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ANNUAL REPORT

GEOLOGICAL SURVEY OF NORWAY

GEOLOGY FOR SOCIETY

NGU
Norges geologiske undersøkelse
Geological Survey of Norway

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the Present Time is always the Stone Age

ved Morten Smelror

In his poem, The Present Time is always the Stone Age, from his anthology *Rå*, Gene Dalby places our social development in an interesting perspective. Society builds on development and progress over generations, but just as a new day dawns our hypermodern everyday life soon becomes history.

On average, each of us consumes more than 11 tonnes of stone and rock a year. Most of it goes to construction work, but minerals can be found in everything we surround ourselves with, from cars and cutlery to mobile phones and make-up. In the course of our lives, each of us will have consumed as much as 940 tonnes.

Dalby's poem was written the same year as Norway collected precious metals during the Olympics in Lillehammer, just as Norwegians did this winter in Vancouver. In the last year, the price of metals has risen strongly, and an Olympic Bronze is soon worth its weight in gold. The marked increase in the demand for metals is linked with the strong economic growth in densely populated countries like China, India and Brazil. Increased urbanisation leads to more consumption of raw materials. Everything indicates that pressure on strategically important metals will continue to rise in the years to come. This presents us with new challenges and opportunities here in our mountainous country. We must find and begin to work new mineral deposits which will help us to secure income and prosperity, at the same time as the resources must be managed in an environmentally safe manner.

New technology gives us the possibility to begin to use new kinds of mineral raw materials and also to find new applications for traditional ones. A modern mobile phone contains some 15 different types of metal. The environmental technology of the future will get nowhere without sufficient access to rare earth elements.

We are surrounded by air, water, soil and bedrock. Global climate change will affect us all, but in the heated climate debate we must not forget the local environmental challenges. Nature is full of naturally occurring hazards. Here in Norway, some 300 people die of cancer each year due to exposure to radon from the bedrock. We build and settle in areas where there is a risk of avalanches, at the same time as loss of life and damage to infrastructure due to our own encroachments on land areas have become a problem for society. We have gradually managed to limit and partly control discharges of industrial effluents to lakes, rivers and the sea, but those from agriculture and fish farming cause problems in several places. Many covered refuse sites are leaking and we have to tidy up old sins.

We are on the right road in many areas. We can increase our production of renewable energy by exploiting geothermal power. Extracting heat from groundwater reservoirs is becoming increasingly common in major developments, and possibilities for extracting it from deep in the bedrock are now being tested. A national strategy to reduce radon exposure has been agreed and important measures have been put in place. There is also a national objective to halt discharges of the most hazardous pollutants by 2020.

According to the Chinese philosopher, Confucius, who lived around 500 BC, the essence of knowledge is, having it, to apply it. We believe it is just as important to share knowledge so that it can be applied by as many people as possible. Effective management and dissemination of geological data and knowledge is a primary objective at NGU. We are now developing our national geoscience databases as an integral part of Norge Digital and making the data compatible with the EU Directive, INSPIRE. Our knowledge and our data are freely available to all users via our web pages *www.ngu.no.*

With the conviction that "the Present Time is always the Stone Age", we have directed our attention forwards. Geology for Society at NGU is specifically geology for the future.

Managing director Morten Smelror looks into the future. In this annual report, NGU shows the way towards transfer of knowledge and the future through ten selected geological themes linked to pictures of children and researchers. Morten Smelror beside a portrait of himself as a child, painted by Dolores Capdevila.

raw materials in an international tug-of-war

The world's enormous demand for goods consumes resources at a great rate. Production of e.g. electronics, cars, toys and even food involves various mineral raw materials. Some are readily available, while others come from just a few deposits in the whole world.

For some minerals, a few suppliers have a virtual monopoly and can therefore decide to whom they will sell and for what price.

Most of the 17 Rare Earth Elements (REE) are important or absolutely essential raw materials for the high-tech industry – particularly for many "green" products. They are essential in the manufacture of lasers, hybrid cars, mobile telephones, computer chips, jet engines and in the magnets in large wind turbines.

The modern world has therefore made itself dependent upon REE as raw materials. Demand is expected to grow 50 % by 2015, but production capacity is limited.

China is often called the world's factory, but it is also the world's leading supplier of many valuable raw materials. 98 % of current world production of REE is mined in China. The government announced export quotas in September 2009, and China will only export 35 000 tonnes of REE annually for the next five years. That covers an estimated 25 % of current world consumption. Leading economists are now speculating that major companies like Toyota will have to move some of their production to China to secure access to raw materials. Such a monopoly situation can be used as a strategy to maximise value creation in China, and this causes concern in the markets.

NGU geologists know that there are REE deposits in Norway. These elements are, in fact, not as rare as their name implies. The designation stems from way back in history. The first elements in this group were extracted from minerals found at Ytterby in Sweden: the minerals are indeed rare, but the elements concerned are found in significant quantities in the Earth's crust. The issue is just how large the deposits in Norway are, and whether they are of a quality that makes them economically attractive for mining.

So far, no systematic mapping of this type of resource has ever been carried out in Norway, but geologists know of several deposits with a considerable potential. Some have a grain size, mineralogy and grade that make them technically difficult to extract, but technological innovations and jumps in the price of the products may nevertheless make mining profitable in the future.

Limitations in the supply of important raw materials also have another effect. When the industry has difficulty in obtaining resources, research into alternative processes and raw materials is given a boost. Consequently, in 10-20 years, we may find that the market is seeking completely new raw materials.

A mobile telephone contains Rare Earth Elements. Klara is listening with Ron Boyd.

rocks that remember

A small group of nanoscientists at NGU is working intensely and laboriously mapping the stable magnetism in Norwegian rock. The aim is to use the properties in industrial products.

Through several projects funded by, among others, the Research Council of Norway and EU, Suzanne McEnroe and her colleagues, Karl Fabian and Peter Robinson, have for several years been studying magnetic properties in minerals on the nanoscale. NGU scientists have discovered and mapped special characteristics in the magnetism of the commonest Norwegian rock, gneiss. Its strong, stable magnetism means that the rock virtually remembers when it was born. The properties may perhaps form the basis for a super-robust, long-term memory in machines for the IT industry, for example in space travel or security.

Together with colleagues at the University of Oslo and the University of Münster in Germany, they are trying to fashion an artificial material with the same magnetic properties as gneiss. This is an important step on the way towards making basic research available and interesting for industrial firms and commercial interests.

One of the earlier discoveries the research group made was to reveal a magnetic property formed on the interface between ilmenite lamellae developed in the mineral hematite. It is this magnetism which is so robust. No other material has yet been found anywhere in the world in which the nanomagnetism remains equally stable relative to pressure, temperature, radiation and time.

It is these hematite-ilmenite properties in the minerals which will be copied over onto thin films. The magnetic, chemical and atomic structures will then be characterised and described. Based on that knowledge, the researchers will produce a synthetic material with the same magnetic properties as the gneiss.

Nanotechnology stands for science operating with structures in the order of size of 0.1 - 100 nanometres, where one nanometre is one millionth of a millimetre, or one billionth of a metre. At that level, the structures are too large to be described by atomic models and too small to be described by theories in thermodynamics, electromagnetism or mechanics.

In electronics, scientists have moved from the microlevel to the nanolevel in the struggle to make components more rapid and structures smaller. Also in gene technology, in biology and medicine, a great deal of work is being performed at the nanolevel. The same applies in chemistry and materials science, where it has been possible for a long time to design substances and structures atom by atom and molecule by molecule. Here, they are moving up one size, and making larger and more complex structures – in fact, at the nanolevel.

Norwegian gneiss has robust magnetism. Tale is playing with Suzanne McEnroe.

searching for perfect lattices

It is used in everything from glass and pottery to car tyres, detergents, beer and high-tech items, and can cost between 90 and 10 000 NOK per tonne. Quartz or silicon dioxide (SiO_2) is one of the world's most used industrial minerals; the demand for knowledge about it and for commercial deposits is enormous. The reason is the great range of products containing quartz. Products like computers, mobile telephones and solar panels are absolutely dependent on the semiconductor metal, silicon, which is obtained from the mineral. If the technology is going to function, not just any kind of quartz will do: the raw material must have specific chemical and physical properties.

Natural quartz generally contains varying amounts of trace elements. These are regarded as impurities and they influence the properties of the end product. The kinds of impurities present, their amount and how these elements are bound to the silicon dioxide lattice determine what the quartz can be used for – and its price.

The Geological Survey of Norway (NGU) has a special team of scientists working full time on quartz. They are among the world's leading specialists in their field, and over the last ten years they have developed unique methods that can reveal impurities even within the lattice structure of the quartz molecules. They can therefore show that deposits which used to be considered top quality, nevertheless contain impurities.

Nowadays, scarcely more than a handful of really top-quality quartz deposits are known throughout the world, even though quartz is the second most common mineral in the Earth's crust. Norway has two mines worked by Norwegian Crystallites, one of several firms employing NGU's expertise in the hunt for new commercial deposits.

The need for new quartz deposits is great, particularly high-purity and ultra-pure quartz, which are essential for the manufacture of halogen bulbs and solar panels. The market has therefore grown in recent years, and securing supplies of the raw material is one of the greatest problems facing, e.g. solar panel manufacturers. To be able to expand, the industry must have more quartz, which means that new deposits must be mapped and approved for production.

Poorer quality raw material is also important for the industry, but will not do for the most advanced products. Many kinds of impurities and trace elements can be removed through processing techniques, but not all of them. Processing also makes the products more expensive and may require large amounts of energy. The market is therefore searching for mineral deposits that require a minimum of processing in relation to their end-use.

The world has a huge need for high-quality quartz. Marion is searching with Peter Ihlen.

calculating with the future

Numerical models can tell us what, in physical terms, may take place in the future or what might have happened long ago. It is possible to model the development of a rock avalanche in 100 years time or the formation of a sedimentary basin 100 million years ago.

It is often absolutely essential to calculate and test scenarios mathematically, either because it is impossible to build up analogue models, since we cannot find answers in our geological observations, or because the numerical models give valuable additional information.

Thus, numerical modelling is concerned with ways of solving problems with a mathematical formulation. A theoretical mathematical model, coded in equations, can show part of the reality very precisely. A number of physical and geological processes can be described with the help of equations of various kinds. The equations in a mathematical model cannot always be solved with pen and paper, but with the help of a computer it is nevertheless possible to get very good insight into the processes that are involved. Modern weather forecasting, for example, is based on computer visualisations of very complex theoretical models.

Numerical modelling is used at NGU among other things to demonstrate how large sedimentary basins are formed, how faults originate and to understand heat flow through rocks. We also examine the movements of crustal plates over geological time. One of the key concepts is the Wilson cycle, which describes how continental and oceanic plates move relative to one another when the oceans open and close.

NGU researchers undertake numerical modelling of the entire Wilson cycle, from subduction, where one crustal plate vanishes beneath another, via plate collisions and on to the opening of a new ocean.

Why is this important? It is important to understand how Norway and the rest of the world came into being, how natural resources are formed and how the landscape is shaped. Here, we model, for example, the closure of the Iapetus Ocean, which lay between Laurentia (North America) and Baltica (Europe) 500 million years ago. NGU researchers are, in particular, looking at the consequences of this process, like the formation of the Caledonian mountain chain 425 million years ago, and are also calculating how the Norwegian Sea began to open 54 million years ago.

From the basis of the mathematical model, information pours forth on changes in horizontal and vertical movements, the building up of mountains and continental margins, and the development of temperature, deformation and stress in the bedrock.

NGU calculates with the future.

Numbers solve geological problems. Yorik finds solutions with Susanne Buiter.

monitoring from orbit

Even though the images look as if they come from computer games from the '70s, they actually represent the future. The coloured squares on the screen depict sections of a mountainside that are moving. The images are from InSAR and are taken by radar satellites orbiting above our heads.

Each square represents an area of 25 x 25 metres. Its colour shows whether the area is stationary or has moved since the previous image was obtained. The red areas are moving away from the satellite and therefore identify sections of mountainside that are in danger of catastrophic sliding.

The satellite images can detect movements almost as small as one millimetre. That explains why the scientists regard them as the tools of the future for avalanche monitoring.

Such satellite images have now been used for the first time to map rock slide hazard throughout an entire region at one time. NGU geologists have mapped the whole county of Troms. The satellite images have enabled them to identify as many as 95 areas where large portions of mountainside are moving. In several of these areas, the hazard of an avalanche damaging property and taking life is imminent because when geologists speak of avalanches it is not small stones that will fall.

In each of the 95 areas in Troms, one million cubic metres or more of rock are moving. One site where a rock slide can have huge consequences is Nordnesfjell, a mountain at the mouth of Kåfjord, a branch of Lyngenfjord. Close on 12 million cubic metres of rock may break away here and crash into the sea. Such avalanche rock slide would generate a flood wave several tens of metres high, which would devastate parts of the three municipalities of Lyngen, Kåfjord and Storfjord.

Nordnesfjellet is therefore one of three mountains in Norway that are now being continuously monitored. State-of-the-art equipment has been installed aimed at registering a possible avalanche sufficiently early to warn the inhabitants and evacuate them to places of safety.

The Norwegian parliament is funding this work because everyone recognises that avalanches of this size cannot be prevented. They are far too huge for that.

Satellite monitoring is just one of the tools being employed, but in the years ahead it can become one of the most important. The technology behind it is being developed continuously and in a few years both the amount of detail and the quality of the images will be greatly improved. At the same time, the scientists are gaining experience and developing skills that will make them better at interpreting the information they acquire. For instance, we still know too little about the kinds of signals that may be seen before an avalanche is triggered.

It is such disasters the new technology can help us to avoid in the future; scientific knowledge is our best way of saving lives.

Satellites monitor Norwegian mountains.
Maya marvels with Iain Henderson.

getting to the bottom of things

Scientists are getting to the bottom of things with the help of aircraft and helicopters. Geophysical datasets provide valuable information on the properties and structures of the bedrock. In the past few years, NGU has surveyed the bedrock in large parts of the Barents Sea. Now it is looking towards land – and the North Sea.

New, detailed, top-quality data from geophysical mapping is essential to be able to find natural resources and to develop the Norwegian oil, gas and minerals industries. Such mapping primarily involves measuring the Earth's magnetic field. These methods help geologists to "see" beneath the superficial deposits into the depths of the Earth. Here they can learn of faults, former volcanoes, salt diapirs and the depth of the bedrock. Scientists can interpret this geophysical data, combined with geological and geochemical data, to obtain a reliable picture of the potential of the bedrock.

NGU plans to carry out a high-resolution aeromagnetic survey of the Norwegian part of the North Sea between Karmøy and Sognefjord. This will span approximately 70 000 square kilometres and cover part of the Danish-Norwegian sedimentary basin, along with the Viking, Stord and Egersund basins.

Many such basins are filled with thick piles of sediment which once contained a great deal of organic matter. Oil and gas may have developed here and migrated out to accumulate as commercial concentrations in porous reservoir rocks in the vicinity. The roughly 600 sedimentary basins around the world have proved to be interesting exploration targets for petroleum.

Extensive investigations were undertaken in the western Barents Sea in 2009. Some 105 000 square kilometres were mapped, corresponding to a third of the Norwegian mainland.

The aeromagnetic measurements in the North Sea will tell us how active the major fault systems in the area were when the North Sea sedimentary basins were forming. If the content of the radioactive elements, uranium, thorium and potassium, is measured it will also be possible to calculate the temperature in the coastal basins and to investigate the possibilities for geothermal power. The mapping can also be used to plan new tunnels, prospect for new mineral deposits and estimate the risk for radon.

NGU also wants to carry out aeromagnetic measurements over land in northern Norway. Northern Scandinavia is one of the richest geological regions in the world. The potential for resources here means that Norway must put greater emphasis on geological mapping as a foundation for more prospecting, commercial development and raw material security.

The last regional aeromagnetic measurements in Finnmark were undertaken in the 1960s and 1970s. The areas that may be given priority in the years to come are inner Finnmark, the coasts of western Finnmark and western Troms, parts of Lofoten and Vesterålen, and the Rombak-Ballangen-Tysfjord district in northern Nordland. A mapping programme of this scale amounts to approximately 50 000 square kilometres.

Aeromagnetic measurements reveal the bedrock.
Janne Marit tests gravity with Marco Brönner.

environmental pollutants revealed

An NGU initiative is helping to reveal environmental pollutants in several parts of the world. "The Norwegian method" is a new, efficient means of mapping pollution in the biggest rivers in the world that is gaining broad support. In addition, NGU is heading an urban geochemistry project to reveal contaminated soil in 10 European cities.

Initially, the river project will map pollutants in floodplain sediments in 26 of the world's largest deltas and along some 150 to 200 major rivers and their most important tributaries.

The objective of the project is to obtain figures for the nutrients and environmental pollutants transported to the sea by large rivers. 75% of the world's population lives on river plains, and the people obtain their water and food there. In many places, the groundwater has a naturally high content of substances that are a health hazard – arsenic in Bangladesh and western Bengal, for instance – or it may be highly contaminated or poisoned from human sources. Sampling and mapping may also help to enhance our knowledge of mineral resources, climate change and agricultural development.

The method involves taking two samples at each locality, one deep down in the sediments and the other at the surface. Nature herself has deposited these samples; the river plains have been regularly inundated so that sediments have been deposited over several hundreds of years. When they obtain samples from deep in the sediment pile, the scientists can determine the former environmental state of the area. Samples from the uppermost layers reveal recent human activity. The method has been developed through close, long-lasting cooperation with the Norwegian Water Resources and Energy Directorate.

The method is cheap and efficient. The sediments in the deltas, at the mouths of the large rivers, stem from the vast seepage areas and catchment basins of the rivers. When samples are taken here, scientists need only 1300 localities to calculate the environmental state of enormous land areas around the world. The aim is to determine the content of 76 elements and some organic components in the samples. China has supported the initiative and made a good start to the work. With UNESCO support, the Chinese also aim to set up an international research centre at Langfang, southeast of Bejing. Several other nations are already planning to collect samples.

NGU is also mapping soil contamination in 10 major European cities under the auspices of EuroGeoSurveys (the Geological Surveys of Europe). Dublin was mapped in 2009. The samples are being analysed in the NGU laboratory. The aim is to find out whether tar and its components and heavy metals, like lead, in urban soil can be a hazard to human health. An NGU employee takes part in all the investigations to ensure that the sampling and analyses are carried out in the same manner from city to city.

Norway has long experience of this type of work. NGU has used the same methodology to map seven Norwegian towns and cities in the past 15 years together with the Norwegian Institute of Public Health, the Climate and Pollution Agency and the local authorities concerned.

Pollutants must be removed from earth. Amalie is playing carefree with Morten Jartun.

energy from deep in the Earth

The bedrock beneath Oslo contains a huge, completely natural source of energy that can probably meet the city's heating requirements. The source is environmentally friendly and renewable. It is also practically inexhaustible because the Earth's crust itself is the power plant.

Part of the city rests on uranium-bearing granite which is responsible for the energy production. Radioactive substances like uranium, thorium and potassium are continuously decaying to form "daughter" products in the bedrock, releasing thermal energy in the process. Brought to the surface, this can be used in heating plants, thus securing densely populated areas CO2-free heating.

Scientists call this form of energy geothermal power. Because of the expertise we have developed in well technology, this form of energy can have a great potential in Norway, both scientifically and in economic terms. If this geothermal power is to be exploited, the wells must be drilled deep, perhaps all of five kilometres. They have to be filled with water which circulates, is heated at depth and then transports the power to a heating plant on the surface. The underlying principles are simple; the well drilling is both the major cost and the technological challenge.

In February 2009, the Norwegian Centre for Geothermal Energy Research (CGER) was set up at the University of Bergen. NGU is one of 21 partners in the centre, which is intended to pave the way for developing know-how and technology that can make geothermal power commercially viable. Heavyweights from research and industry are taking part because many people see a future potential for this form of energy because geothermal power can be geberated near where people live and because it is a stable source irrespective of the weather and the time of year.

NGU geologists have been mapping Norway for more than 150 years and their maps give good indications of where the most favourable bedrock can be found.

Projects have also been carried out in the last couple of years to measure the temperature at a depth of one kilometre and to calculate it down to five. The results show that the exact location of the wells is important. The temperature at a given depth can vary by more than one hundred degrees. The precise location of the well can thus greatly influence the price of the generated power.

So far, nations with active volcanoes have put priority on exploiting geothermal power. Iceland has long been a leader, using the power to produce electricity and to recover remote heat based on energy from hot springs. Politicians, the power industry and scientists are now keen to find out whether geothermal power can become profitable and environmentally friendly for Norway, too.

Deep wells can supply new energy. Maja is lighting the flame with Christophe Pascal.

a journey to the bottom of a fjord

When NGU's marine geologists plot marine base maps for Astafjord in southern Troms, they are performing a job which fishermen and people involved in coastal management characterise as "a revolution" and "a new epoch".

Detailed data on depths, the state of the seabed, landscape forms and current systems in a Norwegian fjord are being acquired for the first time and compiled to produce the first detailed maps and models of the area. The intention is that they will form the basis for sound, sustainable management of the coastal zone in the years to come.

The marine geologists are doing real pioneering work in this area. Astafjord has been chosen as the pilot area, where the aim has been to make a new standard for marine base maps in the coastal zone. Management of coastal parts of Norway has so far been based on what we know of the shore zone and the areas on land, whereas we have little or no precise knowledge of how the fjord systems actually function.

That is what the Astafjord project aims to find out. The project is being run by local and regional authorities in cooperation with aquaculture firms and NGU. The Norwegian Institute for Water Research (NIVA) is also contributing its expertise, and basic data also come from the Norwegian Hydrographic Service and the Norwegian Armed Forces. NGU is responsible for investigating conditions on the seabed and for constructing the marine base maps, while NIVA has modelled the currents.

For thousands of years, the blue depths wreathing the Norwegian coast have provided us with our food. The sea formed the basis for Norwegian wealth – in both ecological and financial terms. Yet, we know little of the landscape which the surface conceals.

When coastal-management experts now acquire knowledge about the volumes of water, conditions on the seabed, currents and the submarine terrain, they can locate new aquaculture facilities where they can be securely anchored to solid rock and have a good exchange of water so that the risk of spreading infections, fertilisers and waste feed is reduced. The marine base maps are a tool which the aquaculture industry can use to comply with nature. They can make the industry more environmentally friendly and more profitable.

Environmental authorities and fishermen also find the maps useful. When the current systems and conditions on the floor of the fjords are mapped, it is easier to predict what might take place if the fjord is hit by an oil slick or some other kind of pollutant.

The mapping also shows where special habitats such as coral reefs or underwater screes occur. Fishermen can therefore plot in localities which they should avoid – for the sake of the environment or to avoid ruining their gear. The completed maps will also help municipal authorities to look after their shore zone.

The scientists are now entering the third phase of the Astafjord project. The area has been extended westwards, and the Vågsfjord basin is the next area to be surveyed. Eventually, they hope to map the whole area within the ground line. They hope, too, that other parts of the country will become aware of the value of such detailed marine base maps so that the project can become the model for such mapping nationwide.

The seabed is revealed along the Norwegian coast. Nikolai removes the water for Heidi Olsen.

the radon hazard

Alum shale is the loser in the fight against radon. This uranium-rich black shale in the bedrock frequently causes high radon values inside buildings. NGU is now constructing a radon awareness map highlighting the caution that must be taken with respect to alum shale. Occurrences of alum shale are known in the counties of Akershus, Oslo, Oppland, Buskerud and Hedmark.

The construction of the alum shale map follows work done to prepare the radon awareness maps for the central part of south-eastern Norway, which were completed in 2006 in cooperation with the Norwegian Radiation Protection Authority. These maps cover an area of 10 000 square kilometres from Hadeland and Romerike in the north to Fredrikstad and Skien in the south.

The work is important and essential, not least because the Radiation Protection Authority introduced more stringent recommendations in 2009 for measures in housing exposed to radon. It now recommends implementing measures against radon already when values exceed 100 Becquerel per cubic metre of air (Bq/m^3), and the maximum limit in buildings is placed at 200 Bq/m^3. This means that the former limits for taking action are halved.

The reason is as simple as it is frightening. Radon takes lives. Each year nearly 300 people die of lung cancer in this country as a consequence of prolonged exposure to excessively high concentrations of radon indoors.

The radioactive gas, radon, forms during the decay of the element, uranium, which is naturally present in the ground beneath us. This heavy noble gas has poor ability to bind to solid substances. This means that radon readily avoids materials and is liberated into the air. Its geology, climate and building practices mean that Norway has some of the highest concentrations of radon in the world.

It is first and foremost rocks like alum shale and granite that cause problems. In 2009, high radioactivity was, for example, mapped in the Løvstakken granite in densely populated areas southwest of the centre of Bergen. Here, as elsewhere in the country, the authorities have asked house owners to measure the radon concentration in their homes.

Last year, the government published its new radon strategy up to 2014. It states, for example, that levels of radon in all types of buildings and premises must not exceed the limits set, and exposure to radon in Norway must be reduced as far as possible. NGU will take part in this work, partly by ensuring that sand, gravel and crushed stone used in construction work do not contain too much radon.

Radon gas is invisible and odourless, but its concentration is easily measured. The gas is also largely easy to remove. It is therefore still healthier to breathe than not to breathe.

Radon gas may give lung cancer.
Dina relies on Trond Slagstad.

ACCOUNTS

Accounts 2007-2009

	NOK million			% expenses/income		
Expenses	2007	2008	2009	2007	2008	2009
Salary/nat. ins. expenses	116,2	122,4	126,4	59,3	57,6	57,9
Other expenses	69,2	79,6	81,5	35,3	37,5	37,3
Investments	10,4	10,5	10,4	5,3	4,9	4,8
Total expenses	195,9	212,5	218,3	100,0	100,0	100,0
Income	2007	2008	2009	2007	2008	2009
Ministry of Trade and Industry	137,1	140,3	137,4	68,0	67,0	62,1
Other income	64,1	68,0	84,0	32,0	33,0	37,9
Total income	201,2	208,3	221,4	100,0	100,0	100,0

Accounts 2009 by main objective (NOK million)

Main objective	Total	Extrenal finance
Sustainable added value from geological resources	57,7	18,8
Effective use of geoscience knowledge in land-use planning and development	69,6	32,0
Better knowledge of geological development and processes in Norway	68,3	27,7
Management and dissemination of geological data and knowledge	22,7	3,0
Other income		2,5
Total	218,3	84,0

NGU's total productions of reports, publications, presentations and maps for 2006-2009

Produkttype	2006	2007	2008	2009
NGU-reports	79	73	85	67
Articles, refereed journals	98	125	145	166
Articles, other publications	60	90	74	41
Talks, teaching and posters	379	458	545	484
forskning.no	24	20	19	19
Bedrock and surficial deposits maps	12	4	14	9

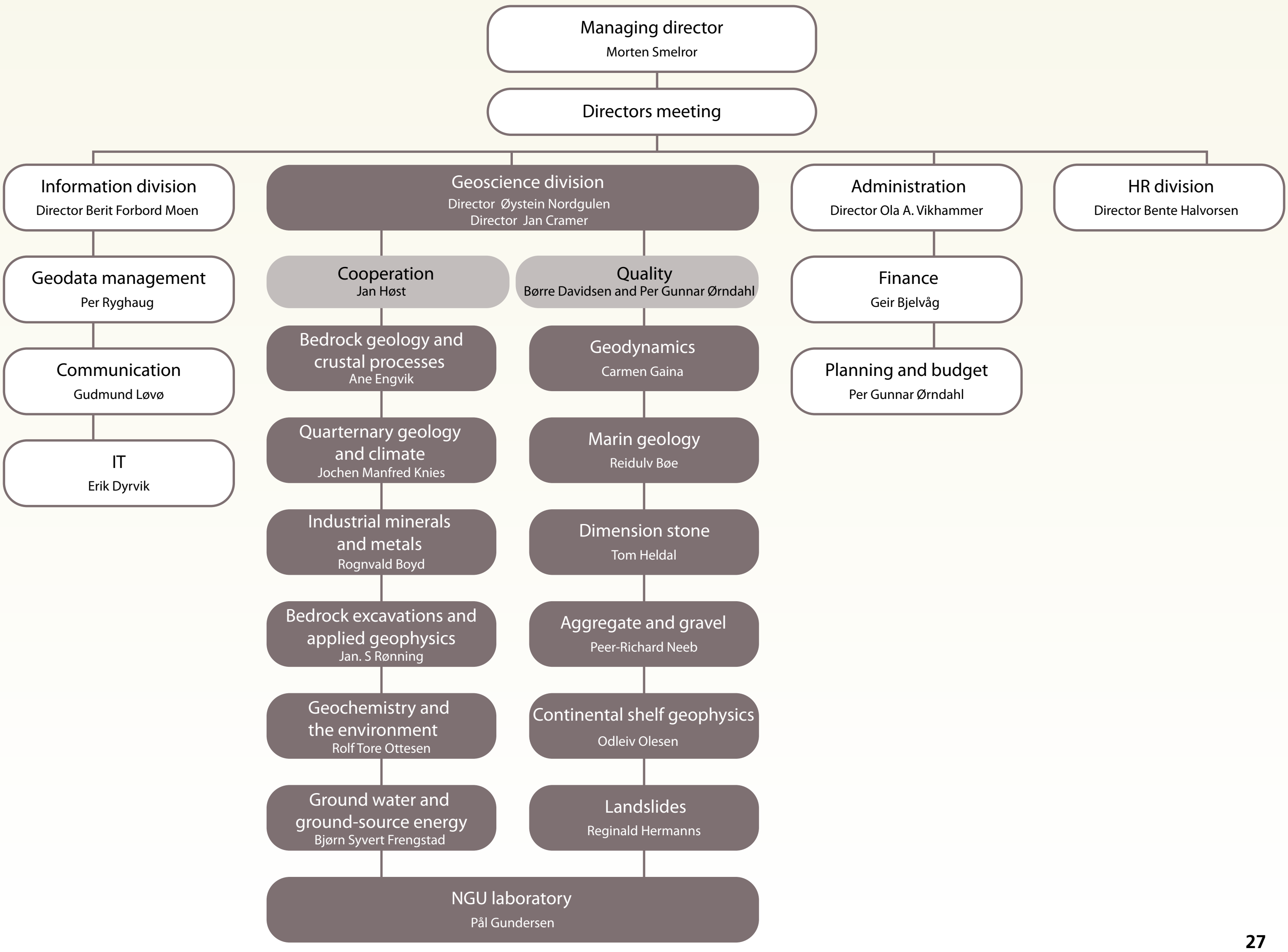
NGU IN BRIEF

The Geological Survey of Norway (NGU) is the leading national institution for knowledge on bedrock, mineral resources, superficial deposits and groundwater. NGU is a government agency under the Ministry of Trade and Industry.

NGU must ensure that geological knowledge is utilised for efficient, sustainable management of the nation's natural resources and environment. NGU's expertise can be used in development aid projects. As a research-based management agency, NGU also advises experts in other ministries on geological matters.

Under the vision, "Geology for Society", NGU must provide better maps and organise quality-assured geological information in national databases. Its activity is aimed at the following main objectives:

- Sustainable added value from geological resources
- Effective use of geoscience knowledge in land-use planning and development
- Better knowledge of geological development and processes in Norway
- Management and dissemination of geological data and knowledge



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