Annual Report 2002

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF THE ENVIRONMENT

GEUS

New setting
New partnership

During the spring and summer of 2002, the Geological Survey of Denmark and Greenland (GEUS) moved into the Copenhagen University building on Øster Voldgade, in central Copenhagen, thus realising the desire to establish a stronger, unified, geoscientific environment – 41 years after the idea was first seriously raised. Geocenter Copenhagen houses approx. 550 employees and 1000 students from the Geological Institute, the Geographical Institute, the Geological Museum, the Danish Lithosphere Centre, and GEUS.

Prior to the physical establishment of the Geocenter, the building complex at Øster Voldgade 10 was extensively renovated and rebuilt. The old, hydraulic test equipment from the building's former tenant, the Technical University of Denmark (DTU), was dismantled to make room for a canteen, library, and tutorial rooms, and three floors have been built on top of the old machine hall, enabling GEUS to bring together most of its laboratories in a new laboratory wing.

The new premises provide the setting for a formalised cooperative venture between the five independent institutions – a venture aimed at establishing a centre for geoscientific research, education, and consultancy at a high international level.

Geocenter Copenhagen was officially opened on 16 September 2002 by the Minister for Science, Technology, and Innovation, Helge Sander, at a ceremony attended by over 600 invited guests. The Rector of the University of Copenhagen, the Head of the Faculty of Science and the Permanent Undersecretary of State for the Ministry of the Environment, took this opportunity to wish the Geocenter well for the future, while GEUS' managing director, as the chairman of the Geocenter's Board of Management, expressed gratitude for the magnificent new centre on behalf of its users. In his opening speech, the Minister described the Geocenter as a good example of how Danish research ought to be organised: "Sector research and the universities must together form the cornerstones of the foundation for a unified knowledge system. This is essential if Denmark is to have a place in the international knowledge society. A small country like Denmark simply cannot afford to do otherwise." He then ignited a thunderous, smoking, fire-belching volcano, to mark the beginning of the cooperative venture in the Geocenter, which has the following goals:

- **Enhance the professional synergy between pure and applied research**
- **Enhance interdisciplinary research**
- **Enhance and develop geological and geographical study programmes**
- **Ensure an improved knowledge base for advising public and private enterprises**
- **Contribute to the sustainable utilisation of resources and far-sighted management of the environment**
- **Increase the scope of Danish environmental assistance**
- **Increase cooperation with trade and industry with regard to energy, raw materials and the environment, both nationally and internationally**
- **Attract Danish and foreign researchers**
- **Enhance the participants as attractive working partners**
- **Improve communication of geographic and geological information to the public**

Foreword

The most important event for GEUS in 2002 was the move into Geocenter Copenhagen at the new premises at Øster Voldgade 10. For decades to come, the Geocenter will provide the setting for GEUS' activities, in close cooperation with the University of Copenhagen.

2002 was the first year under the leadership of the new government. This has had a number of impacts on GEUS' job portfolio. New initiatives have been started, focus has shifted in several areas, and research areas have been given lower priority. GEUS has had to reconcile itself to receiving declining government funding with which to perform its tasks in the future. One consequence of this has been staff lay-offs.

Out of several hundred projects, this year's annual statement will provide a glimpse into some of them. Examples have primarily been chosen where the geology is directly "beneficial" to the community and where the research has crucial importance.

Clean drinking water is at the top of the environmental agenda for the Danish population. GEUS is the government's watchdog in this area. Investigations completed in 2002 have shown that the situation is grim for the smaller water-supply systems. Many are polluted with pesticides and bacteria. Other recent research results suggest that even the deeper groundwater continues to be threatened by chemical pollution, despite many political initiatives.

Oil and gas from the North Sea is an important Danish resource. Denmark is currently Europe's third largest producer of oil. In a cooperative venture involving Mærsk Olie og Gas AS and other organisations, a research project aimed at improving the exploitation of "difficult" deposits was completed. In another context, GEUS provided the geological work which led to successful drilling for hot water to a depth of 2400 metres in Copenhagen. Perhaps the use of geothermal energy will become an important element in the future energy supply for the Greater Copenhagen area.

Greenland Home Rule will focus in future on exploiting the country's raw materials – oil and minerals. GEUS is contributing its expertise towards the realisation of this goal. A licensing round in 2002 has led to the oil exploration off the West Greenland coast being continued by a Canadian company.

In the area of minerals, GEUS' activities have contributed to maintaining the industry's interest in diamond exploration and other attractive targets.

In 2002, the Danish government initiated extensive new geological surveys in the sea surrounding Greenland and the Faeroe Islands. Over ten years, and with an extra funding framework of DKK 150 million, information is to be gathered about the continental shelf. This might possibly lead to the territorial waters for the Kingdom of Denmark being extended in places beyond the existing limit of 200 nautical miles. GEUS has been entrusted with the professional leadership of this ambitious project. In 2002, the options for and expenses associated with collecting data in the Polar Sea between Greenland and the North Pole were assessed.

GEUS has contributed to international climate research into the melting of the Greenland ice sheet and climate-dependent variations in the ocean currents in the North Atlantic. GEUS has also been involved in a European research project concerning storage of CO_2 in the underground in order to reduce emissions into the atmosphere.

In the area of international assistance, GEUS has extended its cooperation with Vietnam to include the protection of water resources. In Tanzania, GEUS has assisted the Tanzanian government in establishing databases with the aim of issuing licences for the exploitation of the country's mineral wealth.

As the Chairman and Managing Director of GEUS, we feel there is good reason to be satisfied with the professional achievements for the year, the financial result, and not least, with the committed efforts of the staff during a difficult year.

Per Buch Andreasen
Chairman, Board of Directors

Martin Ghisler
Managing Director

Top marks to www.geus.dk

Throughout 2001 and 2002, GEUS' website has been reorganised to be more relevant and user-friendly. The volume of popular-science material has been increased and gathered together under the menu item "Geologi for alle" (Geology for everyone). A user survey has subsequently been carried out to gather ideas for the continued development of the website. In 2002, the user survey was followed up. The changes include the establishment of a flexible news facility, with facilities for the rapid and targeted communication of news, a mailing list users can subscribe to, and improved navigation. The number of external visits to the website has risen from 108,000 in 2000, to 267,000 in 2002. In 2002, the website scored top marks in the "Best on the Net" evaluation, organised by the Ministry of Science, Technology, and Innovation, in cooperation with the National IT and Telecom Agency.

Databanks, information tech and information to the

Geophysical data are pouring in

The national geophysical database, GERDA, operated by GEUS, has come into full operation. The database has been under development over the last few years, and during 2002 data have poured in from the geophysical consulting companies. The data come primarily from the counties' groundwater mapping activities and from GEUS' investigations of drill holes. The database can store geoelectric and electromagnetic data and drill-hole logs. Both data measurements and geophysical interpretations of the electrical resistances are stored. At present there are approx. 29,000 interpretations in the database. It is particularly the so-called TEM data and logs which have now been loaded into the database, but older Wenner and Schlumberger geoelectric data also exist. The database can also handle the more recent methods such as PACES and MEP. Data are available on the Internet at gerda.geus.dk. With just two or three clicks of the mouse, one can search data on a map, have them displayed graphically, and download them. GEUS is currently in the final stages of uploading geophysical logs from over 400 water-drilling operations carried out over the last ten years. Thus log data in standard LAS format and PDF files of log plots will soon be available. The GERDA database has been developed in close cooperation with the University of Aarhus, Århus County, the Danish Forest and Nature Agency, and the consulting companies.

IT relocation without problems

Preparations for the relocation of GEUS' IT facilities started back in 1997, before the reconstruction of GEUS' new premises at Øster Voldgade had commenced. GEUS was involved in determining the specifications and design of the network at the new premises, so that these fully met the requirements of the institution. IT staff from GEUS carefully monitored work on the network during the construction. This initiative bore fruit, in that it contributed to 22 km of cable being replaced in time because it did not meet specifications. Thorough preparations and plans for the actual relocation of the IT equipment were also necessary during the four-month moving period. Employees needed access to the IT system every day, whether they were sitting in the old or new premises, and regardless of whether the servers, etc. were at one location or the other. GEUS therefore installed new switches etc. everywhere in the network at Øster Voldgade, so that there was a complete local network at both premises throughout the moving period, and the connection between the two addresses handled the traffic throughout the entire period, in part because all the servers were moved over a single weekend, once half of the employees had changed address.

Geology weekend

Many Danes took the opportunity during the last weekend in September to enjoy a nature walk or visit institutions and museums as part of the "Days of Geology" event, coordinated by GEUS and the Danish Forest and Nature Agency. Throughout the country, people from county and municipal councils, forest districts and associations together with producers of raw material, researchers and many others with a knowledge of geology have organised over 60 trips. GEUS directly hosted two events. The doors were opened to the extensive store of drill cores in Rødovre, and to the new premises at Øster Voldgade. On two of the nature walks, residents were told about forest history and geology and were able to participate in a TV safari in the groundwater, in which GEUS' advanced equipment for investigating drillings was demonstrated in a drill hole.

nology

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

general public

Geological stories for residents and schools

Several natural science articles have been communicated to residents and schools via four issues of the popular-science magazine, Geologi – Nyt fra GEUS. From Greenland came articles about the oldest stones and the oldest signs of life, clear evidence of lightning strikes in the bedrock, and the mechanisms behind a dramatic landslide in West Greenland. From Denmark, the mapping of the Baltic Sea and Denmark's earlier agriculture were described, along with the efforts to designate areas in the country which are sensitive to pesticide leaching. All issues can be read and downloaded from GEUS' web site and the article about the landslide has also been published in Greenlandic in cooperation with Greenland Home Rule.

Environment Portal and Digital Administration

An agreement was made in 2002 with Danish Regions, that the Jupiter database at GEUS would become the groundwater database in the Counties' Environment Portal. Jupiter is the heart of GEUS' environmental information system and contains information about drillings, the quality of groundwater and drinking water, and data about groundwater levels and resources. In cooperation with the Danish Water Well Drillers Association, GEUS has also worked on the development of a new module for Jupiter for digital reporting of drilling data. The work is being done as a project in association with the introduction of Digital Administration in the Ministry of the Environment.

Greenland glacier water and ice for export

Over the last two years, GEUS has worked on surveying where ice of sufficient age and purity, to make it attractive on the international market for "high profile" consumer ice and water, can be mined. On the basis of data from GEUS' glacier database, in 2000, an overview was prepared of the glaciers in southwest Greenland which were potentially suited to production, based on criteria about the characteristics of the ice surface, the stability of the ice front, and accessibility. In 2001, measurements were taken of the levels of impurities in the ice at selected locations. Ice from the period prior to the start of industrialisation and after the end of the last ice age, 12,000 years ago, is particularly attractive, as both the younger and older ice is generally more polluted. In 2002, further focus was given to suitable areas. Using dynamic ice calculations, the four most favourable areas for ice extraction have been selected based on glaciological criteria and the stability of the ice front against changes, which could have an impact on extraction activities. The work has been funded by the Bureau of Minerals and Petroleum, Greenland Home Rule.

Nitrate breakdown

The ability of the soil layers to break down nitrate, called nitrate reduction, has great significance for the interplay between land use and water quality. When nitrogen in the form of nitrate is washed out of the root zone, its fate will largely be determined by the factors which prevail deeper down in the soil. The breakdown of nitrate, by both microbial and abiotic processes, takes place in oxygen-free conditions. In the soil layers' unsaturated zone, where both air and water are found between the grains, the reduction of nitrate is limited to oxygen-free microenvironments which can arise wherever oxygen consumption exceeds oxygen supply – for example, as a result of microbiological activity in areas where easily-metabolised organic material is added. GEUS is in the process of investigating the capacity for the reduction of nitrate in unsaturated conditions, under a project for the Environmental Protection Agency. The work involves a review of relevant Danish and foreign studies, as well as field studies of the factors deemed significant for the breakdown of nitrate. The results will be incorporated into the general knowledge base regarding the nitrogen cycle under Danish conditions, which has significance for the implementation of the Water Framework Directive and the work on future aquatic environment plans.

Water

The EU Water Framework Directive in focus

Throughout the year, GEUS has participated in a number of working groups appointed by the Ministry of the Environment in connection with the implementation of the EU Water Framework Directive. This participation relates to the drafting of a "Daughter Directive on Groundwater" and a report for the Environmental Protection Agency to provide an overview of how groundwater affects surface water. The report, produced in cooperation with the National Environmental Research Institute, also identifies a number of areas where more knowledge is needed in order for Denmark to be able to implement the Water Framework Directive at the best possible professional level. Finally, GEUS has commenced three new research projects under the EU Fifth Framework Programme, which all deal with problem situations related to the Directive. The projects relate to the harmonisation of modelling tools and procedures for ensuring the quality of model calculations, and the development of methods to assess the uncertainty of data and models. In this connection, a network of representative catchment areas in Europe is going to be established, from which data will be made available for free use in other research projects. In cooperation with Funen County, Odense Å has been selected as one of the nine catchment areas in the European network.

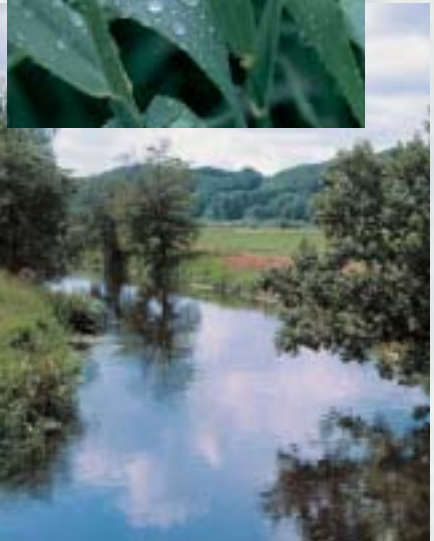
Residents involved in groundwater protection

A new EU project (MERIT) with participation by GEUS and Københavns Energi (KE) is in the process of investigating how farmers, residents and other interested parties can be involved more effectively in the decisions necessary to protect Danish groundwater. The project is testing a decision tool, "Bayesian networks", for the general management of water resources. This tool makes it possible, with one tool, to illuminate the significance of various factors in a conservation initiative, such as the water cycle, groundwater quality, natural values, macro-economics, and commercial aspects. The capture zone around St. Havelse Kildeplads north of Frederikssund has been chosen as a pilot area. It is one of the most intensively utilised groundwater reservoirs in Denmark. In November, GEUS and KE held a meeting with residents in order to get local input into the project. At the meeting, possible conflicts of interest were discussed, and suggestions for resolving these were presented, together with ideas for measures to protect the groundwater. A similar meeting was held with the local authorities, the county, and the local and regional interest organisations.

– This method is meant to help us make good decisions, says Hans Jørgen Henriksen, leader of the project in GEUS.
– These networks can shed light on the factors we should seek further information about, and they can localise disagreement and ease communication about decision situations, he adds.

resources

Procuring knowledge for optimal management of our water resources



Pesticides in small water supply systems

The drinking water in small, private water supply systems is polluted with pesticides and bacteria in many locations. This has been shown in an investigation by GEUS, conducted in cooperation with four counties – Viborg, Sønderjylland, Storstrøm, and Copenhagen. Pesticides and their decomposition products were found in more than half of the 600 systems investigated. The limit value for pesticides in drinking water was exceeded in one third of the systems, and in 10% of the bores/wells, the pesticide content exceeded the limit value for drinking water by more than 10 times. Many systems were also found which were in significant breach of the bacterial drinking water requirements, and which exceeded the limit value for nitrate and other inorganic substances. The combined proportion of systems which exceed one or more limit values for drinking water is 40–50%. The project is not yet complete, but there is broad agreement between the results in the four counties. The investigation is a sample-based investigation, and it suggests that more than 30% of the approx. 70–80,000 small private bores in Denmark fail to comply with the drinking water requirements for pesticides. Due to the magnitude of the problem, the Minister for the Environment has appointed two working groups to further quantify the scope of the problem.

Year of the atlases

2002 was the year in which several large atlas works were published – all with contributions from GEUS. A petroleum geology heavyweight in a class by itself was introduced in November in the form of the comprehensive work: The Millennium Atlas – Petroleum Geology of the Central and Northern North Sea. The work gathers together all the knowledge about petroleum geology from the oil-producing region of the North Sea. Over a hundred authors and contributors from the oil industry, research institutions, and the governments of Great Britain, Denmark and Norway have worked since 1997 to produce this work, based on information from thousands of drillings and millions of kilometres of seismic data collected for over 30 years. The Millennium Atlas has been produced with financial support from 48 companies in the oil industry. GEUS has also contributed to the atlas: The Neogene Stratigraphy of the Glaciated European Margin from Lofoten to Porcupine, which presents a regional survey of the geological successions formed over the last 25 million years along the Northern European continent from Northern Norway to Ireland. This work has been produced with financial support from the EU and several oil companies. Finally, GEUS has contributed to the Atlas of Geothermal Resources in Europe, which together with a similar atlas from 1988, compiles and assesses the geothermal resources in the entire European region from Portugal to Russia. The last two atlases have been published under the auspices of the European Commission.

Energy

Delimiting the continental shelf north of Greenland

The UN Law of the Sea Convention, or "the constitution for the oceans" as it is also called, opens up the possibility that coastal countries can make claims to extend their continental shelf beyond 200 nautical miles. It is necessary, however, that the depth and geology of the ocean floor fulfil a number of conditions, described in section 76 of the Convention. Denmark expects to ratify the Law of the Sea Convention during 2003. In this connection, a pilot project was carried out in 2002 for a region in the Polar Sea north of Greenland, with the aim of assessing the existing data and working out a proposal for collecting the supplementary data necessary to put forward a claim for extension of the continental shelf in this extremely inaccessible region. Contact has also been made with several institutions in a number of countries to explore the possibilities for cooperation. The section 76 activities in the region north of Greenland are being conducted by the Royal Danish Administration of Navigation and Hydrography, the National Survey and Cadastre Denmark and the Danish Polar Center, with GEUS as the project leader and funding from the Danish government.

Licensing round and new exploration models, West Greenland

This year has been the year of the licensing round. In July, the licensing round for offshore areas in West Greenland closed, and in October, an exploration and exploitation licence was issued to the Canadian oil and gas company, EnCana. Prior to the round, GEUS had been busy presenting exploration possibilities in West Greenland at numerous meetings, and on CD-ROMs and websites. A large number of oil companies have also been visited by GEUS, or have visited GEUS themselves. GEUS then also participated in processing applications and in the negotiations. Parallel with these activities, GEUS has continued to work on developing and marketing new exploration models in Greenland. This work involves comparisons of oil and source rock types from Canada and West Greenland, and the development of geological models for possible source and reservoir rock types, incorporating Canadian data. Finally, a large amount of petroleum geology and geophysical data was compiled for the offshore regions in West Greenland in: Geophysical Atlas of the West Greenland Basins, prepared by TGS-NOPEC and Volcanic Basin Petroleum Research in cooperation with GEUS.

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resources

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

Oil and gas exploration on the Faeroe Islands

In 2002, three research projects were started with the goal of increasing the geological knowledge of the Faeroe Islands region in connection with future exploration for oil and gas. All three projects belong to the SINDRI programme, financed by the oil companies active on the Faeroe Islands shelf. Two of the projects are working to analyse the origin and structure of the offshore sedimentary basins. The third project is investigating how seismic signals propagate in the basalts covering the major part of the Faeroe Islands sediments like an interfering blanket. As part of the project, GEUS had the primary responsibility for drilling a 700-metre deep bore, Glyvursnes-1, at Thorshavn, to investigate the acoustic properties of the basalts. Similar investigations were carried out in the existing 660-metre deep bore, Vestmanna-1. The work is taking place in cooperation with Danish and foreign universities, Ødegaard A/S, and the Faeroe Islands Geological Survey, Jarðfrøðisavnið.

Knowledge to help increase oil production

The desire to exploit a greater volume of the oil contained in the North Sea has motivated the five-year research project, PRIORITY, which was completed in 2002. The interdisciplinary project involving participation by researchers from GEO, the Technical University of Denmark (DTU), and GEUS, has worked on improving our knowledge about the Lower Cretaceous carbonates, which form the reservoir for the Valdemar Field. Large quantities of oil are contained here, but they are difficult to recover, as the limestone is very fine-grained and fragile. GEUS has particularly worked on understanding how the geological layers have been built up, what the structure is, and where one could expect to find the oil and gas. GEUS has also contributed with knowledge of production characteristics and the stability of recovery wells in extremely fragmented limestone. More than 25 GEUS reports have resulted from the project, which received financial support from the Danish Energy Authority`s Energy Research Programme and Mærsk Olie og Gas AS.

Hot water for the people of Copenhagen

A trial on Amager succeeded in pumping up 70 degrees hot water from a sandstone layer deep under Copenhagen through a more than 2,600-metre deep bore. Prior to the successful drilling, GEUS had carried out assessments of six possible geothermal drilling sites and prepared the geological foundation for the Margretheholm-1 drilling on East Amager, using DONG as the operator. Geologists from GEUS participated in the work both during and after the drilling, analysing the drilling results. The project was organised by the Metropolitan Geothermal Cooperation (HGS), which has planned another drilling operation in 2003.

Compilation of mineral knowledge for East Greenland

East Greenland is known for its many types of mineral deposits, found during extensive exploration and surveys by mining companies, universities and GEUS over more than 50 years. Several of these are found in igneous rock, which originally solidified in passages or chambers deep below the surface, called "intrusions". In 2002, GEUS finished compiling the extensive volume of existing geological data for 69 intrusions in East Greenland, and collected it in a database. This includes data from well-known locations like Malmbjerget, Flammefjeld, Skærgården, and Kap Edvard Holm, with finds of minerals such as molybdenum, silver, gold, platinum and palladium. And there might well be more waiting, as many of the localities described have not been investigated as thoroughly as one might wish, despite many activities throughout the years. GEUS has also carried out detailed mineralogical studies of samples from Skærgården, in cooperation with Russian researchers, to assess the region's economic potential.

Mineral resources and

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

Better marketing of Greenland mineral resources

The potential for finding minerals in Greenland has been presented throughout the year at several large conventions attended by mining industry representatives from all over the world. GEUS has participated in large conventions in Canada, Australia, and Northern Scandinavia. The advances in Greenland diamond exploration were presented, together with the mineral potential in South Greenland, with a special focus on gold and speciality metals. Marketing has been further improved in 2002 with the launch of two new publication series. These are the "Geology and Ore" magazine, in which readers can find information about geology, exploration and mining operations in Greenland, and "Fact Sheets", which discuss mineral issues in brief. These publications are available via MINEX, on-line on GEUS' website. The MINEX newsletter is also available here. These marketing activities have taken place in cooperation with the Bureau of Minerals and Petroleum and Greenland Resources A/S.

Focus on gold and diamonds

In 2002, field surveys of the mineral resources between Maniitsoq/Sukkertoppen and Disko Bugt in West Greenland continued. The surveys in 2002 have focused on possible gold deposits and the possibility of finding diamonds. The work of analysing potential diamond sites follows up on earlier diamond exploration by mining companies. Despite extensive activities by these companies, there are still regions which have not been closely investigated. Our geologists are particularly looking for kimberlites, a type of rock which can be diamondiferous. The goal is to publish an overview of the potential for diamonds, describing where microdiamonds, kimberlites, and signs that kimberlites might be diamondiferous have been found. In this connection, a database has been established which compiles all the public available data from private diamond exploration in West Greenland. These diamond exploration activities also involve the use of advanced hyperspectral data, collected by aircraft during the summer over a 7000 km^2 region, with financial support from the Bureau of Minerals and Petroleum. In South Greenland GEUS has collected geological information with the aim of preparing an ore geological description of the Nalunaq region, where Greenland's first goldmine is expected to open. This work is being carried out together with the Bureau of Minerals and Petroleum and the mining company, Nalunaq I/S, which has the license for the area.

Patent on new stable, high-quality concrete

A new type of high-quality concrete has been produced by adding a cheap, fibre-shaped clay mineral. It is self-compacting, which means that it does not have to be vibrated during pouring. It also has viscoelastic properties which ensure that the reinforcement is well enveloped, and it has high stability, so that it does not separate into water and powder phases. Finally, it can be pumped, for example into a mould, even under high pressure. The new concrete has been developed as part of an EU research project, and GEUS had a European patent approved in 2002 and issued in 2003 for the invention, together with Dansk Beton Teknik A/S, and the Dutch company, Intron BV. A number of clay minerals have been analysed by GEUS and tested throughout the project, with the final result that Palygorskite was identified as giving concrete these useful properties. The Palygorskite, which comes from Spain, has a quite unique fibre structure. This clay type is used today, for example, to produce cat litter. In 2002, GEUS continued to work on applications for clay minerals as additives in concrete as part of a project funded by the Materials Technology Development Programme under the Danish Natural Science Research Council.

Greenland mapping

The geological structure under scrutiny

The geology in West Greenland was under scrutiny for the third year in a row, with the aim of producing more detailed geological maps – one of the items the mining industry asks for before they commit themselves to investment in mineral exploration. The roots of a now disappeared, ancient mountain range called the Nagssugtoqidian Orogen are being mapped in order to explain the geological environment and the processes which have reigned here for billions of years. The work is being carried out together with a number of foreign universities and the Geological Institute of the University of Copenhagen. In 2002 the Christianshaab map sheet was surveyed, together with smaller adjacent regions. North of Disko Bugt, between Uummannaq and the Svartenhuk Peninsula, a number of investigations have started of the equally ancient mountain range called the Rinkian Belt. One of the aims of this work is to shed light on whether the entire region between Kangerlussuaq/Søndre Strømfjord and Upernavik is one large cohesive mountain range formation, similar in width to the Himalayas. The results will also shed light on the early movements of the earth's lithosphere plates, since the Rinkian Belt connects mountain range formations in Labrador, Baffin Island, the southern part of West Greenland, East Greenland and on to the Baltic. This work is being carried out together with universities in the USA and England, and is financially supported by the Carlsberg Foundation.

Nature and environment

Geology, ocean currents and climate

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

Large volumes of cold, heavy seawater flow along the ocean floor from the Greenland and Norwegian Seas, across the Greenland–Scotland ridge, to the North Atlantic deep-ocean basins. The intensity of the exchange of water across this ridge has crucial significance for the climate in the North Atlantic region. One of the important outlets for this cold water is a channel system in the ocean floor east and south of the Faeroe Islands. Over several years, GEUS has demonstrated a correlation between the intensity of the flow through this channel system, and the climate. A decline in the flow along the ocean floor is thus associated with cold climate periods, and an increase in flow is associated with warmer periods. In 2002, GEUS completed a project which provides new opportunities for monitoring the variation in the important ocean floor currents in large regions. Using sound waves, a number of geological formations on the ocean floor which have been created by the ocean floor current have been mapped. The study of the ocean floor formations shows that it is possible to map the progress and intensity of the current along the entire channel system – a task which is nearly insurmountable using traditional current meters. The work has been carried out together with researchers from several European countries and the Faeroe Islands, and has been supported by the Danish Natural Science Research Council, Deutsche Forschungsgemeinschaft, and the Faeroe Islands offshore consortium.

Development of the European beech forests

Danish traditional songs are full of praise for the pale green beech woods, even though the beech is a relatively new tree species in Denmark. Beech trees immigrated to the country around 4500 years ago from Southern Europe. This has been revealed by a comprehensive study of the development of the beech woods in Europe throughout the last 10,000 years, carried out by GEUS. Climate is the crucial factor determining the spread of the beech tree in Europe, but over the last 2500 years, the development of beech woods has also been powerfully influenced by human activity. The study, based on a large volume of pollen data from all over Europe, also describes how the beech tree has thrived with other tree species throughout the ages, and identifies environments which promote or hinder the spread of the beech forest. This work is part of the NATMAN EU project, the goal of which is to develop nature-based management of the beech woods, taking into account both recreational and financial interests. The results will also be included in the development of biodiversity monitoring under the national monitoring programme, NOVANA.

New method for measuring the melting of ice

A warmer climate in the future will mean rises in sea levels. A likely contributor to these rises is the Inland Ice in Greenland, which is the world's second largest ice mass. In this connection, GEUS and many international researchers are trying to work out whether the Inland Ice is growing or shrinking in the present climate. In 2002, GEUS performed measurements of the climate and the extent of ice melting in West and East Greenland, in areas where satellite measurements had revealed thinning of the Inland Ice. The goal of the work was to shed light on the causes of the thinning. In this connection, GEUS has developed new equipment to measure automatically the extent of ice melting, which is cheap, robust and requires a minimum of maintenance. The international research community has worked for years to develop methods for monitoring the vast regions which comprise the melting zone of the Inland Ice, but the methods proposed have either been inadequate or very expensive. The development of the new equipment has brought the possibility of more extensive monitoring of the Inland Ice a step closer. This work has been supported by the Danish Natural Science Research Council, Greenland Home Rule, and the EU.

Geological mapping of Denmark

GEUS has carried out geological mapping in several regions in Denmark. This year's mapping has been organised so that it comprehensively accommodates the need for geological maps for current community tasks. In 2002, map sheet 1117 II Hanstholm was printed and the fieldwork has been completed for map sheet 1411 II Lolland. In addition, fieldwork has been carried out in the northern part of Ribe County, such that the survey of the county has now been completed. Our geologists have also surveyed three map sheets in Ringkøbing County in connection with the county's designation of areas with special drinking water relevance. The survey work in the Ribe and Ringkøbing areas has been supported by these counties.

Problems with steam cleaning of soil

The method of using steam to clean contaminated soil is not without problems. This has been shown by a recently completed research project. The steam cleaning of contaminated soil, such as is used extensively in the USA, removes the toxins from the soil either directly or by stimulating the bacteria which break down the toxins. However, it has been found that the steam can also stimulate some harmful fungi and bacteria which have not previously occurred here, and which can cause respiratory problems, allergies, and urinary tract infections in humans. The steam stimulates the germination of spores from certain fungi and bacteria in the soil, which can survive and propagate at these very high temperatures. The result is surprising, since these fungi and bacteria were not present in the soil samples prior to steam cleaning. Further work is being done to analyse the microbial community in the soil to see whether the unusually large populations of these organisms disappear again after the soil has cooled down.

Flashes of the year

Young people in the classroom

Throughout the year, students and school pupils have been in the classroom at GEUS, learning about geology. As part of their study of geophysics at the University of Copenhagen, a team of students has been taught about seismic methods and the interpretation of seismic data, and several tours of the laboratories have been conducted for students from the Technical University of Denmark (DTU), focussing on petroleum geology research. The younger age groups have also visited GEUS as part of their school education. Throughout the year, several senior high school classes have had whole or half day teaching sessions at GEUS. Through lectures, they have heard about the monitoring and pollution of groundwater and the work of interpreting the geological layers in drillings. Finally, the very young school pupils have visited GEUS as part of their work experience.

12,000 boxes plus furniture and equipment

In 2002, GEUS moved to new premises at Øster Voldgade. The starting gun for the "big move" was fired at the beginning of April, and the last boxes were carried in at the end of July. Thorough planning and discipline were some of the ingredients in a painless move, which involved all the furnishings for around 300 people, equipment and devices from many large laboratories, numerous archives and stores, and a large library. During the moving period, removal vans carried 185 loads from the old premises at Thoravej. A total of approx. 6,500 cubic metres of goods were moved from one end of Copenhagen to the other. Around 12,000 boxes were used for the process, and the removals company spent 5,766 man-hours on the task. When you have lived at the same place for many years, a move is also a natural opportunity to tidy up your things, and before the move there was an extensive cleanup – especially in the stacks of paper. A total of 110 tonnes of waste was thrown out.

Gold for article on gold

It was a happy senior researcher from GEUS who received the Wardell Armstrong Prize 2000 in 2002. Agnete Steenfelt received the prize for the best article, published in the international journal, Transactions of the Institution of Mining and Metallurgy, Section B, Applied Earth Science, in 2000. The article describes how the chemical composition of sand samples taken from approx. 2100 watercourses all over South Greenland can be used as an exploration tool to identify regions with gold deposits. The article also contains a review of the known gold deposits in South Greenland and proposes a theory for how some of these have been formed.

Treasure hunt on TV

Geologists face many challenges as they try to read the secrets of the Greenland bedrock. They have to use their brains to crack the riddles of nature, but strong arms and legs are also needed as they carry stone samples and equipment around in the field on foot, in boats or by helicopter. In 2001, a camera crew accompanied geologists from GEUS on one of the summer's scientific expeditions to West Greenland, to observe the work of finding minerals and mapping Greenland's geology. The result was the programme, "Geological treasure hunt in Greenland", which was broadcast on DR1 on Danish TV and Greenland television. The programme was followed up with comprehensive information about the work in Greenland on the Danish Broadcasting Authority's Education website. The programme was produced in a partnership between GEUS, Dansk AV Produktion and the Danish Broadcasting Authority, with support from the Commission for Scientific Research in Greenland (KVUG), the Geological Museum, Greenland Home Rule, and the Ministry of Education. Results from GEUS' many years of study of some of the world's oldest stones at Isua in West Greenland were also presented in the Danish Broadcasting Authority programme, "Viden Om". The programme told the story of the incredible discovery of water from the world's earliest oceans, encapsulated in crystals in these ancient rocks.

Event for night owls

In October, the doors at Geocenter Copenhagen were opened to Copenhageners for the Culture Night event, where GEUS, in cooperation with its partners in the Geocenter, arranged exhibitions, talks and presentations. Seven different guided tours conducted the guests of the Culture Night into GEUS and the Geological and Geographical Institute to hear information about Greenland landscapes, the Inland Ice, continental drift, use of satellite images and aerial photos, floods in Europe, and strange creatures from the earth's antiquity.

Two new professors

In 2002, Lars Stemmerik was employed as research professor at GEUS, to enhance the research in the area of limestone, with the particular aim of gaining a better understanding of the oil resources in the Danish North Sea. Furthermore, Carsten Suhr Jacobsen from GEUS has been appointed as adjunct professor at the Chemistry Department and the Department of Ecology at the Royal Danish Veterinary and Agricultural University. He is working with the DNA of microorganisms, with the aim of understanding the significance of microorganisms for the metabolisation of foreign substances in the soil and groundwater.

Evaluation of the research

In 2002, GEUS commissioned an evaluation of its research activities within the programme area of Mineral Resources and Greenland Mapping. The evaluation, carried out by an international expert panel, involved the evaluation of publications and maps produced in the period 1996–2001, interviews with management and staff, and laboratory visits. The goal of the evaluation was to highlight areas of high-quality research, and areas where the research should be improved.

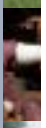










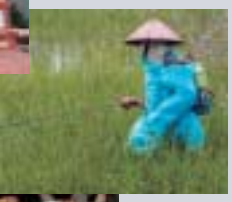




New strategy for development assistance

There is broad political support in the Folketing for Danish development assistance. In its capacity as the national geological survey, GEUS is making its knowledge and experience available so that it can contribute to fulfilling the Danish assistance goals. Participation in the assistance work is concentrated on projects involving skills which are central to GEUS' areas of operation, and which can contribute to developing the institution's own research activities. GEUS is prioritising its participation in projects in the areas of integrated management of water, mineral and oil resources, and integrated management of the coastal zone. GEUS is working on participation in an increasing number of multilateral projects from the Nordic Development Fund (NDF), the World Bank, the EU, and the regional banks, as a supplement to its participation in the national, bilateral assistance programmes. Research cooperation is one of the keywords in GEUS' assistance strategy, and GEUS is therefore working to establish close partnerships with organisations in the recipient countries, and to exploit the partnerships in the recently established Geocenter Copenhagen. "Help to help oneself" is another concept in GEUS' assistance strategy. GEUS is striving in this context to establish professional competence through the assistance work which can be used in connection with performing GEUS' national tasks.

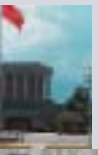
Oil expertise to be built up in Vietnam

The cooperation project between the Vietnam Petroleum Institute (VPI) and GEUS, to improve Vietnam's capacity to assess the country's oil and gas resources, made a good start in 2002. Eight candidates from VPI have passed their entrance examinations and started on the MSc programme at the Hanoi University of Mining and Geology, after completing a series of preparatory courses. Several of them have since completed courses and job training at GEUS and at the Geological Institute, University of Copenhagen, as part of their MSc programme. Training these Vietnamese researchers is taking place via work on a specific research project, the goal of which is to understand the geological structure of the Phu Khanh basin and assess the potential for oil and gas in it. In this connection, in 2002, a 495-metre deep core drilling operation was undertaken – the ENRECA-1 drilling, contributing valuable information about the geology of the area, and old seismic data from Vietnam has been processed based on new, contemporary methods at GEUS in cooperation with Vietnamese researchers. Finally, a project database has been established, which geological and geophysical data is now pouring into. The second annual project workshop was held at VPI at the end of the year, at which the results of the initial studies were discussed by the researchers on the project. Afterwards, representatives from the Vietnamese energy authorities and the oil and gas companies active in Vietnam were introduced. The project is financed by Danida's ENRECA programme and also has participation from the Geological Institute at the University of Copenhagen and the Hanoi University of Mining and Geology. The project is exchanging experience and data with other ENRECA projects active in the area of surveying groundwater reservoirs and management of water resources under the Danish Water Sector Programme Support in Vietnam.


Knowledge building in developing countries through research and consultancy services

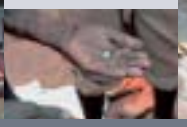
GEUS around the world





Survey of groundwater quality in Latvia

A large proportion of the drinking water supply in Latvia is based on groundwater, and the risk of pollution from pesticides and nitrate is very clear in many locations. However, no serious pollution of the groundwater has yet been discovered. This might be explained by inadequate measurement techniques in the laboratories, and the almost exclusive selection of water samples at deep levels. In 2002, GEUS started a project to support Latvia in surveying the groundwater quality. The project involves a large number of shallow bores into the young groundwater, and the transfer of knowledge about the difficulties of analysing water for pesticides to Latvian laboratories. The project, financed by the Danish Cooperation for the Environment in Eastern Europe (DANCEE), will introduce new analysis methods for pesticides developed at GEUS.


Improved management of mineral licences in Tanzania

Tanzania has undergone rapid development from being a low-priority country for mineral resources, to a high-priority region, where interest in gold, diamonds, and precious stones is in particular focus for both foreign and national companies. Tanzania's administrative system for mineral licences has difficulty handling this high level of interest, with more than 10,000 licences issued. In 2002, GEUS completed a project in cooperation with the local authorities in Tanzania, analysing the existing system and mining law and then preparing proposals for a strategy of necessary changes and plans, so that a new cadastral register for mineral licences could subsequently be implemented by the Ministry of Energy and Minerals in Tanzania. The proposals involve plans and specifications for an administrative and technical system to manage the numerous licences, secure the licence holders' rights and obligations, and make it impossible to issue overlapping licences. The project has been carried out in cooperation with COWI and the local partner, Southern and Eastern African Mineral Centre, and has been financed by the Nordic Development Fund.

Implementation of a new Water Act in Vietnam

In January 1999, a new Water Act came into effect in Vietnam. As a result, in future, the country's water resources are to be managed, to a much greater extent, based on the principles of integrated water resource management. In this connection, in 2002, GEUS assisted the Vietnamese Ministry of Agriculture and Rural Development (MARD) with the implementation of the new Act. The project involves technical assistance to MARD in the preparation of a statutory order on how to issue and register permits for the recovery of groundwater. The work also involves testing the new principles in selected provinces in Vietnam and training the local authorities in how to handle the new guidelines. Finally, the project involves assistance in the preparation of a statutory order for the issue of authorisation for well drillers who are permitted to carry out water drilling operations. The work, financed by Danida, will continue in 2003 as part of a broader Danish-supported initiative for the implementation of the Water Act in Vietnam.

Key figures

More detailed key figures for GEUS' activities are found in "Årsrapport 2002"
Report and Accounts 2002 available in Danish from GEUS and on www.geus.dk

Number of employees: 344, including the Danish Lithosphere Centre (23)

ACCOUNTS 2002*

Amounts in million DKK.

Revenue **	**217.6**
Net figures (appropriation)	134.3
Operating revenue	76.4
Aktstykkemidler*** brought forward from 2001	6.9
Expenditure	**222.0**
Salaries	136.4
Other operating expenditure	85.6

* *The accounts include the Danish Lithosphere Centre - a research centre financed by the Danish National Research Foundation.*

** *Added to this were authorised drawings on reserves of DKK 8.0 million.*

*** *Supplementary funding appropriated by the Danish Finance Committee.*

PRESENTATION ACTIVITIES

Long-term knowledge building	
Articles in international scientific magazines/publications	101
Articles in own scientific series	21
Other scientific publications	27

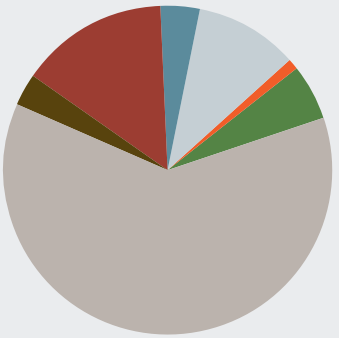
Ongoing scientific task solution, consultancy and presentation	
Publicly available reports	125
Confidential reports	37
Memoranda, opinions, reviews, etc.	73

General presentation	
Institution reports (annual report, etc.)	7
Popular science articles	35
Lectures, exhibitions, etc.	47

TRAINING OF SCIENTISTS

PhD students	27
PhD graduates	7
Master's students	30

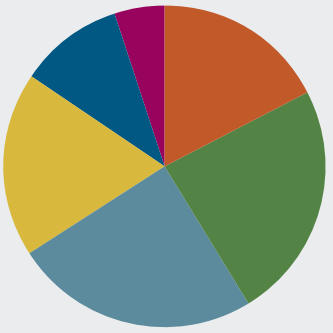
Revenue broken down by sources of revenue



Amounts in million DKK.

Budget appropriation:	134.3
Aktstykkemidler brought forward from 2001:	6.9
Programme and external funds:	31.7
Other co-financed contract research:	8.4
Commercial contracts and sale of data:	22.1
Other revenue:	2.3
Danish National Research Foundation to the Danish Lithosphere Centre:	11.9

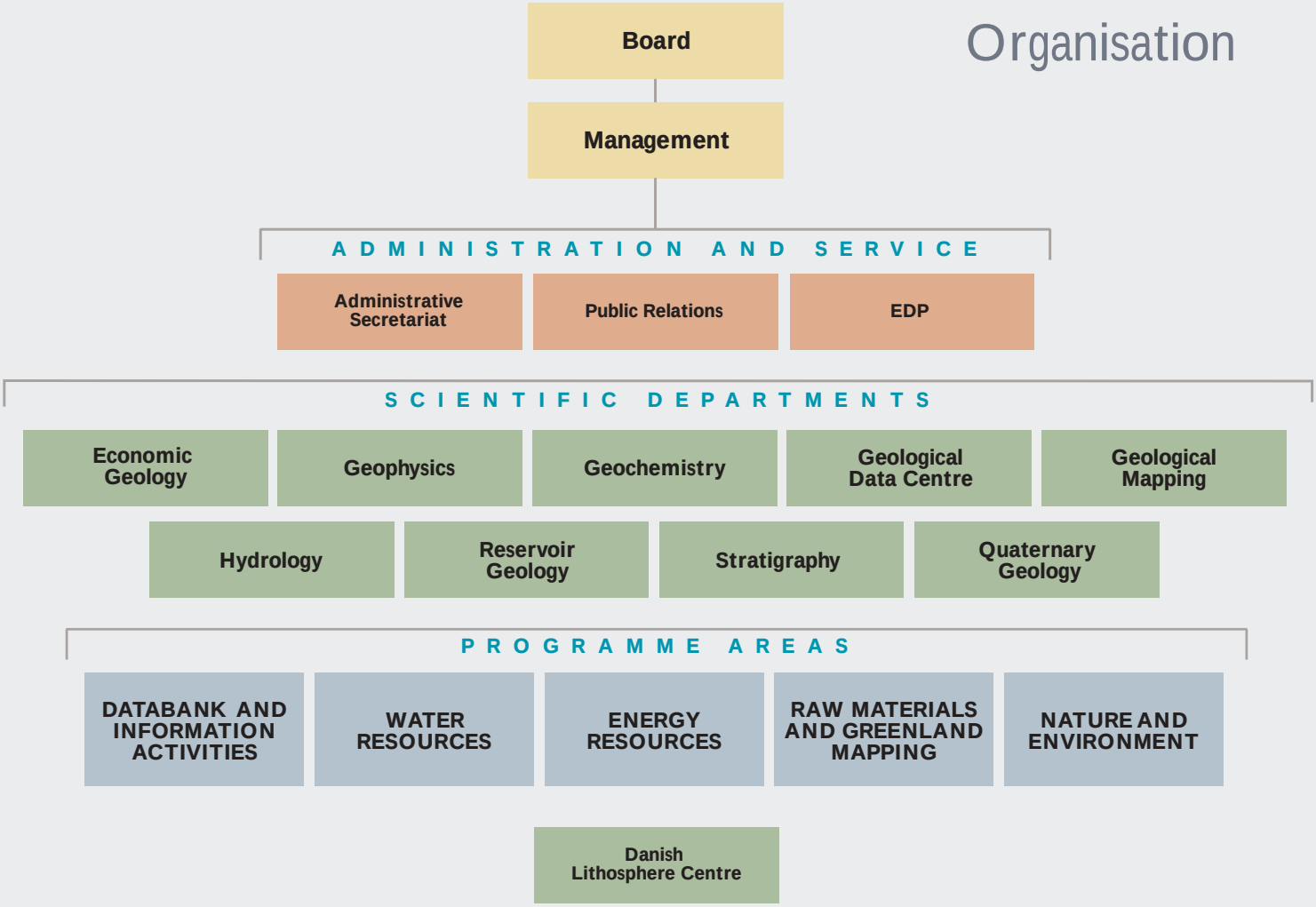
Expenditure broken down by programme areas



Amounts in million DKK.

Databanks, information technology and information to the general public:	38.6
Water resources:	53.0
Energy resources:	54.7
Mineral resources and Greenland mapping:	41.2
Nature and environment:	23.3
Danish Lithosphere Centre:	11.2

Organisation



An organisational change took place in 2002. The Department for Quaternary and Marine Geology and the Department for Environment and Climate were amalgamated to become the Department for Quaternary Geology, and a number of employees have been moved to other departments. GEUS now has nine research departments and three administrative/service departments. In addition, the Danish Lithosphere Centre (DLC) under the Danish National Research Foundation is administratively attached to GEUS. Scientific activities are conducted in five programme areas with projects implemented in project groups of varying sizes.

Programme area: Databanks, information technology and information to the general public
Archiving and data processing in connection with statutory reporting of geodata 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 and Greenland mapping
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.

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