

BGR Report

Federal Institute for Geosciences and Natural Resources

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Raw material monitoring assists companies

German Mineral Resources Agency at BGR provides information on global developments in resource markets

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Contact

Bundesanstalt für Geowissenschaften und Rohstoffe
Stilleweg 2
30655 Hannover
Telefon +49 511 643-0
Telefax +49 511 643-2304
E-Mail info@bgr.de
www.bgr.bund.de

Editorial Office

Janine Seibel
Dr. Thomas Schubert (responsible for the content)

Editorial Services

Klaus Kruse
Bettina Landsmann
Dr. Karsten Piepjohn
Dr. Marc Filip Wiechmann

Photographies "Contact"

Siegfried Pietrzok

Texts (German)

Ute Kehse

Translation

High-Tech-Translations;
R. Clark Newcomb

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This BGR Report presents projects that BGR was working on in 2015 and looks ahead to future projects.

Editorial



*Prof. Dr.
Ralph Watzel*

President
of the Federal Institute
for Geosciences and
Natural Resources

Dear Readers,

Germany is dependent on imports for its metalliferous natural resources. Although prices have been declining significantly in recent months, numerous raw materials such as platinum, cobalt and rare earth elements continue to be exposed to price and supply risks.

To ensure that German industry can respond better to this situation in their procurement activities, the German Mineral Resources Agency (DERA) at BGR has developed a raw material monitoring system on behalf of the German government. DERA experts have configured a screening method for the early identification of possible procurement risks. This is the platform which enables German companies to gain the specific advice they require. All of the most important information on this issue is bundled within DERA's internet portal (www.deutsche-rohstoffagentur.de). Find out more on this raw material monitoring in the interview on page 70.

BGR also provides its expertise in other important fields with great societal relevance. BGR has been advising the national commission on "Storage of High-level Radioactive Waste" since 2014. Due to their comprehensive research activities in the field of radioactive waste disposal, BGR scientists are important technical experts to which the commission can turn to for geological information and advice. Read more about this in the article on page 6.

I hope you will find it an interesting read!

Projects

Subsurface Use

- 6 Difficult selection process
- 8 Re-evaluation of salt deposits
- 10 Predicting the future
- 12 Tectonic forces in action
- 14 Replacements in bentonite
- 16 Heating up systematically
- 18 Stability verified
- 20 Purity and its problems

Exploration of Polar Regions

- 22 In the realm of the Arctic Ocean

Securing the Supply of Raw Materials

- 24 A platform for Europe
- 26 The clock is ticking
- 28 How manganese nodules grow
- 29 Valuable residues
- 30 Facts about energy resources
- 32 Exploration by induction

Sustainable Livelihoods

- 33 The secret of the Kalahari sands
- 34 144 pages of soil information
- 36 Water balance in the Ovambo Basin
- 37 The waters of the Logone
- 38 The breath of the marshes
- 40 Precision farming
- 41 No more mob/demob

Development and Linking of Geoscientific Knowledge

- 42 Aschersleben case study
- 43 Groundwater 3.0
- 44 Europe in vector format
- 45 Quality-assured soil data
- 46 Sentinel in orbit
- 48 Geodata in good hands
- 50 The Europe puzzle
- 52 Comparison of Soil Profile Description Systems

Geohazard Protection


- 53 The cause of the rumbling
- 54 Earthquake data – daily updates
- 55 Earthquakes in real time

Support for Developing Countries

- 56 Merged expertise
- 57 Green light for geothermal energy
- 58 Soil data for Cameroon
- 59 A plan for Dhaka
- 60 Training courses for disaster risk management

Nuclear-Test-Ban Monitoring

- 62 Mobile and modular



“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.

Outlook

- 63 ■ Horstberg borehole back in operation
- 63 ■ New phase for DECOVALEX
- 64 ■ Behaviour of subhorizontally-bedded salt formations
- 65 ■ Potential of “Doppelsalinare” and subhorizontally-bedded salt deposits
- 66 ■ CO₂ streams in the spotlight
- 66 ■ Old ore bodies rediscovered
- 67 ■ Improved planning for well construction
- 67 ■ Safeguarding drinking water supplies
- 68 ■ When are contaminants available?
- 68 ■ Transport in percolating water
- 69 ■ New mass spectrometer
- 69 ■ Minerals in mixtures

People & Projects

- 70 Raw material monitoring assists companies
- 71 The future of groundwater
- 72 Energy from deep underground
- 73 Water for Jordan

Spectrum

- 74 20 years of Mont Terri
 - 74 Transparency and sustainability
 - 74 Tradefair highlight
 - 75 Year of Soils
 - 75 Geo-Show for pupils
 - 75 Zypries opens congress
 - 76 No more atomic testing!
 - 76 Trainees wished all the best
 - 76 Workshop in Maputo
 - 76 Salt in the Geoviewer
 - 77 Treaty with Canada
 - 77 Energy transition and soils
 - 77 More intense involvement
 - 77 Efficient utilisation
 - 78 Selected publications
 - 79 GeoChannel
 - 80 Change at the top of BGR
 - 81 Contact
-

Difficult selection process

BGR experts advise the repository commission on geoscientific issues

The Bundestag and the Bundesrat established a commission in 2014 to undertake preparatory consultations for the search for a repository site for high-level radioactive waste. The 34 members of the committee receive advice from BGR on geoscientific issues. At least one BGR expert is present at all of the meetings of the repository commission.



▲ Gallery in the international Mont Terri Rock Laboratory in Switzerland. BGR has been doing research here for 20 years, investigating the properties of claystones as a host rock for a repository.

Transparent and fair – this is how the repository commission should do its work. All of the meetings are public, and are transmitted live in the internet. There are also audio recordings: everyone can use the internet portal to ask the commission questions

and to make comments. The internet portal also gives access to all of the documents discussed by the commission – whose official title is “Storage of High-level Radioactive Waste” – as well as all of the documents which are important for its work.

“The commission’s task is to do preparatory work for the actual search for a repository site,” explains Dr. Volkmar Bräuer, head of the “Underground Space for Storage and Economic Use” department at BGR. The members of the commission not only

include politicians from the Bundestag and the governments of the German states, but also representatives from the scientific community and society as a whole. The different tasks are delegated to three working groups. One group for instance develops regulations and criteria for societal dialogue and public participation during the subsequent search for a repository. The main priority here is again transparency and the involvement of the general public.

Transparency and public participation

The second working group is currently reviewing the existing Site Selection Act, whilst the third working group is elaborating decision-making criteria. A site is being sought that provides the best possible levels of safety, and is also socially acceptable. The committee plans to submit a final report by the middle of 2016 which provides the basis for the next steps in the search for a repository.

The necessary expertise when it comes to geoscientific questions is provided by BGR scientists: the BGR President and another scientist are present at all of the commission's meetings. Volkmar Bräuer takes part in all of the meetings of working group 3.

Valued experts

Thanks to BGR's many years of com-



▲ BGR scientists in the Mont Terri Rock Laboratory in Switzerland. They use high resolution geophysical surveying methods to investigate whether claystone is suitable as a host rock for the final disposal of high-level radioactive waste.

prehensive research experience on the topic of repositories, the BGR scientists are highly valued as experts by the members of the commission. “BGR is the institute in Germany which boasts all-round technical expertise on geoscientific and geotechnical issues for the complete site selection process, all the way to assessing the suitability,” says Volkmar Bräuer.

The work undertaken by working group 3 includes looking at various disposal options, general safety requirements, and the ability to correct any possible defects. “The geoscientific aspects are crucial here for the safety of the repository. This is why

minimum geoscientific requirements for the site regions, the exclusion criteria, and the weighing criteria, have to be defined with the incorporation of the necessary technical expertise,” reports Bräuer.

Scientific expertise

BGR has already made numerous expert contributions since the first meeting of the commission, including lectures, data sheets, review articles, and data collections. Topics included geoscientific criteria for repository projects in other countries, and easily understandable facts on claystone research.

Contact: **Dr. Volkmar Bräuer**

Re-evaluation of salt deposits

BGR investigates subhorizontally-bedded salt layers

The search for a site for a repository for high-level radioactive waste was restarted in 2013. All of the potential host rocks existing in Germany must be re-evaluated and compared as a result. The list now also includes so-called “subhorizontally-bedded evaporite formations”. BGR is analysing today’s knowledge base on these salt deposits as part of the BASAL project.

Parts of Germany were covered by shallow seas or large salt lakes several times over the last 250 million years. These seas were sometimes even more salty than today’s Dead Sea. Evaporation led to the deposition of salt layers in these waters, which were gradually covered by younger sediments.

Salt minerals were originally laid down on the seafloor in horizontal

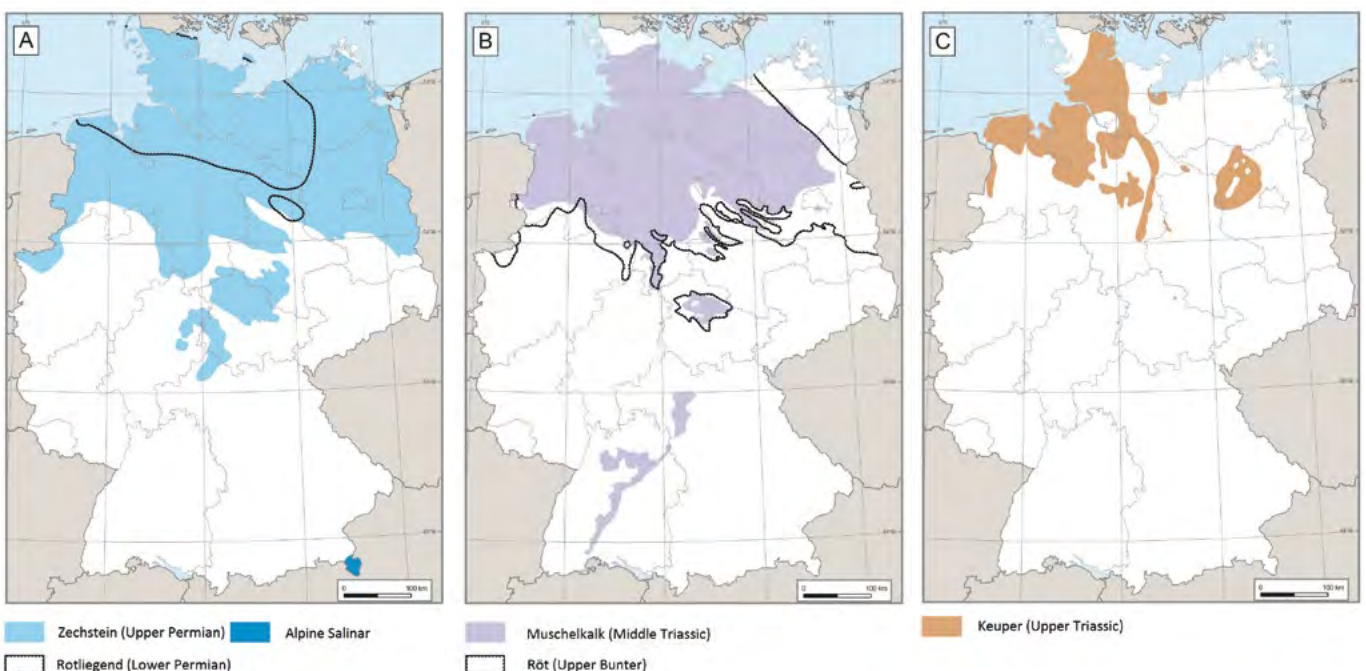
layers. Later on, the weight of overlying rock layers caused the salt to rise up in some places as far as the surface of the earth – giving rise to mushroom-shaped or pillar-shaped salt domes.

New start to the search for a repository

For a long time, salt domes were the main focus of the search for a

repository for high-level radioactive waste. “BGR published rock salt studies in 1977, 1982, 1983, 1991 and 1995, which all concentrated on salt domes,” reports Dr. Jörg Hammer, head of the “Geological exploration” sub-department at BGR.

However, ever since the Site Selection Act came into force in 2013, the search for a repository site has now



started from scratch again, and includes the whole of Germany. This means that in addition to salt domes, “subhorizontally-bedded evaporite formations” are also now being investigated to see whether they are also suitable host rocks for a repository. These salt layers are often located several thousand metres below the surface, and their bedding conditions have hardly changed since they were originally deposited.

New distribution maps

BGR scientists headed by Klaus Reinhold and Jörg Hammer are currently compiling all of the known data on the salt formations in Germany as part of the BASAL project. The scientists have already prepared new distribution maps. These reveal the

parts of the country where there are evaporites of Rotliegend, Zechstein, Röt, Muschelkalk, Keuper, Malm or Tertiary age.

In addition, the BGR experts have also compiled data from numerous representative wells drilled into the salt formations in question. Concise datasets are now available on the composition of the layers, the thickness of the rock salt sequences, and the depth of all of the differently aged salt formations.

How well are radioactive toxins contained?

Specific regions will be looked at in much greater detail during the course of the project. “We will prepare thickness maps and depth maps,” says Jörg Hammer. In addition, BGR scientists also intend to analyse samples from deep wells and mines. “We will analyse the chemical composition and physical properties of the rocks. We are also looking at the influence of fault zones and how heat generation, raised fluid contents, and varying geomechanical properties, affect the barrier properties of the rock salt.”

These questions are important to establish whether subhorizontally-bedded salt layers may also be suitable

for the final disposal of high-level radioactive waste. The next phases in the project, which is scheduled to be completed in 2019, involve scientists in elaborating 3D geological models, and using these to carry out numerical modelling. The aim here is to find out whether the final disposal of heat-generating radioactive waste alters the salt layers – and the effects this could have on the properties of the rock formations. In addition, the scientists will also simulate how a possible repository located in subhorizontally-bedded salt layers could be affected by a glaciation.

Contact: **Dr. Jörg Hammer,**
Dr.-Ing. Sandra Fahland



◀ Distribution of evaporite rocks from various geological eras in the Federal Republic of Germany.

Predicting the future

BGR develops a safety demonstration concept for a repository in claystone

Radioactive waste is to be safely stored in deep geological formations for the long term. Experts are considering a period of one million years to demonstrate the safety of high-level radioactive waste. BGR scientists are currently developing a concept to enable them to systematically demonstrate the long-term safety of a repository in claystone. Two models simulate the typical geological situations in North and South Germany.

It is not clear how the earth's climate will develop in the distant future. Over the next million years, parts of Germany could be covered several times by thick sheets of ice during new ice ages. However, if the climate continues to warm up, and the sea level continues to rise, central Europe could also be covered by a shallow sea.

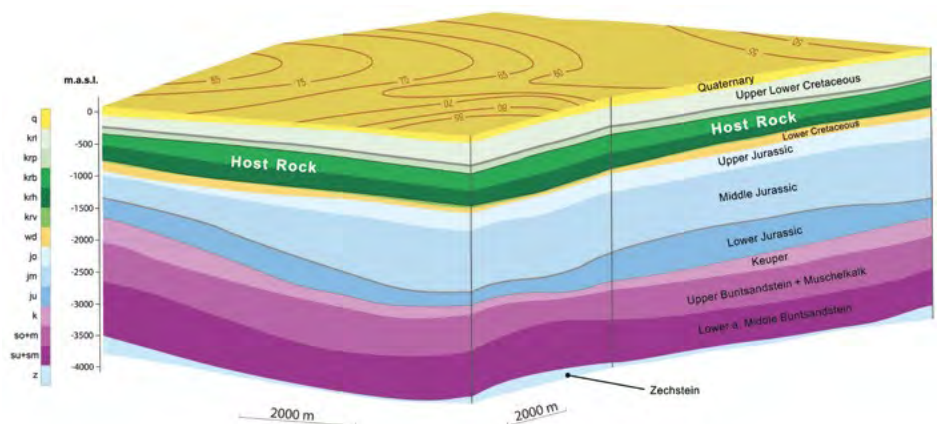
Such developments need to be taken into consideration when planning a repository for radioactive waste. "It is necessary to isolate the waste from the biosphere for a period of around one million years to prevent toxic effects on people and the environment," reports BGR scientist Sabine Mrugalla.

Safety demonstration for claystone
Mrugalla is involved in the AnSichT project. Together with its project partners DBE TECHNOLOGY GmbH in Peine, and the Gesellschaft für Anlagen- und Reaktorsicherheit mbH

(Plant and Reactor Safety Ltd.) in Braunschweig, BGR is elaborating new methods that can be used to carry out a safety demonstration for a repository in claystones.

"Together with our partners, we are not only regarding the geology, but also the technology and the build-ings in a repository mine. We then

describe the possible development scenarios," explains Sabine Mrugalla. It is usual international practise in repository projects to initially make a scientific description of the conditions at the start. This is followed by the documentation of the processes which could influence the repository system in the future. This includes for instance the evaluation by various



▲ 3D block diagram of the NORD model covering north Germany.

experts of the physical properties of the host rock, the corrosion of the containers, underground transport processes, and geological events – including meteorite impacts in extreme scenarios – all of which are then classified into conditions and processes. BGR’s task in the AnSichT project is to describe the geoscientific processes involved.

Geological repository site models

In the case of a repository in claystone, different geological developments are possible depending on whether the repository site is in north or south Germany. “We have therefore decided to build up two models, one for north Germany and one for south Germany,” reports Sabine Mrugalla.

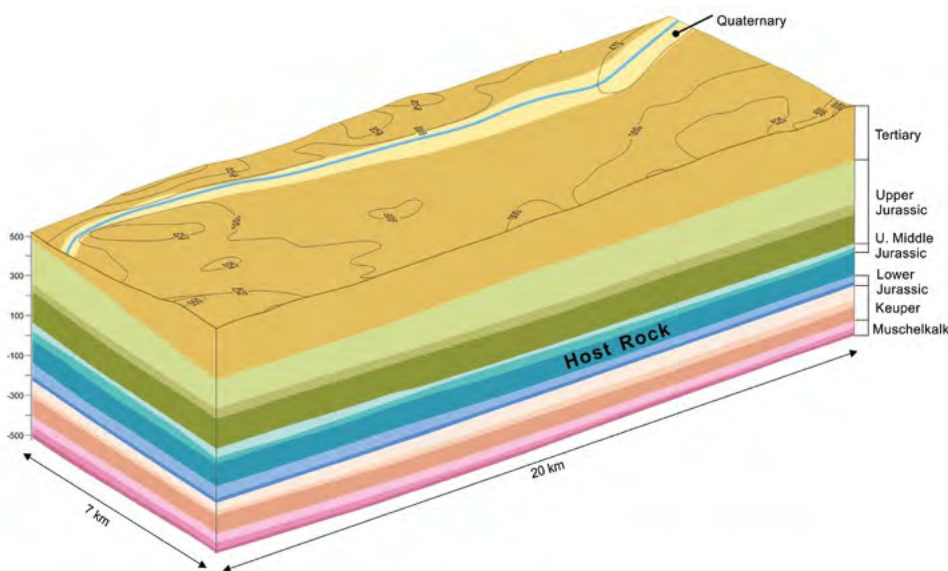
In the NORD (north) model, the scientists look at the Lower Cretaceous claystones as the potential host rocks. The model includes 17 geological units from Zechstein to Quaternary. The SÜD (south) model consists of 16 layers and is more than 1,000 metres thick in total. In this model, the scientists chose the Opalinus Clay from the Middle Jurassic as the host rock.

Long-term forecasts

BGR elaborated long-term geoscientific forecasts for both models. These forecasts describe how the models could develop over the next one million years when they are affected, for instance, by several ice ages which could cause erosion at the surface, or whether and how the earth’s crust could become deformed.

“One of the main objectives was to structure the catalogue in which the various conditions and processes are documented, much more clearly and unequivocally. We wanted to transparently document the information which is used for the development of the scenarios,” says Sabine Mrugalla. She and her colleagues have already implemented this objective in the catalogue for south Germany. The probabilities of the processes actually occurring are now being assigned to the different processes. This makes it possible to determine the more probable and less probable future development of the repository system.

Contact: **Sabine Mrugalla**



▲ 3D block image of the SÜD model covering south Germany.

Tectonic forces in action

Microstructures in claystones reveal how faults arose and what influence they have

In the BASTION project, BGR experts are working on behalf of the Federal Ministry for Economic Affairs and Energy to analyse samples taken from the underground rock laboratories in Switzerland and France. They want to find out more about the properties of claystones relevant for repository safety. The most important questions: how do geological fault zones affect the stability of claystones? What influence do these heterogeneities have?

The forces of tectonics can grind down even the hardest rocks. In areas where the earth's crust moves under the influence of the forces inside the earth, it is often possible for fracture zones to develop with thicknesses of

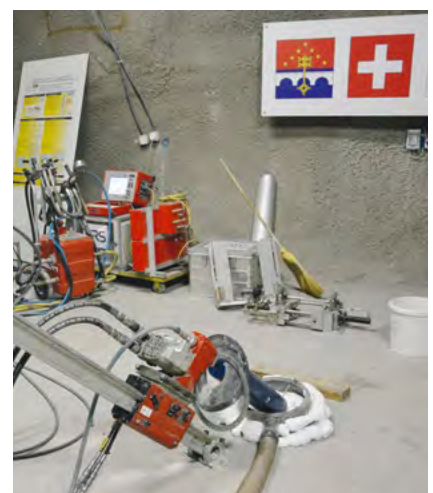
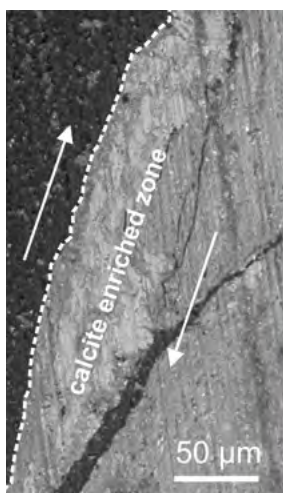
decimetres to kilometres. The originally hard rock is often ground down to fine flour within these faults.

“Rocks with deformation fabrics” of this kind, as they are called by the

experts, are often problematic for mining. This is because the deformed fault zones often behave in unpredictable ways. The experts planning a repository for high-level radioactive waste also need to know how the host rock reacts to mechanical stresses of this kind. “To prepare for the implementation of the Site Selection Act, we have intensified our investigations of claystone as a host rock,” reports Dr. Jörg Hammer, head of the unit “Geological exploration” at BGR.

Comparison between claystone and rock salt

He and his colleagues are particularly interested in comparing the deformation processes taking place in salt rocks and claystones – with the aim of finding out how potential faults heal up again in these plastic or brittle rocks respectively. “We have been investigating claystones since 1991, and



▲ A fault zone in a claystone under the electron microscope (l.) and in a drill core (r.). The slickenside surfaces reveal the direction of the movement.

▲ Drilling activities carried out by BGR in the international Mont Terri Rock Laboratory in the Jura canton in Switzerland.

are involved in several international co-operation projects,” emphasises Jörg Hammer.

As part of the BASTION project, BGR will be looking until 2019 at how for instance, deformation processes, the addition of heat, and the bedding relationships, influence the properties of claystones. This involves the scientists analysing samples from the Mont Terri Rock Laboratory in Switzerland, as well as from other locations.

Boreholes in the underground laboratory

The BGR experts are looking first at undisturbed rock samples from the Opalinus Clay – a rock formation of Jurassic age, which has been investigated in Switzerland as a potential host rock for radioactive waste, and which is also widespread in South Germany. The investigations revealed that the clay content and the proportion of other minerals, such as pyrite, quartz or carbonate, can vary considerably, and thus also affect the properties of the rock.

In other samples, Tilo Kneucker and his colleagues are identifying artificial fracture patterns created for instance during drilling, or during the excavation of the underground galleries in the underground laboratory. They then compare these samples with cores taken directly from a borehole

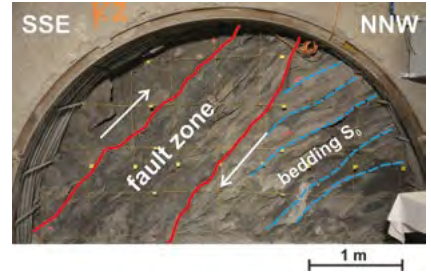
drilled in the Mont Terri Rock Laboratory in Switzerland. This borehole cut through a fault zone with a thickness of several metres, and therefore provided important insights into natural deformation processes.

Geological interpretation

“These investigations enable us to understand in detail how natural deformations affect the structure of claystones – at a microscopic as well as a macroscopic level,” says Tilo Kneucker. Moreover, geophysical and geotechnical measurements are also being carried out by BGR colleagues in Mont Terri to characterise the area directly surrounding a borehole. “This interdisciplinary approach enables us to gain a better understanding of the geological processes taking place in the rock” explains Tilo Kneucker.

BGR is also investigating natural analogues of a repository for radioactive waste, in claystones that were heated up by natural processes. Numerical modelling is carried out in parallel to the mineralogical investigations. Findings from the BASTION project therefore provide an important basis for comparing all of the potential repository host rocks existing in Germany.

Contact: **Tilo Kneucker,**
Dr. Jörg Hammer



▲ Fault zone outcrop in claystone in the Mont Terri Rock Laboratory.

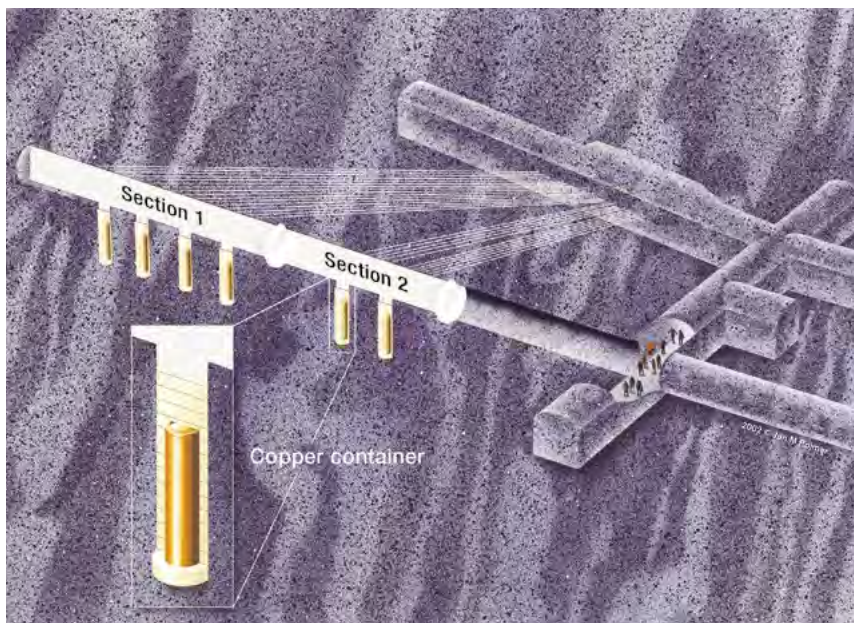


▲ Claystones often contain fossils, such as this ammonite.

Replacements in bentonite

What happens when groundwater comes into contact with the barrier?

BGR scientists are investigating samples from the Swedish underground rock laboratory in Äspö to find out which geochemical processes are involved in the final disposal of radioactive waste in underground rock formations: such as when the clay buffer in the geotechnical barrier comes into contact with groundwater.



Source: Dohrmann, R., Kaufhold, S., 2014, Clays & Clay Minerals, 62

▲ Design of the “Prototype Repository” emplacement tests with radioactive waste in the Äspö Hard Rock Laboratory in south Sweden.

Red Swedish houses in the middle of an idyllic skerry landscape – this is the setting of the Äspö Hard Rock Laboratory near the town of Oskarshamn in south Sweden. Most of the research facility is invisible: the experiments undertaken by the Swedish scientists and their international colleagues to test various repository technologies take place under the ground.

A spiral tunnel winds down from the surface into the solid granite to a depth of around 500 metres. Numerous side tunnels and niches are used by scientists to investigate the processes taking place underground when containers filled with heat-generating radioactive waste are stored under such conditions. “The underground rock laboratory resembles a future repository in many ways,”

says Dr. Reiner Dohrmann, head of the “Technical mineralogy and clay mineralogy” unit of BGR. “However, there is one crucial difference: Äspö contains no radioactive waste.”

Dohrmann and his colleague Dr. Stephan Kaufhold are involved in a particularly important experiment: “Prototype Repository”. “This is an emplacement test at a scale of 1:1,” says Stephan Kaufhold. “We use the exact dimensions of a planned repository so that the investigations provide the most realistic picture possible.”

Long-term tests since 2001

The prototype repository consists of six vertical, seven-metre-deep boreholes with a diameter of 1.75 metres. Between 2001 and 2003, cylindrical copper containers were lowered into each of these large holes. The containers have electrical heaters which can be used to heat up the surface of the containers to around 90 degrees Celsius. The metal cylinders are encased in thick rings of compacted bentonite

Source: SKB



Source: SKB

▲ Employees of the Swedish company SKB install the dummy containers for the radioactive waste emplacement test in underground test tunnels in the Swedish Äspö Hard Rock Laboratory.

with a thickness of almost 60 centimetres. This clay buffer is considered to be very suitable for the containment of radioactive nuclides, and thus to prevent them from spreading. Experts classify bentonite as a geotechnical barrier: because the granite host rock is riddled with fractures through which groundwater flows, the radioactive waste also needs to be embedded within a material which is as impermeable as possible in order to retard the toxins. “However, we do not yet fully understand the properties of bentonite,” reports BGR scientist Reiner Dohrmann.

Complicated replacement processes

When the first two copper containers were removed in 2011 after eight years in the prototype repository, BGR received samples from several of the bentonite rings. Dohrmann and

Kaufhold already knew that cation exchange processes were taking place between the swelling clay minerals and the groundwater: over a period of a few years, this mainly involves the substitution of sodium ions, which were previously bound up in bentonite, by positively charged calcium ions.

Barrier remains stable

When they investigated the barrier material, the BGR scientists were therefore not surprised to see that the concentration of calcium ions in the clay buffer had risen during the experiment. However, they also found out that this substitution had not caused any damage to the barrier material. Another observation: magnesium ions from the bentonite were shown to have migrated to the contact surface with the copper

containers during the emplacement period. “Although this phenomenon has already been observed in other in situ tests with bentonite barriers, it is not completely understood so far,” says Reiner Dohrmann. This phenomenon does not take place in laboratory experiments. The BGR scientist is convinced: “This highlights the value of large-scale experiments of this kind.”

Contact: **Dr. Reiner Dohrmann,**
Dr. Stephan Kaufhold

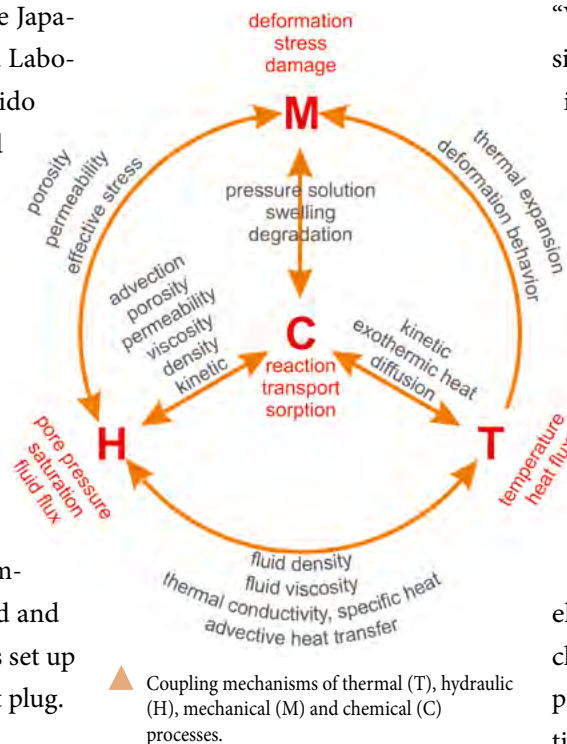
Heating up systematically

Numerical calculations and experiments go hand-in-hand in repository research

Conditions change in many ways when radioactive waste is stored in the underground repository: the changes can be thermal, hydraulic, mechanical and chemical. Before final disposal takes place, these complex processes need to be understood and numerically simulated. The BGR scientists use the OpenGeoSys computer code for modelling claystones.

The experiment gallery of the Japanese Horonobe Underground Laboratory on the island of Hokkaido lie 350 metres below ground level, and are surrounded by soft claystone. Researchers working for the Japanese Atomic Energy Authority JAEA, set up a unique experiment here in 2014: they installed an electrical heating device into a 4.20-metre-deep hole with a diameter of 2.40 metres, and embedded it in a mixture of sand and bentonite, a clay mineral. This set up was then sealed with a cement plug.

The heating is set to maintain a temperature of almost 100 degrees Celsius until 2020. Sensors in the backfilled material, in the gallery, and in the surrounding rock register how the material reacts to the heat. In this way, the scientists hope to establish the effects caused by the heat generated by radioactive waste.



“We develop numerical methods to simulate the complex processes taking place in repository locations,” reports Jobst Maßmann. To do this, BGR experts use the open source code OpenGeoSys.

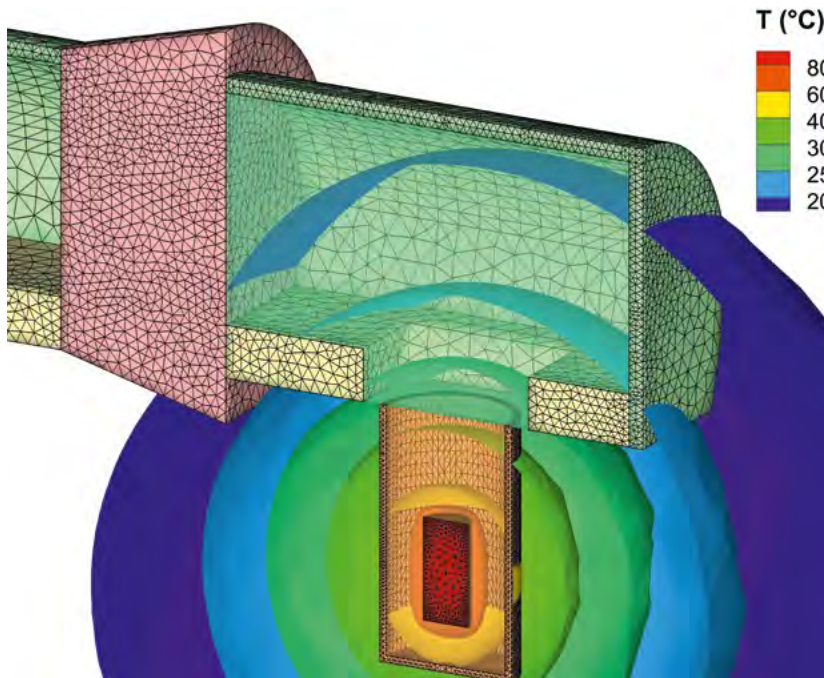
OpenGeoSys is managed by the Department of Environmental Informatics at the Helmholtz Centre for Environmental Research (UFZ) in Leipzig. The main focus of this software is to numerically model coupled thermal-hydraulic-mechanical-chemical processes within porous and fractured media. In addition to its use in repository research, OpenGeoSys is also used in research on CO₂ storages, or on geothermal energy for instance.

Benchmark studies

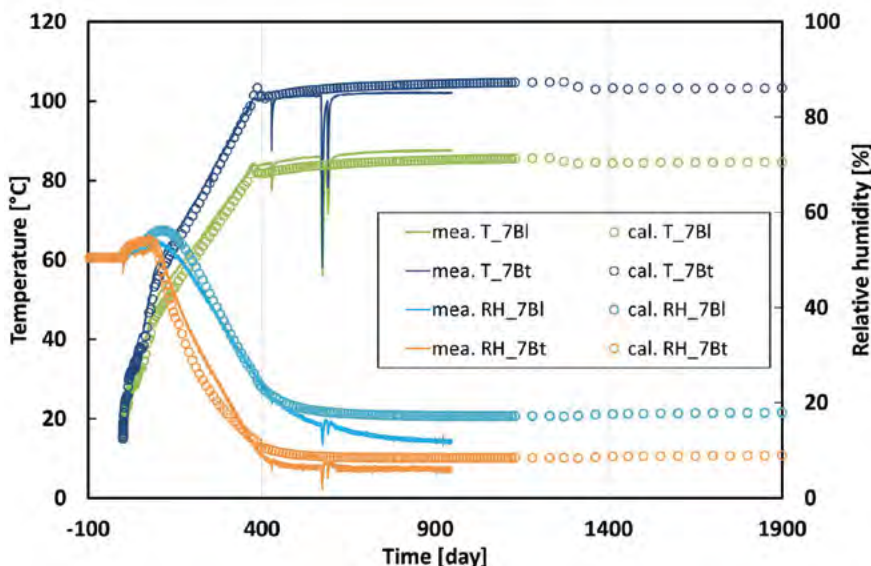
Every time a source code is changed, the scientists involved use well-known examples to test whether the results remain valid. The team documented

International co-operation

They are supported in their activities by BGR scientists Dr. Jobst Maßmann and Dr. Hua Shao as part of the international DECOVALEX project (DEvelopment of COupled models and their VALidation against EXperiments in nuclear waste isolation).



▲ The temperature distribution of the heating experiment in the Horonobe Underground Laboratory on the Japanese island of Hokkaido calculated using the OpenGeoSys computer code.



▲ Measured and calculated change in temperatures and moisture levels over time in the Mont Terri Rock Laboratory in Switzerland.

the results of these benchmarks in a book in 2015 that was published by the Springer publishing house as part of the “Terrestrial Environmental Sciences” series. One of the editors was the BGR scientist Hua Shao.

However, the final disposal of radioactive waste is a very special challenge for the modelling experts. “All physical processes are very closely linked to one another,” emphasises Hua Shao. For instance, the degree to

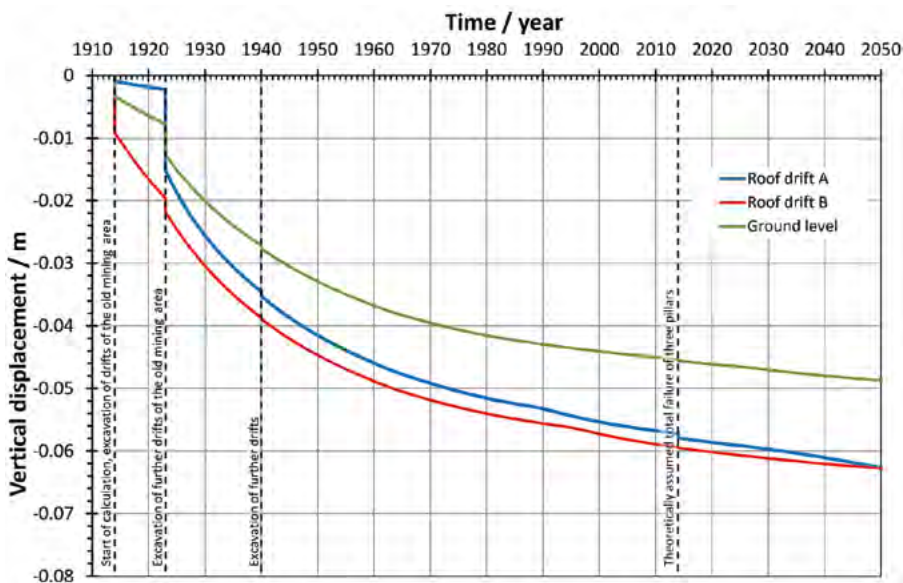
which the fine pore spaces in the rock are saturated with water depends on the temperature. On the other hand, the degree of saturation of the rock determines how well it can conduct heat. The repository scientists therefore first have to carry out laboratory experiments to determine which laws govern the capillary pressure and the propagation of the temperature. This is a necessary step before they can enter the proper formulae in their computer code. Amongst other things, Shao and Maßmann have simulated how the water saturation and temperature develop during the heating experiments in the Horonobe Underground Laboratory in Japan, and in the Mont Terri Rock Laboratory in Switzerland. The Japanese experiment is a vertical borehole at the same scale as planned for subsequent repository use. The Swiss experiment is at a scale of 1:2, and has been running since 2012, and models horizontal emplacement. It was shown that there is good agreement between the calculated and the measured temperatures and moisture levels in both underground laboratories.

Contact: **Dr.-Ing. Jobst Maßmann,**
Dr.-Ing. Hua Shao

Stability verified

Underground facility of the German army is not endangered

BGR has evaluated the stability of the army stores in Neckarzimmern in Baden-Württemberg since the middle of the 1960s. The BGR experts carry out regular investigations of the underground workings, develop surveying programmes to monitor the facility, and evaluate the stress and deformation measurements recorded in the rock.



▲ Development over time of the calculated subsidence at two points in the roof of two old underground extraction chambers (A, B) and at ground level (GL). The position of the points is marked in the other figure. Most of the subsidence has already occurred in the past. There will only be minor additional subsidence in future. Total failure of several pillars in the abandoned part of the underground workings would have very little effect on the development of subsidence underground, and no effect at all on the ground level.

Hornberg Castle, the ancient home of the knight Götz von Berlichingen, dominates the surrounding area from its lofty position high up on the steep slopes of the Neckar valley. The magnificent castle is not the only

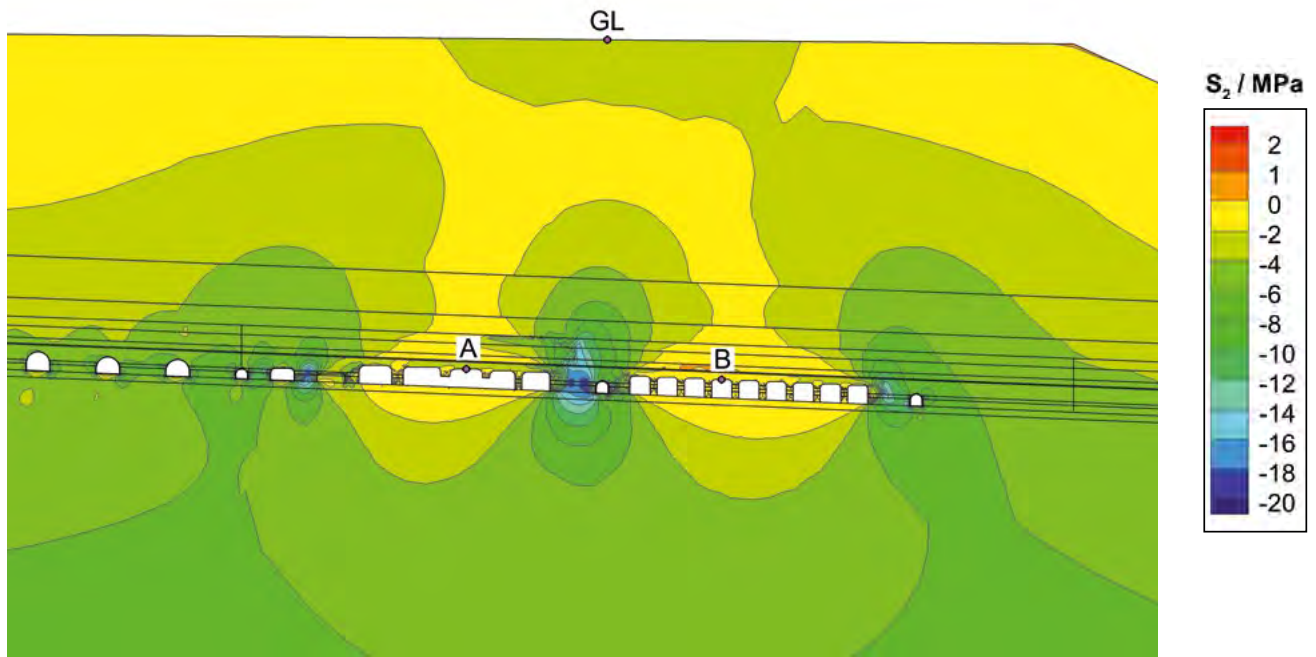
attraction, however, of the village of Neckarzimmern in Baden-Württemberg: a labyrinth of underground tunnels used by the German army to store materials is located directly beneath the castle.

“The mine was originally used to extract gypsum,” reports Dr. Jürgen Hesser from BGR. Since 1957, when the German army first leased the underground workings, the facility was expanded and converted into a material store, up until the 1960s. The army and the airforce still store equipment underground here because there is hardly any corrosion, and the material is safe from theft. Neckarzimmern is one of the largest and most modern underground facilities operated by the German army.

Legacy of mining

However, the previous mining activities have left their mark. “The former chambers from which the gypsum was extracted were only partially backfilled and not secured,” says Hesser. On occasions, rocks in the abandoned chambers can loosen. This alters the stress distribution within the rock formation. “This gives rise to additional loads on the neighbouring chambers used for storage,” reports BGR expert Ralf Eickemeier. Some cracks can already be seen in the pillars between the old chambers, and the rock is peeling off in layers in some places. This situation is also observed in other abandoned mines.

A team headed by Hesser and Eickemeier has now investigated the stability of the underground facility in



▲ Calculated distribution of stresses in the rock mass after the total failure of three pillars in the abandoned part of the underground workings. The stress in the rock mass is clearly reduced in the area above the abandoned extraction chambers (zone around points A and B) (yellow). Stresses are higher at the sides of the underground workings (green). The stress arch which has formed there transfers the weight of the overlying rock to the sides.

detail. The scientists calculated what the consequences would be if some of the pillars collapsed in the abandoned part of the mine. They modelled various scenarios and investigated the stability of the facility, as well as any potential effects at the ground level.

Arches as protection

“We incorporated very realistic models of the geology and all of the underground workings in our simulation,” explains Ralf Eickemeier. The scientists even took into consideration the sequence in which the underground tunnels were drifted. The model was tested by matching it with the results of the actual measurement data. The results of the analysis: a type of arch has developed above the

old underground workings, which is supported by the intact zones outside of the area affected by the chambers, and not by the already brittle pillars. “The strength of this arch will be hardly affected even if three adjacent pillars failed,” says Jürgen Hesser. Calculations reveal that the rock above the old underground workings would also hardly deform in the event of such a scenario.

Only minor subsidence of the ground level

“We would also not expect any major subsidence of the ground level arising from failure of this kind,” says Ralf Eickemeier. The BGR expert comes to the conclusion that most of the deformation within the underground

workings took place in the past. This means that the galleries used today will hardly experience any deformation in the future.

“We have impressively demonstrated with these findings that the stability of the drifts and chambers used to store material is guaranteed for the next 30 years, even if a few individual pillars fail,” wrote the BGR scientists.

Contact: **Dr.-Ing. Jürgen Hesser,**
Ralf Eickemeier

Purity and its problems

Trace gases play an important role in the storage of CO₂

Carbon dioxide streams separated from flue gases of power plants contains gaseous impurities. This changes the chemical and physical properties of the gas stream. BGR experts use numerical simulations to investigate how different trace gases affect the storage rock. Their test object: a pilot site in Israel.

Source: Dorothee Rebscher



▲ Investigations on geological CO₂ storage are performed at the Heletz pilot site in Israel.

The Heletz pilot site lies ten kilometres to the south-east of the town of Aschkelon in Israel. Oil has been produced in the area for more than 50 years. The sandstones at a depth of about 1,600 metres at the edge of the oil reservoir are now being tested for CO₂ storage. Several international research projects are investigating how the greenhouse gas spreads out underground, and which chemical reactions take place within the rock formations.

Two research wells are available for the scientists to carry out their experiments: one to inject carbon dioxide

into the underground rock formation, and a second well for monitoring. BGR scientists in a team headed by Dr. Dorothee Rebscher are also involved in this pilot project. As part of the CO₂QUEST international co-operation project, they are investigating how impurities in the separated carbon dioxide stream will influence the rock in Heletz. “An injection test with pure CO₂ is to be carried out in the middle of 2016,” reports the BGR scientist. “An experiment with CO₂ and SO₂ will follow shortly afterwards.”

Ambitious climate goals

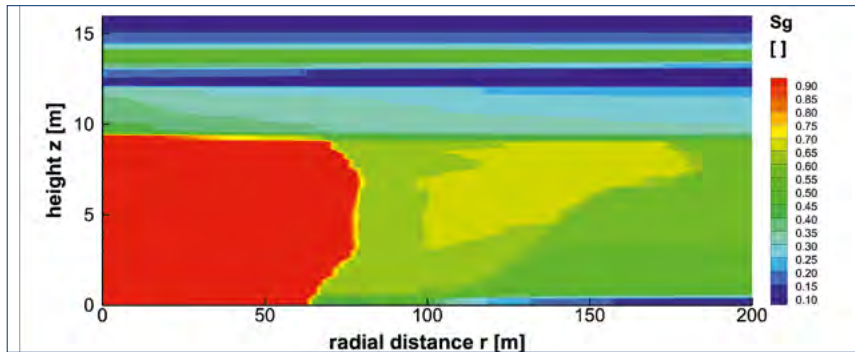
The project is based on the idea of

separating out carbon dioxide from the flue gas emitted by conventional power plants, and storing it underground. Known as CCS (Carbon Capture and Storage) this technology could play a part in helping to achieve the German government’s climate goals. Germany’s target is to reduce CO₂ emissions into the atmosphere by 80 percent by 2050.

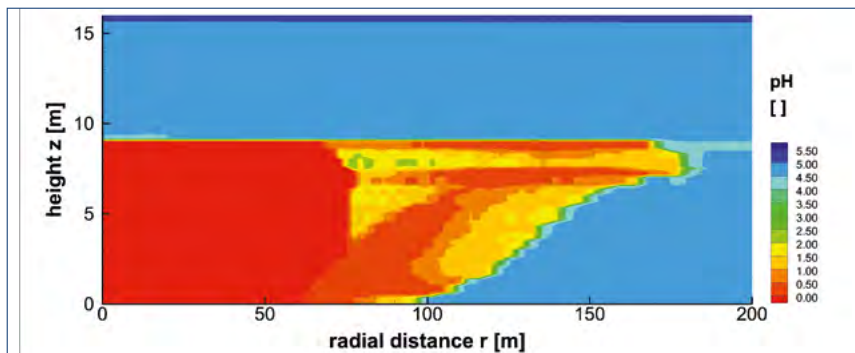
“However, the CO₂ streams generated by conventional power plants do not consist of pure CO₂,” reports Dorothee Rebscher. Depending on the method used to separate the greenhouse gas from the flue gas, CO₂ streams can also contain a range of impurities, such as sulphur dioxide, nitrogen, or water. “Although the purity can be influenced, the options are not only governed by the technical possibilities, but also by economic considerations,” says Rebscher.

Complex simulation calculations

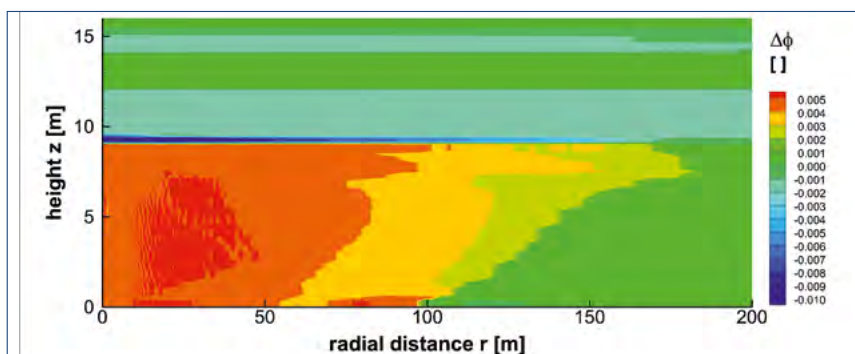
She and her colleagues are now simulating the thermal, hydraulic, and



▲ Development of the gas saturation S_g in a 2D simulation after the injection of a carbon dioxide/sulphur dioxide mixture after ten years. A dry-out zone develops around the injection zone, which can be easily identified from the high gas saturation values (red).



▲ Development of the pH in a 2D simulation after the injection of a carbon dioxide/sulphur dioxide mixture. The change in pH in the upper part of the sandstone reservoir in a zone with a maximum distance to the injection well of around 200 metres is observed after ten years. The lower the pH, the higher the corrosive attack on the reservoir rock.



▲ Changes in the porosity $\Delta\phi$ in a 2D simulation ten years after the injection of a carbon dioxide/sulphur dioxide mixture. The complex interaction of fluid transport with the precipitation and/or dissolution of minerals creates a complicated pattern. Porosity compared to initial values is slightly reduced along the boundary between zones with higher and lower permeabilities (dark blue). The red to yellow colours, however, mark zones in the sandstone where the porosity has slightly increased, i.e. improved fluid flow.

chemical processes taking place in the underground. These THC simulations are performed using the

TOUGHREACT software package from Lawrence Berkeley National Laboratory in California. The sim-

ulations provide information on the spatial and temporal changes in pressure, gas concentration, and pH, as a result of CO_2 injection. In addition, the model calculates which minerals react chemically with the injected fluid, and where and when these alterations take place.

The results of the simulations: if the gas stream contains sulphur dioxide, the proximal zone around the injection site is mainly chemically influenced by sulphur dioxide, while more remote areas are mainly influenced chemically by carbon dioxide. Different minerals can dissolve or precipitate depending on the composition of the CO_2 stream, the minerals and fluids in the reservoir formations, as well as the temperature and pressure conditions. This also changes the pore space in the reservoir rock. The pore space is important for the injectivity – a parameter measuring how easily a liquid or gas (here the CO_2 stream) can be injected into the subsurface. “The exciting challenge we now face is to compare the predictions from the simulations with experimental data,” says Rebscher’s colleague Dr. Jan Lennard Wolf.

Contact: **Dr. Dorothee Rebscher,**
Dr. Jan Lennard Wolf

Exploration of Polar Regions

Case 17/18: Circum-Arctic Structural Events; PANORAMA-2: Analysis of the potential of the Arctic North Atlantic and adjacent marine areas

In the realm of the Arctic Ocean

BGR combines work on land and sea for the first time in the Svalbard archipelago

In BGR's largest Arctic campaign so far, the three expedition teams were on their way around Spitsbergen simultaneously in summer 2015. Two groups investigated the onshore geology on the group of islands, whilst a third team studied the sedimentary basins of the northern Barents Sea from the OGS Explora research vessel. The aim of the campaign: to clarify the genesis of the European Arctic.



▲ The face of the Esmarck glacier on the north coast of Isfjorden (Spitsbergen) in the area investigated by the CASE 17 expedition. The mountains are built up of folded, 350 to 250 million year old rock layers of Carboniferous and Permian age.

Lined overalls, hats, lined gloves and thick working boots – the typical workwear of the scientists on the OGS Explora research vessel even in the middle of August. “Despite taking place in late summer, the weather conditions could better be described as autumnal to winter-like,” reports

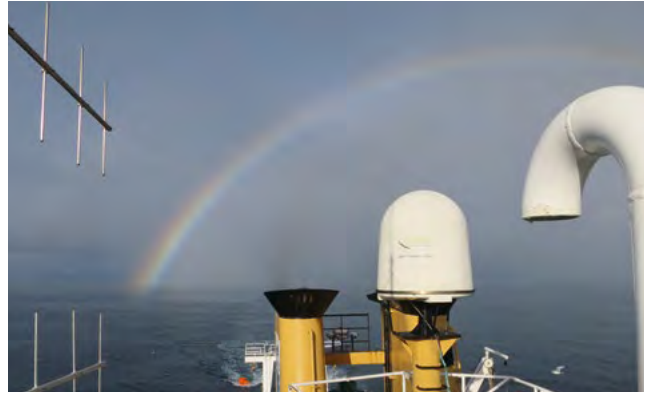
geophysicist Dr. Axel Ehrhardt from BGR, expedition leader of the PANORAMA-2 expedition.

At temperatures of between two and eight degrees Celsius, strong winds and heavy swells, the expedition team had to improvise on several occasions

to uncover the secrets of the Barents Sea between Bear Island and Spitsbergen.

Life on the seafloor

“We used geophysical methods to investigate the structures beneath the seabed,” reports Dr. Kai Berglar.



▲ The research vessel OGS Explora during the expedition PANORAMA-2: the weather conditions have a strong influence on whether the survey can be carried out.

The BGR scientist and his colleagues wanted to find out the thickness of the sedimentary layers in the northern Barents Sea, and how they have become deformed over the course of geological history. Microbiologists on board also investigated the sediment samples to study the largely unknown microbial communities on the floor of the Barents Sea.

The marine expedition was the second surveying campaign of the PANORAMA research programme. This project aims to reconstruct the depositional history of the sediments of the Arctic North Atlantic and the adjacent marine areas offshore Greenland and Norway. This information can be used by BGR's natural resources experts to estimate the opportunities and risks associated with any potential future exploitation of oil and natural gas in the Arctic.

Simultaneous surveys

Whilst the scientists on the OGS Ex-

plora used seismic waves to survey the sedimentary layers of Triassic and Jurassic age, the members of the CASE 17 onshore expedition took a close look at the same rocks in Isfjorden on Spitsbergen.

The team headed by Dr. Karsten Piepjohn, which included scientists from Canada, France, Germany, Norway, Poland, Sweden and the USA, were interested in the oil source rock potential of the sediments. "Because these rocks crop out onshore, we were able to take samples which we can chemically analyse later in the laboratory," reports the geologist.

A trip into the past

Two more of the CASE 17 objectives were to gain a better understanding of the paleoclimate and the geological history of the Arctic – and particularly the origin of the Arctic Ocean. Members of the CASE 18 expedition wanted to look even further back into the past: they spent two weeks on the

extreme north-eastern tip of Spitsbergen. "In this remote area, we did not meet a single person, only six polar bears," reports Karsten Piepjohn.

The team investigated the most northerly fringes of the Caledonian mountain range which was created 450 million years ago but is still only poorly understood. The ancient rocks also provide indications of how the continental plates moved long ago – and where deposits of natural resources could be hidden.

Contact:

**Dr. Karsten Piepjohn (CASE),
Dr. Kai Berglar (PANORAMA)**



▲ The base camp of the CASE 18 expedition in August 2015 near Mosselbukta in north-eastern Spitsbergen, slightly below 80 degrees latitude.

Securing the Supply of Raw Materials

Minerals4EU: Minerals Intelligence Network for Europe

A platform for Europe

Scientific basis for mineral resources created

Geological surveys from 26 European countries, as well as four other institutes, have come together in a network. The aim of the Minerals4EU project is to make the existing information on mineral resources more easily accessible. The result is a web portal, a yearbook on mineral resources, and foresight studies analysing European raw material supplies.



Source: Jari Väätäinen, GTK

▲ The scientists involved in the Minerals4EU project at their conference in 2013, posing at the entrance to the Finnish Geological Survey GTK in Espoo.

The national geological surveys in Europe are experts when it comes to natural resources. However, each of the geological surveys works in a different way, uses different data formats, and has a different publication philosophy. The consequences: the knowledge existing in individual countries has never been compiled in one database before. This deficit has now been remedied for mineral resources by the Minerals4EU project which ended in August 2015.

Joint database

The data on mineral resources in Europe is now accessible via a web portal. The digital yearbook contains, for instance, production data on 65 mineral resources, as well as comprehensive data on secondary resources, as well as trading data. The yearbook is accessible via the European Minerals Knowledge Data Platform web portal at <http://minerals4eu.brgm-rec.fr/>. This contains the official national statistics from 28 EU countries and

twelve other European countries for the first time. In addition, the geological surveys also aim in future to jointly regularly publish a European yearbook on mineral resources.

Another scientific part of the project was a foresight study. This study takes a detailed look at possible future developments which could influence the supply and demand of natural resources in Europe. The study involved the BGR scientists Dr. Henrike Sievers, Dr. Dominic Wittmer, and Dr. Michael Szurlies. This team bundled the expertise from nine geological surveys and three research institutes. The first issue of the study was ready in October 2015. "One of the topics of the study was the mineral resources supply and demand in Europe, with a focus on critical resources," reports Henrike Sievers.

Raw material potential in Europe

The scientists identified factors which directly or indirectly influence supply and demand. These factors can in-



▲ Aitik copper mine near Gällivare, Sweden. Gold and Silver are produced as by-products.

clude political decisions which have a tangible effect on the natural resource markets in Europe, and can also include new technological developments or long-term trends in natural

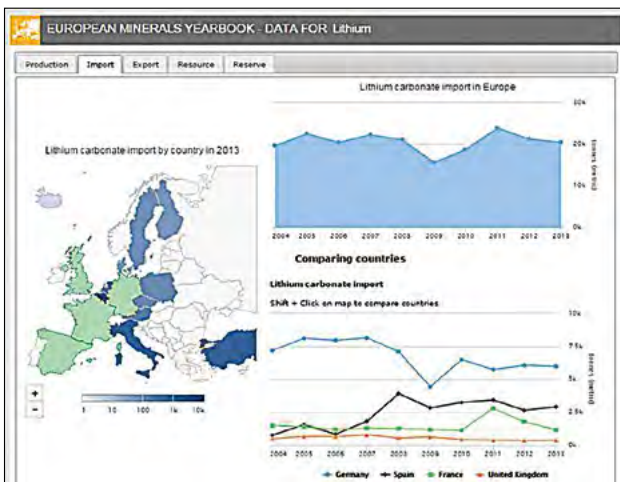
resource production. “We looked at numerous topics, such as the natural resource potential in Europe, and global exploration investment, as well as the legal and social frameworks in Europe,” says Sievers.

ers involved in the natural resources sector,” explains Dr. Michael Szurlies.

The project makes a crucial contribution to integrating information on natural resources across all of the countries involved. It therefore also supports the European Commission’s goal of developing a more efficient and sustainable natural resource strategy for Europe, and to safeguard the supplies of natural resources.

www.minerals4eu.eu

Contact: **Dr. Henrike Sievers**



▲ European nickel production from 2004 to 2013 as an example of data contained in the “European Yearbook”. The Yearbook forms an integral part of the web portal “European Minerals Knowledge Data Platform” and was produced within the Minerals4Eu-project.

The web portal, the yearbook, and the foresight study, are all part of a knowledge platform which brings together the overall information on mineral resources in Europe. “It is an important portal for all of the play-



Securing the Supply of Raw Materials

INDEX: Metal sulphide deposits on the seafloor – German exploration licence in the Indian Ocean

The clock is ticking

Expeditions in the Indian Ocean discover widespread ore deposits

BGR and the International Seabed Authority signed a licence agreement in May 2015 for the exploration of sulphide deposits in the Indian Ocean. BGR now has 15 years to explore an area covering 10,000 square kilometres. The first two expeditions in the licence area took place at the end of 2015 and the beginning of 2016.



▲ The PELAGIA research vessel sails out of the port of St. Denis on the island of La Réunion.

The first expedition began on 19 October 2015: the research vessel PELAGIA sailed out of the port of St. Denis on the island of La Réunion in the Indian Ocean, and headed for the German licence area located 830 sea miles away. The INDEX 2015 expedition team had several new surveying systems on board to explore the seabed.

For instance, a bright yellow device, resembling a wagon wheel, and called “Golden Eye” was used for the first time during the eight-week expedition. This huge coil is used by the scientists headed by expedition leader Dr. Ulrich Schwarz-Schampera, to measure the electrical conductivity of rocks and ores on the seafloor – and

thus to determine the distribution of the metallic sulphide ores found at the bottom of the ocean. “Golden Eye enables us for the first time to also collect information on sulphide concentrations below the surface of the seafloor,” explains the BGR expert for marine and terrestrial mineral deposits.

Whale protection

A new multibeam sonar called “Homeside” was also successfully tried and tested. “The system is towed behind the ship at a depth of around one hundred metres above the seafloor,” reports Schwarz-Schampera. One of the aims of this layout is to prevent whales or dolphins being injured by the noise of the sonar.

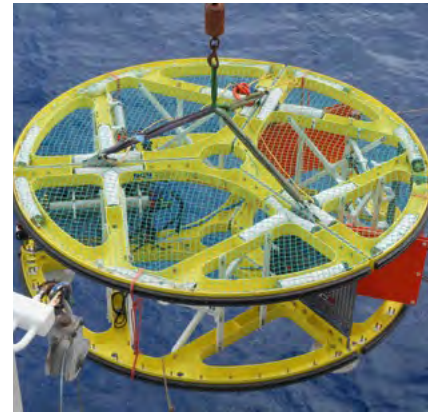
In addition, the “Homeside” is capable of very accurate surveying because it operates only a short distance from the seabed. The sonic images of the seafloor even showed the separate chimneys of hydrothermal vents – the discharge of hot fluids from so-called “black smokers”.

New ore deposits

During the two-month expedition, the team also investigated a part of the German licence area which had already been the target of earlier expeditions. The scientists discovered a new ore-rich area with three active and seven inactive ore fields. An al-



▲ Sampling an inactive sulphide field with a sub-sea robot.



▲ The “Golden Eye” surveying tool – a device for measuring the conductivity and magnetisability of the seafloor and the underlying sediment. The measurements provide information on sulphide enrichments below the surface of the seabed.

ready known ore field proved to be twice as big as previously assumed. “Sulphides in both areas appear to be covered by basalt debris over wide areas. This suggests that these fields have even larger potential,” reports Schwarz-Schampera. During the following INDEX 2016 expedition, other new deposits in the southern part of the licence area were looked at in more detail from the French research vessel POURQUOI PAS? chartered by BGR. The survey was supported by VICTOR, a French sub-sea robot – which enabled detailed sampling of the seafloor as well as surveying to the nearest centimetre.

The sulphide ores ejected by the black smokers contain a high proportion of non-ferrous metals such as lead, copper and zinc, as well as gold and silver, not to mention various trace elements, including antimony, bis-

muth, gallium and indium. These elements are essential for a number of high-tech applications such as in windpower generators and photovoltaic installations, and flat bed devices like smartphones.

The licence signed in May 2015 gives BGR exclusive rights to intense exploration of the area to the south-east of Madagascar and Mauritius. It can be converted into a production licence at the end of the current licence period. BGR’s objective is to develop sustainable technologies and environmentally-compatible standards for deep sea mining.

Comprehensive environmental activities

Environmental research therefore plays an important role in the expedition: “It accounts for more than half of the work and costs,” says

Schwarz-Schampera. The INDEX scientists, including biologists from the German Centre for Marine Biodiversity Research in Wilhelmshaven, and several universities, took more than 960 samples of the seafloor fauna during the expedition to determine the extent to which the creatures could be negatively affected by the potential extraction of metal sulphides. The exploration is also very positive for marine biology science, says Ulrich Schwarz-Schampera: “The intense work undertaken in the licence area also leads to significant advances in marine environmental research.”

Contact:

Dr. Ulrich Schwarz-Schampera

Securing the Supply of Raw Materials

FLUM: Fluid flow and manganese nodules

How manganese nodules grow

Low-temperature seawater circulation under the seafloor dissolves metals from rocks

During an expedition in the Pacific, BGR scientists discovered that some of the metals in manganese nodules originated from basalt rock deep below the surface of the seabed. The team discovered signs of large-scale seawater circulation in the seafloor.



Source: Rasphal Singh

▲ Releasing a sensor to measure the heat flow within deep sea sediments during the SO-240 expedition.

Manganese nodules are considered to be a future source of mineral resources, because they contain metals such as copper, nickel and cobalt. These valuable metals not only originated from the soft sediments directly on the seafloor, but also from greater depths.

This is one of the findings of the seven-week SO-240 expedition undertaken by the new German research vessel SONNE in May and June 2015. “Our target was the German licence area 1,600 kilometres to the west of the Mexican coast,” reports expedi-

tion leader Dr. Thomas Kuhn from BGR. “The seafloor is 4,200 metres deep there. The topography varies between plains and seamounts”

Scientists took samples from the seafloor, filmed the animal world in the area around the manganese nodule fields, and conducted geophysical surveys. This enabled them to demonstrate for the first time that sea water also circulates over large areas below the seafloor in the investigated area – and not only in the sediments, but also in the underlying solid oceanic crust consisting of basalt. “It was previously assumed that a circulation of this kind only took place locally between seamounts,” reports BGR scientist Dr. Carsten Rühlemann.

The measurements revealed that the sea water extracts heat from the floor of the ocean and washes out certain elements which then become enriched in manganese nodules. “The solid rock reaches right up to the seafloor along fracture zones within the area of investigation. These are also localities where sea water can penetrate the rock and dissolve metals,” explains Thomas Kuhn.

Contact: **Dr. Carsten Rühlemann,**
Dr. Christian Reichert

Securing the Supply of Raw Materials

ROBEHA: Raw material potential of mine heaps in the Harz Mountains

Valuable residues

Mine heaps in the Harz Mountains contain economically interesting metal deposits

Rare metals such as silver, antimony and indium are found in high concentrations in some of the mine heaps in the west Harz. This was revealed by chemical, mineralogical and geophysical investigations carried out in the ROBEHA project. Two heaps were explored in detail.

The Harz Mountains are full of spoil heaps from mining activity: experts reckon there are several hundred heaps of various ages and sizes, used as dumps for slag, sludge and crushed rock amongst other things.

These heterogeneous heaps are now the focus of research, because they boast a high potential for recoverables. The residuals could be economically interesting again because of their metal concentrations.

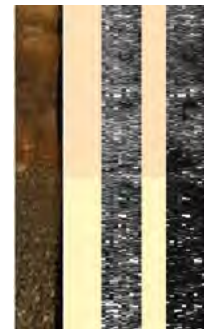
In the ROBEHA project, BGR scientists worked together with other partners to investigate 28 abandoned mine heaps in the west Harz. The team wanted to find out whether the residues in the heaps could be economically processed and recovered. Two heaps were selected for detailed investigations. “The heaps are very different because of their special histories,” report the BGR scientists Kerstin Kuhn and Dr. Tina Martin. They

and their colleagues used aerial and satellite images, boreholes, a range of geophysical measurements, as well as new chemical and mineralogical analysis techniques, to characterise the material in the heaps.

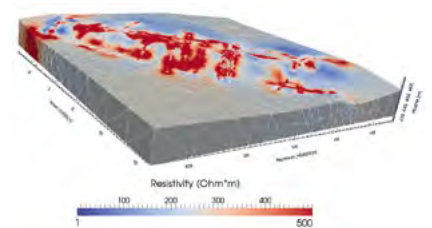
The mineral residues in the two heaps investigated in detail not only contain high concentrations of lead, zinc and copper, but also valuable trace metals such as silver, antimony, indium and gallium. “We identified several heaps with enhanced recoverables potential, but the actual volume of material was comparatively small in many cases,” says BGR expert Dr. Dieter Rammlmair. Whether production could be profitable needs to be assessed on a case-by-case basis. However, remediation, such as separating the valuable recoverables from the toxic fraction, could reduce the remediation costs and avoid potential environmental risks. This would also upgrade the affected areas.



▲ Cores cut by ram core sampling on the Pochsand heap near Clausthal-Zellerfeld in the Harz Mountains.



▲ Photo of part of a core cut in the Pochsand heap (l.). The residues contain fine material (clay-silt, orange), as well as coarse material (sand-gravel, yellow). This is shown alongside the associated LIBS element distribution photos for lead (middle) and silver (r.).



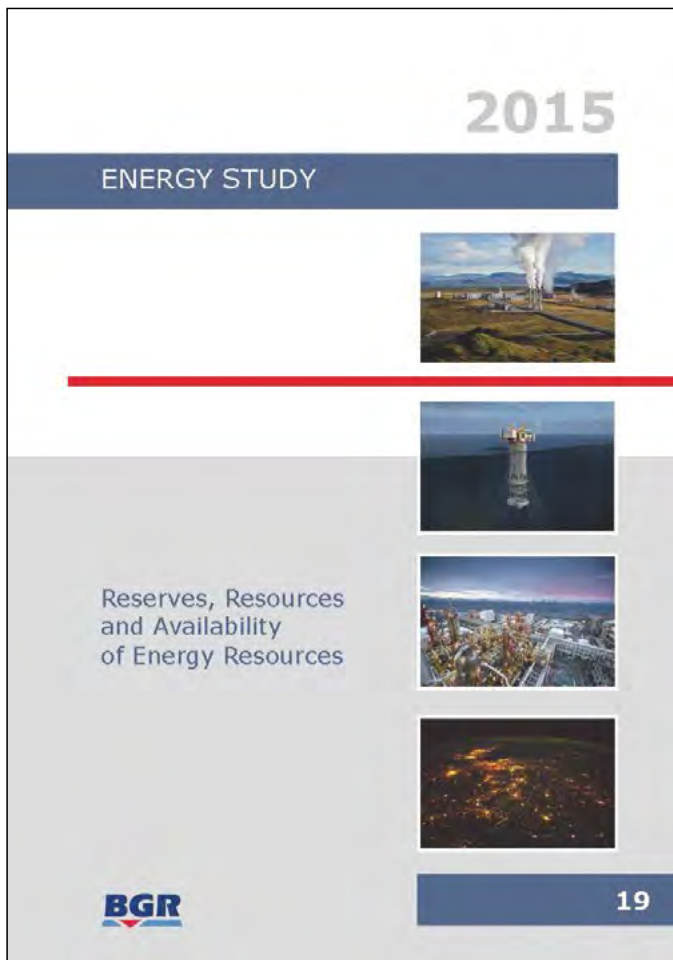
▲ Three-dimensional visualisation of the geoelectrically surveyed Pochsand heap. The metal-enriched processing residues are characterised by high resistances (red colours).

Contact: **Dr. Dieter Rammlmair,**
Kerstin Kuhn

Facts about energy resources

BGR Energy Study: there are still major reserves world-wide

Renewables are gaining in importance in the future energy mix. However, crude oil, natural gas and coal will still continue to play an important part according to the findings of the latest BGR Energy Study. They currently still cover 80 percent of German primary energy consumption. From a geological point of view there are still adequate reserves of all energy resources world-wide – with the exception of conventional crude oil.



▲ Cover page of the Energy Study 2015.

they are required. This is crucially important for the transition to the low-carbon energy system,” emphasises BGR expert Dr. Harald Andruleit. Using less carbon in the energy industry can only be implemented globally in the long term.

With the title “Energy Study 2015 – reserves, resources and availability of energy resources”, BGR scientists have compiled and

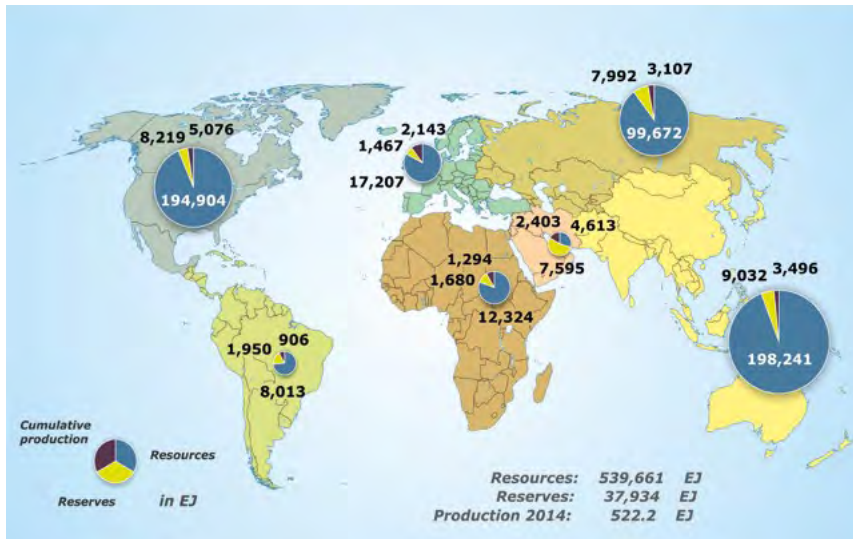
published in German and English since 1976, is one of the most important publications issued by BGR.

All-time high for crude oil production

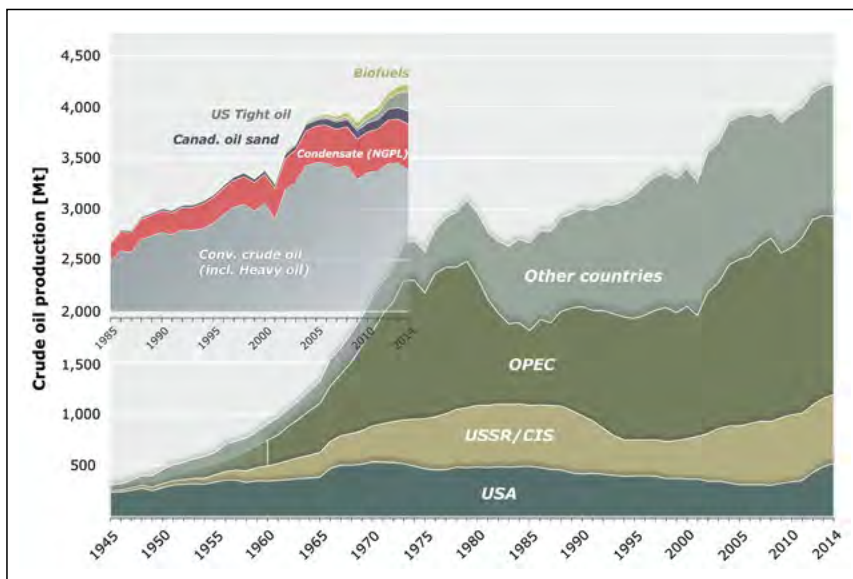
The BGR experts expect the crude oil sector to undergo major changes in the near future. “The low oil price and the continuous high production rates mean that the oil industry has reduced its level of investment,” according to Andruleit. The price could therefore climb again in the medium to long term.

With a share of around one third of global primary energy consumption, crude oil continues to be the most important fuel. The amount of crude oil produced in 2014 world-wide broke all previous records and totalled 4,240 million tonnes. Saudi Arabia, Russia and the USA, as the countries with the highest production, were able to boost their production even more. “From a geological point of view, supplies can

“Fossil fuels must also continue to be supplied in future to the degree evaluated data from numerous sources. The Energy Study which has been



▲ Regional distribution of the total potential of fossil fuels and nuclear fuels.



▲ Development of global crude oil production according to regions and shares up to 2014.

be maintained in the following years if global consumption of crude oil only rises moderately,” says Andruleit.

Declining natural gas production in Germany

Natural gas consumption world-wide rose by 1.4 percent in 2014. Even if

future demand continues to grow, as considered likely, the study concludes that global supplies can still be maintained for many decades to come.

Natural gas production in Germany has declined by around 32 percent in the last five years, whilst production

in Europe has dropped by eleven percent. This increases dependence on imports, particularly from the Russian Federation, the Middle East and Africa.

Coal has the largest potential

A growing demand for coal could also be covered for many decades according to the study findings. Germany currently has to import 87 percent of its demand for hard coal and hard coal products. Although nuclear power is decreasing in significance in Germany, it still continues to be an important source of energy worldwide. BGR experts are also forecasting no shortage in the supplies of uranium.

The proportion of renewables in global primary energy consumption rose to 13.5 percent in 2014. Despite the large growth rates for solar and windpower, firewood continued to be the most important renewable worldwide. And although the potential for deep geothermal energy is very high, its use has so far been very limited.

Contact: **Dr. Harald Andruleit**



www.bgr.bund.de/energiestudie2015_en

Securing the Supply of Raw Materials

DESMEX: Deep Electromagnetic Sounding for Mineral Exploration

Exploration by induction

New method aimed at detecting ores at depths of up to one thousand metres

Electromagnetic signals can provide information on the electrical conductivity of rocks deep underground. BGR scientists working in a joint project are developing a new technique to discover ore deposits at great depths.



▲ Rock sample with an antimonite crystal.

The needle-like crystals of antimonite shine with a silver-grey colour. This mineral was mined in eastern Thuringia in the past, but the mines were decommissioned many years ago. However, it is possible that interesting quantities of the mineral are still hidden underground near the village of Schleiz, and could be used to extract

the rare metal antimony. However, it has hardly been possible in the past to locate deep-lying ore bodies from the surface.

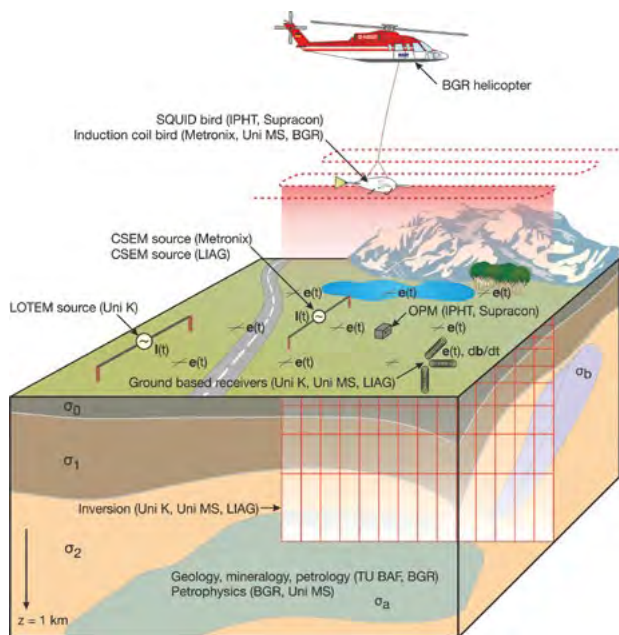
BGR scientists are now hoping to change this situation. As part of the DESMEX joint project funded by the German Federal Ministry of Education

and Research, they are developing a new exploration method which can sense up to a thousand metres below ground. “We are using an electromagnetic induction technique,” reports Dr. Annika Steuer. “This method provides a three-dimensional visualisation of the underground electrical conductivity, and therefore indications of ore-bearing deposits.”

receivers in the ground and in the air. The work carried out by the BGR scientists concentrates on modifying an aerial sensor previously used for groundwater exploration, so that it can also detect ore deposits in future. In addition, BGR used its helicopter surveying system to carry out preliminary exploration of the shallow horizons of the former mining area around Schleiz.

In the petrophysics sub-project, the BGR team is investigating the physical properties of sample material. The ultimate aim of the scientists is to find out whether the new technique is suitable to determine the prospectivity of the deposit reliably by remote sensing.

Contact: **Dr. Annika Steuer,**
Dr. Stephan Costabel



▲ Sketch of the semi-airborne surveying configuration with an active source on the ground and a receiver-system flown over the surveying area by helicopter.

The scientists use different transmitters and re-



The secret of the Kalahari sands

Nine tonnes of borehole cores tell the story of the sedimentary basin

The German-Namibian team has drilled a continuous core for the first time through the Kalahari deposits in the Namibian part of the Kalahari Basin. The scientists' objective: understanding the geological setting of the groundwater system.

A huge sedimentary basin lies at the heart of the southern part of Africa – the Kalahari Basin. It stretches for more than 2,000 kilometres from South Africa to the Democratic Re-

public of Congo. The deposits in this basin were laid down over the course of many millions of years by rivers, inland lakes and aeolian sedimentation.

These sediments now form different groundwater systems which are not easy to use. "It is very challenging to differentiate and classify the horizons in the aquifers and aquicludes," reports hydrogeologist Christoph Lohe from BGR. Although they appear homogenous at first sight, the sediments are far from uniform.

To gain a better understanding of the history of the Kalahari Basin, geologists from Germany and Namibia cut a continuous core for the first time in 2015 in the centre of a huge sedimentary fan, known as the Cubango Megafan, which comprises a former gigantic river delta in the north of



▲ Geologist Dr. Roy Miller investigating the core from the Cubango Megafan sedimentary fan in the north of Namibia.

Namibia. The core with a total length of 400 metres was then analysed in Hannover using the most up-to-date scientific methods.

The results of the coring produced a small sensation for Dr. Roy Miller, the former director of the Namibian Geological Survey. "This core tells us a great story about the climatic and geological development in the north-western Kalahari from the Tertiary up until the present day," he says. From its development, hydrogeologists can now draw conclusions about the available water resources underground. The borehole also provided important information on the hydraulic properties, and the water production capacity of specific sedimentary horizons.

Contact: **Christoph Lohe,**
Dr. Georg Houben



▲ The extent of the Kalahari Basin and the precise position of the WW203302 core borehole in the Cuvelai-Etoshia Basin in the north of Namibia.

144 pages of soil information

New soil atlas describes the properties, functions and importance of soils

BGR marked the International Year of Soils 2015 by publishing the first Soil Atlas of Germany. 48 maps and numerous figures vividly show the configuration of the soils in Germany. The BGR atlas provides both a basic thematic overview as well as looking at the potential and the threats to which this key georesource is exposed.



▲ The Soil Atlas of Germany provides basic information on the properties, function and significance of soils.

Everyone who has gone there on holiday knows that it rains a lot in the Harz Mountains. The north German mountain range is also easily identifiable as a rain hot spot in the map showing percolation rates of soil water in the new “Soil Atlas of Germany”: a very dark blue signature

indicates that a large amount of water infiltrates into the ground at this location – good news for groundwater replenishment in the area.

The map shows at a glance all the areas where a great deal of rainfall percolates into the ground in Germany: “Favourable conditions also exist in the Rhenish Massif, the Black Forest, the Bavarian Forest, the Thuringian Forest and in the Ore Mountains,” reports Klaus Kruse, who co-ordinated the soil atlas project.

Comprehensive information

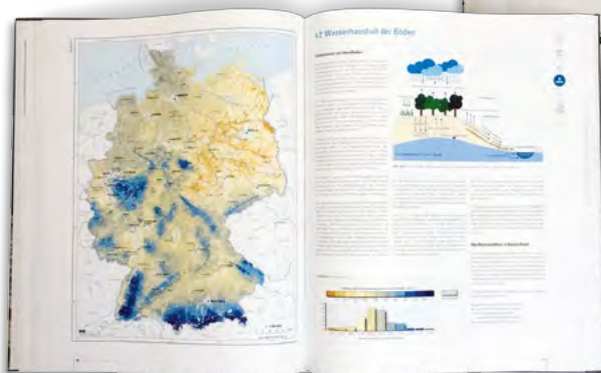
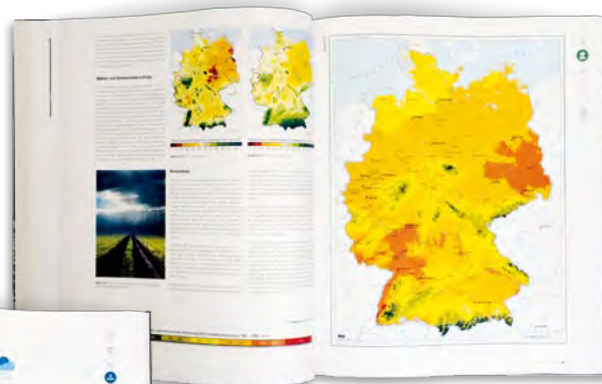
The new soil atlas which BGR presented at the Agritechnica industrial fair in November 2015, is a reference work that presents vividly and in great detail, basic information on the structure, properties, function and significance of soils in Germany for the first time.

“The aim of the atlas is to raise awareness of the vital significance of soil in Germany,” explains Klaus Kruse. This is because soil is the basis for human life – it is essential for the production of the food we eat, it keeps water clean, and protects the environment and biodiversity. “BGR shows in the soil atlas of Germany why we need soil, and why it is so important to protect it,” says Kruse.

Broad spectrum of topics

In addition to geoscientific and soil-science maps, the atlas also contains detailed explanations. It describes the typical soil properties in the various regions in Germany, and also highlights the most important threats.

The spectrum of topics in the scientific atlas is very broad-based: the seven chapters contain information on the organic substances in soil, and on the background values of trace elements for instance. Other aspects which are presented are the storage capacity of elements and organic compounds in



◀ Typical pages from the Soil Atlas of Germany – profile descriptions in the soil base map (above), soil and climate, water budget in the soils (below).

soil, soil compaction, and the crop yield potential of the soils.

Erosion by wind and water

The BGR team has prepared numerous new maps – such as on soil erosion. “The soil atlas very clearly shows how soil is harmed by wind and water erosion,” explains Kruse. The water erosion map for instance shows that around one third of arable land in Germany is at risk of being flushed away by heavy rain.

The areas which are particularly affected are the highland regions of Lower Saxony, the foreland of the Ore Mountains, the Neckar and Tauber

river valleys, as well as Lower Bavaria. The North German Plains are also threatened by erosion from strong winds – particularly in spring when the weather is dry and the fields are still bare.

Digital soil atlas

In addition to the printed atlas, the BGR experts have also developed an internet application. This can be found at www.bodenatlas.de. “We provide all of the latest updates to the data here,” says Klaus Kruse. The map application is based on the BGR Geoviewer.

Both the printed atlas and the digital atlas are not only aimed at specialists

but also at interested members of the public. Anyone interested in geoscientific matters can quickly and easily find information on the condition of the soil.

Contact: **Klaus Kruse,**
Dr. Florian Stange

Bodenatlas Deutschland
2016. 144 pages.
ISBN 978-3-510-96855-8, 38,80 €
Language: German

The atlas can be ordered from:
www.schweizerbart.de

Water balance in the Ovambo Basin

Scientists estimate how much groundwater is formed in the north of Namibia

Arid areas such as the Cuvelai-Etoshia Basin in Namibia are characterised by low rainfall and high evaporation. It is therefore difficult to determine how much groundwater is regenerated there. BGR scientists have now tested the latest field methods on location.



▲ Sampling groundwater.

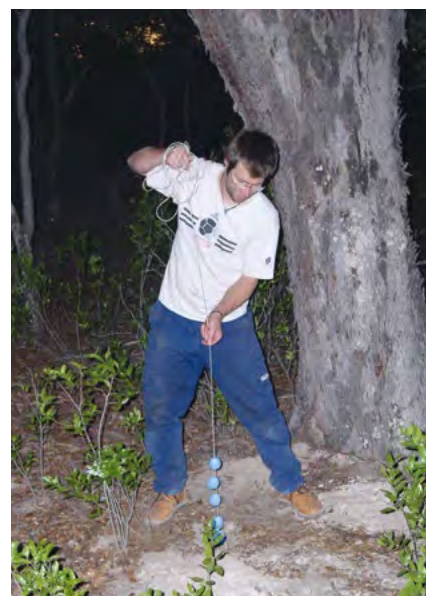
Around one in every 500 water molecules on the earth has a slightly heavier mass than the others: instead of oxygen with an atomic weight of 16, these heavyweight water molecules contain oxygen-18, a natural, non-radioactive version. An even rarer type

of water molecule is one in which hydrogen atoms have also been replaced by the heavier but also stable isotope deuterium. The proportion of heavy water molecules in groundwater samples enables hydrologists to determine from which source the water originates for instance.

In 2015, BGR scientists took part in two field expeditions in Namibia, and investigated various water samples from the Cuvelai-Etoshia Basin in northern Namibia to test the concentration of stable isotopes. The aim of these investigations was to estimate the amount of groundwater recharge, and thus to provide the basis for the sustainable management of the groundwater resources. This is one of the most important sources of water supplies for the growing rural population in the region.

On one of the field tests undertaken by the BGR scientists, they injected deuterium at five monitoring stations as an artificial tracer into the soil. Working together with colleagues from the University of Namibia, BGR scientists determined that groundwater regeneration during the 2013/2014 rainy season at the Eenhana locality, was between five and 30 millimetres from a total precipitation of 660 millimetres. They established that around 80 percent of the rainfall, and therefore the major proportion, entered the atmosphere again via plants. Scientists now plan to compare the innovative isotope measurements with the results of other groundwater recharge estimation methods.

Contact: **Dr. Markus Wallner,**
Prof. Dr. Thomas Himmelsbach



▲ Injecting deuterium into the soil using small balloons of water as artificial markers.

The waters of the Logone

BGR scientists determine the water balance in the area south of Lake Chad

Annual floods are typical for the Waza-Logone wetlands in northern Cameroon and in adjacent parts of Chad. BGR analysed the groundwater recharge as a basis for sustainable water management.



▲ Fishing in the wetlands is one of the traditional activities of the local inhabitants.



▲ Agricultural use of the flood plains.



▲ Groundwater level is measured from a monitoring well.

The Logone River is just a trickle from January to June, but this Central African river changes into a roaring torrent every year in September. The masses of water carried by the Logone pour into the plains in the north of Cameroon and the south of Chad. Here they give rise to huge temporary wetlands. The water disappears again in November or December: it evaporates, percolates underground, or flows back into the Logone. This is a tributary of the Chari River, the most important river feeding Lake Chad.

“The Waza-Logone wetlands are of enormous ecological significance, but

also forms the economic basis for the livelihoods of 20 million people,” reports the hydrogeologist Dr. Sara Vassolo from BGR. Water management in the region depends on the temporary swamps as well because they are the source of new groundwater.

BGR scientists have undertaken many field work campaigns in the Waza-Logone wetlands since 2011. For instance, they measured groundwater levels as well as the discharge of the Logone and its tributaries. They analysed the quality of the groundwater and the surface water, and their isotopic composition once a year.

“Our analyses have revealed that groundwater is regenerated in the Waza-Logone wetlands and flows northwards,” says Sara Vassolo. The estimates show that at least 32 million cubic metres of groundwater are recharged every year. “This is enough to supply around 1.2 million people,” says the scientist.

www.bgr.bund.de/lcbc

Contact: **Dr.-Ing. Sara Ines Vassolo**

The breath of the marshes

BGR investigates methane levels in the groundwater across the state

The Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency monitors the groundwater in the state of Lower Saxony in more than one thousand wells. The methane concentrations were recently measured for the first time in these wells. The natural regional background values are to be determined by a joint project in which BGR plays an important role.

Methane in groundwater – probably a rather worrying thought for most people. But this hydrocarbon occurs naturally in the groundwater everywhere in Lower Saxony, although usually in minute concentrations. This is the finding of a joint project undertaken by BGR, the State Authority for Mi-

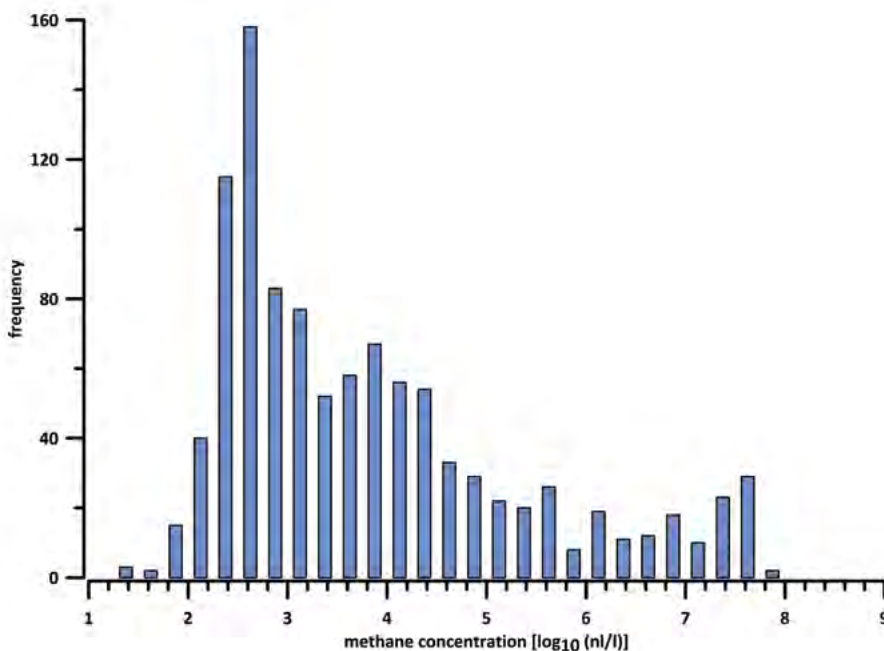
ning, Energy and Geology, and the Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency. The three institutes measured the background values of the gases methane, ethane and propane across the whole state in shallow groundwater horizons.

“The background of this analysis has been the debate about natural gas production methods such as fracking,” says Dr. Stefan Schlömer from BGR. Critics are worried that methane and other hydrocarbons could escape from leaky wells or fractures in the rock, and enter shallow groundwater horizons and come into contact with drinking water. “However, nobody knew before how much methane actually occurs naturally in groundwater, and how the levels vary,” says the scientist.

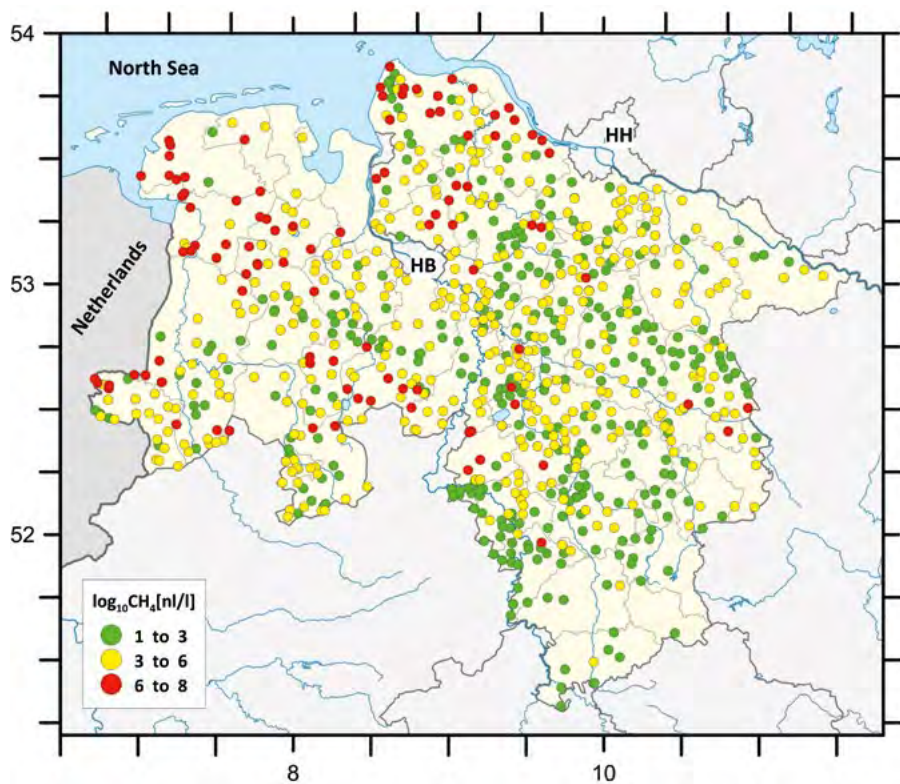
Samples from a thousand wells

He and his project partners therefore started work in autumn 2014 to take samples from almost a thousand wells that make up the groundwater monitoring grid in Lower Saxony. The gas contents in these samples were then analysed. “Analogous studies are also taking place in England and the USA,” reports the BGR expert.

The results of the first sampling are



▲ Frequency distribution of methane concentrations of some samples in nano-litres per one litre of water (logarithmic scale). The number six in the diagram corresponds to one millilitre per one litre of water. This is around the volume of half a sugar cube.



▲ Methane concentrations in groundwater in Lower Saxony. Figures in nano-litres per one litre of water (logarithmic scale).

now available: this reveals that the methane concentrations in Lower Saxony vary by several orders of magnitude. In most of the groundwater monitoring wells, one litre of groundwater contains less than a millionth of a litre of methane. The maximum concentration measured was 60 millilitres per litre. “Traces of higher hydrocarbons such as ethene, ethane, propene or propane are present in 30 percent of the samples, but in very much lower concentrations,” reports Stefan Schlömer.

Natural origins

The analysis carried out by the team

also indicates that the methane, as well as the higher hydrocarbons, were formed naturally and are not associated with the production of natural gas. “We can rule this out from the distribution of the stable carbon isotopes ^{13}C and ^{12}C ,” explains the scientist.

Biogenic methane is produced when biological material is broken down by microbes in the absence of air. It has a different isotope concentration to the methane in natural gas found in deep rock formations: biogenic methane is slightly lighter, it contains a smaller fraction of the heavy carbon isotope ^{13}C . “The isotope values pre-

dominantly indicate that the methane has a microbial origin,” reports Stefan Schlömer.

More methane in the north-west

Groundwater with higher methane concentrations was primarily found by the scientists in the northwest of Lower Saxony. The scientists think this is probably attributable to the large amount of organic matter found in the soils of the Marsch and Geest landscape types typical of this area. This means that good conditions for biogenic methane formation are frequently found in sediments close to groundwater.

“However, the values fluctuate very strongly from locality to locality,” comments the scientist. Detailed regional investigations are required to find the cause of this local variation. The second measuring campaign starts in early 2016 to determine the changes over time. In addition, the scientists also want to include areas for which there is no past data. Stefan Schlömer and the project partners expect to have data from 1,300 water samples in total in the summer.

Contact: **Dr. Stefan Schlömer,**
Dr. Martin Blumenberg

Precision farming

Soil mapping from the air

To apply the correct dose of fertiliser to every point on their cultivated fields, farmers need high-resolution soil information. The composition of the soil can be determined from the natural gamma radiation – measured for instance using the BGR helicopter.



Source: Stefan Fitzold

▲ The BGR helicopter surveying agricultural land.

From vineyards on the Upper Rhine to sweet corn fields in the Münsterland: cultivated land was the target of the BGR helicopter several times in recent months. With a speed of 60 to 80 kilometres per hour, the helicopter races over the fields and registers the natural gamma radiation of the soil.

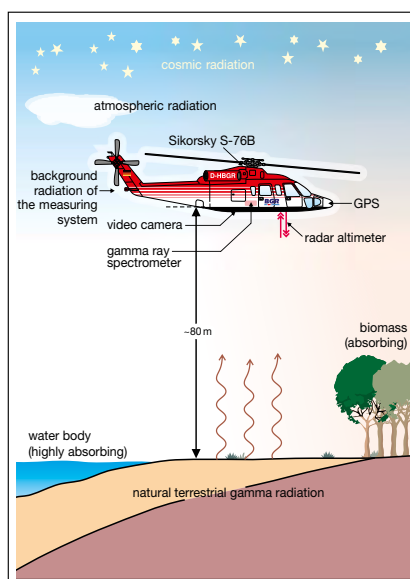
The BGR team headed by Dr. Malte Ibs-von Seht and their project partners were interested in finding out whether aeroradiometrics was a suitable method for supporting the latest

agricultural trend – precision farming. “The aim here is to adapt the fertiliser dose to the changing soil conditions,” explains Ibs-von Seht.

It has so far not been possible to make the detailed soil information required for this available cheaply and quickly. Gamma spectrometry could be an option for mapping soil types over large areas in a very short time. Ibs-von Seht and his colleagues plan to use the gamma radiation generated by the natural radionuclides potassium, uranium and thorium in the soil, to interpret the minerals which are present in the soil, and therefore deduce whether the ground is sandy, clayey or silty.

The team compared the results of the helicopter surveys with ground-based gamma radiation measurements and other geophysical techniques. Their conclusion: the helicopter can be used to map up to 500 hectares per day, although the resolution is slightly lower than from ground-level measurements. Aeroradiometrics could therefore be used in future to supplement classic soil mapping.

Contact: **Dr. Malte Ibs-von Seht,**
Dr. Uwe Meyer



▲ The graphic on the poster shows BGR's aeroradiometrics surveying system and the various sources of natural gamma radiation.

No more mob/demob

Helium balloon lifts logging coil up into the air

Exploring groundwater deposits could be much simpler in future thanks to a new geophysical surveying technique developed by BGR and the Leibniz Institute for Applied Geophysics. The key component is a huge helium balloon.



▲ The coil measuring the nuclear magnetic resonance of the groundwater floats over the surveying area with the help of the balloon.

From the air, the BGR balloon looks like an oversized bicycle tyre. This torus floated high above the Döberitzer Heath army training ground in Brandenburg for two weeks in April 2015. Held in place by a van and a jeep, the 22 metre-sized ring-shaped balloon moved at walking pace four metres above the ground.

The aim of the team of scientists headed by Dr. Annika Steuer and Dr. Stephan Costabel was to detect

signals from a groundwater horizon more than ten metres underground. The scientists are testing a new method to measure the nuclear magnetic resonance of hydrogen nuclei in the ground using an aerial technique for the first time.

“This measurement functions according to a similar principle to that used in medicine in nuclear magnetic resonance tomographs,” explains Stephan Costabel. Huge coils are used

to enable the scientists to stimulate the hydrogen nuclei in the groundwater molecules at various depths in the soil to transmit a signal. This enables them to find the aquifers and to characterise their hydraulic properties.

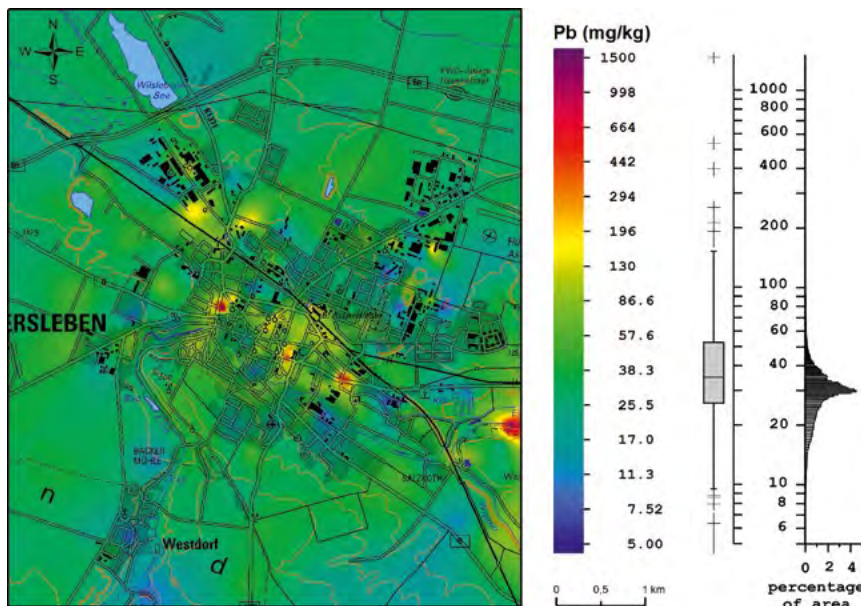
Geophysicists and hydrogeologists have been using this technique for groundwater exploration for two decades. However, the huge coils previously had to be placed on the ground – an extremely laborious process. With the balloon, a much larger surveying area can be measured in a much shorter time. Stephan Costabel considers the new system to have great practical potential: “The balloon is optimal for carrying out lower resolution exploration over large areas.”

Contact: **Dr. Stephan Costabel,**
Dr. Annika Steuer

Aschersleben case study

BGR analyses pollutants in the topsoil

Urban soils frequently contain heavy metals and organic pollutants – the legacy of industrialisation. In the “Urban Geochemistry” project, the geological surveys of several European countries have created a database suitable for characterising the condition of urban soils.



▲ Distribution of lead concentrations (Pb) in the topsoil of Aschersleben in Saxony-Anhalt.

Potash and salt mining, chemical and paper industry, aircraft engineering, manufacturing and mechanical engineering – these industrial sectors characterise the history of the town of Aschersleben in Saxony-Anhalt. Soils in Aschersleben still contain substances which probably entered

the environment long ago, such as lead and dioxins.

This is the finding of the “Urban Geochemistry” EU project which involved BGR. Soil samples were collected using standardised methods from 15 European cities, and

then analysed and evaluated. The team headed by Dr. Manfred Birke took 379 topsoil samples in total in Aschersleben.

The team analysed the air-dried samples using various methods to test for 51 inorganic elements. Special samples were also used to measure ten organic pollutants including dioxins, furans, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons.

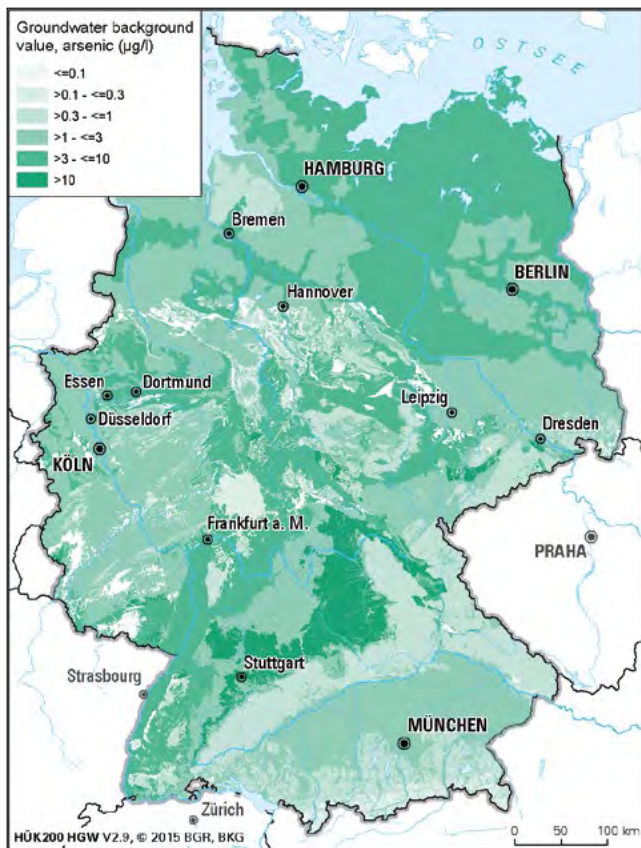
The team used the results of the project to develop models which could be used for instance for urban planning, with the aim of minimising environmental risks. BGR scientists also developed maps visualising the geochemical anomalies in Aschersleben. They show the distribution of the element lead, as well as other organic and inorganic parameters. “Unlike many other cities in Germany, there are hardly any values which exceed the limits in Aschersleben,” according to Manfred Birke. The limit for lead for instance was only exceeded at two locations across the whole city.

Contact: **Dr. Manfred Birke**

Groundwater 3.0

Harmonisation of base maps

Aerial and digital information on the upper aquifers – this is provided by the hydrogeological base map of Germany at a scale of 1:200,000 (HÜK200). The third version of this map was presented by the scientists involved at the end of 2015.



▲ Map of background values showing arsenic as an example.

The history of HÜK200 began in February 2000. “It was in response to the European Water Framework Directive which came into force shortly afterwards,” reports BGR scientist Dr. Stefan Broda. “A nationwide hydrogeological base map was required

geological base map, which provided information on the rock types and the stratigraphy of the rocks. Additional data was provided by the SGSs.

In the meantime, the hydrogeologists have already finished the third

to implement this directive.”

Up till then, there were already separate groundwater maps produced by the state geological surveys of each of the German states, but no base map for the whole of Germany. Within only three years, BGR and the state geological surveys (SGS) worked together in a joint project to complete a digital, harmonised base map covering all of the states. The map was based on the already existing digital

version of HÜK200. “This version contains a few corrections and some improvements in the data technology, but primarily now boasts a seamless vector dataset,” reports Stefan Broda. All of the inconsistencies at the borders between the states or between the 55 separate sheets of the atlas, have now been removed.

HÜK200 provides the basis for numerous more detailed projects. For instance, a working group in which BGR was involved prepared a base map on the geogenic background values of the groundwater. Currently, a team is working on converting the map scale from 1:200,000 to 1:250,000.

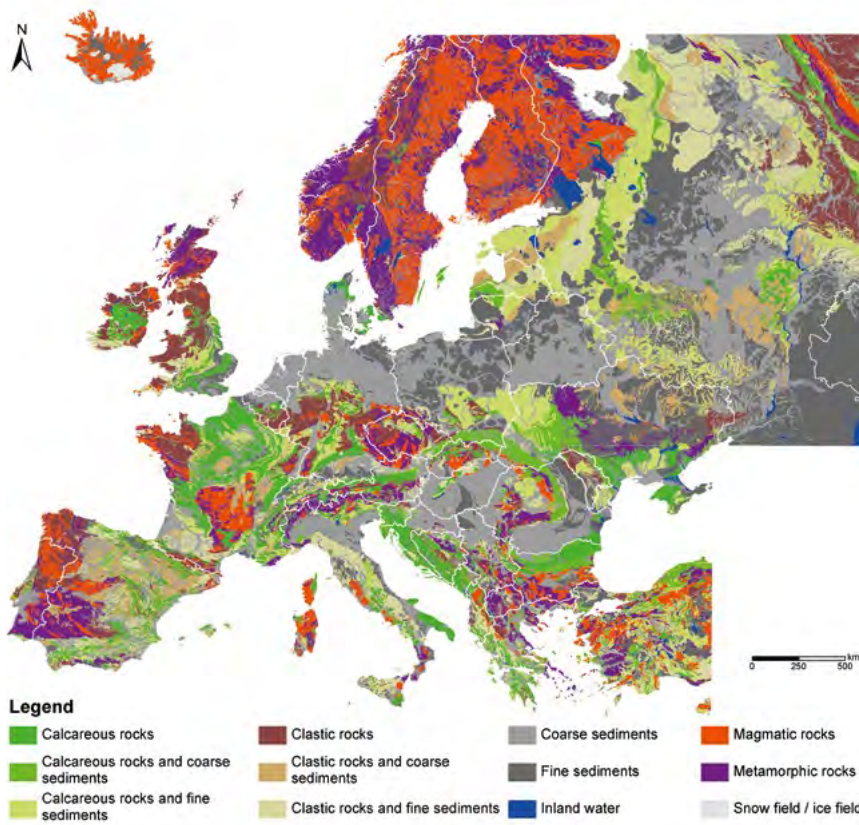
Contact: **Dr. Stefan Broda**

IHME 1500: International hydrogeological map of Europe 1:1.5 million

Europe in vector format

International hydrogeological map has been digitised

The 25 map sheets of the International Hydrogeological Map of Europe at a scale 1:1.5 million (IHME 1500) have been available as a vector dataset since April 2015. The data can now be processed using geographical information systems.



▲ Lithology layer of the IHME 1500 – GIS data.

Geographical information systems (GIS) are extremely helpful tools for geoscientists. With software of this kind, they can not only visualise spatial data, but also organise, process and evaluate it. Hydrogeologists now also have access to this application

if they want to acquire information on groundwater resources throughout the whole of Europe. This is because the relevant base map – the IHME 1500 published in 2013 – is now available in a standard format for geographical information systems.

Specialists can look at various aspects by having layers superimposed on the map, showing for instance six types of aquifers, or the various types of rock – the lithology. The digital atlas also shows geological faults, as well as areas where groundwater has been salinated by advancing seawater. “The next version (1.2) will also show the locations of springs,” reports Klaus Duscher, who together with Dr. Andreas Günther co-ordinates the project on behalf of BGR.

The team is also working on compiling the hydrogeological information from some marginal areas which have been missing so far. IHME 1500 will therefore soon also cover the North Cape and north Russia.

Contact: **Klaus Duscher,**
Dr. Andreas Günther

Quality-assured soil data

The soil map at a scale of 1:200,000 is scheduled to be completed in 2017

BGR and the state geological surveys in Germany have been working together on the soil map of Germany (BÜK 200) since 1995. 50 of the total of 55 map sheets have now been published. A detailed database which supplements the map series is being developed.

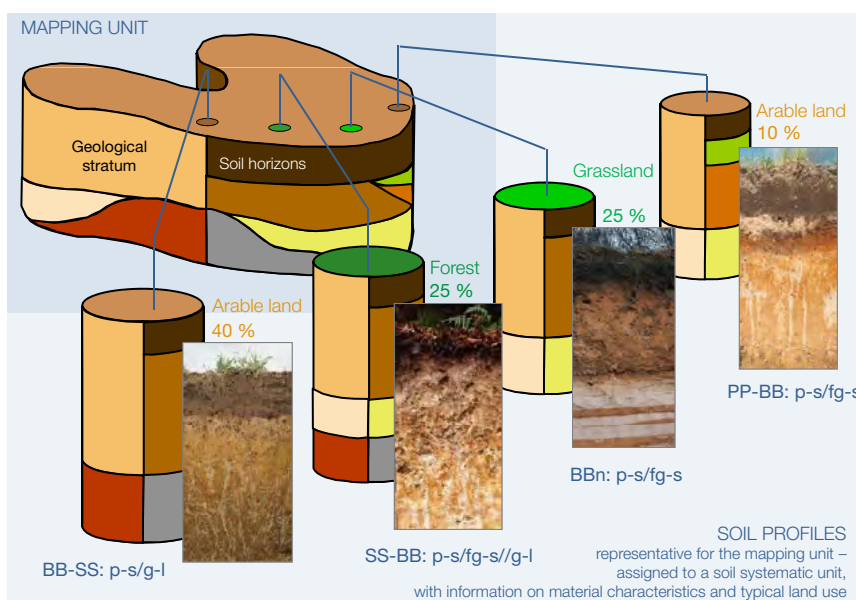
When soil scientists describe a landscape, they often encounter science and poetry. Terms such as albeluvic glossae, outwash sands or boulder clay remind of the ice age which disappeared long ago, and which was behind the development of our soils today. Visualising the properties of various soil types in Germany, their bedrocks, and their composition, in one standardised base map is a huge scientific endeavour in which numerous scientists from BGR and the state

geological surveys (SGS) have been involved in for over 20 years.

Alongside the map series, the team is also setting up a database containing all of the soil information in a standardised format. This information is to be evaluated and made available to the public before the map series is completely finished as planned in 2017. The scientists have now carried out detailed analysis to determine whether the entries in the soil profile

database are standardised and plausible. This involved the production of numerous maps by the team to visualise the specific soil properties. This data is now being checked by the colleagues from the SGSs with their regional expertise. The specialists have also been working on a general legend since 2013 which will make it much easier to name the various soils which are present. “This enables supraregional evaluations to be structured more simply for instance,” says Dietmar Krug, who co-ordinates the project at BGR.

The soil scientists evaluate the graphic and profile data representative of an area of various topics. The BGR team of scientists headed by Krug and his colleague Dr. Einar Eberhardt are currently working, for instance, on maps on thermal conductivity, and on the diggability of the soils – important topics in the context of the energy transition and adapting to climate change.



▲ Principle behind the content descriptions of the map graphics with soil profile data. Each of the three types of use can be explained with one or more soil profiles.

Contact: **Dr. Einar Eberhardt,**
Dietmar Krug

Copernicus service to assist risk analysis and regional planning in the Rhine-Mosel district

Sentinel in orbit

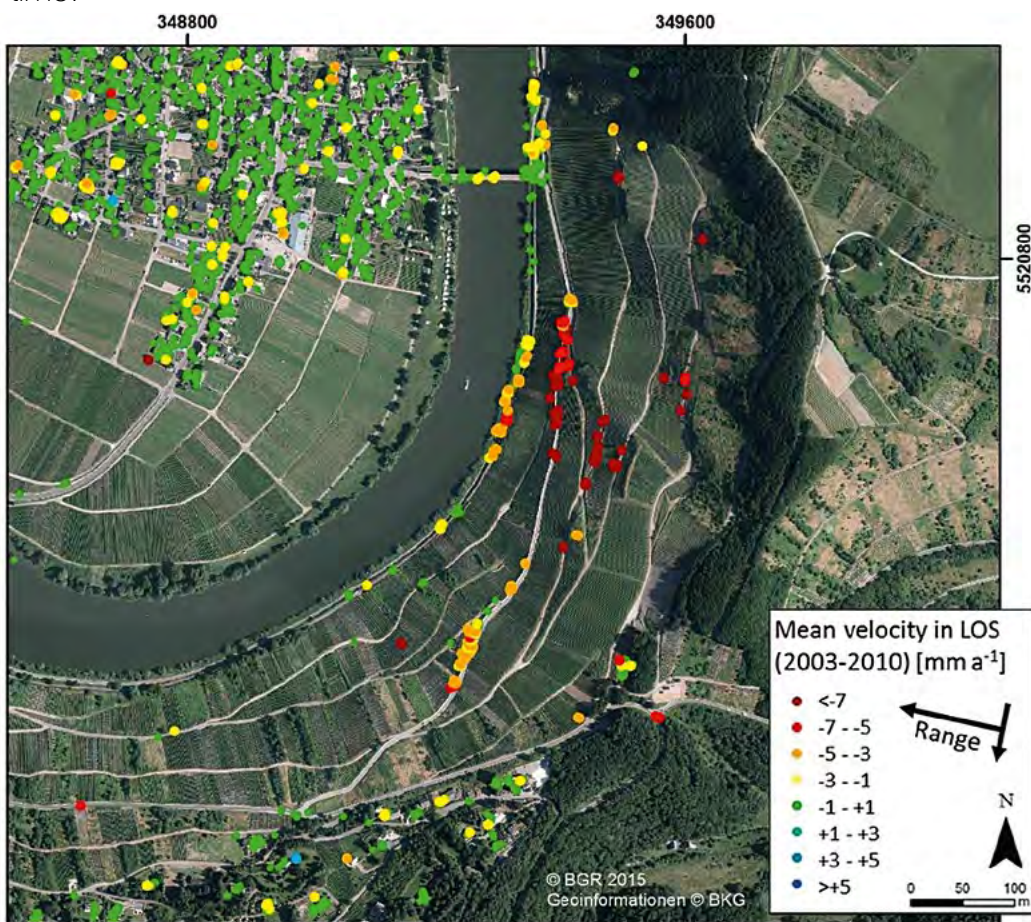
BGR expert makes satellite data usable by authorities

Ground motions can be precisely monitored to the nearest millimetre with the help of radar satellites. However, only a few authorities have had the ability so far to use satellite data to help them with their activities, such as risk analysis. As part of a research project, BGR has now analysed the satellite-supported measurements of ground motions in the Rhine-Mosel district for the first time.

The European Sentinel-1 satellite has been in orbit since April 2014. The “Sentinel” uses microwaves to monitor the earth’s surface, and is unaffected by daylight and cloud cover. The data collected by Sentinel-1 and seven more, still planned Sentinel satellite missions – is available free of charge.

These Satellites are part of an ambitious initiative: “Copernicus” is the name given by the EU Commission and the

European Space Agency (ESA) to the earth monitoring programme they initiated to create a global earth monitoring system.



▲ Persistent scatterer interferometry (PSI) measurements reveal movements of a slope on the Mosel down to the nearest millimetre.

Satellite data for monitoring

“Many public bodies are not yet adequately prepared to optimally make use of satellite-supported earth mon-

itoring information,” says BGR researcher Corinna Wolf. On behalf of the State Authority of Geology and Mining Rhineland Palatinate, she re-

Source: Envisat Daten 2003-2010

cently analysed satellite data capable of measuring surface movements in the Rhine-Mosel district.

“The aim of the project is to test new applications for geoscientific remote sensing data,” says the scientist. Her analysis of the data primarily concentrates on zones of weakness – locations where ground motions,

ter Interferometry (PSI) enables to pick out even extremely small movements of the surface from Radar satellites. This method uses buildings, bridges, electricity pylons and rock faces as so-called “stable reflectors”. These fixed points on the earth’s surface normally reflect the radar signal in the same way. If the distance between a reflector and a satellite changes by even as little as a millimetre, this is detected in the reflected signal.

Other data from sources such as aerial photographs, digital topographic models, as well as other satellites, provided Wolf with additional indicators of potential natural risks. Hidden structures underground can be detected because, for instance, they are associated with lower soil moisture levels or unusual vegetation.

Landslides on the Mosel

The satellite data revealed more than 700 localities in the area of investigation where the soil is on the move. The changes are mostly attributable to human activities. However, the BGR scientist also identified natural movement on slopes, especially along the river Mosel between Trier and Cochem. Corinna Wolf also identified several areas of surface subsidence around the city of Mendig in the Eifel after investigating the remote sensing data in detail. Extensive un-

derground basalt mining took place here from the Middle Ages up to the middle of the 20th century, and this has given rise to the risk of collapse in some places today.

The scientist concludes that the Sentinel-1 data will enable the hazardous areas to be continuously monitored. Authorities will be able to use this data in future via a nation-wide ground movement service, which is currently being established by BGR. The scientists are currently using the ground motion data to develop application-oriented information products.

Contact: **Dr. Michaela Frei**



▲ Location of the investigation areas in Germany and in the state of Rhineland Palatinate.

landslides or sinkholes could occur. Her study incorporates data from the precursor of the Sentinel satellite: ERS-1, ERS-2 and Envisat.

Stable reflectors on the earth’s surface

A technique called Persistent Scat-

Geodata in good hands

GIW commission develops code of conduct for companies

With the GeoBusiness Code of Conduct (CoC), companies can now verify that they handle personal geodata in a responsible way. To do this, they just need to join the code of conduct online and then allow their business processes to be accredited. This voluntary obligation makes the process of exchanging data between government authorities and commercial users easier and more transparent.



Source: fotogstoer/fotolia.de

▲ It only takes a few clicks for companies to demonstrate at www.geodatenschutz.org that they handle personal data responsibly.

Geodata can be very revealing in some cases. High resolution aerial photographs, information on monuments, and other real estate, can be used for instance to draw conclusions on personal data. Companies using such data therefore have a high level of responsibility.

An uncomplicated method for companies to show that they comply with

the valid data protection regulations has been available since August 2015 – by simply joining the GeoBusiness CoC. This code of conduct has now been officially recognised by the data protection supervisory authorities. Companies who wish to sign up to the code of conduct must for example document that the data can only be accessed by authorised members of staff, that their computer systems

have adequate levels of protection, and that the data cannot be linked to other personal information.

Co-operation between industry and authorities

The office of the Geoinformation Industry commission (GIW commission) integrated within BGR implemented the regulations in the code of conduct together with Selb-

stregulierung Informationswirtschaft e.V. (SRIW) (Information Industry Self-Regulation Association). Harald Lembke, the chairman of the association explains: “Co-operation between industry and the authorities made it possible to develop a practical solution which not only makes geodata more easily accessible, but also safeguards data protection at the same time. This established a precedent for others to follow.”

Geodata is mostly generated by government authorities, who themselves have the choice of whether to make the information available for commercial use. The high resolution geodata in particular boasts considerable economic potential. It now takes only a few clicks for companies to join the code of conduct using the www.geodatschutz.org web link, and to thus demonstrate that they handle personal data in a responsible way.

On the other hand, GeoBusiness CoC enables the authorities to gain an insight into the business processes involved. This means that the providers of the data can satisfy themselves that the data is in good hands.

No new regulations

“GeoBusiness CoC does not create any new regulations, it merely brings together the existing regulations,” explains Jens Ibendorf, the manager



Source: Maxim Kshakou/forobla.com

▲ The GeoBusiness Code of Conduct, and the geodatschutz.org application, make it easy for companies to put data protection regulations into practise.

of the GIW office. “This considerably simplifies their use.” This makes it much easier for small and medium-sized enterprises in particular to make use of the geodata, because they frequently do not have the resources available to negotiate with the authorities each time they wish to use the data.

GIW manager Jens Ibendorf says that there is no justification for worrying that data protection gets in the way

of innovation: “By simply joining GeoBusiness CoC, and allowing its business processes to be accredited, a company can then very easily put the data protection regulations into practise.” The GIW office is responsible for the accreditation. For its part, SRIW is the contact for complaints, to thus ensure that the companies comply with the data protection regulations.

Contact: **Jens Ibendorf**

The Europe puzzle

Geologists harmonise offshore data

Although the marine areas around Europe are relatively well explored, each country has developed its own methods to describe the geology, which means that the information is usually incompatible. The aim of the EMODNET 2 project is to harmonise all of this highly varied information and make it accessible to users. BGR is responsible here for the seafloor geology.

“Harmonisation costs time and effort,” says Dr. Kristine Asch, expert at BGR for geological information and maps. The scientist knows this

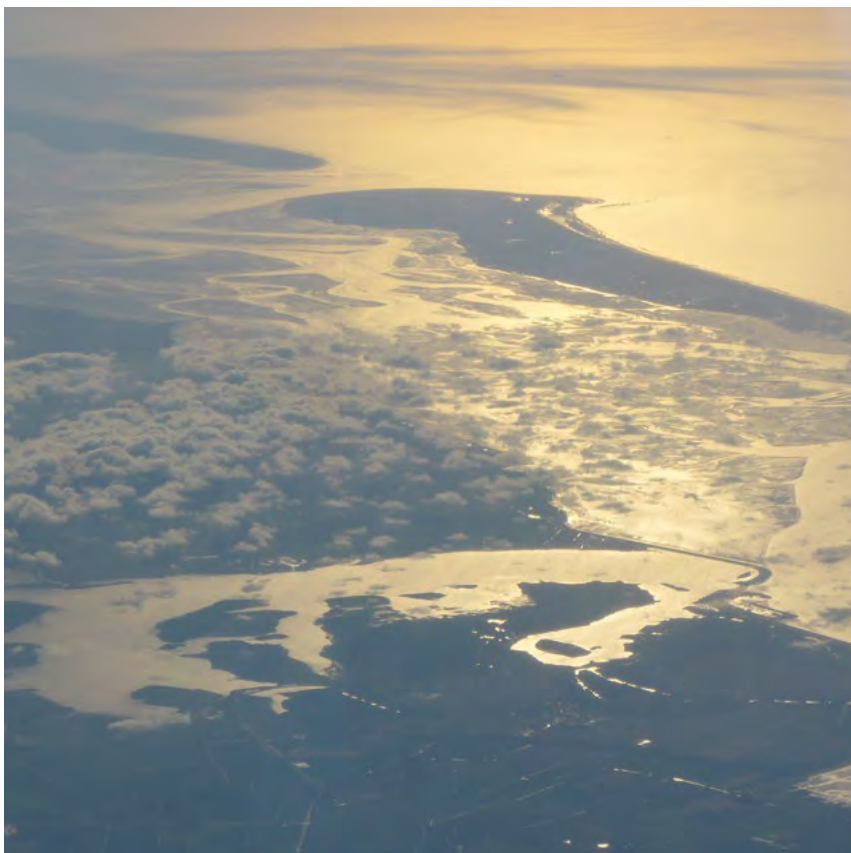
only too well because during the pilot phase of the EMODNET project, it was her job to collect the seafloor data from all of the various European countries, and to co-ordinate the harmonisation.

This process can give rise to numerous problems: the same geological unit could be described in a completely different way in two countries; the scales of the maps could be different; and different models could be used to digitise the raw data and to use this to create the maps.

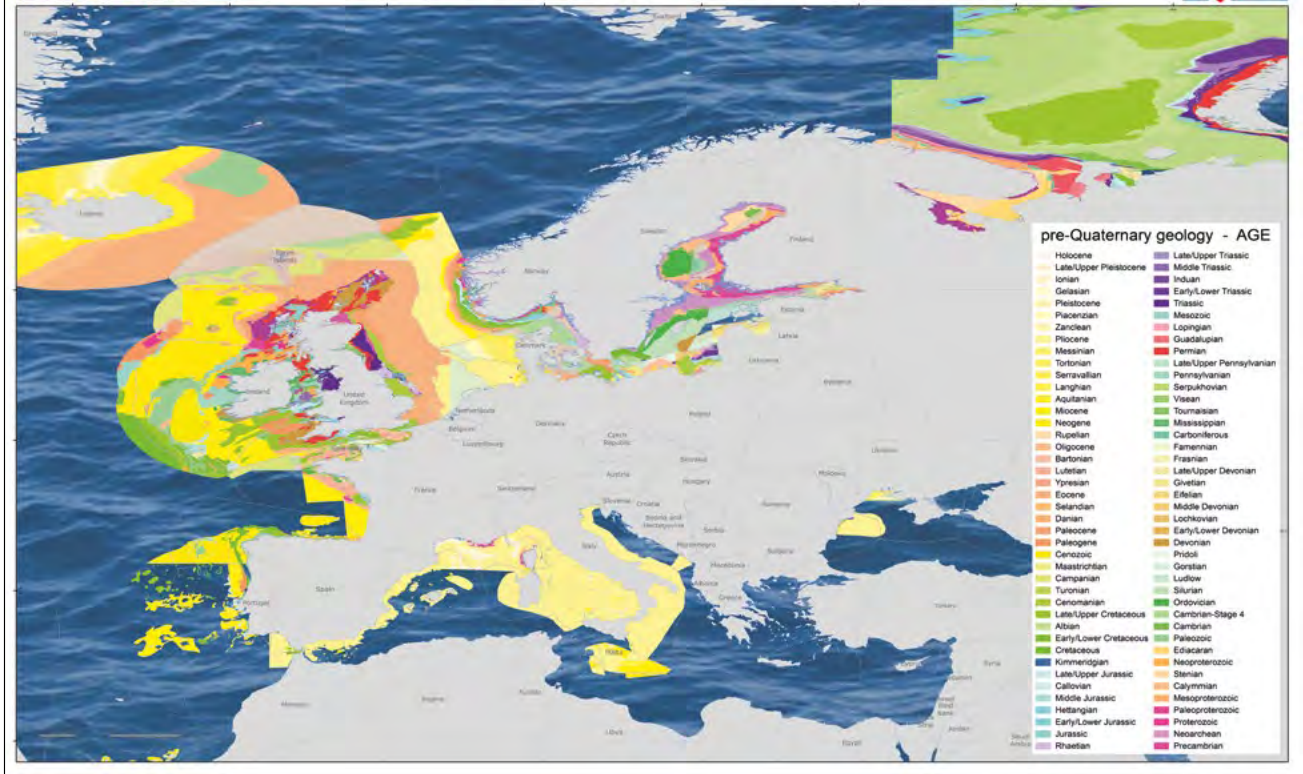
Second project phase

Asch and her colleagues are currently involved in collecting data from the still missing areas of the seafloor, such as parts of the Mediterranean and the Black Sea. 30 countries in all are involved in the second project phase, which was launched in Lisbon in 2014. From Russia to Cyprus, from Portugal to Turkey, the national geological surveys are making their data available and working hard to revise them to match the joint standard.

“The aim is to create a detailed digital geological map of all European marine areas, and to make these maps accessible via a web portal,” says Asch. The project area was significantly extended in the second phase. It now covers the marine area of the whole of Europe. “A map of this kind is a



▲ Scientists working on the EMODNET 2 project also include detailed information on the European coastal regions, including the sediments of the Wadden Sea UNESCO World Natural Heritage Site.



▲ Map of the pre-Quaternary offshore geology compiled by BGR for the EMODNET 2 project.

fundamental prerequisite for every cross-border offshore project,” underlines the scientist.

Appetite for marine data

The first EMODNET project made available a wide range of geoscience data at a scale of 1:1 million in the North European Seas. “This has whetted peoples’ appetites to have access to more detailed marine data for Europe’s southern marine zones as well,” says Kristine Asch. The project is divided into six different topics: sea-floor habitats, chemistry, physics, biology, bathymetry and geology. BGR

co-ordinates the “seafloor geology” work package. The BGR team headed by Asch is responsible for merging in detail the map data for the whole marine geology of Europe with GIS specialist Alexander Mirko Müller. This not only involves basic information such as the age of the rocks: it also integrates data on rock types and their origins. Information on natural resources, earthquake epicentres, volcanic activity and submarine slides are also incorporated within the project, and will be made available later in different map layers. The EU has provided Euro 4.2 million to

fund the project. The data and experience gained during the pilot phase form the basis for the work being carried out at the present time. The seafloor map at a scale of 1:250,000 is scheduled to be available by October 2016. It can be accessed via the www.emodnet.eu/geology website.

Contact: **Dr. Kristine Asch**

Comparison of Soil Profile Description Systems

Uniformly characterizing unsaturated zone

Soil at five sites in different soil regions were analyzed in a pilot study by BGR scientists. The objective was to uniformly describe the entire unsaturated zone from the ground surface down to the groundwater table.



▲ Drilling in the field to obtain soil cores from the entire unsaturated zone.



▲ A soil profile near the village Markhausen in the North German Plain.

Very different things are found when a soil trench is dug in a forest, a pasture, or in cropland. Sometimes a bright ochre-colored layer is observed below a grey-brown surface layer, in other places a black topsoil overlies loose white rock.

In Germany, soils are described according to the Bodenkundliche Kartieranleitung (Soil Survey Guidelines). Internationally another system of guidelines is used: the World Reference Base for Soil Resources (WRB).

“In our databases there are no soil profiles that have been described using both the national or the international mapping guidelines,” says BGR soil scientist Dr. Einar Eberhardt.

Therefore, in cooperation with the state Geological Surveys, BGR has drilled at five selected sites down to the groundwater table to obtain soil cores. This has been done in a pilot study called ‘Benchmark Profiles’. The purpose was to determine how laborious and complex it can be to

describe deep-reaching profiles in such detail that all requirements are fulfilled. In addition to the use of different drilling methods and physical measurements in the field, extensive laboratory analyses were made.

With uniformly described soil profiles better predictions of the composition and amount of percolation water should be possible.

Contact: **Dr. Daniel Rückamp,**
Dr. Einar Eberhardt

The cause of the rumbling

Fluids control swarm earthquakes in Vogtland

Scientists at BGR Hannover, the GFZ Helmholtz Centre Potsdam and the University of Leipzig have explored the underground geology in the area bordered by Bavaria, Saxony and the Czech Republic with modern seismological techniques. Investigations revealed indications of the presence of fluids in the deep underground, as well as the pathways along which volcanic gases and liquids could rise up to the surface.

The ground beneath the Czech city of Nový Kostel, only a few kilometres to the east of the German border, experienced more than 30 earthquakes in May and June 2014. Weak to medium earthquakes of this kind are called swarm earthquakes by seismologists because they occur without any strong main quake.

The earthquakes in the Vogtland are probably caused by hot rocks in the deep underground – according to the findings of a DFG project in

which the BGR was involved. The BGR seismologists, Dr. Peter Gaebler and Dr. Ulrich Wegler, as well as Sima Mousavi and Professor Dr. Michael Korn from the University of Leipzig, provided information in their work package on the frequency-dependent seismic damping parameters, by applying radiativetransfer theory.

These parameters help describe the small-scale structures of the underground, and thus provide indications of the presence of fluids in the swarm earthquake region. A joint interpretation of all of the work packages revealed a now solidified intrusive body at a depth of more than ten kilometres. At least 100,000 years ago, molten rock must have moved up out of the Earth's mantle into the Earth's crust, but came to a stop a few kilometres below the surface. The seismological analysis indicates that this intrusive body is located a short distance below the epicentres of the earthquake swarms. The earthquakes



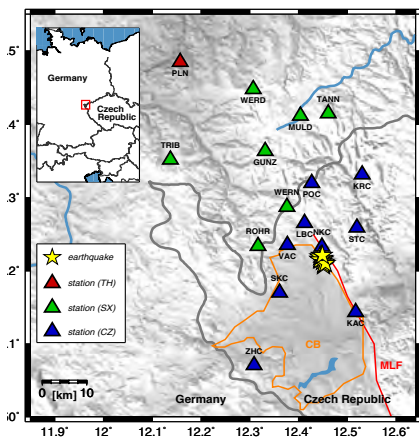
Source: Josefine Umhant

▲ View of a mofette. This clearly shows the carbon dioxide gas escaping at the surface.

are possibly caused by volcanic gases rising up towards the surface along fractures. There are numerous carbon dioxide springs in the region, called moffetes. The seismologists identified the path along which the gases rise up by comparing the velocities of various seismic waves with one another.

These seismological studies are part of the preparations for a planned international deep drilling project aimed at investigating the magmatic activity in more detail.

Contact: **Dr. Peter Gaebler,**
Dr. Ulrich Wegler



▲ Map of the investigation area with some seismic monitoring stations.

Earthquake data – daily updates

BGR catalogues merged

Earthquake catalogues are the basis for seismic hazard analysis. All of the available seismological data for Germany has now been brought together at BGR in a common database. This information can now be more effectively evaluated and processed.

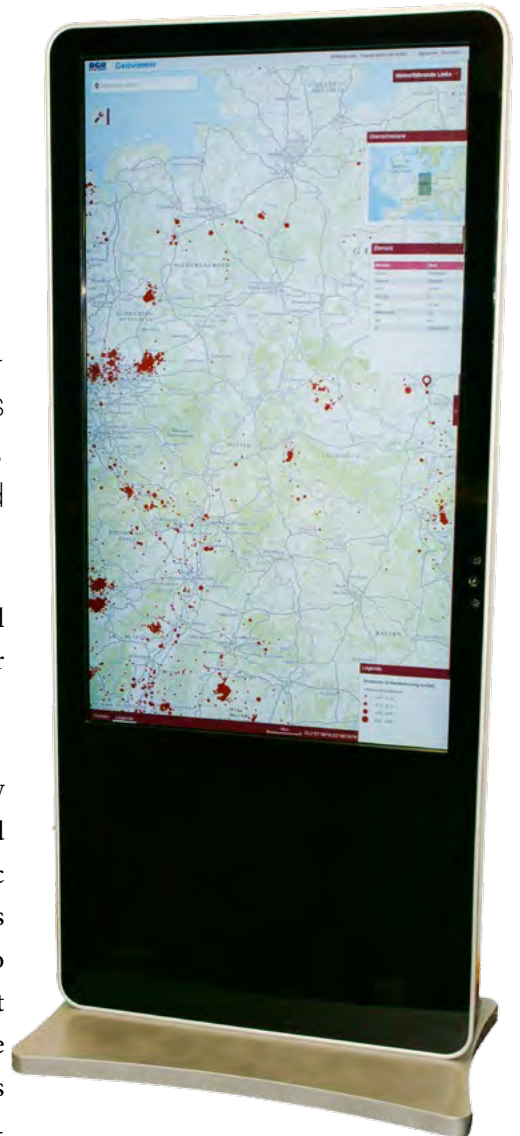
The first event recorded in BGR's historical catalogue is an earthquake which took place in 813. This earthquake shook the ground beneath Aachen – as recorded in the city chronicles. But how credible are reports of this kind? To investigate this further, BGR seismologists have compiled information from a range of sources in recent years.

“This often reveals the existence of contradictory reports. Clarifying things unequivocally is a challenging process requiring a lot of detective work,” say geophysicists Gernot Hartmann and Dr. Diethelm Kaiser at BGR. They and their colleagues merged two main databases to create the uniform all-encompassing earthquake catalogue for Germany: the “Earthquake catalogue for Germany and adjacent areas”, which goes back as far as the year 800, and

a second earthquake catalogue for all earthquakes reported by seismometer measurements since 1975.

The overall database which has now been completed reports around 50,000 seismic events – tectonic earthquakes, as well as explosions in quarries. Experts are now able to access all of the earthquake-relevant information for Germany from the Middle Ages to the present day, as required for their specific investigations.

One result for instance is the clear visualisation of seismicity in Germany, available free of charge in the BGR Geoviewer at <https://geoviewer.bgr.de>. The database is updated daily with any new earthquakes. In the near future, these updates can also include older events or reassessments: historical earthquake research and palaeo-



▲ BGR-Geoviewer with map of the earthquakes in Germany since 813.

seismology once in a while provide new information on earthquakes which took place centuries or even thousands of years ago.

Kontakt: **Gernot Hartmann,**
Dr. Diethelm Kaiser

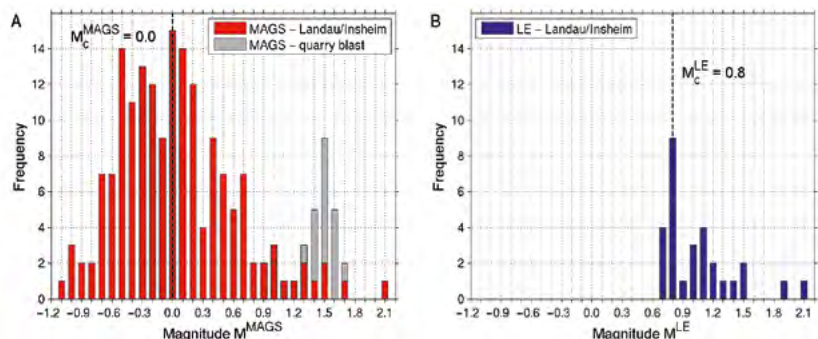
Earthquakes in real time

BGR seismologists monitor geothermal systems in real time

18 seismic monitoring stations in total register seismic events around the Landau and Insheim geothermal power plants in the southern Palatine in Germany. The events are detected in real time – thanks to a new method developed by BGR scientists.

If geothermal power plants extract hot water from the underground, this can give rise to earthquakes. Experts call this “induced seismicity”, in other words, artificially generated earthquakes. “In many cases, this only involves microseismicity, which can only be detected by highly sensitive seismometers,” reports the geophysicist Margarete Vasterling from BGR.

However, the largest events can sometimes also be felt by the local population at the surface of the earth. With the aim of monitoring the induced seismicity, and quickly establishing which events are attributable to the geothermal activities, BGR and the local seismological survey of the Geological Survey and Mining Authority of Rhineland-Palatinate, co-operate



▲ A comparison between the catalogues for a period of one year from October 2013 to October 2014. Left: catalogue generated automatically by the detector with induced events from Insheim and Landau (red) and blasts (only Waldhambach) in grey. Right: catalogue covering the same period from the Seismological Service of Southwestern Germany (blue).

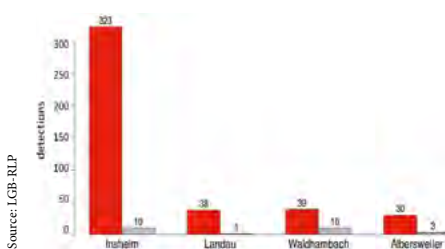
within the MAGS2 project and operate a local seismic network consisting of 14 surface stations and four borehole stations, located around the two geothermal power plants in Landau and Insheim.

“The seismic data is transmitted to BGR in real time,” reports Margarete Vasterling. The seismic events occurring in the reservoirs, as well as in two neighbouring quarries, are also detected in real time and assigned to the relevant sources thanks to a method developed by her and her colleagues. The so-called envelope cross-correlation detector makes it possible to differentiate the relatively

weak earthquake signals from natural earthquakes and the sometimes high seismic noise occurring in the area around the stations.

The local seismic network recorded 454 quakes in total between October 2013 and the end of October 2015. These were caused by the geothermal operations or the blasts in two neighbouring quarries. And the two reservoirs in Landau and Insheim could be seismically clearly differentiated from one another.

Contact: **Margarete Vasterling, Dr. Ulrich Wegler**



▲ Detections from 01.10.2013 to 30.10.2015 in the geothermal reservoirs in Insheim and Landau, as well as the quarries in Albersweiler and Waldhambach. Correct detections (red) and local tectonic quakes (grey) which caused erroneous detections.

Merged expertise

Independent analysis of mining and human rights

When human rights are discussed in a mining context, this frequently occurs in a heated political atmosphere. BGR and the Max-Planck Foundation for International Peace and the Rule of Law have scientifically analysed human rights risk areas in mining.

us to bring together leading experts from mining and international law,” reports Johannes Danz. The study published in January 2016, deals with the problems associated with industrial mining projects, as well as those associated with artisanal mining. In addition, researchers have also analysed special situations such as violent conflicts, corruption, and weak state



Source: SONY SAIFUDDIN (2006)/AFP/Getty Images

▲ Miners in a sulphur mine in Banyuwangi, East-Java. Hundreds of labourers work under dangerous conditions without any safety equipment or protective clothing.



Source: Robert Nickelberg (1985)/Getty Images

▲ Brazilian miners in Serra Pelada climbing up a wooden ladder carrying a 40-pound sack of gold on their backs.

The mining of extractive resources has a considerable impact on the daily lives of people living in the affected area. Conflicts about land, working conditions and environmental pollution arise if no measures are implemented, or if those affected do not receive compensation. This directly impinges upon human rights.

However, tackling these problems is frequently a difficult task: “Societal and business interests often adopt

conflicting positions because the debate about human rights in mining takes place in a highly charged political atmosphere,” reports Johannes Danz from BGR. In an attempt to make these discussions more objective, BGR and the Max-Planck Foundation for International Peace and the Rule of Law in Heidelberg have now presented an independent study analysing the risks to human rights associated with mining. “This co-operation project has enabled

structures. “The study encompasses a spectrum of the most important risks. Its independent orientation creates the conditions required for a rational debate without any political distortion,” says Danz.

The team is now involved in elaborating country risk analyses, and identifying good practice examples.

Contact: **Johannes Danz**

Support for Developing Countries

Geotherm II: Promoting the development of geothermal energy through surface exploration, training and political consultation

Green light for geothermal energy

BGR assists several projects in East Africa

Geothermal power plants could satisfy a large proportion of East Africa's power requirements. A BGR employee has advised the African Union (AU) in Addis Ababa since 2013 on geothermal energy issues. Kenya, Tanzania, Djibouti and Ethiopia in particular have profited from this co-operation so far.

The Paka volcano in the Kenyan Rift Valley is just one of many locations in East Africa which have the potential to become sites for geothermal power plants. It is even obvious to the naked eye that conditions are hot underground – for instance, the clouds of steam rising up from numerous fumaroles.

However, despite this major potential, geothermal energy currently only accounts for four per cent of total power generation in East Africa. “The main challenge is that companies have high upfront costs in the exploration phase, and risk significant financial losses if the exploration proves unsuccessful,” reports Max Winchenbach from BGR. To minimise this risk, BGR has been involved in surface studies in developing and emerging economies since 2004 to explore potential geothermal energy locations.

BGR also assists the Geothermal Risk Mitigation Facility (GRMF), a KfW development bank fund.

The main focus has turned increasingly to East Africa since 2009. In 2014 and 2015 for instance, the co-operation gave rise to operational guidelines for deep geothermal drilling, taking into consideration the latest environmental and safety standards.

In another co-operation project, the work looked at monitoring the uplift and subsidence in the vicinity of volcanoes where the construction of power plants is planned: BGR's remote sensing experts assisted the Kenyan state owned Geothermal Development Company (GDC) in using satellites to monitor the Paka volcanic cone. Another geophysicist worked in parallel testing the monitoring pro-



▲ A view from the substructure up into the derrick of a drilling rig with a pulley and hook in the Menengai field in Kenya.



▲ Reservoir test of a new well in the Menengai field in Kenya.

gramme set up by GDC on a different volcano, Silali. BGR also advised the state geothermal energy authorities in Djibouti and Ethiopia. The training further training of local experts in surface exploration methods is another main aspect of the work which will be continued in future as well.

Contact: **Max Winchenbach**

Source: Georg Meyer, 2014.

Source: Max Winchenbach, 2014

Support for Developing Countries

Information on georesources focusing on soils for regional planning activities in the south-west and north Cameroon regions

Soil data for Cameroon

Geoscientific information helps develop regional strategies for regional planning

Cameroon is rich in natural resources. However, its forests, extractive natural resources and farmland have so far only been used in an uncoordinated way. A BGR project now intends to provide data on georesources which are important for regional planning. The new focus is on soils.

The rainforest in the south-west of Cameroon is one of the world's biodiversity hot spots. However, the biological diversity is threatened: the forest cover in this Central African country has reduced by a fifth in the last 20 years.

“The high population growth and the rise in the demand for products, such as palm oil, are fuelling conflicts between various types of land use,” says Dr. Dierk Schlütter from BGR. The jungle is often cleared to cultivate plantations.

Politicians have hardly had any mechanisms at their disposal so far to balance out the competing interests – such as between nature conservation and agriculture. This is often attributable to a lack of information. “One requires quality-assured geodata to assess the advantages and disadvantages of various types of use,” says Dr. Robert Kringel. He has managed a BGR

project in Cameroon since February 2016, aimed at giving the policy makers the tools they require to develop regional planning strategies. Together with four authorities from Cameroon, the BGR team prepares regional data and information on soils and other georesources in two pilot regions.

“The results include thematic maps with explanatory information,” says Kringel. “This gives decision makers



Source: Robert Kringel

▲ Palm fruits ready for collection on a coastal road in the south-west region.

and civil society the instruments they require to reach thoroughly evaluated decisions.” The project also has the objective of helping harmonise economic and environmental interests, and to enable more sustainable agriculture.

Contact: **Dr. Robert Kringel,**
Dr. Dierk Schlütter



Source: Robert Kringel

▲ Soil from young volcanic ash layers overlaying a nutrient poor tropical red soil.

A plan for Dhaka

BGR assists Geological Survey of Bangladesh

The subsurface geology of Dhaka, the capital of Bangladesh, largely consists of soft sediments. Geological information is to be used in future to assist the very dynamic urban development – that is the goal of the technical co-operation work between BGR and the Geological Survey of Bangladesh (GSB).



▲ New building plots are created at the edge of the capital city of Dhaka by filling in areas with sand.

There are regular reports in Dhaka about the ruins of unfinished buildings leaning over as strongly as the famous leaning tower of Pisa. More than half of the capital of Bangladesh is at risk of flooding, and the ground beneath the city consists in part of marshland and flood plains. “Many of these areas are subjected to landfills and developed at a large scale,” reports Dr. Andreas Günther from BGR.

The RAJUK authority, which is responsible for urban planning, is do-

ing its utmost to properly control the rapid growth of the metropolis. However, information on the subsoil on which the buildings are to be constructed has so far not been taken into consideration in the urban planning. “This is because there are no geoscientists working in this authority”, says Günther.

The consequences of this uncoordinated activity: dramatic planning failures are a regular occurrence, because the bearing capacity of the subsoil

is often overestimated – and only revealed when the houses have been constructed.

BGR has been collecting data on the building ground and relief in Dhaka since 2005 by working together with the Geological Survey of Bangladesh (GSB) in several small projects. The GSB has been supported in the set up of an information system and the training of employees.

BGR and GSB began a new project in 2013 to strengthen GSB’s technical capacities, so that geological information can flow into the urban planning activities in future. Euro 1.5 million has been made available for this project. Dr. Günther underlines that “the special focus here is to involve the users of geodata, in other words, architects, regional planners and decision makers.”

Contact: **Dr. Arne Hoffmann-Rothe**,
Dr. Andreas Günther



▲ Exploratory drilling to analyse the subsurface conditions.

Training courses for disaster risk management

BGR strengthens competence of project partners in Latin America

Protection against natural disasters is the main focus of the “Capacity Building Measures – Risk-Sensitive Spatial Planning” training course given by BGR experts on behalf of the Federal Ministry for Economic Cooperation and Development. The two-week training measure took place for the fourth time in November 2015.

Perfect white beaches, palm trees and a turquoise sea – this is how most holidaymakers remember the Dominican Republic. But this Caribbean country also has another side: a large part of the population lives every day with the latent threat of natural risks.

People in rural areas in particular, that live in very simple houses, are at risk and vulnerable to hurricanes, flooding and landslides. Usually, however, nobody really knows how many people actually live in the continuously expanding settlements. “Information of this kind is extremely important for disaster prevention in developing countries,” reports Dr. Dirk Kuhn from BGR.



▲ Informal housing developments in flood-risk areas such as here in the estuary of the Rio Soldado in the Dominican Republic, are a frequent problem for disaster management in developing countries.

Principles of disaster risk management

BGR expert Kuhn and his colleague, Dr. Dirk Balzer, are now also making a contribution to ensure that countries such as the Dominican Republic are better prepared in future when a natural disaster strikes. They both developed a training course on the prin-



▲ The participants of the training course in El Salvador showing their Certificate of Completion.



▲ Participants and representatives of the National Disaster Prevention and Response Agency SINAPRED and the National Institute for Territorial Studies INETER of Nicaragua.



▲ The successful participants and the Director of the Dominican National Emergency Commission (Comisión Nacional de Emergencia - CNE) Mayor General Rafael De Luna Pichirilo (upper row, 3. from left).

ciples of disaster risk management. The employees of Latin American authorities and ministries taking part in the course learn how to conduct a risk exposure analysis.

“The training courses teach the participants about the spatial analysis of natural risks,” explains Dirk Balzer. The Dominican Republic for instance is threatened by earthquakes, flooding, landslides and tsunamis. The participants of the course – including geoscientists, regional planners, construction engineers and GIS experts – are taught how to determine the risks associated with the respective natural hazards.

Planning for the worst case

“Disaster managers must know for instance which areas are at risk of flooding, and how many people this flooding will affect,” explains Dirk Kuhn. The planning also determines the infrastructure which is at risk, such as roads, bridges, schools and hospitals. Another objective of the courses is to train the participants in elaborating contingency plans – in other words, plans for the measures to be implemented when a natural disaster actually takes place.

“Risk exposure analysis enables the derivation of information on where and how the risk of a natural disaster can be avoided or mitigated,” explains

Dirk Balzer. Risk analysis is therefore a key element of sustainable regional planning. “Potential risks first have to be identified. This information can then be incorporated in land use planning and urban development planning,” says Balzer.

Significant practical value

BGR has already implemented four two-week training measures for 15 participants in each case between 2013 and 2015: these courses took place in El Salvador, Nicaragua, the Dominican Republic and Argentina.

“These courses bring together experts from various institutions and from many Latin American countries,” reports Dirk Kuhn. The training therefore also promotes communication between the experts. “It is important that the authorities become more integrated, because the risks associated with earthquakes and volcanic eruptions do not stop at the borders of any particular country,” underlines Kuhn.

The participants were all very satisfied with the four courses carried out so far. They said that the training had a great deal of practical value. Balzer and Kuhn now also plan to carry out similar courses in Southeast Asia from 2016 onwards.

Contact: **Dr. Dirk Kuhn,**
Dr. Dirk Balzer

Nuclear-Test-Ban Monitoring

Development of modern autark seismological monitoring stations

Mobile and modular

BGR develops seismological monitoring stations for universal applications

BGR seismologists often set up monitoring stations for testing purposes. The engineers from the Central Seismological Observatory have now developed a new type of mobile monitoring station which can be remotely controlled.



Source: Luchino - Fotolia

▲ BGR's mobile seismological stations measure earthquakes and transmit the data in real time to the Central Seismological Observatory in Hanover. The picture shows the room in a house in Peru after an earthquake.

The black box is slightly bigger than a briefcase, but only just: BGR's new mobile seismological stations do not require a lot of space to do their job – detecting even the smallest earthquakes.

“When seismologists want to test a new location for a permanent mon-

itoring station, they usually install a mobile station first,” explains electrical engineer Erwin Hinz from BGR. He and his colleagues have now developed a concept to make stations of this kind – previously designed for brief periods of operation – more rugged, and therefore better suited for longer periods of outdoor operation.

The new seismological stations, of which there have so far been several prototypes, can for instance, be powered by a fuel cell which uses methanol. If a problem occurs, it can be remotely restarted. They are also protected from lightning strikes by a surge arrester. The data is transmitted in real time to the Central Seismological Observatory in Hanover via a mobile phone connection.

“Another feature is that the stations have a modular construction,” underlines BGR engineer Mark Hanneken. If it is then planned to turn a test site into a permanent station – a fairly frequent occurrence – it is easy to simply replace the fuel cell with a mains electricity supply.

Contact: **Erwin Hinz,**
Mark Hanneken

■ Subsurface Use | **Horstberg geothermal well: Research platform for geothermal investigations**

Horstberg borehole back in operation

BGR assessing the potential of geothermal energy

Several circulation experiments will be carried out in the next three years in the Horstberg research well on Lüneburg Heath. Research is being carried out to investigate how heat can be extracted from tight sandstone at great depth.

A large artificial fracture already exists at a depth of 3,600 metres in the Horstberg well, hydraulically connecting two sandstone horizons. BGR scientists now plan to circulate thermal water through the fracture to assess the geothermal energy potential.

In addition, the team headed by Dr. Torsten Tischner will be investi-



▲ Horstberg drilling site during the installation of a production pump.

gating whether the BGR concept of using only one well to extract geothermal heat can be applied at other locations. The scientists also want to find out what risks are associated with corrosion and the deposition of salt, and how this affects geothermal energy production. BGR is monitoring groundwater and seismicity as a precaution during the experiments to demonstrate that the planned measures will not have any influence at the surface.

Contact: **Dr. Torsten Tischner**

■ Subsurface Use | **DECOVALEX: DEvelopment of COupled models and their VALidation against EXperiments in nuclear waste isolation**

New phase for DECOVALEX

International co-operation in final repository research moves into the next phase



▲ Participants at a DECOVALEX 2015 workshop in Leipzig.

DECOVALEX is probably one of the longest running and most successful of all international projects. Scientists from around the world have been working together since 1992 in their efforts to model the complicated processes which play a part in a reposi-

tory for high-level radioactive waste. The project now enters its seventh phase with the launch of DECOVALEX 2019. BGR co-ordinates a work package looking at the behaviour of fluids during the tunnelling of a repository drift in tight rocks.

Other research aspects include modelling gas flow through a tight technical barrier, and developing a simulation for the hydro-mechanical processes taking place in faults in claystones. “In DECOVALEX 2019, we are continuing our interdisciplinary research on the thermal-hydrau-

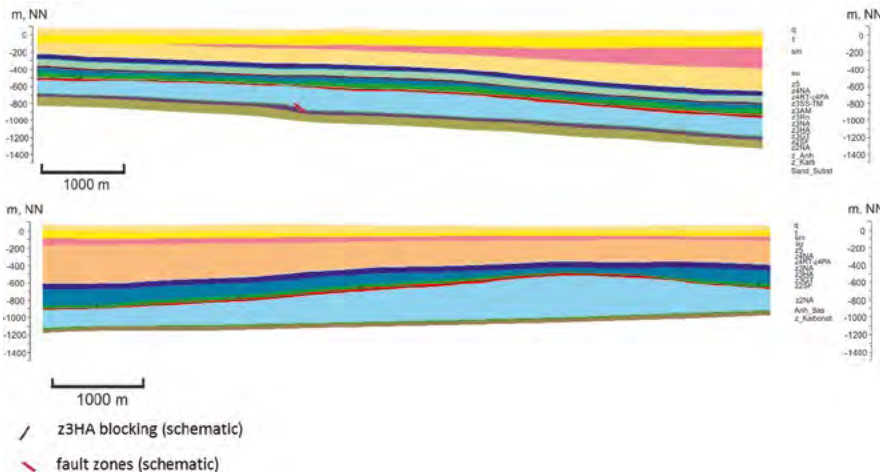
lic-mechanical-chemical processes which play a role in the release and transport of radionuclides,” says BGR expert Dr. Hua Shao. The intense exchange of know-how between the project partners, which now come from eleven countries, is invaluable to improve the overall understanding of the complex, coupled processes.

Contact: **Dr.-Ing. Hua Shao**

■ Subsurface Use | **KOSINA: Concept development for a generic repository for heat-generating waste in sub-horizontally-bedded salt formations in Germany, as well as developing and testing a safety and demonstration concept**

Behaviour of subhorizontally-bedded salt formations

BGR elaborates basic geological data for a repository concept



▲ Reference profiles for the model types “subhorizontally-bedded” (above) and “salt pillow” (below).

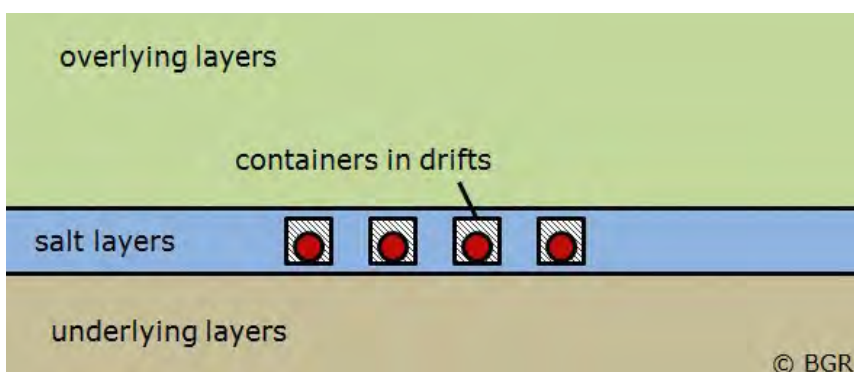
Rock salt not only forms mushroom-shaped salt domes deep underground, which are created when a load compresses a salt horizon and forces the salt to rise upwards. Moreover, rock salt is also preserved as subhorizontally-bedded layers or slightly bulging salt pillows. These almost subhorizontally-bedded salt layers are also potential host rocks for a repository

for high-level heat-generating radioactive waste: as stipulated in the Site Selection Act adopted in 2013. BGR is therefore investigating these types of salt deposits in activities including the BASAL project (more on this in the article on page 8). The team led by Tatjana Kühnlenz and Dr. Sandra Fahland are also involved in the KOSINA project along with

several other partner organisations. The project is funded by the Federal Ministry for Economic Affairs and Energy, and has the aim of developing a repository concept for this type of salt rock.

BGR’s participation here is primarily focused on geological issues. For instance, it is elaborating generic geological 3D models for two types of subhorizontally-bedded evaporite formations: type “subhorizontally bedded” and type “salt pillow”. In addition, already existing datasets are used to derive parameters for numerical modelling. The simulations based on this form the basis for investigating the integrity of geological barriers.

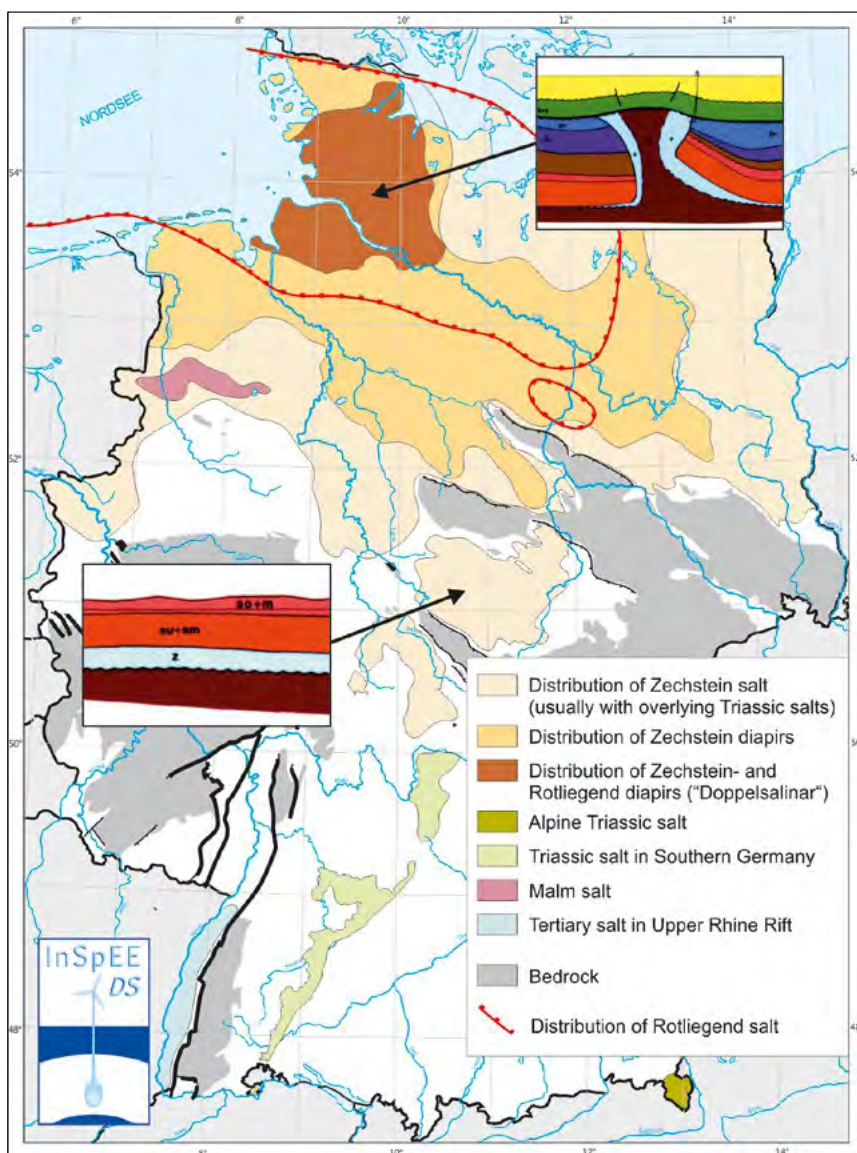
Contact: **Tatjana Kühnlenz,**
Dr.-Ing. Sandra Fahland



▲ Sketch of the principle for a repository in subhorizontally-bedded salt layers.

Potential of "Doppelsalinare" and subhorizontally-bedded salt deposits

Salt information system expanded



▲ Salt deposits in Germany investigated as part of the InSpEE-DS project to analyse their storage potential for renewables in the form of hydrogen and compressed air.

potential of north German salt structures, and elaborated an information system (more on this in the article on page 76). The aim of the InSpEE-DS follow-up project funded by the Federal Ministry for Economic Affairs and Energy is now to also look at subhorizontally-bedded salt deposits and so-called "Doppelsalinare".

"Doppelsalinare" are salt domes that are primarily found in Schleswig-Holstein, and contain salt from several periods of the earth's history; and unlike the salt domes, subhorizontally-bedded salt deposits are also found in southern Germany," explains BGR scientist Stephanie Fleig. The project will now look at both types of salt formation in more detail. The team aims to calculate cavern layouts using geological 3D models, and to supplement the existing salt information system.

At the end of the project, users will then be able to incorporate information on all of the salt formations in Germany in their planning activities.

Underground storages for compressed air or hydrogen are an important part of the energy transition. Salt caverns and the energy sources stored in them are to help buffer the

fluctuating output of windpower and solar energy.

In the InSpEE joint project, a team of scientists has already determined the

Contact: **Stephanie Fleig**

■ Subsurface Use | **Criteria for regulating the injection of CO₂ streams into a downstream transport and storage network**



CO₂ streams in the spotlight

CLUSTER project investigates impurities in captured CO₂ streams

When CCS technology is used at commercial scale, carbon dioxide captured from power plants and industrial facilities is to be collected in large pipelines in future and injected into underground storage reservoirs in line with the stipulations in an EU directive.

However, the composition of captured CO₂ streams varies depending on whether they come from, for instance, a coal-fired power plant or a cement works. The CO₂ streams can contain impurities such as nitric oxides, sulphur oxides or carbon monoxide.

These could give rise to geotechnically significant reactions in the pipelines or in the storage formations.

BGR scientists participating in the CLUSTER joint project, are doing research together with several partner organisations to determine the conditions under which CO₂ streams from various sources can be combined, safely transported, and permanently and safely stored underground.

The BGR team headed by Dr. Sebastian Fischer is carrying out laboratory

experiments and numerical modelling to investigate the reactions taking place between the injected fluids and the reservoir rock. They are looking at how porosity and permeability vary depending on the impurities. In addition, the scientists also want to find out whether the ground surface will become deformed by the storage activities. The results of the work will be used to define recommendations on the composition of CO₂ streams in CO₂ transport and storage networks.

Contact: **Dr. Sebastian Fischer**

■ Securing the Supply of Raw Materials | **HTMET: High-technology-relevant metals in German sulphurous non-ferrous metal ores – resource potential estimation**

Old ore bodies rediscovered

BGR prepares database for high-tech natural resources

Mineral resources of non-ferrous metals such as copper, lead and zinc are often found in brightly-coloured ores. These minerals frequently also contain low concentrations of rare high-tech natural resources such as germanium, gallium, indium and antimony.

In the HTMET joint project, BGR scientists headed by Dr. Torsten Graupner are now preparing a new database for high-tech natural resources in sulphurous ores in Germany and some neighbouring countries. This is done by analysing rock sam-

ples taken from former metalliferous mines found in the collections at BGR and those of its project partners. The database also includes data on the remaining ore reserves, infrastructure, and environmental risks at each site. The scientists also carry out exemplary laboratory tests to determine whether the metals and trace elements can be extracted economically. This approach also involves testing innovative ore processing methods.

The database is to be used later on to select regions and suitable deposits for the exploration and extraction



▲ Samples of sulphuric lead-zinc-copper ores from historical German deposits.

of natural resources. “The database strengthens Germany as a business location because it helps make use of domestic raw materials potential,” says Torsten Graupner. The project is funded by the Federal Ministry for Education and Science.

Contact: **Dr. Torsten Graupner**

■ Sustainable Livelihoods | **FGUK groundwater: improved energy-efficiency in groundwater extraction, treatment and transport**

Improved planning for well construction

Reducing energy losses

Public water supply companies in Germany mainly use underground water resources. BGR scientist Dr. Georg Houben has discovered that a lot of energy is frequently lost when pumping up this groundwater. For instance, fine particles can collect on the walls of the borehole during drilling and thus reduce the permeability of a well. “The pumps therefore have to work at a higher capacity,” explains Houben.



▲ Core sample from the wall of a borehole showing deposits of fine particles.

The groundwater expert presented a new software in the “Hydrogeology Journal” which calculates losses and compares production parameters. He now plans to develop this program further with the aim of optimising the efficiency of existing wells, and to improve the planning of new wells. The calculations are to be supplemented by experiments and field work.

Contact: **Dr. Georg Houben**

■ Sustainable Livelihoods | **Groundwater resources: BGR broadens involvement in Jordan**

Safeguarding drinking water supplies

Refugee crisis exacerbates situation in Jordan

The groundwater table in the north of Jordan has sunk by up to 60 metres in the last 20 years. This was revealed by investigations carried out by BGR

and the Jordanian Ministry of Water. Jordan now has to cope with the influx of around 1.45 million refugees, mostly from Syria, since the outbreak

of the crisis in the Near East. This corresponds to an increase in population of almost 22 percent.

In a new project, BGR is therefore now planning additional measures to improve the supply of drinking water in north Jordan. This involves implementing a more

science-based water management system in the most important well fields in north Jordan. Technical staff will be provided with the necessary training for the three well fields in this project.

BGR will also take over the geoscientific planning required to secure the extraction of groundwater in the long term. BGR experts are elaborating a map for the most densely populated part of north Jordan, which reveals the sensitivity of certain groundwater resources to pollution. This enables the resources to be given better protection.

Contact: **Dr. Mathias Toll**

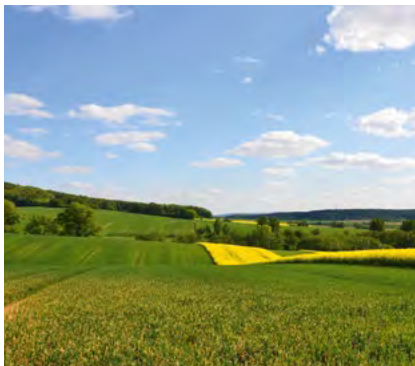


▲ Dried-out well in the north of Jordan.

■ Sustainable Livelihoods | **Taking the filter and buffer properties of soils into consideration for the eco-toxicological evaluation of inorganic contaminants in soils on the basis of the bio-available fraction**

When are contaminants available?

Soil parameters to be determined



Source: Luita23 - Fotolia

▲ Scientists investigating soils for heavy metals as part of the BIOS project.

Heavy metals in soils can be a risk to the environment. However, whether substances such as lead, arsenic and cadmium actually cause damage de-

pends on whether they are “bio-available” – in other words, whether they can be taken up by living things.

“Heavy metals are to be re-evaluated in future legislation,” reports the soil scientist Dr. Daniel Rückamp from BGR. The critical value in the past was the total content, but in future, the intention is to only take into consideration the bio-available and eco-toxicologically effective fractions.

“Soil properties such as the pH or the clay content, play an important

part in heavy metal availability,” says Rückamp. “The soil type is therefore crucial when deriving new precautionary values.” In the BIOS project, Rückamp is working together with project partners to investigate the bio-available and eco-toxicologically effective fractions of selected heavy metals in representative soils. In addition, the team plans to use this as the basis for deriving precautionary values for the development of legislation.

Contact: **Dr. Daniel Rückamp**

■ Sustainable Livelihoods | **MetaBoTiG: Transport and retention of PSM metabolites in the unsaturated zone and in groundwater**

Transport in percolating water

How pesticide residues spread out



▲ Taking samples of percolating water in the field.

Drinking water should contain as few contaminants as possible: as stipulated in the Drinking Water Directive. However, in some regions, the break-

down products of pesticides enter the groundwater via water percolating through the soil. In the Fuhrberger Feld – a drinking water protection area to the north of Hannover – the total values of these metabolites in percolating water can be up to six micrograms per litre.

But why are these substances transported through the soil? This is the question being looked at by the MetaBoTiG BGR project. Scientists Dr. Florian Stange and Dr. Georg Houben are concentrating here on the so-called unsaturated zone – this is the

soil horizon which is located above the groundwater. “Amongst other things, we want to determine where the break-down products are formed, and how they enter the groundwater via the percolating water,” reports Florian Stange. “We assume that the metabolites are already formed in the topsoil.” The scientists also want to investigate the spread of substances in the groundwater by determining the age of the groundwater in the Fuhrberger Feld.

Contact: **Dr. Florian Stange,**
Dr. Georg Houben

New mass spectrometer

Better isotope analysis in the BGR water laboratory

The hydrogeochemical laboratory at BGR has been able to analyse stable isotopes of carbon and nitrogen since March 2016 – thanks to a new mass spectrometer.

BGR already had the analytical apparatus required to measure heavy hydrogen and oxygen isotopes in water molecules. “Thanks to this new technology, we are now able to make much better descriptions of the environmentally-relevant processes taking place in water and in soils,” says Dr. Paul Königer from BGR.

The new isotope ratio mass spectrometer (IRMS) measures the isotope concentrations in measuring gases. However, the BGR scientists are particularly interested in investigating aqueous solutions. Various peripheral pieces of equipment are therefore used to convert the constituents of water samples – such as dissolved inorganic carbon – into measurement gases. The actual isotope analysis can then be carried out.

The new analytical technology in the water laboratory strengthens BGR’s

isotope competence, which also includes isotope geology and isotope geochemistry. This now enables the isotope scientists at BGR to investigate the components of the carbon cycle and the nitrogen cycle much more easily – for instance, to simplify identification of the causes of nitrate pollution in groundwater. The new method is also used for paleoclimatic investigations.

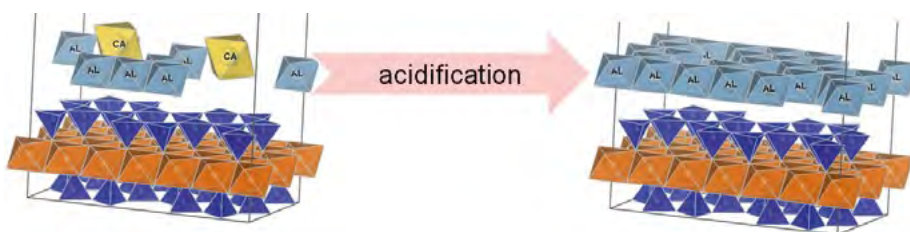
Kontakt: **Dr. Paul Königer,**
Prof. Dr. Thomas Himmelsbach

Minerals in mixtures

Development of new crystallographic tools

Manganese nodules and weathered clay layers have one thing in common: they consist of various, often disordered minerals – and are therefore difficult to analyse using conventional techniques. In BGR’s “Technical Mineralogy and Clay Mineralogy” unit, scientists are now working on how to reveal the secrets of these complex rocks.

The team headed by Dr. Reiner Dohrmann and Dr. Kristian Ufer aims to improve the so-called “Rietveld method”: this is a mathematical tool for evaluating X-ray diffraction diagrams. However, additional chemi-



▲ Crystal structure model of a soil clay mineral affected by acidification.

cal analysis is required to determine the mineral content of rocks such as claystones. “This method has been so complex in the past that we still don’t even have a semi-automatic procedure,” says Reiner Dohrmann.

BGR scientists are now working on simplifying the method by incorporating the results of other techniques

in the evaluation. They also want to improve the “Rietveld method” so that they can improve their characterisation of manganese nodules, and clay minerals in acidified soils.

Contact: **Dr. Reiner Dohrmann,**
Dr. Kristian Ufer

Raw material monitoring assists companies

Commodity prices have declined significantly in recent months. However, this does not relieve the situation of companies when procuring raw materials. Although the current price levels reduce the procurement risks, many mineral resources are still subject to price and supply risks. Dr. Torsten Brandenburg from the German Mineral Resources Agency (DERA) at BGR, explains how companies can respond to this situation.



▲ Dr. Torsten Brandenburg from the German Mineral Resources Agency (DERA) at BGR.

gated. Together with the detailed studies of specific natural resources, this enables DERA to provide companies with a broad spectrum of information.

What options are available in particular for SMEs?

For SMEs – as is also the case for large companies – it is important to identify and quantify the raw materials required for their products. Implementing options for procurement activities is only possible by understanding the company-relevant raw materials in the products. The screening of the raw material monitoring focuses precisely on this aspect, and therefore assists SMEs in particular when analysing their supply chains for the first time.

What other advisory services does DERA provide?

In addition to advisory services bundled within the raw material monitoring, DERA also assists companies in evaluating and supporting measures aimed at securing their natural resources and diversifying their sources of supply. This involves highlighting new investment and supply potential in collaboration with partner institutes in other countries.

What should companies be particularly careful about at the present time?

Companies in the manufacturing sector need to follow the commodity markets very closely in future as well, despite the current favourable procurement costs, which are due in part to considerable reductions in the prices of many metals and energy resources since the middle of 2014. The potential price and supply risks for numerous resources such as platinum, cobalt and rare earths continue to remain at a very high level in the face of the current developments in some natural resource markets.

What are the biggest market risks?

The consolidation currently observed in the markets can increase the supply concentration for some commodities. Some businesses in the sector may not survive the competition for

market shares. This would further increase the concentration on what is often already only a small number of providers. In addition, the low prices also have an influence on the supplies of natural resources: production capacities have been cut back in many markets, and projects have been postponed or shelved. The associated lack of investment could strengthen price rises in future when demand increases.

How can DERA help specifically with its raw material monitoring?

A screening system was developed as part of the raw material monitoring to enable the early identification of potential procurement risks in the commodity markets. We investigate here the global development in the supplies of mineral resources, and trading with the most important intermediate products. The development in demand and prices is also investi-

The future of groundwater

BGR also provides advice to the German Federal Government on groundwater, which is an important natural resource. Broad scientific work undertaken on this issue highlights the current state-of-the-art of science and technology. According to Professor Dr. Thomas Himmelsbach, head of the BGR sub-department “Groundwater Resources – Quality and Dynamics”, this involves an important detail which fundamentally differentiates BGR from consulting companies.

What is the importance of groundwater as a georesource?

The georesource groundwater is an essential base of life supplying people with water for drinking water and other purposes. Unlike in Germany, where two thirds of the water supply is sourced from groundwater, this can be as much as 100 percent in the arid regions of the world. Sustainable management and protection is required given the conflicts between climate change, growing populations, and changes in consumption due to rising living standards and industrialisation.

Which major challenges will tomorrow bring?

Climate change is a global challenge. This applies to agriculture in Niedersachsen as well as irrigation farming in Africa. These areas are already characterised by an increase in the use of groundwater. Although this will probably not have any dramatic consequences in Germany, the increased use in many developing and emerging countries has already caused wells to dry up. Climate change is also causing sea levels to

rise. The coasts of Europe, Asia and Africa, home to over two billion people, are already threatened by the creeping salinification of groundwater adjacent to coast lines. The quality of groundwater aquifers is also not only affected by salination, but also by pollution. The culprits include fertiliser and pharmaceutical residues, as well as pesticides, and in developing countries, primarily untreated sewage.

How can these challenges be tackled?

Society will ask us hydrogeologists how groundwater bodies will change over time. To be able to answer this question, we have to be able to prepare reliable scenarios on the development of groundwater resources. An example of this is a groundwater model which simulates the future land use, taking into consideration water consumption by the inhabitants and industry. In Jordan, this method provides the basis for improving the management of known groundwater resources, as well as for developing new resources. To protect coastlines, analysis and evaluations are required on the fragile equilibrium between



▲ Professor Dr. Thomas Himmelsbach.

saltwater and fresh water beneath the ground, so that the appropriate measures can be implemented.

What are you currently working on?

In future, we must increasingly analyse groundwater resources in their overall context. This means that we will become involved in increasing interdisciplinary co-operation activities with other departments within and outside of BGR. A typical example of this is geophysics and remote sensing with satellites. The first promising results of this interdisciplinary co-operation indicate amongst other things, the possible existence of new, previously unknown aquifers in southern Africa.

Energy from deep underground

The German Federal Government has committed itself to the transition to renewable energy sources. This means that by 2050 Germany intends to cover 80 percent of its electricity needs from renewable energy sources – and their share is to reach 60 percent of final energy consumption. Deep geothermal energy can make a contribution to achieving this goal. Dr. Johannes Peter Gerling is head of the BGR sub-department “Subsurface Use”, and responsible for BGR’s activities in the field of deep geothermal energy.



heat. The advantage of geothermal energy compared to e.g. windpower and photovoltaics is its independence from daily or seasonal weather changes.

What is the research focusing on?

Research concentrates on improving the technologies to extract geothermal heat – in terms of methods and costs. This includes improvements in the materials used in the boreholes and at the surface, e.g. in pumps and heat exchangers.

Which contributions can be expected from BGR?

We are currently converting our Horstberg Z1 geothermal borehole into a material testing site. It will later also be open for external parties to carry out long-term material investigations. In our Groß Buchholz Gt1 deep borehole drilled in the backyard of the GEOZENTRUM Hannover, our

research aims to test the possibilities of using hydraulic stimulation to extract heat from almost impermeable rocks.

What does hydraulic stimulation mean?

Unlike the technology used in oil or gas production, our hydraulic stimulation of rocks – also known as fracking – for deep geothermal energy production only uses pure water. And because this technology is mostly applied at depths well below 2,000 metres, it has no influence on drinking water or the environment. This assessment is shared for instance by the Umweltbundesamt in a report published in 2015.

How do you assess the geothermal potential of Germany?

The challenges in the prospective sedimentary basins increase from south to north: the extraction of geothermal energy in the area north of the Alps has now been successfully established – particularly in the area around Munich. Good results have also been achieved in the Upper Rhine Graben, although this area is associated with risks from induced seismicity caused by the improper reinjection of the cooled-down water. This is due to the geotectonic stress in this particular area. In the North Germany basin we expect the greatest geothermal potential. However, the rocks here frequently have only very little pore space. We therefore have to unlock the potential in these rocks by using stimulation techniques.

Why is BGR working on deep geothermal energy?

The earth’s core has a temperature of several thousand degrees. The temperature rises on average by 30 °C for every kilometre we go down beneath our feet. We should use this geothermal energy to satisfy our needs, given that more than 60 percent of all energy used in Germany is converted into

▲ Dr. Johannes Peter Gerling.

Water for Jordan

Groundwater issues play an important role in BGR's technical co-operation activities with other countries. This involves access to clean drinking water, and the question of how the use of groundwater resources can be regulated in future. Dr. Mathias Toll is desk officer Middle East, and is currently managing projects in Jordan as part of German Development Cooperation activities (DC).



▲ Dr. Mathias Toll with tribal chief Sawarieh at a workshop in Wadi Seer in Jordan.

What is the importance of groundwater issues in DC?

People need reliable access to clean drinking water, as well as to process water for agriculture. Groundwater is the most important source of supply in many arid regions around the world. But groundwater is also extracted in densely populated areas. This availability is, however, jeopardised by excess extraction and pollution. Safeguarding adequate supplies, and the sustainable management of groundwater, is therefore one of the stipulated objectives of global DC.

What contribution does BGR make in this regard?

BGR contributes its hydrogeological expertise in technical co-operation

projects with DC countries on behalf of the Federal Ministry for Economic Cooperation and Development. Most of the state partner institutions in the water sector are assisted in gathering and evaluating data on the groundwater situation in their countries. This lays the foundations for the partner countries to take over responsibility for the sustainable utilisation and protection of their own groundwater resources. However, the specific topics involved in cooperation and consultation can vary, such as in Jordan.

Can you explain that?

BGR has been involved in a scientific partnership with the Kingdom of Jordan for over 50 years. The specific issues involved in this collaboration in the groundwater sector have changed over time along with the country's development. In the beginning, the cooperation work focused on exploring and exploiting the resources. This was followed by protection, in terms of adapted land use, as well as groundwater quality issues. And now, the current inflow of refugees to Jordan means that the provision of adequate supplies and resource management have again gained a higher priority.

What are the consequences of the influx of refugees to Jordan?

Jordan's water resources are amongst the most limited in the world. Most of the population live in a few densely populated areas. Since the crisis in the Near East began, Jordan has had to cope with an inflow of 1.45 million refugees, mostly from Syria. This corresponds to an increase in population of almost 22 percent. There is therefore enormous pressure on the use of the already scarce water resources.

What can BGR do to help here?

BGR assists the Ministry of Water in Jordan in elaborating a fact-based utilisation plan for the groundwater resources. This is achieved by having a good understanding of the resources, by the appropriate management, and by providing advice against the background of the measures carried out by the state – all with the aim of ensuring the responsible management of this vital resource.

20 years of Mont Terri



The Mont Terri Rock Laboratory in Switzerland celebrates its 20th anniversary in 2016 – and BGR joins in the celebrations. The federal institute



participated from the early beginning of the international consortium which has been carrying out experiments underground in the canton of Jura

◀ BGR employees carrying out high-resolution mini-seismic surveys in the Mont Terri Rock Laboratory in Switzerland to characterise the rock mass.

on the final disposal of high-level radioactive waste since 1996. 16 partners from eight countries are now involved in the project which analyses the properties of claystone. This year's annual meeting in February was dominated by the anniversary and prospects of a potential extension of the laboratory.

Transparency and sustainability



▲ The State Secretary of the Federal Ministry for Economic Affairs and Energy, Matthias Machning, and Prof. Dr. Hans-Joachim Kümpel, former BGR President, at the international raw materials conference in Berlin (from the left).

Using raw materials responsibly was the main focus of the international raw materials conference “Assuming responsibility – promoting sustainability in the raw materials sector”. More than 300 guests took part in the event which was held in the Federal Ministry for Economic Affairs and

Energy in Berlin in November 2015. The former BGR President Prof. Dr. Hans-Joachim Kümpel presented a new study at the conference which highlighted the key role played by small and medium-sized enterprises in the due diligence regarding so-called conflict minerals.

Tradefair highlight



▲ BGR departmental head Dr. Michael Kosinowski and BGR soil expert Klaus Kruse, handing over the new Soil Atlas of Germany to Dr. Lothar Hövelmann, member of the board of the German Agricultural Association (from left). In the background: the BGR research helicopter.

BGR presented its own research helicopter at the Agritechnica agricultural machinery show in Hanover in November 2015. On its surveying flights, the helicopter can measure parameters such as the natural radioactivity of the soil, to assist soil mapping. The helicopter technology was therefore a perfect exhibit in the main show

topic at Agritechnica: “Smart Farming – Digital Cropping”. The BGR experts Dr. Michael Kosinowski and Klaus Kruse also presented the new Soil Atlas of Germany. It was ready right-in-time for the International Year of Soils.

Year of Soils

The United Nations defined 2015 as the International Year of Soils. The aim was to strengthen awareness of the significance of soils world-wide. BGR made several contributions including: the technical conference “Energy transition - a topic for

soils?” in March 2015; the Soil Atlas of Germany; the “Soil from a different perspective” campaign; and various presentations and exhibitions. These activities also highlight BGR’s position as the technical institute for soils in Germany.



Geo-Show for pupils



Source: Siegfried Pietzok

▲ ARD presenter Johannes Büchs with the “Underground” Geo-Show.

Fascinating insights into research were enjoyed by more than 650 pupils at the main lecture theatre of Leibniz University Hannover in 2015. Johannes Büchs, a presenter on the German ARD TV channel, was joined by, among others, scientists from BGR and the Leibniz University. Together they informed the young audience about volcanism, plate tectonics, and marine natural resources. The highlights of the Geo-Show entitled

“Underground” were the model of a “black smoker”, and a live broadcast from the JOIDES RESOLUTION drilling vessel in the Indian Ocean.

To the film on YouTube:



www.youtube.com/watch?v=gFsIM0Su9oo
Language: German

Zypries opens congress



“The digital world of geodata – identifying and using economic opportunities” – was the subject of the GeoBusiness Congress 2015. Around 180 participants discussed the value-added of state geodata in Berlin in April. The congress was opened by Brigitte Zypries, State Secretary at

the Federal Ministry for Economic Affairs and Energy. The participants included businessmen and women and experts from advertising, culture, tourism and energy. The participants were informed about how their companies could profit from geodata.

◀ In her opening speech, Brigitte Zypries, State Secretary in the Federal Ministry for Economic Affairs and Energy, highlighted the major importance of the availability of state geodata for the digital future of Germany.

No more atomic testing!

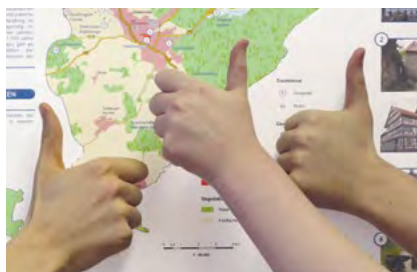
The exhibition “No more atomic testing – Germany and the Test Ban Treaty” was on show in the atrium of the Federal Foreign Office in Berlin in September 2015. The topics included the technical implementation of the

treaty. BGR made numerous exhibits available including an element from the infrasound station in the Antarctic, and a seismometer, which registered the ground movements generated by the visitors themselves.



▲ Exhibition in the atrium of the Federal Foreign Office in Berlin.

Source: Sven Krohn, 2015, kempphoto.com



▲ The geomaticians trained at BGR are delighted to have successfully qualified.

Trainees wished all the best

Three trainees successfully finished their geomatics training courses at BGR in July 2015. This officially recognised job qualification was first launched in 2010. Geomaticians are experts on handling geoinformation.

The training focuses on the integrated geodata management process – from capturing to processing, all the way to the visualisation and presentation of the data.

Source: Susanne Glick



▲ Participants at the fourth Geoscience Information in Africa (GIRAF) workshop in Maputo, Mozambique.

The fourth GIRAF workshop held in Mozambique in October 2015 was all about the application and man-

Workshop in Maputo

agement of geoscience information connected with sustainable mining and artisanal mining, bulk natural resources, and the environment. BGR organised the meeting of the “Geoscience Information in Africa” (GIRAF) network in the capital city of Maputo. 88 geoscientists from 18

countries took part. The co-ordination of the network founded in 2009 has been undertaken by BGR ever since, together with the African Steering Committee and GIRAF national ambassadors, and will be placed in African hands at the end of 2016.

Salt in the Geoviewer

Information on the salt structures of north Germany is now available via a web application. The results of the InSpEE project on possible cavern storages are visualised in a so-called geoviewer available at <http://geoviewer.bgr.de> under

“Geology”. Users can see graphic displays of the data they require. And the various tools available make it possible, for instance, to measure distances or print out parts of maps.



▲ The results of the InSpEE project are available in the BGR Geoviewer: information system on salt structures.

Source: German Embassy Ottawa



▲ Prof. Dr. Hans-Joachim Kumpel, former BGR President, and Dr. Daniel Lebel, Director General of the Geological Survey of Canada, signing the treaty (from left).

Treaty with Canada

Germany and Canada are strengthening their co-operation in the field of geoscientific research. The former BGR President Professor Dr. Hans-Joachim Kumpel, and the Director General of the Geological Survey of Canada, Dr. Daniel Lebel,

signed a treaty covering this aspect in February 2015. The main focus is on joint natural resources research in the Canadian Arctic, such as on the islands of Ellesmere, Axel-Heiberg and Ellef Ringnes.

Energy transition and soils

As a source of energy, an energy producer, and an energy conductor, soils are important for the energy transition. However, soil is also a non-renewable resource. This conflict was the focus of the “Energy transition – also

a topic for soils” conference held at the GEOZENTRUM Hannover in March 2015. 200 participants discussed various aspects including the consequences of the expansion of the power grid and the use of geothermal energy.



Source: Uwe Hammerschmidt

▲ Trench on a buried cable route through the state of Lower Saxony.

More intense involvement

Source: Siegfried Pietrzok



▲ BGR geophysicist Dr. Christian Reichert is new commission chairman at the International Seabed Authority.

BGR scientist Dr. Christian Reichert was elected Chairman of the Legal and Technical Commission of the International Seabed Authority in Jamaica (ISA). The international and interdiscipli-

nary commission supports the work of the ISA. The commission is currently drafting regulations for the future extraction of raw materials in deep sea locations.

Efficient utilisation

Research on carbon-concrete construction material, cooled sensor systems, and an innovative milling ring

– these were the innovations which won the German Material Efficiency Prize 2015. The Parliamentary State Secretary of the Federal Ministry for Economic Affairs and Energy Uwe

Beckmeyer praised the three projects as outstanding examples of the efficient and intelligent use of raw materials, and thanked the prize winners for their “pioneering creativity”.



▲ Prize winners of the German Material Efficiency Prize 2015 from the companies Majja-Frästechnik GmbH, IAS GmbH Industrie Automationssysteme, and C3-Carbon Concrete Composite e.V., with the Parliamentary State Secretary of the Federal Ministry for Economic Affairs and Energy Uwe Beckmeyer (3rd from left), and the former BGR President Professor Dr. Hans-Joachim Kumpel (right).

Selected publications



Ad-hoc-Arbeitsgruppe Hydrogeologie
Regionale Hydrogeologie von Deutschland
Die Grundwasserleiter: Verbreitung, Gesteine, Lagerungsverhältnisse, Schutz und Bedeutung
2016. 456 pages, 264 images
Language: German [Geologisches Jahrbuch A 163]
ISBN 978-3-510-96852-7, 62,00 €

Regional hydrogeology of Germany

This book contains the first comprehensive description of the regional hydrogeology of Germany. In accordance with the systematics behind the regional hydrogeological differentiation, the area covered by the Federal Republic of Germany was divided up into ten hydrogeological major-regions, 36 hydrogeological regions, and 247 hydrogeological sub-regions (which formed the focus of the publication). Rock type, pore space type, consolidation, hydraulic transmissivity, and the geochemical rock type of the most important regional aquifers are all described in detail.

Available from: www.schweizerbart.de



J. P. Gerling, T. Tischner, M. Kosinowski, V. Bräuer
Erdwärmegewinnung mittels Generierter geothermischer Systeme (GeneSys)
Teil 1: Testarbeiten in der Bohrung Horstberg Z1 und Abteufen der Bohrung Groß Buchholz Gt1
2015. 264 pages, 131 images, 1 DVD
Language: German [Geologisches Jahrbuch A 162]
ISBN 978-3-510-96853-4, 48,80 €

Geothermal heat extraction in Germany

The possibilities of harnessing deep geothermal energy sources to extract energy in Germany are currently being investigated by BGR in Hanover as part of the GeneSys project. The first part of the documentation has now been published and describes the results of the preliminary exploration measures in the Horstberg Z1 borehole drilled in the rural district of Uelzen, as well as the technical planning and execution of the Groß Buchholz Gt1 GeneSys borehole (final depth: 3,901 metres) that was drilled at the BGR premises in Hanover. The findings derived from the analysis of the drill cuttings, cores and borehole logs are all described in detail.

Available from: www.schweizerbart.de



Report on the raw materials situation in Germany

BGR published the latest report on the raw materials situation in Germany. The report which has been published annually since 1980, informs policy makers, business and the general public about the current developments in raw materials production, foreign trade, prices, as well as the consumption of mineral resources and energy resources. The developments on the international raw materials markets are also reviewed. The report can be downloaded free of charge.

Download (PDF): www.bgr.bund.de/rohstoffsituationsbericht-2014

Language: German

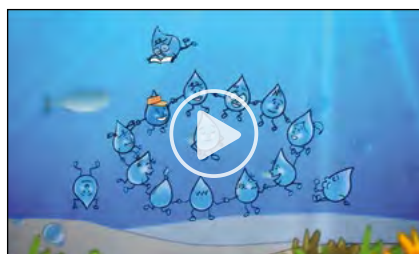
Geo-topics in the spotlight



The “GeoChannel” from BGR and the State Authority for Mining, Energy and Geology (LBEG) has been online on the YouTube video platform for two years now. More than 140 videos

published here present the work, projects and events of both institutes in various languages. The short videos cover most of the topics dealt with by BGR and LBEG: helicopter surveys, groundwater exploration, remote sensing, and many other subjects. The videos have been viewed for over 200,000 minutes so far. They have also been shared many times in social networks.

Droppy's global adventures



In an animated cartoon, a five-minute video shows the first story “The long trip” of the “The worldwide adventures of Droppy” comic. “Droppy” and his water drop friends experience the world’s water cycle during this adventure. The film has been translated into German, English, French and Spanish, and is available free of charge on a DVD together with a water cycle poster.

More information: www.bgr.bund.de/wassercomic

To the film: www.youtube.com/watch?v=-AXMHIxaWqQ

Language: German



Co-operation with Zambia



Zambia is the most water-rich country in southern Africa. Nevertheless, many of the people living there still have no access to clean drinking water. And the demand is rising because of population growth and commercial-industrial development. As part of the German “Water sector reform programme”, BGR has supported the Zambian government since 2005 in its activities exploring for groundwater – which is so important for safeguarding drinking water supplies – and to protect the groundwater to ensure its sustainable utilisation. The video shows aspects of this work.

To the film: <https://youtu.be/kJ7wExNl710>

Language: English



Change at the top of BGR

Dr. Rainer Sontowski, State Secretary at the Federal Ministry for Economic Affairs and Energy, officially inducted Professor Dr. Ralph Watzel as the new BGR President at a ceremony held in the GEOZENTRUM Hannover. The permanent secretary also thanked the outgoing president Professor Dr. Hans-Joachim Kümpel, who headed BGR since August 2007.



Source: Siegfried Pietrzak

▲ Professor Dr. Ralph Watzel (r.) takes over from Professor Dr. Hans-Joachim Kümpel as the BGR President.

In his speech, permanent secretary Sontowski praised the outgoing president for his work, and thanked him and the employees of BGR for their very competent and application-oriented advice to the German government. “The scientific expertise of BGR, as the departmental research institute of the German government, is very valuable to us. It is therefore in our interests that BGR maintains and further intensifies its scientific competence,” he added. Sontowski also highlighted the importance of co-operation with national and inter-

national geological surveys, research institutes and universities. He wished the incoming president all the best in his new role.

In his farewell speech, the long-serving, outgoing BGR president thanked the BGR employees. “I am very grateful to all of the staff for the high level of professional commitment at all times,” said Kümpel. He pointed out that geoscientific knowledge is becoming increasingly important to maintain the earth’s life support systems. This is one of the reasons why

geosciences have gained strongly in importance in the eyes of the public in recent years.

The new president talked about the importance of public relations work in his inaugural speech. In addition to the continuous expansion of scientific expertise, which has to be oriented to economic and social needs and requirements, Watzel said that another important objective of his work would be for the activities carried out by BGR to be communicated in the most customised and target-group oriented way. “The requirements that BGR has to satisfy as the central geoscientific advisory institute of the German government, include transparency and the comprehensibility of its activities as a public authority,” emphasised the president. The use of underground resources always needs to carefully weigh up the opportunities and the risks. “Geoscientific analysis must therefore not only be based on solid foundations, but also be responsibly elaborated, and adequately communicated,” said Watzel.

Before being appointed to his position as BGR President, Watzel had been the head of the “State Authority for Geology, Mineral Resources and Mining” department of the Regierungspräsidium in Freiburg for ten years. Watzel studied geology at the universities of Heidelberg and Karlsruhe and gained his doctorate from the University of Freiburg im Breisgau for hydrogeological research.

Contact



Dr. Harald Andruleit
Head of unit in the “Geology of Energy Resources, Polar Geology” sub-department
Harald.Andruleit@bgr.de



Dr. Stefan Broda
Head of unit in the “Basic Information – Groundwater and Soil” sub-department
Stefan.Broda@bgr.de



Dr. Kristine Asch
Head of unit in the “Geoinformation, German Geobusiness Commission (GGC)-Office, Stratigraphy” sub-department
Kristine.Asch@bgr.de



Dr. Stephan Costabel
Member of the „Geophysical Exploration – Technical Mineralogy” sub-department
Stephan.Costabel@bgr.de



Dr. Dirk Balzer
Head of unit in the “Geo-Hazard Assessment, Remote Sensing” sub-department
Dirk.Balzer@bgr.de



Johannes Danz
Member of the “International Cooperation” sub-department
Johannes.Danz@bgr.de



Dr. Kai Berglar
Member of the “Marine Resource Exploration” sub-department
Kai.Berglar@bgr.de



Dr. Reiner Dohrmann
Head of unit in the “Geophysical Exploration – Technical Mineralogy” sub-department
Reiner.Dohrmann@bgr.de



Dr. Manfred Birke
Head of unit in the „Soil as a Resource – Properties and Dynamics” sub-department
Manfred.Birke@bgr.de



Klaus Duscher
Member of the “Basic Information – Groundwater and Soil” sub-department
Klaus.Duscher@bgr.de



Dr. Martin Blumenberg
Head of unit in the „Resource Geochemistry” sub-department
Martin.Blumenberg@bgr.de



Dr. Einar Eberhardt
Head of unit in the “Basic Information – Groundwater and Soil” sub-department
Einar.Eberhardt@bgr.de



Dr. Volkmar Bräuer
Head of the “Underground Space for Storage and Economic Use” department
Volkmar.Braeuer@bgr.de



Ralf Eickemeier
Member of the “Geotechnical Safety Analysis” sub-department
Ralf.Eickemeier@bgr.de

Contact



Dr.-Ing. Sandra Fahland

Member of the “Geotechnical Safety Analysis” sub-department
Sandra.Fahland@bgr.de



Dr. Jörg Hammer

Head of unit in the “Geological-geotechnical Exploration” sub-department
Joerg.Hammer@bgr.de



Dr. Sebastian Fischer

Member of the “Subsurface Use” sub-department
Sebastian.Fischer@bgr.de



Mark Hanneken

Member of the “Central Seismological Observatory, Nuclear Test Ban” sub-department
Mark.Hanneken@bgr.de



Dr. Michaela Frei

Head of unit in the “Geo-Hazard Assessment, Remote Sensing” sub-department
Michaela.Frei@bgr.de



Gernot Hartmann

Member of the “Central Seismological Observatory, Nuclear Test Ban” sub-department
Gernot.Hartmann@bgr.de



Stephanie Fleig

Member of the “Geological-geotechnical Exploration” sub-department
Stephanie.Fleig@bgr.de



Dr.-Ing. Jürgen Hesser

Head of unit in the “Rock Characterisation for Storage and Final Disposal” sub-department
Juergen.Hesser@bgr.de



Dr. Peter Gaebler

Member of the “Central Seismological Observatory, Nuclear Test Ban” sub-department
Peter.Gaebler@bgr.de



Prof. Dr. Thomas Himmelsbach

Head of the „Groundwater Resources – Quality and Dynamics” sub-department
Thomas.Himmelsbach@bgr.de



Dr. Torsten Graupner

Member of the “Geology of Mineral Resources” sub-department
Torsten.Graupner@bgr.de



Erwin Hinz

Member of the “Central Seismological Observatory, Nuclear Test Ban” sub-department
Erwin.Hinz@bgr.de



Dr. Andreas Günther

Member of the “Basic Information – Groundwater and Soil” sub-department
Andreas.Guenther@bgr.de



Dr. Arne Hoffmann-Rothe

Head of unit in the “International Cooperation” sub-department
Arne.Hoffmann-Rothe@bgr.de

Contact



Dr. Georg Houben

Head of unit in the “Groundwater Resources – Quality and Dynamics” sub-department

Georg.Houben@bgr.de



Dr. Robert Kringel

Member of the “International Cooperation” sub-department

Robert.Kringel@bgr.de



Jens Ibendorf

Head of unit in the “Geoinformation, German Geobusiness Commission (GGC)-Office, Stratigraphy” sub-department

Jens.Ibendorf@geobusiness.org



Dietmar Krug

Member of the “Basic Information – Groundwater and Soil” sub-department

Dietmar.Krug@bgr.de



Dr. Malte Ibs-von Seht

Member of the “Geo-Hazard Assessment, Remote Sensing” sub-department

Malte.Ibs-vonSeht@bgr.de



Klaus Kruse

Member of the “Basic Information – Groundwater and Soil” sub-department

Klaus.Kruse@bgr.de



Dr. Diethelm Kaiser

Member of the “Geo-Hazard Assessment, Remote Sensing” sub-department

Diethelm.Kaiser@bgr.de



Dr. Dirk Kuhn

Member of the “Geo-Hazard Assessment, Remote Sensing” sub-department

Dirk.Kuhn@bgr.de



Dr. Stephan Kaufhold

Member of the “Geophysical Exploration – Technical Mineralogy” sub-department

Stephan.Kaufhold@bgr.de



Kerstin Kuhn

Member of the “Geology of Mineral Resources” sub-department

Kerstin.Kuhn@bgr.de



Tilo Kneuker

Member of the “Geological-geotechnical Exploration” sub-department

Tilo.Kneuker@bgr.de



Tatjana Kühnlenz

Member of the “Geological-geotechnical Exploration” sub-department

Tatjana.Kuehnlenz@bgr.de



Dr. Paul Königer

Member of the “Groundwater Resources – Quality and Dynamics” sub-department

Paul.Koeniger@bgr.de



Christoph Lohe

Member of the “Groundwater Resources – Quality and Dynamics” sub-department

Christoph.Lohe@bgr.de

Contact



Dr.-Ing. Jobst Maßmann

Member of the “Geotechnical Safety Analyses” sub-department
Jobst.Massmann@bgr.de



Dr. Daniel Rückamp

Member of the “Soil as a Resource – Properties and Dynamics” sub-department
Daniel.Rueckamp@bgr.de



Dr. Uwe Meyer

Head of the “Geophysical Exploration – Technical Mineralogy” sub-department
Uwe.Meyer@bgr.de



Dr. Carsten Rühlemann

Member of the “Marine Resource Exploration” sub-department
Carsten.Ruehlemann@bgr.de



Sabine Mrugalla

Head of unit in the “Long-term Safety” sub-department
Sabine.Mrugalla@bgr.de



Dr. Stefan Schlömer

Member of the “Resource Geochemistry” sub-department
Stefan.Schloemer@bgr.de



Dr. Karsten Piepjohn

Member of the “Geology of Energy Resources, Polar Geology” sub-department
Karsten.Piepjohn@bgr.de



Dr. Dierk Schlütter

Member of the “International Cooperation” sub-department
Dierk.Schluetter@bgr.de



Dr. Dieter Rammlmair

Head of unit in the “Geology of Mineral Resources” sub-department
Dieter.Rammlmair@bgr.de



Dr. Kristof Schuster

Head of unit in the “Geological-geotechnical Exploration” sub-department
Kristof.Schuster@bgr.de



Dr. Dorothee Rebscher

Member of the “Subsurface Use” sub-department
Dorothee.Rebscher@bgr.de



Dr. Ulrich Schwarz-Schampera

Head of unit in the “Geology of Mineral Resources” sub-department
Ulrich.Schwarz-Schampera@bgr.de



Dr. Christian Reichert

Head of the “Marine Resource Exploration” sub-department
Christian.Reichert@bgr.de



Dr.-Ing. Hua Shao

Member of the “Rock Characterisation for Storage and Final Disposal” sub-department
Hua.Shao@bgr.de

Contact



Dr. Bernhard Siemon
Head of unit in the “Geophysical
Exploration – Technical
Mineralogy” sub-department
Bernhard.Siemon@bgr.de



Dr.-Ing. Sara Ines Vassolo
Member of the “Groundwater
Resources – Quality and Dynamics”
sub-department
SaraInes.Vassolo@bgr.de



Dr. Henrike Sievers
Member of the “Geology of Mineral
Resources” sub-department
Henrike.Sievers@bgr.de



Margarete Vasterling
Member of the “Central
Seismological Observatory, Nuclear
Test Ban” sub-department
Margarete.Vasterling@bgr.de



Dr. Florian Stange
Member of the “Soil as a Resource –
Properties and Dynamics”
sub-department”
Florian.Stange@bgr.de



Dr. Markus Wallner
Member of the “Groundwater
Resources – Quality and Dynamics”
sub-department
Markus.Wallner@bgr.de



Dr. Annika Steuer
Member of the “Geophysical
Exploration – Technical
Mineralogy” sub-department
Annika.Steuer@bgr.de



Dr. Ulrich Wegler
Member of the “Central
Seismological Observatory, Nuclear
Test Ban” sub-department
Ulrich.Wegler@bgr.de



Dr. Torsten Tischner
Member of the “Subsurface Use”
sub-department
Torsten.Tischner@bgr.de



Max Winchenbach
Member of the “International
Cooperation” sub-department
Max.Winchenbach@bgr.de



Dr. Mathias Toll
Member of the “International
Cooperation” sub-department
Mathias.Toll@bgr.de



Dr. Jan Lennard Wolf
Member of the “Subsurface Use”
sub-department
JanLennard.Wolf@bgr.de



Dr. Kristian Ufer
Member of the “Geophysical
Exploration – Technical
Mineralogy” sub-department
Kristian.Ufer@bgr.de

About BGR

The Federal Institute for Geosciences and Natural Resources (BGR) is a higher-level technical and scientific federal agency that reports to the German Federal Ministry for Economic Affairs and Energy (BMWi). 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 (LBEG) and the Leibniz Institute for Applied Geophysics (LIAG), BGR forms the GEOZENTRUM Hannover.

The BGR Report is available free of charge.

The pdf-version can be downloaded from:



www.bgr.bund.de/Report2016_en

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Bundesanstalt für Geowissenschaften und Rohstoffe
(Federal Institute for Geosciences and Natural Resources)
Stilleweg 2
D-30655 Hannover

Telephone: +49 511 643-0

Fax: +49 511 643-2304

E-mail: info@bgr.de

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