carried out, e.g. in Birkerød Lake. In a way, Danish lakes hold nature's own 'national archives'. Here, in an ever-ongoing process, sediments and silt are deposited on the lake bed which contain plant and animal residues from the lake itself and its surroundings. By analysing the content of these residues in drill cores retrieved from the lake bed, detailed information can be ascertained about the physical appearance of the lake and its vicinity and about changes to these across millennia. On 6 October, the general public could watch while geologists carried out drilling work in Birkerød Lake.





New screening tool for climate change adaptation

Future climate change will affect groundwater conditions. Areas that today are dry may become wetter in the future, with significantly raised water tables. Therefore, knowledge about expected changes to water table depth and groundwater recharge will be important parameters in land-use and water management planning. In 2012, a new tool became available at the Danish Portal for Climate Change Adaptation. The tool can be used to screen for climate-related changes to groundwater in Denmark. Consisting of a series of groundwater maps, the tool can be used to examine variations in groundwater recharge and water table depth as a consequence of the expected future climate change.

The groundwater maps have been produced by GEUS using the national hydrological DK-model, and the calculations were made using data from various climate models. The tool is based on likely scenarios and is meant exclusively as a guide. Thus, the objective of the tool is to provide its users with an initial foundation for possible further investigations. The tool is targeted at planners in local government and water utility companies as well as others who work with climate change adaptation. The groundwater maps were produced with support from the *Coordination Unit for Research in Climate Change Adaptation*.

Sea currents and melting of the Greenland ice sheet

The objective of the SEDIMICE project is to achieve greater knowledge about sea-current changes around Greenland and how these changes affect the melting of the ice sheet. This knowledge is particularly important for our ability to predict how much the oceans will rise as a consequence of ongoing climate change. In this project, researchers from GEUS, Aarhus University and the University of Boulder, Colorado, USA, are collaborating to analyse sediment cores from the eastern Greenland shelf.

On the basis of a sediment core retrieved from just outside Sermilik Fjord at Tasiilaq, one study reconstructed the variation over the past ca. 6,000 years in the warm deeper-lying Irminger Current and the cold surface-near East Greenland Current. This work revealed that the warm Irminger Current became more intense on the eastern Greenland shelf and in the entire Irminger Sea during the Little Ice Age, when the cold East Greenland Current became significantly stronger, the Greenland ice sheet advanced, and north-western Europe had cold winters. Both the air and sea temperatures are important for the melting of the Greenland ice sheet. The inflow of warm water to East Greenland could have increased melting locally at the bottom of the floating outlet glaciers during a period in which melting from the ice surface was limited due to low air temperatures. The results of the core analyses therefore provide new input for models which calculate the stability of outlet glaciers from the Greenland ice sheet. The study was financed by the *Danish Council for Independent Research, Nature and Universe*, the *Danish Centre for Marine Research* and *Geocenter Denmark*.

GEUS around the world

Knowledge-building in developing countries through research and consultancy

Oil and gas surveys in Cambodia and Vietnam

Since 1995, GEUS has been working on capacity building in Vietnam in order to enhance the country's ability to assess its own oil and gas resources. The research and training activities, which receive funding from Danida ENRECA programme, have revealed e.g. that there is important geological information in the mountains in southern Cambodia, which can be used to assess oil and gas resources in the offshore area off the coast of south-western Vietnam. In collaboration with the Cambodian National Petroleum Authority (CNPA) and the Vietnam Petroleum Institute (VPI), during the year GEUS examined the mountain regions in Cambodia and Vietnam and collected large numbers of samples from geological layers; layers that are identical to the layers found deep under the seabed, south-west of Vietnam. Analyses of samples will shed light on the geological development of the area and the potential of the oil and gas producing layers. Researchers from CNPA, VPI and GEUS are responsible for the analysis programme, which is being partly funded by an oil company.





Small-scale mining in Mozambique

Small-scale mining is an important source of income for millions of people throughout the world. Often, the minerals are mined under very poor safety conditions in cramped and deep shafts. When workers are mining for gold, for example, mercury is often used in the process and this causes enormous environmental and health problems if it is not managed properly. During 2012, GEUS looked at the small-scale mining industry in selected areas in Mozambique. In the project, which is being financed by the World Bank, GEUS worked for, and in close collaboration with, the Ministry of Mineral Resources (MIREM) in Mozambique.

Health, safety, the environment, profit performance and child labour were among the subjects that were examined in the two provinces of Manica and Nampula. The results of the project will be included in preparations for a large World Bank project aimed at ensuring that mineral resources extraction in Mozambique takes place sustainably and in the most optimal way for the country. The project also includes the small-scale mining industry, and in June the results were presented and discussed at a workshop in Maputo with a view to producing input for the large Mining and Gas Technical Assistance Project, planned by the World Bank to commence in 2013.

Developing the water sector in Zambia

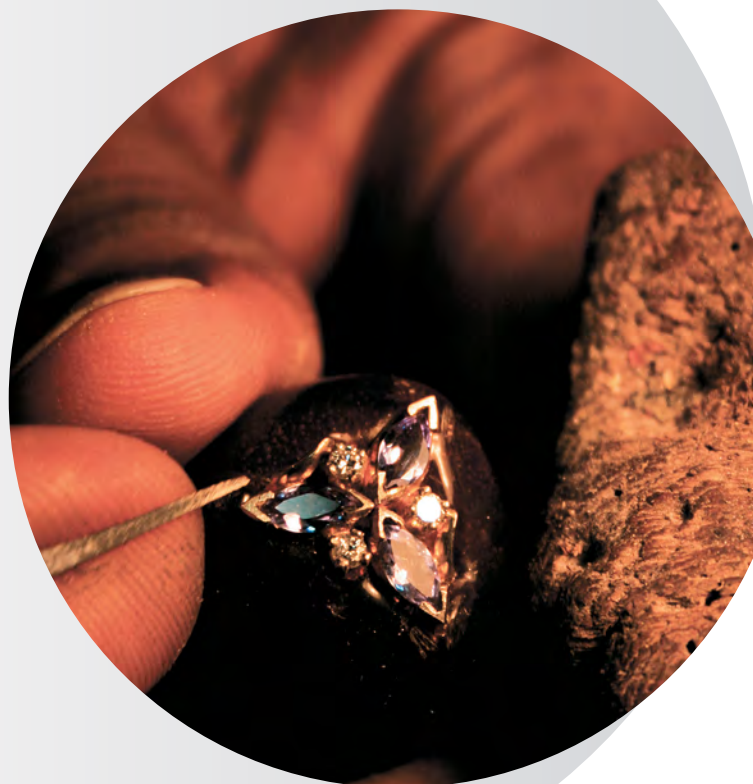
GEUS is assisting Danida in implementation of a water sector programme in Zambia. The goal of this programme is to promote more effective and more sustainable exploitation of the country's water resources. GEUS is heading a sub-project in the programme to support and develop teaching and research competences in Zambia's water sector. The project, which is being carried out in collaboration with the University of Zambia, the Technical University of Denmark and Aarhus University, involves training for PhD and graduate students. This is done partly through surveys of the saline groundwater in the western part of Zambia. Airborne geophysical surveys have been performed to map the spread of the saline groundwater. Also geophysical surveys of drill holes have been made and water samples have been taken. Researchers are now working on a synthesis and on modelling data in order to interpret the formation and extent of the saline groundwater.

The preliminary results suggest that the source of the salt is deposits in the subsurface that originate from an old, large salt lake, which used to cover part of the current northern Botswana as well as the south-western part of Zambia. The possibility of removing the salt from the groundwater in small-scale water treatment plants is also being looked into.

Sustainable management of mineral resources in Tanzania

Interest from local as well as foreign companies in exploiting mineral resources has been increasing rapidly in Tanzania. Exploitation of mineral resources can be a driver of growth and welfare, however, if not managed properly, mineral resources could lead to poverty and environmental disaster. The Ministry of Energy and Minerals (MEM) in Dar es Salaam is conducting a large project aimed at ensuring sustainable management of its mineral resources. In this context, in 2012, GEUS took part in a project that completed a thorough analysis of the country's mineral resources sector – a so-called *Strategic Environmental and Social Assessment (SESA)*.

The primary objective of this type of analysis is to help raise the environmental and socio-economic standards in the mineral resources sector. The project achieved this by influencing priority-setting by MEM and the state companies involved in the mineral resources sector, and by influencing the way in which policies, legislation and regulation is carried out. The analysis was made through a series of workshops with the participation of the sector's key stakeholders. The project was carried out in collaboration with the British firm, LandUse Consultant and the Kenyan company Matrix. The project received funding from the World Bank.



Glimpses of the year



Visit by Korea's Minister of Foreign Affairs and Trade

Korea's Minister of Foreign Affairs and Trade Kim Sung-Hwan visited Denmark in January 2012. As a part of his programme while in Denmark, Kim Sung-Hwan visited GEUS accompanied by the Danish Minister for Foreign Affairs, Villy Søvndal. During the visit, the ministers were introduced to the natural characteristics and opportunities for exploration of a number of resources in the Arctic; a subject currently receiving considerable global attention. The purpose of the visit was to find areas in which the cooperation between Denmark and Korea within the Green Growth Alliance can be developed further. The Korean Minister expressed his country's great interest in exploiting minerals such as rare-earth elements, but also its interest in water projects, while GEUS presented its suggestions for areas of common interest. Finally, there was a status report and an outline of Denmark's, Greenland's and the Faroe Islands' plans and expectations for the Continental Shelf Project in the Arctic Ocean.

"It was very exciting to be able to contribute with ideas on how to give substance to a green alliance. This is an area in which together Denmark and South Korea will have a strong potential for green growth, and taking part in the visit was an inspiration. We will be working to further the ideas up to our participation in a visit to Korea by a Danish delegation," said Johnny Fredericia, Managing Director of GEUS, after the visit. GEUS has subsequently visited institutions and companies in Korea on several occasions, and has also hosted visits from Korea. In August 2012, GEUS signed a Memorandum of Understanding with its Korean sister organisation, KIGAM, in connection with the President of Korea's visit to Ilulissat in Greenland.

Participation in geologists' world conference

Geologists from far and wide travelled to Brisbane Australia in August to take part in the 34th International Geological Congress. More than 6,000 people from 112 countries took part in a comprehensive programme with scientific symposia, workshops and days with geoscientific themes of special importance to society. As many as 283 institutions and companies displayed their geological expertise. At the Nordic Resources stand, in collaboration with the Greenland *Bureau of Minerals and Petroleum*, GEUS and the geological surveys of Finland, Norway and Sweden, presented the mineral resources of their areas. The subject of GEUS' and the Bureau of Minerals and Petroleum's presentation was Greenland's minerals, in particular its rare-earth elements (REE), zinc and copper. Visitors to the stand were introduced to a new online web-based service, the Greenland Mineral Resources Portal, which provides access to all available data on mineral resources in Greenland.





Recipients of awards in 2012: Kim Esbensen, Henrik I. Petersen and Walter Brusch

Three GEUS employees received awards for their work in 2012. In March, research professor Kim H. Esbensen received the Russian Chemometrics Society's Gold Medal for his valuable contribution to developing the field of chemometrics in Russia over a ten-year period. In September, senior researcher Henrik Ingermann Petersen received the Ralph J. Gray Award 2012 for the best scientific article in organic petrology. This article is a description of the formation of coal layers in the Krabi Basin in southern Thailand. Finally, in November, senior advisor Walter Brusch received the Danish G.O. Andrup's Groundwater Award for his persistent efforts over many years to create awareness about pesticides and their consequences for groundwater.

New research professor

In 2012, a new research professor joined GEUS. Jason Box was employed as a research professor in glaciology at the Department of Marine Geology and Glaciology at which he is to help strengthen GEUS' research in glaciology, with special focus on Greenland and the Arctic region. Jason Box qualified as a geographer at the University of Colorado Boulder, USA, from where he also obtained his PhD in 2001. Since 1994, Jason Box has been on 23 field trips to Greenland to study the response of the Greenland ice sheet to climate change.

Boat for marine geological measurements

In 2012, GEUS purchased the 31-foot motor boat *Maritina* for marine geological day cruises in Danish coastal waters. *Maritina* is 15 years old and has been specially built to carry out environmental and measurement tasks. She is equipped with hydraulics, fittings and a generator to handle and provide power for GEUS' sample-taking equipment and geophysical instruments. The boat will be used to collect marine geological data in shallow waters, for example for seabed classification, marine archaeological studies, raw material exploration or preliminary surveys for marine construction work. With this new boat, GEUS will be able to collect marine geological data considerably faster and cheaper than previously.



Key figures 2012

More detailed key figures for the activities of GEUS are available in *Årsrapport – Regnskabsåret 2012 (Report and Accounts 2012)*, and in *Faglige resultater 2012* (the latter in Danish only). Both of these are available at www.geus.dk – publikationer – institutionsrapporter.

Number of employees: **342**

Number of scientific projects: approx. **600**

ACCOUNTS 2012

Amounts in million DKK

| | |
|-----------------------------|--------------|
| Revenue: | 355.6 |
| Net figure (appropriation) | 140.6 |
| Operating income | 215.0 |
| Expenditure: | 353.4 |
| Salaries | 180.0 |
| Other operating expenditure | 173.4 |

INFORMATION ACTIVITIES

Long-term knowledge building

| | |
|---|-----|
| Articles in international scientific journals/publications (incl. 21 RoSa articles) | 169 |
| Other scientific publications | 11 |
| Conference contributions with abstracts or posters | 166 |

Ongoing scientific tasks, consultancy and presentation

| | |
|---------------------------------------|----|
| Publicly available reports | 84 |
| Confidential reports | 90 |
| Memoranda, opinions, expositions etc. | 77 |

General information

| | |
|--|-----|
| Institution reports (annual report etc.) | 5 |
| General and popular-science presentations – including popular-science lectures | 127 |
| | 64 |

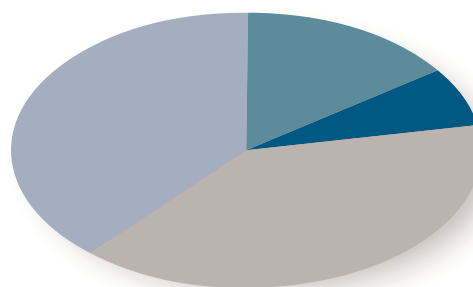
Use of GEUS web

| | |
|--|---------|
| Visits to www.geus.dk | 502,000 |
| Use of GEUS' web map services | 180,000 |

RESEARCHER TRAINING WITH GEUS TUTORS

| | |
|-----------------------|----|
| Current PhD students | 74 |
| Completed PhD degrees | 15 |

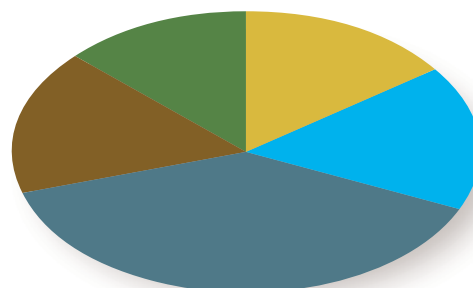
Revenue broken down by sources of revenue:



Amounts in million DKK

| | |
|--|-------|
| National budget and supplementary government appropriations: | 140.6 |
| Programme and external resources: | 137.6 |
| Other co-financed contract research: | 53.2 |
| Commercial contracts and sales of data: | 24.2 |

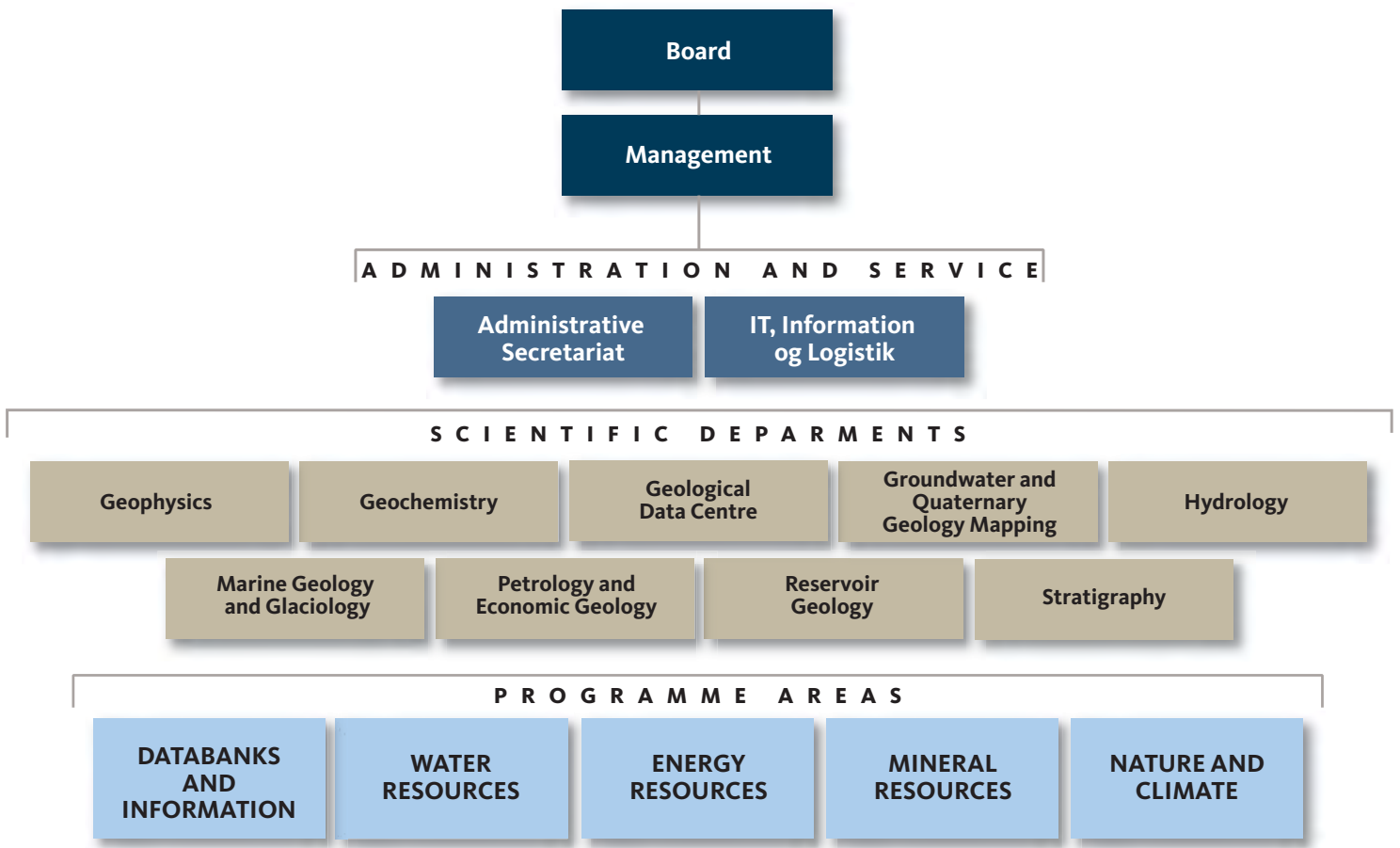
Expenditure broken down by programme area:



Amounts in million DKK

| | |
|----------------------------|-------|
| Databanks and information: | 53.6 |
| Water resources: | 59.0 |
| Energy resources: | 136.5 |
| Mineral resources: | 58.7 |
| Nature and climate: | 45.6 |

Organisation



In 2012 there were nine research departments at GEUS and two administrative/service departments. Scientific work is being done in five programme areas, where tasks are carried out in project groups in a matrix structure.

Programme area: Databanks and information

Storage, quality assurance and presentation of geological knowledge and data. The aim is to establish a level of quality of data and sample collections which helps work on monitoring, emergency management, advisory services and research. In addition, the programme area comprises IT projects, which ensure efficient and modern IT tools at GEUS, as well as presentation of data to the scientific community and the public.

Programme area: Water resources

Knowledge to optimise the management of Danish water resources. Activities are directed at the water cycle, the extent and quality of water resources, and transport and decomposition of xenobiotic substances in the aquatic environment, focusing mainly on the groundwater. The activities also form the basis for advisory services to authorities, regions and municipalities in Denmark and abroad.

Programme area: Energy resources

Knowledge for continued exploration and exploitation of energy resources in Denmark and Greenland. This work comprises own research projects and international cooperation within oil/gas and renewable energy. The collected knowledge forms the basis for GEUS' advisory services to authorities in Denmark and Greenland, and also for projects carried out for the industry.

Programme area: Mineral resources

Scientific basis for targeted and environment-friendly exploitation of mineral deposits in Greenland and Denmark. This work includes geological mapping and mineral exploration in Greenland, as well as official processing and advisory services for the Government of Greenland. In addition, surveys are carried out in connection with raw materials and construction work in Denmark and internationally.

Programme area: Nature and climate

Identifying processes leading to today's climate and environment in Denmark and the North Atlantic in particular. The objective is to improve the prospects of distinguishing between natural and human-induced environment and climate changes. The programme area also includes a mapping of onshore and offshore geological conditions, as well as earthquake research and monitoring.