

Present and future

resources

**water
energy
minerals
nature**



GEUS

ANNUAL REPORT 2010

THE GEOLOGICAL SURVEY OF DENMARK AND GREENLAND (GEUS)

MINISTRY OF CLIMATE AND ENERGY

GEUS

GEUS hosts EGS annual meeting

Geology in a European perspective

For many years, European geologists have been working together to provide national and international institutions with better knowledge about geology, mineral resources and the environment. Denmark has benefited greatly from this cooperation, and today the EU is also benefiting from the cooperation under the auspices of EuroGeoSurveys (EGS), representing 32 national geological surveys in Europe. In September 2010, GEUS hosted the EGS annual meeting in Copenhagen, where directors of all the geological surveys were gathered.

EGS has been the prime mover behind enhanced European cooperation, especially as regards projects which involve the core tasks of all EGS members i.e. knowledge about natural resources, data and surveying, subsurface, as well as harmonisation of the knowledge pool. The results generated by EGS have been of great benefit to the European community, and GEUS has been involved in most of the initiatives. One of the main functions of EGS is to create a platform and a pool of expertise for the integration of geological knowledge and data.

"We must work in a more integrated manner in the future to be able to meet the requirements for geological data and knowledge at European level", said Johnny Fredericia, managing director of GEUS, in an interview for the EGS Newsletter.

If the application is accepted that was recently submitted to the EU's 7th Framework Programme concerning a common European infrastructure for research involving the entire EGS, this will enable EGS members to examine such an infrastructure in depth in order to find a model for cooperation. I have no doubt that we must strengthen the work of EGS and its members at European level, but this work must be based on the strengths of the individual national geological surveys. If we cut the link between the geological work carried out nationally and the work carried out at European level, the geological surveys will lose their importance, the quality of common European work will deteriorate, and continuity will deteriorate", says Johnny Fredericia.



Introduction

This Annual Report 2010 provides a brief overview of some of the work that GEUS has been doing over the year. 2010 was a challenging year, and restrictions on GEUS appropriations meant that not all tasks could be completed as planned and that some investment had to be postponed. However, GEUS successfully ended the year with balanced accounts and achieved most of the objectives we had set.

At the beginning of the year, GEUS had a good portfolio of tasks and managed to obtain new, significant projects in research and advisory services that extend into 2011 and 2012.

Over the year there has been increased focus on the international work of GEUS. GEUS enhanced its cooperation with sister organisations within the EU and was involved in a number of projects aimed at increasing the use and usefulness of geology at European level. Establishing common, harmonised data collections was a key task and completion of the OneGeologyEurope project means that users now have access to a comprehensive, digital geological map of Europe. Similarly, databases were set up of energy and mineral resources, as well as mineral resources on the seabed, with associated marine geological data that are relevant for the environment and infrastructure. As part of internationalisation, GEUS hosted the annual meeting of EuroGeoSurveys, attended by directors from 32 European countries, together with participants from the US and the European Environment Agency.

In addition, the international Petroleum Geological Atlas of the Southern Permian Basin Area project was finalised in 2010. This is a compilation of results from 150 years of oil and gas exploration in Denmark and southern and western neighbouring countries - a project costing a total of DKK 50 million.

Globally, GEUS has seen a rapidly growing interest in 'Danish solutions', including water resources where, through partnerships, GEUS' knowledge can form the basis for growth in green exports, especially to the growing Asian economies. GEUS also completed tasks relating to minerals internationally, including improving the conditions for small-scale mining, which provides a

livelihood for many poor people in Third World countries. Another international dimension concerns the continental shelf project, for which GEUS in 2010 provided the scientific basis for the submission of material to the United Nations Commission on the Law of the Sea concerning rights to a marine area off the Faroe Islands beyond the 200 nautical mile limit. The task was completed in cooperation with Faroese and Danish institutions and ministries. The important work regarding the three areas around Greenland, where claims may be made, continued throughout the year.

2010 also saw an audit of groundwater monitoring, and GEUS assisted in the preparation of the Government's Energy Strategy 2050, where GEUS can contribute to solutions relating to fossil and renewable energy sources in the years to come. GEUS priorities were also influenced by adaptation to new hydrological conditions and rising sea levels due to a changing climate. GEUS conducted research and completed tasks on behalf of the Greenland Self Government in order to assess Greenland's mineral potential, especially in the south-western and southern parts of Greenland. An international workshop was held in connection with the great interest in rare earth metals. Finally, GEUS continued major research projects in the North-East Greenland important for future licensing rounds for oil and gas.

GEUS has the knowledge to solving central problems for society and is therefore looking forward to continuing to assist in the development of present and future resources in the Danish and Greenlandic societies in 2011.



Per Buch Andreassen
Chairman




Johnny Fredericia
Managing Director



New online resources for schools

Teachers, students and other interested parties can now obtain lots of new knowledge about groundwater, ice and the climate at GEUS' website. At the World Water Day on 22 March, GEUS launched a new and extended version of its website 'Knowledge about groundwater'. This site has been used extensively by schools and others. The new version includes more topics about groundwater, and all maps and graphics have been updated with the latest information, including on groundwater quality. The many graphic illustrations and maps can be downloaded, and more animations and videos have been added to the pages about how groundwater is mapped and surveyed.



In April, schools were given access to a new web-based teaching programme about glaciers, the Greenland ice sheet, climate change and changes in sea levels. The programme tells us what is happening to the Greenland ice sheet, and how researchers monitor the ice mass. The e-learning programme 'Ice Academy' offers theory, entertainment and demonstrations, and is aimed at 7th–10th grades at primary and secondary schools. Moreover, the academy contains inspiration for lessons in physics, mathematics and geography. The Ice Academy has been developed by researchers at GEUS in cooperation with e-learning experts from a consultancy firm called Context and teachers from Krebs School. Development of the programme has been supported by lottery funds from the Danish Ministry of Education.

Data banks and information

New user-friendly maps and map services

An updated portal was opened at GEUS' website in 2010 to 'Digital Data and Maps', which gives access to new user-friendly, interactive maps and an extension of GEUS' map services for professional users. Now, the maps collect information directly from GEUS' national databases for drillings, geophysics, oil and gas as well as the report database and the geological model database. Moreover, GEUS' other data pages have been integrated into these maps, making it possible to zoom in and access all details directly via the maps. The update also includes several new options for users such as searching for addresses or selecting GEUS' surface geological maps, or aerial photographs and topography from the National Survey and Cadastre as a background theme. In collaboration with the Environment Centres, a new map service has been established which provides access to information about 35 different chemicals that have been found in the groundwater. The groundwater analyses can be retrieved from GEUS' Jupiter database, which contains national information about wells, groundwater and drinking water.

Storage, quality-assurance and presentation of geological knowledge and data



Just as in the rest of the world, there is a growing need in the EU for accessible data on nature and the environment across man-made borders in order to administer resources in the best possible way. Exchange of geodata and environmental data is therefore very important for the EU. Geological maps are an important tool in finding water, oil and minerals, or in minimising the consequences of natural disasters such as earthquakes and volcanic eruptions. Together with 28 partners, including 20 geological surveys, GEUS has participated in the OneGeology-Europe project, which aims to develop a digital geological map of the whole of Europe on a scale of 1:1 000 000. The project was finalised in October 2010 and the geological data are available via a web portal (<http://onegeology-europe.brgm.fr/geoportal/viewer.jsp>) on which maps and information about the surface geology can be found in many languages.

At the conclusion of the project, a book was published called 'One Europe One Geology – Applying Geoscience for Society'. By means of easily understandable texts, maps and graphics this book describes the societal importance of geology. The book is available at the website www.onegeology-europe.eu. OneGeology-Europe is a good example of useful geodata on European scale. Furthermore, in November 2010, EuroGeoSurveys and the European Environment Agency signed a cooperation agreement regarding the use of OneGeology-Europe data for environmental protection in Europe.

In recent years, GEUS has worked on several EU-funded research projects to promote the exchange of geodata between countries in Europe. The projects support the EU INSPIRE Directive on establishing a common European infrastructure for geographical information to make it easier to exchange data across national borders. One of the projects, EuroGeoSource, aims to harmonise data on energy and mineral resources and make these accessible via a common data portal. This concerns data on oil, gas and coal as well as data on deposits of metals, industrial minerals and construction materials such as sand, gravel and clay. These are all important resources for Europe, and the data portal should help to stimulate investment in sustainable exploitation of these raw materials.

Another activity is the Geo-Seas project, which aims at harmonising geological and geophysical data on European marine areas. Data on depth and seabed topography and geology are essential for environmental protection, offshore extraction and the establishment of e.g. submarine cables, pipelines or offshore wind turbines. The new data portal will facilitate access to the many marine data, which are currently available from European national geological surveys and marine research institutes.





EU funding for decontamination of soil and water

Pollution from industry and agriculture is threatening the aquatic environment, and in many cases unwanted concentrations of substances such as nitrates, pesticides and chlorinated compounds have been detected in the groundwater and in watercourses. A new EU-funded research project, AQUA REHAB, aims at developing decontamination techniques for soil and water as well as a management tool that can predict how these new techniques will impact groundwater and surface water. The work is being carried out by 19 research institutions from 12 countries. The techniques will be tested in three watercourse catchments, including the catchment area for Odense River on Fyn.

Guidelines for use of the new decontamination techniques will also be prepared as part of the project which is expected to create a basis for improved administration of the aquatic environment in general as well as for managing decontamination of polluted areas. GEUS is cooperating with the University of Copenhagen on studies to elucidate the potential of new wetlands to degrade pesticides in the Odense River catchment area. Work progressed well in 2010 and the first results are already ticking in. Surprisingly, they show that more pesticides can be degraded without oxygen and in terms of the degradation potential of pesticides in different environments, this is very encouraging.



Water resources



Groundwater vulnerability to road salt

A new study involving researchers from GEUS assesses that chloride from road salt does not represent a significant regional or national problem in terms of groundwater quality. However, on a local scale road salt may increase the chloride content significantly in congested areas where a lot of road salt is used. We do not know exactly how much chloride from road salt ends up in the groundwater. Therefore, the researchers behind the study conclude that there is a need for field research in a larger urban area in order to better assess the impact of the salt.

Pollution of groundwater with chloride is critical as pollution caused today will affect the groundwater quality for many years to come. For instance, calculations in the project estimate that, in Greater Copenhagen, it will take 20–40 years before any groundwater pollution impact by road salt can be seen. Furthermore, the study shows that the top-most layer of Danish groundwater is affected by chloride from several other sources, such as atmospheric deposition and agricultural fertilisers. Precise identification of the sources will require more chemical analysis of the groundwater, and this is also one of the recommendations of the report. The survey was conducted in collaboration with the Department of Earth Sciences, the University of Aarhus, and Rambøll on behalf of the Danish Nature Agency.

Methods for determination of nitrate reduction

Agricultural nitrate leaching must be reduced significantly in connection with the implementation of the European Water Framework Directive; primarily to improve conditions in fjords and marine areas. The existing regulation has covered all areas, disregarding the considerable variations in the natural conditions for nitrate reduction in the subsurface depending on the geological setting. However, these general regulations also cover parts of the Danish agricultural area where they are irrelevant, as nitrate is degraded in the soil layers between the root zone and watercourses. GEUS is in charge of a new research project, called NICA, which aims at developing tools to determine nitrate reduction in the subsurface between the root zone and watercourses. The tools developed will be tested in two catchments in Denmark; Lillebæk in the south-eastern part of Fyn and Norsminde at Odder, south of Aarhus.

In 2010, field research was conducted in Lillebæk, and the first version of a hydrological model for calculation of flow and nitrate transport in the area was set up. Finally, new geophysical equipment has been developed for detailed surveying of surface-near geology. The project will facilitate more cost-effective management at catchment level by identifying agricultural areas, where only a limited quantity of the leached nitrate reaches watercourses. The project is being funded by the Danish Council for Strategic Research and work is being carried out in collaboration with the universities of Aarhus and Copenhagen, Laval University (Canada), DHI, the municipalities of Aarhus and Odder, the Knowledge Centre for Agriculture and SkyTEM, ALECTIA A/S and Aarhus Geophysics.

Training Europe's future groundwater experts

The EU wants sustainable exploitation and good protection of European groundwater resources, and guidelines for protecting the aquatic environment have been laid down in the EU Water Framework Directive and Groundwater Directive. However, there are currently 750,000 areas in Europe which are polluted with various chemical substances. An EU-supported training and research project called GOODWATER ITN will provide the expertise and the knowledge to do something about this. The aim of the project is to train a new generation of groundwater scientists to become multi-disciplinary experts in microbiology, hydrogeology, chemistry and stable isotopes.

Training the new experts will be through specific research projects which are taking place at institutions in Germany and Belgium. The Technical University of Denmark and GEUS are also involved with their expertise. Training and research at GEUS focus on microbiological degradation of low concentrations of pesticides and mapping the spacial distribution of active microbial populations. In 2010, five PhDs from different countries attended training courses at GEUS and research is showing good progress. So far the results indicate that there are populations of micro-organisms in the subsurface which can degrade very low concentrations of pesticides, and these are distributed with large spatial variation.



Energy resources

International research evaluation of GEUS' Energy Resources programme area

The quality of GEUS' research in the Energy Resources programme area was examined by an international panel in the summer of 2010. This is part of a regular evaluation of the quality of GEUS' scientific work. The examination resulted in a report containing a number of appraisals and recommendations.

Having noted the contents of the evaluation report, the Minister for Climate and Energy, Lykke Friis, expressed satisfaction with the high-quality research results that GEUS shows: "I note in particular the comments on research and advice on North Sea oil and gas resources, which will be very important for our economy and for energy supply in a long period of transition. It is also important that GEUS is clearly at the leading edge in other possible uses of the subsurface, for instance exploiting the geothermal energy potential and storage of CO₂ on-shore and offshore. Finally, it is positive that education and research reporting have been highlighted, given the important role of GEUS in recruiting researchers and students".

New eyes on the Jurassic strata in the Central Graben

Even though the Central Graben in the North Sea is a mature oil province, there is still a lack of knowledge about the hydrocarbon potential in the Jurassic strata, which are also very complex. Together with the Danish North Sea Fund, GEUS has discussed the importance of having a detailed study of the Jurassic strata made and in 2010 GEUS presented a proposal for a multi-client study at a workshop for companies that are active in exploring for oil and gas in the Danish part of the Central Graben. The proposal was well received and several oil companies are initially sponsoring a preliminary study of the Jurassic hydrocarbon potential in the Danish Central Graben.

The project will extend existing knowledge which has been published by GEUS in the comprehensive book entitled 'The Jurassic of Denmark and Greenland'. The earlier stratigraphic and seismic interpretations will be updated and revised, and then compared with log data in order to establish a cohesive framework for reservoir rock from the Jurassic period. The work will be presented at semi-annual seminars and will result in a number of summary maps and analyses. The Danish North Sea Fund is fully supporting the project and they write on their website that the results of the study will be of considerable value for companies active in oil and gas exploration in Denmark.

European energy cooperation

Stable, secure and environmentally friendly supply of energy is high on the agenda, and throughout the world politicians are striving to develop energy strategies which take into account both security of supply and sustainable development. GEUS is involved in developing energy strategies for Europe through its work as head of the new Fossil Fuel Task Force under the organisation of European geological surveys: EuroGeoSurveys. The expert group has been set up as a consultative body at the request of the EU Energy Commission (DG-ENER) and the plan is that the group will develop into an Energy Expert Group in 2011.

For several years GEUS has been involved in energy research at European level. One example is the 2010 publication of the comprehensive 'Petroleum Geological Atlas of the Southern Permian Basin Area'. The publication is a compilation of an extensive and systematic overview of the results of more than 150 years of oil exploration in the southern Permian Basin area which stretches into the British, Belgian, Dutch, German, Danish and Polish sectors. The atlas is the result of a collaboration between the geological surveys from the sector countries, universities and sponsoring oil companies, and one of the objectives is that the atlas will stimulate the oil industry to continue their activities in this mature basin.

Progress in the Continental Shelf Project

In 2004, Denmark ratified the United Nations Convention on the Law of the Sea, which opens for opportunities to claim subsurface and seabed resources outside the 200 nautical mile limit. Any claims must be documented, primarily with data on sea depths and sediment thicknesses. As project manager for the Continental Shelf Project, since 2003, GEUS has been busy collecting and interpreting data from the five areas in question. These are 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. In December 2010, the scientific documentation for the claim in the area south-west of the Faroe Islands was submitted to the UN. This concludes the Faroese part of the Continental Shelf Project.

Data from the area south of Greenland were processed during the year to prepare for a later submission of a claim. Finally, in November GEUS took part in a workshop in St. Petersburg at which the scientific aspects of surveys in the Arctic Ocean were on the agenda. The meeting in Russia was attended by delegates from Canada, Denmark and Russia, and representatives from Norway and the USA attended as observers. The Continental Shelf Project is being funded by the Ministry of Science, Technology and Development, with contributions from the Faroese Government, and work is being carried out in collaboration with other institutions from Denmark, the Faroe Islands and Greenland.



Mineral resources

Marketing the minerals of Greenland

Targeted marketing of Greenland's minerals is one of the activities initiated to help attract investment to Greenland from the international mining industry. The mineral potential of Greenland is being marketed through direct contact with the industry and dissemination of knowledge through various media. During 2010, in cooperation with the Bureau of Minerals and Petroleum (BMP) in Nuuk, GEUS took part in two large minerals conventions in Vancouver and Toronto attended by investors and the mining industry. This year's themes on the Greenland stand were the geological environments, possibilities for finding giant deposits, presentation of Greenland's nickel potential, and finally new areas with minerals potential.

At the end of the year GEUS contributed information for the BMP 'Greenland Day - Down Under' in Perth, Australia, where Greenlandic deposits of precious metals, special and base metals were presented to the mining industry. In addition, exploration activities and the geology of Greenland have also been reported through the newsletter 'MINEX' as well as the thematic magazine 'Geology and Ore' and the fact sheet 'Exploration and mining in Greenland'.

New models for studying gold potential

There has been extensive exploration for gold in Greenland for many years, and several sites, especially in West Greenland have come into the spotlight of mining companies. In the same period, geologists from GEUS have been busy elucidating the geological history and mapping the processes and conditions which have led to concentrations of gold in the terrain.

In connection with ore geological field surveys, GEUS has developed structural, geochemical and statistical models which can deduce special characteristics for gold mineralisations. Many different types of data have been used to establish the models, for example detailed geological mapping, magnetic data, gravity data and geochemical data. The results from the models are used as guidelines when exploring for new gold mineralisations in the field and they will enhance the understanding of why the mineralisations appear in certain geological environments. During 2010, the results from the models were applied in the summer field work in order to identify areas which are likely to contain gold mineralisations.

New exciting mineral finds

For two years, geologists from GEUS have been carrying out intensive ore geological surveys of the anorthosite complex near Fiskenæsset, southern West Greenland, which is the remains of an old magma intrusion. The project has included field work and detailed geochemical and mineralogical surveys in order to assess the area's content of platinum group minerals (PGE).

Work was completed in 2010 with very promising results which demonstrate large contents of platinum, palladium and rhodium and in which the mining industry has already shown much interest. The project was carried out with financial funding from the Bureau of Minerals and Petroleum in Nuuk.

Workshop on rare-earth elements

The EU is concerned for future supplies in Europe of rare-earth elements (REE), on which much of European industry is very much dependent. REE are a group of elements which are used in high technology products and green technologies, and supplies of these elements for the world market today come primarily from deposits in China.

Large deposits of REE are known to exist in Greenland, and in 2010 GEUS held a workshop on the potential of these deposits. In addition to experts from GEUS, international experts in REE deposits and several exploration and mining companies took part in the workshop. The workshop was organised in cooperation with the Bureau of Minerals and Petroleum in Nuuk.

Geological mapping and resource assessments

Solid geological knowledge is important for exploration by mining companies, and therefore the industry needs detailed geological maps. In recent years, GEUS has been working intensively on geological mapping and assessment of the mineral potential in West Greenland, and in 2010, a field survey to modernise the geological maps on a scale of 1:100 000, was completed in the area between Frederikshåb Isblink and Sermiligaarsuk.

In parallel with this mapping, geological ore surveys have been carried out to assess the potential for finding new mineral deposits. Work focussed on the Pre-Cambrian supra-crystalline rocks, which can host mineralisations of precious and base metals, and geologists were looking especially for gold. The field surveys have been carried out in a collaboration between the University of Copenhagen and universities in the UK, Canada and South Africa, and activities have received financial funding from the Bureau of Minerals and Petroleum in Nuuk.

During the year GEUS published the 'Geological map of Greenland, 1:100 000, Kangaatsiaq 68 V.1 South and Ikamiut 68 V.1 North' and a considerably revised geological overview map on a scale of 1:500 000. This is the 'Søndre Strømfjord – Nuussuaq 66°45'–71°00'N; 49°15'–55°30'W' map, which covers an area in which several mining companies are exploring.





Nature and climate

International environment award for research in the Baltic Sea

The Danish-led research project BALANCE has been awarded the National Energy Globe Award for Denmark. The award was presented on 3 June at an event in the capital of Rwanda, Kigali, as part of UNEP's celebrations for the United Nations International Environment Day. The project has developed new tools and methods for sustainable management of the Baltic Sea, so surrounding countries can better protect the vulnerable habitats in the marine area. One of the results is development of marine landscape maps of the Baltic Sea, Kattegat and Skagerrak. The maps classify the seabed into different landscape types on the basis of data on sediments, salt concentrations and light conditions, all of which are important parameters to describe the living conditions for plants and animals on the seabed and thus for designating habitats.

The maps are based on existing geological and physical data from all the Baltic countries, and GEUS has been responsible for comparing the data and producing the maps, all of which are available through the project's data portal. Habitats in the Baltic area are exposed to threats from sand-pumping, fishing, tourism and pollution, and the many, often conflicting, interests cause problems calling for common solutions from all the Baltic countries. The marine landscape maps are an important tool in establishing an overall management plan for the area which can create balance between nature and human activities.

Assessment of future sea levels

The world's glaciers and ice caps are melting faster than ever before, causing concern for many. The most recent report from the Intergovernmental Panel on Climate Change (IPCC) emphasises that the greatest uncertainty in projection of increases in global sea levels is the contribution from melting glaciers and ice caps.

A new EU project, ice2sea, in which GEUS is taking part, is investigating the contribution of the ice masses to sea-level rises over the next 200 years. Work involves studying the processes which control the reaction of the ice to the climate and developing models for more reliable projections of the reactions of the ice masses. The studies are looking at representative glaciers and ice caps throughout the world.

In 2010, glaciologists from GEUS carried out surveys of ice movements on five large outlet glaciers from the ice sheet in West Greenland in order to calculate the dynamics of the ice and the glaciers' response to the climate. The ice2sea project is a collaboration between 24 research institutions from 14 countries.

Earthquake measurement and data

GEUS monitors earthquakes in areas throughout the Danish Realm. This is done at four permanent seismograph stations in Denmark and at four permanent stations in Greenland as well as a number of temporary stations. Seismologists register large earthquakes around the world and smaller local earthquakes as well as tremors from explosions, traffic and other human disruptions close to the instruments. Registrations from Denmark and Greenland have been included in a large international network of stations, which monitors large earthquakes throughout the world. GEUS receives many enquiries from the public and the press, who want comments and expert explanations after earthquakes felt in Danish areas or when there are major quakes in other parts of the world.

In 2010, seismologists were especially busy after the earthquake in the North Sea on 19 February, which could be felt in large parts of north Jylland, and after the large, destructive earthquakes in Haiti on 12 January and in Chile on 27 February. GEUS opened a new section of its website as a service to the public and press, a 'Quick Guide to Earthquakes', with answers to common questions about the natural phenomenon and with animations of how earthquake waves affect the earth's surface. The Quick Guide introduces educational pages about earthquakes, www.geus.dk/viden_om/ddj/index-dk.html (in Danish).



Protection of the European national heritage

Shipwrecks and other objects on the seabed are an important part of the European cultural heritage and there is great interest in preserving these. In the Baltic Sea alone there are up to 100,000 well-preserved shipwrecks and other maritime objects. This unique concentration is now in danger of being destroyed by the *Teredo navalis* shipworm which burrows through the wood. With funding from the EU, a group of researchers are developing a tool to localise and predict the spread of the shipworm in the Baltic area and to investigate methods to protect the preservation-worthy shipwrecks on the sites where they lie.

In 2010, researchers developed models which calculate the spread of the shipworm on the basis of data on the tolerance of the animal to various natural conditions such as salt content and temperature. The model results, in the form of maps, show seasonal and long-term changes in the spread of the worm. The maps show areas in which the shipworm has the best possibilities to survive, attack wood, and reproduce. The results show that the shipworm is widespread throughout the Kattegat and the Danish belts in the summer, but less widespread farther east around Bornholm and the southern Baltic. The spread of the reproduction of the shipworm in autumn has increased over the past three decades and researchers have found that climate change could have extended the period in which they damage wood rather than have extended the area over which the worm is spread.

In the future, the maps and guidelines on using the method will help improve management of the European marine cultural heritage. The Wreck Protect project is a collaboration between the Technical Research Institute of Sweden, GEUS, the National Museum of Denmark, the Danish Viking Ship Museum, the Dutch Cultural Heritage Agency and the University of Gothenburg.



GEUS around the world

Quality assurance of geophysical data in Ghana

In January 2010, a four-year project was completed in which GEUS has helped the minerals sector in Ghana. The sector is an important industry in Ghana and the country was previously called the Gold Coast because of its significant gold exports. Even today minerals account for approximately 38% Ghana's revenues. Over the project period, researchers from GEUS have assured the quality of the geophysical data gathered by two commercial geophysical companies, Fugro Airborne Surveys and Geotech Airborne Ltd. using aerial measurements.

The Volta and Keta basins, which cover approximately one-third of the land area of Ghana, were measured by Fugro using magnetic, electromagnetic (GEOTEM), gamma spectrometric and gravimetric methods. The quality of data from the first three methods were subsequently assured by GEUS, while researchers from the DTU Space, the Technical University of Denmark, assured the quality of the gravimetric data in cooperation with GEUS.

Geotech Airborne Ltd. carried out the electromagnetic (VTEM) and magnetic measurements in four smaller areas outside the basins and the quality of these data was also assured by GEUS. Assistance has also included intensive training of employees at the Geological Survey Department (GSD) in quality assurance of geophysical data and the underlying theories as well as organisation of the large amounts of data. The work was funded by the EU Mining Sector Support Programme (MSSP) under the European Development Fund, which is a European aid package for the minerals sector in Ghana.



Marketing the mineral potential of Yemen

The preconditions for a more intensive international investment in the Yemen mining sector are there. The country has a promising geology and many mineral deposits have been exploited in the past. The Yemen Geological Survey and Mining Resources Board (YGSMRB), under the Ministry of Oil and Minerals, has carried out geological and geochemical mapping of the country, but international marketing of the mineral exploitation opportunities is lagging behind. With funding from the World Bank since 2008, GEUS has collaborated with the YGSMRB to make Yemen's mineral potential and investment opportunities more visible. The work has included preparation of printed marketing material on selected minerals in Yemen and posters for the annual PDAC mineral convention in Toronto, Canada.

During the year GEUS has also assisted with a preliminary appraisal of the quality of some deposits of precious stones and Danish geologists have assessed whether these deposits could contain commercially interesting aquamarines, rubies and tourmalines.

Knowledge-building in developing countries through research and consultancy



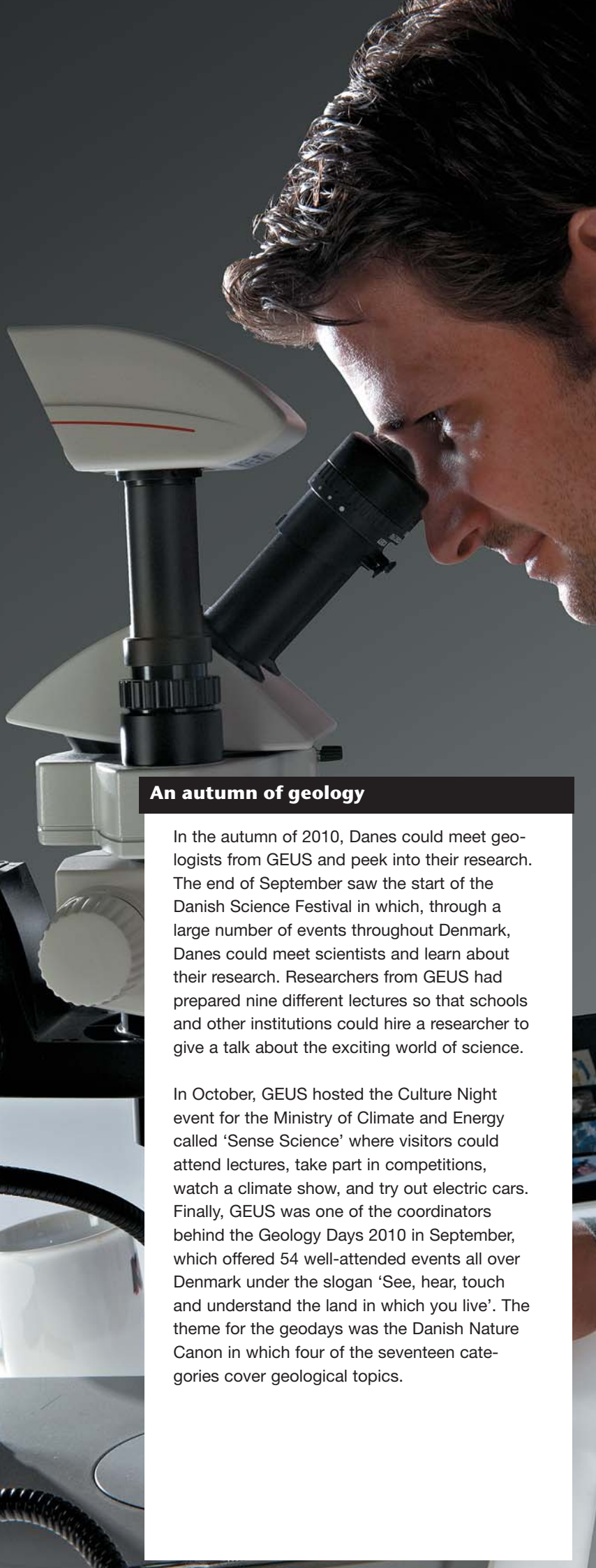
In recent years, on behalf of the World Bank, GEUS has been working in several developing countries to map the extent of small-scale mining and has advised on a more environmentally friendly practice in this type of mining. Small-scale mining (SSM) is an important source of income for up to 100 million people throughout the world. Primarily the extraction of gold and precious stones provides many jobs in small communities. Mineral mining often takes place under very poor safety conditions in cramped and deep shafts. Mercury is used in gold mining and this causes enormous environmental and health problems if it is not managed properly.

In 2010, GEUS completed an assessment of the SSM industry in Nigeria to prepare a 'Handbook on small-scale mining', which contains advice for environmental authorities on safer design of mines and descriptions of how to manage mercury so that it does not damage the environment and workers' health. An SSM training programme has also been developed for selected officials from the Ministry of Mines and Steel Development, so that the project can continue later with Nigerian trainers. The project is being carried out in collaboration with Rambøll and it is funded by The World Bank.

The groundwater pumped up from the flood plain around the Red River delta in Vietnam in many places contains high concentrations of arsenic, and saltwater penetrates the groundwater aquifers in the low-lying flood plains. Arsenic occurs naturally in the sediments under the flood plain, but natural geochemical processes in the groundwater system mean that the arsenic is mobilised and migrates into the groundwater. As the groundwater has good bacteriological quality, all drinking water for the region comes from these aquifers, but arsenic pollution and saltwater penetration are now threatening this supply. GEUS is heading the second phase of the VietAs research project to acquire new knowledge about the mechanisms causing the presence of arsenic in the groundwater aquifers, and to establish a conceptual model for the spread of salt water in the Red River delta.

In 2010, two field sites were set up at which release of arsenic into the groundwater is being investigated, in part under natural conditions, and in part at a water supply facility for Hanoi. Geophysical measurements were also made in 2010 in order to map the saltwater in the Delta, and a conceptual model has been set up for the spread of salt-containing groundwater in the aquifers. The project is aiming at both research and capacity building at three Vietnamese research institutions, and during the year 15 Vietnamese students attended classes in Vietnam and some of these also received training in Denmark. The project is being funded by the Danish Research Council for Development Research under DANIDA and is a collaboration project with the Technical University of Denmark as well as Hanoi University of Mining and Geology and the Hanoi University of Science and Technology.





Glimpses of the year

An autumn of geology

In the autumn of 2010, Danes could meet geologists from GEUS and peek into their research. The end of September saw the start of the Danish Science Festival in which, through a large number of events throughout Denmark, Danes could meet scientists and learn about their research. Researchers from GEUS had prepared nine different lectures so that schools and other institutions could hire a researcher to give a talk about the exciting world of science.

In October, GEUS hosted the Culture Night event for the Ministry of Climate and Energy called 'Sense Science' where visitors could attend lectures, take part in competitions, watch a climate show, and try out electric cars. Finally, GEUS was one of the coordinators behind the Geology Days 2010 in September, which offered 54 well-attended events all over Denmark under the slogan 'See, hear, touch and understand the land in which you live'. The theme for the geodays was the Danish Nature Canon in which four of the seventeen categories cover geological topics.

Specialist support to water resource management

During the year GEUS provided specialist support to the Danish Nature Agency in connection with the nationwide groundwater mapping. A number of geo-guidelines were published during the year which will ensure quality and uniformity in the ongoing groundwater mapping, and the website at www.grundvandskortlaegning.dk has been further developed to allow exchange of information.

In January, employees from GEUS were amongst the teaching staff on a course in applied groundwater modelling for water-resources administrators as well as employees at water utilities and consultancy firms. The course comprises a mixture of lectures, practical exercises in computer modelling and exchanges of experience.



Medal of distinction for GEUS researcher

GEUS senior researcher Peter Appel was awarded the Nairamdal medal by the President of Mongolia, Mr Tsakhia Elbegdorj, during his official visit to Denmark. The presentation was on 8 October at a reception in Asia House in Copenhagen. The Mongolian Nairamdal medal is awarded to foreigners who have helped strengthen collaboration between their country and Mongolia, and Peter Appel received the medal for his work on small-scale mining in 2005. His work included mapping small-scale mining in Mongolia and the methods used, with focus on extraction of gold, fluorspar and coal. The gold miners used mercury to extract the gold and Peter Appel's work has included courses for miners and their families on how they can be better at handling mercury in a more environmentally friendly and less harmful manner. Finally, workshops were held for government and local administrators in Ulaanbaatar and in several small towns.



Young Elite Researcher's Award for GEUS postdoc

Jacob Bælum received the Young Elite Researcher's Award of DKK 200,000 from the Danish Council for Independent Research. Jacob is a researcher at GEUS and he got his PhD in 2008 at LIFE at the University of Copenhagen. He is now working on developing molecular-biological techniques to remediate soil contaminated with chlorinated solvents. These substances are found at many old industrial sites, and in many areas they are a threat to the drinking water. The Young Elite Researcher's Award for talented young researchers provides extra support for their research, and Jacob Bælum can now boost his environmental chemical studies on how we can remediate contaminated soil.

When presenting the award, the Council stated: "This is an elegant research project in which young researchers have looked closely at advanced basic molecular biological research which has a very practical application in solving important contamination problems".

Mapping of East Denmark completed

On 17 September 2010, the final sample was extracted from the soil at Nakskov Fjord. This was the end of the field stage of the geological mapping of Sjælland, Fyn, Bornholm, Møn, Lolland-Falster and the smaller Danish islands, and an important milestone in the geological mapping of Denmark was reached. It was marked by a ceremony, attended by the press and invited guests, at which the GEUS deputy director, Bjørn Kaare Jensen, unveiled a memorial plaque for the work.

Since the mapping commenced 122 years ago, Danish geologists have trudged what amounts to three-times around the world, taken more than 10 million soil samples, and then interpreted their origin. The most recent mapping of Lolland-Falster is now being prepared for print as three map sheets and will be published soon. However this does not mean that the geological mapping will stop. In order to complete the final 14.5% of Denmark which still remains unmapped, mapping has commenced in Himmerland with focus on Mariager Fjord. This mapping will contribute important new understanding of the geological and geomorphological conditions in northern east Jylland, which has never been mapped before.

Key figures for 2010

More detailed key figures for the activities of GEUS are available in *Årsrapport – Regnskabsåret 2010 (Report and Accounts 2010)*, and in *Faglige resultater 2010 (the latter in Danish only)*.

Both of these are available at www.geus.dk – publikationer – institutionsrapporter.

Number of employees: **319**

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

ACCOUNTS 2010

Amounts in million DKK

Revenue:	288.3
Net figure (appropriation):	138.8
Operating income:	149.5
Expenditure:	294.7
Salaries:	170.2
Other operating expenditure:	124.5

PRESENTATION ACTIVITIES

Long-term knowledge building

Articles in international scientific journals/publications	139
Articles in GEUS' own scientific series	31
Other scientific publications	15

Ongoing scientific tasks, consultancy and presentation

Publicly available reports	71
Confidential reports	96
Memoranda, opinions, expositions etc.	84

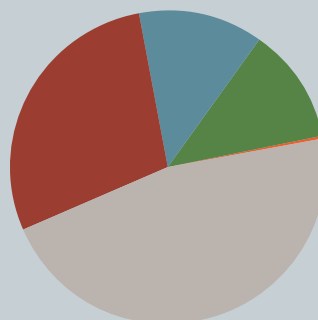
General presentation

Institution reports (annual report etc.)	4
General and popular-science presentations - including popular-science lectures	129 68

RESEARCHER TRAINING WITH GEUSTUTORS

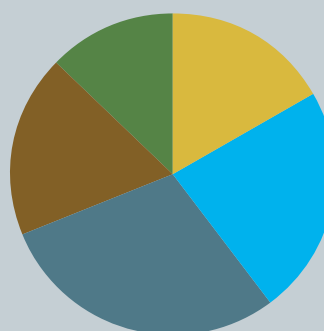
Current PhD students	74
Completed PhD degrees	11

Revenue broken down by sources of revenue in million DKK



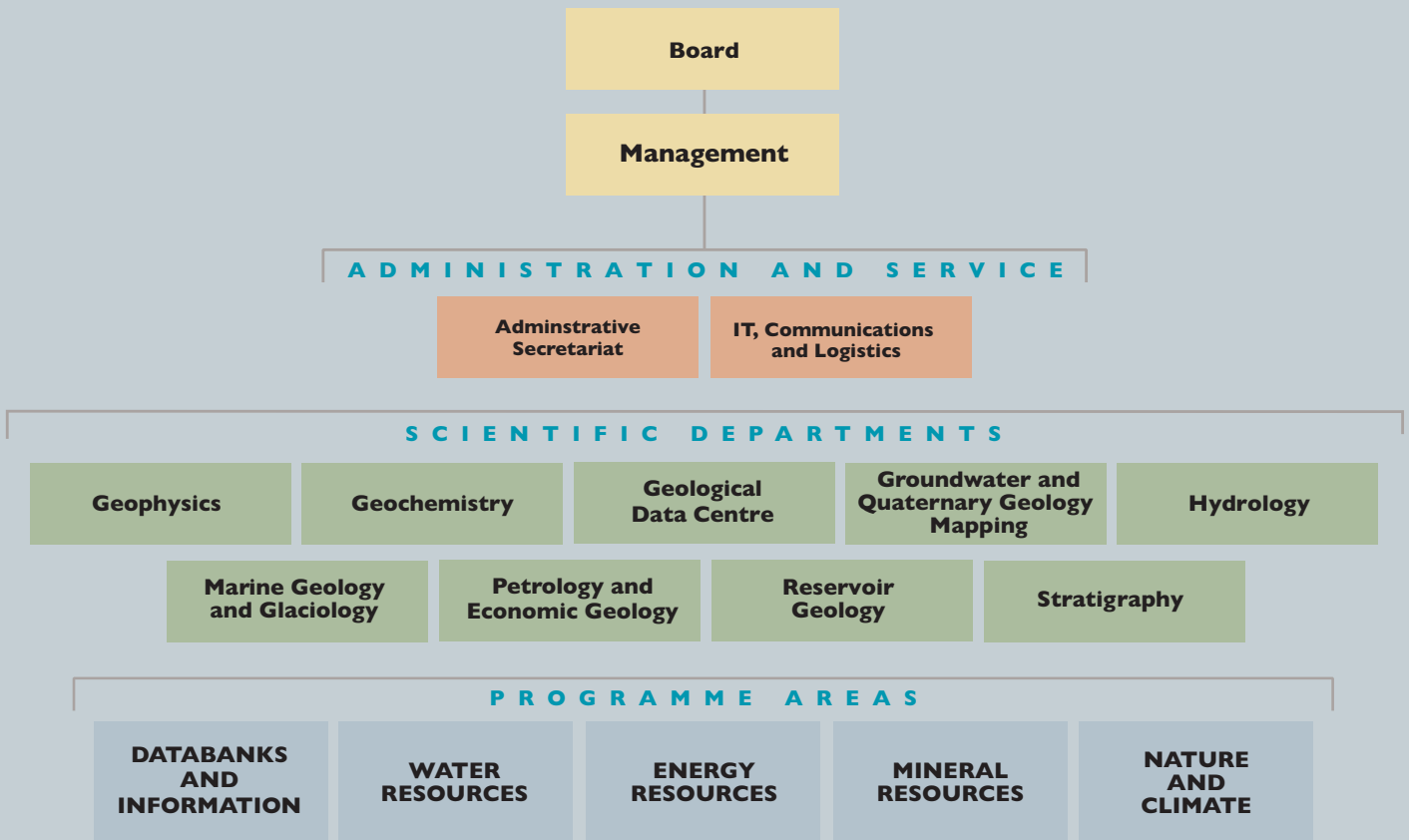
National budget and supplementary government appropriations:	137.6
Programme and external resources:	84.4
Other co-financed contract research:	37.7
Commercial contracts and sales of data:	35.4
Other revenue:	0.2

Expenditure broken down by programme area in million DKK



Databanks and general information:	49.9
Water resources:	68.0
Energy resources:	86.0
Mineral resources:	54.4
Nature and climate:	37.0

Organisation



In 2010 there were ten 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

Archiving and data processing in connection with statutory reporting of geodata to GEUS. 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

Providing the necessary basis for management of 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.

PROGRAMME AREA: ENERGY RESOURCES

Providing and contributing the basis for continued exploration and sustainable exploitation of the energy resources of the Realm. 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

Providing the scientific basis for targeted and environment-friendly exploitation of raw materials and 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 Greenland Self Government. In addition, surveys are carried out in connection with raw materials and construction work in Denmark and internationally.

PROGRAMME AREA: NATURE AND CLIMATE

Examining processes in Denmark and the North Atlantic area which have led to the current climate and environmental situation. The objective is to improve the prospects of distinguishing between natural and human-induced environmental changes. The programme area also includes a mapping of onshore and offshore geological conditions, as well as earthquake research and monitoring.

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- **Geology in a European perspective**
- **Databanks and information**
- **Water resources**
- **Energy resources**
- **Mineral resources**
- **Nature and climate**
- **GEUS around the world**
- **Glimpses of the year**

