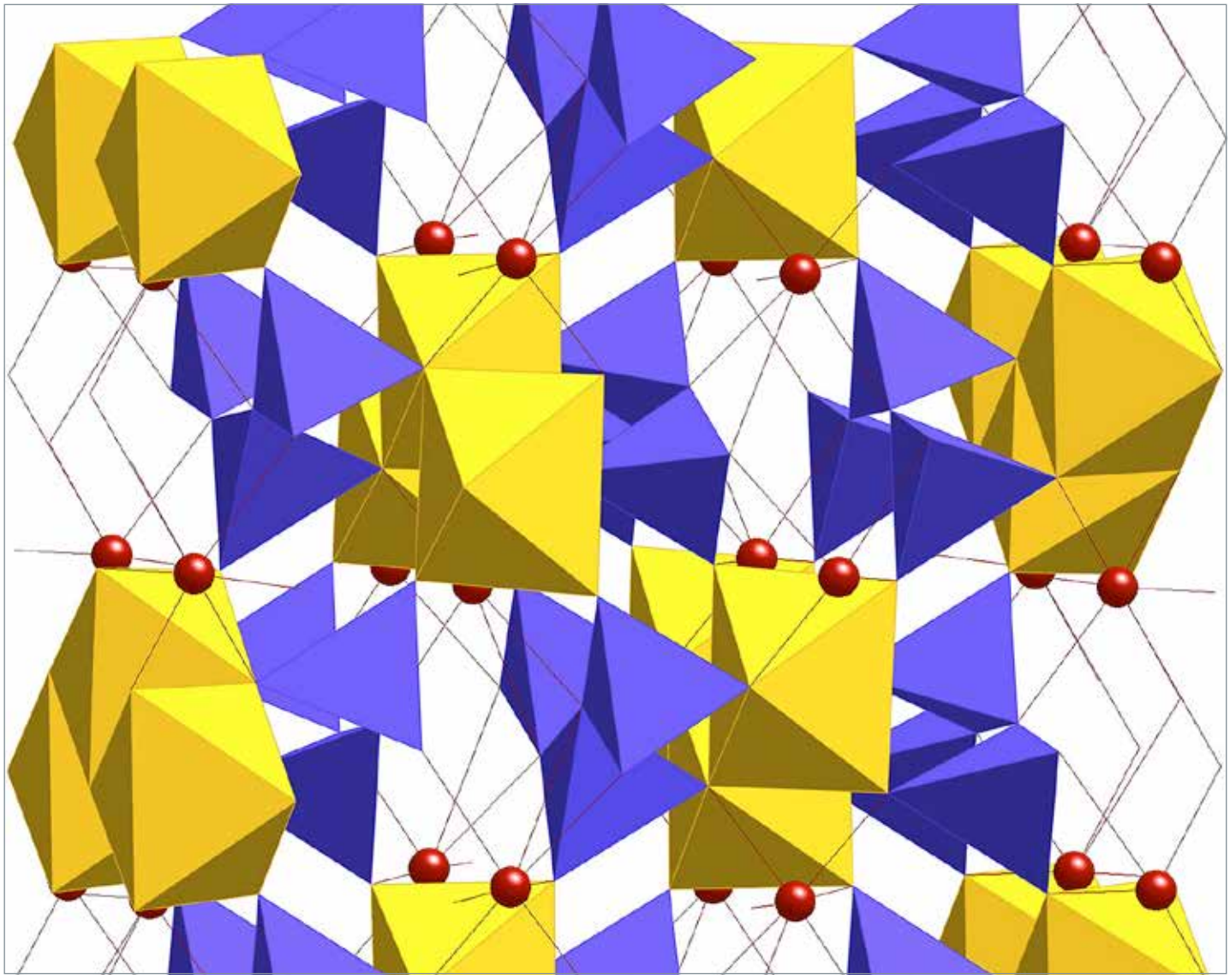
# german research

Magazine of the Deutsche Forschungsgemeinschaft

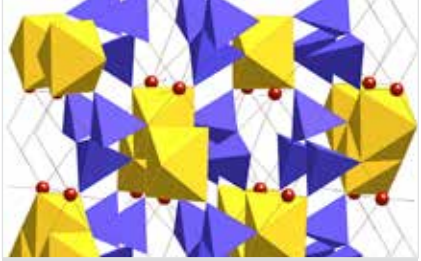
2/2014



**Geology:** Fingerprints from the Depths of the Earth | **Research System:** All Eyes on Early Career Researchers | **Microbial Plankton:** Life at the Limits | **Bird Migration:** A Phenomenal Journey | **Youth Exchange:** When Good Intentions Aren't Enough | **Fracture Mechanics:** Getting to Grips with Cracks | Copernicus Award 2014

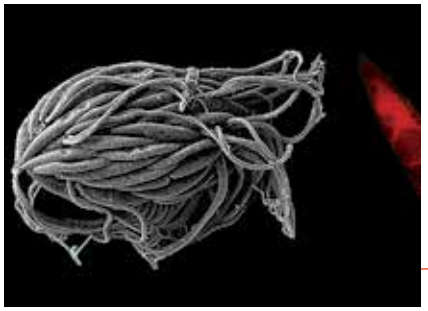
WILEY-VCH

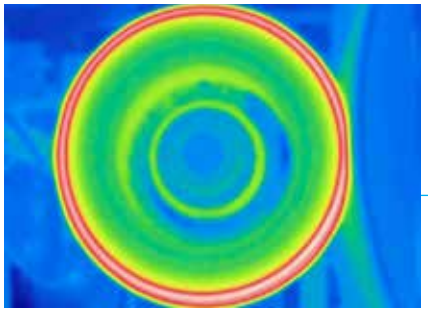
DFG



*Cover: GFZ Potsdam*

**Structure of the mineral enstatite, a chain silicate from the pyroxene family of rock-forming minerals (Colour code: blue: $SiO_4$ tetrahedra, yellow: $MgO_6$ octahedra, red: magnesium).**





Dorothea Wagner

# All Eyes on Early Career Researchers

*When we discuss the future of young scientists and academics, we are talking about the future of our research system. This system will only remain effective if we succeed in attracting and retaining highly qualified individuals as early as possible. One thing is needed above all: flexible career prospects.*

Anyone who has been following the topics of discussion in the German research system over the past few months will have noticed that the foremost question relates to the very future of the system. The major research organisations have set out their positions and initiated intense debate as to the future form of science and academic research and the framework that enables it to flourish.

But other important questions are also challenging the research community, one of which relates to the future of early career researchers. Numerous working groups are tackling this question, for example at the DFG, the German Rectors' Conference, the German Council of Science and Humanities and the Junge Akademie. The question of the next generation of researchers is also addressed in the future concepts of various institutions, some of which have already developed concepts of their own and are now testing them.

This almost general tendency is no random chance, and it is not only praiseworthy but urgently needed. In a sense, the question of the future of early career researchers is really about the future of the research system as a whole. The problems faced by young researchers when they look to the future are in many cases the problems affecting the future of the entire system.

Some of the problems facing these researchers are obvious, but others are less obvious at first glance or might crop up where you least expect them. Let's look at the Excellence Initiative. It has given the German research system considerable impetus, particularly the universities, which largely owe their central role in the system to the fact that they combine research and teaching with the training of early career researchers. The Excellence Initiative had a positive long-term impact on the decisive phase, the doctorate, through the concept of graduate schools. Doctoral researchers are increasingly part of a structured system and quality standards for doctorates have been introduced in many areas. Finally, the Excellence Initiative has created more than 5000 additional research jobs at all career levels, including early career stages.

It may be deemed a success story – yet most of the jobs for early career researchers funded by the Excellence Initiative and the Higher Education Pact are temporary and there are too few permanent positions at universities and non-university research institutions. Long-term staff development strategies designed to create transparent, dependable career paths are still infrequent. Some positions have also been described as "precarious", and not just in public debate.

The discussion within research organisations as to the situation regarding early career researchers must be understood in this context. At the DFG, a working group made up of members of the Senate and the Executive Committee has critically reviewed the range of available programmes in the light of the recommendations drawn up under the

Illustration: Arndt

leadership of the then Vice President Jürgen Mlynek in 1999 ("The Future Funding of Early Career Researchers by the DFG"). The group concluded that most of the recommendations had since been successfully implemented within the funding portfolio. This edition of "german research" provides an overview of the current early career grant programmes offered by the DFG and shares its experiences in this area (cf. "The Next Generation", pages 4–6).

The awarding of positions rather than fellowships at both the doctoral and postdoctoral levels played an important part in making a research career more attractive, not only nationally but internationally. Various measures designed to promote early academic independence have also proved successful. However, the working group also outlined a set of proposals for discussion by the DFG's policy and decision-making bodies: for example, that the standards of quality and supervision promoted in the doctoral phase by Research Training Groups and Graduate Schools should ideally also be available to doctoral researchers outside structured programmes and to researchers in the first postdoctoral phase.

Those who are actively involved in the current debate on early career researchers, here at the DFG and other stakeholders, have made diverse suggestions. One such key (policy) requirement upon which all agree: we urgently need new concepts as to the form that new permanent positions and more professorships should take and how they can be funded. Few would dispute that academic institutions need a constant supply of fresh ideas and fresh impetus, and new staff are an important source of these. Furthermore, change and mobility are as important to early career researchers as they are to institutions, because they mean independence and experience. For this reason, not everyone can or should be offered a permanent post immediately. But there must be a sufficient number of attractive jobs available to keep the best researchers in the German research system while enabling them to progress in their careers.

Early career researchers rightly expect to be offered flexible career prospects and a better work-life balance. The DFG and its third-party funding programmes promote both and can support model solutions for a limited period, as they have done already with a measure of success. But the main challenges are faced by the universities and the policymakers. Those who decide policy must make our universities and the research system as a whole fit for the future – and for the next generation of researchers.

**Professor Dr. Dorothea Wagner**
was Vice President of the DFG from 2007 until July 2014. In this office she was actively involved in issues relating to early career researchers, for example as chair of the Executive Committee working group devoted to this section of the research community.

# The Next Generation

The DFG provides career support to talented individuals in all disciplines by offering funding programmes tailored to different needs and expectations. Here we summarise the opportunities available, illustrated by testimonials from funding recipients.

The DFG has its eye on early career researchers. The first paragraph of the organisation's statutes states "[The DFG] devotes particular attention to the education and advancement of young researchers", thus setting out its position and imposing an obligation. So in addition to developing and offering early career grant programmes, the DFG seeks to improve working conditions and prospects for young researchers throughout Germany.

## Research Training Groups

There are funding programmes for early career researchers at all stages on the career ladder, with even undergraduates being encouraged to undertake research as part of DFG projects. The Research Training Group programme was introduced in 1990 to make the doctoral option more attractive, reduce time to degree and implement quality standards in the training and supervision of doctoral researchers. The programme has evolved over the years, but for over 20 years it has allowed doctoral researchers to be supported in a stimulating environment and to obtain the necessary skills to pursue a successful career after obtaining their doctorates – be it in academia or in another profession. During this time, concepts such as multiple supervision and supervision agreements between supervisors and supervisees have proved to be effective and popular tools.

*A positive atmosphere and intense discussion are already a traditional part of the annual Emmy Noether meeting in Potsdam.*

Illustration: DFG/Lichtenscheidt

*Andreas Zilian, now Professor of Engineering Sciences at the University of Luxembourg, began his academic career in Research Training Group (RTG) 432, "Interaction of Structures and Fluids" at Technische Universität Braunschweig. He completed his doctorate in three and a half years, a remarkably short time in the engineering field. He was particularly impressed by the interdisciplinarity of the group, with supervisors and doctoral researchers not only from different branches of engineering but also from mathematics and computer science. Being exposed to other ways of thinking was an enriching experience for him. Thomas-Peter Fries, another graduate of this RTG, is also now a professor, but the two pursued different career paths. Zilian chose a junior professorship with a DFG research grant and the role of principal investigator leading an individual project in a Collaborative Research Centre, while Fries opted for an Emmy Noether independent junior research group. For Zilian the RTG was the "right biotope", and a group of this type promotes both independence and dialogue between doctoral and postdoctoral researchers from very different academic backgrounds.*

## Graduate schools, projects and supervision standards

As well as Research Training Groups, since 2007 the DFG has also been funding around 40 graduate schools. Supported by funds from the Excellence Initiative, these schools offer doctoral researchers beneficial working conditions in an internationally visible research environment. Doctoral researchers can also join a DFG research project and thus benefit indirectly from DFG funding. All these projects, particularly large groups such as Collaborative Research Centres and clusters of excellence, are set up by internationally renowned experts following a highly competitive review process. As members of a project team, doctoral researchers not only get to grips with the technical side of research but also learn how a research institution works.

The DFG wants people undertaking doctoral research in a DFG project to benefit from the same supervision standards as their counterparts in structured programmes. This is indicated in its recommendations on good scientific practice updated in 2013 (www.dfg.de/gwp).

Working as part of a DFG-funded project or research group may also be a useful and helpful intermediate stage for postdoctoral researchers before submitting a proposal for a project of their own or taking the next career step.

## Eligibility, research fellowships and temporary positions for principal investigators

To be eligible to submit a proposal to the DFG a person must have a research training, usually evidenced by a doctorate, and either be engaged in research work in Germany or intend to carry out a research project in the country. All age limits for applicants were abolished by the DFG a number of years ago.

For early career researchers, particularly in biology and some of the natural sciences, it is the norm to spend a period abroad if they intend to pursue a research career. For this target group the DFG offers research fellowships, which allow an individual to spend a maximum of two years at an international research institution to undertake a smaller research project, learn new methods, build a network of contacts and become familiar with new topics. In the last twelve years, some 4200 early career researchers have received DFG funding to work abroad, over half of them in the USA.

Illustration: Gabi Schoenemann / pixelio.de

*An academic career can be rather like a rollercoaster. The DFG seeks to support excellent early career researchers through programmes tailored to their needs.*

*Today Johanna Pink is a Heisenberg professor at the University of Freiburg. The specialist in Islamic studies started out as a postdoctoral fellow in the RTG "Global Challenges" at the University of Tübingen before being awarded a research fellowship. To her, the value of this opportunity is that it allows a kind of start-up funding after the doctorate – but in order to enable more productive research, the funding would need to be for a longer period. In retrospect she was only able to accept the fellowship because her husband was earning and she could rely on his income. She welcomes the introduction of better support for fellowship recipients with children, as well as the fact that there are now jobs for most early career researchers in Germany, not least because holders of posts at universities*

*count as staff while fellows do not have staff status. With the Heisenberg fellowship, for which she applied from a staff position, the most important consideration was the basic conditions: time to carry out research in the areas she is passionate about. Finally she found the right faculty at the University of Freiburg to establish herself as a Heisenberg professor – a welcome opportunity for the mother of three.*

The DFG is keen to encourage independence as soon as possible in early career researchers as well as to ensure that they have an appropriate degree of security. It was with this in mind that temporary principal investigator funding lines were introduced in 2001. Anyone who wants to carry out a research project in Germany can apply for DFG funding not only for consumables, personnel and other costs, but also for a his or her own position as "(temporary) principal investigator". Although this funding opportunity is now available to any researcher based in Germany and not exclusively those at the outset of their careers, it is an interesting option for early career researchers.

## Emmy Noether and Heisenberg Programmes

The DFG aims to fund outstanding research and the individuals who make it happen. For this reason it offers two special programmes for highly qualified early career researchers. The Emmy Noether Programme, introduced in 1999, supports outstanding researchers who want to qualify for a professorship by leading an independent junior research group. The Heisenberg Programme, which exists in two variants – the fellowship introduced in 1978 and the Heisenberg professorship first announced in 2005 – is aimed at proven researchers who already meet all the requirements for a professorship but are still waiting for an offer and want to continue honing their academic profile in the meantime.

*Tanja and Tobias Gulder (pictured below) are the perfect example of a "dual career couple". Having obtained their chemistry degrees and doctorates together, they spent a period of time working in San Diego – he with a DAAD fellowship, she with a research fellowship from the DFG. Both then applied to set up an Emmy Noether independent junior research group. In 2013 Tobias was appointed professor at Technische Universität München. Tanja and her Emmy Noether group recently also relocated to Munich, so husband and wife – with their young daughter – can now combine family and career in the same place. Both like the Emmy Noether Programme for its excellent facilities, independence and the funding period of five years, which provides a degree of security and certainty in a world of often short-lived funding. Tobias is also pleased that he was able to keep the remaining funds from his independent junior research group after being offered his professor's post. In hindsight, he only wishes that all universities would sign and acknowledge the DFG's sample contract. This, he says, would save a lot of "Emmys" from having to fight for the right to confer doctoral degrees and examine candidates.*

The DFG will continue to listen to young researchers and find out what support they need with a view to adapting its funding programmes where appropriate. Through networking and dialogue with other research organisations at both national and European level, it is working to make research careers more attractive and to recruit and retain the best people to research in Germany.

**Dr. Anjana Buckow** is a Programme Director in the DFG Research Careers Division.

Illustration: Private


Illustration: http://grc2014beijing.cn

*Formal opening ceremony: this year's Global Research Council formally commenced in the Great Hall of the People in Beijing.*

# Towards Global Standards

## Third annual meeting of Global Research Council in Beijing discussed early career support and open access

Discussions at the third annual meeting of the Global Research Council (GRC) in Beijing at the end of May focussed on issues of global interest in research and research funding. At the three-day meeting, senior representatives of more than 60 research funding and research organisations discussed measures with which to find a common basis for the funding of early career researchers and open access to scientific publications. Germany was represented at the meeting by the DFG and its President, Peter Strohschneider.

Founded in 2012, the GRC is a voluntary, informal grouping of the heads of research councils from all over the world. It represents the majority of public research and research funding bodies which do not receive direct governmental funding and acts to strengthen international collaboration on research and between research funding organisations.

The organisation of this year's meeting of the GRC was shared by the Chinese Academy of Sciences (CAS), the National Science Foundation of China (NSFC) and the Canadian Natural Sciences and Engineering Research Council (NSERC). At a formal opening ceremony in the Great Hall of the People, China's Premier Li Keqiang gave a highly regarded speech in which he emphasised the importance of freely accessible opportunities for development, of intellectual property and of knowledge-driven research to an effective research system.

Plenary sessions took place on the second day in the Sino-German Center for Research Promotion (SGC). This was opened in 2000 by the DFG and the NSFC, a partner organisation of the DFG, and since then has played a significant part in establishing collaborative research ventures between the two countries.

In a speech given at the closing session DFG President Strohschneider emphasised the importance of science and research for social development and business innovation. "In order to achieve their full potential, science and research need space and scope in addition to as much funding as possible. The GRC can make a significant contribution in this respect. Concerned with important overarching themes such as the principles of multilateral collaboration on research, good scientific practice, early career support and open access, it facilitates processes through which international agreement can be achieved and make a considerable contribution to such principles", said Strohschneider.

www.dfg.de/en/service/press/press_releases/2014/press_release_no_20

# Copernicus Award 2014

## Physicists Duo from Munich and Gdansk to receive the Award from the DFG and the Foundation for Polish Science

Physicists Professor Harald Weinfurter from the Ludwig Maximilians University (LMU) in Munich and Professor Marek Żukowski from the University of Gdansk have been chosen to receive the 2014 Copernicus Award from the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) and the Foundation for Polish Science (FNP, Fundacja na Rzecz Nauki Polskiej) for their services to German-Polish research cooperation. The jury, which was made up of representatives from the DFG and the FNP, said that the physicists had been selected both as "outstanding individual researchers" and as "collaborating researchers" whose "joint research projects have yielded clear and important results". The Copernicus Award, with 100,000 euros in prize money, will be presented on 10 September 2014 in Berlin by the Presidents of the DFG and the FNP, Professor Peter Strohschneider and Professor Maciej Żylicz.

Weinfurter and Żukowski have been working together successfully for many years and have produced numerous joint publications. Professor Żukowski contributes his expertise in theoretical quantum physics, whereas Professor Weinfurter conducts experiments in this area. According to the jury, these two aspects complement each other well and also offer the potential for more joint research projects in the future.

The two physicists are the fifth pair to receive the Copernicus Award, which since 2006 has been conferred every two years to two researchers, one from Germany and one from Poland. Named after the astronomer Nicolas Copernicus (1473–1543), the award is intended to symbolise the close collaboration between the countries on research. The prize money is donated by the DFG and the FNP in equal shares and is divided evenly between the two prizewinners, who may use it for any scientific purpose that is within the scope of the funding programmes of both organisations. Priority should be given to jointly supporting early career researchers.

www.dfg.de/en/service/press/press_releases/2014/press_release_no_14/index.html

Illustration: Website LMU

Illustration: Fokierska-Żukowska

Illustration: Anuroopa Gupta

***"It's really an experience to travel over 1500 kilometres, visiting so many research sites and institutions."*** *This summed up the feelings of a group of young researchers from India, Thailand and China who, in two delegations, visited a series of medical research facilities in Germany in July at the invitation of the DFG. Prior to this they attended the Nobel Laureate Meeting in Lindau. All members had their own goals and motivations, as well as their own perspectives. "India is still a developing country," said one researcher, "which is why it's so important for us to explore science and technologies in other countries." The Indian delegation paid a visit to the Max Planck Institute (MPI) of Molecular Cell Biology and Genetics in Dresden, the MPI for Biophysical Chemistry in Göttingen, the Berlin-Brandenburg School for Regenerative Therapies and the International Research Training Group "Functional Molecular Infection Epidemiology". The trip culminated in a visit to the cluster of excellence "Cellular Stress Responses in Aging-Associated Diseases" at the University of Cologne, before the delegation called in at the DFG's Head Office in Bonn. "Through the Post-Lindau Tour the DFG is seeking to raise awareness of Germany as a place to research, because in partner countries the first choice for most researchers is an English-speaking country," says Ingrid Krüßmann, who is responsible for the Post-Lindau Tour at the DFG Head Office.*

# "Hopeful Pictures"

## German-Jordanian research cooperation: DFG delegation visits successful archaeological projects

Mid-May saw the culmination of a long-term German-Jordanian research project when, in the presence of HRH Prince El Hassan bin Talal and his daughter Princess Sumaya bint El Hassan (our photo below), the restored early Islamic desert palace of Qasr al-Mshatta was formally handed over to the public. The ceremony was attended by a delegation from the DFG (German Research Foundation), the Prussian Cultural Heritage Foundation and the German Federal Foreign Office.

Researchers from TU Berlin, the National Museums in Berlin and the Jordanian antiquities authority spent six years studying and restoring the ruins. The archaeological research was funded by the DFG, with funding for the restoration work coming from the Jordanian antiquities authority and the German Federal Foreign Office. DFG Secretary General Dorothee Dzwonnek, speaking at the site, described the project as "a very successful collaboration of two German funding agencies with outstanding results".

The DFG delegation also took advantage of the opportunity to find out about the current situation regarding university research in Jordan. The civil war in neighbouring Syria has triggered not only a humanitarian crisis with 1.5 million refugees, but also a considerable burden for the education system. "We must help by nurturing contacts and supporting new partnerships. Academic research is a vital bridge for the country's development and stability," said DFG Vice President Peter Funke.

*In a ceremony attended by a delegation from Germany, the restored desert palace of Qasr al-Mshatta is handed over to the public. 3rd from right Prince El Hassan bin Talal.*

Illustrations: Bienert

*Briefing at a burial site: DFG Secretary General Dorothee Dzwonnek and DFG Vice President Peter Funke (2nd from right).*

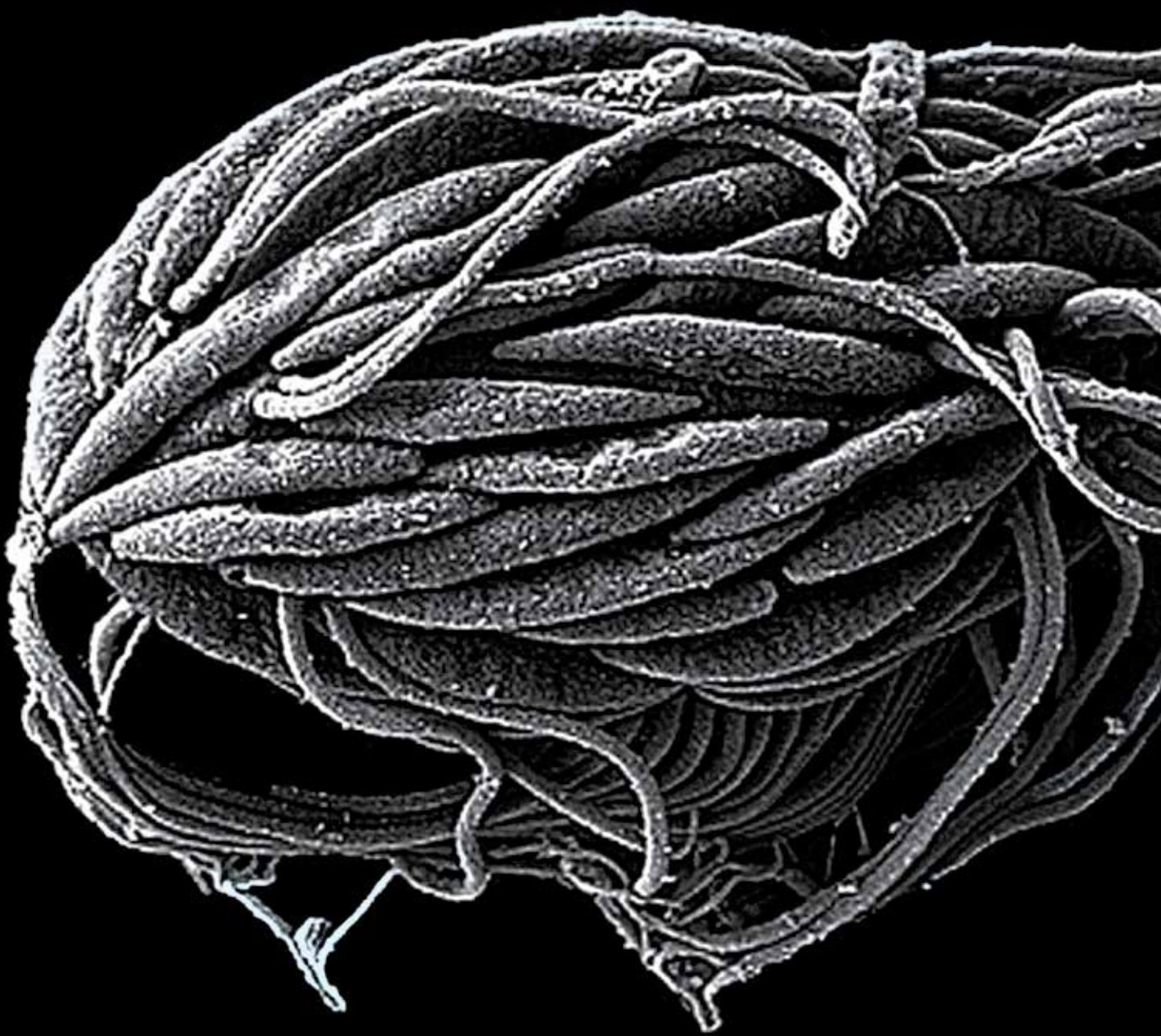
The DFG delegation also visited Jordan's new national museum in Amman, where the director, Professor Zeidan Kafafi, told them about Jordan's richly varied history at the intersection between ancient civilisations. The country's rich archaeological heritage includes the ancient town of Gadara in the north, the Roman fort of Qasr Bashir on the Limes Arabicus, and the Nabataean capital Petra. In Gadara and Petra the DFG delegation visited a number of German-Jordanian research projects. The close partnership and in many cases friendship between researchers from the two countries was once more in evidence. In the words of the DFG Secretary General: "In a region with little cause for optimism in certain aspects, it was an extremely pleasing and hopeful picture".

**Dr. Hans-Dieter Bienert** is the DFG Programme Director for Ancient Studies.

Thorsten Stoeck and Lea Weinisch

# Life at the Limits

Protozoa play a key role in the food webs of the oceans. Ecologists are seeking to understand the evolution and species diversity of microbial plankton – both in the laboratory and at the bottom of the hostile, low-oxygen deep-sea basins of the Mediterranean Sea.



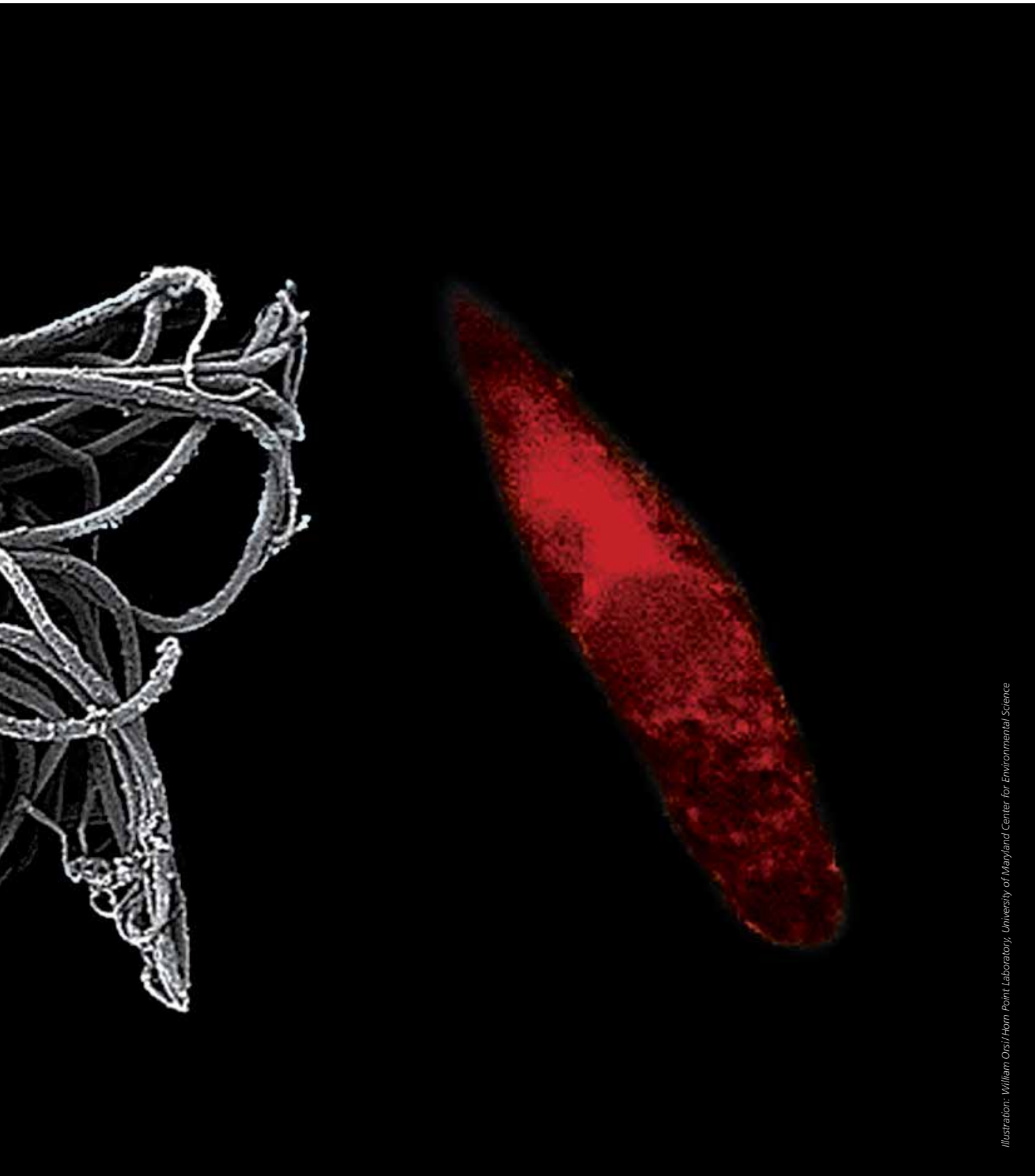


*Illustration: William Orsi/Horn Point Laboratory, University of Maryland Center for Environmental Science*

27 November 2011, 4.25 a.m. In an air-conditioned, darkened control room on board the research vessel *R/V Atlantis*, a team of marine biologists, oceanographers and technicians has gathered to witness something no one has ever seen before. They are observing the submersible robot *Jason* as it embarks on a journey into the deep. It takes the robot over three hours to reach its destination. On the computer monitors, the first images appear. It is absolutely dark, the blackness pierced only by *Jason's* searchlights. Then suddenly the researchers see a glimpse of a fascinating world: a saline lake on the bottom of the eastern Mediterranean Sea, over 3500 metres below sea level.

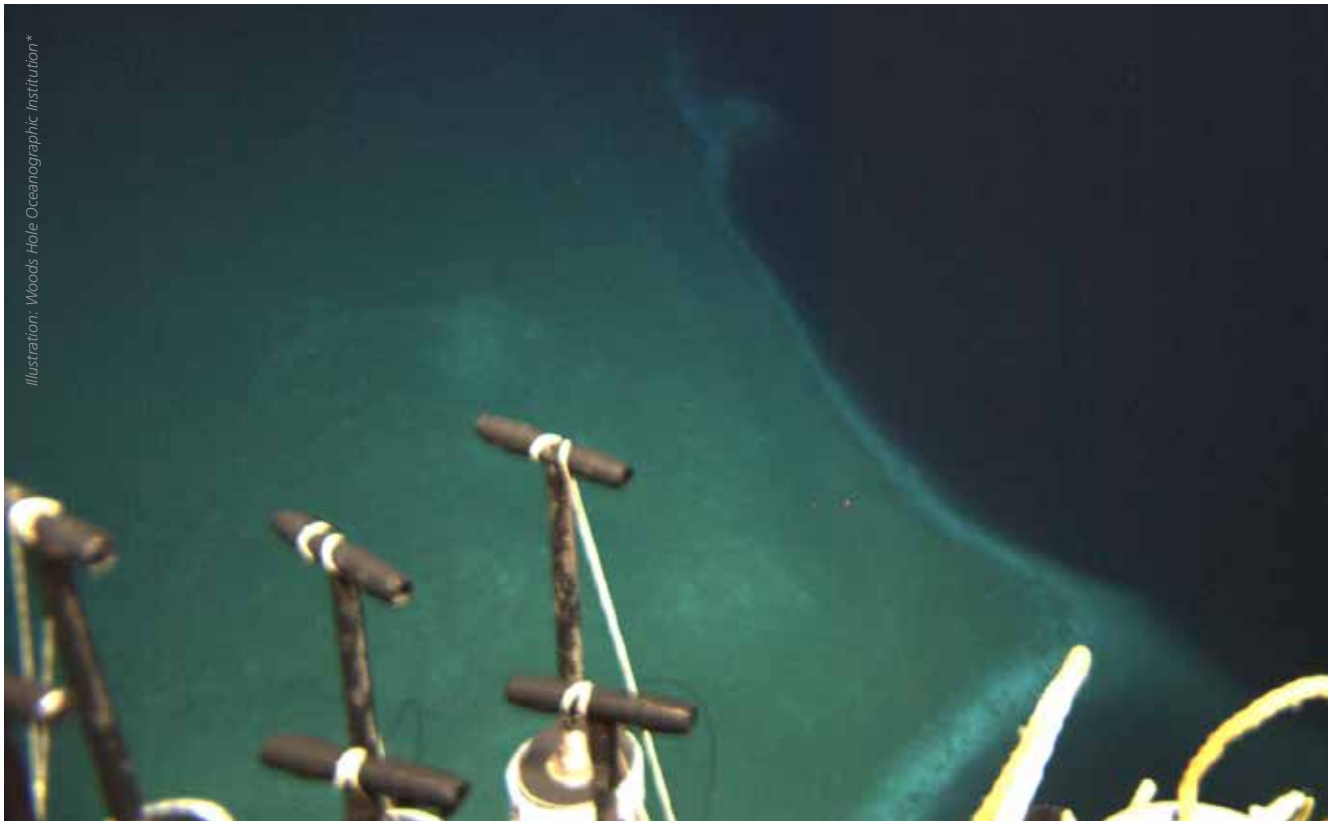
As if weightless, *Jason* floats over the brine lake, the boundaries of which are marked by a white fringe where the lake meets the seabed. Bizarre creatures appear in the light of the searchlights. But no living thing dares to penetrate the black mirror of the lake's surface and the world below. This is very wise because a combination of poisonous gases, particularly hydrogen sulphide ($H_2S$), saturated salt concentrations and a lack of oxygen would quickly kill these inhabitants of the deep.

These "hypersaline basins" at the bottom of the eastern Mediterranean Sea formed approximately five to six million years ago when the movement of tectonic plates blocked the link between the Atlantic Ocean and the Mediterranean Sea. As a result much of the Mediterranean Sea dried up. In the deepest basins, huge evaporites (mineral sediments produced by evaporation) formed, some several kilometres across. Once the Strait of Gibraltar opened around four million years ago, the Mediterranean basin was re-flooded. The evaporites began to dissolve in the water, increasing the salt concentration in the deep-sea basins. The salty and heavy bottom water did not mix with the water of normal salinity and lower density above it. As a consequence, consumed oxygen in the deep water was not replenished and anoxia formed in the salty brines – extremely hostile to life.

Knowledge about life in these extreme habitats is very scarce, largely due to a lack of suitable methods for studying life in such environments. But new technologies developed in recent decades, designed for both expeditionary and laboratory use, are opening up

*Even while* Jason *is suspended above the water's surface, the crew of research vessel* R/V Atlantis *is busy preparing it for the next dive. In the deep sea it will collect samples and take images of an unknown world.*


Illustration: Stoeck




*The submersible robot* Jason *gazes at the Discovery Brine Lake on the bottom of the eastern Mediterranean Sea, 3500 metres below sea level. The lake appears black in the illumination of the searchlights. A white fringe, the White Beach, marks the boundaries of the lake.*

new avenues. Taking advantage of these strategies, we set out to study the polyextreme deep hypersaline anoxic basins (DHABs) and gain new insights into the very limits of eukaryotic life.

With their combination of high pressure, low oxygen, hydrogen sulphide and saturated salt concentrations, these basins are among the most extreme habitats on our planet. Hydrogen sulphide is a highly poisonous and lethal gas. Apart from its irritant effect, it also gives off an extremely unpleasant smell of rotten eggs. However, the single most challenging factor in this environment is the salt concentration. Salt has been used since ancient times as a preservative. Just as it removes water from foodstuffs by osmosis, it deprives organisms of the water that is essential to cellular processes.

Water availability is measured as "water activity" ($a_w$), with pure water being defined as having $a_w$ of 1. The lowest $a_w$ at which cell growth has been measured in laboratory cultures is 0.61, in certain fungi and yeasts. The levels in the basins in question are between 0.35 and 0.4 – similar to the water activity measured in the Atacama Desert, the driest region on Earth.

For four years the team from the Ecology Division at the Technical University of Kaiserslautern has been studying eukaryotic microbial plankton or protists in DHABs. These single-celled organisms floating in the ocean play a key role in aquatic food webs and global biogeochemical cycles. The importance of microbial plankton, including all bacteria, Archaea, fungi and protists, becomes evident when you consider the size of their biomass in the world's oceans: ten times greater than that of all multicellular organisms in the oceans.

At the start of the study we wanted to find out whether there

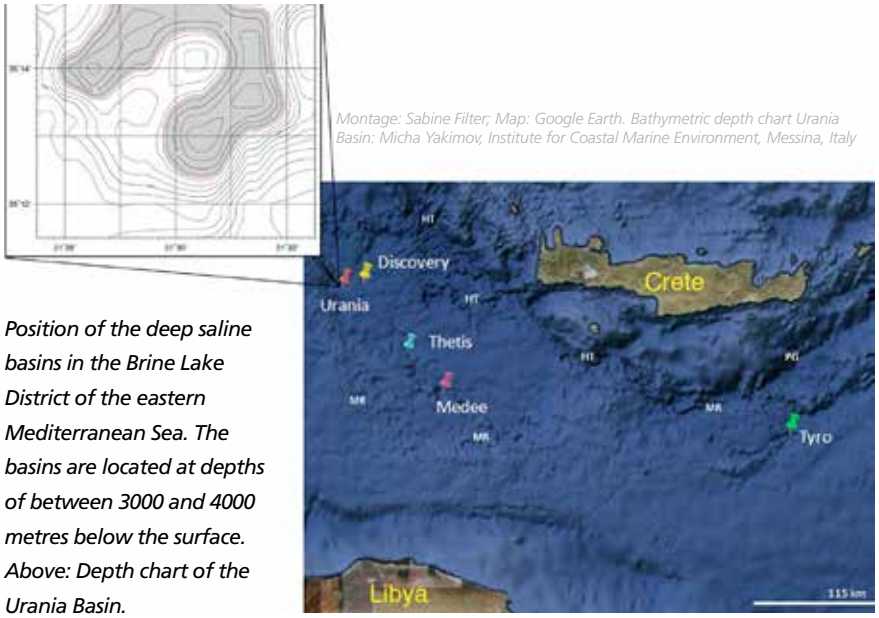
* ROV Jason *image is used by permission of Woods Hole Oceanographic Institution and were generated by collaborators J. M. Bernhard and V. P. Edgcomb (WHOI) during a cruise on* R/V Atlantis *in Nov–Dec. 2011, funded by NSF OCE-0849578 to V. Edgcomb and J. Bernhard.*


*In the control room: In a cramped but air-conditioned container on board the research vessel,* Jason *is controlled and monitored by the research team.*

was actually any evidence of eukaryotic plankton living in the brine lakes of the eastern Mediterranean's deep-sea basin. By analysing genes from water samples taken from the hypersaline broth, we got a definite answer. To our great surprise we found many different genes within the basin, pointing to the presence of a surprisingly large variety of plankton organisms in spite of the extreme conditions. However, we cannot identify species with certainty as most of the genes are new to scientists and indicate previously unknown life forms.

But do these genes actually come from organisms that eke out an existence in these hostile habitats? Or could they be the dead remains of organisms that have sunk down from the 3500 metres of water above the brine lakes? The only way to find out was to use a molecular biology technique known as fluorescence in situ hybridisation. Using the identified genetic information, specific gene probes are developed and labelled by attaching a fluorescent dye. If a target organism is present in the sample, the probe will bind to its genetic information and make it fluorescent under the microscope when exposed to certain wavelengths of light.

Bringing microplankton from the deepest part of the ocean safely on board the research vessel requires specialised equipment, because there is a high risk that the deep-sea creatures might be destroyed on their journey to the surface. Therefore a new, highly promising device was designed and developed in collaboration with colleagues from Woods Hole Oceanographic Institution, of which the prototype (Submers-




*Montage: Sabine Filter; Map: Google Earth. Bathymetric depth chart Urania Basin: Micha Yakimov, Institute for Coastal Marine Environment, Messina, Italy*

*Position of the deep saline basins in the Brine Lake District of the eastern Mediterranean Sea. The basins are located at depths of between 3000 and 4000 metres below the surface. Above: Depth chart of the Urania Basin.*

ible Incubation Device – In Situ Microbial Sampler, or SID-ISMS for short) underwent successful testing in 2010. SID is computer-controlled and allows researchers to manipulate samples deep underwater, carry out experiments "in situ" and even preserve sample material in the ocean depths. Preservation prevents the cells from disintegrating when the samples are recovered.

Back in the lab it was soon established that the organisms whose genetic signatures we found in the deep-sea brine lakes were in fact intact and alive. This was the first piece of evidence to show that eukaryotes can survive in almost saturated magnesium chloride concentrations (the equivalent of more than a kilogram of magnesium chloride per litre of water) – at high pressure and without oxygen. Faced with this evidence, we need to redefine the limits of eukaryotic life in saline environments.

New findings throw up new questions, such as: Why are the various hypersaline basins of the eastern Mediterranean Sea home to different plankton communities? The following scenario offers a possible explanation. When the various basins were flooded, their original plankton communities were recruited from the same incoming seawater. The gradual dissolution of evaporites and the independent geological and hydrochemical evolution of each basin then forced the organisms to gradually adapt to these specific habitat conditions. Organisms that could not keep pace with the changes in their environment ceased to be part of the plankton community in the forming brine lake.

The hypersaline basins also developed differently in terms of their physical and chemical characteristics, evidently depending on the evaporites and prevalent microbiological processes. This would explain the difference in salt concentration and type and the gaseous composition of the different basins. The obvious assumption is that a combination of environmental selection and evolutionary history has caused the development of different communities. Any interchange between the plankton communities of these basins, which are fairly close together geographically, is unlikely, as the surrounding "normal" deep-sea water presents a lethal barrier to these organisms. The plankton communities therefore specialised to cope with their habitat over thousands, if not millions, of years.

These low-oxygen saline basins are increasingly emerging as model habitats. With their help we can study ecological principles relating to the distribution, diversification and evolutionary history of protist plankton. The next questions are already clamouring to be answered: How, for example, does environmental selection work at a physiological level? What mechanisms allow these survival experts to exist in a habitat where freely available water is as scarce as in the desert? Their feat is all the more amazing for taking place at the very bottom of the sea!

**Prof. Dr. Thorsten Stoeck**
is head of the Ecology Division in the Department of Biology at the Technical University of Kaiserslautern.

**Lea Weinisch**
is a doctoral researcher in the Ecology Division/Department of Biology at the Technical University of Kaiserslautern.

Contact: TU Kaiserslautern, Fachbereich Biologie, Abteilung Ökologie, Erwin-Schrödinger-Straße 14 / Geb. 14, 67663 Kaiserslautern, Germany

The use of the research vessels *R/V Oceanus* and *R/V Atlantis* and the submersible robot *Jason* and the development of SID-ISMS for this project were supported by the National Science Foundation in association with Woods Hole Oceanographic Institution (MA, USA).

www.bio.uni-kl.de/ecology/home/

Rembert Unterstell


# A Phenomenal Journey

The wonder of bird migration: Armed with modern research methods, ornithologists at the Wilhelmshaven Institute of Avian Research are studying the internal and external mechanisms of annual migratory movements. Their latest model is the small northern wheatear.

When autumn comes and the leaves start to fall, something tugs at Germany's bird population. Migratory birds like starlings are gripped by a collective restlessness. They gather into flocks and perform a stunning, wonderfully synchronised flying ballet, sometimes in huge formations, to protect themselves against predators. Those of a romantic disposition might be inclined, standing on a balcony, to send their regards south with the starlings. To a bright child, meanwhile, the explanation is obvious: "It's not fair, they're all flying off on holiday!" Bird migration is one of the most spectacular phenomena in nature – and has mystified naturalists for hundreds of years.

Every autumn, 50 billion birds migrate from their breeding grounds to warmer winter quarters. Five billion make the journey from Eurasia to Africa alone. By the time these nomads of the air return to the north in spring, they have accomplished a truly amazing feat, having travelled thousands of kilometres over sea, mountain and desert. But why do they do it? And how do they achieve it? Cross-breeding experiments have shown that intensity of migratory activity, direction and destination are genetically programmed as basic patterns. The actual route is also

*Left: Always a natural spectacle – a flock of migrating birds, here a formation of cranes. Right: Recognition for Vogelwarte Helgoland. The German postal service issued an attractive special stamp to mark the station's 100th anniversary.*

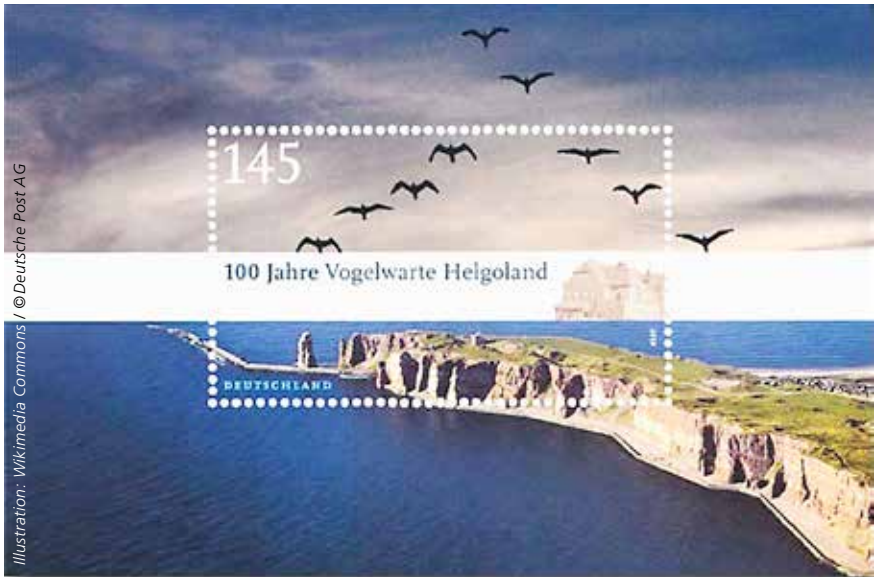



*Illustration: Wikimedia Commons / ©Deutsche Post AG*

influenced by environmental factors – weather, availability of food, predators – but these interactions are still poorly understood.

Research by both professional ornithologists and "birders" has shown that bird migration patterns vary enormously. There are short-distance migrants which travel up to 2000 kilometres, such as the robin, which migrates no further than the Mediterranean coast. And there are long-distance migrants, such as the common swift and the Arctic tern, which fly as far as southern Africa or the Antarctic. There are even "partial migrants", and of course non-migratory or "sedentary" birds, such as the tawny owl, the greater spotted woodpecker and the common magpie.

Researchers at Vogelwarte Helgoland, an ornithological station on Helgoland off Germany's North Sea coast which is part of the Institute of Avian Research, have been studying passage migrants ever since the station was first established in 1911. To date, over 800,000 birds have been captured and ringed at Germany's second oldest ornithological station, "more than any other site in Germany", says Professor Franz Bairlein, director of the institute. Because of its isolated island location, it is mainly migratory birds that receive a "Helgoland ring" and not "birds from the neighbour's garden". As the amount of data grows year on year, researchers are finding answers to many questions on the development of species populations and migration routes.

However, their aim is not to create a descriptive picture, but to achieve an "integrative understanding of the complex phenomenon of bird migration", says Bairlein, who in 2010 was elected president of the International Ornithologists' Union. The main area of interest is the interplay of innate and environmental factors, combined with the objective of "understanding the internal and external control mechanisms of bird migration". This calls for observation in the field combined with laboratory work (and vice versa).

*Illustration: Schmaljohann / IfV*

*The northern wheatear weighs just 25 grams but flies over 15,000 kilometres from Alaska to Africa. A geolocator on the bird's back helps researchers to map its exact route.*

But with which species can this type of work be carried out? For over ten years, Bairlein, 60, an eloquent old master of migratory bird research, has been studying the northern wheatear *(Oenanthe oenanthe)* at the Wilhelmshaven-based institute. Why this particular bird? The small songbird, weighing an average of just 25 grams, has one of the largest natural distributions and is a long-distance migrant with a complex migration system. Its breeding grounds range from eastern Canada and Greenland to Scandinavia and as far as Siberia and western Alaska; it winters in sub-Saharan Africa.

As "open-ground" birds, wheatears are also easy to observe. Another advantage that helps with outdoor work is the fact that they are relatively easy to capture and tag with coloured rings. And because they can be successfully bred and kept in captivity, the birds are also suitable for laboratory experiments under controlled conditions. So the small bird has many factors in its favour.

Bairlein and Dr. Heiko Schmaljohann, 39, have been studying "Migration Strategies of the Northern Wheatear" as part of a DFG project since 2001. They use the term "strategies" to refer to the "decisions and causes" that affect the birds' migration. A number of variants in migration routes have been documented for the first time. Before they departed on their annual migration, 20 birds from a breeding population in the Palatinate region of western Germany were equipped with tiny dataloggers. This revealed that the outward and return routes are not specific to the population but, in individual birds, may depend on different winds at the beginning of the autumn and spring migrations. Wheatears migrate solitarily and mostly during the night.

Wheatears that breed in Alaska migrate in a long arc from northern Russia across the expanses of Asia and the Caspian Sea to East Africa (Sudan to Kenya). They travel approximately 30,000 kilometres per year, maintain a steady 50 kilometres per hour through the night for hours at a stretch, and depending on wind, can cover 450 kilometres in a single night. "It's an extraordinary feat for a little songbird", enthuses Heiko Schmaljohann. The discovery attracted a lot of media attention and made the wheatear the world record holder among migratory songbirds.

The skills required for this Olympian feat are partly inborn. Experiments carried out with 20 hand-reared wheatears born in Alaska revealed that even in captivity, the birds developed "zugunruhe" (migratory restlessness) at night and exhibited a typical weight increase, also known as fat deposition, prior to migration. This sheds light on the internal and external factors of their extraordinary mobility, and confirmed to scientists that the wheatear was an extremely promising research model.

New methods for laboratory and field research also proved helpful. New analytical methods are being used to study the metabolic and biochemical processes in-

*Left: To study genetically inherited migration behaviour, young wheatears in Alaska are taken from the nest and hand-reared. Right: A wheatear tagged with coloured rings feeds from a dish of mealworms at a stopover on its migration route. The scales measure exactly how much food the bird takes.*

Illustration: Rolf Nagl / IfV


Illustration: Schmaljohann / IfV


Illustration: Rolf Nagl / IfV

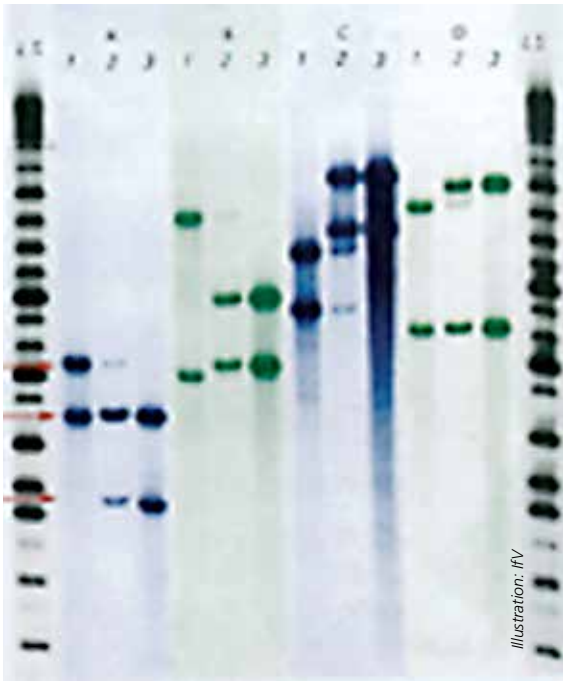


Illustration: IfV

*Heiko Schmaljohann (left) and Franz Bairlein carry out concentrated fieldwork in Alaska: here they are ringing a wheatear and fitting a geolocator. Right: Molecular genetics methods enable researchers to compare different wheatear populations with accuracy.*

volved in migratory bird behaviour, for instance in fat deposition. For field observation the researchers are using a method known as light-level geolocation. Satellite transmitters are currently too heavy for a small bird, but a geolocator can be used instead. Weighing less than a gram, the device is fitted on the bird's back.

The technical principle is simple, but evaluating the data is less so. The bird is equipped with a logger, which has a photocell that records the brightness of light over time. When the birds are recaptured the data can be retrieved from the logger. The researchers can use the times of midday and midnight to calculate the longitude and the length of daylight and night to calculate the latitude – and thus work out the migration route. The drawback of this technique is that, unlike satellite-based telemetry, geolocators do not allow the bird to be tracked directly. But for small birds it is the method of choice. Heiko Schmaljohann, who was awarded a Heisenberg fellowship by the DFG in 2013, is one of the researchers using the technique. The key question of his current research work is: "What effect does experience have on migration routes?" In Alaska he fitted geolocators on 240 wheatears to compare the journeys of old and young birds to East Africa.

In the future, data trails may be provided by a new tracking technique. The ICARUS project (International Cooperation for Animal Research Using Space, coordinated by Professor Martin Wikelski from the Max Planck Institute for Ornithology) will enter its pilot phase in 2015. In collaboration with NASA, an international consortium intends to establish a satellite system that can track even the tiniest living creatures. This requires miniaturised transmitters with a range extending as far as the International Space Station and, not least, immense financial resources.

What is certain is that bird migration is "a fascinating survival strategy in nature", which, as Bairlein emphasises, is still far from properly understood. Ornithologists and others are advocating for the freedom to study bird migration across political boundaries and cultural spaces in the interests of conservation. Bird migrations are a worldwide natural phenomenon that can only be understood with a global and holistic approach.

**Dr. Rembert Unterstell**
is Publishing Executive Editor of german research.

www.ifv-vogelwarte.de/index.php?action=sprache&lang=en

Sandro Jahn

# Fingerprints from the Depths of the Earth

Minerals and fluids contain basic information about the formation and structure of the Earth. Using new computer simulation techniques, scientists can now model concentrations of major and trace elements and their isotopes with great accuracy. This enables them to reconstruct geological processes that occurred billions of years ago.

Who isn't fascinated by the powerful forces that are unleashed when the Earth shakes beneath our feet or a volcano spits out ash and lava that can be seen from miles away? Can these events, with their often catastrophic consequences, be predicted? And could the energy stored beneath our feet be used for the benefit of humanity and the planet? Researchers in various disciplines of the Earth sciences are seeking answers to these very questions. Although current technology only allows direct samples to be taken to a depth of around 12 kilometres below the Earth's surface, our knowledge of deep Earth structure and processes is growing all the time thanks to interdisciplinary research approaches.

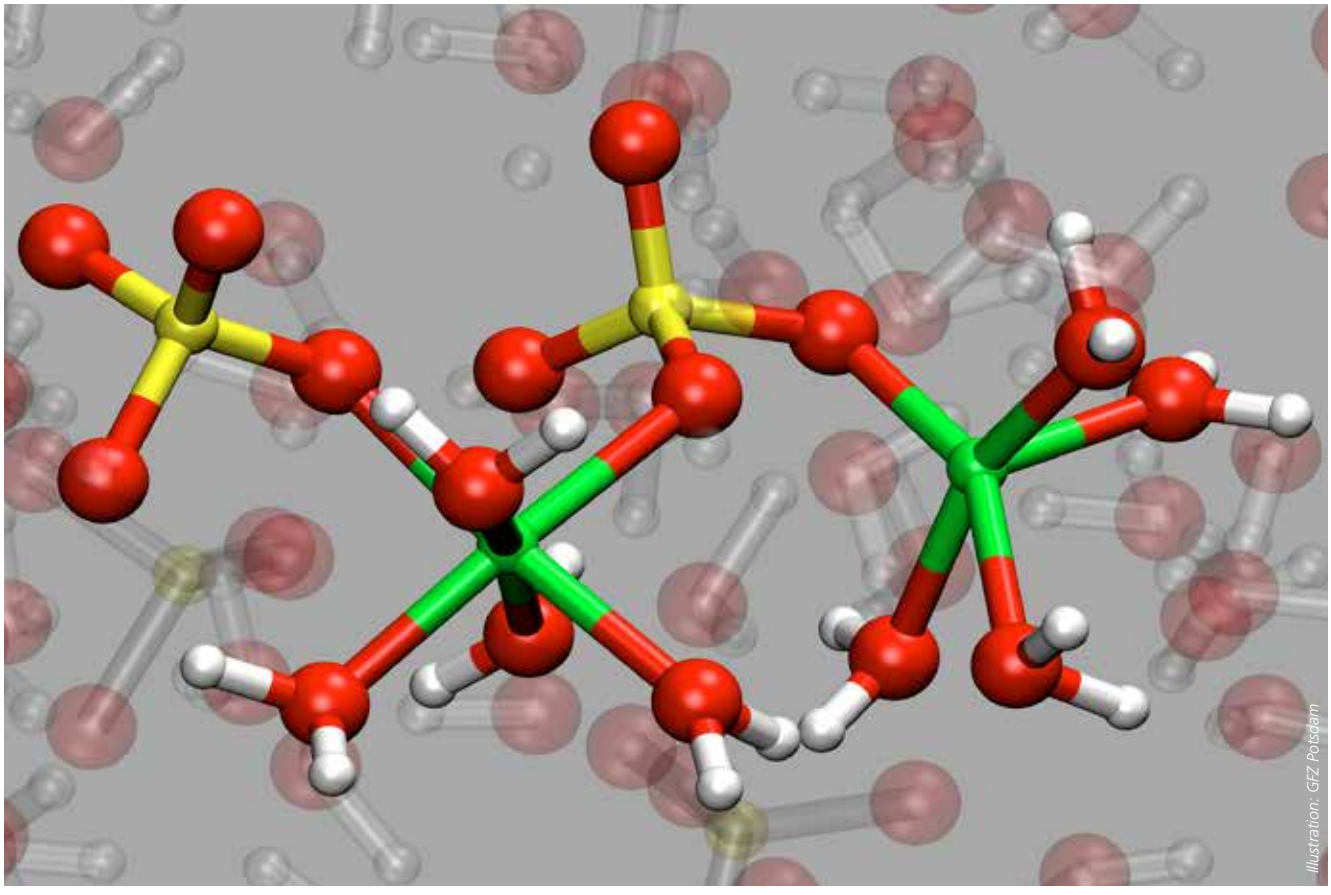


Illustration: GFZ Potsdam

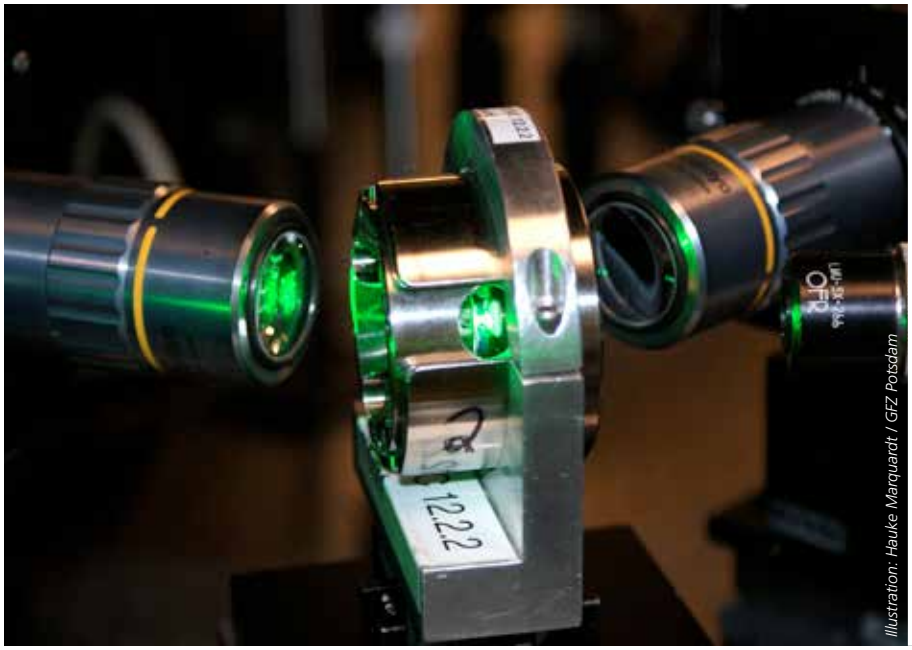



Illustration: Hauke Marquardt / GFZ Potsdam

Illustration: Christian Schmidt / GFZ Potsdam

*Studying the Earth in the lab: an apparatus with a diamond anvil cell is used for high-pressure and high-temperature experiments. Right: Close-up of a diamond anvil cell, which can be seen on a very small scale in the sample chamber in the left picture.*

While geophysicists probe the Earth's structure by measuring the speed of sound waves or electrical conductivity, geochemists reconstruct the planet's history by studying the chemical composition of rocks. To interpret these geophysical and geochemical "fingerprints", researchers use both laboratory experiments and computer simulations.

An important role is played by mineralogy, the most important representative of geomaterials research. Among the questions mineralogists seek to answer are: What substances form under the extreme pressure and temperature experienced in the Earth's core and what are the physical and chemical properties of these substances? For experimental purposes scientists use high-pressure equipment that simulates the conditions in the Earth's mantle and core in the laboratory. Pressure is the ratio of force to area, which means that you can create pressure with either large forces or small areas, in other words small samples.

The highest pressures are currently produced in diamond anvil cells, by compressing a sample between two specially cut diamonds with a minute cross-sectional area of less than one tenth of a millimetre. By combining this pressure cell with laser heating, scientists can produce pressures of up to several million atmospheres and temperatures of thousands of degrees Celsius. This reproduces the conditions at the Earth's core.

One of the biggest challenges is to determine the physical and chemical properties of the sample under these extreme conditions. Because the samples are often so small that they cannot be seen with the naked eye, microscopic methods such as X-ray or laser spectroscopy are used. Although the measurement data provides unique signatures for the tested sample, it needs to be interpreted cautiously in terms of its applicability to geological processes. This is where computer simulations are playing an increasingly important role. Researchers are particularly interested in modelling methods that make predictions about the behaviour of geologically relevant material systems and do not depend on (often unknown) experimental findings.

Simulation methods like this are based on natural constants and the quantum-mechanical description of the atomic and electronic structure of the material being studied, which is why they are

*Left: Salt water under extreme conditions – an ab initio simulation of magnesium sulphate molecules dissolved in water at a pressure of 25,000 atmospheres and a temperature of 500 degrees Celsius.*

often described as ab initio (Latin for "from the beginning"). What substances form under particular conditions mainly depends on the chemical elements that are available and how the atoms arrange themselves to achieve the lowest possible energy state.

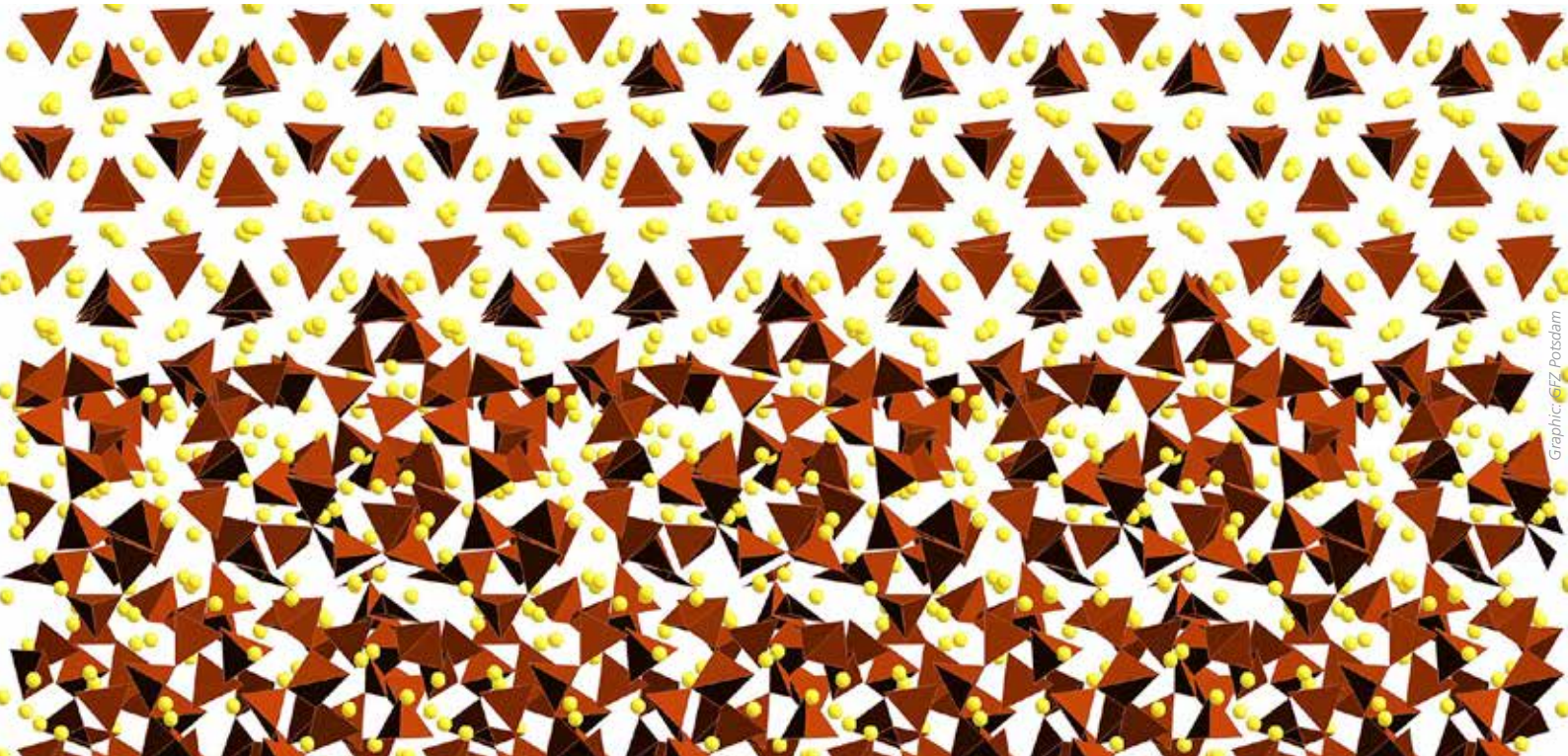
A large proportion of the Earth consists of minerals and rocks. Geological processes are also significantly influenced by liquids like water and generally aqueous fluids, which normally contain dissolved minerals, and melted rock, which may emerge to the surface as lava during a volcanic eruption. In our ab initio simulations we are able to calculate the total energy of a mineral, melt or aqueous fluid from the interactions between atomic nuclei and electrons. This allows us to establish a direct link between the atomic structure of the substance and its chemical and physical properties.

How is a realistic structural model created? Minerals are crystals, which means they have a periodically arranged atomic structure that can be established experimentally with techniques such as X-ray diffraction. The atoms in melts and fluids, on the other hand, are mobile, and their "disordered" structure is dominated by the interactions between immediately adjacent atoms. This local structure can be investigated with experimental approaches, but complete three-dimensional structure models of disordered substances often derive from molecular dynamics simulations. In a simulation of this type, virtual atoms are moved in a simulation box in accordance with the laws of classical physics.

In ab initio molecular dynamics simulations, the forces between the atoms are calculated using quantum mechanics. Simulations of this type demand enormous processing power and can only be performed by supercomputers like JUQUEEN at Forschungszentrum Jülich. The quality of a structural model is indicated by how well experimentally measured spectra are reproduced by those calculated through simulation.

The accuracy and predictive usefulness of ab initio simulations offer new perspectives on key questions in the Earth sciences. They enable us to measure the concentration of main and trace elements and their isotopes in minerals and fluids with a high degree of accuracy and thus reconstruct material cycles that have taken place over various time-scales from a few years to billions of years. The redistribution of chemical elements and isotopes mainly takes place in processes associated with the dissolution or formation of minerals. Processes like these are particularly efficient in the presence of melts

*Atomic structures: a crystal-liquid boundary as a model of a partially molten rock. Colour code – brown: $SiO_4$-tetrahedra, yellow: magnesium.*



Graphic: GFZ Potsdam


*Producing a geodynamic model requires huge amounts of data. The supercomputer is a key piece of equipment: author Sandro Jahn (right) with two doctoral researchers.*

and fluids. The distribution of elements and isotopes between two substances depends on the respective structural environments and chemical bonds.

By studying isotopes of light elements such as boron and lithium, we were able to demonstrate that ab initio simulations produce quantitative predictions and the isotopic signatures in rocks observed in experiments and in nature can be explained with the help of molecular models. For example, during subduction of an oceanic plate, as pressure and temperature rise with increasing depth, mineral transformations take place that release aqueous fluids. Due to their molecular structure, these fluids are richer in heavy boron and lithium isotopes than the newly formed minerals and their low density gives them buoyancy. In this way, the isotopic signature produced by the fluid-mineral reaction several kilometres below the Earth's surface is transported to the surface, where it can be measured – for instance in volcanic rock.

In addition to the modelling of geochemical processes, molecular simulations also provide fresh insights into the physical transport of materials and heat inside the Earth and the processes that shaped the planet's early history. It is assumed, for example, that the Earth's metallic core formed after a separation of molten silicates and metals in a global magma ocean many hundreds of kilometres below the surface. The heavy molten metal sank with gravity into the less dense siliceous environment, causing the metal to collect at the centre of the Earth.

The period over which this process could have taken place depends on a number of factors, including the viscosity of the silicate melt. Molecular dynamics simulations indicate that a typical magma ocean, down to great depths, has approximately the same viscosity as olive oil. Recently, we have started to look at the distribution of elements between silicate and metal melts and heat transport within minerals and melts, which is very important to our understanding of geodynamics.

A system as complex as the Earth can only be understood through interdisciplinary research approaches. Molecular simulation methods combined with rock sampling and high-pressure high-temperature experiments supply basic data for geodynamic models. The ongoing development of supercomputers is increasingly allowing researchers to describe geological processes quantitatively with basic physical and chemical principles.

**Dr. Sandro Jahn**
leads the Emmy Noether independent junior research group "Melts and Fluids in Geomaterials: From First Principles to Geological Processes" at GeoForschungsZentrum Potsdam.

Contact: Deutsches GeoForschungsZentrum GFZ, Telegrafenberg, 14473 Potsdam, Germany

www.geomaterials-modeling.de/

Susanne Krogull and Annette Scheunpflug

Illustration: Welsch / Deutsche Pfadfinderschaft Sankt Georg

# When Good Intentions Aren't Enough

Youth exchange programmes between industrialised and developing countries are flourishing. But how do they help young people learn more about world society? An empirical study shows that the pedagogical setting and organisational framework are decisive factors.

Learning to understand globalisation is an important educational goal. In order to understand political and economic processes, interrelationships in a global context, tolerance and interculturality, it is crucial to have a global perspective. This can be acquired through numerous learning opportunities, including travel and international exchanges. Educational trips and exchanges for young people have been popular ever since the Second World War, as European cooperation and German-American understanding increased. But it is well known in pedagogical research that they do not always, or automatically, remove prejudices or build mutual understanding.

For over ten years, exchange programmes for young people have taken place not only in Europe and North America, but also in devel-

oping countries. In Germany, the federal and state governments promote and encourage such trips, for example through a development-oriented schools exchange programme known as ENSA, with the motto "Learning to see one world". Until recently, little was known about the demonstrable effects of such programmes. But what do young people and young adults aged between 14 and 20 actually learn from these trips? And what lessons can we draw from this with respect to the process of learning about world society? The research project is concerned with the experiences, reflections and learning processes of young people and young adults who participated in two- to four-week trips, six months to two years after returning home. Participants were selected from among young people in Germany, Bolivia and Rwanda, with those from an industrialised nation having visited a developing country and vice versa. Contact was made with the young people and the group discussions, usually involving four to eight participants, were recorded.

In this way it was possible to reconstruct the learning experiences of one group from Germany who travelled to Rwanda, four groups from Germany who travelled to Bolivia, and eight Rwandan and nine Bolivian groups who travelled to Germany. In total, the views of over 130 young people were incorporated in the empirical study. What were the key findings?

Firstly, it is too optimistic to expect the visit to automatically produce an understanding of the economic and political situation in the host country. Instead, rather like analyses of intercultural learning in Europe, it is apparent that a carefully supervised "pedagogical learning setting" is necessary to stimulate interest where none was previously present, to challenge stereotypes and to promote understanding. If the young people receive no guidance, prejudices are often reinforced. Simply living in another culture does not create understanding, especially not with respect to complex development issues.

However, if young people receive such guidance, for example by being encouraged to reflect on their experiences or being made aware of other points of view in evaluation discussions, they gain a better understanding of global interrelationships. Working together on a "third topic" also facilitates the process of learning from each other. In other words, an exchange is more effective when participants not only experience the local culture but either engage with a third topic (such as climate change) or participate in a group activity (such as renovating a kindergarten).

Secondly, the study shows that the organisational structure of the groups is significant. School groups are markedly more suscep-

*A tent school in Rwanda (left) and a primary school classroom in Germany. The vast differences between developing and industrialised countries aren't limited to the home environment for children and young people.*

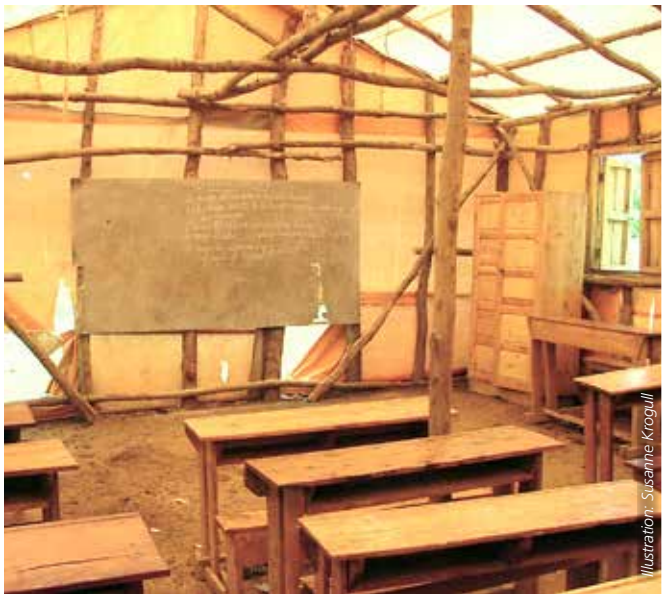


Illustration: Susanne Krogull

Illustration: Dieter Schütz / pixelio.de

tible to the reinforcement of prejudices and feelings of superiority or inferiority than groups from international youth organisations. School groups may generate a climate in which, as with the presumed situation in the classroom, differences are put down to differences in individual effort and ability, with social and political factors not being taken into account.

School groups from the North exhibit orientations that could be described as assistance-oriented, paternalistic and with a tendency to romanticise poverty. One German high school pupil, Nadine (all names have been changed), said after a four-week school trip to Bolivia: "The people there are different from people here, very open, friendly. You get to know new people quickly. There is always a good atmosphere, almost everywhere. Even the poor people seemed to radiate something, a kind of cheerfulness."

School groups from the South tend to be deficit-oriented and not infrequently romanticise affluence. François, a high school pupil from Rwanda, was particularly struck by two things: "Flying to Germany in an aeroplane, travelling to another country, another continent, that is very good. That is the first thing. And the second thing for me was visiting a white [emphasis] family. We shared meals at the same [emphasis] table. That is the second thing." Feelings of inferiority and superiority are in evidence.

In other words, these groups lack the (thought) categories with which to approach these experienced differences constructively. By contrast, young people in youth organisations which are internationally organised and permit a high degree of codetermination (such as scout associations), exhibit greater sensitivity to development issues. In the case of young people belonging to organisations with strongly uniform traits (such as Catholic youth groups travelling as part of church activities), the characteristic trait of this institution is dominant, with the result that experiences of foreignness take a back seat.

Thirdly, we were able to demonstrate that it is clearly necessary to possess sufficiently differentiated knowledge about societal structures, societal orders and different concepts of society before a trip in order to

*Discussing and reflecting as a group: The "written conversation" is a useful technique. It presents questions, answers and thoughts generated by a group.*

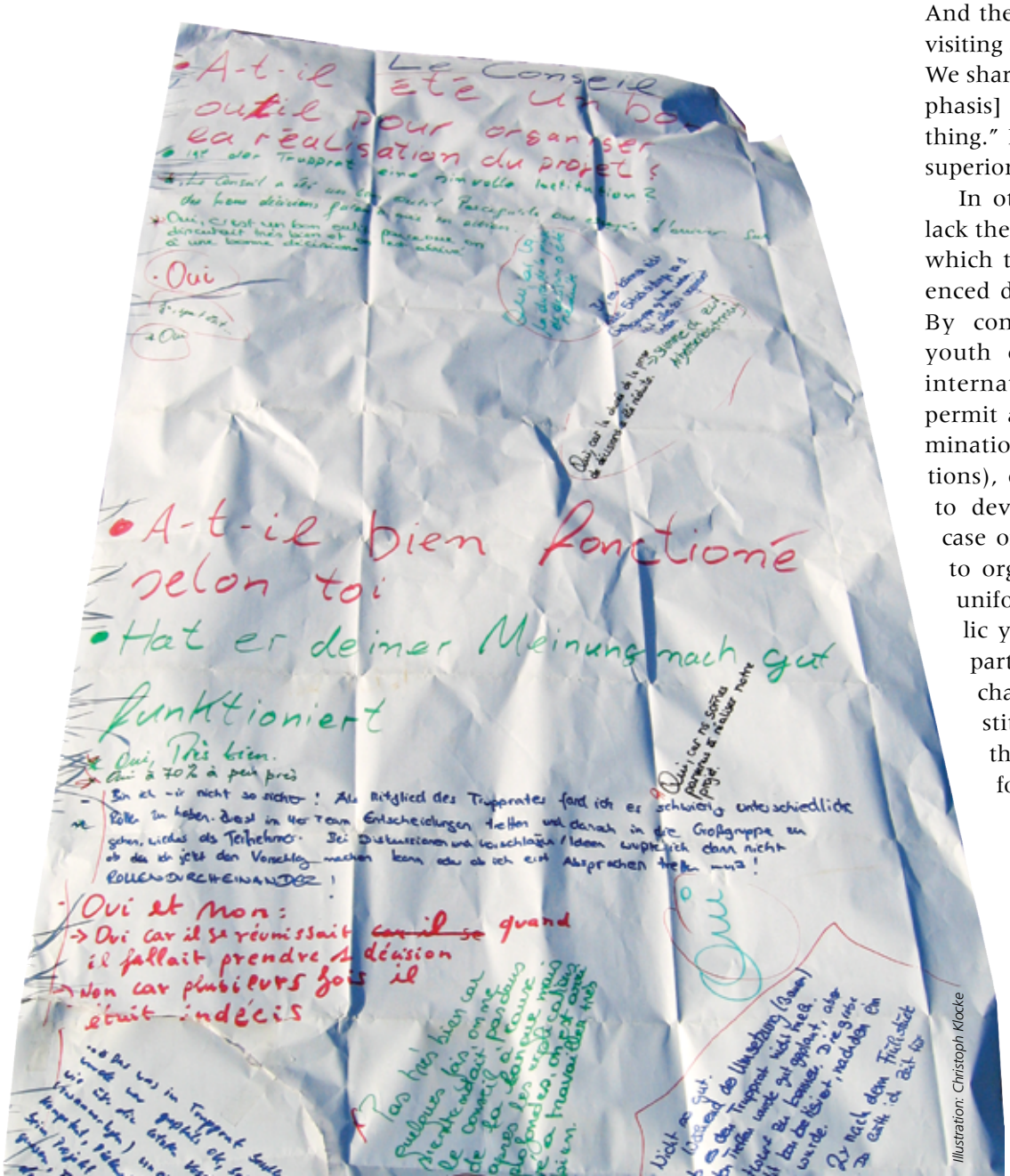



*Illustration: Christoph Klocke*


Illustration: Markus Kreuter


Illustration: Susanne Krogull

*Buying fruit and vegetables: on the left a "colourful" farmers´ market in Bolivia, on the right a neatly arranged display in a German supermarket. Outer appearances are one thing, different business mentalities another.*

perceive to any degree the world society dimension of globalisation. Young people from Rwanda, who come from an environment in which the contractual nature of a society is absent but where family structures and values constitute the dominant pattern, often only notice differences in close personal proximity, such as food, clothes and people's houses. Monique, a high school pupil from Rwanda, mainly noticed the differences in building styles: "Buildings in Germany are different from those in Rwanda, because we use small bricks and the Germans use large bricks." This pattern is less frequently and less markedly observed in participants from Germany and Bolivia.

Only once an individual understands that a social order is based on a set of rules created by people will he or she be interested in the way these rules are organised in other countries. Pablo, a Bolivian teenager who belongs to a youth organisation, says: "I really think I have learned something very important about what a new concept of order is: order in society, order in behaviour, order in a whole society that works to make a society what it is." Here we see evidence of abstract ideas being perceived and reflected on in an international context.

The research findings provide an important foundation for further research in political education. For example, the contractual nature of society, mentioned above, has scarcely been touched on in international comparative studies on political education. Our study provides encouragement to those who for some time have been calling for differentiation in this area. The results may also be of use in the design of funding programmes for international trips of this kind. Finally, they suggest a wide range of preparatory didactic measures that could be used prior to a trip, including exercises for changing perspectives, management games relating to the contractual nature of societies, and others. This too could help young people travelling to and from the global South to better perceive development challenges – and gradually, it may be hoped, to better understand them.

**Susanne Krogull**
is research assistant to the Chair of General Pedagogics at the University of Bamberg.

**Prof. Dr. Annette Scheunpflug**
is the holder of the Chair.

Contact: Otto-Friedrich-Universität Bamberg, Lehrstuhl für Allgemeine Pädagogik, Markusplatz 3, 96047 Bamberg, Germany

www.uni-bamberg.de/allgpaed/leistungen/forschung/

Michael Kaliske

# Getting to Grips with Cracks

Components made of rubber are everywhere – and everywhere they are subject to wear and material fatigue. To make tyres, bearings and gaskets more durable and reliable, engineers are turning to fracture mechanics. Complex simulations are producing new insights.

Elastomers have some amazing properties. Unlike other materials such as glass, steel or wood, they retain both their structural shape and their elasticity even when subjected to large deformation. The properties of both material and the component remain unchanged. This makes rubber the ideal material for gaskets, bearings and pneumatic tyres.

One key criterion for the practical usability of rubber is the durability of the component, as damage to bearings or seals in engines and other machinery can cause major failure. A punctured tyre on a vehicle can have disastrous consequences. In the late 1990s, tyre failure in a particular tyre/vehicle combination, particularly in the USA, caused a series of accidents with a high number of casualties.

It became necessary to improve the durability and quality of products

Illustration: naphtalina / istockphoto.com

*Specialised knowledge of fracture mechanics, computer simulations and new research-generated insights into the behaviour of rubber components play a key part in day-to-day work at the Institute for Structural Analysis in Dresden.*

Illustration: ISD / TU Dresden

made from elastomer materials. Experimental and theoretical-numerical research was stepped up with the aim of developing better concepts for the characterisation and prediction of the durability properties of elastomer components, particularly pneumatic tyres.

The properties of natural or synthetic rubber, vulcanised and reinforced with various additives, that make it so attractive for technical use, also hamper analysis and our understanding of the material's "structural behaviour". The degree of deformation may amount to several hundred percent. Although rubber is highly elastic, it also converts mechanical energy into heat in a process engineers call "dissipation". This can cause the properties of the polymer material to change. These changes must be measured experimentally and incorporated into the theoretical-numerical structural analysis.

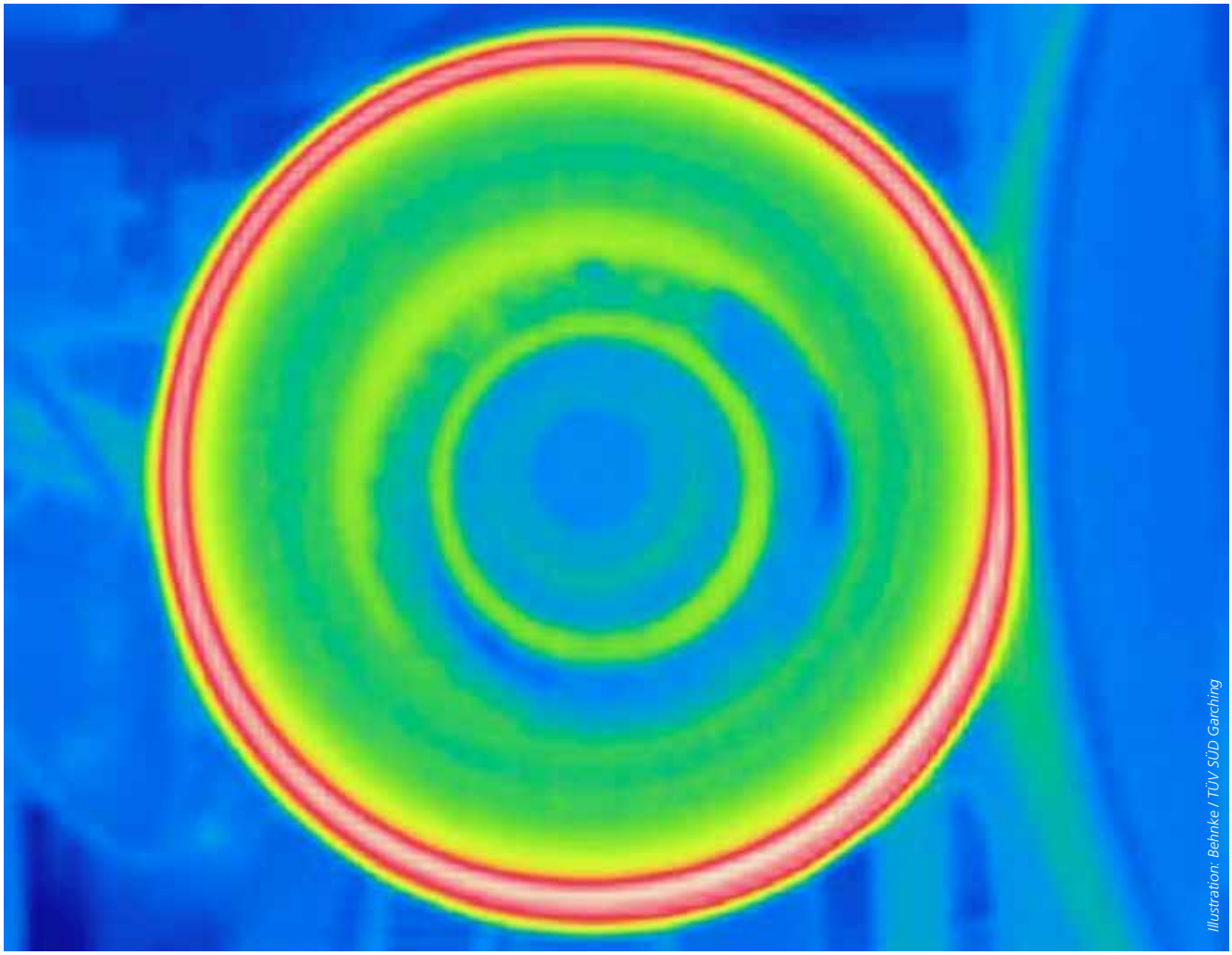
The area of research concerned with the formation, characterisation and growth of cracks in materials and structures is known as fracture mechanics. During the 1930s and 1940s, welded steel structures on ships and bridges began to experience damage with catastrophic consequences. This gave considerable impetus to the field of fracture mechanics, which studies structures at risk of fracture. It is obviously crucial to be able to assess the robustness of a component, its sensitivity to crack growth and its structural behaviour.

With the rapid development of computer technology in recent decades, which has opened up new horizons for the theoretical-numerical description of complex materials, structures and processes, questions in computational mechanics have grown in importance. The virtual representation of the structural behaviour of rubber components – i.e. the realistic description of geometry and material on the computer – allows scientists to study load scenarios and influences without having to build actual prototypes.

One of the most important questions is the analysis of durability characteristics, in other words the influence of cracks and crack growth on structural behaviour. This area of research and the ever-growing possibilities of computer and simulation technology have together driven progress in studies and approaches in fracture mechanics. The DFG Research Unit 597 "Fracture Mechanics and Statistical Mechanics of Reinforced Elastomer Blends" is contributing new findings to this field. In a sub-project, "Macroscopic Modelling and Numerical Simulation for the Characterisation of the Fracture and Durability Properties of Reinforced Elastomer Materials", the basic theoretical-numerical methods for elastomer fracture mechanics were further developed and adapted for use in computer-aided applications.

Essentially, the goal is to develop computer-based indicators and analytical methods for cracks in elastomer products that provide realistic and reliable predictions of durability. One challenge facing scientists is the question of how to take the particular material properties of elastomers into account in simulations, including enormous deformation, temperature dependence, absorption properties and time dependence.

In the next step, the researchers study the durability properties of a component made of this material with its complex characteristics. Simulation not only allows us to predict properties without hav-



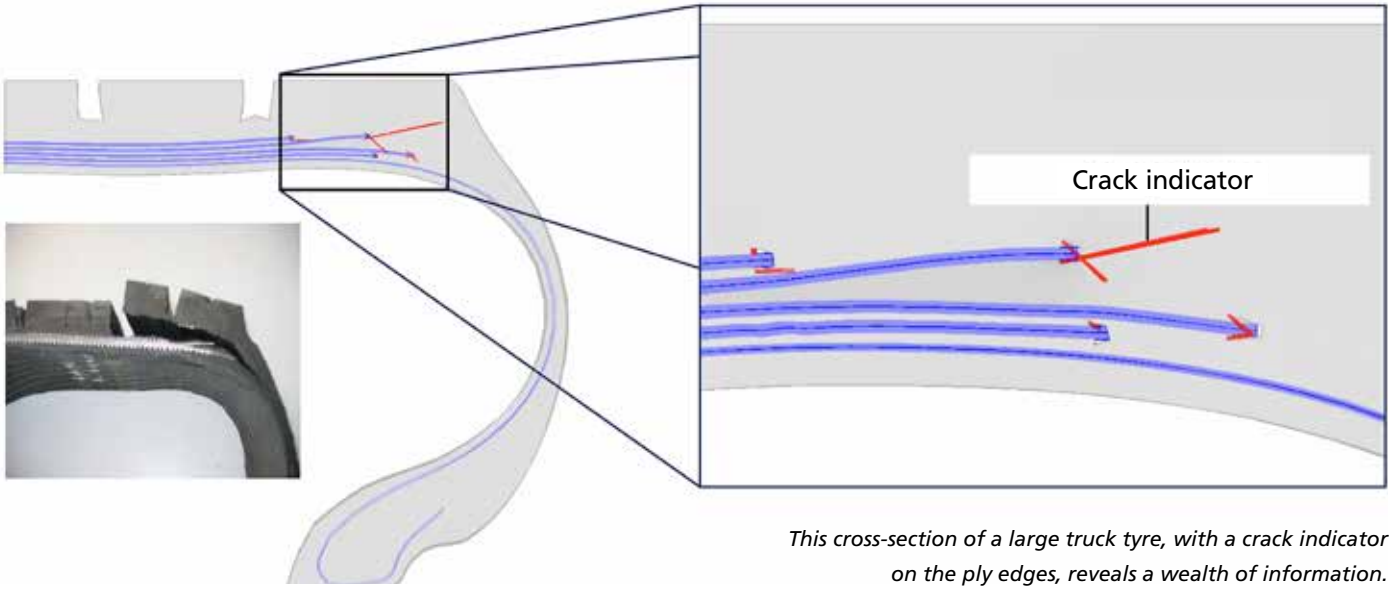

*Colourful and dynamic: it might look like modern art, but in fact this image shows the heating of a tyre on a drum test rig.*

ing to physically manufacture the component, but also enables us to answer questions that are difficult or impossible to study experimentally. Armed with these findings, we can optimise the design and "dimensioning" of components.

The elastomer structures often have a complex geometry and consist of different material components. The load-bearing properties of elastomer components are "toughened" by textile reinforcements according to the application in which the components are being used. Pneumatic tyres, for example, are supported by plies which may be made of steel or polymer cords. In the simulation, the component – represented in a high-resolution virtual model with a crack – is subjected to various load scenarios. The cracks may be caused during production (for instance on the ply edges) or by improper use. The computer simulates the response of the material.

As the material is dissipative, mechanical energy is converted, characterised in tyres by rolling resistance and the production of heat. Damping can be a desirable phenomenon in bearings, for example when it reduces vibration, but in rolling tyres it increases fuel consumption. The effects of forces and temperature on the structure are calculated in a numerical simulation. The calculation is usually based on a nonlinear equation system with many thousands of unknowns. Once the structural behaviour of a component has been realistically modelled and predicted on the computer, researchers can turn their attention to the area of interest with respect to durability – the area around the crack.

Studying new indicators that provide information about fracture




Graphic: ISD / TU Dresden

*This cross-section of a large truck tyre, with a crack indicator on the ply edges, reveals a wealth of information.*

sensitivity and crack development allows us to predict the maximum load level and so-called "failure behaviour". Once we have interconnected information about potential crack growth, including the direction of propagation, and methods for simulating the cracks that form, we can describe failure processes and, therefore, predict failure scenarios. What is important is that simulation methods require experimentally acquired information about material characteristics. Together with experimental component analysis, they provide fresh insights that are efficient, comprehensive and of a new quality. A development engineer can use all this information to help design a component.

*Investigating a test specimen: The researchers are interested in the durability of elastomer components.*

Illustration: Polymer Service GmbH / Merseburg

The methods used for the macroscopic description of components with numerical simulation represent a leap forward in our understanding of polymer/elastomer components. Future research must link macroscopic simulations with microscopic and mesoscopic descriptions of the material so that we can eventually describe polymer materials on smaller length scales, which offers promising outcomes.

In order for these methods to be practically applicable, it is essential to allow for the "uncertainty"of the information in the modelling process. Variations in material properties, geometric inaccuracies and imprecisely definable loads, for instance, all produce uncertainty. A practical, usable structural model can only be achieved when, far from an idealised depiction, the uncertainty of the material properties, loads and measuring techniques are quantified and modelled.

In other words, we must always keep the research practical and application-focussed. Putting methods to practical use is precisely the objective of a current transfer project, "Thermo-mechanical Durability Analysis for the Improved Design of Elastomer Components in Industrial Research and Development". This project brings together researchers and an industry partner.

**Prof. Dr.-Ing. habil. Michael Kaliske**
is the Director of the Institute for Structural Analysis at the Technische Universität Dresden.

Contact: Institut für Statik und Dynamik der Tragwerke, Technische Universität Dresden, 01062 Dresden, Germany

http://tu-dresden.de/die_tu_dresden/fakultaeten/fakultaet_bauingenieurwesen/sdt/index_html/document_view?set_language=en

# The Deutsche Forschungsgemeinschaft

The Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) is the central self-governing organisation responsible for promoting research in Germany. According to its statutes, the DFG serves all branches of science and the humanities. The DFG supports and coordinates research projects in all scientific disciplines, in particular in the areas of basic and applied research. Particular attention is paid to promoting young researchers. Researchers who work at a university or research institution in Germany are eligible to apply for DFG funding. Proposals will be peer reviewed. The final assessment will be carried out by review boards, the members of which are elected by researchers in Germany in their individual subject areas every four years.

The DFG distinguishes between the following programmes for research funding: In the *Individual Grants Programme,* any researcher can apply for financial assistance for an individual research project. *Priority Programmes* allow researchers from various research institutions and laboratories to cooperate within the framework of a set topic or project for a defined period of time, each working at his/her respective research institution. A *Research Unit* is a longer-term collaboration between several researchers who generally work together on a research topic at a single location. In *Central Research Facilities* there is a particular concentration of personnel and equipment that is required to provide scientific and technical services.

*Collaborative Research Centres* are long-term university research centres in which scientists and academics pursue ambitious joint interdisciplinary research undertakings. They are generally established for a period of twelve years. In addition to the classic Collaborative Research Centres, which are concentrated at one location and open to all subject areas, the DFG also offers several programme variations. *CRC/Transregios* allow various locations to cooperate on one topical focus. *Cultural Studies Research Centres* are designed to support the transition in the humanities to an integrated cultural studies paradigm. *Transfer Units* serve to transfer the findings of basic research produced by Collaborative Research Centres into the realm of practical application by promoting cooperation between research institutes and users.

*DFG Research Centres* are an important strategic funding instrument. They concentrate scientific research competence in particularly innovative fields and create temporary, internationally visible research priorities at research universities.

*Research Training Groups* are university training programmes established for a specific time period to support young researchers by actively involving them in research work. This focusses on a coherent, topically defined, research and study programme. Research Training Groups are designed to promote the early independence of doctoral students and intensify international exchange. They are open to international participants. In *International Research Training Groups,* a jointly structured doctoral programme is offered by German and foreign universities. Other funding opportunities for qualified young researchers are offered by the *Heisenberg Programme* and the *Emmy Noether Programme.* In so called *Reinhart Koselleck Projects,* the DFG supports especially innovative research undertakings by outstanding scientists and academics.

The *Excellence Initiative* aims to promote top-level research and improve the quality of German universities and research institutions in the long term. Funding is provided for graduate schools, clusters of excellence and institutional strategies.

The DFG also funds and initiates measures to promote scientific libraries, equips computer centres with computing hardware, provides instrumentation for research purposes and conducts peer reviews on proposals for scientific instrumentation. On an international level, the DFG has assumed the role of Scientific Representative to international organisations, coordinates and funds the German contribution towards large-scale international research programmes, and supports international scientific relations.

Another important role of the DFG is to provide policy advice to parliaments and public authorities on scientific issues. A large number of expert commissions and committees provide the scientific background for the passing of new legislation, primarily in the areas of environmental protection and health care.

The legal status of the DFG is that of an association under private law. Its member organisations include research universities, major non-university research institutions, such as the Max Planck Society, the Fraunhofer Society and the Leibniz Association, the Academies of Sciences and Humanities and a number of scientific associations. In order to meet its responsibilities, the DFG receives funding from the German federal government and the federal states, as well as an annual contribution from the Donors' Association for the Promotion of Sciences and Humanities in Germany.

# Impressum

***german research*** is published by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation);
Publisher: WILEY-VCH Verlag GmbH & Co. KGaA, P.O. Box 10 11 61, D-69541 Weinheim;
For the annual subscription rate please refer to the Wiley Online Library:
http://olabout.wiley.com/WileyCDA/Section/id-404508.html
Address of editorial staff: DFG, Press and Public Relations Office, Kennedyallee 40, 53175 Bonn;
postmaster@dfg.de; www.dfg.de

Editor-in-chief: Marco Finetti (responsible for content)
Publishing Executive Editor: Dr. Rembert Unterstell
Copy Editors: Stephanie Henseler, Angela Kügler-Seifert
Translation: SciTech Communications GmbH, Heidelberg; oneword GmbH, Böblingen
Printed by: Bonner Universitäts-Buchdruckerei (BUB);
Printed on Inapa Oxygen silk, coated, 100% recycled, FSC certified paper with a semi-matt surface.

ISSN 0172-1518


*Illustration: www.beruf-und-familie.de*

"Taking career balance a step further": the DFG has again been awarded the 'berufundfamilie' certificate for its family-friendly personnel policies. In mid-June, Kirsten Hüttemann, a Director in the DFG's Human Resources and Legal Affairs Division (centre in picture), accepted the certificate in Berlin from Caren Marks, Parliamentary State Secretary at the office of the Federal Minister for Family Affairs, Senior Citizens, Women and Youth, and Frank-Jürgen Weise, chair of the Hertie Foundation. It is the fifth time that the DFG has been awarded the certificate since 2001, making the organisation one of a very small group of German businesses and public institutions to have won the recognition more than once. Balancing a career and family is a central component of the culture at the DFG's Head Office, said DFG Secretary General Dorothee Dzwonnek, which is visibly put into practice at all levels. "This certification motivates us to maintain the same high standards in our family-friendly personnel policies and continue enabling researchers to combine a career with family commitments. But of course we want to see this happen outside the DFG too, which is why we will continue to promote family-friendly policies at universities and research institutions."