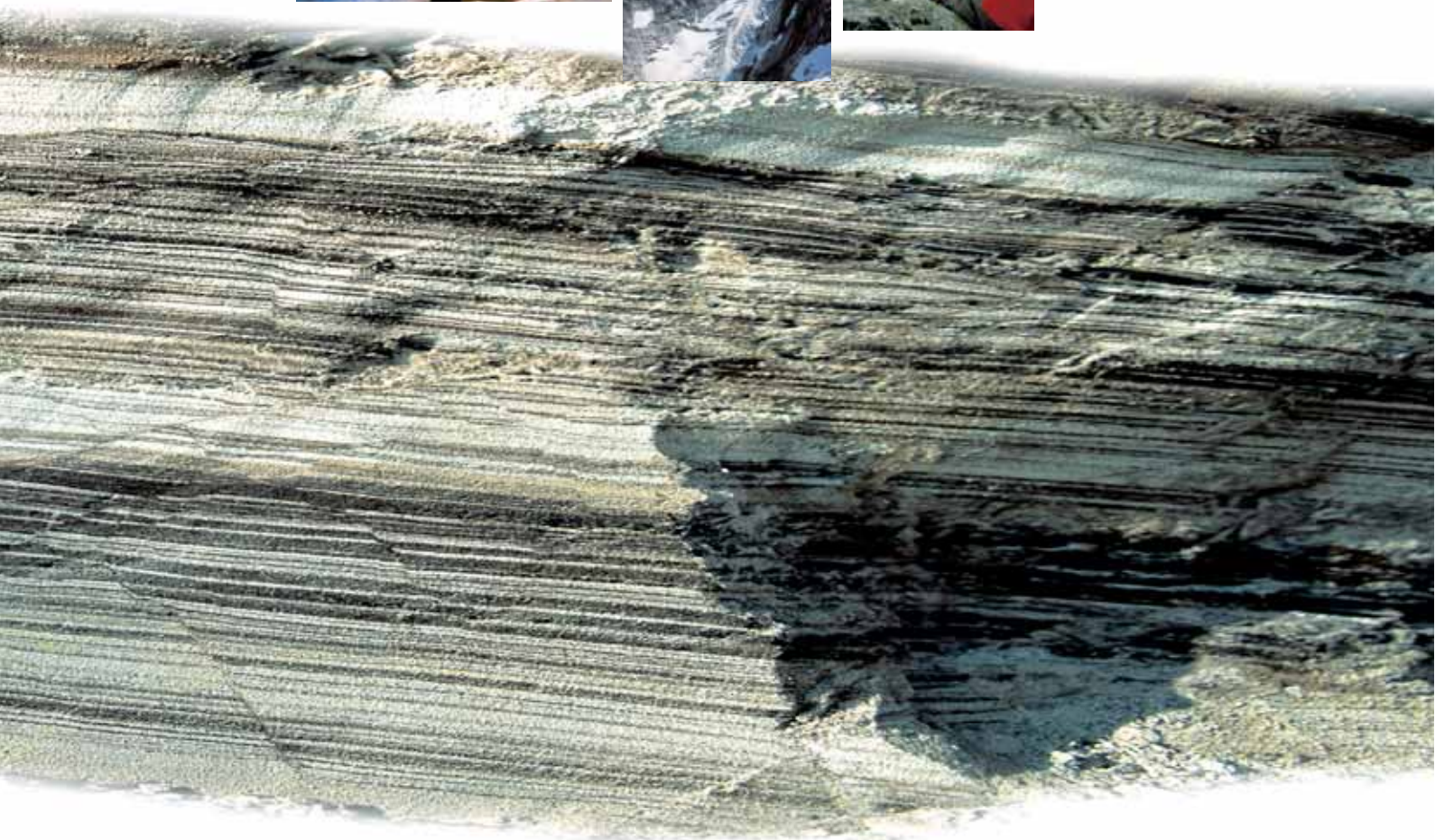


Research for Welfare and Balance



Water
Energy
Mineral resources
Nature



Annual Report 2004

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF THE ENVIRONMENT




G E U S

Earthquake research and monitoring now a part of GEUS

Seismology and earthquake research become a part of GEUS activities in 2004

On 1 July 2004, sector research in seismology moved from the National Survey and Cadastre (KMS) to GEUS. The movement was the result of an amendment to the KMS Act adopted by the Danish Parliament in April 2004, which states that KMS will no longer be a sector research institution.

"We all know the terrible TV pictures of earthquake disasters around the world, and they are a clear demonstration of why earthquake research is of such great international interest. Seismology goes hand in glove with other GEUS work on geological research for the benefit of society, and it is a good supplement to GEUS' many activities in Denmark and Greenland," says Jens Jørgen Møller, state geologist and head of the geophysics department at GEUS, which is responsible for seismology.

Thus, several tasks of importance to society within seismological monitoring and research have now changed address:

The Seismic Service for Denmark and Greenland

The Seismic Service operates four permanent seismograph stations in Denmark, and four permanent stations in Greenland, as well as a number of temporary stations. The Service registers large earthquakes around the world, tremors from nuclear tests, and smaller local earthquakes and tremors from traffic and other disturbances caused by human activity near the instruments. The measurements are an element in calculating where earthquakes appear and the size of the earthquakes. Records for Denmark and Greenland make up important data for a large international network of stations monitoring the larger earthquakes across the globe.

National authority under the UN

Accompanying seismology is the role as the national authority for the United Nations CTBT Treaty (Comprehensive Nuclear Test Ban Treaty), under which an international network of seismographs and other geophysical stations monitors whether countries are complying with the UN agreement banning nuclear tests.

Advice in Denmark

In Denmark, seismologists advise the authorities and enterprises on risks of earthquakes in connection with major construction projects such as the large bridges over the Great Belt and Øresund.

Seismology and the earth's interior

Seismological research is an important element in the exploration of the interior of the earth and in the structure of the deep subsurface in Denmark and Greenland. This research area is of great immediate use in Danish exploration of the possibilities for claiming rights to the resources of the subsurface and seabed beyond the 200 nautical mile limit in five areas near Greenland and the Faeroe Islands.



Foreword

This year we have chosen "Research for Welfare and Balance" as the title of our annual report. By this we would like to stress GEUS' double task of, on the one hand, contributing to increased welfare in society by providing knowledge that will facilitate our exploitation of natural resources, water, energy and minerals; and on the other hand, safeguarding that we use the resources in an environmentally considerate way so that the earth's natural assets are still available for future generations.

The need for water, in particular clean drinking water, is a top priority for many people around the world. Denmark does not lack water, but our drinking water is threatened by man-made pollution. GEUS is the government's watchdog in this area and throughout 2004 we were actively working to develop operational methods which may limit the effect on groundwater from pesticide use in agriculture. In the developing countries, GEUS supported Honduras, Mozambique, and Vietnam with advice. In Vietnam, arsenic is the great threat to groundwater.

Oil and gas still play a central role as energy sources. In the North Sea, the goal is to find potential, undiscovered occurrences and to exploit the known ones more efficiently. GEUS is active in research in both areas. In Greenland, we are contributing, in particular, to the creation of knowledge about the geological conditions, so that it will be possible to attract international industry and find oil. This may form the basis for a more independent Greenlandic economy. At the same time, GEUS is researching the possibilities for subsurface storage of CO₂ arising from the burning of fossil fuels, as well as the possibilities for geothermal energy. These are research areas which, in future, may contribute significantly to reducing the release of greenhouse gases into the atmosphere.

Denmark ratified the United Nations Convention on the Law of the Sea in 2004, with support from Greenland and the Faeroe Islands. Among other things, the Convention makes it possible for coastal states to claim rights to the resources of the subsurface and seabed beyond the 200 nautical mile limit. GEUS has been documenting possible claims to four marine areas around the Faeroe Islands and Greenland, and has made preparations for surveys of a fifth area in the Arctic Ocean north of Greenland.

Mineral resources are constituents of many important materials and processes fundamental to our industrial and service society. GEUS is contributing

with basic research that enables targeted exploration for specific mineral resources. In Greenland the current focus is on gold and diamonds in particular. In the international arena, GEUS is contributing with advice on how to reduce harmful environmental effects, for example, how to achieve more environmentally considerate use of mercury in gold extraction from small-scale mining in Mongolia. This is a primitive form of mineral exploitation by the poorest parts of the population in many developing countries.

Balance in nature is continuously being influenced by the exploitation of natural resources, e.g. mineral resources. GEUS is therefore researching the actual effects of mineral-resource excavations on land and in the sea and the development of the man-made landscape in Denmark. However, research on how to restore the balance in the upper strata is also on the agenda in connection with treatment of contamination from xenobiotic organic substances. Denmark is moreover contributing to the international climate research in Greenland because of the significant melting away of the Inland Ice being observed each year.

Welfare and quality of life are also about opportunities for experiencing nature, especially where the basic human needs have been met. GEUS contributes with knowledge and advice about nature parks and landscapes of high conservation value. In Greenland, GEUS' preparatory work formed the basis for inclusion of the Ilulissat Icefjord in UNESCO's World Heritage List in 2004.

In the following, you will find descriptions of GEUS activities in 2004 which exemplify the issues mentioned above. If you want to find out more about our activities, please refer to our website (www.geus.dk) for an easy overview. The website had 375,000 visits last year.



Per Buch Andreassen
Per Buch Andreassen
Chairman of the Board



Martin Ghisler
Martin Ghisler
Managing Director



Databanks and inform

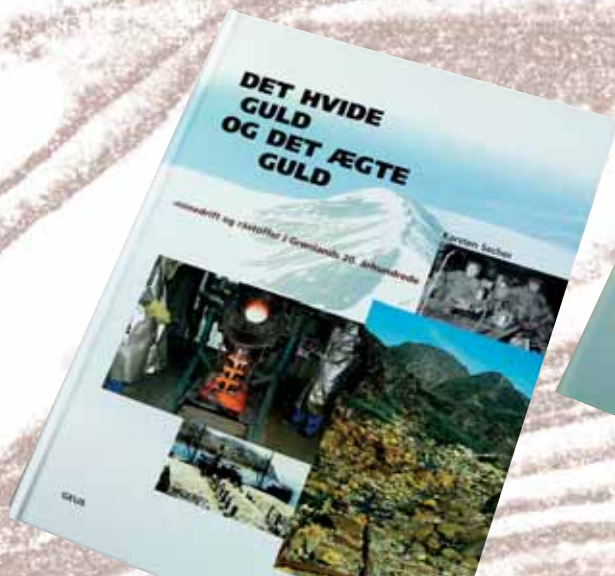
Storage, quality assurance, and presentation of geological knowledge and data

Book publication about Greenland and Denmark

Magazines with geological content

2004 saw the start of new magazines with geological content. It was also the year in which the last two editions of the magazine "Geologi - Nyt fra GEUS" (Geology news from GEUS) were published: one about the Skaw, Jutland's most northern tip, and one about geological storage of CO₂. Since the beginning of 1996, there have been a total of 34 editions of the magazine, all of which are available electronically at the GEUS website. The magazine will be replaced in 2005 by a new popular-science magazine called "Geoviden - Geologi og Geografi" (Geoknowledge - Geology and Geography), which GEUS will be publishing in collaboration with its partners in Geocenter Copenhagen: the Geological Museum, the Geological Institute and the Geographical Institute, all at the University of Copenhagen. Geoviden will cover even more subjects about the Earth. From 2004, moreover, GEUS has been contributing steadily to the Ministry for the Environment's joint magazine, "Environment Denmark". This magazine features news articles, features, interviews and background articles about nature and the environment. The magazine also brings stories from the Ministry's other institutions: The Danish Environmental Protection Agency, the Danish Forest and Nature Agency, the National Survey and Cadastre Denmark, and the National Environmental Research Institute of Denmark.

In connection with the silver jubilee of the Greenland Home Rule, GEUS published the book called "The white gold and the genuine gold. Mining and mineral resources", commissioned and supported financially by the Bureau of Minerals and Petroleum. The book tells the history of mineral resources in 20th century Greenland. Amongst other things, it accounts the story of cryolite, Greenland's white gold, as well as the story of Greenland's genuine gold, which is now being mined from the country's first gold mine in South Greenland. In the preface, Jørgen Wæver Johansen, Member of the Greenland Home Rule Government, writes: "There is a saying that no one knows the day until the sun has set. This book illustrates perfectly how no one will know the value of Greenland's subsurface before the last rock has been turned and analysed". Later in the year, the book called "Southern Jutland" was published. It describes the geology of Southern Jutland, which holds Denmark's geological history for the past 25 million years. Readers can find information about 25 locations of national and regional significance. The book was published by the Danish Forest and Nature Agency and GEUS in collaboration with Geografforlaget. It is volume 5 out of 6 in a series called "Geologisk Set" (From a Geo Perspective).



ation



A geological autumn

More than 60 events across the entire country lured many Danes away from their homes during "Geology Days", an event coordinated by the Danish Forest and Nature Agency and GEUS. During the last weekend in September geology professionals from Danish counties, municipalities, forest districts, research institutions, and petrologic societies stood ready to tell stories about the geology of Denmark, volcanoes, dinosaurs, fossils, and much more. Geology, however, was also on the programme during the Danish Science Festival in the days up to the "Geology Days". Here, researchers from GEUS travelled the entire country to give lectures at schools, libraries, and associations. Furthermore, in October the citizens of Copenhagen could see, hear, and taste their way through the world of geology, as GEUS in collaboration with its partners in Geocenter Copenhagen opened the doors of

the Geological Museum with lectures, films, photos, experiments and activities for children during the Night of Culture in Copenhagen.



Keen interest in environmental data from "Jupiter"

The Jupiter database is the heart of GEUS' environmental information system. It contains information about drillings, the quality of groundwater and drinking water, and data about groundwater levels and resources. Towards the end of 2003, the 232,000 drillings in the data base were made available online. Searching among the many drillings is by maps or via a search formula, and in 2004 the service was expanded so that drillings can now be displayed graphically. Interest in drilling data has been great and the number of visits to the website has been steadily increasing throughout the year. In the last half of 2004, an average of 2900 drillings was shown each week. GEUS has agreed with Danish Regions that the Jupiter database is to become the groundwater database in the Counties' Environment Portal. In this way the many data will become available together with data on soil contamination, environmental data from lakes and watercourses, as well as miscellaneous administrative data related to water extraction. In the course of the year, GEUS commenced work to adjust Jupiter so that

it can receive data from Danish counties and transmit it to the Counties' Environment Portal.



New national database for geological models

Geological models, describing the geology, are an important basis for work to protect the groundwater. Recent years' hard work on groundwater zoning in Danish counties, which is to lead to action plans for groundwater protection, has meant an increase in the need for building 3D geological models, spanning from point source scale over field scale to basin scale. Today, numerous geological models are being constructed in connection with different types of surveys by the counties, consultancy firms, and GEUS. In 2004 GEUS, in collaboration with Danish counties, started work to establish a national database for geological models. The database will give a good overview of existing models and provide inspiration in work on geological modelling. The database, which is to store the geological models in a flexible, well-defined, and open format, will become an integrated part of the GEUS Jupiter database, which contains drilling information and groundwater data. This will provide users the opportunity to be advised whenever new drillings are reported in an area where work is being carried out to construct geological models. The database will create an overview of the spatial location of groundwater reservoirs, which will be important in relation to the requirement to reporting groundwater occurrences and their status set out in the Water Framework Directive. Knowledge about groundwater occurrences will also be important in connection with the forthcoming EU Groundwater Directive.

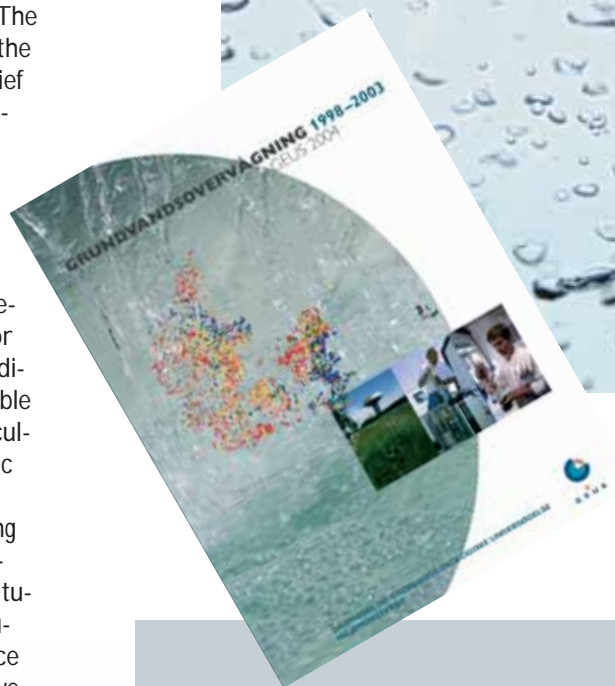
Groundwater protection through stakeholder involvement

During the summer, GEUS and Københavns Energi (KE) completed an EU project, which examined how farmers, residents and other interested parties can be involved more effectively in the decisions necessary to protect Danish groundwater. The project tested whether graphical models can be applied in the management of water resources; the so-called Bayesian Belief Networks (BBNs). This decision-making tool makes it possible, with one tool, to illuminate the significance of various factors in a given protection measure, such as water cycle, groundwater quality, natural values, macroeconomics, and commercial aspects. By involving a stakeholder group of professionals and a citizens group, different measures were tested at St. Havelse Kildeplads north of Frederikssund, a recovery catchment area owned by KE. The project shows, for example, that voluntary cultivation agreements based on individual negotiations with each farmer are not readily applicable as a means of groundwater protection. Establishment of a cultivation agreement is not only dependent on farm economic consequences; it is also dependent on attitudes and basic values and opinions. The method has proven apt for mapping some of these fundamental factors. This is important knowledge to have when assessing how to ensure support for future implementation of planned measures. The project concludes e.g. that use of BBNs has made broader local acceptance of decisions possible, as well as improved the dialogue between water companies, local stakeholders and the authorities.

Groundwater monitoring 1998-2003

In 2004, the annual report on the state of groundwater in Denmark concentrated on the period 1998 to 2003, when the monitoring programme NOVA 2003 was underway. The report concludes that the Maximum Admissible Concentration (MAC) for nitrate was exceeded in around 16 per cent of all monitoring boreholes. However, there is a downward trend with regard to nitrate content in the youngest groundwater, although average concentrations here lie close to the MAC of 50 mg/l. A further reduction is therefore desirable, out of consideration for both nature and the quality of drinking water. The MAC was only exceeded in one per cent of the waterworks' abstraction wells, which is due to the fact that wells with a high content of nitrate are abandoned and the abstraction moved to deeper lying aquifers or to less affected areas. The frequency rate of pesticide findings in connection with groundwater monitoring has been constant in recent years, but there has been a slight increase in the number of incidents where MAC for drinking water have been exceeded. In contrast, there has been a drop in the frequency of incidents where MAC in the waterworks' abstraction wells have been exceeded. This is probably due to the fact that abstraction wells with high concentrations of pesticides are being discontinued. Finally, the report shows that the amount of water abstracted since 1998 has gone down. This has reduced the pressure on groundwater resources and the effect of water abstraction on water flow in water courses.

Water re



Possible to identify particularly pesticide-sensitive sandy soil

Due to lack of knowledge, the counties' task of identifying areas which are particularly sensitive to certain types of contamination has not previously included pesticides. A project, entitled KUPA (Concept for identification of Pesticide -Sensitive Areas) was therefore launched as part of Pesticide Plan II to investigate whether it is possible to identify areas which are sensitive to pesticide leaching. GEUS and the Danish Institute of Agricultural Sciences had been working on this since 2000, and in 2004 this work was completed with a report concluding that identification of sandy soils especially sensitive to pesticides is possible. The work shows e.g. that there are significant differences in the degree of sensitivity of sandy soils to leaching, and that for most of the known pesticides, the ability to bind depends on the same physical or chemical properties in the soil. Furthermore, it appears from the conclusion that the general sensitivity to leaching can be described by relatively few simple properties in the soil, and that it will be possible, with the help of known and relatively few new data, to carry out identification of particularly sensitive soils. The project also reviewed the development of methods for use on clayey soils. In a separate report, GEUS and the Danish Institute of Agricultural Sciences conclude that a similar basis for identification can be provided for clayey soils. This work has not yet been finished and will continue in the years to come with funding from the Government's Pesticide Plan 2004-2009.

sources

Procuring knowledge for optimal management of our water resources



Status and assessment of pesticide use

The Danish Crop Protection Association has asked GEUS to make a status of the incidence of banned and approved pesticides and their breakdown products in Danish groundwater, as well as an assessment of the probability that the use of the substances applied by agriculture today will create problems for groundwater in the future. In the report "Pesticidanvendelse i landbruget" (Pesticide use in agriculture) GEUS assesses that groundwater quality will be considerably improved in 20 to 30 years time, if the re-evaluation of approved substances is continued, e.g. on the basis of the results from the Danish Pesticide Leaching Assessment Programme. The majority of the substances being applied today are not likely to give rise to groundwater aquifer pollution exceeding the permitted limit value; however GEUS also assesses that there are substances in use today which may have to be regulated following testing under the Pesticides Leaching Assessment Programme. It is probable that some pesticides will leach due to local conditions or accidents, but this risk of contamination can be minimised if experience from research project KUPA is applied to sandy and clayey areas, and if guidelines are prepared for managing spraying equipment and pesticides. Finally, GEUS assess that Danish groundwater monitoring is better than in most other countries in Europe.

Studies of chloroform in groundwater

Groundwater containing more than one microgram of chloroform per litre must not be used as drinking water. A high content of chloroform can be due to human activities, however new research shows that naturally occurring chloroform may also be the cause. In 2004, GEUS commenced on a project to examine whether chloroform in groundwater is a problem for Danish drinking water supply and how much of the substance comes from natural sources. In collaboration with the Danish Hydraulic Institute (DHI), Rambøll, and Viborg Vand A/S, studies of current knowledge in the area were carried out during 2004, supplemented by new studies from a catchment area south of Viborg in Jutland. The results show with great certainty that natural production of chloroform is the cause of chloroform pollution in the Viborg area. Laboratory measurements of soil samples showed that chloroform production is greatest in the soil under coniferous forests. The work will continue in 2005 and will include a review of treatment principles, their financial aspects, and preparation of a practicable guideline for waterworks that have chloroform problems. The project is receiving financial support from the Danish EPA. Universities from Sweden and Switzerland are taking part in the project.





Energy from the Earth's interior

Heat from the interior of the Earth in the form of geothermal energy is being exploited in many places throughout Europe, and in Denmark a geothermal plant near Thisted has been producing heat for 20 years. The hot water is collected from deep sandstone aquifers in the subsurface. For a number of years GEUS has worked on developing geological models to describe and predict the distribution of geological strata in the subsurface that can be used for geothermal energy. In recent years DONG has worked with GEUS on geological interpretations of borings on Amager, where the erection of a new geothermal plant is underway. This new plant near Copenhagen utilises the energy in the 70-Celsius hot water present 2.7 kilometres below the Danish capital. Experience from the surveys in Copenhagen has spurred new interest in exploiting the deep-lying hot water, and during 2004, DONG and GEUS worked together to interpret seismic data and data from borings in order to build geological models of the subsurface beneath a number of Danish cities.

Greenlandic oil licensing round 2004

In October the licensing round for 2004 for four offshore areas in West Greenland closed, and in January 2005, the Bureau of Minerals and Petroleum under the Greenland Home Rule issued a new exploration and exploitation licence to the Canadian oil and gas company, EnCana Corporation, and the Danish-Greenlandic Nunaoil A/S. Prior to the licensing round, GEUS in collaboration with the Bureau of Minerals and Petroleum worked on developing and marketing new exploration models in Greenland. Many years of research, data collection, and exploration for oil in Greenland have revealed interesting geological structures and attractive source rocks and reservoir rocks in the area. The extensive knowledge and data enabled a change of strategy for the licensing round, and in 2004 there was a higher degree of focus on industry efforts. The oil industry is only interested in large findings and GEUS' work has therefore been about identifying the areas with the largest geological structures and where there is a possibility of oil formation nearby. The work resulted in the identification of four licensing areas, all of which comprise structures in the subsurface larger than 100 km². After the application date, GEUS participated in the processing of applications and in the negotiations.



Research on geological storage of CO₂

Emissions of CO₂ from burning fossil fuels, such as coal, oil and gas, may have a number of undesirable effects on the world climate. The international community has voiced a common will to reduce CO₂ emissions, as expressed in the Kyoto Protocol. However, with a world that is thirsting for energy, these goals may be difficult to achieve. Storing CO₂ in the subsurface could be one way of minimising emissions, and GEUS participated in several EU-funded international research projects in 2004. In an area near Kalundborg on Zealand researchers are examining the geological and technical possibilities for storing CO₂ from the Asnæs power plant and an oil refinery in the deep-lying sand beds near the installations. The work is part of project CO₂STORE, and it is being conducted in collaboration with the industry partners Energi E2 and Statoil. Furthermore, two new storage projects have been launched. These are project CASTOR, in which GEUS is conducting surveys of the CO₂ storage capacity in eight East European countries, and project CO₂SINK, that is to construct and run the world's first plant for storage of CO₂ from a power plant near Berlin. This project is intended to demonstrate that it is technically possible and safe to store CO₂ from conventional power generation in underground storage sites.





gy resources

Procuring of knowledge for the continued exploration and exploitation of energy resources in Denmark and Greenland



Time limit for making national claims

In 2004 Denmark, with support from Greenland and the Faeroe Islands, ratified the UN Law of the Sea Convention, or "the constitution for the oceans" as it is also called. The Convention provides e.g. coastal states with an opportunity to make claims to the resources of the subsurface and the seabed beyond the 200-nautical-mile limit. It presupposes, however, that water depths and the geology of the subsurface meet a number of conditions, which are described in Article 76 of the Convention, and Denmark now has 10 years in which to document possible claims. Five areas are at stake. These are: one area in the Arctic Ocean, two areas offshore Northeast Greenland and South Greenland, and two areas northeast and southwest of the Faeroe Islands. In 2004, preliminary surveys were conducted in the form of water-depth measurements from the sea ice in the Arctic Ocean, and seismic stations were established in three places on land in North Greenland to document the structure of the earth's crust. Furthermore, seismic surveys and borings in the seabed were conducted southwest of the Faeroe Islands in order to document the geological conditions and possible connection between the Faeroe Islands and the Hatton-Rockall plateau. Finally, in 2004 efforts were made to interpret data from the other three areas in which field research was carried out in 2002 and 2003. Preliminary results show prospects for making claims in these areas. The project is financed by the Ministry of Science, Technology, and Innovation with contributions from the Faroese Home Rule Government, and efforts are a collaboration between GEUS and other institutions from Denmark, the Faeroe Islands and Greenland.



New knowledge about the energy-rich North Sea chalk

The dominant reservoir rock in the North Sea, from where Denmark gets its oil and gas, is chalk. The Upper Maastrichtian - Danian chalk constitutes an important reservoir in the Danish part of the Central Graben of the North Sea. The methods and the techniques for extracting oil from chalk have become still more sophisticated in the course of the 30 years of production, and today a far greater part of the oil found can be pumped up. The new sophisticated production techniques, which the oil companies have developed, and which include horizontal borings and water injection, make ever more demands on our knowledge about the formation and structure of the chalk. In 2004, GEUS completed a large project which provided a new high-resolution stratigraphical framework for the Upper Maastrichtian - Danian chalk in the Central Graben. The work covered a large number of different geological studies aimed at creating a model for the early oceanographic development in the area and the formation of the characteristic chalk layers. The project has created new and important knowledge about the geological development in the Upper Maastrichtian in the Central Graben, the formation and the sedimentation of the chalk, and new insight into the geological conditions that can create some of the highly porous layers from which oil is pumped up today. The work is being supported financially by the Danish Energy Authority's Energy Research Programme, the EFP-2001, and it marks the end of oil and gas-related research under the EFP programme.

Mineral resources

Creating a scientific basis for targeted and environmentally friendly exploitation of minerals in Greenland and Denmark



The hunt for diamonds continues

A total of 119 micro-diamonds and 9 macro-diamonds are among the results of GEUS' examination of tonne-sized kimberlite samples collected in West Greenland in 2003. This is evident from a report published by GEUS in 2004, and the findings have helped spur on the mining industry's interest in diamond exploration in Greenland. An exploration company found macro-diamonds in the same area. The occurrence of diamonds in West Greenland has been known for decades, but it was not until after the establishment of diamond mines in Canada that the mining industry began to show real interest in West Greenland. In the 1990s there was a large-scale search for diamonds and several mining companies have retained interest in the area. In recent years, GEUS has followed up on the work of the companies through support from the Bureau of Minerals and Petroleum, since opportunities for finding more of the attractive diamonds have been far from exhausted. Geologists continued their examinations and surveys of kimberlitic rock in West Greenland in 2004. Toward the end of the year, GEUS published a new digital comparative overview of diamond data from West Greenland with a plethora of information from mining company research and GEUS' own data. The overview of data comprises many new research data, which have become available as the period of confidentiality for several company reports ended, and data collection has almost doubled compared to the previous overview published in 2003.



Treats for the mining industry

The mining industry is demanding more geological knowledge and access to several other types of geodata when deciding whether a region is worth investing in. In order to attract the industry to Greenland, for a number of years GEUS has been presenting its knowledge in a user-friendly form, so that it is easier for companies to access. In 2004, a summary and evaluation of geodata from the Precambrian Shield of West Greenland between 66 degrees north and 70 degrees 15 minutes north was published. The information is collated on a DVD and in four reports, which describe and evaluate the data. The content of the DVD includes maps of topography, geology, geophysics, geochemistry, mineral resources licenses, descriptions of 160 known mineral occurrences, as well as lists of publications and company reports from the region. Greenland's potential mineral resources are also being marketed by GEUS at large conventions where the mining industry is present. In collaboration with the Bureau of Minerals and Petroleum, in 2004 GEUS participated in two large conventions in Canada and published a theme number of the magazine "Geology and Ore" on diamond exploration in Greenland, as well as four fact sheets in the series "Exploration and mining in Greenland" with the themes: gold in the Nuuk region, diamond exploration, gold in Southwest Greenland, and Greenland's prospective nickel resources. GEUS received regular visits from exploration companies wanting to draw on publicly available knowledge about Greenland's geology at GEUS.





Overview of Greenland's geology

After 40 years' work, in 2004 GEUS completed the geological 1:500,000-scale overview mapping of Greenland with the publication of the map sheet: "Humboldt Gletscher, Sheet 6", which covers the north western corner of North Greenland. Furthermore, a description was published alongside the map sheet. This means that through a total of 14 map sheets an overview has been created of the geology in ice-free areas of Greenland; an area almost 10 times the size of Denmark. Concurrent with the overview mapping, geologists have worked on mapping Greenland in the more detailed scale of 1:100,000, which is more suitable for mineral resources exploration by mining companies. Today, a total of 57 maps in this scale have been published, leaving over 170 map sheets to be prepared before all of Greenland is covered. GEUS is concentrating this work on the areas where mineral resources interests are greatest, and in 2004 two 1:100,000-scale map sheets were published which covered areas in West Greenland. These are "Kangaatsiaq, 68 V.1 Syd" and "Ussuit, 67 V.2 Nord" south of the Disko Bay, and in the summer of 2004, geologists commenced their field work for the map sheet "Kapisillit" in the Nuuk region, known for some of the world's oldest rock types and several financially interesting occurrences of mineral resources.

Focus on gold in the Nuuk area

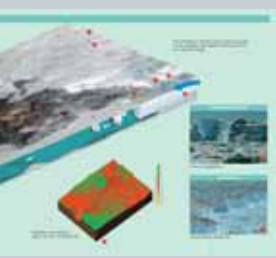
Gold has been found in many places throughout Greenland, and the opening of the Nalunaq gold mine in 2003 in South Greenland has proved that gold occurrences exist which are worthy of mining. Especially in recent years, promising gold mineralisation has been discovered in the Nuuk region, and in 2004 the rock masses in this area were therefore subject to geologists' scrutiny in order to clarify the geological history and to gain a better understanding of the natural processes that have led to concentrations of gold in the rocks. The many types of new data gathered in the previous years, including magnetic, gravity, and geochemical data, were used in the detailed scrutiny of the area. The so-called greenstone belts have the geologists' attention, because they are similar to rocks which have revealed large finds of gold and nickel elsewhere in the world. Closer mapping and surveying the greenstone belts and their formation are therefore of great interest to the mining industry. The activities are being carried out with support from the Bureau of Minerals and Petroleum.

Survey of moler on Mors

Moler is an important Danish mineral resource, of which the main products are absorbent granulate and insulating moler brick. Moler granulate is used, for instance, for cat litter and as an additive in fertilizer and feed stuff, as well as in the medicinal industry. In 2004, GEUS completed a project for the company Damolin A/S and Viborg County to identify the moler reserves and the amount of surface soil in the Barkærgård area in Ejerslev Molerfelt on the island of Mors in northern Jutland. With the help of existing drilling data and data from three new drillings, a mathematical statistical calculation was made of the moler reserves and of the amount of surface soil, which in this area consists of moraine soil and "Askelags-serien" (the ash layer series). Furthermore, a comparison was made with drilling data from Ejerslev Molerfelt. The results will be part of the assessment of the costs of moler extraction in the area and of the County's survey and planning of management of the area and mineral resources extraction.



Greenland's first World Heritage Site



We did it! During the course of the summer Ilulissat Ice Fjord in West Greenland was included in the UNESCO World Heritage List and is now in the company of other distinguished nature habitats such as Niagara Falls, Yellowstone, and the Grand Canyon. With the inclusion in the list comes also a commitment to monitor that the expected increased tourist activities do not cause harm to the area. With support from the Danish Cooperation for Environment in the Arctic (DANCEA), GEUS participated in the work to establish a monitoring programme in collaboration with the Greenland Home Rule and the municipality of Ilulissat. In September, GEUS published a popular-science book entitled "Ilulissat Icefjord - A World Heritage Site" in Danish, English and Greenlandic with support from DANCEA and the municipality of Ilulissat. The book is an edited version of the nomination document and it has received positive reviews. E.g. the Danish newspaper Politiken wrote: "A beautiful photo book, which escapes the status of coffee table book by including scientific aspects in a journalistic style which makes the book accessible to everyone. It is entertaining, and popular science and cultural history in one. Why is more research not presented in this form?".

Method for remediation of fractured soils

Organic contamination of fractured, dense rock, such as moraine clay, constitutes a major problem in Europe, since it is extremely difficult to remediate and because contamination may transport quickly to groundwater through the fractures. GEUS has commenced a new EU research project with partners from Denmark, Poland, Greece, and France. The project, entitled STRESOIL, has as its objective to develop new effective methods for remediation of organic contamination of fractured soils. The project will take place in Poland where a large area with fractured glacial sediments has been seriously contaminated by a former airbase station. The project includes testing different methods to artificially enhance the permeability of the soil; performing laboratory studies of natural processes; and developing a model to help select the optimal remediation method relative to remediation effect, time and price.

Nature
and
environment



Climate change in the Arctic Ocean

The inaccessible Arctic Ocean is one of the least explored areas of the world. However, at the same time it is an area which is very sensitive to climate change. Measurements from e.g. US submarines have shown that the sea ice in this area has become significantly thinner in recent years. In May, GEUS participated in a large international research project aimed at mapping the past climate in the Arctic Ocean and measuring the present thickness and movement of the sea ice. From an ice camp on the sea ice in the almost unexplored area north of Greenland, researchers from Denmark, Great Britain, Germany, and Norway examined the size and the processes of the thinning of the sea ice cover. Through drillings in the seabed, researchers from GEUS examined the climate and changes in the sea ice cover thousands years back in time. The measurements are part of the adjustment of the climate models used to project the development of the climate. The research project, entitled Greenland Arctic Shelf Ice and Climate Experiment (GreenICE), is being financed by the EU.

Monitoring of the Inland Ice

The interplay of the Inland Ice and climate is an important element to understand during an increasingly warmer climate. The large ice masses which cover more than 70 per cent of Greenland can potentially generate both increased sea levels and changes to the Gulf Stream in a warmer climate. In 2004, GEUS continued its establishment and development of automatic weather stations to determine ice melting and ice movements on the Inland Ice. The measurements are being conducted under the ICE-MON project, which is supported by the Danish DANCEA. The work is taking place from 9 stations in West and East Greenland, where measurements from aircraft and satellites have documented a significant thinning of the ice. Furthermore, the project is part of important international efforts to explain how the Inland Ice is reacting to climate changes. In 2004, the American space agency NASA launched the satellite ICESat in order to measure the changes in height of the sea ice and the large ice masses on land. The measurements from the ICEMON project are important to the interpretation of the data from the ICESat satellite. In 2005, a similar satellite, Cryosat, from the European space agency ESA will follow. Here, supported by the Danish Natural Science Research Council, GEUS will be contributing control measurements.

Identifying the conditions leading to the current climate and environmental situation in Denmark and the North Atlantic in particular



Grant for new research centre at Geocenter Copenhagen

GEUS and its Geocenter partner, the Geological Institute, have been granted DKK 7.4 mill from the Danish Natural Science Research Council for a new research centre entitled: "Oceanography and Climate in an extreme Greenhouse World: the late Cretaceous - Danian of Northwest Europe". The centre will be examining one of the periods in the history of the Earth when the global climate was substantially warmer than it is today. For long periods of the Earth's history, the global climate was warmer and the concentration of CO₂ in the atmosphere was larger than we know today. These periods derogate considerably from the present with regard to oceanography, ecology, and geological sedimentation, and the period from late Cretaceous to Danian from 90-60 millions years ago represents a prolonged period with a greenhouse climate. In this period vast areas of the Earth's continents were covered by sea. In the broad-spanning sea which covered north-western Europe white chalk sediments settled, which today can be seen e.g. in the characteristic cliffs on Møn and Stevns in southern Zealand. Through studies of the exposed chalks layers and new drillings, the new project will uncover the oceanographic, climate, and ecological forces at play during one of the most stable and prolonged sedimentary systems in the Earth's geological history, and the project will generate spin-off knowledge for use in connection with exploitation of oil/gas and water from the chalk in the Danish subsurface.



New requirements for competence development

According to the Government's new targets for sector research in Denmark, there should be greatest possible mobility and knowledge exchange between sector research institutions, universities, and industry. In this connection, the Danish Institute of Agricultural Sciences (DJF) and GEUS embarked on a new project to prepare researchers so they will be able to meet new competence requirements. The project will develop and execute training programmes in three key areas: 1) Innovation and commercialisation, 2) Communication and research dissemination; and 3) Pedagogics and didactics. The project will also include pilot projects based on teaching forms different from those applied in the training programmes. These activities will aim at changing the institutions' organisational structure and practices within competence building. Project training programmes will commence in 2005 and will be completed with an evaluation, including making experience gained available to others so that the project may serve to inspire and benefit other sector research institutions. The project is being supported by the Graduate Supplementary Training Committee (ELU) at the Danish Centre for Development of Human Resources and Quality Management (SCKK).



Getting geology to the people

Research on climate and groundwater in 2004 was broadcast on TV and radio programmes. Viewers and listeners were able to meet researchers from GEUS together with other experts and follow their work in the field, in the laboratory, or behind the computer screen throughout several scientific TV and radio programmes. In the Danish Broadcasting Corporation (DR) TV series "Viden Om" the viewers were able to follow researchers' climate survey on the sea ice in the sea north of Greenland, where ice conditions are changing rapidly. Furthermore, in DR's radio programme "Principia" listeners could hear about the efforts of researchers to determine the amount of fresh water at our disposal in Denmark, and how bacteria in the soil help combat contamination of our groundwater. You can hear or see the programmes in Danish via the GEUS website under the Danish menu title "Geologi for alle".

Several new scientific publications

In 2004, GEUS published four editions of its internationally reviewed bulletin series, Geological Survey of Denmark and Greenland Bulletin. These were: a comprehensive volume about the environmental changes in the Late Quaternary period described on the basis of Danish marine mollusc fauna; a volume with seven articles describing sediments from the Jurassic period in northeast Greenland; a volume with six articles about the geology of the Caledonian fold belt in East Greenland; and finally a volume entitled "Review of Survey Activities 2003", which in 23 articles describes selected activities by GEUS in 2003.

Flashes of the year



Gathering of geologists from around the world

Scientific issues were discussed keenly and business cards exchanged at two large geosciences fairs in Copenhagen and Florence, where GEUS was represented with a stand entitled "Geology for Welfare and Balance", presenting the institution's many research and consultancy activities. In Copenhagen in June 1,500 researchers from all over the world visited the Goldschmidt Geochemistry Conference 2004. With Geocenter Copenhagen as the physical locale, hundreds of lectures and workshop meetings were held on subjects ranging from atmospheric chemistry, earthquakes, volcanoes, oil, and minerals, to groundwater. In August, GEUS participated in the 32nd International Geological Congress in Florence, attended by no less than 7,500 geologists. Here, GEUS presented its activities together with the Geological Surveys of Norway, Sweden, Finland, and Iceland. The joint Nordic stand also presented the diverse geology of Scandinavia under the slogan "Lands of Ice and Fire" with the aim of attracting the next world congress to Scandinavia. Competing with Australia, Egypt, and India, the Vikings drew the longest straw and can now look forward to hosting the world congress in Oslo in 2008.



School students try out geology

Gold, oil, water, and geological maps were on the agenda, when several school classes and student groups visited GEUS to hear about how geologists are working on finding resources for society. Danish upper-secondary school students followed researchers' efforts to map the hideouts of oil in the North Sea, and a class from a technical school in Sanaar-tornemik Ilinniarfik in Sisimiut in Greenland followed the preparation of geological maps and joined in the search for gold in Greenland's mountains. Vital resources were also on the agenda when students from a business college visited to learn more about how geological, geophysical, and geochemical maps are produced. Lower secondary school students also came for visits and tried being geologists for a couple of days as part of their school job-training programme.



Courses for counties and industry

New, unexpected findings of groundwater contamination under the dense clay layer have challenged the traditional notion that our groundwater is well protected in areas covered by moraine clay. At the same time, research has shown that large parts of the clay strata are fractured and that the fractures play a significant role in developments leading to groundwater contamination. In 2004, employees at Danish counties and consultancy firms participated in a course by GEUS to learn about the last 10-15 years' research on fractures and how to apply this new knowledge in groundwater contexts. The participants were given insights into e.g. the use of fracture models in risk assessment and zoning of substance-specific sensibility and groundwater protection in areas with a moraine clay cover.



GEUS around the world

Knowledge building in developing countries through research and consultancy services



Building knowledge about water in Mozambique

In collaboration with Carl Bro A/S, in 2004 GEUS completed the First National Water Development Project in Mozambique; a project aimed at enhancing expertise in the water sector in Mozambique. Through support from the Nordic Development Fund, the project helped the Southern Regional Water Board (ARA-Sul), which is responsible for hydrology and water quality, reservoir operation, environmental protection, pollution control, etc. in the areas around Maputo. More specifically, the project helped enhance ARA-Sul's knowledge, capacity, and financial efficiency so that it can fill its role as an effective and independent body for managing of the area's water resources. GEUS also gave support within the field of river basin management, which is part of ARA-Sul's future area of responsibility, and efforts included developing management and monitoring plans, supporting management and training staff.

Arsenic pollution of the groundwater in Vietnam

Pollution of groundwater from arsenic is a serious threat to the health of many people living in flood plains around the world. One of the countries affected is Vietnam, where the groundwater pumped up from the flood plain around the Red River near Hanoi in many places is polluted with arsenic. Arsenic occurs naturally in sediments in the flood plain, but different processes in the groundwater system can mobilise arsenic so that it ends in the groundwater that is pumped up. GEUS is managing a new Danish research project funded by the Council for Development Research under Danida, which over the next three years will attempt to uncover the processes leading to this pollution. Due to the good bacteriological quality of groundwater, about 50 per cent of water supplies for Hanoi are based on groundwater, but arsenic pollution poses a threat to this resource. The Vietnamese know very little about why arsenic occurs in the water and therefore they do not have adequate knowledge to assess whether the problem is likely to become worse. Project work includes detailed hydrological and geochemical surveys to identify and document the processes leading to mobilisation of arsenic. The project aims at both research and capacity development, and Vietnamese researchers are participating in the activities. Seven young Vietnamese will complete MSc programmes with joint Vietnamese and Danish tutors. The project is being completed in cooperation between the Technical University of Denmark and DHI Water & Environment, as well as Hanoi University of Mining and Geology, Hanoi University of Science and the Northern Hydrological and Engineering Geological Division.

Better management of water resources in Honduras

In Honduras, insufficient knowledge about water resource management has for many years led to problems with supplying the population with water, despite plentiful water resources. At the initiative of the United Nations Development Programme's country office in Honduras, the Honduran Water Platform (HWP) was established in 2003 with the aim of implementing more suitable management of the country's water resources. In 2004, GEUS, in collaboration with Kvistgaard Consult, carried out a project that supported the HWP in its preparation of a water resource strategy and action plan. The work included capacity enhancement in the HWP, so that they are now better qualified to support Honduran efforts to create a more efficient framework for protection, rational exploitation, and management of the country's water resources. The project is being supported financially by Nordic funds from the United Nations Development Programme.

Successful outcome and continuation of oil training in Vietnam

In 2004 the Vietnam Petroleum Institute (VPI) and GEUS worked together on a project to establish geoscientific research capacity in the fields of oil and gas in Vietnam. The project was financed by Danida's ENRECA programme and the Geological Institute at the University of Copenhagen and the Hanoi University of Mining and Geology (HUMG) also took part. Vietnamese researchers were trained in oil-geological disciplines through teaching and participation in concrete research projects. During the course of the year, eight Vietnamese students completed their MSc studies, and final reports on capacity building and scientific results of the research project in the Phu Khanh basin were completed. Vietnamese and Danish researchers in 2004 presented the results of their research collaboration at several international conferences, and joint Vietnamese-Danish articles were published in international journals. GEUS held courses in Vietnam, and Vietnamese researchers participated in on-the-job training programmes in Denmark. Furthermore, collaboration was established between Vietnamese students and junior researchers from the University of Copenhagen. Finally, the necessary technology was transferred to the VPI and the Institute's library was equipped with literature. In October 2004, a final workshop was held in Hanoi at which the results of the research programme were presented to researchers and people from the oil industry active in Vietnam. In Danida's Annual Report 2003, local project coordinator, Phung Sy Tai from the VPI said, "The collaboration has definitely generated curiosity and enthusiasm among our staff concerning demand-driven research work at international level; research that is to benefit the people that are the studies concern. We still have a long way to go, but thanks to our participation in the ENRECA project, we at VPI feel that we have already become better at taking up the research challenges of the future". Toward the end of 2004, phase two of the project was approved by the ENRECA programme.

More environmentally friendly small-scale mining in Mongolia

Small-scale mining provides a living for up to 100 million people around the world. Mainly gold mining creates many jobs in small communities. Miners use mercury in extracting the gold and this method leads to significant environmental and health problems, if it is not managed properly. On behalf of the World Bank, GEUS in 2004 conducted work in Mongolia to map the scope of small-scale mining, and the methods used, with emphasis on mining of gold, fluor spar, and coal. Many gold miners, including children, are not aware of the fact that mercury is harmful. The work therefore also included conducting courses for gold miners and their families, so they will become better at managing mercury in a more environmentally friendly way. This includes e.g. recycling mercury through a simple device called a retort. Finally, GEUS arranged workshops for state and local administrators in Ulaanbaatar and in several small local communities.



Key figures 2004

More detailed key figures for GEUS' activities can be found in *Årsrapport 2004 (Report and Accounts 2004)* and in *GEUS' virksomhed i 2004 – Faglige resultater (GEUS' activities in 2004 – scientific results)*, both available in Danish on request from GEUS or at www.geus.dk

Number of employees: 294 including the Danish Lithosphere Centre but excluding student assistants

Number of scientific projects: approx. 500

Accounts 2004*

Amounts in million DKK

Revenue	275.2
Net figure (appropriation)	154.3
Operating revenue	120.9
Expenditure	269.7
Salaries	126.3
Other operating expenditure	143.4

* These accounts include the Danish Lithosphere Centre (DLC)
- financed by the Danish National Research Foundation

PRESENTATION ACTIVITIES

Long-term knowledge building

Articles in international scientific

journals/publications 87

Articles in GEUS' own scientific series 41

Other scientific publications 8

On-going scientific task solution,
consultancy and presentation

Publicly available reports 95

Confidential reports 45

Memoranda, opinions, expositions, etc. 68

General presentation

Institution reports (annual report, etc.) 7

Popular-science articles 55

Popular-science lectures 57

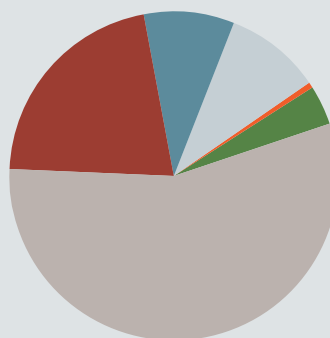
RESEARCHER TRAINING

Current PhD students 23

Completed PhD degrees (not including DLC) 5

Current MSc-thesis students approx. 50

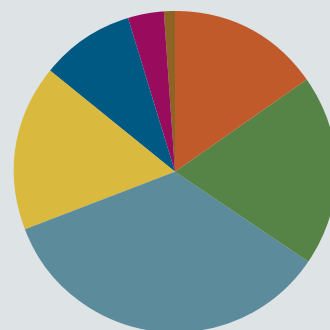
Revenue broken down by sources of revenue



Amounts in million DKK

Budget appropriation:	154.3
Programme and external funds:	58.3
Other co-financed contract research:	24.8
Commercial contracts and sale of data:	25.7
Other revenue:	2.0
Danish National Research Foundation for the Danish Lithosphere Centre:	10.1

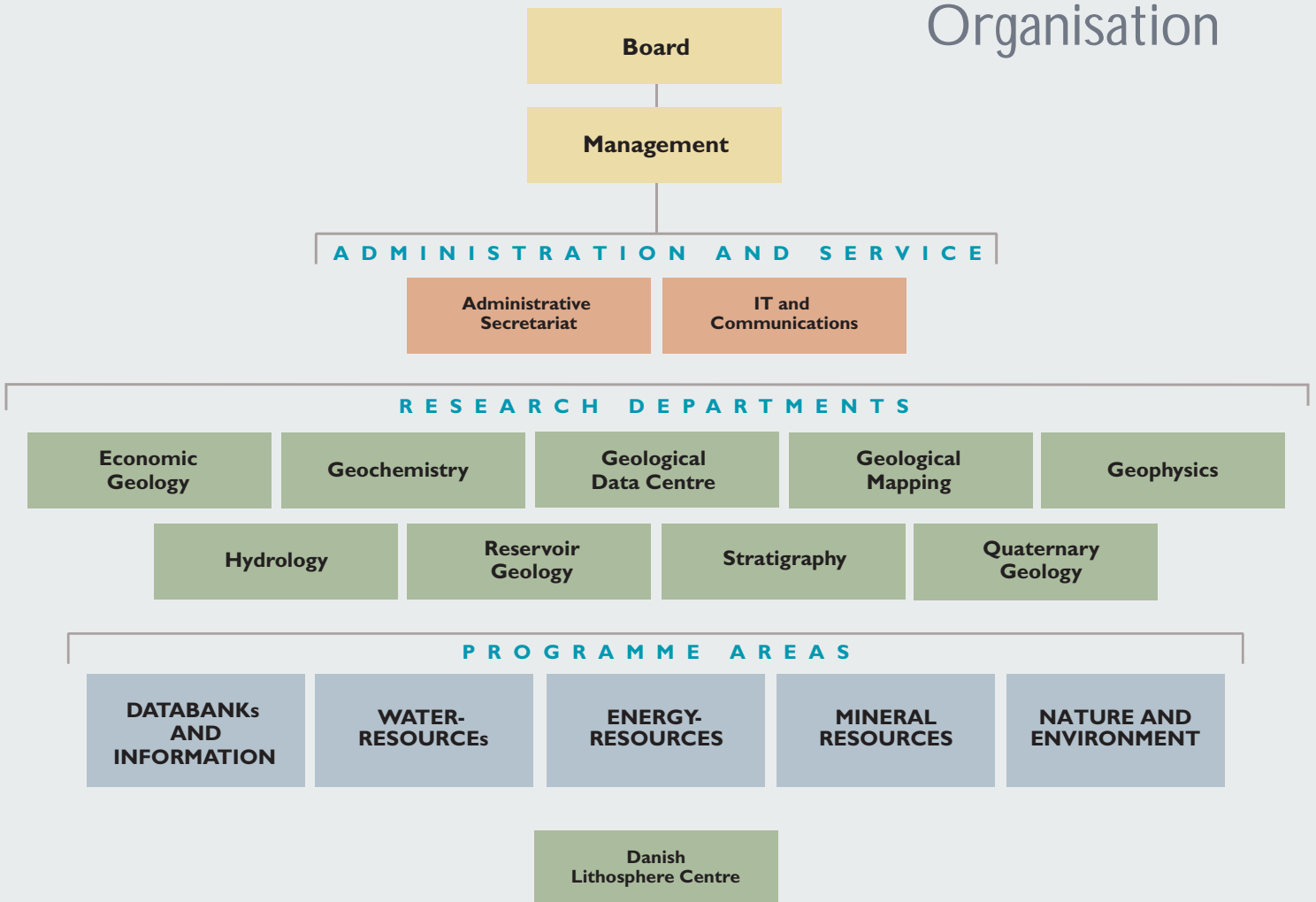
Expenditure broken down by programme areas:



Amounts in million DKK

Databanks and information:	41.4
Water resources:	52.1
Energy resources:	93.6
Mineral resources:	45.1
Nature and environment:	25.3
Danish Lithosphere Centre:	9.7
Geocenter funds:	2.5

Organisation



In 2004, GEUS had nine research departments and two administrative/service departments, since the IT department and the Communications department were merged. Scientific work takes place in five programme areas, where tasks are carried out in project groups in a matrix structure. The Danish Lithosphere Centre (DLC), under the Danish National Research Foundation, is administratively linked to GEUS. The Centre was discontinued at the end of 2004 after 11 years. Several of the Centre's researchers were transferred to the University of Copenhagen and one researcher was transferred to GEUS.

Programme area: Databanks and information

Archiving and data processing in connection with statutory reporting of geo-data to GEUS. The objective is to ensure that data and sample collections are on a quality level allowing them to be used to implement projects in the areas of monitoring, emergency preparedness, consultancy and research. In addition, the programme area includes IT projects to develop efficient and modern IT tools for GEUS and presentation of data to the scientific community and the public.

Programme area: Water resources

Procuring the necessary basis on which to manage our water resources. Activities are aimed at water circulation, the volume and quality of water resources, groundwater protection and transportation of substances injurious to the water environment with special emphasis on groundwater. Activities form the basis of consultancy services to government and local authorities.

Programme area: Energy resources

Procuring and contributing the basis for continued exploration and sustainable exploitation of the energy resources of Denmark and Greenland. Activities include own research projects and international cooperation in the areas of oil/gas and alternative energy. The knowledge retrieved forms the basis of GEUS' consultancy services to government and local authorities and to some extent projects carried out for the corporate sector.

Programme area: Mineral resources

Procuring the scientific basis for targeted exploration and environmentally friendly exploitation of raw materials and minerals in Greenland and Denmark. Activities include geological mapping and exploration of mineral resources in Greenland and official processing and consultancy services for Greenland Home Rule. In addition, studies are conducted regarding raw materials and construction work in Denmark and internationally.

Programme area: Nature and environment

Defining the processes in time and space leading to the current climate and environmental condition in Denmark and the North Atlantic region in particular. One objective is to improve the prospect of distinguishing between natural and man-made environmental changes. This programme area also includes mapping of onshore and offshore geological conditions, as well as earthquake research and monitoring.

Geological Survey of
Denmark and Greenland (GEUS)
Ministry of the Environment

Øster Voldgade 10
DK-1350 Copenhagen K
Denmark

Telephone: + 45 38 14 20 00
Telefax: +45 38 14 20 50
E-mail: geus@geus.dk
Homepage: www.geus.dk



ISBN: 87-7871-165-7

ISSN: 1396-3317c