

BGR Report

Federal Institute for Geosciences and Natural Resources

Edition 2012



Okavango's heritage

How water resources in the Cuvelai-Etoshia-Basin in Namibia can be sustainably exploited

Editorial



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Hans-Joachim
Kümpel*

President of the Federal
Institute for Geosciences
and Natural Resources

Dear Readers,

Wide-ranging responsibilities, some surprising insights, fascinating field and laboratory work, exciting commitments on lakes and seas, and underground, often together with competent partners, are what characterised our fields of activity during the past year. Geotopics are in demand, as shown by the interest in society in general, by media coverage and by the requests for consulting services from policy makers and industry.

Everything you need to know in one compact booklet – that's the objective of the new "BGR Report". A new layout, revised content structure and key additional insights provide an even better overview of our work during recent years. "BGR Report" will appear annually in future and replaces the previous "Activity Report" and our "Resource" research brochure.

"BGR Report" is divided into three sections, describing the projects for 2012, including an Outlook at future tasks and, in a People section, providing an insight into the jobs and duties of BGR staff. Colour bars in each section allow fast and easy navigation.

I hope you enjoy a good read!

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‘Planet Earth represents the basis for all our lives
– its resources are limited.’

This is why BGR is committed to protecting the Earth’s biosphere and
promoting the sustainable use of natural resources.

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Shallow gas beneath the North Sea

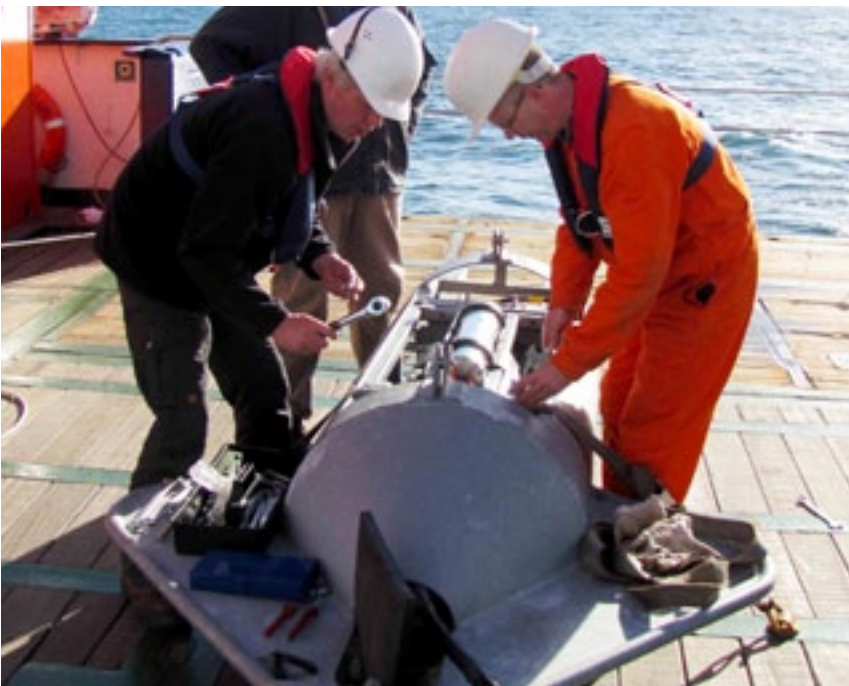
BGR has been investigating the geological history of the German North Sea since 2008. In September 2012, for the first time, a team employed new electromagnetic methods west of Heligoland island in a search for shallow gas reservoirs.

Seafloor natural gas reservoirs represent a profitable energy source, but may become a hazard when they occur only a few hundred metres below the seabed. BGR scientists led by Dr. Katrin Schwalenberg developed new methods and instrumentation to identify such gas reservoirs as well as other marine resources. In September 2012 the team tested two new surveying systems developed at BGR and the University of Toronto west of

Heligoland using the research vessel METEOR.

The scientists use the marine controlled source electromagnetic (CSEM) method. This exploration method images the electrical properties of the seafloor. Free gas is electrically resistive in contrast to conductive seawater which is normally found in the sediment pore space. CSEM can therefore be used to image and quantify gas filled sediments.

Schwalenberg and her colleagues are optimistic: preliminary evaluation of the CSEM data reveals a resistive layer which possibly indicates gas-bearing strata. This result is also in agreement with a seismic anomaly observed in the same region.



Launching the instrument platform 'pig'.

Preparation of the 'pig', carrying the CSEM transmitter, before deployment.

www.geopotenzial-nordsee.de

Contact: **Dr. Katrin Schwalenberg**

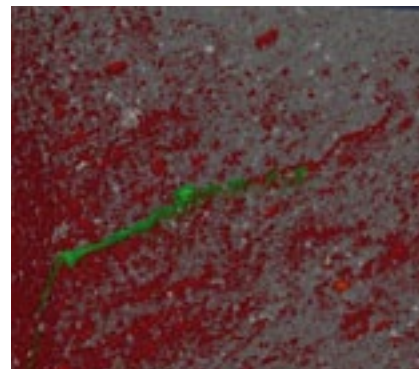
Shale with potential

BGR investigates oil and gas in shales for the NiKo project

Germany has a significant shale gas resource potential. Thirteen trillion cubic metres of natural gas are possibly hidden in three shale formations below northern Germany and the Rhine Graben.

This is the first result of the NiKo project, in which BGR scientists investigate the potential of gas and oil in shales in Germany. Sediments of Carboniferous, Jurassic and Cretaceous age in particular represent possible target horizons. Natural gas found in impermeable shales is a rather new resource and therefore shale gas is referred to as an unconventional resource. The USA already produces large amounts of gas from unconventional, covering much of their demand. The BGR study now provides a first assessment of shale gas resources in Germany.

The assessment is based on calculating the potential total gas volume in the rocks, called gas-in-place. The recent study estimates the gas-in-place volume at 13 trillion cubic metres. However, technically, only about ten percent of this gas-in-place would be recoverable today. That is around 1.3 trillion cubic metres, which is consi-



Computer tomography images of shales allow visualisation of density differences (left), pore spaces (red areas, right) and pore interconnections (green areas, right).

derably more than Germany's conventional natural gas resources of around 0.15 trillion cubic metres. The present database needs to be improved for a more detailed evaluation of the natural gas potential and further assessment of shale oil. Therefore, new potential source rock data are collected to characterise the organic material in these rocks, from which hydrocarbons may be generated under specific geological conditions deep down in the Earth's crust.

In laboratory experiments, the scientists also investigate how mobile hydrocarbons are in the various rocks. This depends primarily on the structure of the pore space. Pores in shales are very small and it is extremely

difficult to determine their properties. Therefore BGR mineralogists are using new analytical methods to study these ultra-fine pores. Together with colleagues from the Leibniz Institute for Applied Geophysics (LIAG) they are investigating how large the pores are and how they are interconnected. The data will provide new input parameters for further shale gas and oil resource assessments.

The BGR geoscientists also examine the hydraulic fracking method, which is a key technology to develop shale gas reservoirs. Fluids are injected with high pressure into the reservoir rock to create artificial fractures. Hydrocarbons locked in the impermeable shale can then migrate through these



Distribution of bituminous facies of target formations (grey area). Red hatched areas correspond to the assessment units where the screening criteria apply.

fractures into the wellbore for production. Modelling carried out by BGR demonstrates that hydraulic fracture propagation in the subsurface can be reliably predicted. The escape of fracking fluids from hydraulic fractures into neighbouring formations and groundwater aquifers can be prevented by adequate site-specific planning.

Contact: **Stefan Ladage**

Opportunities for investors

DERA scientists assess potential of raw materials in South Africa

South Africa is one of the world's most important producers and suppliers of mineral commodities. The reserves of platinum metals, gold, steel additives and industrial minerals are so large that the country will remain one of the world's most important producers for the foreseeable future. To support the German industry in its activities and investments in the South African mining sector, the German Mineral Resources Agency (DERA), as an integral part of the BGR, has maintained a cooperation with South Africa since November 2011 in the area of mineral resources. DERA is currently compiling an Investor's Guide, in which strategically important mineral commodities are analysed. 'The cooperation with South Africa is a vital component on the road to sustainable resource supplies for Germany', said DERA head Dr. Peter Buchholz.

For the Investor's Guide DERA and BGR scientists investigated heavy mineral sands, rare earth metals, antimony, fluorspar, chromite and platinum metals. Together with the Council for Geoscience (CGS – the South African geological survey), they visit mines and other potential deposits, collect samples for mineralogical and geochemical analyses and carry out data evaluation and literature research. During field work in May and September 2012 deposits of heavy mineral sands, rare earths and antimony were investigated. The results will be summarised in the first volume of the Investor's Guide, which will be available in autumn 2013. Chromite and fluorspar were investigated in March 2013 and the field work for platinum will follow in November 2013.

Additionally, DERA, in cooperation with the German Chamber of Commerce and Industry (AHK) for southern Africa and Ger-

Ash with class

Lignite ash contains valuable resources

many Trade and Invest (GTAI – Germany’s foreign trade and inward investment agency in Johannesburg), have prepared a general study about the South African mining sector and the investment conditions and opportunities for German companies in this area. Here, the experts compiled current data on metals, industrial minerals and coal. A total of 18 mineral commodities are characterised in terms of reserves, resources and production. The economic, political and legal framework of the mining sector in South Africa is also discussed in this study and the demand for German technologies and services in the South African mining industry is analysed.

Contact: **Dr. Herwig Marbler**



Source: A. Weitz (LBEG)

Lignite – a valuable resource.

More than one million tonnes of ash are produced annually in central Germany’s lignite-fired power stations. The residues remaining after combustion of the lignite contain transition metals and rare earth elements – including important industrial raw materials.

In the Urban Mining – Power Station Ash collaborative BMBF-project (Federal Ministry of Education and Research, BMBF), BGR and nine other research and industrial partners investigate methods suitable for recovering the substances from the ash.

In a register, the project partners record both the ash volumes accu-

mulated in the power stations, and the stocks in landfill and backfilled into exhausted pits. They also investigate which technologies are suitable for concentrating and separating the valuable metals. It is intended to employ chemical, thermal and biotechnological methods, such as leaching by special microorganisms. Finally, the project partners study how well the concentrates can be reused and which production processes are most suitable.

www.r3-innovation.de/karte.php

Contact:
Prof. Dr. Axel Schippers

Resources seal for high standards

BGR investigates success factors for certifying mineral resources

Currently, there is no certification system in place for mineral resources such as industrial metals. However, since 2008 BGR has supported the development of such a system for the Central African Great Lakes region. The objective is to restrict trade with what are referred to as conflict minerals.

Whether it is fish fingers, furniture from tropical timber or diamonds – certification systems are in place for many internationally traded goods and resources. Created in part thanks to consumer pressure, they aim to guarantee sustainable production, ethical standards or transparent trade routes. A quality seal often demonstrates the unproblematic origin of the goods – one example being the well-known MSC seal for fish from sustainable production. Currently, there is no certification system in place for mineral

resources such as industrial metals. Many conflict minerals still find their way onto world markets. BGR has been supporting the Central African Great Lakes region in establishing such a system since 2008.

In order to guarantee its effectiveness, BGR commissioned the Ludwig-Maximilian University of Munich to investigate which factors govern the success of an initiative for existing standardisation and certification initiatives. The scientists analysed eight systems, for

example the Kimberley process for diamonds or Fairtrade Labelling Organizations International (FLO), a fair trade umbrella organisation.

As was demonstrated, the success of FLO, for example, was primarily due to regular inspections (police patrols) by independent third parties, in order to guarantee adherence to the rules. However, sanctions, which can be imposed in the Kimberley process, for example, are not as effective. A strong steering body and a well-equipped secretariat have also proven to be important elements. The steering body can integrate relevant groups in decision-making, the secretariat ensures that decisions can be implemented timely and correctly.



Tin ore production in Rwanda.



Tin ore prior to processing.

Contact: **Dr. Gudrun Franken**

Weathered but precious

BGR scientists investigate unexploited platinum ores in South Africa

South Africa's Bushveld Complex is the world's largest deposits of platinum metals. However, some of the ores are heavily weathered and have not yet been economically exploited. BGR scientists look into technical solutions.

Around two billion years ago enormous volumes of magma ascended from the mantle below what is now South Africa. The liquid rock stayed in the crust and cooled to form a structure resembling a layer cake. In some layers metals such as ruthenium, rhodium, palladium, osmium, iridium and platinum are concentrated – the so-called platinum group elements (PGE).

These metals, which are chemically very similar, are resources that are now very much in demand, for ex-

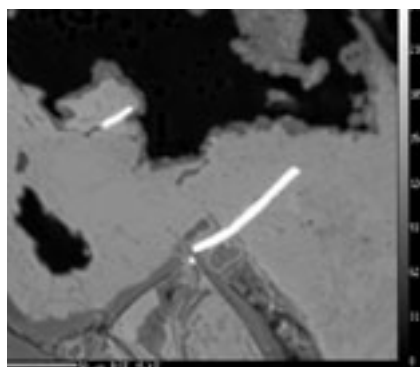
ample for exhaust catalytic converters or in the chemical and electronics industry. 70 percent of global PGE reserves are located in that enormous rock body in South Africa, the Bushveld Complex. South Africa is already the most important exporter of these coveted metals. However, some of the platinum ores, located close to the surface, are heavily weathered. These ores are currently not being mined and are simply stored on mine dumps, as their processing is still uneconomic. 'We don't know anything about the weathering behaviour of platinum metals', says BGR mineral deposits expert Dr. Frank Melcher. As the weathered ores still contain sufficiently high concentrations of technically extractable platinum metals, they may prove profitable. However, suitable beneficiation methods are not yet available. In the context of the GEOFLUXES collaborative project, Melcher and colleagues want to discover in which minerals the platinum metals concentrate during weathering. In the northern section of the Bushveld Complex, known as the



Source: S. Goldmann

Open cast mining in the South African Platreef. The weathered rocks close to the surface can be clearly recognised by their light brown colouring.

Platreef, they investigate both fresh and oxidised ores. They also carry out experimental investigations, in addition to field and laboratory work. They hope to model the path of the metals during weathering – and thereby discover how best to recover the platinum treasure.



Source: F. Melcher

Backscatter electron image of an oxidised platinum ore from the Platreef in South Africa. The lighter phases are platinum oxides in an iron hydroxide matrix (mid-grey) and iron-rich silicates (dark grey).

Contact: **Dr. Frank Melcher**

The treasure in the pipe

In the Vergenoeg deposit in South Africa, BGR scientists are investigating how deposits of high-tech metals form

Many high-tech metals are concentrated in minerals formed under complex geological conditions. To allow them to be economically exploited, BGR develops innovative concepts for deposit exploration, resource extraction and processing.

The rare earth metals, from lanthanum through europium to lutetium, are actually confusingly named. That's because the elements of the third subgroup of the periodic system of elements are not really rare. However, they only occur very rarely in concentrate deposits in the crust, making exploitation very difficult.

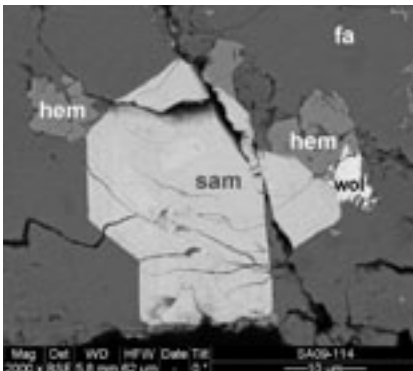
This is a problem, because some of the rare earth metals are coveted raw materials for modern electronics industry. Accordingly, they are current-

ly scarce on world markets. To date, China is the largest exporter of these metals by far. Raw materials experts around the globe are currently searching for alternatives. They include BGR scientists led by Dr. Torsten Graupner: They have set their sights on the Vergenoeg deposit in the north east of South Africa. This deposit is a volcanic pipe with a diameter of 600 to 900 metres, filled with minerals from great depths. To date, the mineral fluorite is primarily exploited. But experts have long discussed whether or not the deposit may also include large quantities of interesting trace elements, for example niobium, yttrium and rare earth metals.

Graupner and colleagues have now investigated the element distributions in a number of field campaigns, searched for enrichments and developed models to explain deposit formation. They want to discover where the most interesting elements may have concentrated. In addition, the isotope composition of the elements samari-

um and neodymium (both elements also form part of the rare earth metals) is investigated in order to constrain the enrichment processes and to determine the age of the deposit.

The initial results are promising: the BGR team discovered numerous typical niobium, yttrium and rare earth mineral phases. The scientists also demonstrated that these metals are very irregularly distributed within the deposit, but are more abundant in certain lithological units. In some minerals they discovered unusually high amounts of the heavy rare earths, which are particularly important for high-tech applications.



Scanning electron microscope image of a niobium-yttrium-rare earth mineral (sam-samaraskite) in mineralised rocks of the Vergenoeg deposit (wol-wolframite; hem-haematite; fa-fayalite).

Contact: **Dr. Torsten Graupner**

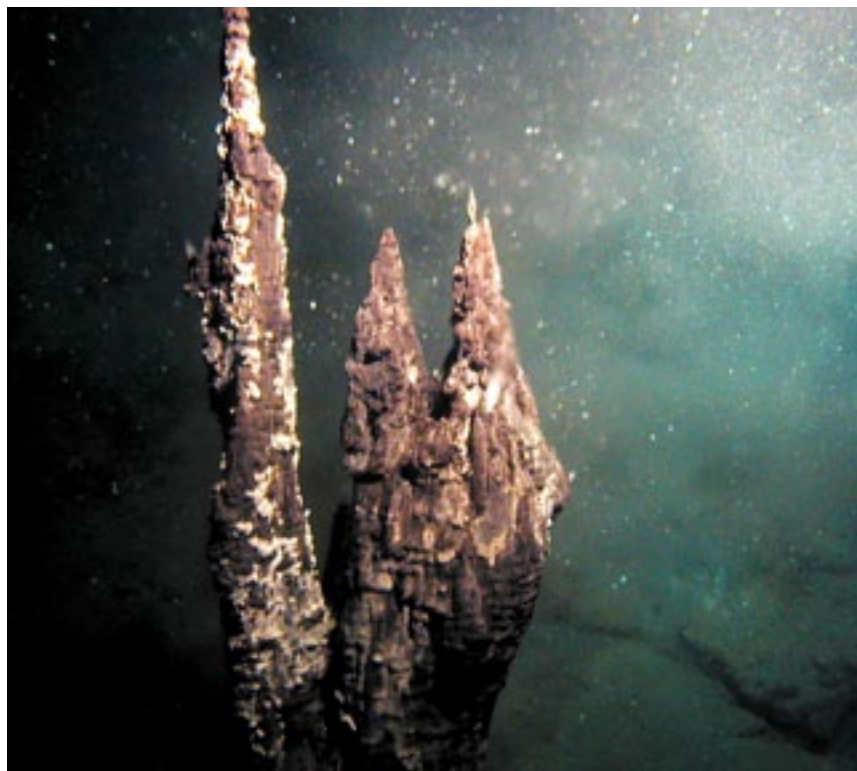
Searching for treasure in the Indian Ocean

BGR scientists explore the sea floor south east of Mauritius

BGR continued the search for mineral resources in the Indian Ocean during 2012. The aim of the INDEX 2012 expedition was to provide additional indicators as to whether it would be judicious to submit an application for an exploration licence for this region to the International Seabed Authority (ISA).

Copper, zinc, gold and silver – in autumn 2011 BGR scientists found these coveted metals on the floor of the Indian Ocean. In December 2012 the team led by Dr. Ulrich Schwarz-Schampera returned to the survey area south east of Mauritius to explore new sections of the south-east Indian ridge.

The scientists' destination was what are referred to as black smokers – hot springs on the sea floor, exuding both metallic ores and caustic fluids. Black smokers generally occur in small fields, in particular along what are known as spreading zones. Here, the tectonic plates forming the Earth's crust drift apart.



Black smoker in the Indian Ocean.

The scientists mapped an area 980 kilometres long and 65 kilometres wide. They also investigated deep sea environmental parameters and ecosystems. At a depth of 3,000 metres they discovered a previously unknown, now inactive field containing zinc- and copper-rich ores. The abundant fauna, typical of active fields, was absent here. 'We were able to considerably expand our knowledge of potential mineral resources in this part of the Indian Ocean', says BGR expert Schwarz-Schampera.

Contact:

Dr. Ulrich Schwarz-Schampera

The treasure in mining heaps

Valuable resources are hidden in mining and smelter heaps of the western Harz

Mining heaps represent a hazard to the environment but also a potential source of raw materials. How the contained residual substances can be sustainably processed and optimally utilised will be investigated by the ROBEHA collaborative project.

ROBEHA

Utilization of the raw material potential of mining and smelter heaps considering sustainability using the example of the western Harz region.

The Harz Mountains region was once one of Germany's most important mining districts. From as early as the young middle ages miners extracted silver, copper, lead and iron, later adding gold and zinc. As a consequence, numerous mining heaps are dotted between the mountains of this range – artificial hills, containing the waste from the mines and the slag from the smelters.

Because the worldwide demand for resources has increased drastically in recent years, the previously neglected resource deposits are now in the sights of the raw materials experts – as a potential source of non-ferrous metals, high-tech metals and construction aggregates. BGR scientists will investigate mining heaps in several Western Harz mining districts as part of the BMBF-funded



Installing electrodes for a geophysical survey of a mining heap in the western Harz.

(Federal Ministry of Education and Research) ROBEHA collaborative project. The scientists intend to carry out more detailed investigations on one or two promising mining heaps in order to discover whether the residues can be economically re-processed.

The problem: mining heaps are extremely heterogeneously structured. In order to successfully recover metallic resources the mining heaps contents must be characterised in detail. Innovative exploration methods and processing technologies are required to facilitate this. BGR's



Sampling a mining heap by means of percussion coring.

duties within the project consist of analysing samples geochemically and mineralogically and characterising the recoverables. BGR also works on improving geophysical methods in order to investigate the internal structure of the mining heaps as economically as possible. Finally, the results are evaluated in an economic assessment.

Contact: **Dr. Ursula Noell**

Technical cooperation project: Introduction and implementation of a certification system for mineral resources (DR Congo)

Difficult conditions in the Congo

BGR supports government in resource certification system

The Bibatama Mine in the Democratic Republic of Congo is barely more than a mud pit. Mining operations all over eastern Congo are similar to here in the province of North Kivu: the local population dig for ores such as coltan, cassiterite, wolframite and gold at their own risk. Experts talk of 'unregulated and informal small-scale mining'. Nobody knows exactly how much ore is produced from these mines or what its destination is after being sold. However, after years of war and mismanagement, income from resource trading may even enable the rebuilding of this republic in the heart of Africa.

To help establish transparent and responsible supply chains, BGR supports the Congolese mining ministry in developing and implementing a certification system. The objective is to register ore volumes, track ore origins, improve working conditions in mining and secure tax income for the state.

In the first part of the project a working group in Kinshasa developed



Tunnel entrance in a tin mine in Nyabibwe, South Kivu province.



Separating tin ore using magnets, Lulingu, South Kivu province.

a national certification system with BGR support, which was implemented in law in the Democratic Republic of Congo in 2011. As the project progressed mine site evaluations were carried out for pilot sites. The first audits could not begin until the end of 2011 due to the poor security situation. Compliance audits performed to examine adherence to regulations, took place in early 2013. It was possible to certify the first mines by the middle of the year. Project Manager Uwe Näher is satisfied: 'The working conditions in some pilot mines have already improved.'



Woman washing ores, Manono tin mine.

Contact: **Antje Hagemann**

A world in turmoil

When resources become scarce, political tensions may increase. BGR analyses the risks together with research institutions from other European countries



Open cast chromite ore mining in South Africa.

How will the world differ in 2040? Will China be the ruling economic power, or will the international community disintegrate into numerous blocks, chiefly powered by internal trading? The EU POLINARES (POLIcy for NATural RESources) project addressed such questions between 2010 and 2012.

The project focused on resources – oil, gas and mineral resources. Scientists from twelve European institutions investigated how changing demand and supply issues may lead to tensions in the future and what the risks are for the European economy, in particular. ‘From a geological per-

spective, no bottlenecks are anticipated’, says Dr. Henrike Sievers from BGR. The scientist led a working group analysing the availability of and demand for the most critical resources. However, Sievers can’t sound the all clear: ‘The greatest risks for supplies to the EU depend more on geopolitical factors.’ In terms of metallic resources, in particular, the EU is entirely dependent on imports of raw materials like rare earths, vanadium, magnesium, cobalt and platinum metals, to name just a few. A large share of the global production of these raw materials may be located in countries without a market economy or that are politically unstable. Sievers and her

colleagues therefore assess possible supply risks with the aid of indicators such as import reliance, country production concentration or the political stability of the supplier nations.

The scientists draw several conclusions for mineral resources. For example, the price structure will change in future due to the increasing demand from emerging nations. Price fluctuations will be more common. Recycling, according to one of the results, will not be sufficient to cover the increasing demand. The substances regarded as critical can quickly alter depending on the political situation and technological developments. According to the scientists, long-term forecasts on the criticality of raw materials are not possible, meaning that the situation must be regularly analysed.

www.polinares.eu

Contact: **Dr. Henrike Sievers**

Full speed ahead for GeneSys

The salt plug blocking the Groß Buchholz Gt1 well is cleared

BGR's GeneSys geothermal energy project aims to demonstrate that geothermal energy can even be produced from northern Germany's deeper rock strata. The well, located in Buchholz, Hannover, and blocked by a salt plug since 2011, is now clear again.

Some parties had already given up on the GeneSys geothermal energy project. Production of geothermal energy from a depth of 3,900 metres at the Hannover GEOZENTRUM was threatened with failure, because precipitated salts had blocked the well. Hot water pumping was no longer possible. However, things took a turn for the better in November 2012: The Dutch company Coil Service was able to remove the plug and recall the well to life.

The engineers forced fresh water into the well through a flexible tube. They

were thus able to dissolve and remove the salt blocking the production string between 650 and 1,300 metres. They then filled the well completely with fresh water to prevent further salt precipitation. So GeneSys may yet be a success story after all. In 2009 the well had already reached a depth of 3,901 metres, where the temperature, at 170 degrees Celsius, was substantially higher than anticipated. However, hydraulic testing revealed that the rock was relatively impermeable. To produce geothermal energy with the aid of hot water it is necessary to create artificial flow paths.

This happened in May 2011 by means of massive hydraulic stimulation, also referred to as fracking. As many as seventeen high pressure pumps forced a total of 20,000 cubic metres of water into the well for five days. In contrast to fracking operations of the petroleum industry, only pure water containing neither proppants nor chemicals was used. The operation presented no technical problems. With the exception of some unavoidable noise during

daytime, no nuisance was noted in the immediately adjacent residential area. The fracking process generated a crack surface of around 0.5 square kilometres at depths between 3,500 and 3,800 metres, with high hydraulic permeabilities. However, when the injected and now heated water was pumped to the surface again in November 2011, unanticipated salt precipitation occurred.

The well is now clear again down to a depth of 3,700 metres. Additional tests will clarify whether repeated freshwater injections can flush the salt from the adjacent rocks. Moreover, the BGR scientists aim to investigate how much geothermal energy can be extracted from the rock via the generated crack surface.

www.genesys-hannover.de

Contact:

Dr. Johannes Peter Gerling



Wellhead being prepared to flush the well clean.

Transparency in Insheim

BGR monitors commissioning of geothermal power station

Development of geothermal energy at risk due to weak earthquakes close to geothermal power stations. BGR develops new monitoring methods for the MAGS project, together with project partners, and evolves concepts for mitigating microseismicity.

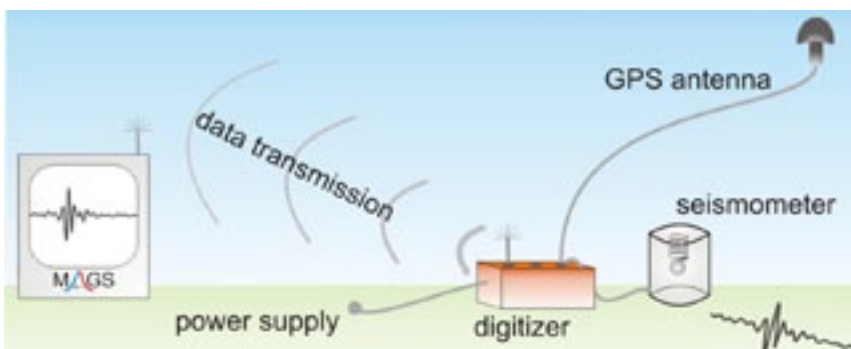
In November 2012 the second industrial scale geothermal power station in the South Pfalz region (Germany) was commissioned in the small town of Insheim. The Pfalzwerke geofuture GmbH pumps hot water with a temperature of 160 degree Celsius from a depth of 3,600 metres to the surface in order to generate heat and electricity.

Because earthquakes up to magnitude ML 2.4 occurred in neighbouring Landau from operating the geothermal power station, the public has become sceptical of the power station. BGR therefore monitors the commissioning process as well as subsequent operation in the context of the MAGS research project. To facilitate the best possible

transparency, a scientific monitoring network consisting of eight seismometers has been installed in the Insheim region since August 2012. It records the very smallest vibrations, not even perceptible to people, from deep inside the Earth. The data are transmitted to BGR in real-time and can be viewed online.

Using the collected data, the MAGS project scientists aim to develop an automatic evaluation algorithm to calculate the strength and location of an earthquake in real-time.

Later, the power station operators will have information on the seismic hazard during stimulation at their fingertips – and can react immediately if seismicity exceeds a given threshold.



Schematic drawing of mobile station configuration around Insheim: ground movement is registered at the seismometer. The digitiser transmits the data to the BGR data centre in real-time.

Operating seismic monitoring station. The box is closed following installation or servicing. The monitoring stations continuously record ground movements and send the data to BGR.



www.mags-projekt.de

Contact: **Margarete Vasterling**

Verification following the test

Two BGR scientists being trained to be CTBTO inspectors

Nuclear weapons tests have become rare in recent years. North Korea was the last country to enter the spotlight because of suspicious underground explosions. The Comprehensive Nuclear-Test-Ban Treaty (CTBT), passed by the UN General Assembly in 1996, aims to prohibit nuclear weapons tests of all kinds. However, it has not yet come into force, because not all nations have signed or ratified it. The monitoring organisation, CTBTO (Comprehensive Nuclear Test Ban

Treaty Organisation), with headquarters in Vienna is still a provisional organisation, but has been developing a global monitoring network since 1997. Its aim is to monitor compliance with the treaty in the future and it is already capable of tracking down any possible treaty violations.

In the meantime, almost 300 monitoring stations are in operation, registering seismic or infrasound waves, for example, caused by nuclear explosions. If the monitoring system cannot verify a test without a shadow of a doubt, the international community has a last resort for verifying a possible treaty violation: the on-site inspection, OSI. A team of inspectors travels to the suspect region for monitoring.

The inspectors carry out a number of investigations. Among others, they monitor aftershocks, search for surface signatures indicative of underground tests, measure concentrations of radioactive substances or employ geophysical methods to track down cavities or changes in the water table, for instance. Two BGR scientists, Nicolai Gestermann and Malte Ibs-von Seht, have been undergoing a three-

year OSI inspector training schedule since 2010.

On two to three training courses per year, together with 64 other delegates from around the world, they learned about the rights and obligations of inspectors, role-played through possible scenarios during an inspection and practised geophysical survey methods in terms of their applicability during an on-site inspection. In practical field exercises in Austria and Hungary they sharpened their communication, navigation and sampling skills. During the winter of 2014 an integrated field exercise in Jordan is planned to complete the training. The aim is to run through all phases of an inspection under realistic conditions.

Health and safety of the inspectors during an on-site inspection has the highest priority and is trained again and again. Special clothing, as seen in this image, is used to protect the inspectors against any possible hazards from radioactive substances in the inspection area.



Contact: **Nicolai Gestermann**

World in motion

BGR scientists involved in the EU Terrafirma project measure subsidence in North Germany with millimetre precision

Slow land subsidence and uplift continue to be very difficult to monitor. The EU Terrafirma project aims to create a European information service that will identify such ground movements using satellite-borne radar. BGR scientists investigate which areas of the marsh in the Elbe-Weser region are endangered by flooding.

Flat, green meadow, as far as the eye can see: this is what marsh looks like, North Germany's typical landform. The flat, alluvial terrain, a mixture of loam, tidal mud and fine sand washed up by the sea, and peats, is a postglacial feature.

This barely consolidated soil continues to settle to this day – especially when heavy structures are placed on it. In the north of Bremerhaven, for example, the ground subsides by up to seven millimetres per year. The house fronts in some residential areas are covered in cracks. In many places the ground beneath our feet is really not as solid as it appears to be. Not only sediment consolidation can, with time, force the surface of the Earth up or down by a few millimetres or even centimetres, the pressure exerted by tectonic plates, the magma beneath a volcano or mining activities can have the same effect. This up and down can present

hazards: because it is subsiding, the marsh around the Elbe and Weser rivers, for example, is becoming more susceptible to flooding. In mi-

earthquake-prone region may, under certain circumstances, be recognised in advance based on ground movements.



Residential area in Bremerhaven: cracks and tilted buildings as a result of insufficient foundations in the marsh sediments.

ning districts such as the Ruhr, subsidence may indicate where an abandoned mine is in danger of collapse. Landslides may also be indicated in advance by slow soil creep. And the increase in tectonic stress in an

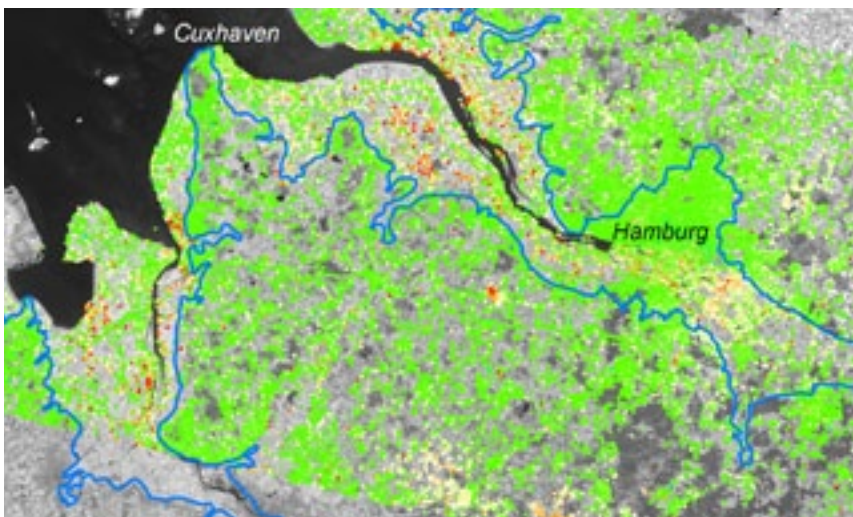
BGR works with partners from around Europe in the EU Terrafirma project to develop an information service to identify, assess, investigate and monitor such ground movements. The project is part of the EU

Copernicus programme, which is intended to create a modern infrastructure for Earth observation and geoinformation services. To track the barely perceptible pulsing of Earth's surface, the scientists employ the persistent scatterer interferometry technique (PSI). To do this, they utilise data from the European radar satellites ERS-1 and ERS-2, which have been available since 1992. The satellites have already scanned some areas more than 100 times, using radar waves, and recorded the reflection data. The radar signal is most intensely reflected by objects on

ted with a precision in the millimetre range.

A method known as wide-area processing (WAP), allowing larger regions than previously possible to be analysed, is being tested as part of the Terrafirma project. BGR scientists Corinna Wolf and Dr. Friedrich Kühn have taken on the task of investigating the data provided by German Aerospace Centre (DLR) for the North German Plain, in particular the marsh around the Elbe and Weser estuaries. The scientists examined the data for plausibility and

a million points suitable for the PSI method were located on an area of 21,000 square kilometres. The result of the survey: the inland Geest ridge appears predominantly stable. Large sections of the marshes, however, are subsiding by between one and seven millimetres per year. The cause is assumed to be the consolidation of the marsh sediments. For example, the Bremerhaven urban area is particularly strongly affected, where the very weak building ground is subjected to heavy loading. The scientists noted additional subsidence in regions where natural gas is produced or underground storage facilities are in operation.



PSI motion data in the investigation area: subsidence in marshes along the Elbe and Weser rivers (green: stable ground, yellow/red: subsidence, blue line: boundary between marsh and Geest).

Earth's surface, such as buildings, industrial installations, bridges and electricity pylons. For these fixed reflectors, providing a stable signal during the entire monitoring period, ground movements can be calculated

carried out a geological interpretation of regions with high motion rates.

For this they analysed a total of 191 ERS-1 and ERS-2 images, recorded between 1992 and 2001. Around half



www.terrafirma.eu.com

Contact: **Corinna Wolf**

From numbers to images

BGR scientists aim to enhance the usability of airborne geophysical data

Extracting illustrative information on the subsurface from an extensive data set can often be a difficult task. In the AIDA collaborative project, BGR works with several partners to achieve this objective: geophysical survey data are successively converted into useable information. BGR focuses on helicopter-borne electromagnetic methods.

Helicopters and aeroplanes are popular with geophysicists, because airborne surveys allow for fast acquisition of detailed information using a variety of measuring instruments simultaneously – and covering large areas. One important parameter, for example, is electrical conductivity. This geophysical parameter provides an indirect indication of subsurface structures. For instance, high conductivity values indicate saline groundwater or clays in the ground. However, data interpretation is often ambiguous. This makes it more difficult for the users – for example structural geologists, hydrogeologists or engineers – to develop geological models.

In the AIDA (from Airborne Data Inversion to In-Depth Analysis) project, BGR and the project partners develop methods to successively convert geophysical data into user-oriented information. Using numerical methods, spatial structures are

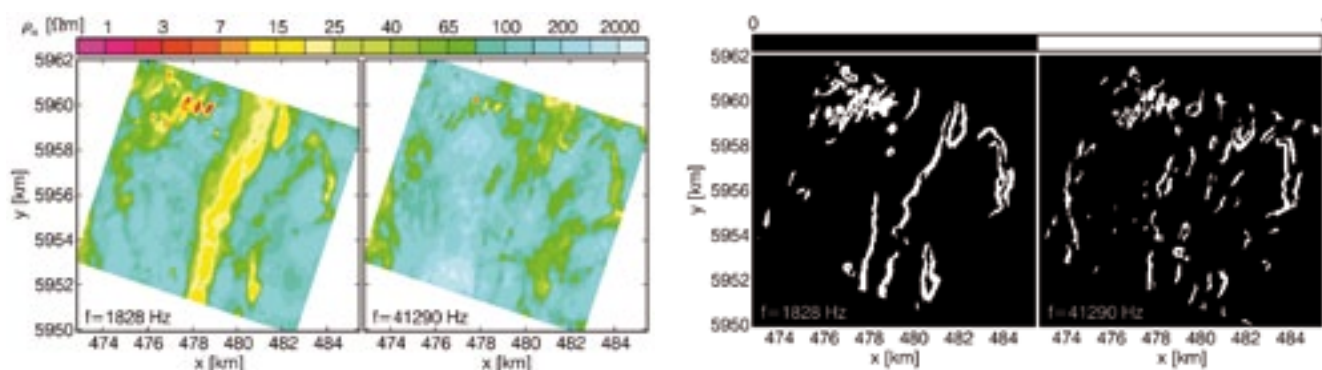
visualised in three dimensions, for example. BGR's project task is to combine various modelling approaches to analyse the helicopter-borne electromagnetic (HEM) data. The scientists, led by Dr. Bernhard Siemon, utilise existing data from areas already extensively investigated, both by airborne and ground based geophysics, such as seismic or down-hole logging.

Helicopter-borne electromagnetic methods are already fairly well optimised in order to determine electrical conductivity as precisely as possible. The objective now is to optimise data interpretation. To obtain a model of the subsurface from the data geophysicists use a method referred to as inversion: firstly, they specify a simple model and calculate the data expected for this given case. By comparing those data to the true data, the model is successively improved until both data sets coincide. However, airborne electromagnetic

surveys often acquire such extensive data volumes that the entire 3D inversion of a large investigation area is no longer practical.

Common practice in helicopter-borne electromagnetics is currently to develop inversion models for one dimension only. Hence, the scientists obtain the conductivity distribution in the subsurface beneath a given point. The conductivity for the entire area is visualised in three dimensions by merging several 1D models. This method only works if strong lateral conductivity contrasts are absent in the subsurface. The BGR scientists Angelika Ullmann and Dr. Bernhard Siemon are now developing methods to automatically detect such contrasts. The resulting anomalies are then modelled in three dimensions and integrated in the regional model. Inversion results can be improved if additional information on the subsurface is considered in the models – for in-

Automatic detection of areas (right) which are not 1D interpretable (white) derived from HEM results (left, in this case: half-space resistivity in the region of the Cuxhaven buried valley at two system frequencies, i.e. at different depths).

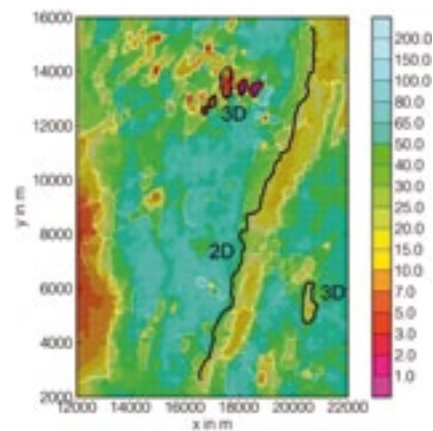


stance geological information based on borehole data. The BGR scientists are developing a new program package that integrates additional datasets in the inversion. Finally, the program, called HEM1D+, merges all results to a consistent result. The program has a practical GUI, which controls data import and export and combines various models. The team anticipates two improvements: the 1D inversion of the HEM data will be more precise due to the use of external data and complex structures can also be more easily interpreted if 1D and 3D models are combined.

One beneficiary would be industry, where airborne geophysics has been used for years in exploration. The aim is to provide German industry with an economic advantage by means of improved analysis methods.

www.geotechnologien-aida.de/

Contact: **Angelika Ullmann**



Classification of HEM results (in this case: half-space resistivity in the region of the Cuxhaven buried valley) in local anomalies (3D) and linear anomalies (2D).

The search for salt water

The D-AERO project investigates where salt water may enter aquifers along the North Sea coast

Coastal aquifers around the world are threatened by salinisation as a consequence of climate change. The Elbe and Weser estuaries are also affected. BGR investigated this area via helicopter as part of the D-AERO project. The objective of the geophysical surveys is to investigate the distribution of freshwater versus salt water.

Saline groundwater is widespread in Lower Saxony and Schleswig-Holstein. Further inland, the main contributors are shallow salt domes. Additionally, saline seawater has displaced fresh groundwater in a broad strip along the North Sea coast. Future climate change may lead to salinisation of additional large areas, for example around the Elbe and Weser estuaries. If sea level rises, the water level in the rivers will also rise, and their brackish water may penetrate surrounding aquifers.

Hydrogeologists estimate the likelihood of this hazard with the aid of geological models and hydraulic flow models. To form the basis for this they require data on the structure of the subsurface and where the groundwater-bearing strata, referred to as aquifers, are located. BGR scientists, in cooperation with the State Authority of Mining, Energy and Geology and the Leibniz Institute

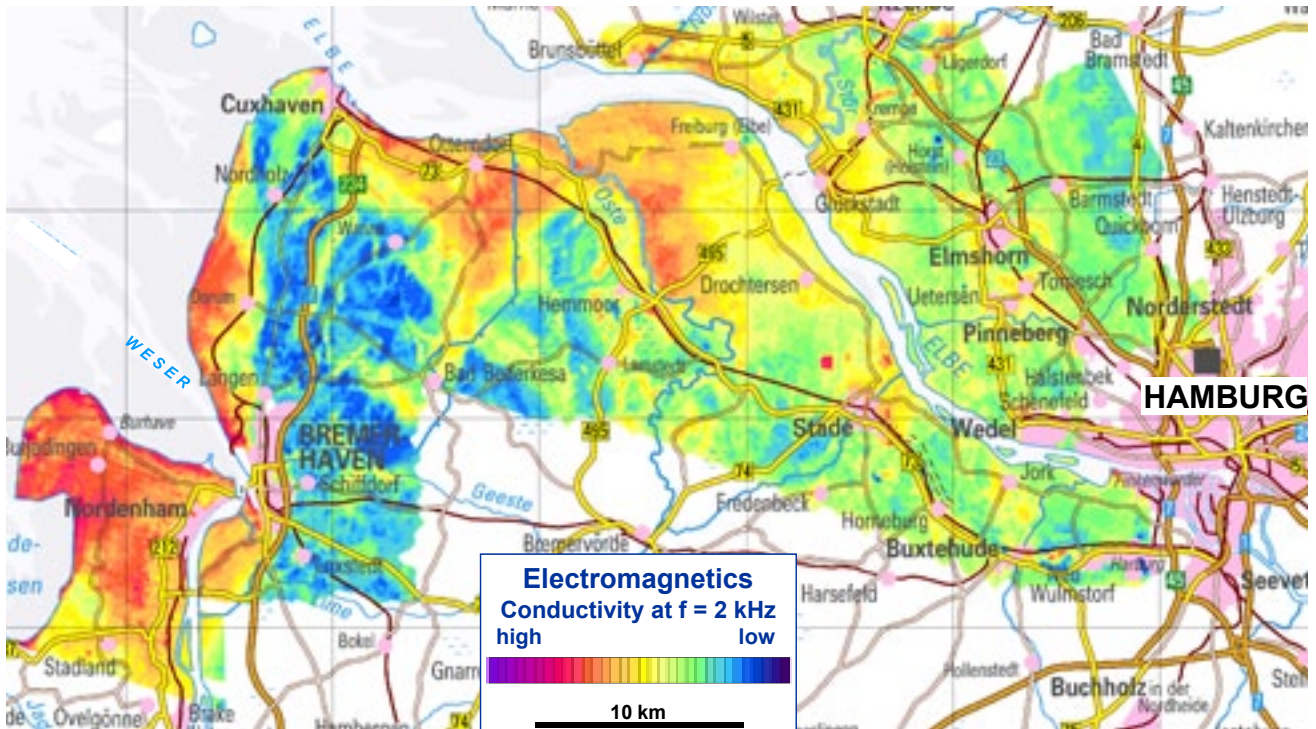
for Applied Geophysics are currently investigating the subsurface in the Weser-Elbe region as part of the D-AERO project. BGR's survey helicopter has therefore recently been out and about north of Hamburg and Bremen. Its job was to map the sediments in the uppermost hundred metres of the subsurface over a wide area. The scientists hoped to discover how sandy and clayey sediments are distributed in the subsurface and where salinisation zones and freshwater regions are located.

The BGR experts are using three different geophysical methods for the D-AERO project: electromagnetics, magnetics and radiometry. The magnetic and electromagnetic sensors are housed in a ten metre long, cigar-shaped tube, which is towed by the BGR survey helicopter in parallel lines approximately 30 metres above the ground. The third instrument, a gamma-ray spectrometer, is installed

in the helicopter, flying at 70 to 80 metres altitude. During the surveys electromagnetic signals at various frequencies, penetrating to different depths, are generated. The result obtained is the electrical conductivity, which in turn allows the type of rock and the groundwater salinity to be determined.

The scientists can differentiate various sediments at the surface with the aid of radiometry. Because the marine sediments in the marshes contain a lot of radioactive potassium isotopes, for example, they are characterised by high natural gamma radiation. Sands, and high moors in particular, have lower natural radiation.

The results of the electromagnetics survey also coincided with the geological map. Sand has a lower electrical conductivity than boulder clay or clay. In the survey data the glaci-



The electrical conductivity distribution reveals salinisation zones (red) and predominantly clayey (yellow) and sandy (blue) regions.

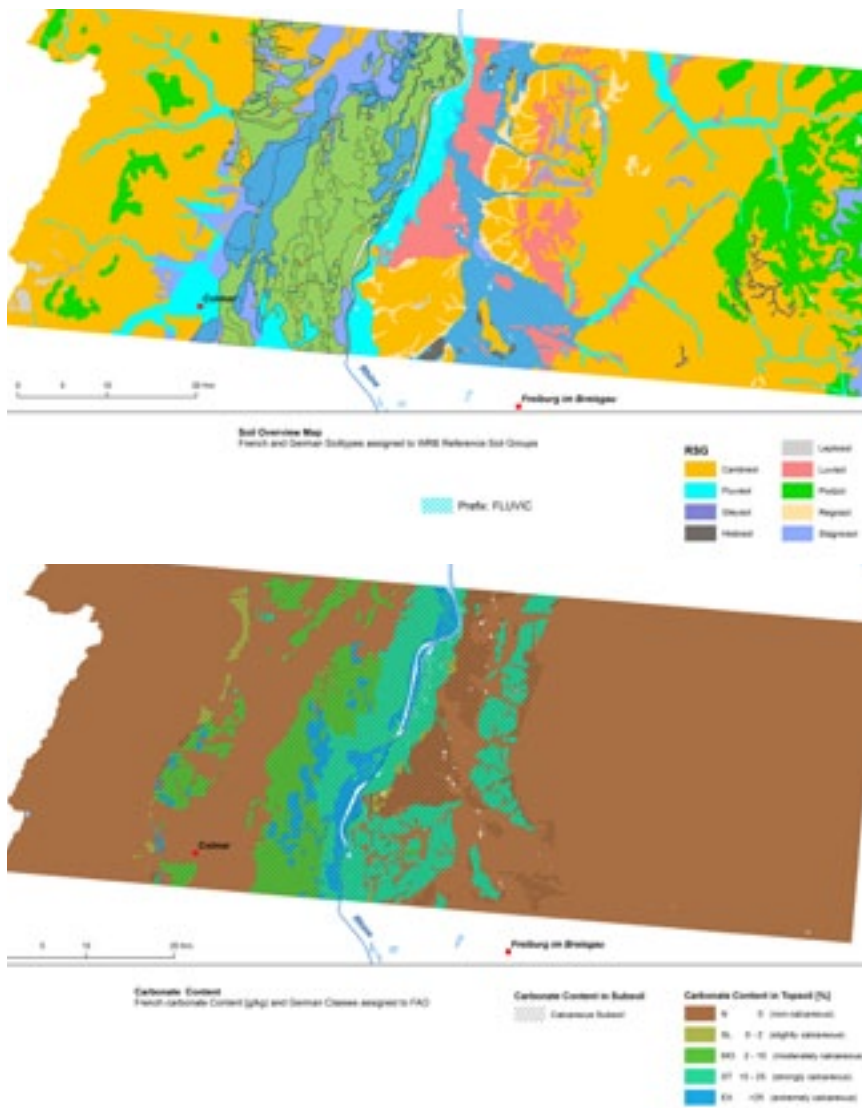
al moraine sediments of the Geest ridge, consisting predominantly of sand, are therefore clearly differentiated from the more conductive marsh sediments, due to their low conductivity. The scientists were also able to identify landfills or regions with saline groundwater at shallow depth. The surveys also revealed saline groundwater and Quaternary channels at greater depth. These are depressions in the subsurface, incised into deeper sediments during the last ice age and now often filled

with clay. They were recognised by their moderate to high conductivity. The magnetic surveys predominantly produced data on the structure of the North German Basin to depths of several kilometres. Once this data was processed, however, shallower structures were revealed, for example the flanks of the Quaternary channels or salt domes.

The subsurface structure can now be modelled in detail using all three

datasets. These geological models are not only very useful to hydrogeologists, they can also be used for regional planning or water pollution control concepts.

Contact: **Dr. Uwe Meyer,**
Dr. Bernhard Siemon



Cross-border harmonisation of soil maps: soil type according to international soil classification WRB (top), and carbonate content according to the FAO-field manual for soil profile description (bottom).

se were differently defined, others, such as pH, for example, used different measuring methods; in some cases, parameters were missing. On the combined cross-border map that the two of them developed together, the Franco-German border therefore remains clearly recognisable. 'At the technical level, we have successful-

ly amalgamated the data. Content harmonisation, however, cannot be achieved with the help of the international soil classification alone', said Annett Pätzold.

To allow soil data to be exchanged more easily in future, at least within Europe, the BGR scientists developed

an easily understandable instruction manual – a type of cook book. 'Exchanging soil data between institutions is difficult, because everybody has their own data structures', explains INSPIRE soil expert Dr. Einar Eberhardt from BGR. The scientists have developed an open data exchange format, through which the content of a wide range of soil databases can be transformed into a standardised structure. It includes instructions on how to convert data from in-house databases into this format. This will guarantee technically correct data exchange. The scientists oriented themselves on a recently developed concept for soil exchange developed by an International Standardization Organization (ISO) working group, and successfully developed it further into an operational solution. 'The text of the corresponding ISO DIS 28258 is highly technical, however', says project leader Baritz. The BGR scientists have therefore drawn up the cook book as a manual to simplify the application of the standard. It will be published in autumn 2013 together with the international standard.

Contact: **Dr. Rainer Baritz,**
Dr. Einar Eberhardt

Soil database with extra benefit

The EU e-SOTER project investigates how digital environmental data can be exploited for soil mapping

Soils are the Earth's living skin. Government agencies and scientists need comprehensive information on their properties to facilitate their sustainable use. Such data is often not available, neither in Europe nor globally.

In the e-SOTER project, BGR scientists around Dr. Rainer Baritz have now developed an efficient method to integrate terrain data with local soil knowledge. The primary data sources are geology and relief.

The classical methods for collecting soil data are ponderous and expensive: field mapping takes a lot of time and traditional processing in printed map format with corresponding tables is no longer state of the art. Users are now looking for digital soil data to download from the Internet.

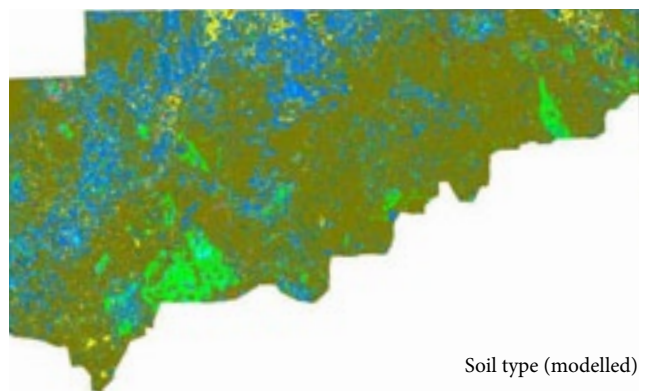
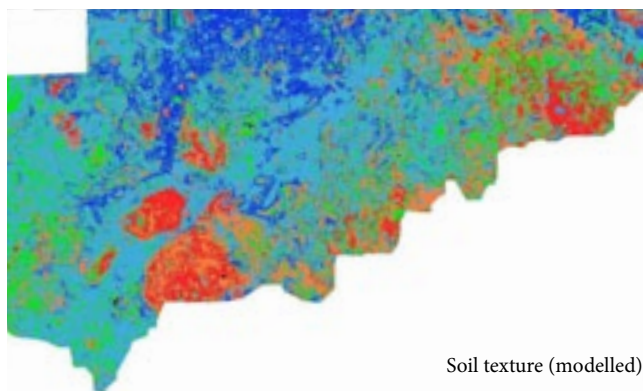
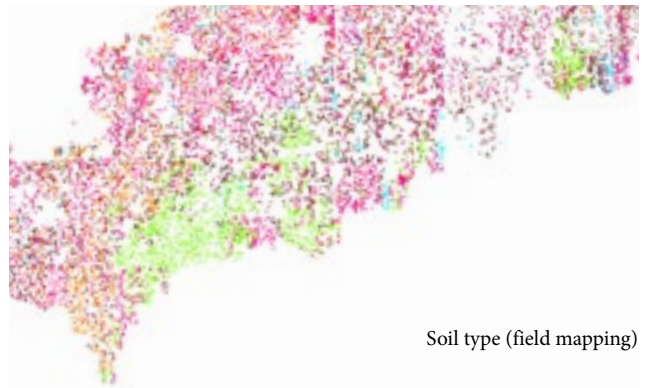
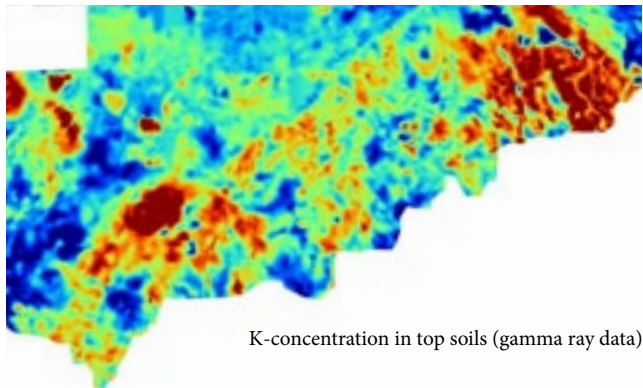


Geomorphographic map, sheet Fes (Morocco).

The original SOTER concept has its origins in a set of 1980s mapping instructions. The scientists led by Baritz adopted up-to-date digital, baseline relief data from elevation models. Geological data was taken from existing geological maps. 'If relief and geology are superimposed, the resulting spatial units are meaningful, but need further refinement so that the dominating soils are correctly represented. Thus, regional information about the formation of soils under specific physio-geographic conditions is also needed', said Jan Willer, pedologist and GIS modeller at BGR. If this information is available, mapping blanks can be filled using this new method, for example for a new soil map of Europe at 1:250 000 scale. Regions with a considerable lack of data, for example Africa, can at least be draft-mapped to allow pedological field work to be efficiently planned.

In cooperation with the Saxon State Office for Environment, Agriculture and Geology and other project partners, the BGR scientists have tested the new method based on the 1:250 000 Chemnitz sheet and the Fes, Morocco, sheet. The data situation for the German-Czech pilot region around Chemnitz was extremely good, even including geophysical airborne survey data. In Morocco, in contrast, there is an acute lack of data. The e-SOTER method was to be explicitly tested in two contrasting data environments.

The BGR scientists concentrated in particular on improved parent rock mapping. Soil maps often deviate from geological maps on this point, because the shallow source rock has been altered by weathering and redistribution. A focus of the BGR work was to uniformly record and represent the rock data. Currently, two



Example maps for modelling in the Chemnitz sheet (Saxony section).

rock classifications are used in Europe for pedological purposes. One is the European Soil Bureau Network, and the other is a United Nations Food and Agriculture Organization (FAO) system. ‘Neither of these classification systems is intrinsically consistent’, says BGR expert Dr. Ulrich Schuler. Moreover, geological map legends cannot be simply reinterpreted for soil mapping. Schuler has now revised the FAO parent rock classification and presents the draft for discussion in scientific circles.

The methodological results of the e-SOTER project will be integrated in a global soil information system, providing soil data from a variety of origins in a web services format. ‘BGR pedology intends to participate more actively in the development of the GEOSS global earth observation system, in particular by the provision of baseline data and transformation tools’, says Dr. Rainer Baritz, head of the BGR groundwater and soil information systems unit. ‘The new methods represent the cornerstone for

this.’ In regions where data is scarce the digital soil maps may open up whole new perspectives – for example, they may facilitate modelling of the consequences of climate change for land use.

Contact: **Dr. Rainer Baritz**

Soil facts in a flash

BGR wants to raise awareness for the importance of soil, a vital resource

Soils are one of the most important factors facilitating human life. They are densely populated environments, produce foodstuffs and protect our groundwater. However, the public is only vaguely aware that soils are both valuable and endangered. To change this situation, BGR is targeting the youngest members of society – in a playful way.

Today, every child knows that water, air, plants and animals need to be protected against pollution. The soil below our feet, in contrast, gets very little attention. ‘Policy makers and the public are currently only insufficiently aware of increasing soil contamination and threats to the soil’, says Klaus Kruse, BGR soil scientist.

And this is despite the fact that healthy soils are at least as important as clean air and water. But numerous hazards threaten the natural resource that is soil: erosion, com-

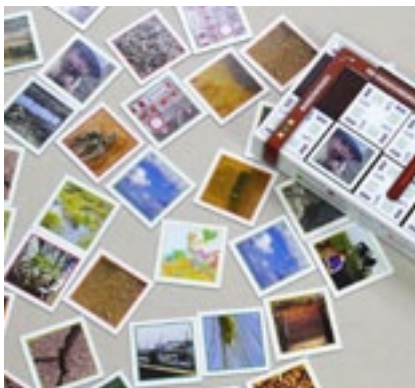
paction, pollutants, acidification, salinisation and sealing mean that more and more valuable soil is lost. ‘Every day in Europe alone, we consume an area larger than the city of Berlin for urban and transport uses’, says Klaus Kruse. Soil erosion is one of the greatest global environmental problems.

BGR has now adopted a new approach to firmly anchor the topic of soil in people’s minds, Kruse reports: ‘Soil scientists really need to cooperate closely with educators.’ Sensitisation and awareness-raising must begin very early – preferably at kindergarten age, because: ‘We generally tend to protect what we know’, says Kruse. ‘Soil education in schools and for the public is therefore absolutely necessary if we are to conserve soil as a valuable resource’.

‘Children often have a completely different perspective on nature than us adults’, says Kruse. ‘They turn

over every stone and want to know what it is that is crawling around in the grass or the compost heap.’ Children initially learn about the world through playing, but with increasing age they begin to think things through and arrive at their own conclusions. ‘By using practical games, and attractive teaching and demonstration materials, we can raise their awareness of the environment and the soil’, says the BGR scientist.

BGR, State Authority of Mining, Energy and Geology (LBEG) in Hannover and the Federal Environment Agency (UBA) in Dessau are now working in unison on this. The three institutions have developed a memory game based on flash cards, with the German title *Bodenwissen im Handumdrehen* (Soil facts in a flash). 24 pairs of pictures show the soil’s multitude of functions. Among other topics, they deal with soil’s relevance to the global climate, or how



Memory game: Soil facts in a flash.



BGR president Prof. Dr. Hans-Joachim Kämpel (right) with the State Authority of Mining, Energy and Geology (LBEG) president Ralf Pospich and Bundesverband Boden (BVB) president Prof. Dr. Gabriele Broll at the joint presentation of the new game on 15 March 2012 in the Berlin Natural History Museum.

soil forms – how rocks weather, how humus gradually develops from a layer of leaves or a moor from bog plants. Aesthetics also play an important role. Cross-sections through various soils, with their finely interlaced brown tones, are reminiscent of abstract watercolours. The game brings fascinating treasures to light: for example a moorland corpse from the Emsland, known as Red Franz, or the European soil map. Others show soil researchers at work.

‘It is important that our children learn that there is more than just

simple dirt beneath our feet’, Nicole Engel from LBEG emphasises. They should also know that a handful of earth contains more organisms than there are people living on earth – and especially that soils cannot be propagated, and that erosion or soil sealing can cause permanent destruction. Because flash cards alone cannot provide all this information, the game is accompanied by an eight page brochure, describing the pictures in easily understandable sentences. This all aims to serve as encouragement for continued interest in the soil. This plan appears to

have come to fruition. The soil memory game, available free to schools, kindergartens and other educational institutions in the environmental field, was out of stock after only a few months. Klaus Kruse promises: ‘A new supply will soon be available.’

www.bgr.bund.de/boden-memo

Contact: **Klaus Kruse**

Well protected underground

BGR scientists develops guideline for artificial groundwater recharge

In Jordan, water is an extremely scarce resource. One strategy to combat water scarcity consists of recharging overexploited aquifers with excess rainwater. BGR hydrogeologist Dr. Anke Steinel has identified the options available for artificial groundwater recharge in Jordan. She has also produced a guideline for similar projects.

When it does rain in Jordan, it pours. In some regions in the Jordanian desert not a drop falls for years. But when it does, it often rains cats and dogs. The rainfall collects and rushes in torrents toward the valleys. 'The water often flows into the Dead Sea or collects in closed basins where it evaporates', reports Dr. Anke Steinel from BGR.

It therefore seemed obvious to examine whether this unused resource could be better exploited. Under certain conditions the water can be collected and diverted underground. Here it is protected against evaporation and at the same time recharges exhausted groundwater reservoirs. The procedure, known as managed aquifer recharge, MAR, may be capable of alleviating the kingdom's water problems.

Water scarcity in Jordan is already at a critical stage and according to

experts will become considerably worse in the coming years as a result of population growth and climate change. On behalf of the Jordanian water ministry, Steinel investigated two large catchments to find possible sites for small dams for managed aquifer recharge.

One of the investigation areas was the Amman-Zarqa basin, a region with an area of 3,700 square kilometres, located in the north of Jordan. More than 65 percent of the population of Jordan live here. In contrast, the second investigation area, the 11,000 square kilometre Azraq basin further east, is predominantly covered by desert.

The most economical method of using excess rain water is to impound it behind a dam and to allow it to infiltrate into the subsurface. The requirement for this is a permeable soil above an aquifer. However,

the most important question is whether enough surface runoff is even available.

In order to identify suitable catchments, Steinel collected information on precipitation, slope, land use, soils and hydrogeology. She included only rural areas in the managed aquifer recharge evaluation, where more than 75 millimetres of precipitation fall per year and no reservoirs exist. In the second stage, she incorporated additional criteria such as the subsurface properties, groundwater quality and infrastructure in order to assess whether a site is suitable for infiltration into an aquifer. She then superimposed the two maps to locate a suitable catchment area upstream from suitable sites.

The result of the survey indicates that there is not enough rain in large parts of the investigated area. Sufficient runoff was only available in



Source: A. Steinel

Example of a small infiltration dam in Wadi Madoneh, Jordan.

3 percent of the catchment area and there were barely any suitable sites for infiltration basins. A detailed site investigation appeared expedient for 9 percent of the area. ‘The analysis shows that the availability of water is the limiting factor in arid regions’, Steinel says. Another important limitation: the torrents carry large quantities of suspended sediments, sand and waste. Infiltration facilities would therefore need to be regularly serviced. ‘In Jordan, however, the lack of funding for servicing is also a great problem’, says Dr. Anke Stei-

nel. Provision of funds for servicing should be obligatory for the new MAR projects.

The BGR expert has summarised her insights in a guideline. It includes recommendations on implementing managed aquifer recharge in arid regions such as Jordan. The approach used can be transferred to other countries and the criteria adapted to local conditions.

Contact: **Dr. Anke Steinel**

Buzzing over the Thuringian Basin

Scientists trace shallow fault zones from the BGR helicopter

The INFLUINS research project investigates how liquids and gases migrate in the subsurface. The survey ranges from the uppermost soil layers down to aquifers at depths of a few kilometres. In this collaborative project, IPHT Jena, Supracon AG, IGW at Friedrich-Schiller University in Jena and BGR have the task of investigating anomalies in the Earth's magnetic field from the air.

During the summer of 2012 the BGR helicopter clattered over the small towns of Ohrdruf and Bad Salzungen, and the Schmalwasser dam in Thuringia, at an elevation of only 40 metres, carrying beneath it a strange teardrop-shaped sensing system. The orange-white probe hanging below the helicopter contained the most sensitive magnetic field sensor currently available. 'We measure distortions in the Earth's magnetic field', explains Ronny Stolz from the Institute of Photonic Technology (IPHT), where the system was developed. 'These anomalies provide information on the movement of water along geological structures'.

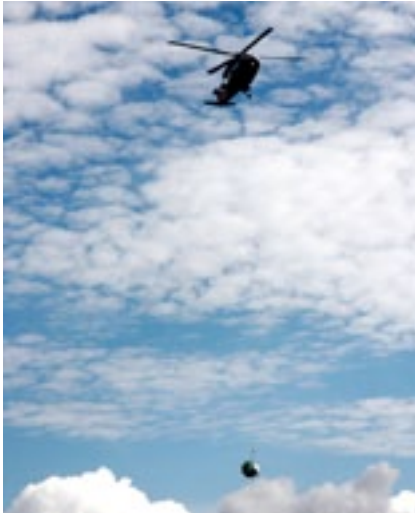
The magnetic field measurements in Thuringia form part of the INFLUINS project (Integrated Fluid Dynamics in Sedimentary Basins).

In the Thuringian Basin case, a total of 50 scientists from a wide range of research establishments led by the University of Jena aim to find out how fluids – i.e. gases and liquids – make their way through the earth's crust. The scientists are especially interested in uncovering relationships between deep and shallow substance fluxes. In twelve sub-projects they gain insights into the hidden fluid paths and the variously permeable rocks in the subsurface. The results of this interdisciplinary project are important for future exploitation of the subsurface, for example for geothermal energy, CO₂ storage, gas and compressed air as energy stores, and for water supplies.

The Thuringian Basin is a low-land area in the centre of Thuringia, framed by a number of moun-

tain ranges. It has the structure of a broad, flat bowl. The subsurface sediments were formed around 250 to 180 million years ago. Today's basin configuration only developed around 80 million years ago, when Africa collided with Europe. Rupture zones occurred, where the rocks were displaced laterally, tipped and in places folded. These fault systems are especially interesting to the INFLUINS team, because they can allow fluids to pass along them.

One method for uncovering these faults is to log the Earth's magnetic field as precisely as possible. Some fluids, such as mineralised groundwater, for example, have good electrical conductivity. If they flow through a fault, they may cause an anomaly in Earth's magnetic field. In addition, the regular stratification



The specially equipped BGR helicopter with sensing instruments in flight.



The BGR helicopter ready to go.

of the rock is interrupted at a fault. This can also lead to anomalies in Earth's magnetic field. IPHT, Supracon AG, IGW at FSU in Jena and BGR have organised an airborne helicopter survey of four large areas in the Thuringian Basin and its boundary zones for 2012 and 2013. The logging equipment used is the white-orange, teardrop-shaped probe. It contains what is known as a magnetic full tensor system. This highly sensitive detector logs changes in the Earth's magnetic field in all three spatial orientations. The heart of the system is formed by extremely sensitive detectors, so-called SQUIDs (superconducting quantum interference detectors). The logging system is designed such that even the tiniest deviations from a homogeneous magnetic field provide signals. A great advantage of this

method: the cost and time requirements are low. The system operates mainly on its own, an engineer only goes along to check the system.

The aim of the project as a whole is to compile a three-dimensional model of the subsurface. The magnetic field measurements contribute to this by identifying the locations of fault zones and the magnetisation of the rocks. In this way they complement seismic and geochemical surveys.

The surveys began in July 2012. The investigation areas were selected such that they included large fault systems within the Thuringian Basin and its boundary zones. The first flight phase was successful. The instrument functioned perfectly and provided high-quality data. It be-

came apparent that the geological structures within the Thuringian Basin were almost invisible magnetically, contrary to previous assumptions. In contrast to this, clear magnetic anomalies, which the scientists can collate well with known geological structures, are seen in the basin's boundary zones and the Thuringian Forest.

www.influins.uni-jena.de

Contact: **Dr. Uwe Meyer**

Okavango's legacy

BGR discovers enormous groundwater body in northern Namibia

A Namibian-German project team found a large freshwater aquifer beneath salt water-bearing strata at the edge of the Cuvelai-Etосha-Basin. The scientists are now investigating how the resource can be sustainably used.



Aquifer exploration drilling in the Cuvelai-Etосha-Basin.

Namibian and German scientists analysing groundwater, Ohangwena region, North Namibia.

The Okavango delta in Botswana, fed by flooding of the river of the same name, is one of the few wetlands in the centre of arid southern Africa. Several million years ago the river had a different destination: the Cuvelai-Etосha-Basin in northern Namibia. On the northern edge of the basin the river deposited an enormous sediment fan, the Cubango megafan. 'Root tubes and microfossils reveal that lakes must have alternated with marshes and savannahs, very similar to today's Okavango delta', re-

ports BGR's hydrogeologist Dr. Falk Lindenmaier. To this day, abundant water is stored in the Cubango megafan deposits. In 2012, a BGR project team, together with experts from the Namibian water ministry, announced that a body of at least five cubic kilometres of exploitable groundwater was located at a depth of more than 250 metres, below strata containing saline water. The volume corresponds to at least 400 times the water currently consumed by the population of northern Namibia every year.

The scientists discovered that the water becomes increasingly saline towards the centre of the basin. In order to use the fresh water sustainably, intelligent groundwater management based on the recharge rate is therefore required.

Contact: **Antje Hagemann**

Italy the fast way

BGR scientists were present at the scientific maiden voyage of the HALO research aircraft

Venice, Rome, Florence, the volcano Etna and the island of Elba: All the beauty of Italy in a single day – this is what the team on board the HALO research aircraft enjoyed in June 2012.

The aerial survey was the new HALO (High Altitude and Long Range Research Aircraft) survey aircraft's first scientific mission to be undertaken under the operational command of the German Aerospace Centre (DLR). The machine is a converted Gulfstream G550, an aircraft type better known to business peo-

ple. The intricate conversion, however, has turned HALO into a flying laboratory that can remain in the air up to twelve hours at a time. High above the clouds the aircraft collects climate data in even the most remote regions. Its large range means that the entire globe is accessible to research – including remote regions over the oceans, in addition to the poles, for example.

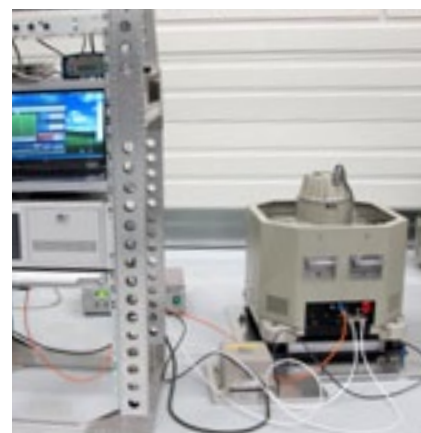
Not only the atmosphere, but also the solid earth, is a HALO research object. BGR, part of the HALO geosciences user group, used a new

gravimetry system to survey earth's gravity field while flying over Italy. Over four days, the aircraft covered a total of 16,150 kilometres from Oberpfaffenhofen, Germany. The GEOHALO mission objective was to demonstrate the capabilities of the geodetic-geophysical instruments on board HALO.

The first analysis reveals the high quality of the acquired gravity field data. The experience gained is important for further planned geoscientific aerial surveys with HALO, for example in the Antarctic.



The HALO aircraft on the runway in front of the DLR hangar in Oberpfaffenhofen, Germany.



Aerogravimetry system.

Contact: **Dr. Ingo Heyde**

Geology below the waves

The EU EMODNET project collects geological data on European seas

In the first project phase the participants collected marine geoscientific data from the North Sea and the Baltic Sea, the North Atlantic and the English Channel. In the second phase the target is the southern European seas and the Atlantic.

About the sea floor, it is often said, we know less than we do about the surface of the moon. As far as the seas around Europe are concerned, this is not entirely true. Many European states are very well informed about the geology of the neighbouring seas: based on numerous seismic measurements, boreholes and samples, scientists have already determined what rocks the seabed consists of in many European seas, how old the sediments are and what mineral resources are found there. However, if research, industry or policy makers previously wanted to initiate cross-border projects, or projects incorporating all the seas around the continent, it often led to problems. The geodata of any subject from the countries involved was not mutually compatible. Every country has developed its own methods for data acquisition and archiving.

Distributed information

The marine sections of the northern European geological surveys, including BGR, worked in the EU EMODNET project on solutions aimed at stan-

dardising existing marine geological data. The scientists started with the North Sea, the Baltic Sea, the English Channel, the Atlantic coasts of northern France and Ireland, and the Irish Sea. The Mediterranean Sea, the Black Sea, the Norwegian coast, the Bay of Biscay and the Atlantic off the Iberian peninsula follow in the next stage, starting this year.

The BGR team centred around Dr. Kristine Asch was responsible for the provision and harmonisation of pre-Quaternary geological data. The scientists used the 1:5 000 000 scale geological map of Europe compiled by Asch, which shows Europe's continental and marine geology, as their baseline. The data are adapted to the more detailed 1:1 000 000 scale for EMODNET purposes. In the next project phase the resolution will be increased further for these regions.

Free access to data

The scientists collected a whole series of geological information: in addition to the type of sediment and the struc-

ture of the rocks in the deep subsurface, they also recorded fault zones and the age of the rocks.

The data were reviewed and supplemented by the participating geological surveys. BGR scientists processed the corrections and performed the final scientific and technical editing. Other project teams compiled data on erosion rates, surface sediments, earthquakes and submarine landslides, as well as mineral and hydrocarbon deposits. All data are available in thematic map format via the OneGeology-Europe internet portal.

www.emodnet-geology.eu/

Contact: **Dr. Kristine Asch**

Keeping perspective in the data cube

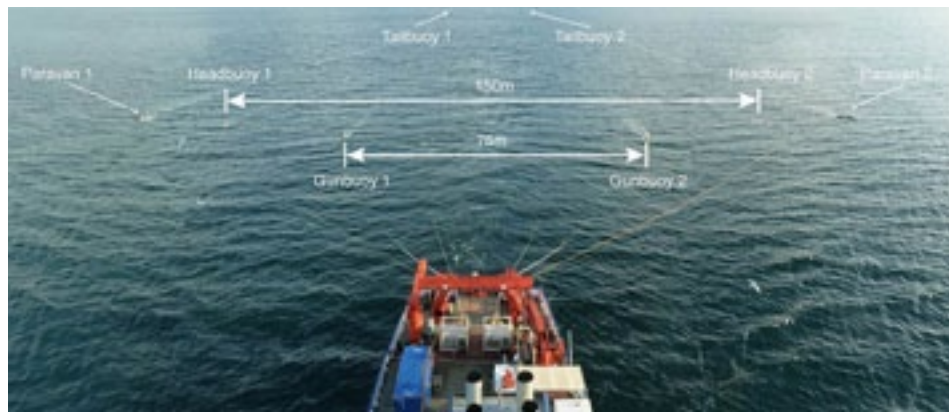
BGR scientists explore the North Sea using 3D seismics

It was a premier for the research vessel METEOR. The team, headed by expedition leader Dr. Volkmar Damm from BGR, tested BGR's marine 3D seismics for the first time in August 2012.

Normally, expensive specialised ships are required to deploy this geophysical equipment. However, since 2009 BGR has developed a mobile system, which is more economical and flexible, especially for research purposes. 'It is unique in the European research landscape', explains Damm.

The seismic method functions in a similar manner to ultrasound scans in medicine. During marine surveys compressed air pulses generate sound waves in the water. These waves are reflected at strata interfaces within the seabed. Special sensors in long cables trailing behind the ship, known as hydrophones, capture the echo.

Normal 2D seismics entails the ship towing a single cable behind it. The result the scientists get is a vertical section through the subsurface.



View of the towed 3D seismics equipment. The towed paravans generate the necessary force to laterally deflect all devices. The seismic survey cables (marked by the headbuoys) are towed with a separation of 150 metres. Between them are the two seismic sources (marked by the gunbuoys, towed with a separation of 75 metres).

When using 3D seismics, on the other hand, at least two cables are required. 'Similar to our spatial vision with two eyes, we can orient the reflected sound waves spatially using two cables', says Volkmar Damm. This new procedure was a challenge to the ship's crew. The two 900 metre long cables had to be positioned exactly 150 metres apart behind the ship. The METEOR also had to travel with extreme precision along the ten kilometre survey lines in order to adhere to the exacting demands placed on data quality. The reward was a three-dimensional data cube of the six by ten kilometre sur-

vey area near to Heligoland, down to a depth of around 1,000 metres. Even the smallest geological structures were revealed. During the expedition Damm and his colleagues primarily wanted to identify shallow gas accumulations within the seabed. This would represent a contribution to the Geopotential of the German North Sea research programme. The procedure can also be used to investigate ground conditions prior to building offshore wind farms.

Contact: **Dr. Volkmar Damm**

The digital resources market

German GeoBusiness Commission facilitates access to geoinformation for German economy

State-held geoinformation represents practically untapped capital. The German GeoBusiness Commission (GGC) of the Federal Ministry of Economics and Technology (BMWi) provides internet based tools for standardised licensing in an easy and comfortable way for both, the provider and the user, in order to make this wide-ranging data accessible. It initiates projects, acts as an intermediary between economy and administration, with the core target to get equal data protection and uniform licensing conditions all over Germany.

Is my roof suitable for a photovoltaic installation? Normally, this question can only be answered by an expensive expert report. Somebody living in Versmold in North Rhine-Westphalia, however, needs only a few mouse clicks. In the town's solar roof cadaster, accessible to anyone online, suitable roofs are shown in red, unsuitable ones in blue. The cadaster was developed for Versmold and several other towns and districts in Lower Saxony, North Rhine-Westphalia and Rhineland-Palatinate. Among other things it is based on airborne laser altimetry logging. The data had been previously collected by states involved. The company offering these analysis is a winner of the Commission's GeoBusinessAWARD.

State-held geoinformation such as this laser altimetry data is an enormous, but previously practically untapped

treasure. Government agencies collect vast quantities of spatial digital data and information; for example on buildings, bodies of water, vegetation, nature conservation, industry and much more. If companies were able to utilise all this information unhindered, many new opportunities would open up. Producers of raw materials could quickly identify where new operations planning conflicts with nature conservation, for instance. But whole new fields of business may be created, as in the case of the solar roof cadaster. Innovative applications are even possible for the government agencies themselves, for example in endangered species protection: the Agency for the Environment in Rhineland-Palatinate, for example, commissioned the Artenfinder (species finder) app for smartphones. Walkers and ramblers who spot an eagle owl, a stag beetle or other protected animals or plants

can use the app to either store the sighting for themselves or report it through a service portal. The phone records the time and location. The nature conservation agency expands its database leading to a better protection of domestic species.

Experts estimate the potential of state-held geoinformation at several billion euro. The GGC, with headquarter at BGR and in existence since 2004, has the task of making existing geoinformation held by public administration available to the economy. The Commission supports German associations and companies in all questions relating to geobusiness. It acts as an intermediary between economy and administration, brings the parties together, opens doors to administration, works out studies, Internet applications and agreements. Together with representatives from



Source: fotolia.de/maxshakov

A heterogeneous licensing framework leads to non-use of state-held geoinformation.

economy and the responsible public authorities, GGC TaskForces negotiate difficult political topics such as licences, pricing models and data protection. Six flagship projects identify the problems currently inhibiting the use of state-held geoinformation.

One central obstruction is the heterogeneous, often confusing licence conditions regulating data use. The GGC has now developed a simple, uniform licence model with eight different scenarios. The procedure was successfully tested by a pilot project in 2012 by the economy and govern-

ment agencies from all administrative levels. With a simple click process, users could get a licence for certain data. The cost was immediately visible and paid electronically. As of now this web application can be reached at www.geolizenz.org. In parallel the impacts of the uniform licensing framework on the market will be observed.

Another central topic for GGC is data protection. In the GeoBusiness data protection Task Force, economy is working together with all the administrative bodies responsible for data protection. The aim is to work out a

self commitment by German economy (so called GeoBusiness Code of Conduct). This self commitment will enable companies to use data, that are sensitive with respect to data protection aspects on an easy and standardized way.

www.GeoLizenz.org

Contact: **Dr. Jörg Reichling**

Rock-solid memory

BGR establishes a national core repository

On 28 September 2012, after a two-year construction period, BGR was able to inaugurate a national repository for continental research wells in Spandau, Berlin. On an area of 1,200 square metres there is room for up to 60 kilometres of cores. Here, science, industry and government agencies have access to cores from a variety of research cores.

For geologists, drilling is the only opportunity to acquire samples from the deep subsurface. Only the uppermost kilometres of the crust, that 30 kilometre thick skin of rock, are directly accessible to us. To find out where natural resources are hidden, geothermal energy can be produced or carbon dioxide sequestered, scientists have only one option: they must erect drilling rigs, prepare diamond-studded bits and drive thick steel pipes into the ground.

If all goes well, special corers raise long, columnar rock segments from the subsurface to the surface. Depending on the era in which the penetrated strata formed, these cores may consist of salt, sandstone, granite or limestone. Some are packed full of fossils, others contain interesting minerals or ores. However, they all contain immeasurable information on Earth's history, the structure of the crust and processes occurring in its depths. 'The long-term and proper storage of these valuable cores is

a task of national importance', says BGR scientist Dr. Jochen Erbacher. Until now, cores from various

storage conditions. An initiative of the German Scientific Earth Probing Consortium (GESEP e.V., Deutsches



research wells have been scattered throughout Germany: state geological surveys, universities, companies and BGR store the fruits of their labours in their own stores. Documentation and access to the cores are as varied as the different

Forschungsbohrkonsortium) means that this will change. In September 2012, BGR established a national core archive for research hard rock cores at their Spandau, Berlin branch office. Another national archive for marine cores has been established at

the Centre for Marine Environmental Sciences (MARUM) in Bremen. One of the three Integrated Ocean Drilling Program (IODP) archives is already located there.

The BGR branch office already houses extensive geological collections, including the collection of the Prussian National Geological Survey and Germany's national polar samples archive. 'The unique diversity of rock samples, fossils and thin sec-

tioned sections of our collection represents BGR's rock-solid memory', says Erbacher. With the national core archive, this memory can now be expanded considerably. Now, cores from new and old German and international research wells can be stored in the 1,200 square metre storage facility in five metre high, heavy-duty racks. Cores of great scientific value that geological surveys or companies wish to dispose of for capacity reasons can also find a place in the national archive. 'The new facility allows long-term, high-quality archiving of valuable cores', explains BGR president Prof. Dr. Hans-Joachim Kumpel. BGR anticipates substantial interest. 'Only a few years ago, the stratigraphic and palaeontological sections of our coll-

ections were primarily in demand', reports Erbacher, 'but the majority of our users now comes from mineral deposits research and industry.' Topics such as natural resource exploration, CO₂ storage or cavern engineering are forcing their way ever more into the foreground. To ensure that all interested parties can use the information held in the archived cores to its optimum, the repository has its own laboratories, containing state of the art facilities for non-destructive analysis. Users can carry out their investigations directly on site. The national research core repository thus aims to become a central contact point for geoscientists both at home and abroad.



Rock cores for research are stored in the newly built national core repository in Spandau, Berlin.

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www.bohrkernlager.de

Contact: **Dr. Jochen Erbacher**

CO₂ Storage

CO₂BRIM: Multi-stage and regional-scale characterisation of potential CO₂ storage formations with particular focus on brine migration risks – an integrated natural and social science approach

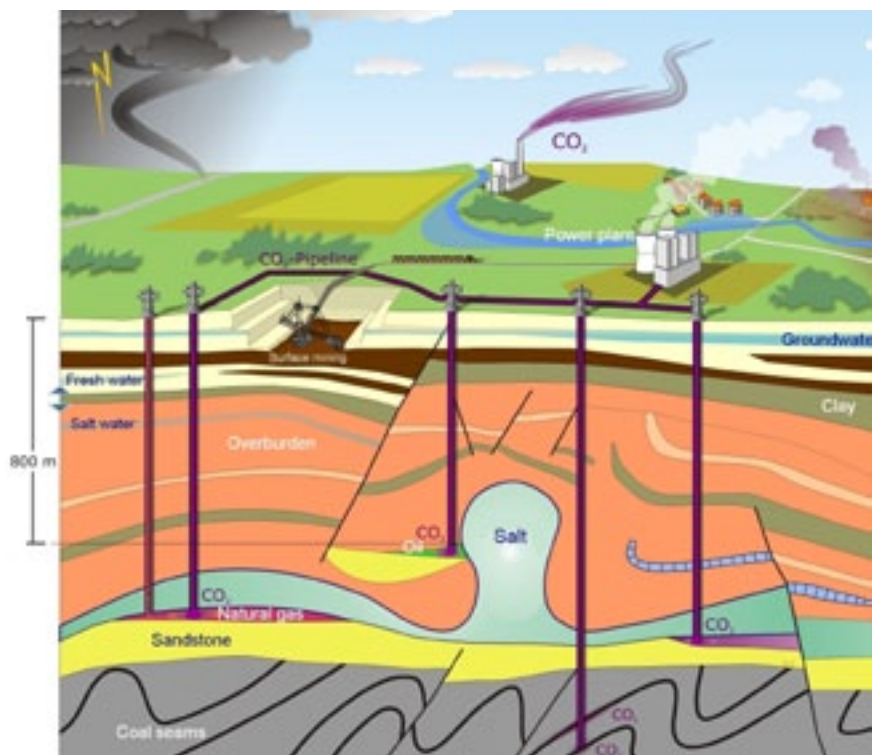
Salt water movements

The CO₂BRIM project addresses geo- and social science aspects of carbon dioxide storage

Storage of the greenhouse gas carbon dioxide in deep, salt water filled host rocks is seen as an important option in the fight against climate change. One of the key questions involved is whether or not the displaced salt water will alter overlying drinking water bodies.

If carbon dioxide (CO₂) is forced into the subsurface, its volume is drastically reduced: 1,000 cubic metres at surface conditions are a mere 3.8 cubic metres at a depth of 800 metres. As a result of the increasing pressure the gas is converted to what is known as a supercritical fluid. This phenomenon makes Earth's crust particularly attractive as a CO₂ store. However, the CO₂ still needs space that was previously occupied by other substances – generally salt water that fills the pores of the host rock.

The CO₂BRIM project addresses the problem of whether or not CO₂ injections at an industrial scale may threaten overlying aquifers filled with drinking water. Using an interdisciplinary approach, researchers from BGR, the institute for hydraulic engineering at the University of Stuttgart and DIALOGIK GmbH will investigate until February 2015 whether the displaced salt water can migrate upwards along geological faults. They will focus on both the

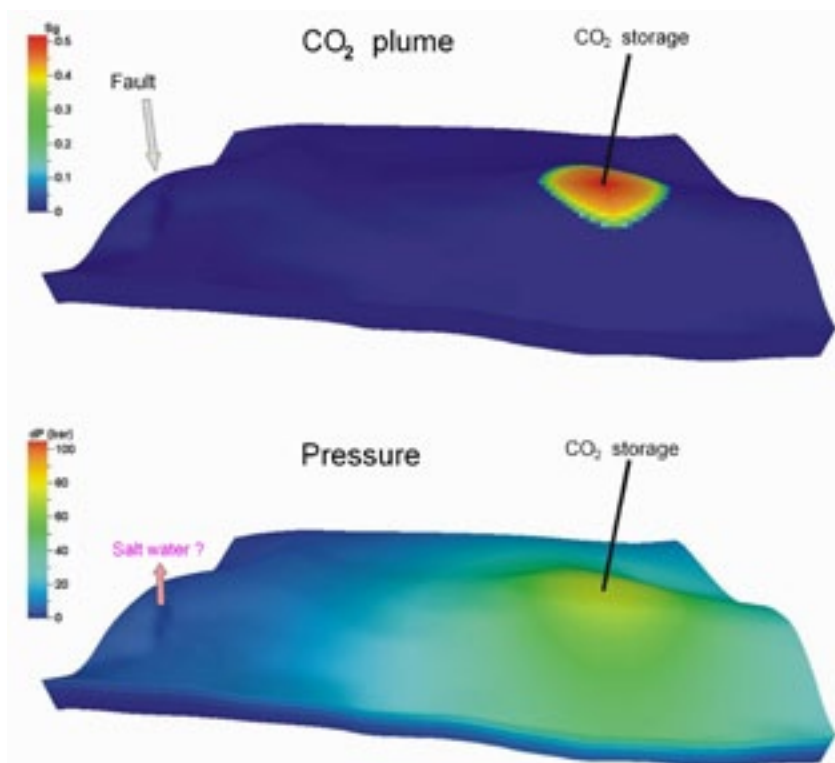


CO₂ is emitted by power stations, compressed and transported to storage via a pipeline.

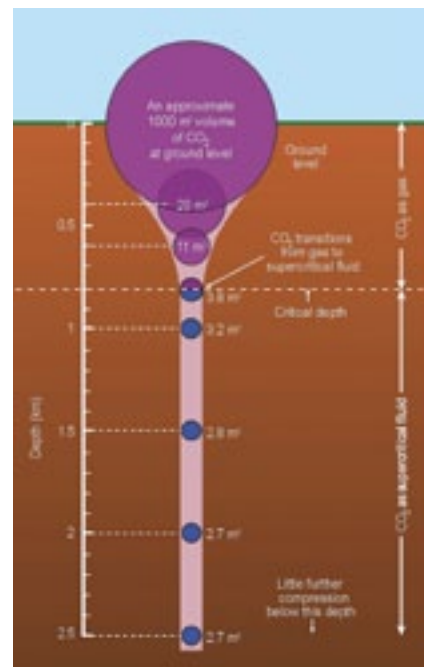
natural scientific-technical and the social aspects of CO₂ storage.

The project will also have an emphasis on numerical computer simulations. The BGR experts will initially simulate various CO₂ storage scenarios for regional scale models. They

will then calculate how the pressure develops within the reservoir and its environs in order to, finally, discover how differing injection strategies impact on salt water flow. In a final step, they will investigate whether or not the salt water can migrate upwards. To do this, the model must



Example of a geological model: how does CO₂ migrate in the vicinity of an injection point (top), how does the pressure evolve (bottom)? The numerical simulation also reveals whether salt water can migrate upwards along a fault (left).



Source: F. Schäfer

If CO₂ is fed into the subsurface its volume is drastically reduced, from 1,000 m³ at the surface, to approximately 3.8 m³ for typical subsurface conditions at a depth of 800 metres.

Source: CO₂ GeoNet

be considerably more precise in the region of potential migration pathways – especially fault zones or the flanks of salt domes – and be extended up to the surface. One of the greatest challenges is modelling the physical properties of the migration pathways.

In the social scientific part of the project the researchers develop a concept for involving various social groups in the search for a storage reservoir. The central aspect: the individual steps are revealed to non-experts. Interest group representatives

from various social groups, the stakeholders, are invited to help select the modelling boundary conditions and scenarios. This process, participative modelling, is a completely new approach for CCS research. Workshops are held during the project, allowing the stakeholders and researchers to evaluate the previous procedures and jointly consider future steps.

www.co2brim.hydrosys.uni-stuttgart.de/index.html

Contact: **Stefan Knopf**

Sniffers on the ground

BGR develops monitoring system for CO₂ storage facilities

Some volcanoes are monitored almost as well as a patient in intensive care. If gases such as carbon dioxide or hydrogen sulphide escape from the ground, this may be an indicator of an imminent eruption. Similar monitoring stations are also suitable for use with underground CO₂ storage facilities. Reliable monitoring is an important requirement for public acceptance of CCS technology (carbon capture and storage), whereby carbon dioxide from power stations and industrial installations is stored below ground.

In the MONACO project BGR is now developing a concept together with the Helmholtz-Zentrum für Umweltforschung (UFZ) and the US Bruker Corporation, to reliably detect CO₂ emissions from an underground



Installed monitoring station.



Installation of CO₂ monitoring wells.

storage facility at the surface. Chemical, hydrogeological and geophysical methods are combined. Monitoring will be hierarchical, i.e. applying different methods on different spatial and temporal scales. Potential weak zones, for instance, are monitored very often and in more detail, while large areas are only monitored rarely and at much larger intervals, for example using remote sensing methods.

The BGR contribution to MONACO builds on the CLEAN project in Saxony-Anhalt, where a large-scale monitoring network consisting of 15 stations has been in existence here since 2009. It continuously records CO₂ soil gas concentration, temperature, soil moisture, hydraulic head and weather data. With MONACO,

BGR and its partners are now testing further monitoring techniques, for example what is known as the eddy-covariance method, special emission measurement chambers and laser techniques. The scientists want to evaluate whether these technologies are also suitable for monitoring related to CCS.

The concept can later be adopted for monitoring other underground storage facilities, i.e. temporary storage of compressed air, hydrogen or methane in depleted gas reservoirs or salt caverns.

Contact: **Dr. Stefan Schloemer**

Important hub

The Carbon Dioxide Storage Act allocates new responsibilities to BGR

A law regulating carbon dioxide storage projects came into force in August 2012. This means that demonstration projects are now possible here in Germany. BGR is developing the geological fundamentals for the new technology.

It is a law with a complex title: the Act on the Demonstration of Technologies for the Capture, Transport and Long-term Storage of Carbon Dioxide (KSpG) allows limited volumes of carbon dioxide from power stations or industrial sources to be stored underground – for research and demonstration purposes. The act

regulates the geo-aspects of research into CCS (carbon capture and storage) technologies aimed at making a contribution to limiting the CO₂ concentration in the atmosphere.

The law assigns an important role to BGR. For example, the Federal Institute's experts must assess

Germany's storage potential. They also identify potential conflicts of interest with other uses, for example with deep geothermal energy or underground natural gas storage. In this context, BGR cooperates closely with the responsible government agencies in the individual states and in neighbouring countries.



Excellent reservoir rocks (bottom) and barrier rocks effective in the long-term (top) are required for sustainable subsurface storage of CO₂.

Moreover, BGR develops a public register, listing plants with CO₂ separation technologies, transportation pipelines and storage facilities. Every three years BGR informs the EU Commission on the status of CCS technology developments in Germany. BGR contributes to easing knowledge transfer between all parties involved.

Contact:

Dr. Johannes Peter Gerling

Standards for CCS

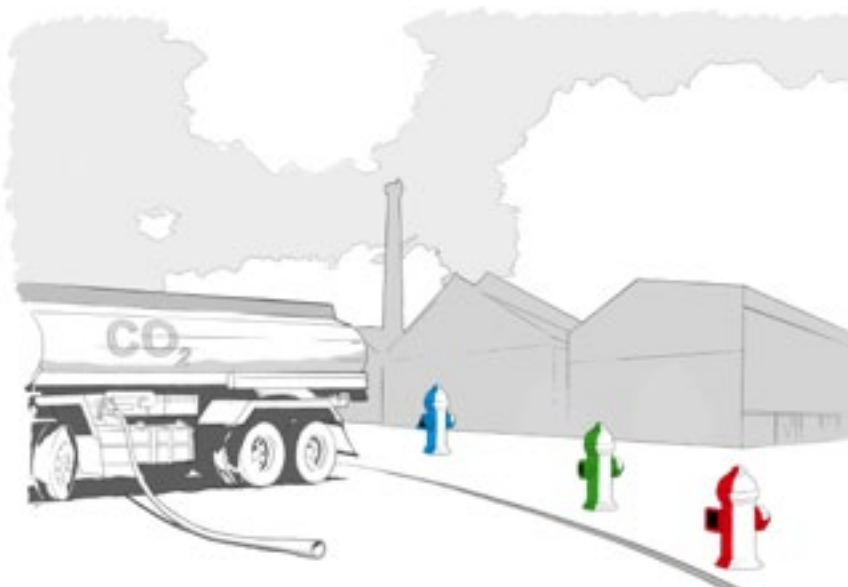
BGR is involved in activities at national and global levels

The International Organisation for Standardisation (ISO) has set up a technical committee to draft standards for CCS technologies. BGR represents German interests and heads the work at the national level.

More than 25 million tonnes of carbon dioxide already rest deep beneath the surface of two Canadian oil fields – equivalent to the emissions from six million cars per year. In Norway and Algeria CCS technology (carbon capture and storage) is already used on an industrial scale. Experts consider geological storage of CO₂ to be an important option in the fight against climate change.

However, the technology is not yet widespread, among other reasons, because there are acceptance problems in many parts of the world. An important step in nurturing trust is the adoption of internationally harmonised standards. A technical committee of the International Organisation for Standardisation (ISO) will develop such standards under the auspices of the Canadian and Chinese standards organisations.

The first committee meeting was held in Paris in June 2012, where a German delegation headed by BGR sub-department head Dr. Johannes Peter Gerling was also present. To ensure that German concepts can successfully contribute to the ISO process, a DIN (German standardisation body) working committee was set up in April 2012 in Berlin as a mirror body. The delegates, among them representatives from industry, associations, research institutes and government agencies, elected Dr. Johannes Peter Gerling as chairman. The delegates set up five subcommittees, oriented on the task structures of the ISO working groups.



The standardisation of processes and facilities for CO₂ storage can make life a lot easier.

www.iso.org

Contact:

Dr. Johannes Peter Gerling

From gold to environmental protection

50 years of Mongolian-German cooperation

The apparently endless green grass of the steppes stretches over the gentle Mongolian hills. The harsh-stunning landscape is quite special: the sparsely populated country, four and a half times larger than Germany, is regarded as one of the most resource rich countries in the world. Copper, coal, gold and fluorspar are among the commonest mineral resources.



Source: T. Abel

Erdenet copper mine external spoil tip in the mountain steppe of northern Mongolia.

German geologists also played a role in the discovery of these resources. As early as 1962 the former Mongolian People's Republic and the GDR (German Democratic Republic) cooperated closely in the geo sector. The first joint expedition was in 1963. The German geologists carried out mapping and exploration work in the east and south of Mongolia – and stumbled across gold ores.

In the decades following this much additional prospecting work was carried out in Mongolia. In the 1970s, for example, the German experts discovered the Tumurtijn Ovoo zinc deposit. According to calculations at the time, it contained almost eight

million tonnes of ore with a zinc concentration of twelve percent. Detailed exploration of the Boroo gold deposit, 110 kilometres north west of the capital Ulaanbaatar, brought its high economic potential to the fore in the 1980s. The gold has been mined by a Canadian company since 2004.

Following German reunification in 1990/91, Mongolia and the Federal Republic agreed to continue close cooperation in a Technical Cooperation framework.

‘We have enjoyed such a long and close partnership only with very few countries’, says BGR president Prof. Dr. Hans-Joachim Kämpel on the occasion of the celebrations to commemorate the 50th anniversary of cooperation in December 2012. The focus of cooperation has now moved to questions of environmental protection in mining, sustainable development by exploiting mining potentials and organisational development. In 2011 BGR published an investor's manual for selected commodities and in 2012 the value chain for gold was analysed.

The German Mineral Resources Agency (DERA) supports Germany's natural resources partnership with Mongolia.

Contact: **Ludwig Feldhaus**

Technical Cooperation

Technical cooperation: work and projects

Cooperation between equals

BGR offers partner countries advisory services based on the most recent geological findings, for example in Zambia, Paraguay or Central Africa. Technical cooperation aims to sustainably improve living conditions in the partner countries.

More than two million people live in the metropolitan area of Lusaka, the capital of Zambia. Because sanitary facilities are practically non-existent, large parts of the city's groundwater are contaminated. Fly tipping, heavy population growth and economic development also represent a threat to groundwater. Although in terms of water, Zambia is regarded as the most plentiful country in southern Africa, the valuable reserves are dwindling. In 2012 BGR developed a strategy for protecting water resources together with the Zambian water ministry. Data were collected and entered into a groundwater information and management system, developed by both

partners in Zambia. Using this information the government agencies involved can now plan independently.

The procedures used in Zambia are representative of BGR's technical cooperation: the work of the team led by Franca Schwarz aims to promote responsibility and self-reliance in the developing countries. To ensure that the results of the projects are implemented, BGR staff advise policy makers and train colleagues in the partner countries. 'With our work we support the partner countries in protecting the essentials for the survival of future generations', says Franca Schwarz.

The main focal points are groundwater, mineral resources, energy resource, mining, georisks and environmental geology. BGR currently runs around 50 projects in developing countries. For example in Central Africa: here, BGR supports the countries in the Great Lakes region in introducing certified trading chains for mineral resources. Gold, coltan, cassiterite and wolframite are often mined illegally and under inhuman conditions. Regional conflicts have smouldered for years.

On the initiative of a BGR project, the mines are now regularly inspected in order to suppress smuggling,



Training personnel of the Paraguayan partner institute SEAM (environmental ministry).

Small waste recycling facility near the town of Villarrica (south-east Paraguay).

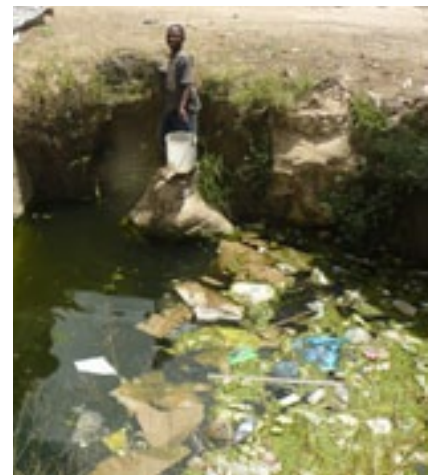


Separating tin ore using magnets.

Men washing coltan ore.



Practical hydrogeological sampling training of technical personnel in Zambia.



Contaminated groundwater in an urban karst region. Germs can enter the groundwater system very easily through open groundwater surfaces such as this.

improve working conditions for the miners and strengthen state structures. Another example of technical cooperation can be found in Paraguay. BGR supported the ministry for the environment in finding suitable sites for a landfill. During the cooperation

a new environmental spatial planning law was drafted and guidelines for selecting landfill sites developed. Planning and environmental departments were established in four towns. BGR also provided equipment and trained specialists.

This ensures that resources such as water and soil are taken into consideration in future planning processes – and remain available to the people.

Contact: **Franca Schwarz**

Underground storage for the energy revolution

Salt caverns may play an important role in the energy revolution – as reservoirs for compressed air or hydrogen. In the InSpEE collaborative research project BGR investigates the size of the storage volume in northern Germany's salt structures.

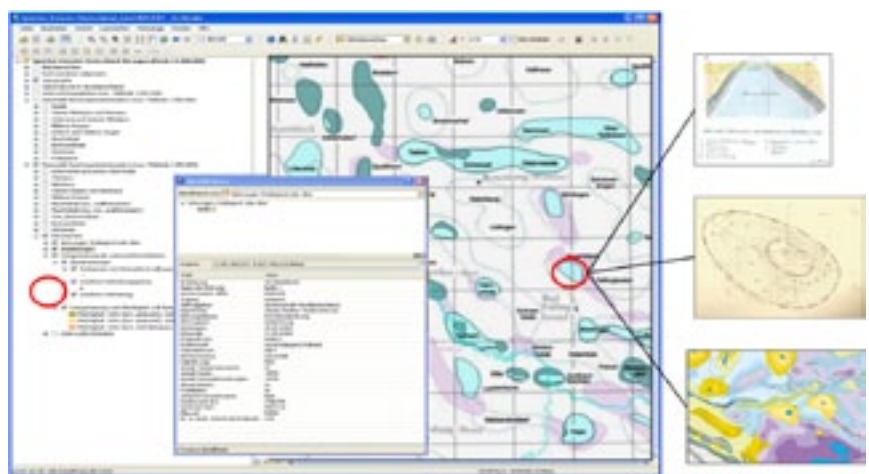
If one wanted to hide the Empire State Building in the ground, it could easily fit into one of these salt caverns. These artificial cavities within salt domes are 300 to 400 metres high. They typically have diameters of 50 to 60 metres – approximately corresponding to the dimensions of that New York landmark. Salt caverns are actually predominantly produced to store gases or liquids, to date primarily gas and oil. But with the energy revolution reservoirs for storing renewable energies are required. By storing excess wind or solar energy, converted to compressed air or hydrogen, salt caverns can play an important role here.

Salt caverns have a number of advantages: they do not leak, are mechanically stable and generally chemically inert for most substances. They can also be quickly and flexibly filled and emptied. However, there are still no reliable estimates of how much energy can be stored below

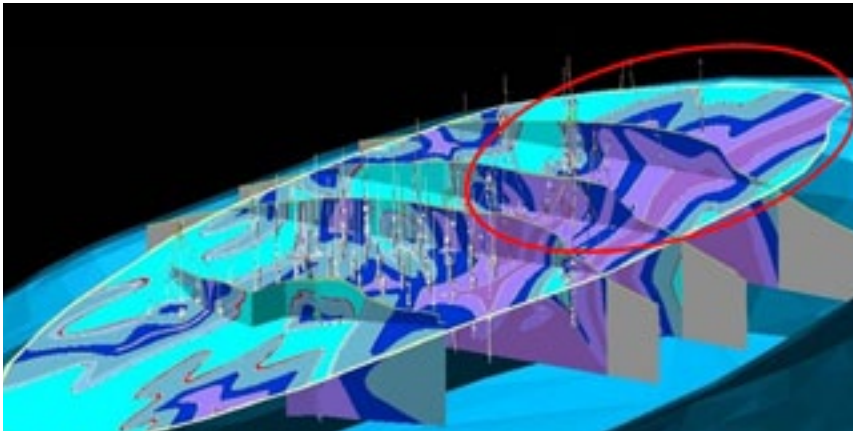
ground in Germany. In the InSpEE collaborative project funded by the German Federal Ministry of Economics and Technology, scientists from BGR, Leibniz University Hannover (LUH) and KBB Underground Technologies GmbH aim to correct this shortcoming. They intend to provide baseline geological and geotechnical data compile criteria for the search for suitable sites. BGR scientists systematically record all available information on northern Germany's

salt structures in a new database and create geological sections (Fig. p. 53, bottom left) through the subsurface at various depths. The results are fed into a geoinformation system (Fig., bottom).

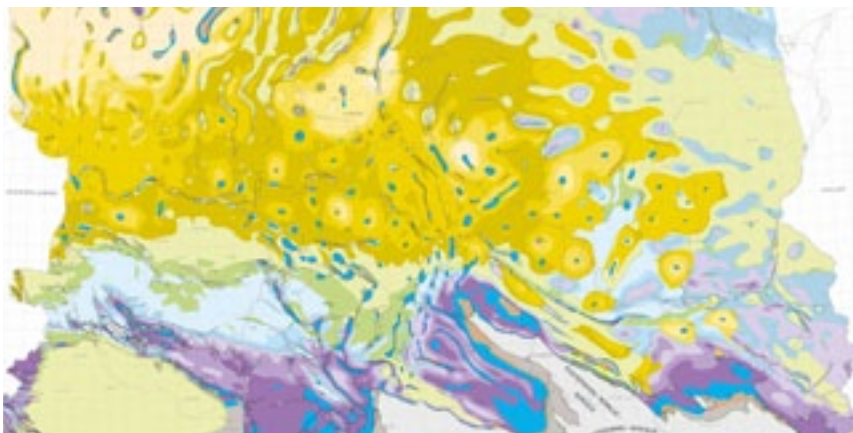
The storage volume of individual salt structures is closely related to their internal structure. An important aim of the project consists of forecasting the internal structure of previously unexplored salt domes.



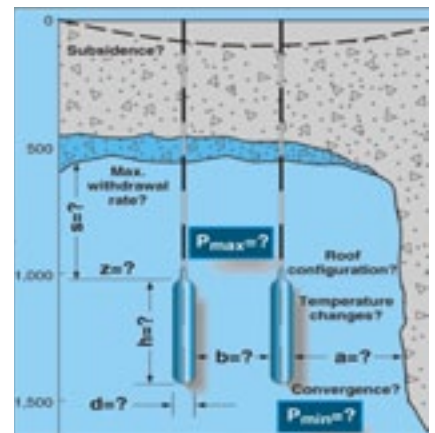
All project partner results are integrated in an information system allowing users targeted research and selection of data relevant to advanced planning.



Forecast internal structure (red) in a 3D model of a salt dome used for planning further cavern bores.



Geological section at the -500 m below datum level.



Source: Lux (TU-Clausthal), modified

Requirements and criteria for the construction and dimensioning of storage caverns for hydrogen and compressed air.

Among other things, BGR scientists compile 3D models of previously developed structures to facilitate this. The results can then be transferred to untouched salt domes (Fig., top).

The LUH project partners also recalculate the mechanical demands on the caverns. The data for natural gas caverns cannot be readily transferred to compressed air and hydrogen storage caverns, because gas is generally stored for several months, but

compressed air must be released and re-stored on a daily basis. The resulting pressure changes are completely different. Safety aspects also play a role in hydrogen caverns, because the gas is highly mobile.

The LUH scientists aim to compile criteria to determine how large the caverns may be, at which depth they should be constructed and what safe separation distances between individual caverns and the edge of the salt

dome are necessary (Fig., bottom right). Based on the results achieved by the BGR and LUH scientists, the task of the project partner KBB is to estimate the energy storage potential of the salt structures in northern Germany.

Contact: **Stephanie Fleig**

Laboratory in the computer

BGR scientists are currently developing the world's first virtual underground laboratory

The VIRTUS computer program produces detailed models of the mines housing final repositories in salt domes – including the complex physical processes occurring once highly radioactive waste has been placed in storage. The virtual laboratory visualises diagrams and test results and helps in preparing experiments. At the same time, it represents a digital archive.

The journey into the mine is very fast. Only at a depth of 800 metres does the speed drop. The shaft suddenly opens into a larger space, from which several drifts exit. The perspective now changes, the camera studies the mine from the outside. The branching adits and drifts form an underground laboratory – but not a real one, a virtual laboratory in the computer.

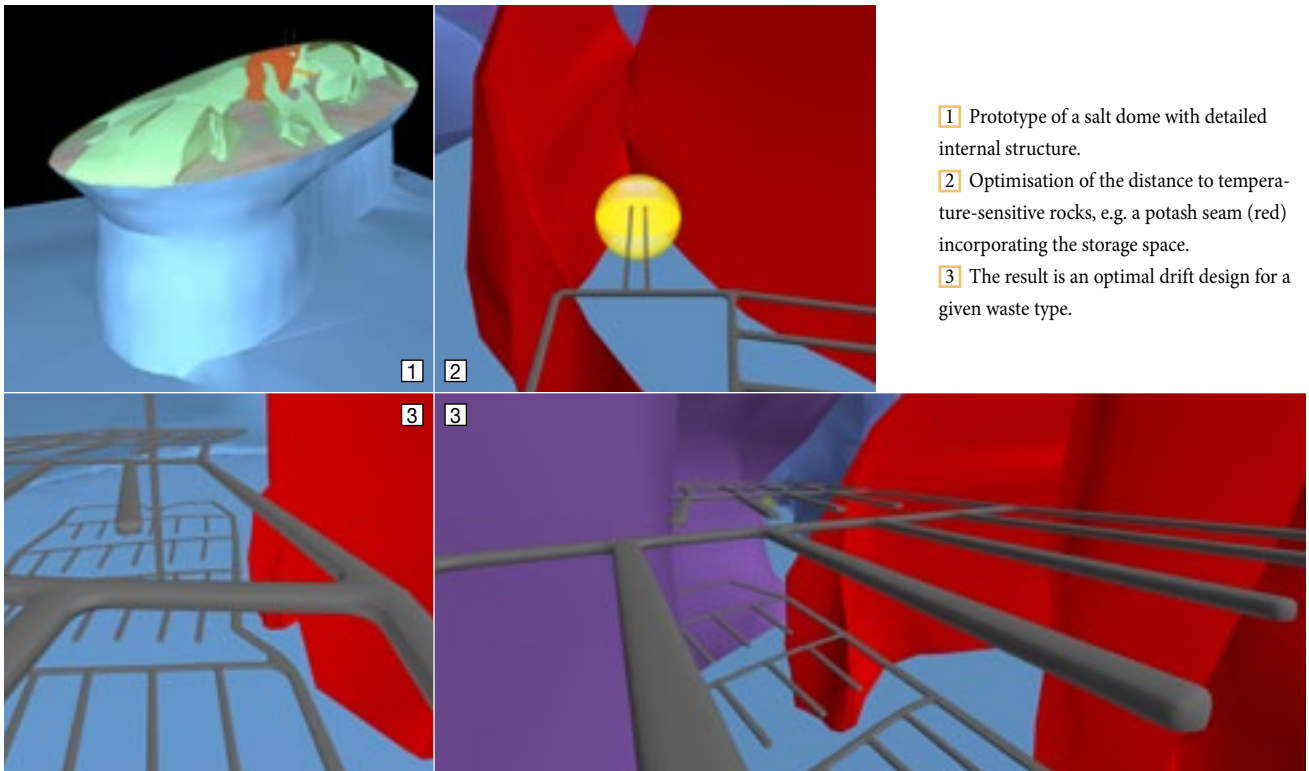
BGR scientists are currently developing the VIRTUS underground laboratory together with colleagues from the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), DBE Technology GmbH and the Fraunhofer Institute for Factory Operation and Automation (IFF). It is a powerful tool: VIRTUS visualises not only the geological relationships (Fig. 1) and the mine, it also simulates physical alterations in the vicinity of the waste vessels and in the rock mass. This simplifies the planning of real exper-

iments in underground laboratories that final repository researchers depend on for their work.

For example, the scientists can calculate how the radioactive heat propagates in the crushed salt surrounding the waste containers and then penetrates the surrounding rock (Fig. 2). Later, they can optimise their test design and perform the experiment for real in natura. In the long-term, scientists from around the world will be able to access the VIRTUS data, experiment with them online and exchange results. To complement the work in saline rocks it will in future also be possible to simulate processes in mudstones and granites.

The results achieved with VIRTUS can also be adopted for selecting sites for a final repository. To investigate the suitability of a given site, it is necessary to conceptually design the mine housing the final repository,

its engineering facilities and the containers used. Only when this is complete can experts assess whether and, if necessary, demonstrate that radioactive waste can be safely stored at the respective site for the required million year period. With VIRTUS planners can identify the best location for the waste with the aid of a variety of model options. For example, they can specify that the storage facility maintains a safe distance to temperature-sensitive rocks (Fig. 2), but that simultaneously as little potential storage space as possible is lost. Similar optimisation steps can be performed for numerous different physical processes. The final result is an optimal drift design for a given type of waste (Fig. 3). With VIRTUS, a final repository concept can thus be compiled much more efficiently than previously. The subsequent safety analyses are better understood. The knowledge and experience of more than 30 years of final repository,



- 1 Prototype of a salt dome with detailed internal structure.
- 2 Optimisation of the distance to temperature-sensitive rocks, e.g. a potash seam (red) incorporating the storage space.
- 3 The result is an optimal drift design for a given waste type.

tory research are incorporated in VIRTUS. The four research institutions involved amalgamated their expertise: BGR provided geological, thermal and geomechanical data, as well as geological models. DBE-TEC provided the data for the mine housing the virtual laboratory. GRS were the project managers. All three institutions have many years of experience in researching and modelling coupled processes in final repositories. The Fraunhofer IFF facilitated the spatial visualisation of the results thanks to its expertise in digital engineering and in optical 3D surveying techniques.

The visualisation of the complex processes occurring in a final repository not only helps the scientists, but will also make it easier to integrate the public in the process. Because VIRTUS amalgamates the results of a variety of research disciplines, it helps the institutions involved to select the site, plan the final repository, archive the results and demonstrate the long-term stability.

Contact:

Joachim Behlau, Christian Dresbach

Why hydrocarbons occur in salt

BGR scientists explore the Gorleben salt dome

BGR investigates the internal structure and composition of the Gorleben salt dome to clarify whether it is suitable for the final disposal of highly radioactive heat-generating waste. Between March 2011 and December 2012 geological exploration focused on investigating hydrocarbon occurrences in those salt rocks proposed as repository emplacement media.

A sea turned to salt – this could be the way to describe the salt deposits in northern Germany. The shallow body of water covering the North German Basin around 250 million years ago dried up on numerous occasions and left behind thick layers consisting of various salt rocks: in particular rock salt (sodium chloride), but also carbonates such as calcite, anhydrite (calcium sulphate) and potassium salts. In younger eras new sediments were laid down on top of the salt. Because rock salt can undergo plastic deformation and is less dense than the surrounding rocks, it began to rise around 150 million years ago and formed the typical salt domes – for example in Gorleben.

This salt dome, just as any other, contains small quantities of gaseous and liquid hydrocarbons such as natural gas and oil. These substances migrated into the salt from older (carbonatic) rocks during the early phases of

salt dome formation. Because hydrocarbons may represent a risk to a final repository containing heat-generating radioactive waste, BGR investigates their composition, their location within the salt dome and their concentrations, on behalf of the Federal Office for Radiation Protection. BGR experts are also investigating how the hydrocarbon-bearing rocks behave when heated and how the hydrocarbons influence the geomechanical properties of the salt rocks.

The Staßfurt Main Salt (Staßfurt-Hauptsalz) is being investigated as the possible emplacement medium. This unit can be divided into three subunits, referred to as Knäuelsalz, Streifensalz and Kristallbrockensalz in accordance with their structure. In addition to the characteristic structure, these rock salt units also have a typical chemical composition and varying hydrocarbon content. The

highest levels were observed in the Knäuelsalz. BGR is currently investigating the hydrocarbons in these rocks to clarify their significance for long-term safety analysis.

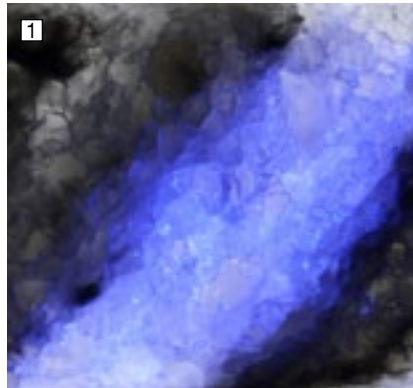
BGR works with a number of cooperation partners on this and uses modern investigation methods. For example, the scientists analyse thin and thick sections, employ a variety of microscopic and tomographic methods and carry out chemical analyses. In the Gorleben exploration mine they investigate how the hydrocarbon occurrences react to pressure release and test methods for identifying hydrocarbons indirectly using geophysical methods.

The investigations reveal that the hydrocarbons occur predominantly in recrystallised zones of the rock salt. They are found at the grain boundaries of rock salt and anhydrite crystals,

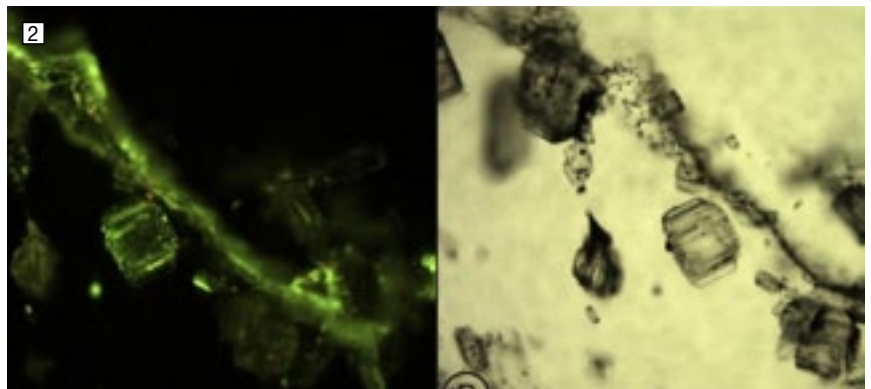
in capillaries within anhydrite crystals or, in rare cases, in cracks caused by drilling or sampling (Figs. 1 and 2). Only a few, small hydrocarbon inclusions are found in the Streifensalz and Kristallbrockensalz. It can be seen that the hydrocarbons are very unevenly distributed (in nests) in the Staßfurt Main Salt (Fig. 3). The content varies heavily even within individual boreholes and range from 0.02 to 443 mg/kg of salt rock. This corresponds to a maximum of around 0.05 percent by weight.

The new investigation results confirm older BGR data claiming that the hydrocarbons were not originally a part of the Main Salt, but migrated later into the salt rocks as they rose upwards. When the salt rocks ascended, cracks temporarily formed, allowing the hydrocarbons to enter from the underlying rock strata. Later, the liquid and gaseous hydrocarbons were transported, together with the surrounding salt rocks, into the higher regions of the salt dome. Together with residual saline solutions, they collected at the grain boundaries of rock salt crystals and in anhydrite-rich zones. Further research work is being carried out to allow conclusions about the long term safety relevance of the hydrocarbons for a potential final repository in the Gorleben salt dome to be reached.

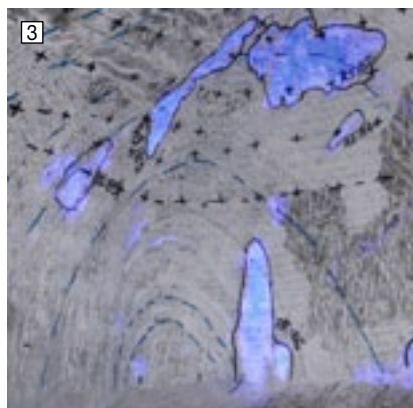
Contact: **Dr. Jörg Hammer**



Layered accumulations of bluish-white luminescent hydrocarbons in a borehole core of the Staßfurt Main Salt of the Gorleben salt dome.



Distribution of luminescent hydrocarbons in the microstructure of the salt rocks (left: fluorescence microscope image; right: transmitted light polarisation microscope image; image width: approx. 1.6 mm).



Distribution of bluish, luminescent hydrocarbons in an approx. 8 m high mined cavity.

Source: N. Themeyer

Source: DBE

Fast-track geological history

BGR scientists investigated Carboniferous, Permian, Triassic and Jurassic deposits on Spitsbergen



Morning departure in an inflatable to the 20 kilometres distant coastal exposures in Billefjorden.

Today, 2000 kilometres separate the islands of the Svalbard archipelago and the Canadian Arctic. But more than 150 million years ago the two were neighbouring landmasses – this is one of the results of the CASE 14 expedition, whose destination was the Norwegian island group in the summer of 2012. The BGR CASE (Circum-Arctic Structural Events) programme aims to unravel the geological history of the Arctic Ocean. During the 14th expedition an international team led by Dr. Karsten Piepjohn (BGR) investigated geological formations in the west and centre of the main island Spitsbergen.

One of the geologists' destinations was the famous Festningen section,



Canadian colleague sampling in the Festningen section in Isfjorden, Spitsbergen.

a rock sequence exposing 175 million years of geological history, almost without a break, including the period of the greatest mass extinction in geological history 250 million years ago. It was noted that younger sequences in the Festningen section were almost identical with deposits in northern

Canada – an indication that both basins have a common origin.

BGR scientists completed their sampling series on Spitsbergen in 2012 to allow them to determine the hydrocarbon potential of the Arctic sedimentary basins. On earlier expeditions they had already geochemically analysed potential oil source rocks aged between 65 and 45 milli-



Tiny ammonite in dark Triassic siltstones with high crude oil potential.

on years, and between 275 and 100 million years. On CASE 14 they took samples from strata up to 385 million years old.

Contact: **Dr. Karsten Piepjohn**

Back to no man's land

BGR visited Antarctica's Sør Rondane Mountains for the third time

Antarctica's Dronning Maud Land is one of the most lonely regions of our planet. But BGR scientists return again and again to this remote ice desert. Below its thick armour of ice it hides unique clues to the geological history of the Antarctic.

At least twice in geological history it has formed part of larger landmasses. A billion years ago it was located in the centre of the supercontinent Rodinia. Later, Antarctica formed the heart of the enormous Gondwana continent, which united all of today's southern continents in one. During the collisions associated with the birth of Gondwana, high mountains, as impressive as today's Himalayas, were raised up. The remains of these mountains are now found in East Africa and in Dronning Maud Land.

A BGR team led by Dr. Andreas Läufer is searching for the frontier marking the continental collision. The scientists suspect that this frontier lies in the Sør Rondane mountain range, the tips of which protrude from the ice armour of Dronning Maud Land. A research team visited Sør Rondane for the third time in late 2012 as part of the GEA (Geodynamic Evolution



The Polar-6 research plane setting off for a survey flight.



The scientists explore the terrain on snowmobiles.

of East Antarctica) project. The GEA III expedition, carried out jointly with the Alfred Wegener Institute for Polar and Marine Research once again used the Polar-6 research aircraft to investigate the mysterious mountains. The scientists continued the geophysical and geologic measurements they began in 2011 and early 2012 during

the GEA I and II expeditions. The methods used include magnetics, gravimetry, ice thickness measurements, laser scanner sensing, aerial photography and other measurements. In addition, the scientists erected magnetic and GPS ground stations at the Russian station Novolazarevskaya and the Belgian Princess Elisabeth base.

Good weather conditions throughout made the GEA III campaign a complete success. During 13 survey flights the Polar-6 covered a total distance of 21,000 kilometres. This allowed the scientists to completely cover the Sør Rondane Mountains with an airborne survey grid.

Contact: **Dr. Andreas Läufer**

■ Soil

Soil carbon dioxide fluctuations

How does additional subsurface CO₂ affect soil?

Carbon dioxide (CO₂) gas is a natural component of the soil: animals and microorganisms exhale it; it is also produced when organic material decomposes. However, CO₂ storage in deep rock formations – also known as CCS (Carbon Capture and Storage) – remains controversial. Critics fear the gas may escape from underground stores and harm the soil ecosystem.

BGR scientists working with Dr. Florian Stange therefore investigated the environmental risks posed by this technology. During the first phase of the project the team witnessed how

difficult it is to evaluate the effect of distributed CO₂ fluxes through the soil to the atmosphere. If stored CO₂ diffuses upwards from the subsurface through the soil's pore system, the CO₂ concentration in the soil increases. They are currently developing a model that will allow possible concentration distributions to be estimated.

Simulation results to date demonstrate that two variables are primarily involved: on one side, of course, how much additional CO₂ enters the soil and, on the other, the soil water dynamics in the unsaturated zone. Even if

the same quantity of subsurface CO₂ moves through the soil, the CO₂ concentration in the soil may vary strongly with time and depth. In sandy, drier soils, the concentration is low, because the gas is quickly transferred to the atmosphere. In loamy, moist soils, in contrast, it resides longer, so the concentrations are higher. Dr. Stange's conclusion: 'The specific site conditions must always be reviewed when evaluating the risks.'

Contact: **Dr. Florian Stange**

■ Groundwater

Water for Africa

BGR scientists aim to improve water supplies in southern Africa

In semi-arid countries like Namibia, Botswana and Zambia, water scarcity is an omnipresent topic – as well as in the neighbouring countries of South Africa and Angola. Climate change may well exacerbate the problem. In the context of the SASSCAL initiative BGR, together with other German and African research institutions, supports these five countries in coping with the consequences of climate change. The BGR team centred around Prof. Dr. Thomas Himmelsbach and Dr. Falk Lindenmaier

concentrates on investigating shallow aquifers. Two doctoral students scrutinise different groundwater bodies using hydrogeological methods and isotope hydrochemistry. They want to learn how much water there is available and what the rate of annual recharge is.

This information will be adopted in integrated management systems, allowing resources to be utilised more sustainably. Another aim is to generally improve numerical modelling

of groundwater recharge in arid regions.

In addition, BGR provides support in developing an environmental geology masters course at the University of Namibia, to furnish the African partner with scientific qualifications.

Contact:

Prof. Dr. Thomas Himmelsbach

■ Energy Resources

Far North energy resource potential

BGR focuses on Arctic hydrocarbon assessment

Between Norway, Spitsbergen, Greenland and Iceland lies a barely explored area: the European sector of the Arctic ocean. In future, this marginal sea off the Atlantic Ocean will probably play an important role in providing Germany with oil and gas. 'Germany already obtains more than 70 percent of its gas imports from countries bordering the Norwegian Sea and from Arctic boundary regions', BGR scientist Dr. Christian Reichert says. According to studies carried out by the US Geological Survey, 25 percent of undiscovered

oil and gas reservoirs are said to lie north of the Arctic circle.

The federal government therefore recommends frontier exploration on the circum-Arctic continental shelf. In the coming decades, oil and gas will continue to play a prominent role in Germany, as they will elsewhere. Natural gas is the fossil energy resource producing the lowest pollutant emissions, and oil will continue to be needed as an important chemical feedstock.

Because production in Germany is

falling, the dependence on imports is increasing. In order to place German supplies on a broader footing, BGR has established the PANORAMA research framework, where all BGR energy resource research between 2013 and 2018 will be amalgamated and focused on the Arctic. Research projects in the region should aim to provide data for political and industry specialists and investigate the possible environmental impacts of future production.

Contact: **Dr. Volkmar Damm**

■ Soil

Background traces

BGR scientists determine background levels of inorganic pollutants in the soil



Soil scientist at work.

Cadmium, lead and other heavy metals in the soil are undesirable. However, they do occur naturally in many rocks and therefore in the soil – in some regions more, in others less. In addition, trace elements enter the soil diffusely everywhere, for example from automotive exhausts or particulates. Soil scientists refer to the natural level and the diffuse input together as the background level of a pollutant in the soil. It is important to know these values in order to define limit values for pollutants. They are also required to allow additional

contamination to be identified. After 15 years, BGR soil experts led by Prof. Wilhelmus Duijnisveld are compiling new representative background levels for soils in Germany. This time they can rely on considerably better data than during the last survey.

When evaluating the data the researchers not only consider the parent rock from which the soil formed, but also the land use and the climatic region. Among others, the nationwide background levels for lead, cadmium, chromium, copper, nickel, zinc, mercury and arsenic will be updated.

Contact:

Prof. Dr. Wilhelmus Duijnisveld

■ Groundwater

Sensitive equilibrium

Freshwater lenses supply many East Frisian Islands with potable water. How can they be sustainably managed?

Thousands of tourists visit the North Sea island of Langeoog every summer. The waterworks of this car-free island then runs at full capacity – the demand for water is huge. The island is supplied from what is referred to as a freshwater lens. These lenticular freshwater reservoirs form in the subsurface of islands because the infiltrating fresh water does not mix with the underlying more dense seawater but rather floats on top of it. Freshwater lenses are constantly recharged by precipitation. However, if too much freshwater is pumped at a given location, salt water can move

upwards – a process hydrogeologists refer to as upconing. If salt water enters the freshwater well, it may be contaminated for decades.

In order to avoid such nasty surprises, BGR scientists led by Dr. Georg Houben are using new methods to investigate the sensitive equilibrium between salt water and freshwater in the FLIN research project. For example, they mapped the spatial extent of the freshwater reservoirs on Langeoog using 3D helicopter electromagnetics. They also determined the depth of the freshwater

lens and its volume using additional, ground-based geophysical methods. The scientists determined the critical management variable, groundwater recharge, based on field and laboratory measurements as well as experiments.

Contact: **Dr. Georg Houben**

■ Polar Research

South Pole construction work

BGR refurbishes Gondwana Station



The Antarctic Gondwana Station at Terra Nova Bay, Ross Sea.

In 2013 the Gondwana Station at Terra Nova Bay will be celebrating an anniversary: BGR's Antarctic station will be 30 years old this year. During the Antarctic summer the red container buildings serve as a base for research expeditions into North Victoria Land, one of the few regions on the continent not completely covered by ice. But now some refurbishment work is needed. The power engineering facilities need to be modernised. Initial survey work is planned for the

2013/2014 Antarctic summer. The refurbishment itself will probably begin in the 2015/2016 season.

The GANOVEX XI expedition will run parallel to the survey work. Together with Korean and Italian colleagues, BGR scientists will research the birth and disintegration of the supercontinent Gondwana.

Contact: **Dr. Andreas Läufer**

Off to the Yukon

Arctic expedition leads BGR scientists to northern Canada



View across the inner Mackenzie Delta toward Richardson Mountains, part of the working area of the CASE 15 expedition.

The only contact in the isolated Richardson Mountains in the Canadian Yukon Territory is normally between grizzly bears and snow owls. However, during July and August in 2013 these wild animals will have some company. An international team of scientists led by the BGR geologist Dr. Karsten Piepjohn (BGR) and Maurice Colpron (Yukon Geological Survey) will visit the desolate region at the edge of the Arctic Ocean.

On the CASE 15 expedition the scientists will be searching for evidence of the disintegration of the Laurasian supercontinent. North America, Eurasia and Greenland once formed

part of this enormous land mass. As Laurasia drifted apart, a new ocean opened up between the fragments – the Arctic Ocean. However, the plate tectonic details of the disintegration are not yet exactly clear. In the Yukon Territory, Piepjohn and his colleagues primarily aim to uncover how the sea, i.e. the Amerasian Basin, between the Canadian Arctic and Siberia evolved.

They will investigate geological faults extending from Alaska to the Mackenzie Delta on the northern edge of the continent. BGR has investigated similar fault systems on earlier expeditions to the Arctic Ellef Ringnes Island and Ellesmere Island, as well

as in northern Greenland. Piepjohn and colleagues now aim to find an answer to the question of whether these breaks in the Earth's crust have a common origin.

Contact: **Dr. Karsten Piepjohn**

Soil resource policy

The Global Soil Week in Berlin centred on sustainable soil management issues

Sustainable soil conservation was the topic of the international Global Soil Week 2012 congress in November 2012. BGR presented two eye-catching, walk-on soil maps – one of Germany and one of Europe.

Germany has a wide variety of soils. In November 2012 visitors to the Global Soil Week in Berlin were shown an unusual view of the colourful mosaic of domestic soils: BGR presented the 1 : 200 000 (BÜK 200) scale generalised soil map in the shape of a three by five metre floor installation.

Global Soil Week, held for the first time in 2012, was initiated by the Global Soil Forum and the Potsdam Institute for Advanced Sustainability Studies (IASS). Around 400 delegates discussed the possible future format

of sustainable soil management and innovative land management.

The delegates compiled an action plan, aimed at guaranteeing improved soil conservation and sustainable soil use. The action plan serves as a policy document for subsequent climate negotiations in Doha. In discussions of topics such as climate change, renewable resources or food security, soil is often forgotten. The timing of the Global Soil Week was therefore deliberately chosen to be before the climate conference.



Walk-on soil maps of Central Europe in the conference foyer in Berlin.

Litmus test or mineralogy laboratory

BGR scientists achieve fifth position globally

During the international Reynolds Cup competition, BGR and State Authority of Mining, Energy and Geology's (LBEG) mineralogy laboratory secured fifth position out of 59 participants. Chevron Texaco initiated this round-robin inter-laboratory study in 2000 in order to pinpoint the accuracy achievable in mineralogical analyses of clay minerals.

The teams were given three artificial mixed clay samples of known composition. The mineral scope was similar to that of typical deposit rocks. The task of the participants was to analyse the samples and quantify the mineral composition.

For BGR, participation in such round-robin inter-laboratory studies

is routine. However, clay mineralogy represents a special challenge. In 2012 oil shale, nickel-laterite and bauxite were investigated. The good placing verifies BGR laboratory's high level of expertise.

New location for DERA

Mineral Resources Agency advises German industry from Berlin office

The German Mineral Resources Agency (Deutsche Rohstoffagentur, DERA) has been in its headquarters in Berlin since August 2012. The Federal Minister of Economics Dr. Philipp Rösler attended the opening ceremony. DERA, a BGR department founded in 2010, was originally established in Hannover.



At DERA's opening in Berlin (from the left): Dr. Peter Buchholz (head of DERA), Dr. Volker Steinbach (BGR department head), Dr. Peer Hoth (head of section in Federal Ministry of Economics and Technology, BMWi), Prof. Dr. Hans-Joachim Kümpel (BGR president), Federal Minister of Economics Dr. Philipp Rösler, Ulrich Grillo (president of the Federation of German Industry) and Werner Rissing (head of department in BMWi).



Ulrich Grillo, president of the Federation of German Industry, and the Federal Minister of Economics Dr. Philipp Rösler receiving the new DERA study on "Supply concentration of metals and industrial metals – Potential price and supply risks (Angebotskonzentration bei Metallen und Industriemetallen – Potentielle Preis- und Lieferrisiken)" from BGR president Prof. Dr. Hans-Joachim Kümpel (from left).

The BGR branch office in Spandau, Berlin, has expanded: the German Mineral Resources Agency (DERA) has now moved into the imposing red brick building that once held the stables of a Prussian barracks. It was opened by the Federal Minister of Economics Dr. Philipp Rösler on 28 August 2012. DERA's job is to advise German industry in questions relating to mineral resources. Background: the global resource situation has been in flux for years. Prices fluctuate, supply bottlenecks are common, and industry requires new, high-tech metals.

In order to ensure that Germany continues to enjoy reliable supplies despite these challenges, DERA experts continuously analyse international commodities markets. They show which mineral resources may become scarce in the future or where price fluctuations threaten. They identify new mineral resource potentials and investigate how mineral resources can be utilised more efficiently. In addition, DERA enters into cooperation with mineral resource-rich countries. The move to the capital strengthens the agency in its role as an information platform.



The Russian Minister for Natural Resources and Ecology S. J. Donskoj and BGR president Prof. Dr. H.-J. Kumpel after signing the declaration of intent (from right).

Germany and Russia reinforce their cooperation in the fields of geology and mineral resources. BGR president Prof. Dr. Hans-Joachim Kumpel signed a declaration of in-

Exchange with Russia

BGR seal closer resource cooperation deal

tent with the Russian Ministry of Natural Resources and Ecology in November 2012 during the German-Russian intergovernmental talks in Moscow. The Russian president Vladimir Putin and the German Chancellor Angela Merkel also attended the memorandum signing ceremony. The focus is on the exchange of scientific knowledge in the fields of geology, geophysics and resource deposit evaluation. The topic of environmental compatibility of exploration and mining works also forms

part of the cooperation. National mining laws and legislative regulations for the exploitation of mineral resources also play a role. In addition, the two nations agreed on joint exploration programmes, projects, seminars and exhibitions. ‘The declaration of intent continues and intensifies the good scientific cooperation already in place since 1995’, said BGR president Hans-Joachim Kumpel.

Better cooperation in western Asia

BGR and UNESCWA present report at the World Water Week



Flow measurements at the Naber al Labbane karst spring in Lebanon.

Long-term water supply security presents a challenge to the Near and Middle East. BGR has been supporting the UNESCWA (United Nations Economic and Social Commission for Western Asia) regional commission since 2005 in improving the previously weak regional cooperation of the UNESCWA member states in the water sector.

In August 2012 experts from both institutions presented their integrated, cross-border water resources management project at the World

Water Week in Stockholm. For the first time, the water experts collected information from 13 Arab nations in western Asia and from Iran, Israel and Turkey. They investigated every water resource in the region in terms of hydrology, hydrogeology, use, status of international agreements and cross-border management efforts. The report will provide water experts with a decision aid.

Visiting central Africa

BGR president Prof. Dr. Hans-Joachim Kümpel visited Rwanda, the Democratic Republic of Congo and Burundi for a week in February 2012. He spoke to government representatives and partner organisations about mineral resource and groundwater projects.

In Burundi's capital Bujumbura Kümpel and Jean-Marie Nibirantije, the Burundian water and environment minister, signed a groundwater management agreement. It aims to ensure improved public provision of clean drinking water.

During his stay in the Democratic Republic of Congo, the BGR president opened a small-scale mining advisory and information centre in the provincial capital of Bukavu. Among other things, a laboratory

will be set up here, where in future the origin of samples will be determined using a geochemical procedure developed by BGR. This geochemical fingerprint forms the basis for certifying mineral resource trading chains.

Central and East Africa are the focal point of BGR's consulting activities in Africa. 'The aim is to support the partner countries with technical expertise and modern instrumentation', Kümpel emphasised.



Etienné Babunga, interior minister of the Congolese province South Kivu (left), and Prof. Dr. Hans-Joachim Kümpel, president of BGR (right), open the small-scale mining advisory and information centre.

Resource efficiency prize awarded

Award went to four companies and a research institute

The winners of the German Resource Efficiency Prize 2012 were Accurec Recycling GmbH, NANO-X GmbH, RecoPhos Consult GmbH, Technische F&E-Zentrum für Oberflächenveredelung und Hochleistungserspannungswerkzeugbau and Institut für Aufbereitung, Deponietechnik und Geomechanik (IFAD) at the Technical University of Clausthal. The companies awarded the prize developed innovative coatings for machine components, for example,

a catalytic converter containing no precious metals and a procedure for thermal utilisation of sewage sludge.

The competition, with € 10,000 prize money, is held annually by the German Federal Ministry of Economics and Technology and BGR's German Mineral Resources Agency. The prize is awarded for application-oriented research results and rewards companies for the efficient use of resources and materials.



Prof. Dr. Hans-Joachim Kümpel, president of BGR, and Dr. Bernhard Heitzer, State Secretary in the Federal Ministry of Economics and Technology, with the winners of the Resource Efficiency Prize 2012 (from the right).

Resources conference in Hannover

Resources for the 21st century were the centre point of the GeoHannover conference at the Leibniz University Hannover in early October 2012. ‘An international conference focussing on resources was hosted for the first time in Germany’, Prof. Dr. Hans-Joachim

Kümpel, BGR president stated. Numerous exhibitors and more than 600 experts attended the event, organised by GEOZENTRUM Hannover, Deutsche Geologische Gesellschaft, Leibniz University and Akademie für Geowissenschaften und Geotechnologie. The topics ranged from industrial metals through shale gas and geothermal energy to marine mineral resources. Other important topics included issues such as sustainable use and environmental compatibility.

New BÜK 200 map services online



BÜK 200-web map service.

BGR and the state geological surveys’ 1 : 200 000 scale generalised soil map (BÜK 200) is now also available online. The map images can be directly integrated into geographical information systems via web map services (WMS). Of the 55 BÜK 200 map sheets in total, 48 have been published

so far. The mid-scale BÜK 200 provides the highest spatial resolution ever archived at national level. A special map viewer documents the status of the map series and allows simple data querying.

www.bgr.bund.de/buek200-viewer

Arid regions in focus

An international groundwater conference was held at BGR in 2012

‘In the Earth’s arid regions, groundwater is often the only resource available to provide water for the population and agriculture’, said Prof. Dr. Thomas Himmelsbach, head of the BGR Groundwater resources sub-department, ‘incorrect use means that groundwater is already dangerously depleted in some regions’. In all, 200 international experts at the Hydrogeology of Arid Environments conference, held at GEOZENTRUM Hannover in March 2012, discussed approaches for finding solutions.

The delegates from 31 different countries discussed future scientific challenges in arid countries and how modern hydrogeology can contribute to a better and sustainable management of the scarce groundwater resources in arid regions. Furthermore, the event focused on the topics of groundwater exploration, safeguarding groundwater quality and deriving future water availability scenarios using groundwater modelling.

Geology congress in Brisbane

BGR was represented with a booth

Resources, soil, water, geothermal energy and international cooperation were the BGR booth topics at the International Geological Congress in Brisbane, the world's largest geology congress. This meeting has been regularly held in a different country every four years since 1878. Around 5000 delegates attended in Australia in 2012. The respective national geoscientific services, commodity and mining companies, and geo-sector institutes and organisations all presented themselves at this event. BGR experts presented a 3D animation of a virtual excursion into a mine. Staff from a number of the agency's departments talked to geoscientists



BGR's booth at the International Geological Congress (IGC) in Brisbane, Australia.

from other countries, presented their projects and took part in workshops.

Earthquakes caused by gas production?

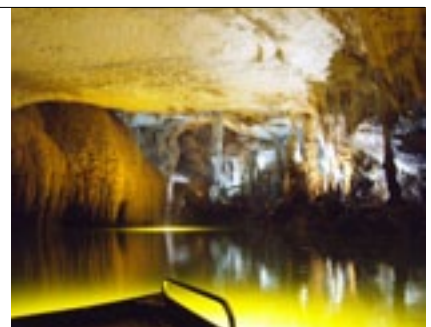
During recent years, several weak earthquakes with magnitudes between 1.9 and 2.9 have occurred in the vicinity of the Völkersen and Söhlingen gas fields near Rotenburg an der Wümme and Verden an der Aller, in northern Germany, the most recent in November 2012.

This event is currently being investigated by BGR seismologists. In June 2012 they set up a number of mobile earthquake monitoring stations close to the epicentre. The first results indicate a focus depth between 3 and 7 kilometres – the same depth range as natural gas extraction.

Where does the water in Jeita spring come from?

With the aid of stable isotopes – i.e. slightly heavier variants of the elements hydrogen and oxygen – BGR scientists have now deciphered the routes taken by the meltwater from the snow-covered Lebanon and Anti-Lebanon mountains. Stable isotopes reveal complex hydrological processes: for example, the quantity

of these isotopes in a water sample can indicate the elevation at which the precipitation infiltrated into the ground. Stable isotopes have been analysed using innovative methods in a new BGR laboratory since 2011. In the course of technical cooperation with Lebanon and Syria, the scientists collected water samples from



Jeita spring near Beirut, Lebanon.

the Jeita karst spring near Beirut and Figeh near Damascus. The results show that the isotope signatures in the spring water fluctuate distinctly depending on the season.

To the North Pole in felt slippers

Who hasn't wanted to trek to the North Pole? In November 2012, in Hannover, it was actually possible to do this in felt slippers. Together with the Alfred Wegener Institute for Polar and Marine Research in the Helmholtz Research Association (AWI), BGR presented Expedition:Arktis – Zu-



Walk-on soil map of „Expedition:Arktis – Zukunftsforschung im Hohen Norden“.

kunftsforschung im Hohen Norden (Expedition:Arctic – future-oriented Research in the Far North) at the Leibniz University Hannover. The core element was a 10 m diameter

walk-on soil map of the Arctic. Surrounding the map, current research projects dealing with topics such as climate, resources and the geology of the Arctic were also presented.

Boreholes in Germany

Data on boreholes in Germany will soon be available online. BGR is currently developing a national internet portal in cooperation with the state geological surveys and the Federal Waterways Engineering and Research Institute. The aim is to make all available borehole data available,

including in-depth information stratigraphic data or groundwater monitoring data, for example, in addition to master data such as location, borehole length and type of borehole. The data are available via the Bohrpunktkarte Deutschland internet portal.

www.bgr.de/app/eEarth/main.php



Data on boreholes in Germany.

Cooperation with AHK office in Chile

The chambers of commerce worldwide network (AHK) office in Santiago, Chile, and BGR's German Mineral Resources Agency (DERA) have agreed to cooperate more closely in the resources field. Both institutions want to hold regular talks and support both German and Chilean companies. 'Chile, as an important mining country, produces metals vital to German industry. Economic contact is therefore very important to both countries' said Cornelia Sonnenberg, head of the chambers of commerce worldwide network office in Santiago.

BGR expands seismographic network

Around 60 earthquakes with magnitudes greater than 2.0 occur per year in Germany. The majority go unnoticed. They do not, however, escape the notice of BGR's seismographic network. The network, consisting of 27 monitoring stations distribu-



Seismometer installation in an earthquake monitoring station in Rethem, Lower Saxony (large and small image).

ted throughout Germany, is now being expanded: in September 2012 a station in Rethem, Lower Saxony, was added, another will be set up in Mecklenburg. In order to keep the seismometer as stationary as possible, it is installed in a 200 metre-deep borehole.

Thermal imaging with the BGR helicopter

BGR scientists can now measure the temperature patterns on the surface of the Earth using the institute's own helicopter. The Federal Aviation Authority issued the permit for thermal imaging equipment installed on the BGR helicopter in mid-2012. Between May and November 2012 the camera was tested on airborne campaigns



The BGR's Sikorsky S-76B helicopter with the thermal camera equipment on a surveying flight (large and small image).

between Kassel and Hildesheim, in the Leine Valley between Einbeck and Kreiensen and near Demmin in Mecklenburg-Western Pomerania. As early as 1992, BGR was carrying out airborne thermal remote sensing, for example to identify coastal freshwater discharges or track down geothermal anomalies, useful in the search for utilisable heat energy in the subsurface.

BGR involved in risk analysis

What dangers are the population exposed to if an extreme meltwater flood occurs in spring on all major German rivers, or a dangerous virus causes a national pandemic? What hazards threaten the population in

Germany? To be prepared for natural events like these and protect the civilian population, the federal government compiles a risk analysis of nationally relevant hazards. BGR contributes its expertise in the

field of geohazards to this task. In 2012 BGR was involved in two expert workshops of the Risikoanalyse Bevölkerungsschutz BUND (Risk analysis for national civil protection) working group.

BGR and ANDRA continue successful cooperation



Source: ANDRA/Studio Durey

Aerial photograph of the Meuse/Haute-Marne underground laboratory surface facilities (France).

BGR and the French National Radiactive Waste Management Agency (ANDRA) extend cooperation until 2016. In May 2012 BGR president Prof. Dr. Hans-Joachim Kümpel and Marie-Claude Dupuis, ANDRA's president, signed a new cooperation agreement. The two institutions

carry out joint research on the final disposal of radioactive waste in the French Meuse/Haute-Marne underground laboratory. Here, BGR extends its geotechnical expertise on the clay host rock. BGR has been working with ANDRA since 2001. ANDRA operates the Meuse/Haute-

Marne underground laboratory at Bure, approximately 175 kilometres west of Strasbourg, on behalf of the French government.

Selection of 2012 BGR publications

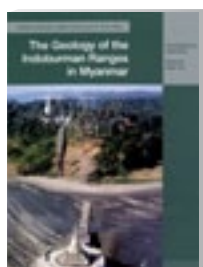
BGR publishes a wide variety of map materials and books about their work. All titles can be purchased from Schweizerbart'sche Verlagsbuchhandlung (www.schweizerbart.de) or as digital documents (www.bgr.bund.de).



G. Leydecker
***Erdbebenkatalog für Deutschland mit
 Randgebieten für die Jahre 800 bis 2008***
 [Geologisches Jahrbuch E 59]
 198 pages, German
 ISBN 978-3-510-95989-1 18,50 Euro

German earthquake catalogue

Geological Yearbook (Geologisches Jahrbuch) E 59 includes information on more than 12,000 earthquakes of magnitude ≥ 2.0 in Germany and adjacent areas. Comprehensive seismological data was collected, revised and updated to compile the new earthquake catalogue. The publication includes reports from historical sources and the results of modern seismographic registers. Eleven maps present thematic earthquake content. Among other things, the accompanying CD contains the complete earthquake catalogue in digital format.



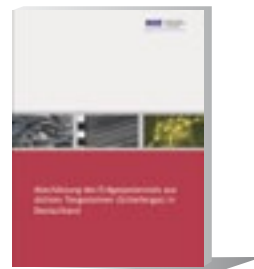
D. Bannert, A. Sang Lyen & Than Htay
***The Geology of the Indoburman Ranges
 in Myanmar***
 [Geologisches Jahrbuch B 101]
 101 pages, English
 ISBN 978-3-510-95993-8 34,80 Euro

Geological Yearbook on the Geology of Myanmar

The geology of the Indo-Burmese ranges in Myanmar is described in Geological Yearbook B101. This 500 km long, N-S trending mountain range separates the fertile and densely populated Irrawaddy Valley from the Gulf of Bengal. It presents the identified stratigraphic sequences and the still-young orogenic processes, based on long term investigations by German and Burmese geologists. A critical discussion of the plate tectonic evolution from today's perspective rounds off the work.

Study of German shale gas potential

BGR scientists surveyed the most important rock formations in Germany displaying shale gas potential. The results have now been published in this study. In addition to estimating the resource potential, the possible environmental impacts of developing shale gas reservoirs by fracking were investigated. The study is available to download free.



Abschätzung des Erdgaspotenzials aus dichten Tongesteinen (Schiefergas) in Deutschland (PDF, 8 MB, German):
www.bgr.bund.de/Schiefergas-Studie

BGR completes Gorleben reports

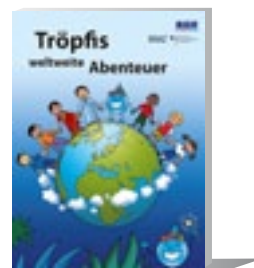
BGR has completed the German-language reports describing the Gorleben site with the publication of the fourth title in the series. In this final volume the authors describe the status of geotechnical investigation work, including the results to date of geomechanical, geophysical and in-situ mine monitoring up to the beginning of the moratorium in 2000. Supplementary laboratory testing and modelling based on investigation results are described.



Standortbeschreibung Gorleben Teil 4: Geotechnische Erkundung des Salzstocks Gorleben [Geologisches Jahrbuch C 74]
 194 pages, German
 ISBN 978-3-510-95988-4 49 Euro
 The English version is provided free of charge and can be downloaded from the BGR website (PDF, 7 MB):
www.bgr.bund.de/Standortbeschreibung-Gorleben-Teil4

Groundwater comic developed for schoolchildren

BGR now publishes the Spanish groundwater comic 'Las Aventuras de Ytyky' in five additional languages. The comic was developed to sensitise young schoolchildren to groundwater issues. The reader goes on a journey with a drop of water through eight adventures, covering the topics hydrologic cycle, water protection, health and heavy metals. The appendix includes a glossary clearly explaining the scientific terminology. The comic is available free from BGR (Vertrieb@bgr.de) and can also be downloaded free from the BGR website.



Languages (printed version): German, English, French, Arabic, Spanish

Languages (PDF): Russian, Spanish, German, English, French, Arabic
www.bgr.bund.de/Grundwassercomic



H.-J. Stephan, B. Urban, G. Lüttig,
B. Menke, M. Sierralta (Hrsg.)
*Palynologische, petrographische und
geochronologische Untersuchungen
an Ablagerungen der Leck-Warmzeit
(spätes Mittelpleistozän) und beglei-
tender Sedimente*
[Geologisches Jahrbuch A 160]
80 pages, German
ISBN 978-3-510-95997-6 29,80 Euro

Geological Yearbook A 160 published

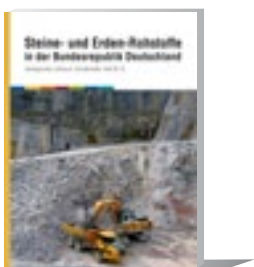
This volume presents the results of tests performed on samples taken from nine boreholes at depths down to a maximum of 300 metres in the north-west of Schleswig-Holstein. Mid- to Upper Pleistocene strata, including the Leck Interglacial, were drilled. The petrographic and geochemical investigations looked at grain size, carbonate content and carbon content. Pollen communities were investigated where sections included organic material.



*Steinzeugen aus 500 Millionen
Jahren Erdgeschichte im Park der
Sinne Laatzten*
80 pages, German
ISBN 978-3-510-95994-5 19,90 Euro

Book describing rocks in Park der Sinne, Laatzten

With the aid of BGR experts and utilising BGR map material, the State Authority of Mining, Energy and Geology has published a book with information on more than 50 rock types exhibited in the Park der Sinne (Park of the Senses) near Hannover. They describe the rocks' genesis, weathering phenomena, working and uses. Since the Expo in 2000, visitors can enter the Park der Sinne free of charge and explore it under the motto 'See, feel, hear, smell, taste'.



*Steine- und Erden-Rohstoffe in der
Bundesrepublik Deutschland*
[Geologisches Jahrbuch Sonderhefte
SD 10]
356 pages, German
ISBN 978-3-510-95995-2 39,80 Euro

New non-metals publication

Together with the individual state geological surveys, BGR has compiled a publication describing the range of non-metal resources in Germany. The main focus of this monograph is on resource geology and the industrial benefits of domestic non-metals. In ten chapters, the publication's authors describe the properties, occurrence, production and use of non-metals resources. The topics of resource recycling, availability and security are also discussed.



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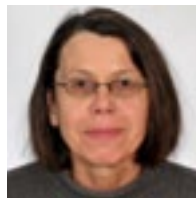


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About BGR

As a federal agency, the Federal Institute for Geosciences and Natural Resources (Bundesanstalt für Geowissenschaften und Rohstoffe, BGR) is the federal government's central geoscientific advisory body. It forms part of the portfolio of the German Federal Ministry of Economics and Technology. In its role as Germany's centre for geoscientific expertise, BGR advises and informs the federal government and German industry on all questions relating to geosciences and natural resources. BGR's work facilitates the security, and economically and ecologically compatible utilisation of natural resources, and thus the provision of basic needs. In its role as Germany's national geological service, BGR participates in numerous international duties. At home, it assumes predominantly coordinating functions. Together with the State Authority of Mining, Energy and Geology (Landesamt für Bergbau, Energie und Geologie, LBEG) and the Leibniz Institute for Applied Geophysics (LIAG), BGR forms the GEOZENTRUM Hannover.

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