

# BGR Report

Federal Institute for Geosciences and Natural Resources

September 2015



## Claystone under the magnifying glass

Scientists analyse the properties of claystone in the international Mont Terri rock laboratory

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### Month of publication

September 2015

**This BGR Report presents projects that BGR was working on in 2014 and  
looks ahead to future projects.**

# Editorial



*Prof. Dr.  
Hans-Joachim  
Kümpel*

President  
of the Federal Institute  
for Geosciences and  
Natural Resources

*Dear Readers,*

*How and where high-level radioactive waste is to be stored in future has not yet been clarified. The German Federal Government adopted the so-called “Site Selection Act” in 2013. The act regulates the fundamental steps in the search for a repository which will guarantee the best possible levels of safety over a period of one million years. The selection process has been agreed to be transparent and will involve the general public.*

*In Germany, the possible host rocks for a repository for high-level nuclear waste material in deep underground formations are above all: rock salt, claystone and crystalline rocks. Each of these rock types has advantages and disadvantages. BGR has been carrying out research since the 1990s to ascertain whether claystone is a suitable geological barrier, and whether clay is apt to function as a geotechnical barrier. In the article “Claystone under the magnifying glass” on page 38, you may read about the research being done by BGR’s scientists in the Mont Terri rock laboratory in Switzerland.*

*The Commission for the Storage of High-level Radioactive Waste has been given a deadline of 2016 to present recommendations to the German Federal Government. These will form the basis for the decision making process in selecting a location. Most important aspects taken into consideration will include safety and the geological criteria. The Federal Government refers to the geoscientific expertise of BGR for advice on these issues. The interview “Criteria for a repository” on page 70 reveals the tasks BGR is involved in to provide this consultancy service.*

*I hope you will find it an interesting read!*

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“Planet Earth represents the basis for all our lives  
– its resources are limited.”

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

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# Securing the Supply of Raw Materials

Reassessment of ore bodies and mineral deposits in Kazakhstan

## German-Kazakhstan raw materials partnership in practice

BGR experts reveal opportunities for investment in mining projects and mineral deposits

BGR has investigated 40 mining projects and mineral deposits in Kazakhstan and re-evaluated their economic potential. The project looked at the mineral resources of particular interest to German industry. The information is used in decision making processes looking at potential joint ventures, applying for sole German permits or developing new supply potential.

vanadium, tantalum, tungsten, molybdenum and titanium as well as iron and fluorspar. The partners on the Kazakh side are the Ministry for Industry and New Technologies, the Central Committee for Geology and Underground Exploitation, the Regional Committees for Geology and Underground Exploitation in north, east, south and central Kazakhstan and exploration companies with their own projects.



▲ Location of the 15 mineral deposits (blue) and projects in Kazakhstan. The map also shows the position of the most important towns (orange).

Of the around 300 projects offered by the Kazakh partners, BGR experts did a more detailed assessment of around 40 mineral deposits and projects. The selection was primarily based on whether the projects could be of interest for supplying mineral resources to German industry, and on the other hand, a promising initial estimate of the economic potential of the resource indicating that a mining project could be successful.

Kazakhstan and Germany have entered a raw materials partnership. This is accompanied by an assessment by BGR of the deposits for the non-ferrous metals copper, lead, zinc and tin, the steel alloy constituents



▲ BGR employees taking samples at the Balasauskandyk vanadium deposit.

At the end of the investigation, the BGR experts presented 15 particularly interesting projects in a workshop. Fact sheets were prepared for the projects which, in addition to basic geographic and geological information, also contained data on ore tonnages and concentrations as well as an estimation of their international ranking. Analyses also included an initial classification of their processability and the technical extractability of the ores. Information on the economic potential was also contained in the fact sheets. In cases of contractless and so-called free mineral deposits, the analysis provided the first assessments determined on the basis of a simplified economic extraction model. Details provided by the companies involved were used for the company projects where there was information available on the economic potential.

The fact sheets also contain project and/or deposit-specific information on the infrastructural conditions required for the development of a project as well as environmental compatibility issues. This enabled derivation of the costs involved for the necessary improvements to the infrastructure, for environmental protection as well as for social aspects. The information is rounded off by sketches of the general conditions which are of vital importance for investment in the mining sector in Kazakhstan. These include the institutional situation in Kazakhstan such as the type of contracts on which mining projects are based, the permit fees as well as the practices and procedures involved in sharing the revenues. Consideration is also given to the economic-policy background such as the tax system or currency

## Raw materials conference 2015

Sustainability is playing an ever more important role in the global supply of raw materials. Sourcing raw materials responsibly involves aspects such as environmental protection, social responsibility, resource efficiency in mining as well as in supply chains.

The Federal Ministry for Economic Affairs and Energy together with BGR are going to organise an international raw materials conference in Berlin in November 2015 on the topic “Accepting Responsibility – Promoting Sustainability in the raw materials sector.” The conference addresses representatives from politics, industry, civil society as well as science. BGR organises raw materials conferences every two years and provides up-to-date facts and information on resource-related issues.

[www.bgr.bund.de](http://www.bgr.bund.de)

controls for repatriating profits. In addition to project-specific data, every study therefore also includes information on the legal frameworks.

Contact: **Dr.-Ing. Jürgen Vasters**

# Securing the Supply of Raw Materials

Passive and sheared continental margin of Mozambique (PAGE-Four)

## Key location for energy resources

The break-up of Gondwana laid the foundations for the East African offshore gas fields

A lot still remains unknown about the break-up of the Gondwana super continent during the Earth's Middle Ages. BGR experts went on an expedition to the Indian Ocean off the coast of Mozambique to look in more detail at the separation of Africa, Madagascar and the Antarctic. In doing so, they discovered that natural gas resources cannot be excluded in the marine area around the Comoros.

The break-up of Gondwana in the Jurassic and the Cretaceous was the last break-up of a super continent into its components so far. Africa separated from Madagascar, India, Australia and the Antarctic. This created the Indian Ocean in the form we know it today. However, many of the specific details of this process lasting more than 100 million years still remain unclarified. The research expedition undertaken by BGR in the marine area between Tanzania, Mozambique and the Comoros on the Sonne research ship in early 2014 was focused on looking at some of these aspects in more detail.

“We are still evaluating the data we collected during the expedition,” reports expedition leader Dr. Dieter



▲ Geophysical measuring instruments being used in the survey area off the coast of Mozambique.

Source: Dieter Franke

Franke. But there are already indications that there is a relatively broad transition zone between the ancient continental crust of Africa and the young crust of the Indian Ocean, and that it extends a long way from the

coast of East Africa. “The question now,” says Franke, “is whether the continental shelf of Africa extends as far as the marine area around the Comoros.” This gave the research expedition a highly practical orientation, because if the African continental shelf stretches this far into the Indian Ocean, there could be potential for gas deposits all around the Comoros. “Our guest on board from the Geological Survey of the Comoros was very thrilled,” says Franke. Geologists had assumed to date that the very young volcanic archipelago, which is only around ten million years of age, did not have any natural resources of this kind.

Hope was initially raised in 2010 by the discovery of the Windjammer deep water gas field off the north coast of Mozambique. This was also in an area previously considered to have hardly any potential by many experts. In the meantime, the assumption is that gas fields holding reserves totalling three trillion cubic metres are present in this area. This is around twice as much as the natural gas reserves in Norway. “Mozambique, which is currently one of the poorest countries in the world, is on the way to becoming a globally important exporting country for natural gas,” in Franke’s opinion. The island state of the Comoros is just as poor, and now hopes that it can develop in a similar





▲ Offshore permit blocks in the Indian Ocean off the coast of Mozambique and Tanzania. Also showing the largest natural gas discoveries, pipelines and liquefied natural gas plants (LNG).

way. The first exploration licenses are already being awarded.

With its research expedition, BGR has provided important basic information for the search for energy resources off the coast of East Africa. “The Strait of Mozambique appears to be a key location,” says Dieter Franke. The narrow arm of the ocean between north Madagascar and the African continent appears to have been the southern

limit of a shallow marine basin during the break-up of Gondwana, in which thick layers of sediment with large amounts of micro algae were deposited. This biomass was converted into natural gas over the course of many millions of years, and has now collected within the sedimentary package at numerous places.

“With our research in the East African offshore area we make a con-

tribution to answering the question of what sort of volumes of energy resources still remain to be discovered around the world in great water depths below the continental margins,” emphasises the geophysicist. After all, mankind will still have to rely on fossil fuels for a very long time into the future.

Contact: **Dr. Dieter Franke**

# Securing the Supply of Raw Materials

Market study: Platinum Metals & Investor's Guide South Africa

## South African dominance

German Mineral Resources Agency analyses the supply situation for platinum group metals



Source: DERA (2013)

▲ The Mogalakwena opencast platinum mine in South Africa owned and operated by Anglo American Platinum is one of the largest platinum mines in the world.

The platinum group metals platinum, palladium and rhodium play a very important role in a wide range of industrial applications. In its 2014 mineral resources list, the German Mineral Resources Agency (DERA) classified these metals as potentially “critical” resources, because production is concentrated in only a few countries. Two detailed studies have now been elaborated.

The platinum group metals (PGM) platinum, palladium and rhodium are primarily used in catalysers in the automotive sector and by the chemical industry – including petrochemistry. Exhaust gas catalysers alone accounted for 79 percent of the demand for rhodium in 2014. 80 percent of the demand for palladium came from the automotive sector and the chemical industry, while these two sectors accounted for 44 percent of the demand for platinum. The latter is also a highly desirable metal for

jewellery making – which accounted for 35 percent of the demand. Because of the industrial significance of the three platinum metals, DERA elaborated the detailed study “Risk assessment of platinum group metals” which will be published in the third quarter of 2015.

Together with the Geological Survey of South Africa (CGS), DERA carried out a re-assessment of the mineral resources potential in South Africa in the “Investor’s and Procurement

Guide South Africa”, which included an evaluation of PGMs. Around 75 percent of the platinum produced world-wide comes from South Africa. 24 of the 33 active PGM mines are located in this country, and another three in neighbouring Zimbabwe. There are also three active mines in Russia, two in the USA, and another mine in Canada. Because of the dominance of South Africa, the mine workers’ strike which took place there in the first half of 2014 slashed global production of platinum over the same



▲ Processing chromites and platinum group metals from tailings material.



▲ Drill cores at the Two Rivers platinum mine in South Africa.

time period by 40 percent. Thanks to the large stockpiles and the simultaneous slight decline in global demand the strike did not affect the prize

The Bushveld complex in north-east South Africa extends for around 66,000 square kilometres and is the centre of PGM mining. Two ore horizons which each average only one to one and a half metres in thickness have a long mining tradition at the western and eastern margins of the complex. However, the amount of technical effort involved is increasing, particularly in the older mines within the western area, because of the increasing depths at which the ore is extracted. The large platinum producers are therefore increasingly closing down their older mines. At the same time, another ore horizon is being developed in the northern part of the Bushveld complex (northern limb) in a formation which locally reaches up to a few hundred metres in thickness and veined in extensive

zones with sulphide minerals containing platinum. There is currently only one producing platinum mine in this area, the Mogalakwena opencast mine operated by Anglo American Platinum, as well as around ten other exploration projects at various stages of development. Mogalakwena contains the largest proven reserves of all South African platinum mining operations, with around one and a half billion tonnes of ore with PGM concentrations of approximately three grams/ton. It was also one of the mines with the highest production in 2014 with 370,000 troy ounces of platinum (around 11.5 tonnes). In Mogalakwena, PGM production is scheduled to double in the next few years.

The PGM potential in the processing tailings is also assessed in the “Investor’s Guide”. The material in these old tailings from decades of platinum and chromium processing in the Bushveld complex is estimated to contain more

than two billion tonnes, and a net PGM content of around 39 million troy ounces (of which around 20 million fine ounces of platinum). New processing methods would allow to extract around 15 million troy ounces of PGM from this former waste material, corresponding three times the annual production of South Africa. In addition, there are considerable quantities of oxidised ores at shallow depths, particularly at the northern limb of the Bushveld complex. Estimates of this potential exceed 300 million tonnes of ore material, with PGM contents averaging three grams/ton. However, it is not currently possible to process them economically. BGR is currently investigating the mineralogical and chemical characteristics of these oxidised ores with the aim of developing an efficient and inexpensive processing technology.

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Contact: **Michael Schmidt,**  
**Dr. Herwig Marbler**

# Securing the Supply of Raw Materials

Ecometals: Extracting industry metals using biotechnology / BioMOre: alternative mining concept



Source: Prof. Dr. Gregor Bog, Martin-Luther-University Halle-Wittenberg

▲ Dump of a former Kupferschiefer mine in Mansfelder Land, Saxony Anhalt, in Germany.

## Mining with the help of bacteria

Biomining exploits metaliferous mine waste dump material and unused mineral deposits

Europe is certainly not as poor in mineral resources as is often maintained, however, the easily minable deposits have become rare. Complex ores, mineral resources with low metal concentrations or unfavourable additional constituents are largely undeveloped at the present time. Geomicrobiologists at BGR are looking at opportunities of mining these deposits with the help of bacteria. This biomining technology may also be suitable for extracting metals from waste dumps.

Copper has been mined in the Mansfelder Land since the 12th century. The only witnesses to the former flourishing mining industry located

between the Harz and the Saale river are numerous old dumps. Although the material in these dumps is not concentrated enough for conventional smelting, the ores could become an interesting copper resource again by using biomining technologies. Experts from the Geomicrobiology working area of BGR have demonstrated that up to 95 percent of the copper can be extracted from Kupferschiefer samples from the Fortschrittsschacht I mine waste dumps near Eisleben, at least under laboratory conditions. This means, that together with lead and zinc, the Kupferschiefer mine waste dumps at the Fortschrittsschacht I alone contain metal with an estimated value of ten million Euros.

In the light of these figures, two European research consortiums in which BGR scientists are involved, are using these experiments as the basis for further developing the method. The German-French Ecometals project is not only looking at the German Kupferschiefer dumps, but also ores from the Kupferschiefer in Poland. The aim is to develop a pilot plant for the bio-hydro-metallurgical processing in tanks. BGR is focussing on optimising the process parameters at a laboratory scale by carrying out leaching experiments in bioreactors.

The multinational BioMORe EU project has even gone underground and is testing biomining in situ in a mine in the Lubmin mining district in Poland. A 100 cubic metres sized block of stone is being prepared here to enable bacteria to be used under controlled conditions. Bacteria float in a solution and leach copper and other metals from the rock so that these can then be extracted in a conventional plant. In a second project phase after 2017 still to be applied for, the aim is then to test the concept in situ in an ore deposit. This practical test does not need a mine to be drifted, because the bacterial solution is to be injected into the deposit via a well, and the metaliferous solution which results is then to be produced via a second well.

Biomining makes use of special microorganisms, which satisfy their energy needs by altering reduced iron and sulfur compounds in a way which releases metal ions. The attraction of these bacteria to sulfur makes them ideal co-operation partners for humans because the ore minerals of copper, nickel, cobalt and zinc primarily occur in nature in the form of metal sulfides. The bacteria and archaea convert the insoluble metal compounds into water-soluble substances.

A significant proportion of global copper production now involves the help of bioleaching, primarily in Chile. The extraction of gold, cobalt, nickel and uranium already functions with the assistance of microorganisms. Using bacteria to extract met-

als from rocks with raised but still unattractive copper concentrations for today's conventional extraction methods, represents the next phase of biomining. The Kupferschiefer deposits in Poland and the mining dumps in the Mansfelder Land are the ideal areas of application for this technology.

The possibility of processing Kupferschiefer by using biomining technology was already looked at by geomicrobiologists at BGR back in the 1970s as part of a third party-funded project. This work established the basic feasibility of the method, and did important basic research for process development.

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Contact:

**apl. Prof. Dr. Axel Schippers**



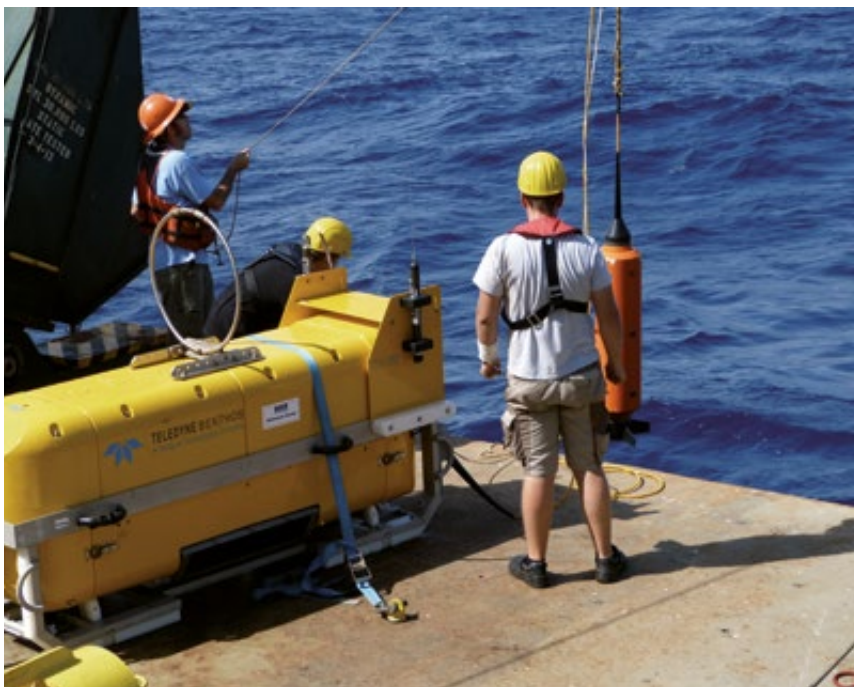
▲ Pregnant leach solution containing copper at a heap bioleaching plant in Chile.

# Securing the Supply of Raw Materials

INDEX: Indian Ocean – Exploration activities for marine polymetallic sulphides

## Clouds of smoke point the way

INDEX 2014 discovers a new hydrothermal field and additional highly promising indications of new ore deposits



▲ Using a side-scan sonar.

Deep sea mining could become an interesting source of raw materials for German industry in the medium term. BGR has therefore concluded exploration licenses for Germany covering areas in the Pacific and Indian Oceans. The INDEX 2014 expedition investigates deposits of massive sulphides south-east of Mauritius.

M/V Pelagia, the chartered Dutch research vessel, gave its name to the youngest new discovery in the Ger-

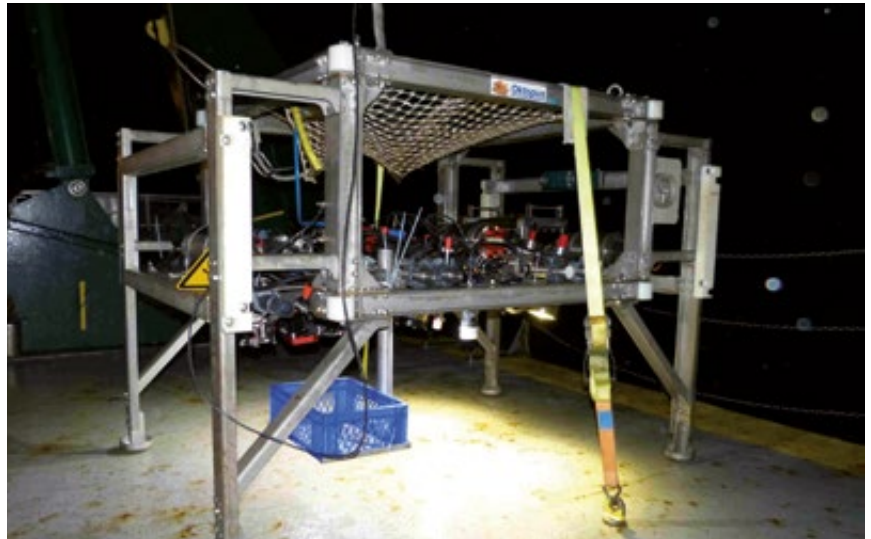
man metal sulphide license permit. An active hydrothermal field in the eighth cluster in the area is now

named after the 66-metre-long ship in which the BGR expedition sailed during the INDEX 2014 field trip. “According to observations to date the field covers a surface area of around 150 by 100 metres,” explains chief scientist Dr. Ulrich Schwarz-Schampera, “numerous inactive chimneys indicate that activity has been stronger in the past.” The Pelagia field is the first of this kind ever discovered on this south-eastern branch of the Indian ridge.

The twelve scientists from the BGR and scientific institutes from Wilhelmshaven, Kiel and Seattle spent six weeks in total in the marine area to the south of Mauritius. It was the fourth INDEX expedition and the last before the official signing of the license contract between BGR, on behalf of Germany, and the International Seabed Authority ISA. BGR now has 15 years to explore 100 so-called blocks (10 x 10 kilometres) on the central and south-east Indian ridges with the aim of making the findings available for future deep sea mining to exploit the non-ferrous and precious-metal-rich sulphides.

All four INDEX expeditions were focused on prospecting for metal sulphides – the piles of rubble on massive ore deposits which are all that remains when the well-known “black smokers” stop smoking. They were

given this name because they resemble dark smoking factory chimneys, even though they do not actually produce any smoke as such. The thick black clouds are actually hot liquids heavily laden with metals which pour out of the deep sea floor and precipitate their metal load in the form of sulphide particles when the hot fluids come into contact with cold seawater. In many hydrothermal fields, they boast significant quantities of precious metals and technologically important trace metals.



▲ Video and photo sledge for visually mapping the seabed.

INDEX 2014 had on board the new BGR sensor sledge as well as the HyBIS deep sea diving robot from the GEOMAR Helmholtz Centre for Ocean Research in Kiel. The scientists were able to use the sensor sledge to locate the hydrothermally active areas in extensive exploration zones, and thus gain a handle on where to search in more detail for extinct fields, which could therefore be interesting for mining. They discovered seven hydrothermal “smoke clouds” – which point the way to active fields – after surveying lines with a total length of 146 kilometres in three license clusters. Magnetic surveys in the four investigated license clusters revealed 19 interesting anomalies which could indicate the presence of metal sulphides.

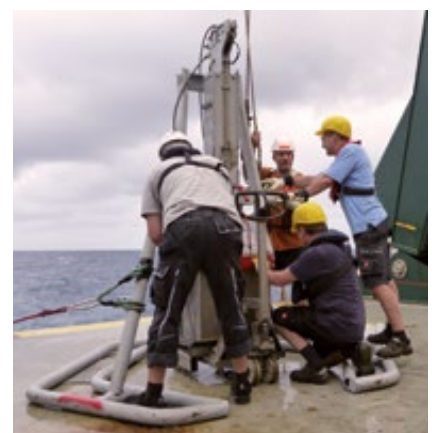
The economic geological work was

supplemented by bathymetric surveying as well as regional and environmental investigations. Sedimentary cores were taken at regular intervals during the expedition to provide additional basic environmental data. This work has been part of the INDEX expedition activities right from the beginning because any seabed mining which may eventually take place has to comply with stipulations that they have as little detrimental effect as possible on the sensitive habitats around active hydrothermal fields. The BGR geoscientists are therefore always accompanied by biologists from the Senckenberg-Institut am Meer in Wilhelmshaven, which undertakes detailed inventories of life around the “black smokers” and in the overlying water columns. In addition, a sediment trap from the University of Hamburg was installed

on the seabed to record the sedimentation on site for a period of one year. Collecting it again will be just as much on the agenda of the next expedition into the German license area in autumn 2015 as the more detailed investigation of the magnetic anomalies discovered in 2014.

Contact:

**Dr. Ulrich Schwarz-Schampera**

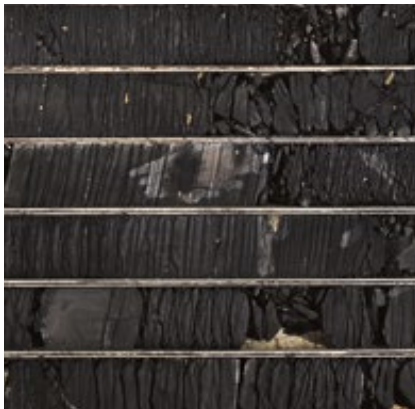


▲ Preparing a box grab for sampling the seabed.

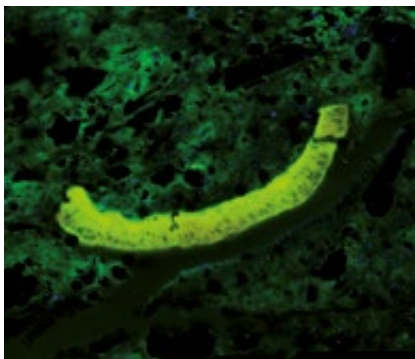
## Shale gas in Germany

BGR estimates the resources

Shale gas is seen world-wide as an important additional natural gas resource. On behalf of the German government, BGR conducted the NiKo project to determine the shale oil and shale gas potential in Germany as well as to investigate the potential environmental impact of fracking technology.



▲ Core sections from a well drilled in shales.



▲ Fluorescence microphotograph of an algal cyst from a sea existing during the Lower Carboniferous (sample from a well on the island of Rügen). Various wavelengths (458, 496 and 633 nanometres) help clearly identify the structure of the alga.

The demand for shale gas is driven by the development of numerous shale gas deposits in North America over the last twenty years. The USA will probably be able to cover its demand for natural gas itself from its own domestic sources in the medium term. Germany, however, has experienced a continuous decline in domestic gas production since the beginning of the millennium, and now has to import almost 90 per cent of its natural gas demand.

Unlike conventional natural gas, a large proportion of the shale gas deposits are located in politically stable regions of the world, including more than one third in OECD industrial countries, of which one fifth alone in North America. Europe can expect around five per cent. The final figures from the NiKo study on the potential of shale gas in Germany will

be available in 2015, but a preliminary estimate made in 2012 shows the general picture. The technically recoverable shale gas resources are estimated to lie between 700 to 1,300 billion cubic metres. By comparison: German natural gas reserves in active fields total around 110 billion cubic metres. Germany is therefore far from the volumes reported for the USA: a shale gas boom analogous to that in the USA can therefore not be expected in Germany. Nevertheless, shale gas could represent an important resource. First of all though, these need to be explored in more detail-work which is just at the beginning in Germany.

To gain a more detailed picture of the geological formations which could contain shale gas, the BGR scientists analysed around 1,500 rock samples. The samples were derived from the core store in Berlin as well as the rock archive in the GEOZENTRUM Hannover. The composition of the organic constituents was determined in the laboratory, alongside the thermal maturity of the shales, because this has an influence on the gas and oil potential.

Experts were also able to make use of the BGR's archives which provided them with more than 1,000 analytical datasets. The comprehensive investigations revealed that numerous rock



formations in Germany have potential for shale gas and shale oil. The most promising include the Posidonia Shale from the Jurassic, the Wealden facies in the Lower Cretaceous, as well as Carboniferous rocks. In regional terms, potential is expected in the North German Basin in particular.

A major part of the project includes analysing the environmental impact associated with the development of shale gas. Could drinking water be at risk as a result of underground hydraulic stimulation? These and other questions on potential environmental risks, which have raised a great deal of concern amongst the general public, are investigated with the help of complex models and laboratory investigations.

For instance, a lithological and hydrogeological cross-section of the North German Basin is used to simulate the potential spread of fracking fluids injected into underground rock formations. A range of scenarios are modelled to determine the upward movement of liquids from their injection sites at depths of more than 1,000 metres over periods of decades and centuries. This is done to clarify whether a safe distance can be maintained between the fracking layers and horizons containing drinking water. The expected seismicity and



▲ Rock formations with shale gas potential in Germany.

the size of the fractures created when liquids are injected underground are also modelled and calculated.

The findings produced to date support the results of a preliminary study undertaken in 2012: this indicated that shale gas could be developed in a controlled and environmentally compatible way from a geoscientific point of view. The greatest challenge

is now to incorporate the scientific findings in the public debate on the topic of fracking.

*Please also read the interview on page 71.*

Contact: **Stefan Ladage**

# Securing the Supply of Raw Materials

New deep sea research vessel, the SONNE: Test voyage with 3D seismic and Golden Eye CSEM surveying system

## SONNE passes the test

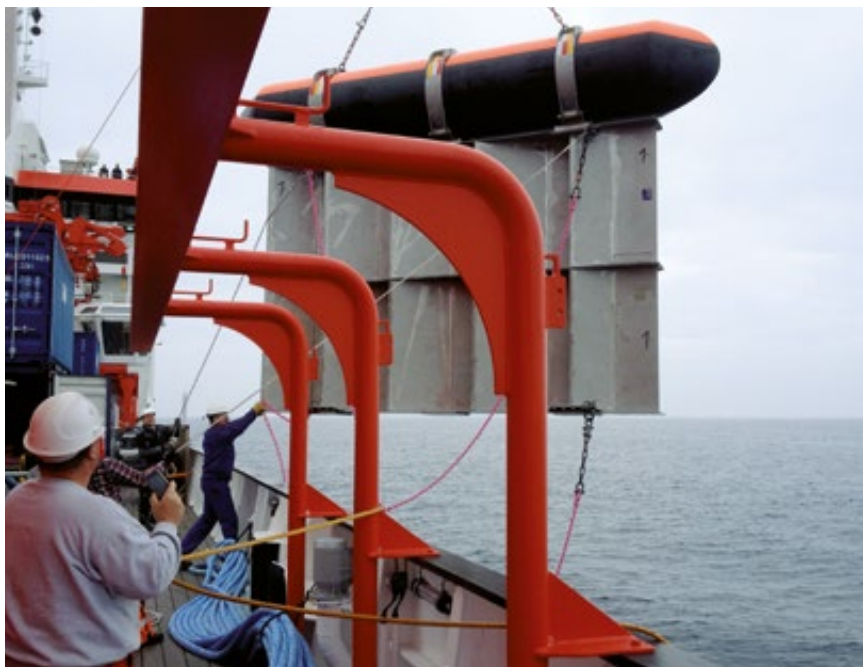
BGR scientists undertake test voyage with the new deep sea research vessel

The SONNE, the new deep sea research vessel for German maritime research, has been in service officially since November 2014. BGR scientists put the vessel through its paces during two test voyages in the North Sea.

The new 116-metre-long and 21-metre-wide deep sea research vessel, the SONNE, will be cruising in the Indian and Pacific Ocean in future as a multi-disciplinary research vessel. Together with other German maritime research institutes including GEOMAR and Marum, BGR was already involved in the planning phase of the large research vessel equipped with state-of-the-art technology.

The SONNE started out from Emden on its first test voyage with BGR scientists in September 2014. To avoid the busy shipping lanes in the German Bight as much as possible, the tests were carried out in parts of the Scottish North Sea.

The focus was on testing the proper functioning of the new 3D seismic. In addition, the precise acoustic pressure level of the seismic air pulses was measured for the first time. “Having as much information as possible on the way the signal spreads out is important to be able to estimate as precisely as possible any potential



▲ The paravanes spread the individual components of a 3D survey up to 150 metres when it is trawled behind the vessel.

influence of the seismic surveys on the marine environment,” says Dr. Axel Ehrhardt from the “Marine Resource Exploration” sub-department. The calm seas and wind conditions ensured good test results during the voyage.

After testing all of the components required for seismic surveying, the scientists and the crew successfully

launched the whole 3D surveying system. During the subsequent voyage, a first test line was shot, accompanied by precise calibration and positioning of the seismic equipment. Steering the ship with metre-accuracy was also tested with the nautical officers.

During the second test voyage of the SONNE, the scientists from BGR and the University of Bremen tested the



▲ The SONNE, the new research vessel, on a test voyage in the British North Sea.



▲ The Golden Eye electromagnetic surveying system was tested for the first time to prepare it for its future deployment in the German massive sulphide license areas.

newly developed Golden Eye electromagnetic surveying system. The bright yellow equipment frame made of glass-fibre reinforced plastic, and the sensors it carries, will be used in future to survey the massive sulphide deposits in the German license areas in the south-western Indian Ocean.

The Marine Geophysics department of the University of Bremen was commissioned by BGR to develop the surveying system.

The huge reel has a diameter of three and a half metres, and is equipped with lights, cameras and other sen-

sors. This enables Golden Eye to detect the presence of ore deposits beneath the seabed because of their high electrical conductivity and magnetic properties. In addition, the system can also be used to characterise sediment porosities and the mineral composition of the seabed down to depths of around ten metres.

Thanks to the equipment on board the new vessel, the surveying system could be easily launched into the water over the stern from the aft deck and hauled back in again. Power supply as well as control and data communication with all sensors are provided via the twelve-kilometre-long deep-sea cable belonging to the ship. Thus, Golden Eye can be completely controlled using an on-board console with video monitors, status information, and various positioning sensors.

Scientists will be taking Golden Eye to the German license areas near Mauritius in winter 2015 to search for long extinct “black smokers” on the seabed. “Black smokers” are also well known as polymetallic deposits, and boast high concentrations of non-ferrous and precious metals, as well as a range of trace elements such as antimony and cobalt.

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Contact: **Dr. Axel Ehrhardt,**  
**Dr. Katrin Schwalenberg**

## Precious metals in soils

### BGR compares platinum group metal concentrations in the soils of Berlin

Scientists involved in the Urban Geochemistry EU project are currently investigating the geochemical composition of the soils in 15 European cities. The main focus in the Berlin investigation area is on the platinum group metals platinum, palladium and rhodium, because samples collected in 1992 are available for comparison.

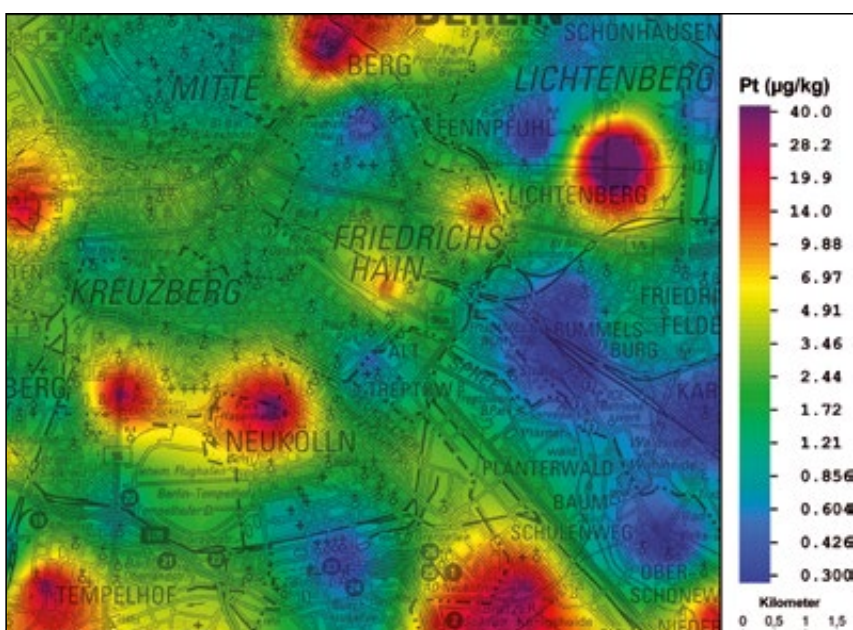
The platinum group metals (PGE) are used for many purposes. The most common use is probably the three-way catalytic converters in automobiles. They have been used in Germany since 1989 where they have significantly cleaned up vehicle exhaust gases. However, these catalysers also release small amounts of platinum, palladium and rhodium which contaminate the soil.

The BGR in Berlin has samples from the 1990s which can be compared with recent samples. This makes the Berlin analyses a very special case in Europe. “This is an invaluable advantage because analytical techniques have been considerably further developed since then,” says Dr. Manfred Birke, head of unit in the BGR sub-department “Soil as a Resource – Properties and Dynamics”. The old

samples were therefore reanalysed using modern methods and then compared with the recent samples taken by BGR and incorporated in the geochemical map produced last year. They show a marked rise in PGE concentrations compared to the 1992 samples.

Over a period of 20 years, the background concentrations of platinum in Berlin’s inner city have risen by 170 percent, by 390 percent in the case of palladium, and as much as 440 percent in the case of rhodium. There is a clear correlation with vehicular traffic – the values rise with increasing proximity to roads and with the density of the traffic. Only in a few cases are high values explained by proximity to existing or former industrial sites such as in the Lichtenberg and Niederschöneweide districts of the city.

Contact: **Dr. Manfred Birke**



▲ Distribution of platinum concentrations in surface soils in the city centre of Berlin.

## Groundwater protection in Burundi

BGR experts investigate water reserves in three regions



▲ Removing the natural soil protection cover to manufacture bricks.

Burundi in East Africa has a similar size and population to Belgium, but the number of inhabitants is growing at one of the fastest rates in the world. Safe and sustainable water supplies are therefore a high priority, also for future generations.

In the four-year technical co-operation project on groundwater management, BGR has advised the competent authorities in Burundi on the sustainable development and protection of groundwater resources. The Ministry of Water and Environment issued a decree containing corresponding regulations in August 2014.

42,000 springs cover the current demand, but have now reached the limits of their capacities. Studies undertaken by BGR have confirmed that around half of these springs are affected by bacterial contamination. There is therefore an urgent need to develop new sources of water and to protect the existing springs. The project demonstrated last year the new

direction to follow in three typical regions: in the northern province of Kirundo, the BGR experts and their Burundian colleagues estimated the groundwater availability, while in the city of Gitega in Central Burundi and the Rumonge district on Lake Tanganyika, the project focused on groundwater protection.

They investigated the bacterial contamination of the drinking water in Gitega, the second biggest city in the country. They also carried out tracer tests to measure the groundwater flow rates. Based on the results of their investigations, the experts recommended establishing drinking water protection areas. In the third investigation area in Rumonge the first drinking water protection areas in the country were implemented on the basis of the new groundwater protection regulations.



▲ Measuring the conductivity of groundwater during a tracer test.



▲ Using water from a captured well.

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

## Carried off by wind and water

Soil erosion endangers more than half of Germany's cropland



▲ Channel erosion as a result of surface run-off from a field in Lower Saxony.

About three to eight tonnes of soil are lost every year on each hectare of cropland. This is hardly noticed because it corresponds to a layer of soil only 0.3 to 0.8 millimetres thick. Nevertheless, erosion is a creeping threat to soil fertility because the process continues for hundreds of years and can therefore transport very large amounts of soil. Two new BGR maps reveal the regional distribution of this erosion risk by wind and water.

The new BGR water erosion map shows that around one third of the cropland in Germany is at least at a medium risk. There are four regional hot-spots: the mountains and hills of Lower Saxony, the hills of Saxony with the Ore Mountains foreland, the Neckar and Tauber-Gäuplatten, and the Lower Bavarian hills. The BGR wind erosion risk map for cropland reveals that this risk primarily affects the North German Plain: the young moraine landscapes in Schleswig-Holstein, Mecklenburg Western

Pomerania and Brandenburg are classified as having a medium to high risk.

The most valuable part of the soil, the humus-rich upper horizons, are lost due to erosion. The depth of the soil which can be penetrated by roots is reduced, and thus the potential to store nutrients and water. Erosion primarily affects cropland because it is periodically not covered by plants and therefore unprotected. The soil which is carried away is deposited at other locations where it affects the nutrient

balance of the areas. In waterways, the eroded soil usually worsens the ecological and chemical situation. Erosion protection is therefore not only good to preserve the soil and its fertility, but also to protect other parts of the ecosystem.

Strong winds with speeds exceeding six metres per second (wind force six) and extreme rainfall events with 20 or more litres per square metre and hour are the two factors which cause erosion. If heavy rain falls on



▲ Potential erosion risk from water on cropland in Germany.



▲ Potential erosion risk from wind on cropland in Germany.

unprotected soil, the kinetic energy of the raindrops breaks up soil aggregates into smaller fragments. These fragments block the fine pores in the soil and therefore reduce its capacity to absorb rainwater. Water which cannot percolate into the soil flows on the surface, taking soil particles along with it.

Human activities influence the water and wind erosion: wide open landscapes of the kind preferred by industrialised agriculture accelerate soil erosion. Conventional ploughing and sowing in spring, for example,

summer cereals, sugar beet and maize in particular, leaves the soil surface unprotected against the forces of rain as well as wind.

In Germany, many intensely used arable areas are affected by erosion. Overall they lose three to eight tonnes on average as a result of water erosion per hectare per year, and in extreme cases, up to 20 tonnes. This corresponds to the removal of up to two millimetres. By comparison, average soil formation processes only create around 0.1 millimetres per year. Soil formation can therefore only com-

pensate for a very small portion of the soil removed by erosion. The consequences are lower yields on the affected fields. Erosion also has a long-term impact on the water balance of the countryside. Dr. Jan Bug from BGR therefore draws the following conclusion: “Soil erosion must be diminished by the active implementation of agricultural measures. Otherwise, fields will slowly lose their fertility and their function as water storages. This would also increase the probability of flooding.”

Contact: **Dr. Jan Bug**

## Groundwater salinisation

### BGR suspends helicopter surveys of the North Sea coast in Lower Saxony

The upper soil horizons play a special role for people living on the Earth's surface. Groundwater, nutrient and pollutant transport all take place in the uppermost 100 metres of the ground beneath our feet. Airborne geophysics is an efficient means of quickly recording basic parameters over large areas. BGR demonstrated this recently along the North Sea coast of Lower Saxony with its D-AERO project.



▲ BGR survey helicopter taking off at Jade-Weser-Airport in Wilhelmshaven.

The sleek red-white helicopter, which tows a similarly coloured red-white cigar only 30 to 40 metres above the ground at the end of a thin cable, has by now been sighted in almost every corner of the North Sea coast in Lower Saxony. The cigar is an electromagnetic sensor which has been

towed along the coast by BGR's own helicopter since 2007 as part of the D-AERO project. The last places to be surveyed were flown in 2014 and included the areas around the cities of Jever, Schortens and Varel on the Jade Bay as well as the Wadden Sea National Park on the southern

Jade Bay – which required special permission from the national park administrators. The airborne survey of the North Sea coast was chosen as an example to demonstrate the capacity of airborne geophysics, and can be extended to cover other parts of Germany at a later date in co-operation with the other federal states.

The BGR scientists use the sensor to map the underground geology. The electromagnetic sensor contains magnetic and electromagnetic measuring instruments, as well as a laser altimeter – all housed in the ten-metre-long Kevlar tube. The helicopter itself also houses a gamma-ray spectrometer and the control and data recording equipment. The electromagnetic sensor identifies the geological structure of the underlying formations, as well as the groundwater reservoirs because of their recognisable electrical conductivity – down to a depth of around 100 metres. The magnetometer can survey the geology to even greater



depths. The gamma-ray spectrometer measures the composition of the uppermost soil layers by detecting their natural gamma radiation. The laser altimeter creates a very accurate map of the surface topography.

The North Sea coast is of particular interest to the geo-experts because, together with the offshore islands and the Wadden Sea mud flats, this area will be especially affected by climate change. The islands, the line of the coast and the mud flats will be exposed to rising sea levels and increasingly frequent and violent storms. Scientists hope that the airborne surveys will help them to identify areas particularly at risk.

The experts are also looking in detail at groundwater resources. Along

the coast, they are threatened by the invasion of seawater and resulting salinisation. The electrical conductivity caused by the salt content in the water enables the scientists to map the distributions of usable freshwater, as well as salt and brackish water occurrences. The airborne surveys above Frisia help the BGR experts to clearly map the extent to which the salt water has already intruded the immediate coastal area underground (areas in the map coloured red). The distributions of permeable sand (blue) and tighter clay (yellow) are also identifiable.

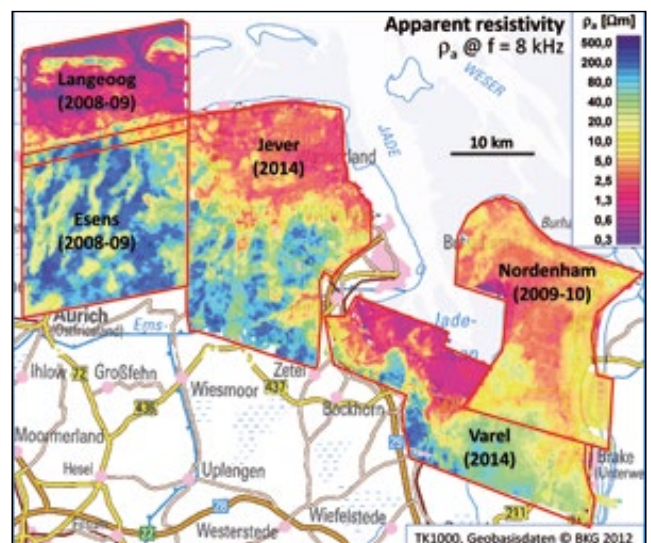
Using the helicopter and an airborne sensor enabled the scientists to gain an insight into the structure and properties of the upper ground layers much faster over a very large area

than would have been possible using conventional mapping methods on the ground. These tend to be patchy as a matter of course and restricted to specific areas, whilst large areas can be mapped from the air. This is particularly important because the interaction of the various parameters over large areas is very significant. For instance, changes in soil use can influence the water balance and therefore change the water table. And this is very important information for infrastructure planning. The data acquired during the airborne surveys is evaluated and then made available via the Geophysics Information System of the Leibniz Institute of Applied Geophysics in Hanover.

Contact: **Dr. Bernhard Siemon**



▲ Airborne geophysical survey areas in North Germany.

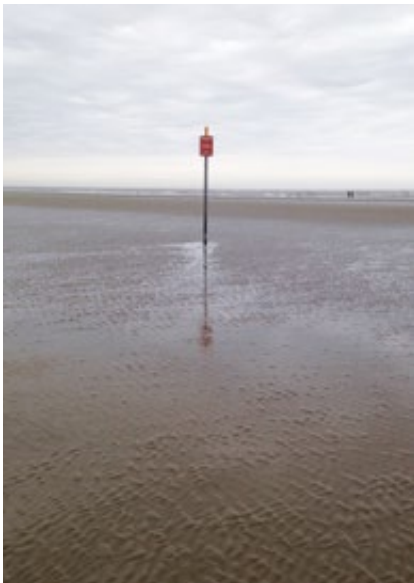


▲ Distribution of freshwater and salt water in East Frisia.

## Freshwater beneath the island

Freshwater lens guarantees drinking water supply on the island of Langeoog

In a situation similar to many islands the inhabitants of the East Frisian island of Langeoog are dependent for their drinking water on subsurface groundwater. The BGR's FLIN project has comprehensively investigated a freshwater lens beneath the island over the last three years.



▲ Coast of Langeoog at low tide and the water tower. Drinking water supply is one of the most urgent issues on islands.

Langeoog is a paradise of sand dunes and beaches for people in search of relaxation. It is separated from the mainland by a strip of the North Sea four to eight kilometres wide. Although this keeps car traffic and the hustle and bustle of everyday life

at arm's length, it also prevents the island from being connected up to the mainland drinking water supply system. The almost 2,000 inhabitants of Langeoog, and their more than 200,000 visitors every year, are therefore reliant on their own supply of

drinking water. The water is extracted from a freshwater lens which lies below the surface of the island and floats on the otherwise salty groundwater.

This lens must also maintain the island's water supplies in future, despite climate change and a rise in sea level. BGR therefore took a detailed look at the freshwater lens in the FLIN project which began in 2012. "Langeoog is a kind of natural laboratory for us," says project leader Dr. Georg Houben. It is a typical model for the basic challenges faced by islands, and is therefore worth studying in detail. Around 500 million people around the world live on islands and the numbers are rising. Drinking water supply is therefore one of the most urgent problems on many islands.

The water utility OOWV has found a sustainable solution on Langeoog. "They extract much less water than is recharged," reports the hydrologist. This also ensures that the surrounding salt water cannot penetrate the lens and contaminate the reserves of drinking water. The freshwater is supplied by rain which percolates underground in large amounts, particularly in the valleys between the sand dunes. It is therefore important that these dune valleys are given special protection, and are not used as building land on this and other islands with



▲ Sampling of groundwater in the dune belt of the Pirola valley, Langeoog.

similar conditions. Langeoog has no problems in this regard because the dunes are a nature conservation area.

The BGR experts surveyed the utilised freshwater lens using various geophysical measures such as electromagnetics and magnetic resonance. They also made use of data from the D-AERO project in which scientists mapped the whole North Sea coast electromagnetically from a helicopter (see also page 24). The FLIN researchers used this data to create a three-dimensional map of the aquifer which is around 25 metres thick at its maximum point. A computer model is scheduled to be ready by the middle of 2015. This will be used by the hydrologists to simulate the reaction of the lens to rises in the level of the

North Sea or if the winter rainfall diminishes or disappears completely.

Georg Houben and his colleagues also investigated the properties of the freshwater by taking samples at regular intervals in the thickest part of the lens. Age dating the water using the hydrogen isotope tritium revealed that it is up to 100 years old. “The biggest surprise though was how intact the layering has remained within the lens,” says Houben. The extraction of drinking water did not result in mixing up of the whole deposit. This is seen by the BGR hydrologists as further evidence of the sustainable exploitation of the water reservoir.

Houben and his colleagues were also able to interpret a temperature profile

for Langeoog for the past 100 years based on the information from the groundwater layers. They did this by measuring the stable isotopes of hydrogen and oxygen. Heavy isotopes evaporate more at higher temperatures so that their proportion in the vapor in clouds and therefore also in condensing raindrops is higher. The shallow and therefore younger freshwater layers revealed much warmer formation conditions than the deeper older layers. The hydrologists estimated that the temperature has risen by 1.5 degrees Celsius over a period of 100 years.

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Contact: **Dr. Georg Houben**

## Breathing lake controls valuable resource

BGR supports the countries bordering Lake Chad in sustainable groundwater use

The basin of Lake Chad covers around 2.3 million square kilometres. For many of its 47 million inhabitants, the eponymous lake is their direct source of water. However, more people actually depend on the groundwater resources of the basin under the influence of Lake Chad. A multi-national commission is responsible for the sustainable use of this resource, and is supported in its efforts by BGR.



▲ Most of the wells in the Kanem region are open. The water quality is therefore at significant risk from contamination.

The Lake Chad Basin Commission (LCBC) is responsible for a limited resource. The lake lies in the dry

Sahel zone, and is only fed by two river systems. This means that the water courses react very strongly to

fluctuations in climate. Lake Chad currently covers around 3,000 square kilometres, around three times the size of the IJsselmeer in the Netherlands, but has nevertheless dried up completely several times over the last 40,000 years. “It is a breathing lake,” says Dr. Sara Vassolo, a BGR hydrogeologist. For instance, in the 1970s, the lake shrank dramatically from 17,620 square kilometres to its current size.

In contrast, around 40,000 years ago, the paleo Lake Chad reached its greatest extent covering around two million square kilometres. This filled almost the whole basin and corresponded to around two thirds of the size of the present day Mediterranean. It then dried out completely for the first time around 20,000 years later. After that, the water level fluctuated strongly during the next 10,000 years before it stabilised around 9,000 years ago to occupy an area of 340,000 square kilometres. But this size was not to last: the lake shrank to reach a new equilibrium around 1,000 years ago. The area fluctuated at around 25,000 square kilometres since then until the start of the 1970s when the Sahel was affected by an extreme period of drought.

This drought shrank the lake to only one tenth of this size within a few years because the only two river systems which feed it react particularly sensi-

tively to fluctuations in climate. The Komadugu and Yobe river system, which enters Lake Chad in the northern basin lies completely within the extreme drought-affected Sahel region of northern Nigeria and Niger. The second river system entering the lake is that of the Chari and Logone rivers which comes from the south and the east with a catchment area extending from the Central African Republic to the Adamaoua plateau in Cameroon. The climatic conditions are less harsh here than in the north, which is why this river system accounts for 90 percent of the water in Lake Chad.

The rise and fall in the size of Lake Chad plays an important role in the recharge of groundwater reservoirs in

the region. New BGR investigations have revealed that the groundwater south-east of the lake in the Bahr el Ghazal region is 9,000 years old, and therefore originates from the time when the lake regenerated after being dry for several thousands of years. Because of its age, this groundwater contains significant amounts of sodium, fluorine, sulphate and arsenic. The fluorine and arsenic in particular are a health risk, which means that the reservoirs can only be used as drinking water after undergoing adequate treatment.

The water shortage is exacerbated in the whole Lake Chad basin by high population growth and the development of irrigation projects. The sit-

uation is not made easier by the fact that the basin and its water resources are shared by eight countries. The six main countries around the lake are members of LCBC – a seventh country, Sudan, is an observer, whilst only Algeria does not take part. LCBC is the only institution with the mandate to handle cross-border conflicts of interest, but it has so far not had the equipment and know-how to do anything effective to counteract the water crisis and the degradation of the ecosystem. BGR therefore supports the commission in the development of its capacities, and training its staff.

[www.bgr.bund.de/lcbc](http://www.bgr.bund.de/lcbc)

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



▲ Small scale subsistence irrigation farming in Bahr el Ghazal.



▲ The economy in Kanem is based on camel breeding.

## Inventory of 16 potential toxins

BGR soil experts determine background levels for the whole of Germany

BGR soil experts are currently updating the background pollution levels of German soils by 16 potentially toxic elements. The data forms the basis for plausible soil protection limits.



▲ Soil profile in a forest near Königstein im Taunus, Germany.

Garden owners in traditional metal mining areas know from their own experience: humans are not necessarily the only source of soil pollution – depending on the rock type from which the soil arose, toxins can also be present naturally. Just like the substances which enter the soil as a result of general environmental pollution, they are part of the so-called background contamination.

BGR soil experts are currently updating the background values for 16 potentially toxic chemical elements. These are not just scientific games, but form the crucial basis for enabling federal and state environmental authorities to define the safe limits of toxins in the first place. “You could say we are preparing the inventory of these elements,” explains Dr. Florian Stange from the “Soil as a Resource – Properties and Dynamics” sub-department at BGR.



▲ Map of the background values of nickel (Ni) in top soils in Germany.

These substances include lead, cadmium and mercury, but also other elements such as copper, selenium and thallium. The diversity of the soils in Germany also flows into the map: the 16 background levels are determined for a total of 13 bedrocks. This is the name given by the experts to the solid or unconsolidated rock which is present beneath the soil and which supplies the soil with new material as a result of weathering. The data is gathered by the competent state authorities. The BGR harmonises and validates the figures.

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Contact: **Dr. Florian Stange**

New petrophysical laboratory in Berlin-Spandau

## Lab measurements for fieldwork

Petrophysical laboratory adapts laboratory methods for hydrogeological fieldwork

The Ground Geophysics Working Group at BGR's office in Berlin-Spandau is now complete with the opening of its new petrophysical laboratory. The laboratory brings together all of the instruments at one location that the scientists use to mainly answer hydrogeophysical questions.



▲ Miniature version of a magnetic spin tomograph for measuring the nuclear magnetic resonance of sediments and soil samples.

“We investigate representative samples at the laboratory scale to determine the relationships between geophysically measurable parameters and the hydrogeologically effective parameters – these are required to characterise aquifers,” explains Dr. Stephan Costabel. One example is the hydraulic conductivity which reveals the level of permeability to water of

soils. It is related to the decay time of nuclear magnetic resonance (NMR) which can be measured using appropriate instruments. In 2014, the hydrogeophysicists were able to verify that this also applies to soils which are not completely water-saturated. These results could be used in future for the on-site measurement of hydraulic conductivity using NMR measure-



▲ Measuring the electrical impedance of a sediment sample in a climatic cabinet.

ments – also in the unsaturated soil zone.

The experts in Spandau also use their methods for searching mineral resources. The scientists Dr. Tina Martin and Sarah Hupfer were able to demonstrate in the BGR petrophysical laboratory that there is a quantifiable relationship between the phase shift of electrical impedance and the mineral content and the mineral grain size – they discovered this by investigating artificial mixture of pyrite, galenite, sphalerite and quartz sand. The aim of this research is to use electrical impedance methods to estimate the exploitable residual mineral content of old mine tips.

Contact: **Dr. Stephan Costabel**

## Making geodata available worldwide

With its new spatial data infrastructure, BGR enables simplified access to geoscientific results in compliance with INSPIRE regulations

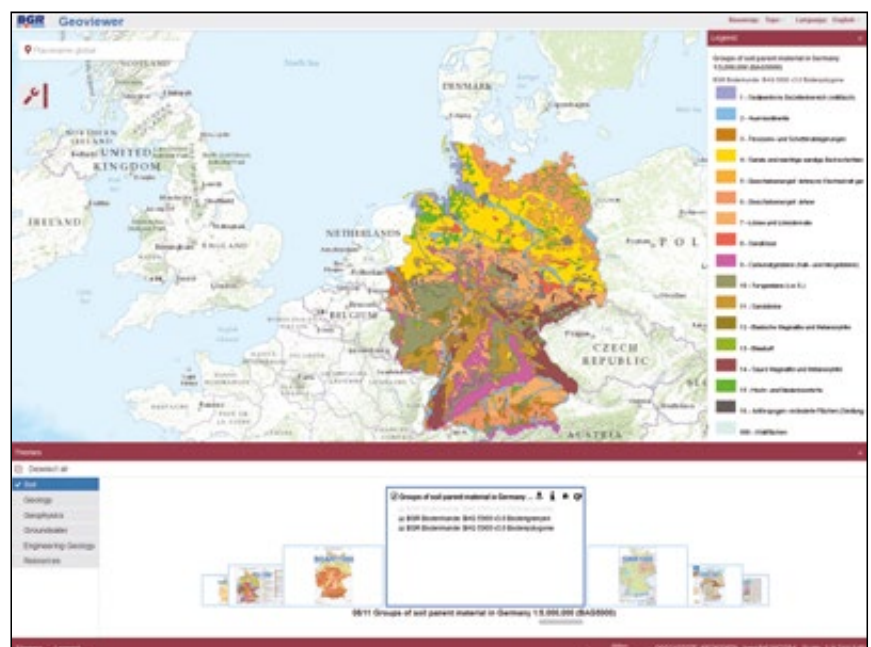
Despite the many difficulties, Europe is growing ever closer together. With the implementation of the INSPIRE regulations, this also now applies to environmental geodata from 28 EU countries. BGR is preparing for the European-wide opening up of geoscientific databases with the development of a spatial data infrastructure – GDI-BGR.

In today's modern world, geodata is highly sought after information, and often provides the basis for decision making at a political level. Maps for instance are needed for every smartphone navigation app, and every car driver with a satnav knows how important it is to have up-to-date maps at all times. The significance of information on the global distribution of resources, soil pollution, chemical groundwater properties, landslide risks in karst quarries or opencast mines in mining areas, or simply earthquake activity, come immediately to mind.

But anyone who wants to use data covering large areas from a range of sources quickly finds out that they are sometimes not combinable with one another. Not only do different countries use different standards and

formats, the providers are often not unanimous even within national borders. This concerns the federal nature of Germany in particular which has to cope with the same co-ordination problems at a national level because

of the sovereignty of the federal states, and is also mirrored at a EU level. Moreover, the various scientific disciplines do not necessarily gather their data on the basis of uniform criteria, but are often frequently in disagree-



▲ BGR's new Geoviewer.





▲ The new Product Centre.

ment about the terms they use and their definitions.

The EU Commission established its INSPIRE regulations with the aim of creating order in the Babylonian chaos of European spatial data. A European-wide geoportal is intended to harmonise access to environmentally-relevant geoinformation from all 28 member countries by 2020. The Federal Republic implemented the EU directives into national law with the amended Spatial Data Access Act (GeoZG) adopted on 16 November 2012. On the basis of the directive, BGR must already make available a large proportion of the data via standardised digital services (spatial data services). By 2020 at the latest, all content and data formats must then be made available European-wide in the standardised form, so that this information can be mutually compared and automatically processed further. The establishment of GDI-BGR was initiated to comply with this mandatory stipulation. All spatial

data-handling processes within BGR are to be mutually co-ordinated and harmonised so that users have access to interoperable products of high scientific quality. This is to be achieved by the step-by-step definition and implementation of joint stipulations for standardised technologies, workflows and data quality assurance.

The renewals in the machine room will also lead to a facelift for BGR product presentations in the internet. The Product Centre and the Geoviewer are the central starting points for all users of BGR products – whether they are interested members of the public or experts. These key components have been modernised and adapted to the more stringent statutory stipulations, the technological change in the in-house IT infrastructure, and the wishes of the various BGR departments to present their geoscientific findings across all departments in a uniform corporate design. A search window in the Product Centre enables users to search product descriptions and contacts for spatial data and web services in the same way as in a catalogue. The INSPIRE stipulations are satisfied by the integrated and standard-compatible CSW-2.0.2 interface, which can be used to access all metadata. The Product Centre is supplemented by the Geoviewer which is accessed via a link so that maps can be opened and

studied in a familiar browser environment. Geoviewer enables users to leaf through the various BGR maps in the same way as in a map gallery, compare them with one another and call up geoscientific data on specific items such as the magnitude of earthquakes or the stratigraphy at specific locations.

These two systems form the central access portals to BGR's range of products at national to global scales. Together, they form the information platform on which the results of geoscientific work are published in cartographic form. The integration of Geoviewer and the Product Centre also facilitate acquisition of the spatial data and their metadata via spatial data services and download file formats. A review is planned in future to determine whether BGR's analogue products – publications as well as maps – can also be made available via an order function. Links to external shop systems are made for their procurement. The viewer has a modular structure which enables new components for technical functions to be realised step-by-step with the aim of integrating BGR's technical applications.

<http://geoviewer.bgr.de>

<http://produktcenter.bgr.de>

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Contact: **Tanja Wodtke**

## Remote sensing for raw materials exploration

### Preparations for the hyperspectral satellite mission commenced

The global demand for mineral resources is enormous, and it is becoming clear that this demand cannot be covered in the long run with the currently known reserves. The development of new sources is becoming indispensable. EnMAP, the German hyperspectral satellite, is intended amongst others to simplify resource exploration from 2018. BGR experts are already paving the way for its use.

Mankind is continually searching for additional reserves of mineral resources. "From the point of view of science and industry, the further exploration of known resources is relatively unproblematic," says Dr. Martin Schodlok from BGR's "Geo-Hazard Assessment, Remote Sensing" sub-department, "nevertheless, we also have to search for new sources of raw materials." However, potential sources can only be expected to be found by using improved exploration methods, or discovering new mineral deposits in poorly accessible areas, which, because of huge expenses involved, still remain unexplored even in times of a commodity bull market.

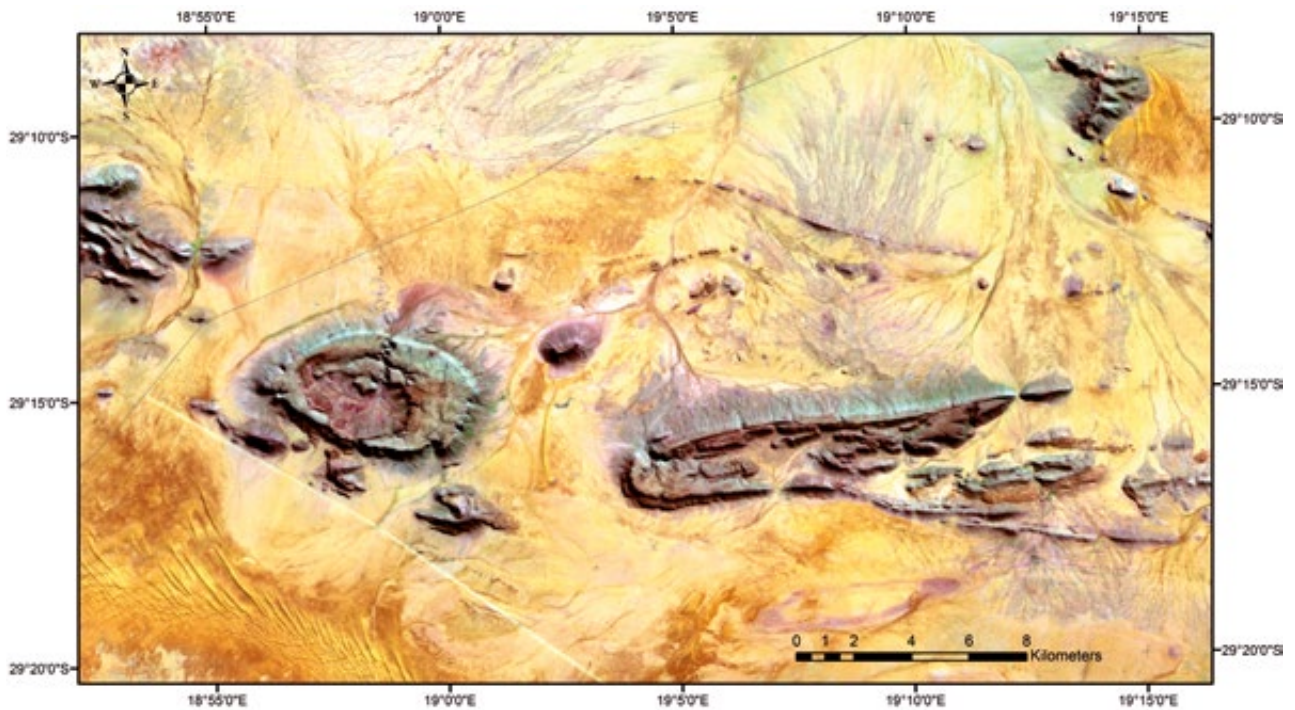
Experts such as Martin Schodlok are convinced that hyperspectral remote sensing assists because this technology can be used to explore the surface of large areas for promising mineral



▲ Field spectroscopy on banded ironstone in Prieska, South Africa.

deposits. This technology measures the reflected radiation from the sun in a large number of narrow spectral bands from visible light to short-wave infrared light. Every visible mineral sends back a characteristic pattern. This information can provide an initial assessment of the location of in-

teresting areas. EnMAP, the German hyperspectral satellite, is scheduled in 2018, and will cover the spectral range with 220 channels. The EnMAP data are interesting for many areas of application: assessment of vegetation density and the vegetation quality for ecosystem research, water ecology, as



▲ Metasediments with lead-zinc-copper mineralisation near Aggeneys, South Africa. Landsat 8, Channel 7,5,3 RGB visualisation.

well as for the exploration of mineral resources.

When the satellite data from the EnMAP mission become available from 2018 onwards, BGR experts plan to start evaluating the data immediately. For this reason, members of the Remote Sensing department undertook investigations and field work in 2014 in South Africa in preparation for the satellite mission. This is followed by aerial surveys with hyperspectral sensors in 2015. “We have to be able to verify the sensor data,” reports Schodlok who took part in the field work.

The team went to three ore body types in the remote Nordkap province and carried out spectral field surveys

on outcropping rocks. Rock samples were also analysed afterwards to verify the results of the measurements. Hyperspectral evaluation methods for exploration are to be further developed and tested during the airborne mission in 2015. The climate in the Nordkap province is primarily arid and semi-arid, so the vegetation cover is usually sparse. This is beneficial for hyperspectral remote sensing operations: the thinner the vegetation, the clearer the soil signal. “We can’t identify anything if the vegetation coverage is too dense,” says Martin Schodlok. This is why the Limpopo province of South Africa lying further to the east cannot be used for the pilot test. There is more rainfall here so the country is dominated by dense bushes and savannah.

“The idea is to use the results of the fieldwork and the aerial data, as well as other geoscientific information, to create an expert system to characterise ore deposits,” explains Schodlok. The spectral signatures of individual minerals are stored in a database which is used in conjunction with the EnMAP data to create mineral distribution maps or geological maps. This method is particularly recommended for largely unexplored, relatively inaccessible and extensive areas such as the desert regions in South Africa and Namibia, or large parts of Mongolia. Just a few satellite transits here can collect the same amount of data as weeks of expensive fieldwork.

Contact: **Dr. Martin Schodlok,**  
**Dr. Michaela Frei**

## Regional planning at a glance

Pilot project in Lower Saxony bundles regional planning for the mineral resources industry

Geodata in the Federal Republic of Germany is gathered from numerous authorities at every federal level. Although geodata is a valuable information base for companies it is difficult to handle. A pilot project in Lower Saxony has now networked the local mineral resources companies and public planning authorities for their mutual benefit.

Germany can rightly claim to be rich in raw materials. 770 million tonnes of mineral resources – primarily sand and gravel – were extracted here in 2011. However, in a densely populated country like Germany, the raw materials sector quickly finds itself in conflict with other interests. The networking

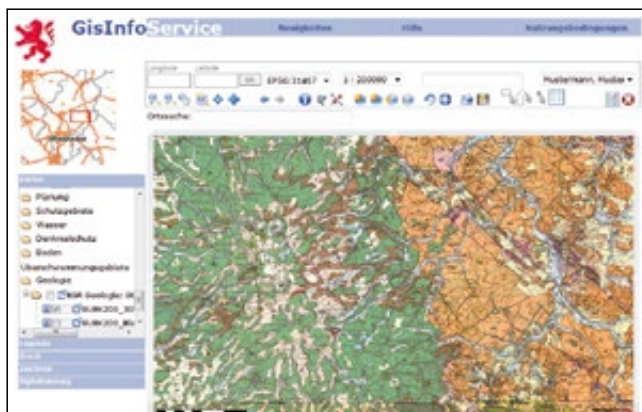
of public and private geodata can reveal potential conflicts early on and therefore enable them to be resolved. A pilot project on the mutual exchange of data produced the first results in 2014. The project is managed by the German GeoBusiness Commission (GGC) whose office is located at BGR.

The regional authorities will bundle the regional plans and make them available to the mineral resources companies in Lower Saxony who are amalgamated in the Association of the Construction and Mineral Resources Industry in the form of a web service. The Ministry for Nutrition, Agriculture and Consumer Protection in Lower Saxony gathers the public data. This means that the project participants no longer have to apply to each individual district council, because they can now see the data in an internet-supported map. For their part, the mineral resources companies make data available on their extraction activities and renaturation measures. These are also made internet-compatible and made available to the regional planning authorities as a web service.

“This is a major advance in the exchange of information between in-



▲ The GisInfoService online application enables raw material companies to plan their operations more efficiently.



▲ The GisInfoService comprises a wide range of items: from aerial photographs and land registry data to a very varied spectrum of technical information covering geology, the environment, nature conservation, regional planning and water resources management.

dustry and the authorities,” explains Lars Behrens, deputy managing director of the GeoBusiness Commission-Office, “because this data was previously reported individually.” The project participants license their data via the online service GeoLizenz.org which was also initiated by the GGC to ensure that the information can be accessed by the relevant addressees in each case. Two thirds of the authority data and the first contributions from the natural resource companies have now been entered into the system.

Public geodata is an indispensable asset for the activities of many companies. The economic potential of this information is estimated to be worth several billion Euros. However, it is not very easy to gain an overview of the many data sources, and to find one’s way in the jungle of user regulations. The GGC therefore supports access to this data in a wide range of projects. The GeoRohstoff project (geo mineral resources) therefore gave rise amongst other things to the GisInfoService which smooths the way to the public geodata for registered users. A web-based pilot application in Baden-Württemberg was commissioned in 2006, and the service is now available to mineral resource companies in almost all federal states – and is also being continuously expanded. The range of data available covers a broad spectrum of aerial pho-



Source: GGC/flytime-fotolia.com

▲ Efficient resource planning is the basis for the economic success of local business operations.

tographs and land registry data, not to mention a huge range of technical information covering geology, environment, nature conservation, regional planning, and water management.

The GGC which was established in 2004 brings together 23 sector associations with a strong interest in using geodata, and the Federal Ministry for Economic Affairs and Energy. The

commission sees its role as a facilitator between the authorities which gather the data, and the companies which use it. The example of Lower Saxony reveals here that the private sector is also able to play a role as a supplier of data.

[www.geobusiness.org](http://www.geobusiness.org)

Contact: **Lars Behrens**

## Claystone under the magnifying glass

International research on claystone in the Mont Terri rock laboratory in Switzerland



▲ BGR employees doing geoscientific measurements in an emplacement tunnel in the Mont Terri rock laboratory in Switzerland.

The search for a safe nuclear repository for high-level radioactive waste considers claystone as a potential host rock alongside salt. Scientists have been doing research for several years in the international Mont Terri rock laboratory in Switzerland to investigate claystones in more detail. In the latest experiments they are looking at the influence of simulated nuclear waste emplacement on the condition of the surrounding rock.

A nuclear waste emplacement test at a scale of 1:1 began in the Mont Terri rock laboratory in the Swiss Jura region at the end of 2014. Nagra, the Swiss nuclear repository company, emplaced three life-size dummy storage containers in a specially drifted 50-metre-long tunnel section,

with the aim of studying the thermal, hydraulic and rock mechanical processes. The containers are electrically heated so that they give off the same amount of heat as high-level radioactive waste. BGR is participating in this test, and was involved in a pre-emplacment investigation on how the tunnel influences the properties of the surrounding rock mass.

Most nuclear repository concepts envisage enclosing high-level radioactive waste far below the Earth's surface for hundreds of thousands of years in rock formations which are as impermeable as possible to place it at a safe distance from the biosphere. However, the rock formations do not stay intact in the process, because the engineering work involved in constructing the underground workings changes the properties and therefore the condition of the rock mass. Deconsolidation is expected in particular in the direct vicinity of drifts and tunnels, and could therefore enable toxins to enter the surrounding areas over the course of a long period of disposal.

To see how claystone behaves when a nuclear repository containing high-level radioactive heat-generating waste is constructed and operated 15 research organisations from eight countries are currently doing testing work in the Mont Terri international

rock laboratory in the Swiss Jura. The Opalinus Clay in which the laboratory is located is analogous to the rock formations in which Switzerland and France plan to construct their nuclear repositories. In addition to salt similar claystones have also been taken into consideration as host rocks in Germany. The tests carried out in the rock itself are necessary to supplement laboratory experiments, because some of the safety-relevant properties of the claystone are dependent on its composition and layering and are only revealed in situ.

The repository scientists use high-resolution geophysical and geotechnical methods in Mont Terri. BGR has modified the measuring techniques and equipment which it developed for research in salt and granite to enable them to be used in claystone as well.

For instance, a so-called slot packer was developed to be able to investigate the directionally-dependent hydraulic properties of the bedded claystone. Because claystone usually consists of layers, the physical properties and therefore also their associated hydraulic barrier effect vary along and orthogonal to these layers.

In the Nagra emplacement test BGR therefore drilled six up to 14-metre-long exploration boreholes with different orientations and carried out measurements in these boreholes. This revealed that the permeability in a zone around two and a half metres wide encircling the tunnel is significantly increased. However, if the tunnel is lined with shotcrete, the depth of the zone reduces to one and a half metres. Calculations using models have verified the influence



▲ Slot packer to determine the hydraulic anisotropy of the direction-dependent hydraulic properties of the claystone.

## BGR fact sheet: Clay and claystone research

What special properties does claystone have which make it a potential host rock for a nuclear repository? How is this rock “looked at in detail”? These and other questions are answered by the BGR fact sheet “Clay and claystone research.” Interested readers can also gain a brief overview of BGR’s work in the field of clay and claystone research for a nuclear repository for high-level radioactive waste. BGR works on behalf of the German government looking at geotechnical and geoscientific issues involved in the nuclear repository field.

BGR fact sheet “Clay and claystone research” as a download:

[www.bgr.bund.de/fact-sheet-clay-claystone-research](http://www.bgr.bund.de/fact-sheet-clay-claystone-research)

of this on hydromechanical-coupled processes in the claystone. Measuring methods and equipment are to be further developed accordingly in future so that they can also be used at other locations.

Contact: **Dr. Kristof Schuster,**  
**Dr.-Ing. Hua Shao**

## Glimpse of the distant future

BGR experts assist investigations on the long-term safety of the Morsleben nuclear repository

In the former Bartensleben salt mine, the German Democratic Republic constructed a nuclear repository in 1971 for low and medium radioactive waste. The Morsleben repository for radioactive waste (ERAM) was used until 1998. It is now to be decommissioned and sealed. The Federal Office for Radiation Protection has engaged BGR and four other project partners with work involved in the long-term safety analysis of the ERAM.

Before a nuclear repository can be decommissioned, it is necessary to undertake a planning approval process pursuant to the Atomic Energy Act. This process includes submission amongst other things of an analysis of the long-term safety of the nuclear repository. After decommissioning, the radionuclides have to remain reliably isolated from the environment until their radiation has ceased.

Working together with four other project partners experts from BGR are elaborating a catalogue on the different events and processes which take place in a repository system after closure or could have an external influence on the system. This takes into consideration the whole range of possible geological, geotechnical, climatic and chemical-physical factors. The aim is to find out which factors can have an influence on the nuclear repository site in future, their mutual dependencies and the probability that they could influence the safety of the nuclear repository. Future scenarios will be developed based on this catalogue.

As part of this collaborative effort, BGR scientists are concentrating on the current geological situation and investigating a range of different geological developments. For instance, the scientists analyse the geological structure of the rock salt and the



Source: Sabine Nestler (2013)

▲ Tunnel-shaped ice cave beneath Nordenskiöldbreen, Spitsbergen, created by the outflow of glacial melt water at the base of the glacier. Conditions such as these also existed at the Morsleben site during past glacial periods.





▲ Glacier crevasse on Harrietbreen, Spitsbergen, and a desert. When forecasting the future development of the nuclear repository site, analysis is also required to determine whether the area could be affected by extreme climatic conditions such as glaciation or an arid climate.

surrounding rock formations. An important role is played here by the thickness of each rock layer, their relative location to one another, the rock material itself, and the permeability of the rocks to aqueous solutions and gases, as well as the rock stress.

Various geological events and processes could have an influence in future on the initial conditions existing now. For instance, the experts assess whether the region around Morsleben could be affected by a volcano, or the probability and potential strength of earthquakes in the area. Should these give rise to fractures and faults in the rock layers, this could jeopardise the safe containment of the radioactive materials. Uplift of the region over

a large area to the north of the Harz Mountains or the potential of mountain building occurring in North Germany are also analysed. Strong uplift would give rise to erosion of the upper layers forming the cover rock and the nuclear repository could itself ultimately be exposed during the course of mountain forming events. However, volcanism, strong uplifts and mountain building are geologically unlikely here in the long term.

Processes associated with climate change also have to be taken into consideration. Forecasts assume that the global climate will cool down after a few tens of thousands of years. The scientists therefore evaluate whether the repository could be covered by

a continental ice sheet, and whether this could give rise to the creation of erosion channels beneath the ice. Another important process is dissolution of rock salt by the groundwater in the cover rock. This process could increase if the natural flow of groundwater at the site is enhanced by meltwater and glacial water.

The catalogue of events and processes provides a transparent platform for deriving future scenarios and additional system analysis to evaluate the long-term safety of the nuclear repository.

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Contact: **Anke Christina Bebiolka**

InSpEE: Information system for salt structures – basis for planning, selection criteria and estimation of the potential for constructing salt caverns for the storage of renewables (hydrogen and compressed air)

## Storing renewables

### Joint project investigating the storage potential of North German salt structures

North Germany's salt structures could be used as interim storages for renewables. In the InSpEE joint project scientists are currently working on a review of which of the around 700 structures appear suitable and how much storage volume is available in total. The final result will be a database with detailed information on each individual structure.

With its energy transition Germany has decided to strongly expand its use of renewable energy sources. However, wind and sun are fluctuating energy sources and are also not available upon demand. Energy storage power plants provide the link between supply and demand by using excess power to generate compressed

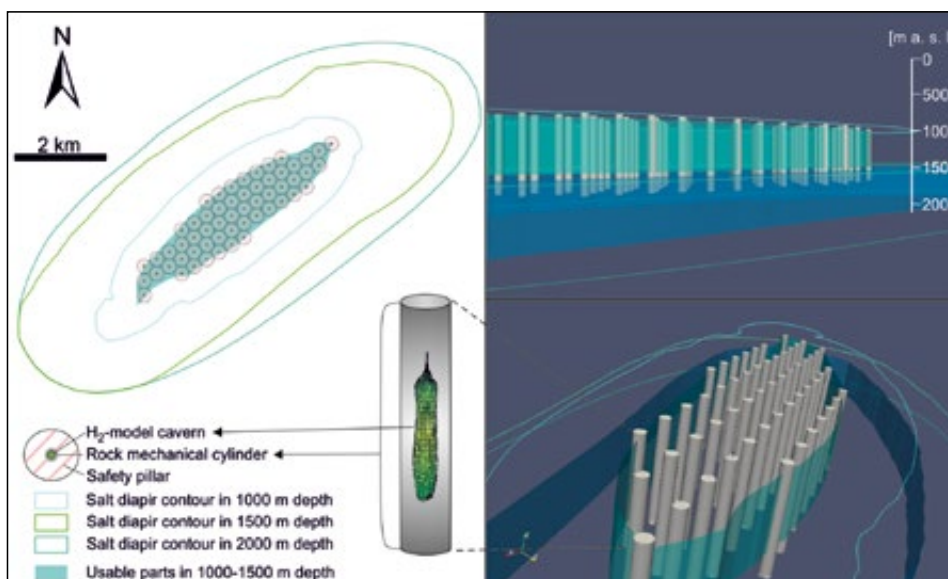
air or hydrogen and storing them in cavities in underground geological formations. Scientists from BGR, Leibniz University Hannover and KBB Underground Technologies GmbH are working on the InSpEE joint project to provide an overview of the salt structures in North Germany required for these storages.

Salt formations are particularly suitable for storages of this kind, because they are tight and mechanically stable. In addition, the material is virtually chemically inert with respect to most materials. There are already more than 300 storage caverns in German salt structures primarily storing natural gas and crude oil. The cavities are usually 300 to 400 metres high and 50 to 60 metres in diameter. They are constructed by the controlled injection of water into the rock salt – so-called solution mining.

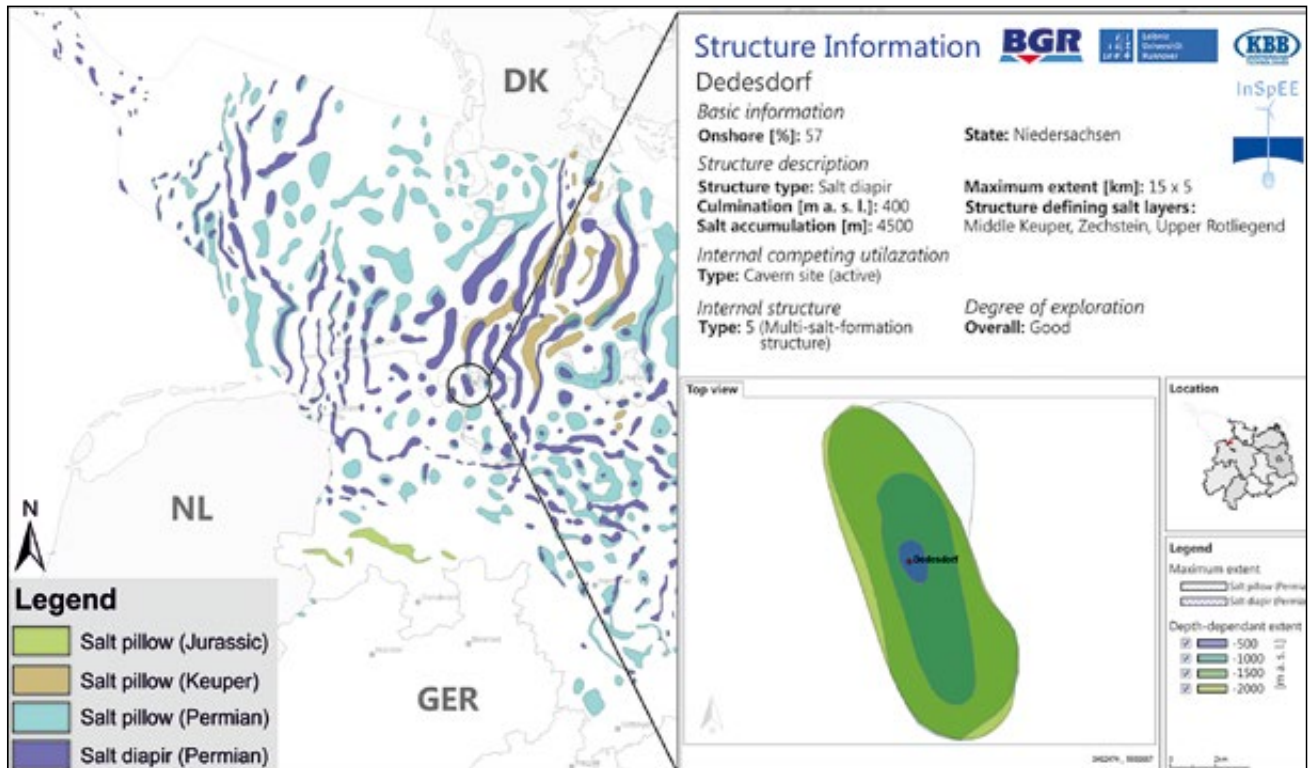
The North German Basin contains around 700 salt structures. They formed over the last 250 million years and now form a huge underground mountain range with a wide spectrum of shapes. It is currently not clear which structures are suitable

for underground storage and how much compressed air or hydrogen they could store. The InSpEE project is aimed at answering these questions. It is part of the nation-wide Energy Storage Funding Initiative, and is financed by the Federal Ministry for Economic Affairs and Energy.

Around 300 structures passed a criteria-based selection procedure, and are now being looked at in more detail. The other structures



▲ Various depth contours of a salt structure. The usable sections and the feasible hydrogen model caverns are visualised between depths of 1,000 and 2,000 metres.



▲ Web-based information system with integrated data for the construction of caverns in North German salt structures.

are either too small, too deep, or their salt is not pure enough to make them suitable for the construction of storage caverns. However, because not every part of a salt dome is suitable for such cavities, the project partners are developing a method for predicting the internal structure of various salt structure types based on the existing information.

Already explored structures in which mines or cavern storages are operated or will be operated provide reference values so that the potentially usable parts of currently unexplored salt structures can be estimated. In co-operation with the state geological

surveys, BGR is also creating depth cross-section maps so that the extent of the salt structures can be determined at precisely the depth at which the storages are planned.

The rock mechanical specifications were recalculated by the Institute for Geotechnical Engineering at Leibniz University Hannover. Natural gas and oil caverns are usually only filled and emptied once a year. However, the storages in a power industry strongly focused on renewables must be able to cope with injection and withdrawal cycles on a daily or weekly basis.

With this basic information, KBB

Underground Technologies GmbH estimates the total energy storage potential for compressed air and hydrogen in the North German salt structures. At the end of the project there will be a database which contains all of the relevant information on each location in a publically accessible geoinformation system, and which will be made available to the competent licensing authorities and interested members of the public as well as industry as a whole.

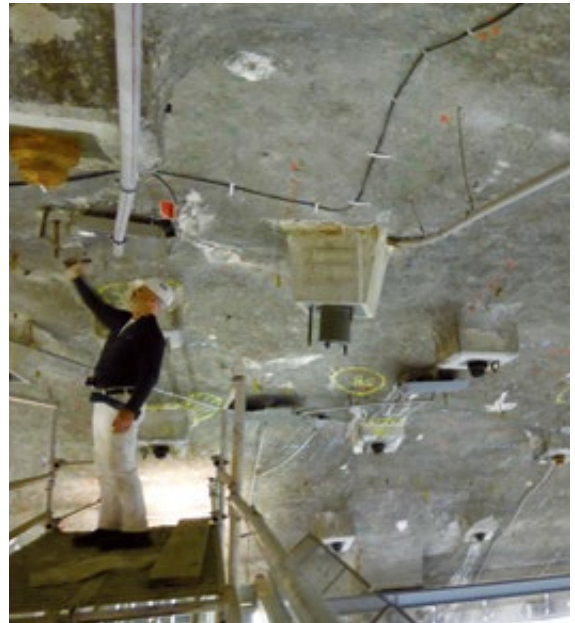
<http://forschung-energiespeicher.info/en/>

Contact: **Lukas Pollok**

Monitoring the stability of the Waldeck II pumped-hydro storage power plant

## Power from a cavern

BGR monitors the stability of the Waldeck II pumped-hydro storage power plant



▲ Aerial photograph of the Waldeck I and Waldeck II storage ponds at the Edersee in Hessen.

▲ Inspecting the shotcrete lining in the roof of the machine cavern.

The Waldeck II pumped-hydro power plant at the Edersee reservoir is completely constructed underground with the exception of the storage pond. BGR has been responsible for the geomechanical monitoring of the caverns and tunnels since the construction of the power plant in 1969. The BGR engineers are also involved in the planned expansion work.

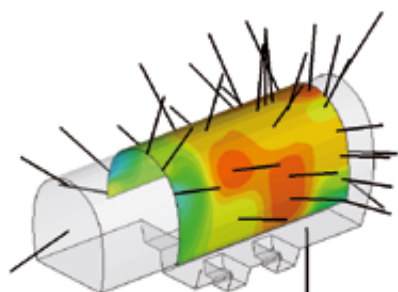
The Waldeck I and II pumped-hydro power plants at the Edersee reservoir together comprise the fourth largest pumped-hydro complex in Germany. The water stored in both ponds corresponds to an energy content of 3.9 million kilowatt-hours. This is approximately the annual power consumption of 1,500 households. The purpose of a pumped-hydro power plant is to release the energy stored in

the water within a very short period of time. It stores excess power which is not required during periods of low demand, and can then be quickly fed back into the grid during demand peaks.

More storage capacities of this kind are required in the German grid to make it fit for a power mix primarily consisting of renewables. This is be-

cause wind and solar power fluctuate and are not necessarily generated when required by electricity customers. There is therefore an increase in the significance of pumped-hydro storage plants for supplying power: they can provide precisely the kind of buffer capacity to balance out the supply and demand in a post-energy transition power market.

However, the two pumped-hydro power plants in the hills of Hesse were constructed at a time when no one was thinking about energy generated by the wind and the sun. They were built and are still used as peak load power plants at times when there is a particularly high demand for power. Their additional use for the provision of balancing power when wind and solar power are in short supply is a new function. The older Waldeck I power plant was built in



▲ 3D model of the machine cavern showing the positions of the extensometers and deformation of the lining.



▲ Machine cavern during excavation with a combined lining with reinforced shotcrete and system anchors.

the early 1930s and has a conventional design: the water flows between the two storage basins through pipes laid on the surface. Waldeck II was built four decades later and has more than tripled the capacity of the older plant at 460 megawatts. In this power plant, the water in the upper pond at the top of the Peterskopf, rushes downhill within the rock through a penstock into the Francis turbines which are installed in a gigantic cavern.

BGR has been involved since the power plant was constructed in the mountain in 1969. BGR permanently monitors the rock and the walls of the caverns so that the power plant can be operated safely. In addition to the 100-metre-long, 54-metre-high and 33-metre-wide machine cavern, BGR also monitors the associated system of tunnels and the surge tank which balances out the pressure during the opening and closing of the pipes.

The caverns are not only special because of their size, but also because of the way the rock has been secured: the engineers initially lined them with shotcrete and then secured them additionally with system anchors. If the rock is affected by stresses which exceed the strength of the rock, this can have a negative effect on the securing systems, and thus also on the operation of the pumped-hydro power plant. The systems are therefore

regularly controlled with special geotechnical measurements.

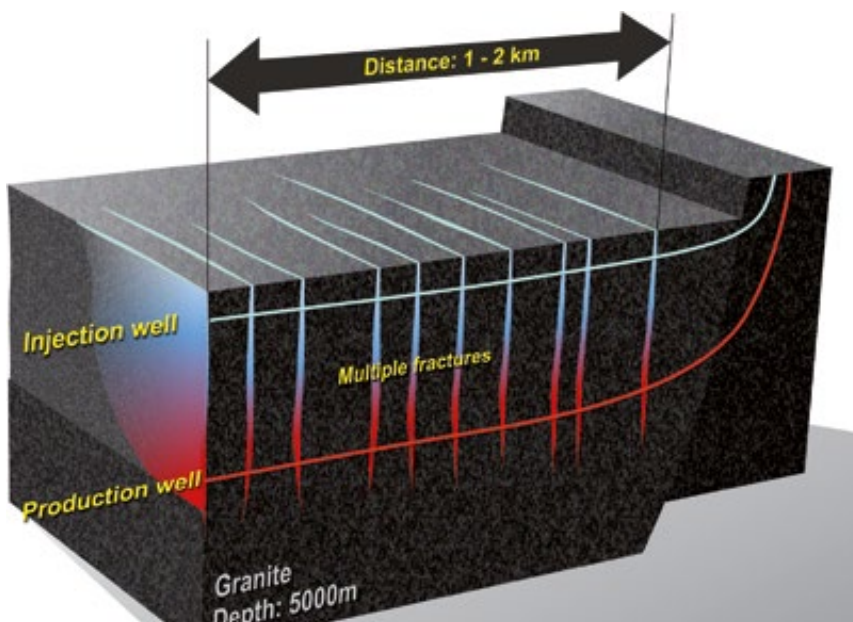
The enlargement of the pumped-hydro power plant planned by the operator E.ON Kraftwerke GmbH would supply even more balance power to stabilise the power grid. The capacity of the power plant would be significantly increased by an additional 300 MW pump turbine in its own cavern and with dedicated penstocks. Although the plans have currently been shelved, an exploratory tunnel and cavern were already constructed in 2011 using the new Austrian Tunnelling Method which causes less damage to the rock. These exploratory underground workings show that the conditions underground in the mountain are favourable and that nothing stands in the way of the expansion from a geological point of view. The geomechanical processes in the exploratory underground workings are regularly recorded and evaluated by BGR. This guarantees continuous monitoring of the rock behaviour right from the start of exploration, through to construction of the underground workings, and during future operation. It is not currently foreseeable when the work to expand the pumped-hydro power plant will begin.

Contact: **Christian Lege,**  
**Dr.-Ing. Jürgen Hesser**

## Multifracking minimises earthquake risks

Concept study investigates geothermal energy measures in crystalline rock

Impermeable rock layers in the deep underground have the highest geothermal energy potential in Germany. However, exploitation first requires fractures to be created in the rock, in a process which could give rise to seismic events or microquakes in earthquake zones. In the Multifrac Study, BGR and its partners are investigating a fracking concept which reduces the risk of such earthquakes.



▲ Diagram of an underground system for geothermal exploitation using multiple fractures. Cold water is injected into the upper well, heats up by coming into contact with the hot rock along the fractures, and is then produced as hot water from the lower well.

Geothermal energy in crystalline rocks lying in the deep underground has been the focus of research in Europe for a long time. A European research laboratory was established in

Soultz-sous-Forêts in the Alsace in 1987 which was connected to the grid as a small power plant in 2008. However, small earthquakes were initiated here during the creation of the frac-

tures, just as in Basel 150 kilometres away. In Basel, the earthquakes gave rise to so much concern among the inhabitants that the project had to be shelved.

The Multifrac Concept Study looked at the alternative multifracking concept for the so-called “petrothermal geothermal energy”. The input conditions were assumed to be those present in a granite complex at a depth of 5,000 metres. Extensive fracture surfaces are required for the exploitation of geothermal energy in those tight rocks. It is also possible though to create many small fracture surfaces sequentially: which has the two benefits of promoting more effective heat extraction, as well as reducing the risk of an earthquake. The project involved BGR alongside the TU Mining Academy in Freiberg, and the GFZ German Research Centre for Geosciences in Potsdam.

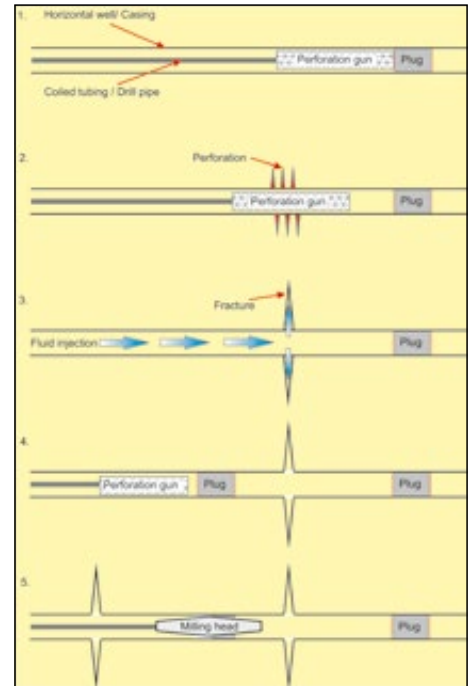
Multifrac technology is already used for the production of natural gas from sedimentary reservoirs. Unlike gas production, water without any addi-

tives is used for the fracture generation (fracking) in crystalline rocks. The fracture surfaces then act as migration paths for thermal water and as the heat exchangers where heat is extracted from the rock.

In the Multifrac Project, the TU Mining Academy Freiberg and the GFZ German Research Centre for Geosciences are focusing on mechanical and hydraulic processes taking place during fracking and the subsequent operation of the underground system. BGR's job is to investigate the technical challenges involved with the vertical and horizontal wells, and the subsequent fracking at a depth of five kilometres. It is possible in principle to drill horizontal wells in hard granite at these kinds of depths. A rotary-steerable system is recommended to drill the deviated and horizontal well sections as effectively as possible. This tech-

nology guarantees good drilling rates and optimal control of the well path. However, the engineers are operating at the limits of this technology because of the large diameter of the wells needed in geothermal plants, and in the horizontal sections as well.

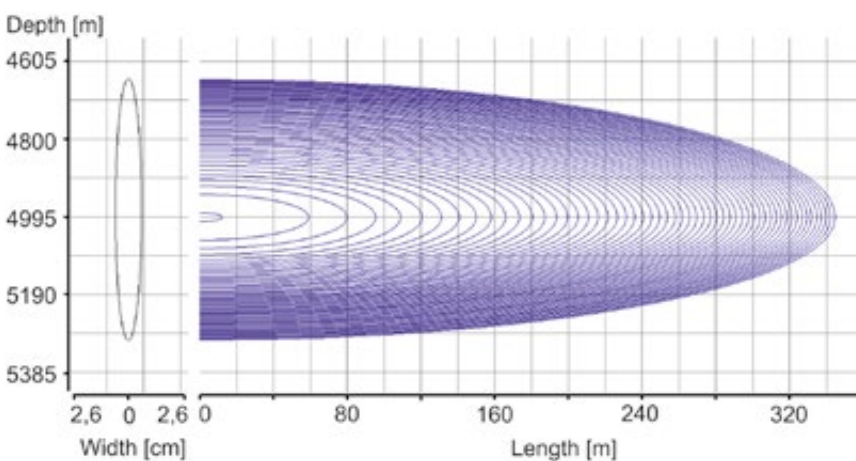
The oil and gas industry has developed various technologies to generate multiple fractures underground. However, these methods cannot be used without any modifications at depths of five kilometres because the temperatures here exceed 150 degrees Celsius. The co-called "Plug & Perf" method is considered to be the safest fracking technique from a technical point of view: in this instance, fracking starts at the end of the well and is then continued section-by-section. Every section is temporarily sealed off upwards by a kind of plug – a so-called "bridge plug". All of the plugs



▲ Schematic sequence of multifrac generation using the "Plug & Perf" method.

are then milled out at the end of the operation to completely open the well again. Computer simulations revealed that water injection would create sufficiently large fracture surfaces to hydraulically connect two horizontal wells drilled a few hundred metres apart. This enables the thermal water to circulate between the wells.

Because the limits of today's technology are reached in many cases at operative depths of five kilometres, there is a high risk of failure. It is recommended to test the multifrac concept at shallower depths first before transferring the technology to greater depths at a later date.



▲ Simulation of the fracture propagation (height and length) during injection of 5,000 cubic metres of water with an injection rate of 50 litres per second in a low permeable rock. The blue rings symbolise the propagation of the fracture against time at a depth of 5,000 metres.

Contact: **Dr. Torsten Tischner**

## Sizing up a quarry

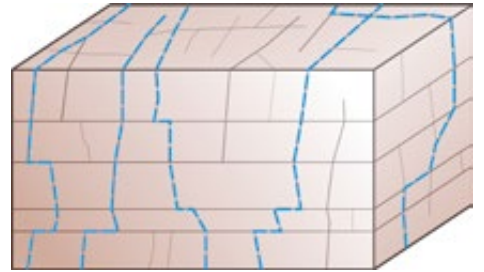
Bunter Sandstone outcrops on the surface provide information on the jointing of CO<sub>2</sub> storage rocks

The capture and storage of CO<sub>2</sub> (CCS) is seen in Germany as a bridging technology for a limited period. The intention is to permanently isolate the greenhouse gas carbon dioxide from the atmosphere. BGR and other EU partners therefore investigated the storage capacity of Bunter Sandstones.

Even though Germany plans to have a low-CO<sub>2</sub> energy supply in the long term, fossil fuel-fired power plants will still be connected to the grid for a long time. During this period the carbon dioxide they emit could be captured and stored deep underground to isolate it from the atmosphere. One of the prerequisites, however, is that the cap rocks of the deep un-

derground geological formations in which it is stored are completely tight.

BGR investigated the storage capacities of sandstone formations as part of the ULTimateCO<sub>2</sub> EU project. These rocks are one of the prime targets in Germany for CO<sub>2</sub> storage. They are found for instance in Rotliegend and Bunter Sandstone sequences.



▲ Possible migration paths for fluids.

The lithological, mineralogical-geochemical and physical properties of core samples from depths of around 670 metres were looked at as typical examples. The cores come from formations with natural carbon dioxide accumulations. The CO<sub>2</sub> was generated in the upper mantle of the Earth by magmatic processes and then rose upwards along joint zones. The cores make it possible to study the natural products of the interaction between carbon dioxide, formation water and sandstones.

However, studying the core samples from deep horizons does not provide any information on the degree to which such rocks are penetrated by fractures and joints. The experts therefore visited the Middle Bunter Sandstone quarries in the Gaggenau part of the northern Black Forest which is considered to be representative of the deep lying Bunter Sandstones in places like the Upper Rhine Graben.



▲ Quarry in Bunter Sandstone in Baden-Württemberg, Germany.





▲ Laser scanner used in the field.

The experts investigated the joint network in the quarries in an aquifer analogue study. The geologists determined the spatial orientation of the joints in the field by using geological compasses and recording their separations and lengths. They also used a 3D laser scanner to precisely survey the whole of the outcrop. The

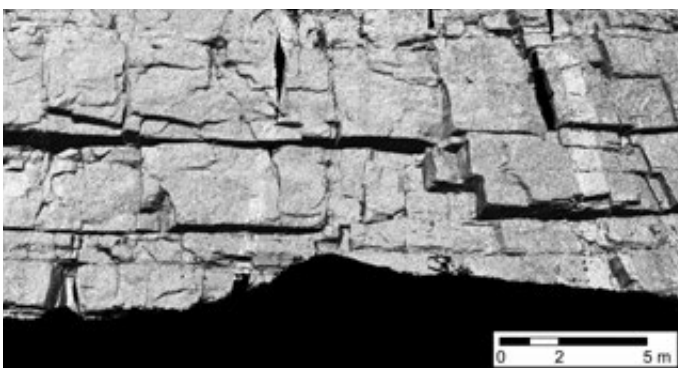
structural data was geostatistically evaluated and compiled in an overall model to supplement and verify the manual measurements.

In the following step, the geologists created a geological 3D joint model using the SKUA-GOCADTM software and the Fracture Modelling

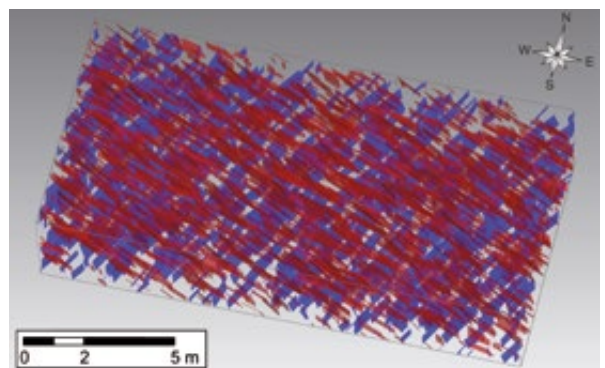
Module (FracMVTM) from Paradigm®. This enables the porosity and permeability of the jointed rock to be determined and thus also its fluid transport properties. Crucial aspects for the transmissivity of the rock to carbon dioxide and fluids is whether the joints form an interconnected joint network and whether the rock reaches the so-called “percolation limit”. Other important factors are the roughness of the joint surfaces, and the size of the apertures. Additional fieldwork and laboratory measurements on the joint surfaces were carried out with various optical, geochemical and mechanical methods to supplement the joint model and to gather this additional information. The joint model was used by other project partners to simulate scenarios for the spread of CO<sub>2</sub> in sandstone horizons.

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Contact: **Dr. Franz May,**  
**Axel Weitkamp**



▲ Model of the scanned rock surface.



▲ Simulated 3D joint model.

## Utilising stakeholder know-how

Transdisciplinary project models risks of carbon dioxide storage in saline aquifers

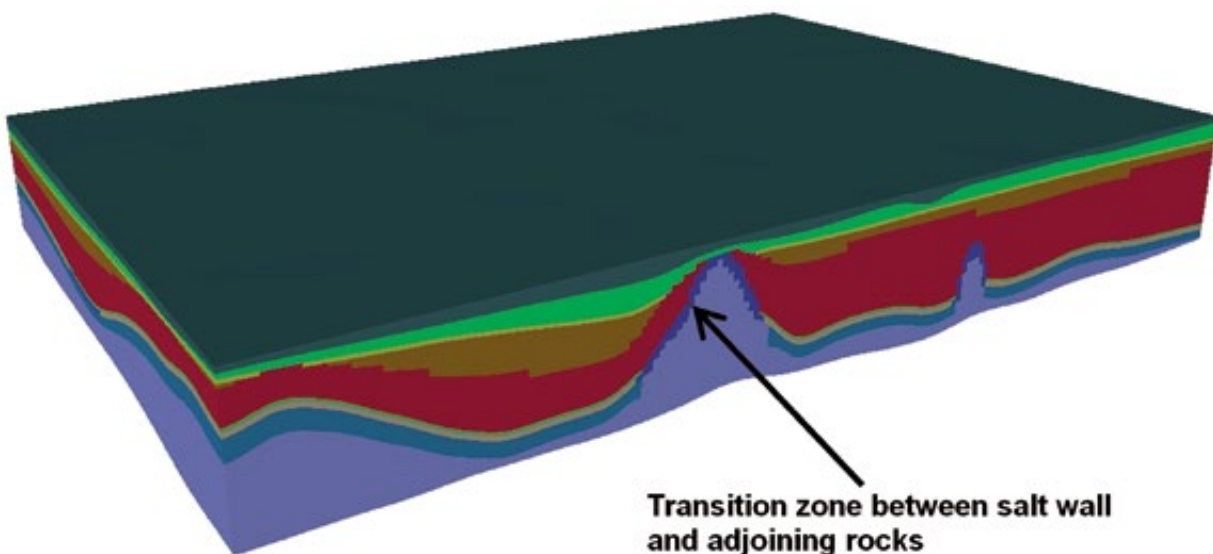
When storage rocks for carbon dioxide are sought in Germany, eyes quickly turn to the so-called “saline aquifers”: deep-lying formations filled with highly saline water. The CO2BRIM project investigates the risks associated with injecting the gas into the brine-bearing horizons and used a transdisciplinary approach for this purpose.

Porous rocks lying deep underground and containing salty water are basically considered ideal storage rocks for large volumes of carbon dioxide. However, injection causes a local and regional increase in the storage pres-

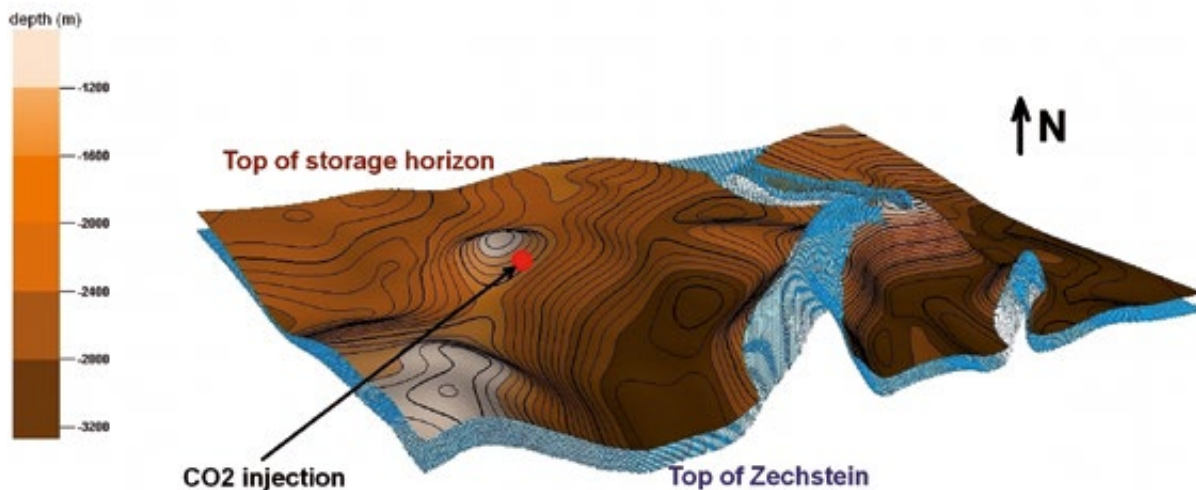
sure in the rock because the brine is displaced in the proximity of the injection well. This could cause salty water to rise up into the overlying cover rocks at weak points, even a long distance away from the injection

well, and in the worst case scenario, contaminate drinking water aquifers close to the surface. One of the key questions for the storage of carbon dioxide in saline aquifers is therefore how the displaced formation water behaves underground. In addition to BGR, the Institute for Modelling Hydraulic and Environmental Systems at the University of Stuttgart as the project coordinator and DIA-LOGIK GmbH are also involved in the CO2BRIM project looking at this problem with an integrated natural and social science approach.

BGR geologists have created a regional 3D structural model with typical features of the underground geology in north-west Germany. Even during the creation of this model, representatives of external interests



▲ BGR's geological 3D structural model for the numerical simulation of CO<sub>2</sub> injection scenarios. The transition zone between the salt wall and the surrounding rocks is seen as a potential migration path in the scenarios.



▲ Depth of the surface of the storage horizon in the Middle Bunter Sandstone. The storage horizon is bordered in the east by an elongated salt wall (Zechstein surface shown in blue).

(stakeholders) were already involved via expert interviews and a workshop. This kind of participation breaks new ground in the field of geological CO<sub>2</sub> storage. Representatives of scientific institutes, authorities, and industrial companies, used a preliminary model sketch to comment on the model being created, and highlighted points of weakness in the geological cover rocks, and potential migration paths for the formation water.

This revealed that the external experts considered the transition zone between a vertically extensive salt wall and the surrounding rock to be a potential migration path. In addition, they also pointed out gaps in the Oligocene Rupelton, a widespread barrier in north Germany between the shallow freshwater horizons and deeper salt water horizons. These zones of weakness could also act as

migration paths for the salty water. With the incorporation of this external contribution, BGR geologists then created a model which assumes that the storage rock is a sandstone horizon in the Middle Bunter Sandstone subgroup and has a thickness of 20 metres. The storage horizon is limited in the east by a salt wall. In addition, areas where the Rupelton is absent were also incorporated within the model. The realistic 3D structural model has eleven geological horizons showing the structure of the underground geology from the base of the Zechstein to the surface. The model represents an area of 58 by 39 kilometres and a thickness of around four kilometres.

However, high to very high permeability values were assumed in part in the simulations for the transition zone between the salt wall and the storage

horizon, but which are considered to be purely theoretical assumptions, because values of this kind would not occur naturally. This opinion was also shared by the external experts. The assumptions therefore represent a theoretical scenario in which salty water could rise up almost completely unhindered. The Institute for Modelling Hydraulic and Environmental Systems in Stuttgart used the model to simulate various CO<sub>2</sub> injection scenarios. The evaluation of the simulated storage scenarios was not available on the editorial closing date. However, it is already clear that the involvement of the stakeholders produced a better understanding of the processes acting in the geological formations deep underground and can improve communication with the general public.

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Contact: **Stefan Knopf**

## Search for the ideal barrier

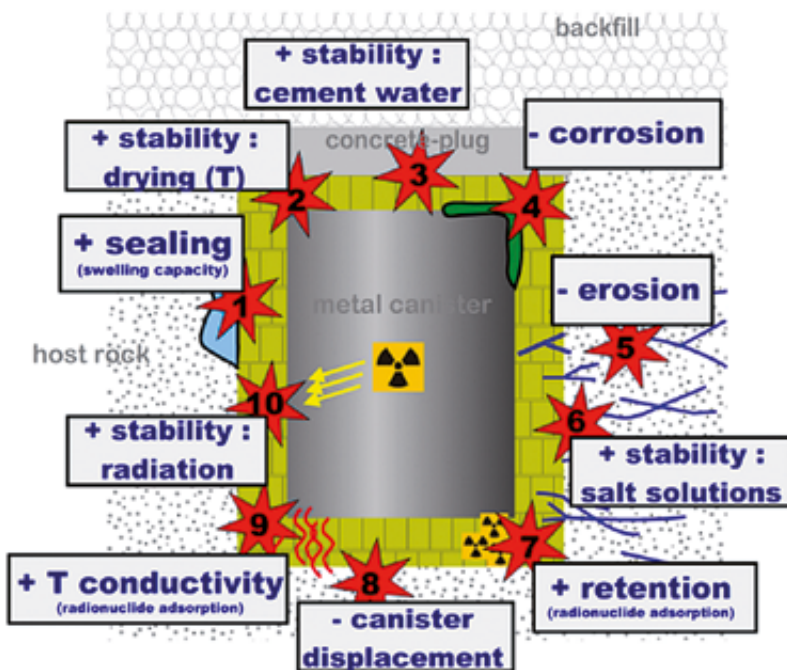
BGR mineralogists elaborate criteria for nuclear-repository bentonite

Deep underground rock formations are currently considered the most suitable option for the safe and permanent disposal of high-level radioactive waste (HLRW). The containers could be additionally surrounded by bentonite in some nuclear repository structures because this clay provides a particularly good barrier against water. BGR is doing research on the optimal composition of this material for various nuclear repository concepts.

BGR has elaborated the first criteria type for this purpose on the basis for the selection of the most suitable of a twelve-year study. The material

swells up strongly and can also hold back toxins because of its pore structure and surface charge. This is particularly important when storage is planned in rock which could contain water. This clay has already been used for decades in landfills because of its swelling properties, but empirical data on HLRW bentonites is rare.

Investigations carried out by BGR revealed that some of the properties of bentonite can be regulated by varying the level of compaction of the raw material during production of the barrier elements. However, the stability of the clay minerals and therefore the barrier depends on the selection of the right type of bentonite. It should contain very little or no soluble and/or reactive components such as organic material or sulphur compounds. Calcium bentonite is better than sodium bentonite, because it is associated with a lower risk of erosion. This aspect may be less important, because recent results indicate a fast equilibration of the interlayer composition with surrounding water. Less iron in the minerals increases the resistance to heat and improves the chemical stability. And clays with a high layer-charge density should be used to minimise the corrosion of storage containers made of iron.



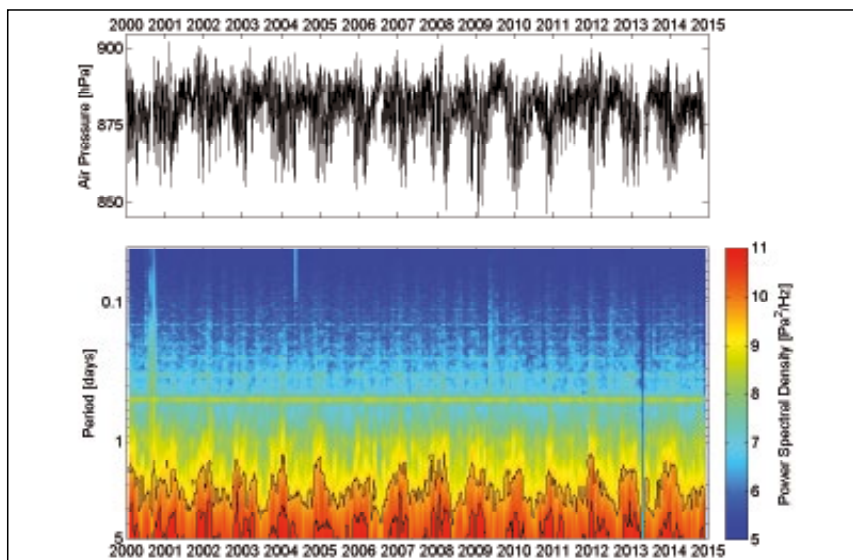
▲ Schematic diagram of a multi-component barrier and ten crucial factors for the selection of the right bentonite.

Contact: **Dr. Stephan Kaufhold**

## On the track of atmospheric waves

European research project quantifies the dynamics at three levels in the atmosphere

Although weather forecasts have become fairly reliable, meteorologists are often wrong when they make long-term forecasts. This is because of the dynamics of the atmosphere which is not adequately taken into consideration in weather models. The ARISE European research project aims to solve this problem.



▲ Air pressure data from the IS26 infrasound monitoring station in the Bavarian Forest (above) and variations in power spectral density (below) over a time period of 15 years. Annual and daily fluctuations highlight the intensity and duration of low pressure cells as well as the occurrence of wind fields in the upper atmosphere.

The ARISE project combines measurements from different monitoring networks. BGR contributes data from the infrasound monitoring stations used to monitor compliance with the Comprehensive Nuclear-Test-Ban

Treaty (CTBT) and is significantly involved in the evaluation of large datasets. All of the three ARISE measuring technologies have been collocated for the first time at the French Haute Provence observatory, around

100 kilometres north of Marseille. A LIDAR station surveys the Earth's atmosphere with lasers. Infrasound sensors listen to wave movements in the atmosphere and infrared spectrometers record the so-called airglow at a height of 90 kilometres.

The measurements made by the observatory reach up to this upper boundary of the mesosphere. Wind and temperature profiles were recorded here in 2014 and then compared with weather model forecasts. The result: the models were pretty good at handling activity up to heights of 50 kilometres within the troposphere and stratosphere, but became increasingly inaccurate within the mesosphere.

The reason: the simulations were poor at incorporating the different atmospheric wave systems which add dynamism to the atmosphere. These include the mainly horizontally meandering Rossby waves and gravity waves which break through the atmospheric layers in a vertical direction. The aim of projects like ARISE is to be able to take these phenomena into consideration to a greater degree in future measurements.

<http://arise-project.eu>

Contact: **Dr. Christoph Pilger,**  
**Dr. Lars Ceranna**

# Making landslide hazards visible

### BGR assists the Geological Survey of Pakistan in mapping hazards

In the mountains of north Pakistan, landslides are one of the most frequently occurring geohazards. Moreover, there is hardly any specific information available. A German-Pakistan project has now estimated the landslide hazard in a typical area.

Together with their local colleagues, BGR experts mapped the landslides and entered them into an inventory database. The data was supplemented with information on the general geology and tectonics, land use, vegetation and the climate to produce a hazard index map for landslides.

“We have now got to the stage where we can estimate the risks for the district,” says Dr. Dirk Balzer, head of the “Engineering Geological Hazard Assessment” unit of BGR. The ge-

Source: Geological Survey of Pakistan (2013)



▲ A landslide blocking the N15 road east of Paras, Mansehra district, in Pakistan.



▲ A house destroyed by a landslide on the road from Islamabad to Muzaffarabad in Pakistan.

Deeply-cut valleys with steep slopes plus the monsoon which regularly brings torrential rain: landslides are a frequent hazard in north Pakistan. Because the strongly growing population is taking up more and more land, the significant risk to people and infrastructure is increasing.

“These risks have not been taken into consideration to date,” explains BGR

project coordinator Annette Lisy. The reason is simple: the relevant information is simply not available. BGR has therefore started a pilot project in the Mansehra district with the Pakistan Geological Survey. The district in the northern Khyber Pakhtunkhwa province is the main focus of the German-Pakistan development co-operation activities.

ological information on the risks is currently compiled and evaluated with data on the population, settlements, roads and hospitals. The local authorities in this region can then also use the information on geological risks in their regional planning activities.

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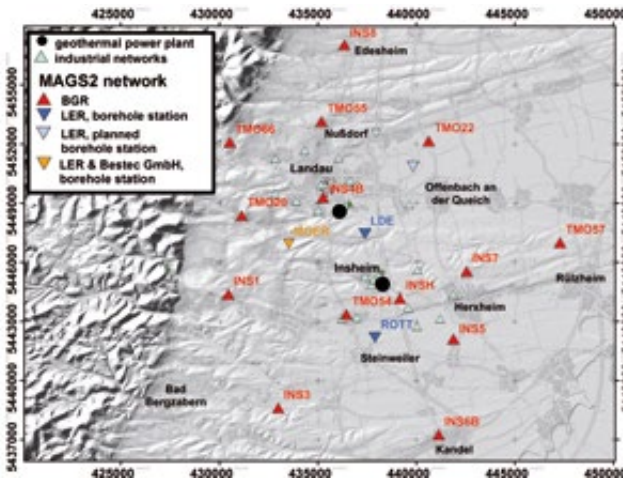
Contact: **Dr. Dirk Balzer,**  
**Annette Lisy**

## Under mutual influence?

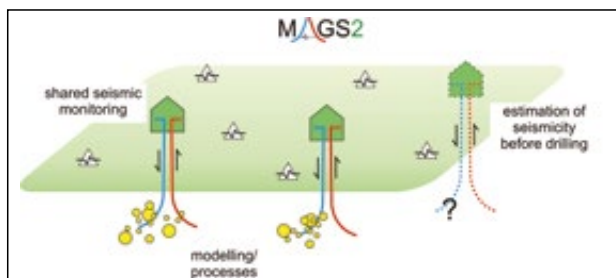
### Joint project investigates seismicity in geothermal fields

Geothermal projects are only a few kilometres apart in the area to the south of Bavaria's state capital Munich and in the South Pfalz region. In the MAGS2 joint project co-ordinated by BGR, the scientists want to find out how the seismic activity can be monitored in a region with several geothermal plants.

Earthquakes are amongst the accompanying effects which can be initiated by not only the construction but also the operation of geothermal power plants.



▲ Seismic network around the power plants in Landau and Insheim.



▲ Diagram showing the principle of the three pillars of MAGS2.

estimate the probability of whether geothermal projects can cause earthquakes with certain peak ground velocities. With the MAGS2 project, BGR and its project partners are now also extending the investigation to include geothermal fields because it is still unclear whether neighbouring projects can mutually influence one another seismically.

A joint sensor network is planned incorporating all of the sites to the south of Munich with the aim of monitoring the underground activity as well as providing the data required for probabilistic hazard analysis models. The geothermal companies will continue to operate the network after the end of the project. In the South Palatine region with the Landau and Insheim geothermal power plants a seismic network was set up for the preceding project MAGS. It is extended within MAGS2 and covers the area around both reservoirs. Precise geotectonic models are to be elaborated here to enable the experts to predict the spatial distribution of the ground shaking at the Earth's surface.

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



Scientists are looking at this problem with seismic monitoring networks and probabilistic hazard analysis to

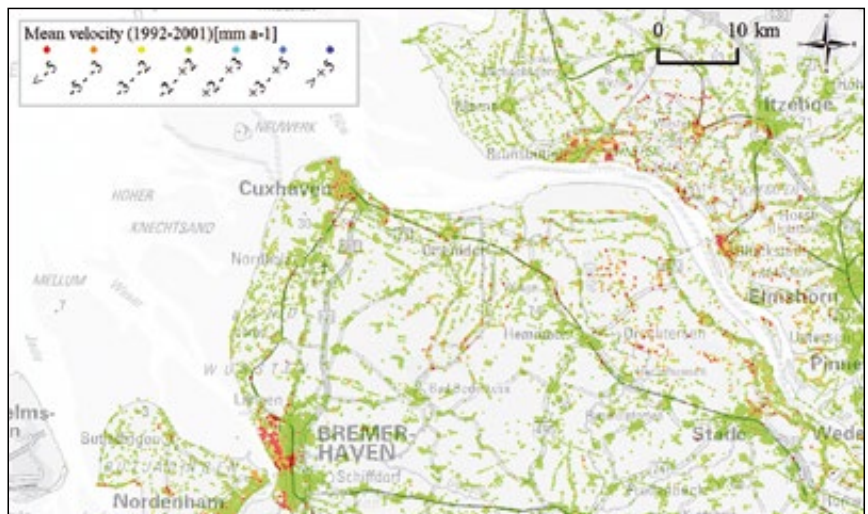
Source: Landesamt für Geologie und Bergbau Rheinland-Pfalz, Landeserdbodenamt Rheinland-Pfalz.

## Movement sensors in orbit

ESA – Earth monitoring satellite provides data for nation-wide German ground movement map

Ground movements are a hazard for buildings and infrastructure, even in Germany which is usually tectonically quiet. Earth monitoring satellites provide completely new opportunities for measuring the movement of the Earth's surface. BGR plans to expand its Geoviewer so that this data can also be visualised on maps.

Subsidence in mining regions, landslides, uplift and subsidence around salt deposits in northern Germany, are only a few examples which reveal that the ground in Germany is not always static. Specific objects including dams, dykes or bridges, are therefore monitored using ground-based measuring techniques. Satellites, however, can use their radar antenna to survey whole regions with high resolutions and at regular intervals. Ground movements for whole regions can then be derived using remote sensing measures such as Persistent Scatterer Interferometry (PSI). As part of the European Copernicus Earth Observation Programme, BGR and the German Aerospace Centre (Deutsches Zentrum für Luft- und Raumfahrt, DLR) are working together with small and medium-sized enterprises to produce a ground movement map. It will be based on data from the brand new ESA Sentinel-1 mission whose first satellite was launched in April 2014.



▲ Vertical ground movement rates at the Elbe and Weser estuaries based on radar satellite data.

A map is planned showing areas affected by ground movements across the whole of Germany. DLR is responsible here for processing the satellite data, whilst BGR takes over the validation, calibration and integration with the geodata available across the whole of the country. Data from the TerraSAR-X mission for instance will then be utilised for further spatial verification in areas of potential movement. Work is currently being carried out on preparing a map on a

pilot region in Niedersachsen which is still based on data from the ERS1/2 satellites and the TerraSAR-X data. A relevant supra-regional visualisation for the whole of Germany will be generated step-by-step as soon as the Sentinel data becomes available.

Contact: **Dr.-Ing. Thomas Lege,**  
**Dr. Michaela Frei**



## Mining in Africa

BGR provides assistance for the development-oriented structuring of the mineral resources sector

Africa's wealth in geological resources forms a good basis for development and prosperity. BGR assists three African countries in organising their administrations for the sustainable regulation and supervision of the mining sector.

With the assistance of BGR, the Ministry of Mines in Burundi is setting up a mineral deposit database which brings together all of the information required for issuing exploration permits. A digital mining cadaster is also planned to make the governmental administration of the production permits more efficient. Investors and the operators of domestic small-scale mining sites will gain more legal security from the cadaster. The third pillar of the co-operation work is the assess-

ment of the environmental compatibility of planned mining projects.

The Ministry of Mines in Mozambique is supported by the German experts to improve its technical capacities and its basis for reaching decisions on authorising new mining projects. This will enable the country to sustainably develop and control its natural resources sector. In addition, the recently established Geological and Mining Institute in Mozambique

will be assisted by BGR in collecting information on the potential of non-metallic resources, particularly construction raw materials. This is important because the construction sector is an important engine for economic development.

Mauritania is given assistance in the diversification of its mining sector with the aim of reducing its dependence on the iron ore mining industry which is very sensitive to economic fluctuations. BGR is therefore advising the responsible authorities on how to systemise the geological database and economically evaluate deposits of non-metallic resources. Also, facilities to make respective information available to investors will be established and improved.

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Contact: **Dr. Dirk Küster**



▲ Small-scale mining for cassiterite and tantalite in northern Burundi.



▲ Opencast copper mine near Akjoujt in Mauritania.

# Support for Developing Countries

Advising the Niger Basin Authority on groundwater management

## Greater focus on groundwater

BGR prepares employees of the Niger Basin Authority for the future

The Niger Basin Authority (Autorité du Bassin du Niger, ABN) has been responsible for water management in the catchment area of Africa's third longest river since 1964. The authority is now setting up an integrated groundwater management system with BGR's help.



Source: Philip Dorian Schuler

▲ The water supply in the Sahel is frequently maintained by simple, collectively used hand pumps.

The Niger is the lifeblood of a large part of the Sahel. Its topographic catchment area of 2.2 million square kilometres is half the size of the Euro zone. Around 105 million people live here in nine countries. The river and its tributaries are crucial for the water supply and the economy. ABN is the multinational organisation responsi-

ble for harmonising national water policies and for ensuring sustainable integrated water management in the region. On behalf of the Federal Ministry for Economic Cooperation and Development, BGR advises ABN on the setting up of a comprehensive regional groundwater management system. This is because the authority had previously focused on surface waters only – the rivers and lakes. The groundwater, however, will become more important for water supplies and economic development in future.



Source: Sven Menge

▲ Groundwater measurements at a monitoring well in Niamey.

By training ABN employees and national staff from technical authorities and providing basic hydrogeological work the German experts are laying the foundations for effective groundwater protection. In addition, cross-border regions have been identified in which groundwater problems could lead to conflicts.

The pilot area in Niamey, the capital of Niger, also involved installing a monitoring network to measure the quantity and quality of the water reservoirs. Investigations by BGR have revealed that the water at most of the monitoring stations in Niamey is contaminated by bacteria. Analogous projects have now begun in the second pilot region between Benin, Nigeria and Niger.

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Contact: **Martin Jäger**

## Potential for sustainable development

### ASEAN countries intend to set up a Mining Inspectorate

Most countries in South-East Asia are rich in mineral resources so the mining sector is one of the promising sectors for the development of these mostly still very poor countries. BGR assists some countries in the Association of South-East Asian Nations (ASEAN) with the establishment of an effective state agency for inspection.



▲ Village in Laos.

In the Laotian capital of Vientiane, experts from the Federal Institute and their partners from Laos, Vietnam and Mongolia presented projects to their colleagues from other ASEAN countries at a workshop. Focused on state control on mining these projects all face very similar challenges.

The host country Laos is currently modernising the state management

and inspectorate of the mining sector of the country with German help with the aim of making it sustainable and to guide it into a useful direction for the benefit of society as a whole. Laos's Mining sector is already responsible for more than ten percent of the gross domestic product (GDP), and is the second largest generator of hard currency after the tourism sector. The mineral resource sector

is intended to generate one fifth of GDP by 2020.

The co-operation project aims to improve the qualifications of the employees of the supervisory authority, equipping them with the necessary material, and establishing a reasonable regulatory framework in accordance with international standards. This is all done with the aim of developing a sustainable mining sector with benefits for the economy as well as for the environment. An analogous project is currently being started in Myanmar. This country is making an enormous effort to modernise its economy after many years of isolation. Sustainable structures for mining are to be established in the Shan state at the borders of Laos and China. The priority here is also on training the human resources.

Contact: **Dr. Arne Hoffmann-Rothe**

## Sustainability for more prosperity

Development initiative for the mineral resources sector provides demand-oriented concepts

Developing and emerging economies are important suppliers of mineral resources to Germany. On behalf of the German government, BGR is working together with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) to develop concepts for the establishment of a sustainable mineral resources industry in developing countries.



▲ Mining safety – mine workers in safety clothing.

The Global Extractive Resources Initiative (GERI) is the project with which BGR and GIZ aim to develop concepts for development co-opera-

tion in the mineral resources sector and to test them in practise. The initiative is implemented on behalf of the Federal Ministry for Economic Co-operation and Development. It strengthens the development-policy involvement of Germany in the mineral resources sector and assists resource-rich developing countries in developing a sustainable resource industry. A key aspect in this is incorporating industrial companies as central players in the sector.

Along these lines, the Mining Governance Assessment (MGA) was charted. The aim of the MGA is the systematic and comprehensive evaluation of investment conditions in the mineral resources sector initially in Sub-Saharan Africa. The evaluation takes into consideration amongst

other things the participating countries' legal framework, existing infrastructure as well as the qualifications of the workforce. The project seeks to assist developing countries in progressing reforms in the mineral resources sector, and to thus make it more attractive for investors. At the same time, it will provide relevant information to other sector stakeholders including investors and civil society groups. The project was presented at Mining Indaba in Cape Town in February 2015 and is implemented together with the World Bank Group.

In addition, Enterprise around Mining (EAM) will be further developed as an instrument to promote structural economic development around mining. The goal of EAM is to strengthen regional economic clusters through the involvement of international small and medium-sized enterprises. They possess the necessary means and experience to advance vocational education, create jobs and enable a sustainable economy beyond mining through the transfer of technology. Further, EAM prominently features construction minerals as these play a major role in the development of related sectors of the economy including infrastructure and housing.

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Contact: **Dr. Sven Renner**

# Nuclear-Test-Ban Monitoring

IFE14 – Integrated Field Exercise 2014 / field exercise for on-site inspection

## No test remains hidden

Field test of Nuclear-Test-Ban Treaty inspectors in Jordan was successful

The international Nuclear-Test-Ban Treaty has been in place since 1996. Monitoring networks already span the globe, and thus identified the North Korean nuclear weapons tests in 2006, 2009 and 2013. When the treaty comes into force, teams of inspectors undertake inspections on site when suspicion has been aroused. A large-scale exercise took place last year which simulated such an incident. BGR experts were involved.



▲ Suspicious objects or zones are defined after the first helicopter flight over the inspection area. These are then looked at in more detail by the teams of inspectors. Additional measurements and investigations are then planned on the basis of the findings.



▲ Commissioning a seismic station to record possible aftershocks. The procedure is accompanied by a state representative of the country being inspected.

“The biggest challenge was the size and inaccessibility of the area,” is how geophysicist Nicolai Gestermann sums up his involvement as an inspector monitoring the international Nuclear-Test-Ban Treaty in Jordan. Together with his BGR colleague Dr. Malte Ibs-von Seht and five other Germans, Gestermann took part in the integrated field exercise in 2014 (IFE14). This is the first exercise

of its kind in six years, and was organised this time in the Hashemite Kingdom by the UN Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO). Gestermann was one of a team of 40 inspectors who spent six weeks on location in the desert to the east of the Dead Sea for an inspection of a simulated illegal nuclear weapons test under the most realistic conditions possible. “Through this

exercise, we have shown the world that it is absolutely hopeless to try to hide a nuclear explosion from us,” announced satisfied CTBTO Executive Secretary Lassina Zerbo at the end of the exercise.

The exercise involved around 200 experts, many of which were responsible for planning and logistics behind the scenes. In Jordan, the 40

inspectors met a team with a similar number of people which played the part of the representatives of a state being controlled. “And they played their parts very convincingly,” comments Gestermann. The inspectors then had to find the site in an around 1,000 square kilometres area of the Jordanian desert where they assumed a nuclear bomb test had been carried out. The aftershocks were simulated during the exercise by exploding three packages of explosives and releasing a small amount of radioactive noble gas.

The CTBTO employees searched with a seismic network specifically set up for the purpose, to detect aftershocks of the explosion, and undertook inspection flights to search for other signs of suspicious activity. Gestermann was responsible amongst other things for the analysis of the seismological data – a task which he also undertakes as part of his main job at BGR. Here, in the Monitoring and Verification department, the geophysicist is responsible amongst other things for monitoring the artificially-generated earthquakes caused by natural gas production, for instance in north Germany.

To set up the seismometer network, the CTBTO flew in 30 of its own stations from its headquarters in Vienna. “We only ended up installing 16,” says



▲ The precise determination of the location of the seismological stations – such as being determined here by two inspectors – is a prerequisite for the subsequent analysis of the ground motion recorded by the instruments, which may hide signs of possible aftershocks.

Gestermann. It was not possible to install more given the local conditions. Installing and operating the stations involved a great deal of time, and the stations also attracted a very large amount of attention. The sensitivity with which the smaller network can register shocks is still currently being investigated. A complete network of stations can register very small earthquakes with a magnitude of down to -2.

After the seismologists had pinned down the approximate location of the “nuclear weapons explosion” on site, the teams were then deployed with special noble gas detectors to detect the radioactive traces of nuclear explosions. “It is ultimately the combination of several technologies which were used to verify the nuclear weapons test,” says Gestermann. However, the CTBTO employees can currently only carry out exercises to simulate a

real life situation because they currently lack the control authorisation. The treaty has not yet come into force because eight countries with nuclear-weapons-capable technology have not yet ratified it.

All they can do is therefore carry out joint exercises. Gestermann began his training to become a CTBTO inspector in 2010. Since then, the participants in the programme have got together several times a year for training courses and to carry out small tests. The previous major field exercise was in Kazakhstan in 2008 because these events are expensive and complex. But the effort last autumn was well worthwhile. “The whole of the co-operation work was excellent,” sums up Nicolai Gestermann with satisfaction.

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Contact: **Nicolai Gestermann,**  
**Dr. Malte Ibs-von Seht**

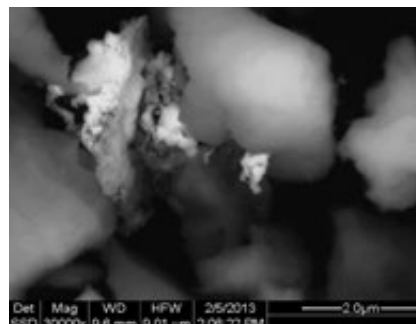
■ Sustainable Livelihoods | **DENANA: Design criteria for sustainable nanomaterials**

## Engineered nanoparticles

Experiments to clarify the mobility of nanoparticles in soil

Nanoparticles are being increasingly used in many areas. Nanosilver for instance is used to disinfect hospital walls, suppress sweaty smells in shirts and socks, and prevent algae from adhering to the walls of houses. Very little is known, however, about the effects of these tiny particles when they are released in the environment. The DENANA joint project run by the Federal Ministry of Education and Research intends to fill this gap and develop design criteria for sustainable nanomaterials by 2017.

BGR experts involved in the project, and working together with colleagues from Leibniz University Hannover and other research institutes, use a range of nanoparticles as examples to see how mobile they are in the environment. Scientists conduct experiments to see whether the particles remain in various soils and soil-sewage sludge mixtures, or whether they enter the groundwater. The first results should be available before the end of this year.



▲ Interaction between silver nanoparticles and a ferrihydrite.

Contact: **Martin Hoppe**,  
**Dr. habil. Elke Fries**

■ Sustainable Livelihoods | **FRESHEM: FRESH Salt groundwater distribution by Helicopter ElectroMagnetic survey in the Province of Zeeland**

## Helicopter maps conductivity distribution

BGR investigates the salt content of groundwater in the Dutch province of Zeeland



▲ BGR helicopter with surveying system.

The Dutch province of Zeeland on the border to Belgium largely con-

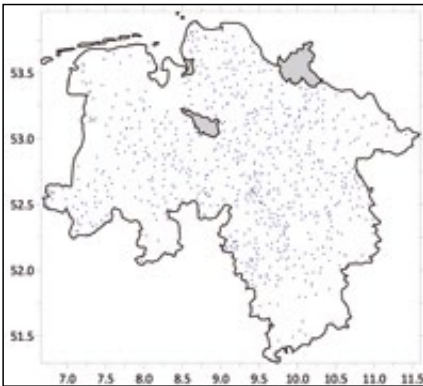
sists of islands and peninsulas in the estuary of the Schelde – a classic coastal landscape characterised by intense contact with the North Sea. A major airborne surveying campaign with the BGR helicopter is now planned to map the distribution of freshwater and salt water below the surface in Zeeland. In this FRESHEM project, BGR is working together with the Dutch research institutes Deltares and TNO with the aim of creating a

three-dimensional groundwater salinisation model.

On every survey flight, the helicopter tows an around ten metres long electromagnetic sensor to map the electrical conductivity below the surface down to a depth of around 100 metres. The conductivity of water rises with increasing salt content. This allows the different salt concentrations in groundwater to be detected. The first flights took place in autumn 2014. Others are planned in 2015.

Contact: **Dr. Bernhard Siemon**

## Sustainable Livelihoods | Methane background levels in Lower Saxony's groundwater



▲ Around 900 measuring stations in the Lower Saxony groundwater monitoring network are planned to analyse dissolved hydrocarbons.

## Natural methane concentrations in groundwater

### Joint project measures background values for Lower Saxony

One of the reasons why unconventional gas production using fracking technology and geothermal energy production are controversial is because of the concerns that groundwater could be at risk from rising gases or other fluids. Detailed information on the amount of hydrocarbons naturally dissolved in groundwater is

therefore required. However, the German state of Lower Saxony currently has no full data coverage on methane, ethane or propane. The data is only available for a few small project areas. Investigations in the United Kingdom and the USA have shown, however, that the concentrations can vary very strongly from place to place.

The background methane levels in groundwater in Lower Saxony project is aimed at determining the concentration of these three gases in the

groundwater for the whole of Lower Saxony by 2018. The first samples were taken from around 900 measuring stations in autumn and winter 2014. The joint project undertaken by BGR, the State Authority for Mining, Energy and Geology and the Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency publishes the data on the NIBIS map server.

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Contact: **Dr. Stefan Schlömer**

## Sustainable Livelihoods | HYMDAS: Hydrogeological Monitoring – Database & Analysis System

## Customised solutions

### Modular expert system for groundwater management



▲ Modular pictograms: the application comes from a combination and modification of readymade modules.

Modern groundwater management is impossible without the combined evaluation of data from various measuring networks. The targeted strategy for gathering, processing and evaluating this information is therefore very important. BGR has begun work on the development of

the HYMDAS modular expert system which can be used to implement a solution of this kind. The system consists of a central database holding all of the relevant information at the right quality and a local graphic user interface for simple access to this data.

HYMDAS is to be used on technical co-operation projects, and can be adapted to the requirements and options available to the local partners. Many

years of experience have shown that this is the best way for a successful implementation of this kind of system. The amount of work involved for this purpose is intended to decline further in future by modularising the system, reusing source codes, and developing solutions for the automatic modification of the user interface.

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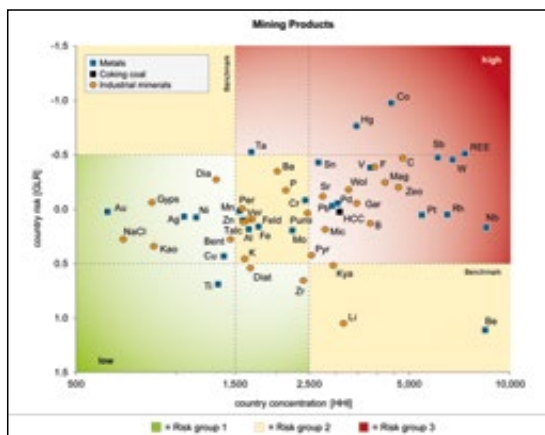
Contact: **Martin Blümel**



■ Securing the Supply of Raw Materials | **German Mineral Resources Agency – resource monitoring**

## Information for companies

Mineral resource monitoring provides assistance in assessing the markets



Source: DERA Mineral Resources List 2014

▲ Country concentration and weighted country risk of mine production in 2012 – green area: low risk, yellow area: medium risk, red area: high risk.

Germany is dependent on imports of mineral resources. The German Mineral Resources Agency (DERA)

In addition, DERA organises workshops to inform interested German companies.

at BGR therefore monitors the activities of the mineral resources markets.

The aim of DERA is to indicate price and supply risks to German companies, and to help them to develop appropriate mitigation strategies. The products of its monitoring activity are available on the DERA website.

DERA offers regular analysis of the supply concentrations on the markets for mineral resources, as well as the medium to long-term demand. The price and volatility monitor published monthly reflects the current and historic changes in prices. Furthermore, DERA elaborates detailed risk analyses for specific potentially critical resources.

Contact: **Dr. Martin Schmitz, Sonja Göcke**

■ Securing the Supply of Raw Materials | **Secondary mining – extraction of strategic elements**



▲ Precipitation of mobilisates on the top of a tailings impoundment: iron hydroxide (reddish) and copper sulphate (blue, white).

Chile is the largest copper producer in the world. Millions of tonnes of ore are mined every day in its open pit and underground mines, and the residues are dumped when the metal has been extracted. However, the material on these dumps is far from worthless because it might contain many addi-

## Co-operation with Chile

Experts plan to extract commodities from mine tips

tional interesting elements – albeit in low concentrations. With the SecMinStratEl project a German-Chilean consortium in which BGR is involved plans to investigate the potential of these valuable elements.

The project partners – including Chilean mining companies – plan to investigate selected mine dumps to see which of the valuable resources can be extracted from the dumped material. This first requires an analysis of the dumps to determine their structure

and composition. This is to be done using mineralogical, geochemical and geophysical techniques. The second step is to develop suitable processing methods. The residues are then to be safely stored for the long term. This would also solve a major environmental problem for the country.

[www.bgr.bund.de/SecMinStratEl\\_en](http://www.bgr.bund.de/SecMinStratEl_en)

Contact: **Dr. Dieter Rammlmaier, Wilhelm Nikonow**

## ■ Subsurface Use | **BASAL: Distribution and properties of flat bedded salt formations in Germany**

# Flat bedded salt formations

### BGR updates the geological data

Salt rock, claystone and granite formations are being investigated worldwide as potential host rocks to find sites for repositories for high-level radioactive waste. In the BASAL project, BGR is completing and updating information on flat bedded salt formations in Germany on behalf of the Federal Ministry for Economic Affairs and Energy.

The first interim report was published in December 2014 describing all of the flat bedded evaporite formations in the form of distribution maps and typical well sections. It also contains a new compilation of details on the



▲ Starobinsk deposit in Belarus – flat bedded, rhythmically layered salt rocks.

lithology, thicknesses and depths of the rock salt sequences.

Supplementary information on the distribution and composition, structural geology, and the repository-relevant properties of the evaporites will be gathered by the end of 2019. In addition to mineralogical-geochemical investigations, geomechanical laboratory tests and numerical modelling will be carried out to improve the planning and construction of repositories in flat bedded salt layers.

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Contact: **Dr. Jörg Hammer**

## ■ Subsurface Use | **Analysing rock properties in the laboratory**

# New tasks for engineers

### Testing machine for claystones being developed

BGR scientists are presented with new challenges because of the increasing importance of claystone research for industry. BGR's geophysical laboratory has therefore developed a new triaxial test machine to be able to test claystones more accurately and in more diverse ways.

The heart is a volume measurement cell which systematically reduces the errors which can influence the volume measurements. This is achieved by minimising the volume of fluid by

adapting the internal pressure cell to the size of the test specimen, and controlling the temperature with Peltier elements. Three cylinders running inside one another guarantee the constant volume of the cell under axial deformation. Pressure equilibrium with respect to the external pressure cell prevents the internal measurement cell from deforming when the confining pressure changes. The seals represent another challenge: they must not disturb the measurements by causing any friction, and must not

Claystone test specimen with a diameter of 10 centimetres: sandy facies of the Opalinus Clay from the Mont Terri underground laboratory in Switzerland. ►



change the volume of the measurement cell during changes in pressure or movements.

BGR is currently looking for a partner to help develop the volume measurement cell, preferentially from a university. The test machine is intended to be ready for use in 2016.

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Contact: **Dr. Werner Gräsle**

■ Subsurface Use | **TUNB: Subsurface Potentials for Storage and Economic Use in the North German Basin**

## Underground assets in the spotlight

3D structural model of the North German Basin in preparation



The geological surveys of the north German federal states and BGR will create a three-dimensional model of the deep subsurface in the North German Basin over the next six years. The TUNB project has been launched

to provide an improved information platform to satisfy the growing interest in using subsurface rock formations. In addition to the production and storage of hydrocarbons, there is a growing demand for geothermal energy production. However, the greatest interest relates to the storage potential for energy, generated by renewable energy sources such as wind and solar.

The model will include 13 of the most significant stratigraphic horizons as

well as faults and salt structures, and seamlessly and consistently integrate the partial models prepared by the German federal states. In the future, this information is to be supplemented by details on volumes and rock properties so that users can immediately use the model to derive the information required for estimating the potential they are interested in.

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Contact: **Dr. Gabriela von Goerne,**  
**Dr. Christian Müller**

■ Subsurface Use | **Computer tomography for the structural analysis of claystones**

## Making the invisible visible

Computer tomography visualises stress tests

Claystones mainly consist of a range of clay minerals with a grain size of less than 0.002 millimetres. Their composition and their mechanical behaviour are therefore much more complex than that of rock salt. Complex petrophysical processes occur during mechanical loading.

Scientists in the BGR geophysical laboratory want to find out how the structure of claystones changes during a strength test. The structural changes in the rock take place in the

bulk material and are mostly invisible to the naked eye.

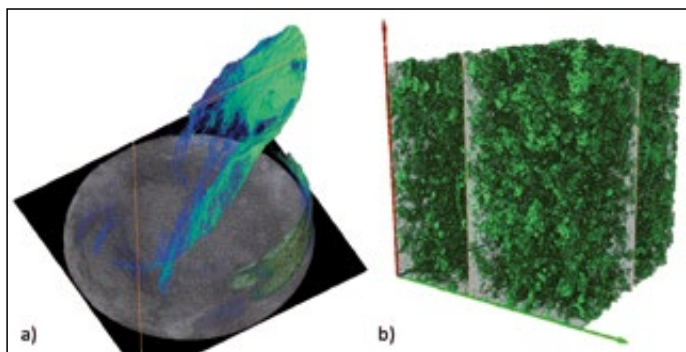
The BGR experts are therefore developing a special triaxial rock test cell which is also transparent to X-rays.

This is possible by combining a rock testing machine and a computer tomograph. The computed tomography images simultaneously visualise the geophysical processes taking place in the sample. Evaluation of the images

makes changes in the structure of the rock – such as fractures – visible.

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Contact:  
**Dr. Annette Kaufhold**

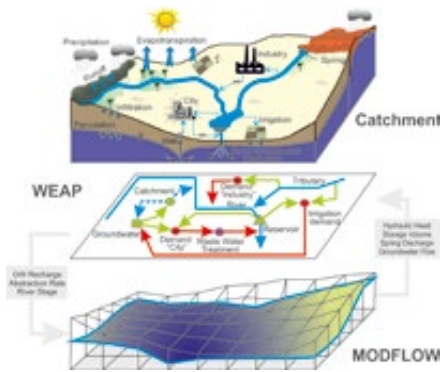


▲ 3D fracture system in a claystone test specimen with a diameter of 100 millimetres and a length of 118 millimetres (a). 3D carbonate particle distribution in a claystone. Specimen size 2.5 x 2.5 millimetres (b).

■ Development and Linking of Geoscientific Knowledge | **Integrated water resource management: coupling of decision support systems and groundwater models**

## Decision support for water managers

Program package couples planning software with groundwater flow models



▲ Diagram showing the WEAP-MODFLOW coupling.

Over 50 percent of mankind's demand for water worldwide is currently covered by groundwater resources. To ensure that these resources can

be used sustainably, in other words permanently, the volumes available have to be estimated realistically and properly managed. Computer-based decision support systems provide the responsible institutions with the necessary information. They combine planning systems for the development of water demand and supply with groundwater flow models, which reproduce the flow behaviour of the resource in the underground.

A coupled system of this kind is the freely available (for developing coun-

tries) program package in whose development and adaptation BGR has been involved for many years. It combines the WEAP planning software of the Stockholm Environment Institute with the three-dimensional MODFLOW groundwater flow model of the US Geological Survey. The plan now is to extend and generalise the interface between the two components so that instead of MODFLOW, other groundwater flow models can be used in future.

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

■ Exploration of Polar Regions | **CASE: Circum-Arctic Structural Events**

## CASE 17 expedition

Spitsbergen's geology reveals a great deal about the Arctic

Spitsbergen as part of the Svalbard archipelago was located in the centre of the Laurasia supercontinent for almost 250 million years, until it broke apart around 125 million years ago. This break-up gave rise to the formation of the North Atlantic and Arctic oceans. "The archipelago is therefore a key scientific area for understanding the geological development of the Arctic," says Dr. Karsten Piepjohn.

He and Dr. Lutz Reinhardt will head up the CASE 17 BGR expeditions in summer 2015. A group of geologists

will go to the northernmost tip of Spitsbergen to explore in more detail the creation of the Caledonian basement which heralded the formation of Laurasia 550 million years ago.

In the centre of Spitsbergen, thick sedimentary units are exposed which are also present underneath the waters of the neighbouring Barents Sea. Therefore, field work during CASE 17 will take sediment samples at the coasts of Isfjorden to assess the crude oil potential. The Barents Sea is also a key local area of the PANORAMA



▲ Geologists set up camp for four to eight weeks on the lonely coasts of the Arctic Ocean such as here on Isfjorden/Spitsbergen in summer 2012.

project (Petroleum Assessment of the Arctic North Atlantic and Adjacent Marine Areas) run by BGR.

Contact: **Dr. Karsten Piepjohn**

■ Development and Linking of Geoscientific Knowledge | **Surveying the gamma spectrum of the uppermost soil layers from the air**

## With the help of gamma rays

### Soil science on a helicopter flight

Large areas can be surveyed in a relatively short period of time by helicopter or aircraft using modern sensors. BGR's helicopter has had a new gamma ray spectrometer on board since May 2013 which measures the rock types on the Earth's surface. This is done with the help of energetic gamma radiation emitted by naturally occurring radioactive isotopes of potassium, uranium and thorium. Sandy soils for instance will have small amounts of these radionuclides, whilst clay soils often contain much

higher amounts. Working together with other instruments, the sensors can therefore very quickly provide an indication of the soil types which are present.

Flights made by the BGR helicopter in the loess-rich Rhenish foothills to the west of Bonn and in the sandy Uckermark to the north of Berlin are used to test the system. The surveying flights are intended to clarify which aspects the information collected by the helicopter surveys can answer,



▲ The BGR Sikorsky helicopter on a survey flight.

and for which questions additional ground-based investigations are required.

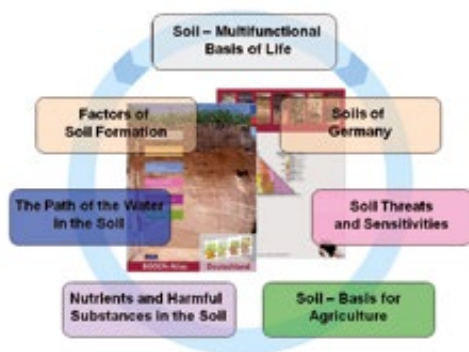
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Contact: **Dr. Annika Steuer**

■ Development and Linking of Geoscientific Knowledge | **Soil Atlas of Germany**

## Soil Atlas of Germany

### Nation-wide maps on paper and on the web



▲ Layout - Soil Atlas of Germany.

A comprehensive atlas on soils and their properties is still lacking for the whole of Germany. This gap will be closed by the Soil Atlas of Germany BGR is preparing right now. The in-

formation will be made accessible to the general public through geoscientific maps.

Readers will find maps on some factors of soil formation, on the soils of Germany and their water balance. In addition, the atlas will also look at soil as the basis for agriculture, its threats and sensitivities, as well as content of nutrients and harmful substances.

The aim is to create the most detailed and differentiated picture possible of the conditions just under the earth's surface, based on today's scientific state-of-the-art.

The printed atlas will be supplemented by an atlas information system in the near future – an internet application that contains up-to-date data, based on the latest evaluation methods. The Soil Atlas of Germany is BGR's key contribution to the International Year of Soils 2015.

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Contact: **Klaus Kruse**

# Criteria for a repository

The German Federal Government set up the Commission for the Storage of High-level Radioactive Waste in 2013. In the commission, scientists, association representatives and politicians are to work together with the aim of elaborating criteria for the search for a nuclear waste repository. Dr. Volkmar Bräuer, head of BGR's "Underground Space for Storage and Economic Use" department, advises the commission on geoscientific issues as a permanent guest.



Source: Siegfried Pietzok

▲ Dr. Volkmar Bräuer advises the German Federal Government's Commission for the Storage of High-level Radioactive Waste as a permanent guest.

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### **What are the responsibilities of the commission in detail?**

One of the main responsibilities of the commission is to develop criteria for a new site selection act. The first question to be looked at here is whether a nuclear repository for high-level radioactive waste should be located in deep underground geological formations or whether alternative disposal options should be considered.

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### **Which criteria play a role in selecting a site?**

We fundamentally differentiate between geoscientific and social-scientific criteria. The geoscientific criteria are based on safety-relevant questions, for instance, the thickness of the host rocks for a nuclear repository. These could be salt, claystone or

crystalline rocks such as granite. The social-science criteria for instance include societal and economic aspects such as infrastructure measures.

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### **How is the general public integrated?**

Interested parties can participate live in the commission meetings from the start to the end. This is necessary to establish transparency. All materials and minutes are accessible via the website. The commission has also set up a working group looking at the issue of the general participation of the public. This not only involves information, but also a dialogue.

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### **What are BGR's responsibilities as a permanent commission guest?**

Our BGR President and I take part in all of the commission meetings and contribute our opinions when necessary. There are also regular so-called "expert hearings" where we advise the commission on geoscientific issues.

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### **How are the chances that the commission will be successful?**

The intention is for the commission

to submit its recommendations to the German Federal Government by the end of this year. However, nothing much has happened in this field for many years. I therefore think that the commission's work will continue to 2016. The aim is then to select a site by 2031. This may also take longer. We must not forget the question of socio-political dialogue in this regard: how will the people in the affected municipalities react subsequently? The time involved here is very difficult to estimate.

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### **What are you working on?**

We are currently working on investigations concerning the German repositories in Asse, Morsleben and Konrad. In addition, we are also looking at aspects such as the structure of host rocks, and we are collecting important data for subsequent selection criteria. And when the work of the commission has finished, BGR will continue to advise the government during the search for a nuclear repository, undertake geoscientific investigations and make evaluations and assessments.

# Energy from shales

Fracking is the method used to produce shale gas. The term is a quite emotional one for adherents and particularly opponents of this technology. The geophysicist and President of BGR, Prof. Dr. Hans-Joachim Kümpel, explains what fracking is all about.



▲ Professor Dr. Hans-Joachim Kümpel, BGR President.

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### How is shale gas produced?

By injecting a fracking fluid consisting of water, sand and up to two percent chemicals into a mature shale gas formation. This creates millimetre-wide flow paths for natural gas. The technology is mostly applied at depths below 1,000 metres. Fracking has been used in Germany since the 1960s to produce natural gas from tight sandstones.

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### What happens to the fracking fluid?

Some of it comes back out of the borewell during production and is properly disposed of or recycled for other fracking measures, and some remains deep underground. The residues disperse here in the huge accumulations of natural, often extremely saline for-

mation fluids. Because of their rather high densities, these formation fluids cannot rise up to shallow depths in the subsurface. The companies are obliged to maintain large safety distances to shallow rock layers containing drinking water when they carry out fracking operations.

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### What are the criteria production companies have to observe in general?

There are a number of special regulations in Germany the industry has to comply with. The boreholes for instance have to be constructed with completely tight and encased multiple casings. In addition, borewells are only allowed to be drilled from a drill pad which is perfectly sealed off from the underground rock formations. These measures prevent the fracking fluid or produced hydrocarbons from coming into contact with the groundwater. Such stringent regulations do not exist everywhere in the USA.

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### Who checks to see that these criteria are being complied with?

In Germany, the mining authorities of each German state are responsible

for authorising fracking measures and their subsequent monitoring. This is regulated in various legal ordinances issued by the states, such as the deep drilling ordinances.

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### Can fracking give rise to earthquakes?

Data available so far on the connection between fracking and artificially generated earthquakes worldwide reveal that the earthquake risk is clearly lower than that, for instance, associated with conventional gas production, underground mining or the construction of larger reservoir lakes.

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### How important is fracking for the future?

BGR has estimated that around twelve billion cubic metres of shale gas could be produced annually in Germany up to the end of this century. This corresponds to a present day value of around four billion Euros per year. This could reverse our currently shrinking production volumes, and thus avoid excessive dependency on natural gas imports.

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### Do you consider this method to be safe?

From a geoscientific point of view, my answer to this question is Yes. If the statutory regulations are observed, the technical standards maintained, and detailed site-specific preliminary investigations carried out, then the use of the fracking technology is possible in a controlled, safe and environmentally-compatible way.

Source: viafoto - Fotolia.com



## Hardly any change in supply concentrations

▲ The DERA-Resource Monitoring provides information on developments in the global mineral resources markets.

The German Mineral Resources Agency (DERA) presented its new Resource Monitoring at a workshop

on 11 December 2014. More than 80 experts discussed the developments on the global mineral resources markets. This clearly showed that despite significantly sinking prices, there has been hardly any reduction in the

supply concentration of numerous mineral resources in the last years. Therefore the price and supply risks persisted in the previous years.

## Investment opportunities in Chilean mining

Source: CAMCHAL



◀ Guests at the German-Chilean Natural Resources Forum: Juan Pablo Hess, President AHK Chile, Prof. Dr. Reimund Neugebauer, President Fraunhofer Gesellschaft, the President of Chile, Michelle Bachelet, and the Deputy Managing Director DIHK, Dr. Volker Treier (from left to right).

High ranking representatives of the Andean state presented specific opportunities in Chilean mining at the third

German-Chilean forum for mining and mineral resources in Berlin. The German Mineral Resources Agency at

BGR was one of the organisers of the meeting. Chile is not only an important importer of German technology, but also a supplier of mineral raw materials to the German industry.

## CASE-Workshop in Hanover

Source: Karsten Preppohn



▲ Came along from ten different countries: the participants of the Arctic workshop 2014 in the GEOZENTRUM Hannover.

70 polar researchers from ten countries came together on 19 to 21 March 2014 at the international workshop of the CASE (Circum-Arctic Structural Events) research project. In addition to an update on the current research status they also discussed future ex-

peditions aimed at closing the still large gaps in understanding the Arctic region. These expeditions are only possible on the basis of international co-operation.

## Fascinating soil

For the Long Night of Science on 13 May 2014 in Berlin BGR laid out a five by three metres walk-on map of German cropland quality in front of the Geographical Institute of the Humboldt

University in Berlin. Accompanied by a small exhibition the map aimed at getting across information on the best soils in Germany – and raising the visitor's interest to find out more about soils.



▲ Fascinating soil – BGR's walk-on soil map.



## 25 years of nation-wide German soil science



▲ Poster – BGR and the topic of soil against the background of reunification.

At the public festival held in honour of the Day of German Unity in Hanover in 2014, BGR presented a poster of how the soil science in both states has grown together during the last 25 years. The soil systematics and nomenclature – as well as the soil data from east and west – were merged into a uniform system by

1994. The combined soil map at a scale of 1:1,000,000 was published in 1995 and a 1 : 200,000 soil map has been worked on since 1997.

Poster download (7 MB):

[www.bgr.bund.de/  
25jahre-gesamtdeutsche-bodenkunde](http://www.bgr.bund.de/25jahre-gesamtdeutsche-bodenkunde)

(Language: German)

## Recommendations in the new site selection for a final repository

Germany's Commission for the Storage of High-level Radioactive Waste, pursuant to Section 3 of the Repository Site Selection Act, met for the first time on



▲ Bundestag President Prof. Dr. Norbert Lammert (2nd from right), CDU/CSU, participates at the first meeting of the Commission for the Storage of High-level Radioactive Waste. The chair is shared by Ursula Heinen-Esser (3rd from right) and Michael Müller (4th from right).

22 May 2014. The commission's job is to develop recommendations for action for the Bundestag and Bundesrat on how a nuclear repository site for high-level radioactive waste can be selected.

The 34-person committee is made up of representatives of science and societal groups, members of state governments (Bundesrat) and members of the German parliament (Bundestag). BGR provides the commission with technical advice, particularly on the development

of geoscientific criteria, as well as on other geoscientific issues involved in a repository for radioactive waste.

The topics to be looked at by the commission over a period of two years include general safety requirements, other disposal options, exclusion criteria, minimum requirements, criteria for correcting potential errors in the subsequent proceedings as well as the organisational structure and the involvement of the general public.

## Helping fight mineral resources smuggling

The Ruanda, Burundi and Congo triangle is rich in valuable minerals. However, the political instability means that this brings no benefits for the people living there. BGR is therefore helping to establish mechanisms which can help track and control the

movement of the mineral resources. Three polishing laboratories were set up to produce analysable samples. The samples are then to be analysed in another laboratory which still needs to be set up in the region. The analytical fingerprint helps to check

accompanying documents, and therefore to track the trading channels.



▲ Polishing laboratory in the Congolese city of Bukavu.

## Water for Syrian refugees

The water resources in northern Jordan are facing a hard test because of the accommodation of Syrian refugees. Between 2012 and 2013 the water demand has risen by 16 percent while the supply of water per capita in northern and central Jordan has dropped by 50 percent.

BGR experts therefore provide the

government of Jordan with advice on management issues in the northern areas of Jordan, and have prepared an up-to-date review of the groundwater situation to improve extraction planning. Another focus of the activity is providing advice on monitoring water quality around the Zaatari refugee camp which has about 80,000 inhabitants.



▲ Testing the drinking water quality in northern Jordan.

## Face-to-face with deep sea treasures



◀ During the Open Ship Days on the SONNE research vessel, BGR presented numerous exhibits including a “black smoker”.

With samples from the seabed and ultramodern technology BGR took

part in the Open Ship Days cruise by the new SONNE research vessel, when it presented itself to the public at five German ports. These included Wilhelmshaven and Hamburg. Thousands

of interested people visited the exhibition and had an opportunity to come face-to-face with exhibits including a manganese nodule from the Pacific Ocean and a “black smoker” from the Indian Ocean. BGR scientists explained the technology used to search for these valuable resources.

## Groundwater comic in Zambian schools



▲ Children and their teacher at the SOS Kinderdorf primary school in Zambia tested the digital version of “Droppy” for two months and were given a certificate for their involvement.

The groundwater comic “The world-wide adventures of Droppy” is also a

big success in Africa. BGR originally developed it with South American

partners to playfully introduce children to the topic of “water and environment”. BGR got together with the local iSchool company in Zambia to adapt the comic to a digital learning environment. “Droppy” could then be installed as an app on a tablet PC which iSchool had previously developed for Zambian schools. Form-six children at three schools tested the tablet and comic for two months during lessons and were very thrilled.



Source: Sylvia Storge

▲ Entry in the visitors' book: Federal Minister for Economic Affairs and Energy Sigmar Gabriel with BGR President Prof. Dr. Hans-Joachim Kümpel (from left).

The Federal Minister for Economic Affairs and Energy Sigmar Gabriel

## Federal Minister visits BGR

informed himself about the responsibilities and work of BGR at the GEOZENTRUM Hannover on 17 April 2014. As the overriding technical-scientific authority under the auspices of the Federal Ministry for Economic Affairs and Energy BGR advises the German government and German industry on all geoscientific and raw material industry issues.

In his speech to the employees Gabriel emphasised BGR's growing importance in safeguarding Germany's supplies of mineral resources

and energy. BGR President Prof. Dr. Hans-Joachim Kümpel informed the minister about current projects and research work.

The focus here was on "Potential for utilising deep underground rock formations". In this context the institute evaluates the domestic shale gas potential, investigates salt caverns as potential energy storages, and analyses aspects of the use of groundwater and soil, and the risks, amongst other things.

## Incorporating geological expertise

The development of shale gas deposits is a highly disputed topic in Europe. In their Copenhagen Declaration on 12 September 2014 directors of the geological surveys in the North Atlantic area therefore argued that scientific findings and conclusions be taken into consideration more strongly in the debate.

The signatories see it as a matter of concern that the expertise of government geologists may not be adequately taken into consideration when decisions are reached in future on the supply of mineral resources.

The directors emphasised that their specialist institutes held most of the basic information on the under-



▲ Shale is a common source rock for shale gas.

ground geology of their countries. This enables decisions to be reached on the basis of the best available scientific expertise.

The geological surveys are therefore in a position to advise decision makers and the general public objectively

and neutrally on the potential of shale gas and any potential environmental risks.

Copenhagen Declaration (PDF):

[www.bgr.bund.de/kopenhagenerklaerung](http://www.bgr.bund.de/kopenhagenerklaerung)

(Language: German, English)

## More care and attention for soils



Source: Rainer Baritz

▲ Dr. Michael Kosinowski (1st row, 2nd from right), head of BGR's "Groundwater and Soil Science" department, at the general meeting of the Global Soil Partnership in Rome.

There is an urgent need to improve the condition of agricultural soils. This is the message of the second general meeting of the Global Soil Partnership in Rome at the headquarters of the FAO (UN Food and Agriculture Organisation). More soil

protection is required to be able to continue to supply the growing world population with food, water, energy and natural resources in the future. A set of plans of action was adopted to achieve this goal. German representatives included BGR experts.

## International nuclear repository research



▲ Participants at the closing conference of the PEBS project in the main auditorium of the GEOZENTRUM Hannover.

The closing conference of the EU PEBS project (Long-Term Performance of Engineered Barrier Systems) co-ordinated by BGR took place in February 2014 in Hanover with the participation of over 180 experts from 17 countries. The project

and the conference were focused on research into engineered barriers in nuclear repositories for radioactive waste in claystone, salt or granite host rocks. The conference ended with a podium discussion on future research topics.

## Ten years for a strong geoinformation economy

Public geodata are highly valuable for economy. The German GeoBusiness Commission (GGC) at BGR was established ten years ago to make its use as simple and as inexpensive as possible. The GeoInfoMarkt and

GeoLizenz services enable the sought after data sources to be found and licensed very quickly. The GGC reviewed its work to date and look forward to the future at INTERGEO 2014 in Stuttgart, the trade fair for



Source: GGC-Office

▲ Discussion panel: "We are celebrating an anniversary! 10 years of German Geobusiness Commission" at INTERGEO2014 in Stuttgart.

geodesy, geoinformation and land management.

## Geosciences on YouTube

BGR and the State Authority for Mining, Energy and Geology (LBEG) have been online for more than a year with the GeoChannel in the YouTube video portal, showing exciting videos

on expeditions, research findings and events. For instance, every YouTube user can watch BGR scientists on board the SONNE research vessel during their search for raw materials

on the seabed. New videos are added regularly.

[www.youtube.com/GeoChannelBgrLbeg](http://www.youtube.com/GeoChannelBgrLbeg)

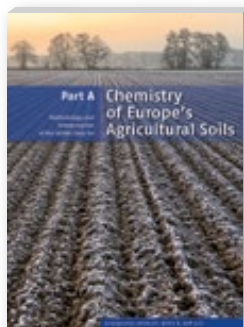


## Selection of BGR publications

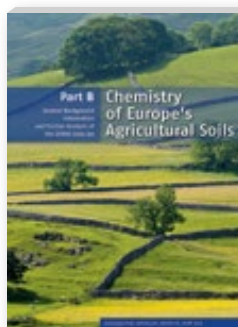
BGR publishes a wide variety of map materials and books about their work. All titles can be purchased from Schweizerbart'sche Verlagsbuchhandlung ([www.schweizerbart.de](http://www.schweizerbart.de)) or as digital documents ([www.bgr.bund.de](http://www.bgr.bund.de)).

### Geochemical "North-South divide" verified

The two volumes of "Chemistry of Europe's Agricultural Soils" present the first overall depiction of the elemental compositions and concentrations of agricultural soils in Europe alongside evaluations. The atlases are the result of the joint European Geochemical Mapping of Agricultural and Grazing Land Soil project (GEMAS). This involved taking 2,108 cropland samples and 2,023 grazing land samples in 33 European countries and analysing them to determine 52 elements by aqua regia digestion, 41 elements as total contents and 57 elements in mobile metal ion fractions.



C. Reimann, M. Birke, A. Demetriades,  
P. Filzmoser, P. O'Connor  
**Chemistry of Europe's Agricultural Soils,  
Part A**  
**Methodology and Interpretation of the  
GEMAS Data Set**  
523 pages, 1 DVD, English  
ISBN 978-3-510-96846-6, bound  
€ 118



C. Reimann, M. Birke, A. Demetriades,  
P. Filzmoser, P. O'Connor  
**Chemistry of Europe's Agricultural Soils,  
Part B**  
**General Background Information and  
Further Analysis of the GEMAS Data Set**  
352 pages, English  
ISBN 978-3-510-96847-3, bound  
€ 78



H. von Hartmann, T. Beilecke, H. Buness, P. Musmann, R. Schulz,  
**Seismische Exploration für tiefe Geothermie**  
 [Geologisches Jahrbuch B 104]  
 271 pages, German  
 ISBN 978-3-510-96850-3, bound, € 39.90

## Seismic exploration for deep geothermal energy

The volume “Seismic exploration for deep geothermal energy” presents the principles and options available for the seismic exploration of deep geothermal energy projects. The topic is introduced by a brief overview of the areas in Germany suitable for exploiting deep hydrogeothermal energy. This is followed by detailed descriptions of the scientific measures, how to plan seismic surveys, as well as seismic data processing and interpretation. The book ends with an overview of the costs of seismic surveys as well as a discussion of the potential for cutting costs.



*Study: Mineral deposits and production of mineral resources – a country comparison*

## China dominates global mineral resources production

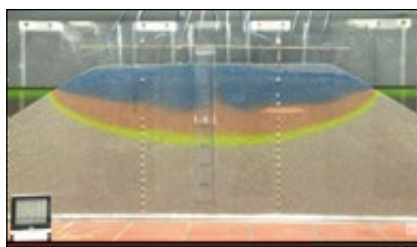
The Federal Institute for Geosciences and Natural Resources (BGR) has published a study on the mineral deposits and production of mineral resources in 180 countries. This country comparison provides an overview of the reserves (technically and economically extractable mineral resources), resources, and the mine and refinery production of various countries according to the value of the mineral resources.

[www.bgr.bund.de/laendervergleichsstudie-miner-rohstoffe-2014](http://www.bgr.bund.de/laendervergleichsstudie-miner-rohstoffe-2014)  
 (Language: German)



Look at the films on: [www.youtube.com/GeoChannelBgrLbeg](http://www.youtube.com/GeoChannelBgrLbeg)

## Teaching video on how to protect freshwater lenses on marine islands



BGR's FLIN project (Freshwater Lens INvestigations) investigates the dynamics of freshwater lenses under islands. The time lapse photos to visualise the flow paths and the differently aged layers have been used to create short videos in German and English language versions.

[www.youtube.com/watch?v=1N4Fd4SxHR4](http://www.youtube.com/watch?v=1N4Fd4SxHR4)  
 (Language: English)



## Groundwater exploration by helium balloon



BGR tested a new system for geophysical surveying. A helium balloon is the key element of this method based on transient electromagnetics (TEM). It can be used to explore the underground geology to depths of several 100 metres.

[www.youtube.com/watch?v=ucOp5HoGAKM](http://www.youtube.com/watch?v=ucOp5HoGAKM)  
(Language: German)



## New research vessel SONNE on a test voyage in the North Sea



The new deep sea research vessel SONNE sailed out of the port of Emden on 7 September 2014 in the direction of the British North Sea. Scientists from BGR and other scientific institutes tested the technical-scientific equipment on the vessel for the first time during the two-week voyage.

[www.youtube.com/watch?v=oAfhMATKAfc](http://www.youtube.com/watch?v=oAfhMATKAfc)  
(Language: German)



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**BGR** Bundesanstalt für Geowissenschaften und Rohstoffe

**LBEG** Landesamt für Bergbau, Energie und Geologie

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## 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.

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