CGB - Centre for

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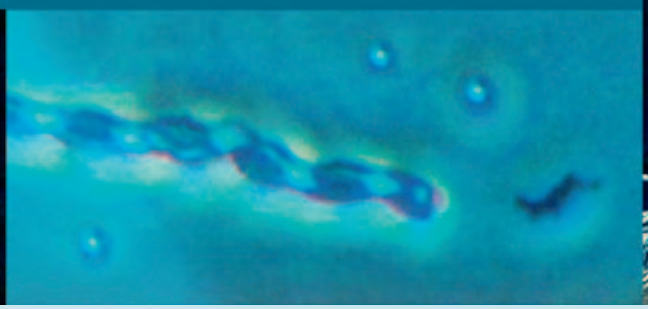
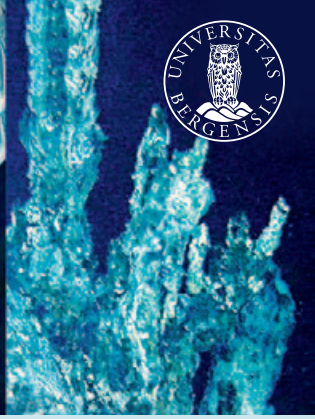
Annual Report 2009

Centre for Geobiology

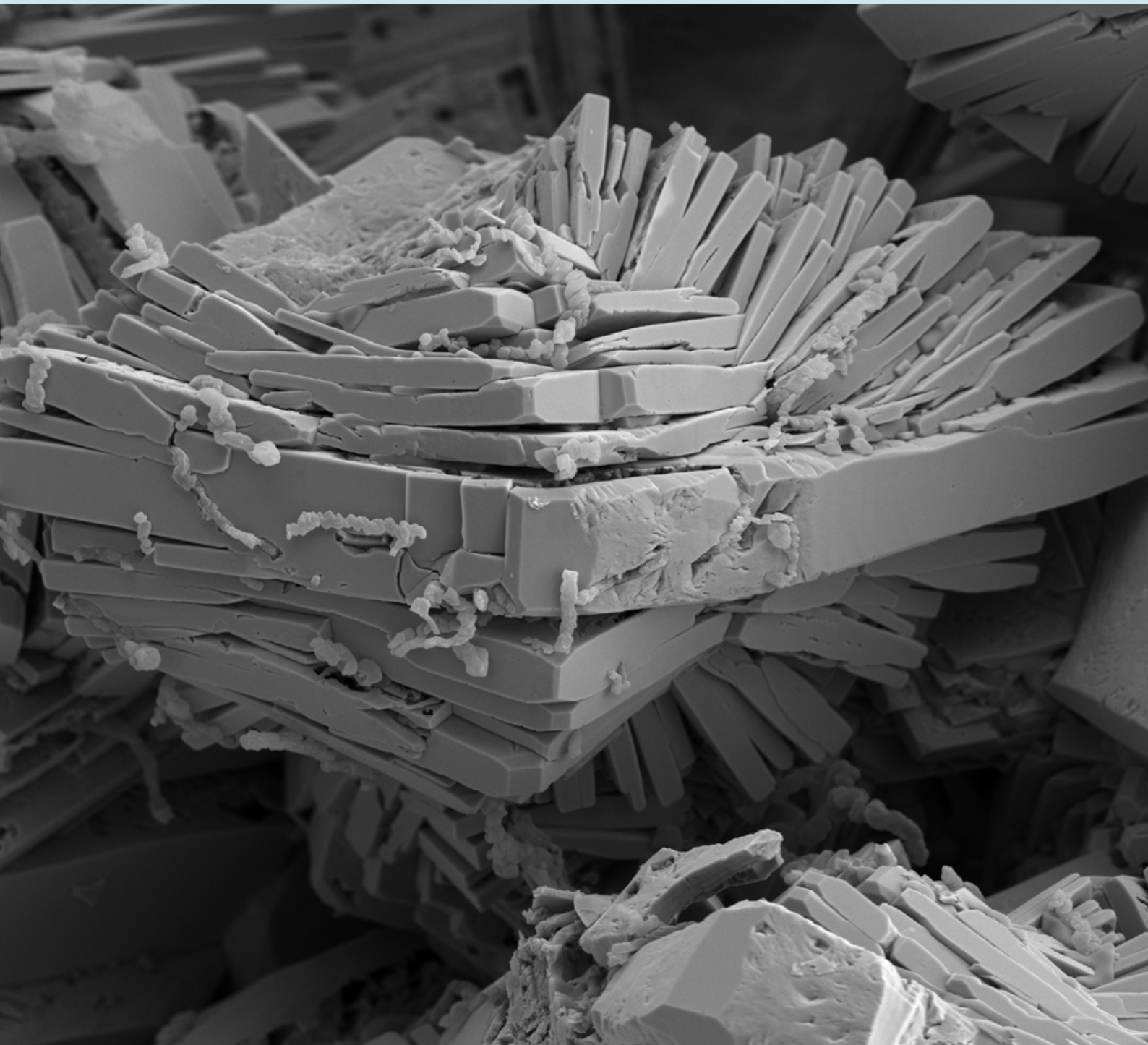
Norwegian Centre of Excellence





Annual Report 2009

Deep Seafloor • Deep Biosphere • Deep Time & Roots of Life



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Editor
Rolf Birger Pedersen

Copy editors
Elinor Bartle
Anne Fjellbirkeland

Print
Bodoni AS
www.bodoni.no

Miljømerket
trykksak
241 699

Frontpage photo:
Figure caption: Electron microscope picture of recently formed barite crystals and microbial filaments collected summer 2009 at Loki's Castle vent field. (Photo: Ingunn Thorseth)

Darwin collage by Eva Bjørseth 2009

2009 – a year of development

If 2008 was the year of discovery – then for us 2009 has been a year of development.

In 2008 we collected unique biological and geological sample material. This year our work focused on testing, developing and expanding a wide range of analytical techniques and methodologies to use in studying this material. In addition, efforts have been made to improve our bioinformatics and statistical procedures to optimise the reliability of the information we extract from the data.

- Cu, Zn, Fe and Cr isotopes are now routinely being analysed in our mass spectrometry lab, providing information about the effects of inorganic reactions or living organisms on the isotopic ratio of these heavy elements. By analysing some of Earth's oldest rock sequences, we aim to provide new information about the environment on early Earth and possibly identify biomarkers of early life.

- The amount of genetic information delivered from modern sequencing technology keeps increasing. Bioinformatics is needed to manage the analysis of so much data. By combining forces with the Computational Biology Unit at University of Bergen and with international collaborators we aim to stay in the forefront of this rapidly developing arena. A recent paper in Nature Methods underlines our success in this area.

- 2009 has been characterised by significant investments in equipment and human resources. A new Raman spectrometer was installed. The instrument provides new analytical opportunities for both geologists and biologists. Organic compounds can now be analysed in rocks in the search for traces of life, and microbial organisms can be labelled with molecular techniques and studied in situ to better understand their interaction and role in the microenvironment.

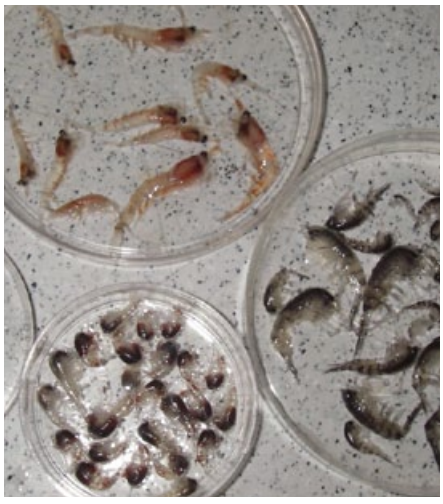
- A new laser-ablation system was also acquired in 2009. Coupled to our mass spectrometers this greatly expands the range of questions that can be addressed including improving our age-dating capabilities.

Continued careful characterisation of sampled material was ongoing throughout 2009. The kilometres of core from South Africa and Russia drilled in 2008 were carefully described and documented, and now represent physical archives of the early Earth environment that will be studied further by CGB researchers and international collaborators. A return expedition to Loki's Castle and the Håkon Mosby mud volcano with Discovery Channel onboard collected new, exciting material from hot vents and cold seeps.

In the three short years of its existence thus far, it has been particularly rewarding to experience how the knowledge being generated by CGB's basic, curiosity-driven science has relevance for new research initiatives with high societal relevance. Our expertise on seabed fluid flow environmental impacts is highly relevant for research on sub-seafloor CO_2 sequestration and potential leakage scenarios. Deep-sea mineral resources and bioprospecting for potentially interesting compounds from organisms living in extreme marine environments are other topics where our new knowledge is critical, providing a foundation for further development.

In 2009 the interdisciplinary mission of CGB has become increasingly clarified. It has been nurtured through workshops, weekly seminars, joint cruises - and in courses in biology for geologists and vice versa. Our Science Advisory Committee visited us in September 2009, giving us inspiration and guidance, confirming that we are on the right track - and underling the importance of further integration.

Professor Rolf Birger Pedersen



Highlights from the SAC Report

Three members of the Scientific Advisory Committee (SAC) had their first visit to CGB in autumn 2009. Centre researchers prepared an extensive poster display highlighting ongoing activity. In addition, there were presentations by each of the six theme leaders and by a number of young scientists leading seed projects. The feedback from the three international experts was unanimous: briefly their report stated that they were "impressed by the quality and ambition of the science being planned and undertaken," that CGB's research activity "is already of a high standard within all 6 themes" and that "the Center has developed very well after only 2.5 years of operation". In particular they noted that "the establishment of Early Earth and Biosignatures theme within the CGB is one of the most progressive aspects of the Center as a whole and puts the Norwegian community at the forefront of international mid-ocean ridge research where early-Earth studies are more typically quite decoupled from modern-day ridge-crest studies".

The SAC was also pleased "to learn about the success of the Center in raising additional funds for projects, and in establishing international collaborations," and "were impressed by their visit to the Centre's laboratory facilities". They noted that CGB researchers have "made considerable progress with developing and testing a number of molecular methods, including phylogenetic and functional marker genes, as well as metagenomic analyses. They have demonstrated the capability to deal with large molecular data sets, and have contributed to recent developments in bioinformatics."

In terms of field-work and sampling opportunities the SAC wrote that "a truly outstanding and important achievement is the exploration of a number of key target areas of high international relevance, such as the Northern vents, and the Nyegga and mud volcano seeps. Further field work in these areas seems an integrative point for all six themes of the Center." They feel that the potential results will be "highly relevant for the international community".

This experienced group of international researchers also recognized the challenges of inter-Department and inter-disciplinary collaboration. They encouraged Centre leadership and participants to continue to prioritise integration in their scientific endeavours.

Research themes

Research at the Centre for Geobiology is organised around six themes:
1) Deep Seafloor Geodynamics; **2)** Water-Rock-Microbe Interactions; **3)** The Deep Biosphere;
4) Vent, Seep and Fall Biota; **5)** The Roots of Life; and **6)** Early Earth and Biosignatures.

Below are some highlights from ongoing research or work published as a result of these thematic efforts in 2009.

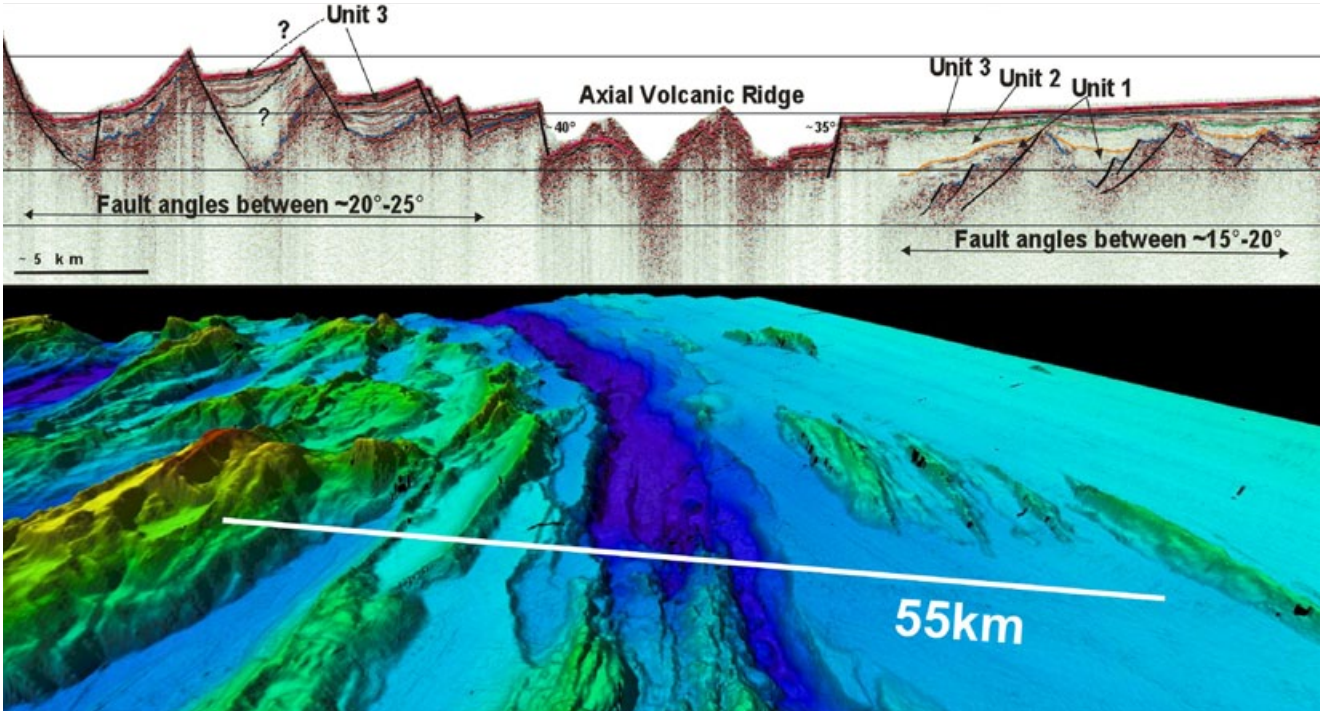
Deep Seafloor Geodynamics

Sedimentary deposits represent Earth's history book. By digging deeper and deeper into sedimentary layers, archeologists can read the history of mankind, and by sampling older sedimentary rocks paleontologists study the prehistoric life on Earth. Spreading ridges - like the Mid-Atlantic ridge - are the most geologically dynamic environments on Earth with thousands of active volcanoes and faults, and probably around a thousand active hot springs. Since spreading ridges usually are located in the middle of the oceans where sediments accumulate very slowly, there are no sedimentary archives of the geodynamic history of these features. Researchers would like to know more because spreading ridges are responsible for forming around 60 percent of the Earth's crust over the last 180 million years, but since there is little sedimentary record it is inherently difficult to determine the timing of events: How frequently do the volcanoes erupt? How fast do the fault zones move? How frequent do hot springs develop and how long do they last? This lack of temporal information restricts our understanding of this important geodynamic system.

However, in a few unique places on Earth the conditions are different. Where the Arctic-Mid Ocean Ridge system (AMOR) approaches the continental margin in Norwegian waters, it approaches an area where large amounts of sediment have been shed from the Barents Sea into the deep ocean during repeated glaciations in the Arctic over the last 2-3 million years. Here the thick sedimentary layers that form the Bear Island fan reach out to the spreading ridge. Sediments transported into the deep ocean by underwater avalanches have been deposited in the rift valley of the ridge. Scientists therefore, have a unique opportunity to read the history of active volcanoes, hot vents and faults in the sediment record here.

In 2009, we published a paper reporting seismic images across the ridge in this region. These images illustrate how the sediments record the fault movements over the last 500.000 years. The images show that at the eastern side of the ridge, faults have been inactive or locked over a long period of time, whereas at the western side, there have been rapid movements of crustal blocks along faults. As a result, the volcanic seafloor has been elevated thousands of meters forming large seamounts that provide a habitat for diverse marine ecosystems.

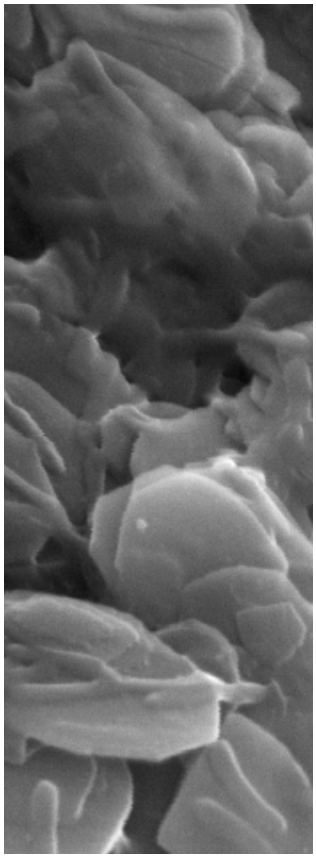
During the last cruises to the area we have sampled the upper 5-metres of these sediments with different coring systems. From these sediment cores we can read the most recent history of volcanic eruptions and the life cycles of hot springs at the seafloor here. As part of the Integrated Ocean Drilling Program we aim to drill deeper, and to read the changing history of the ridge further back in time to better understand the dynamic processes that form our ocean floor.



Water-Rock-Microbe Interactions

It was earlier believed that life on Earth was exclusively linked to photosynthesis and the production of organic matter and oxygen or oxygen-derived compounds. The discovery of hydrothermal vent systems in 1977 documented that life on Earth can be supported by chemosynthesis - as proposed by Sergei Vinogradskii already 90 years before. Today we know that hydrogen and other reduced compounds may be produced by water-rock interactions in the subsurface and that these may support a deep microbial biosphere in the earth's lithosphere that is independent of photosynthesis.

Basalt-hosted hydrothermal systems along the mid-ocean spreading ridges are known to emit hot, acidic fluids rich in reduced sulphur that is utilised as an energy source by microorganisms living in these extreme environments. In 2000, Debbie Kelley - now an adjunct professor at CGB - discovered the Lost City hydrothermal field together with an international team of researchers. This new class of hydrothermal fields is hosted by ultramafic, mantle rocks and emits very alkaline fluids rich in hydrogen and methane. Such systems may have been common on the early earth, and it is therefore hypothesized that life could have emerged and developed in this type of environment.

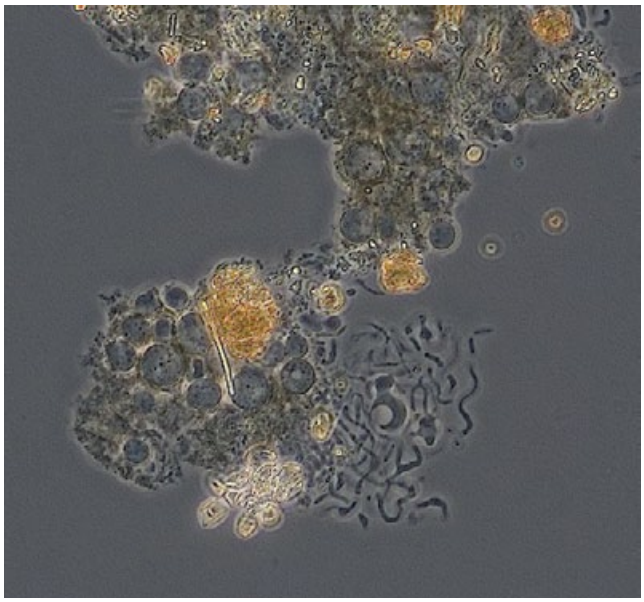


The conditions under which hydrogen, methane, heavier hydrocarbons and also some essential building blocks of life may form by water-rock interactions, is now being studied in several laboratories.

At the island of Leka in Mid-Norway, ultramafic rocks that are similar to those hosting the Lost City hydrothermal field are exposed on land. Members of CGB studied these unique rocks in the 1980's to understand how oceanic crust forms. Today the same rocks provide a natural laboratory for CGB researchers to study subsurface geochemical and microbial processes. Analyses of the percolating groundwater in a drill hole that we drilled a few years ago, show that this highly alkaline subsurface environment supports microbial life that is driven by hydrogen that continuously forms through low-temperature water-rock interactions. In 2009 we deployed experiments using inert titanium in the drill hole to monitor changes in the hydrogen and fluid compositions with time, and to grow microorganisms in reaction chambers that later will be extracted and analyzed. We are also simultaneously carrying out laboratory experiments at the CGB-labs at UiB to further improve our understanding of water-rock-microbe interactions and subsurface life.

Deep Biosphere

The past two decades have seen tremendous growth in our understanding of the deep biosphere that exists beneath the Earth's surface. Hydrothermal vent systems provide a window into this largely invisible and inaccessible ecosystem. What lives there? How can we learn more about them?



As part of the deep biosphere initiative iron oxidation has been studied as an ancient metabolic pathway that provides an energy alternative to photosynthesis. Only a few isolates using this pathway have ever been cultivated. CGB researchers have used a combination of culture-dependent and -independent approaches in order to learn more about these fascinating microorganisms.

Samples from iron mounds near the deep sea vents underwent high throughput sequencing (pyrosequencing/454 sequencing) to learn more about the community of microbes living there. Clone library and 454 pyrosequencing were used to estimate the number of operational taxonomic units (OUT) in the samples. Phylogenetic analyses showed a large diversity of uncultured bacteria where proteobacteria (55%) and planctomycetes (16%) were the numerically abundant groups.

To further investigate the potential role of the microbial communities living in these iron mounds and their interaction with the environment, cultivation experiments were undertaken focusing on the enrichment of iron oxidisers using FeS as substrate. Dominant members in the enrichments showed closest phylogenetic affiliation (97% identity) to the newly described *Mariprofundus ferrooxidans*. The most abundant OUT, however, shows phylogenetic affiliation to a novel organism that was present in our enrichments. This organism is currently being characterised and described.

We undertook in situ experiments using crushed glass pieces to generate a large surface area for colonisers to grow on. We used vent fluids to provide all the energy and nutrients for growing the organisms. The results from both the native sample analyses and the in situ experiments revealed a remarkable diversity that was higher than predicted. This diversity is largely determined by a long tail of taxa present in low abundancies.

Vent, Seep and Fall Biota

In 2009 CGB researchers and colleagues at Bergen Museum have together with other collaborators been sorting, identifying, characterizing and archiving the extensive sample collection from 2007, 2008 and 2009. The ongoing extensive and time consuming taxonomic work has led to a well-documented and surprising conclusion; while the vent fauna at Loki's Castle is mainly locally derived, it has a higher degree of similarity to the vent sites in the NW Pacific than to those found further south in the Atlantic!

We have now largely finished the identification of the faunistic investigations on the Mohn ridge shallow vents and the results were published online. The main conclusion is that the Jan Mayen vent field is dominated by bathyal fauna from the surroundings with only a small number of species adapted to reducing habitats.

Summer 2009 the Centre's research cruise also sampled at the Håkon Mosby mud volcano, a deep sea cold seep environment. Together with the Jan Mayen results, the two collections provide a solid basis for comparisons with the fauna collected at Loki's Castle. Here there are dense fields of tube-worms, the kinds that are normally found on cold seeps. One of the most characteristic members of this vent community was a new species of amphipod, which was found in high numbers on the chimneys and which were also numerous in the tube worm fields. Some of the chimney walls were also densely populated by very small gastropods characteristic of other reduced habitats.

Work is now continuing with studies of the food webs surrounding the vent areas. This will involve analyses of the fatty acid composition of the benthic fauna of the Jan Mayen vents, and studies of trophic interactions in the waters around the vents. A number of artificial falls have also been sunk both at deep sea sites and in more accessible coastal locations. The first were already re-visited in 2009 and sampling provided the first records of the polychaete worm Osedax from Norwegian waters.

Roots of life

Many consider that the deep sea hydrothermal vent systems existing today are the closest modern analogs to conditions under which life first began on Earth around 3.8 billion years ago. What lived then? What did it live on? How did it evolve into the organisms we know today? Roots of Life researchers have a unique opportunity to find out information that may provide insights into these fundamental questions.

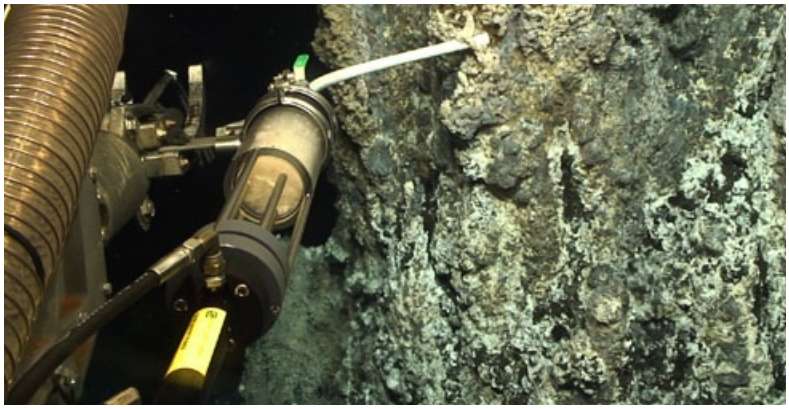
CGB's sampling programmes in 2007, 2008 and 2009 have given Roots of Life researchers opportunities to collect unique microbiological material from a variety of deep sea venting and seeping locations. It is a real asset to be able to compare results from different locations. Better understanding of the phylogenic patterns of these sampled organisms, their evolutionary processes and their adaptations to their geochemical environment may provide valuable insights into the first life-forms on Earth.

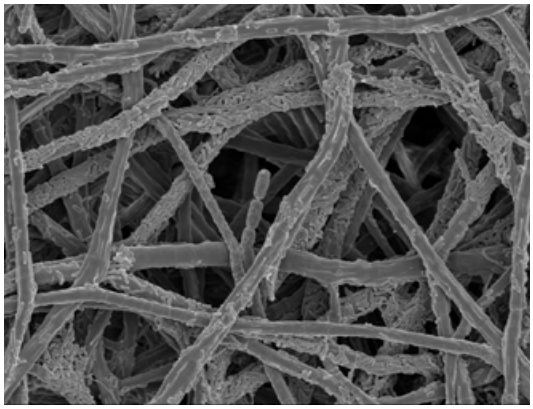
Most proteomics tools were developed for isolated micro-organisms or cell cultures. It has been challenging to expand these techniques so that they can be applied to complex microbial communities. Since the Centre was established nearly three years ago, Roots of Life researchers have been developing and combining community level approaches to analyse their samples using integrative proteomic, transcriptomic and genomic tools. The results provide information that tells us something about the types of microorganisms that are present as well as what they are doing, where and how they are doing it.

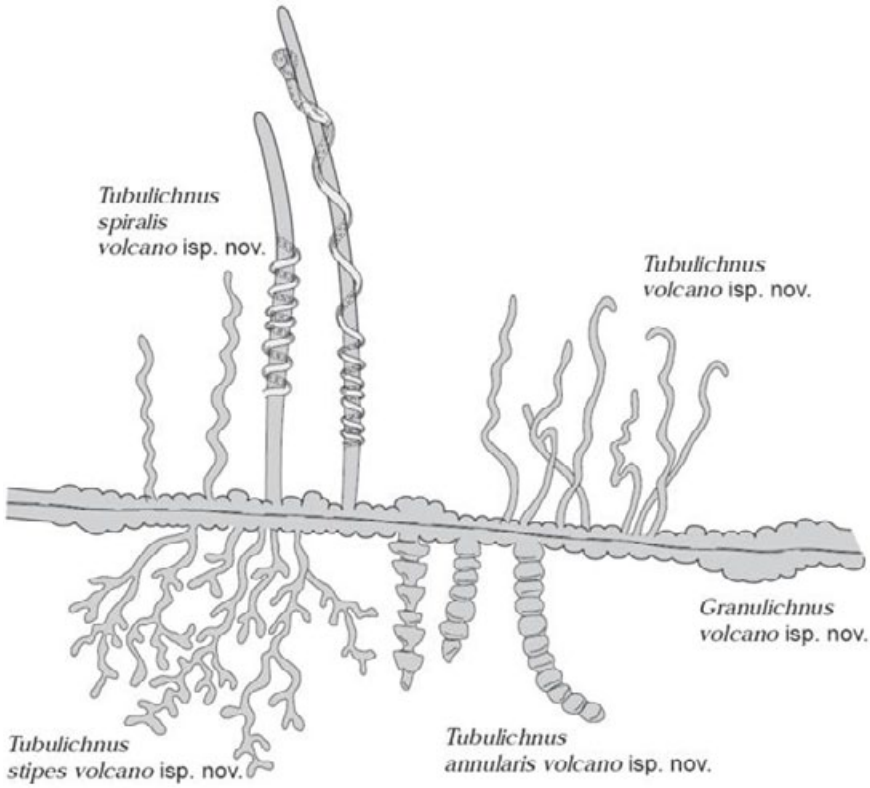
In 2009 researchers from the Roots of Life applied the integrated proteomics and genomic tools they have been developing to samples taken from cold methane-seeps at Nyegga. By detecting the expression of key enzymes in certain metabolic pathways they were able to trace the metabolism of anaerobic methanotrophic archaea inhabiting these environments. These results demonstrate that this approach provides a promising model for future investigations such as studying the microbial mats taken from Loki's Castle summer 2009.

Over the past three field seasons, CGB researchers have collected unique microbiological material from environments that are new to science or poorly studied. The metagenomic tools being developed and tested by Roots of Life researchers will enable them to extract and characterize new biological compounds from this sample material that have enormous bioprospecting potential.

The research and information potential of the groups unique sample material is beginning to attract international attention. This autumn the theme leaders were able to establish a collaboration with the company Agilent's R&D Department whereby researchers will be able to have access to the company's newest Mass Spectrometry technology to analyse their sample material.







Early Earth and Biosignatures

In 2009 one of the key publications on this theme describes the twists and turns of microbial life in volcanic glass and the microscopic tunnels created by these "rock eating" microorganisms. Such microbial "footprints" were discovered by scientists in Bergen more than 15 years ago, yet the full diversity of shapes that these microbes can make is only now becoming apparent. A study by McLoughlin et al. (2009) describes the diversity of intricate twisted, annulated and helical microbial tunnels in volcanic glass. This paper presents a framework for their classification so that scientists from around the world can build a global picture of life in modern and ancient sub-seafloor environments. This work has preceded hand-in-hand with ongoing studies to understand non-biological, purely chemical and physical mechanisms of tunneling in rock substrates. In a forthcoming paper we present criteria for distinguishing such biotic and abiotic tunnels in the rock record on the basis of their shapes and distribution. This will enable geobiologists to confidently reconstruct the evolutionary history or twists and turns of microbial life in the sub-seafloor back to the earliest Archean ~3.4 billion years ago.

Initial results of our drilling programme into the ancient Archean rock the Barberton Mountainland of South Africa were also published in 2009. Work is continuing apace to characterize the 800 meters of drill core and analyze the priority horizons for understanding Archean environments and traces of life. As part of this research effort Prof. Harald Furnes undertook further fieldwork in South Africa and Nicola McLoughlin spent an extended research stay at the Africa Earth Observatory Network at the University of Cape Town.

We are now working to develop and refine technological approaches. This activity will be greatly enhanced by the purchase and installation of a Confocal Laser Raman microscope in the Bergen Geoanalytical Facility. This new instrument will be used for high resolution mapping and investigation of biosignatures found in ancient rocks, especially organic carbon bearing remains and for rapid mineral identification. Several other research teams within the Center are also undertaking pilot studies to use this new instrument to address diverse geobiological questions.

Fieldwork

Research cruise to Loki's Castle and Håkon Mosby mud volcano

1-11 August CGB researchers were once again aboard the G.O.Sars re-visiting the Loki's Castle hydrothermal vent field and the Håkon Mosby Mud Volcano, one of the world's largest underwater mud volcanoes. This year a production team was onboard to film a segment for Discovery Channel's series called "Mighty ships" [in action].

The cruise had two goals: the first was to return "Loki's Castle" for mapping and sampling to document more information about this newly discovered hydrothermal vent field; and the second was to sample and map the Håkon Mosby mud volcano. Of particular interest is methane cycling at this volcano, the microbial metabolisms involved and the assoicated tube worms.

The Loki's Castle hydrothermal vent field was discovered by CGB researchers summer 2008. In summer 2009 researchers were able to sample vent and plume fluids specifically as well as taking sea-floor samples near to the site of active venting, including actual chimney pieces.

The Loki's Castle hydrothermal vent field sits atop a hydrothermal mound on a 30 km long volcanic ridge in the rift valley of the Mohn's Ridge near to its junction with the Knipovich Ridge. The results thus far indicate that the Loki's Castle hydrothermal vent field has a significantly-sized plume that manifests the characteristics of high-temperature venting (chemical, temperature and particle anomalies). However, as a result of strong and changing currents the plume is difficult to detect consistently. The characteristic signal, of elevated Eh, methane and hydrogen values, is found at 2000-2100 m depth, or 300-400 m above the vent field.

On the seafloor, black smoker fluids issue from five, up to 11 m tall chimneys. The chimneys are situated on a hydrothermal mound that was estimated to be 20-30 m high and approximately 200 m across; comparable to the dimension of the TAG mound, which is one of the largest mounds discovered on the sea floor thus far.

The Loki's Castle hydrothermal vent field poses an interesting puzzle. Based on surface geology, the Loki´s Castle field is clearly basalt-hosted; however, the CH_4 values in the vent fluids are some of the highest reported from a volcanic-hosted field. These high CH_4 values in concert with the elevated NH_4^+ concentrations also measured seem to indicate a sedimentary influence.

Cruising in the Southwestern Pacific

CGB researcher Lise Øvreås participated in a research cruise in the Lau basin, east of Fiji, where scientists were investigating

extreme organisms living around the hydrothermal vents found there.

The cruise was led by Anna-Louise Reysenbach (Portland State University), a microbial ecologist whose research focuses on high temperature ecosystems. Her lab combines classical culturing techniques with genomic approaches to explore the diversity and role thermophiles play in terrestrial and deep-sea hydrothermal systems.

Participation in international cruises gives scientists a chance to share best practices and gain experiences that are of value to research work at CGB.

Lab facilities

Reflecting the increasingly multi-disciplinary nature of research as well as increasing costs of technology, laboratories at the University of Bergen (UiB) are being increasingly reorganised as department-wide, faculty-wide or even university-wide facilities. As part of this trend, seven individual laboratories originally based at the Department of Earth Science have been reorganised into a centrally administered unit, the Bergen Geoanalytical Facility (BGF, http://www.geo.uib.no/bgf). The facility is hosted by Department of Earth Science and operated jointly by the Department and Centre for Geobiology. BGF became fully operational in 2009. The main expertise of the BGF is in phase, elemental and isotopic analysis of inorganic samples (geological, archaeological, biological and environmental) but it also undertakes analyses of various organic matrices such as blood serum, shells or organic-rich sediments.

Bergen Geoanalytical Facility could not exist without the effort of people who work in the laboratories. Master and doctoral students, research and academic staff are supported by five technicians and engineers who make sure that the analytical instruments and laboratories are functional and contribute to the flawless operation of the facility. Technicians and researchers together are active in development and implementation of new analytical techniques, and tests involving inter-laboratory comparisons and development of new reference materials.

By the end of 2009 the Department of Biology had moved into its new building. CGB researchers will benefit in particular from the new microbiology and biodiversity laboratories and infrastructures.

Small scale variations in composition revealed by laser ablation ICP-MS analysis

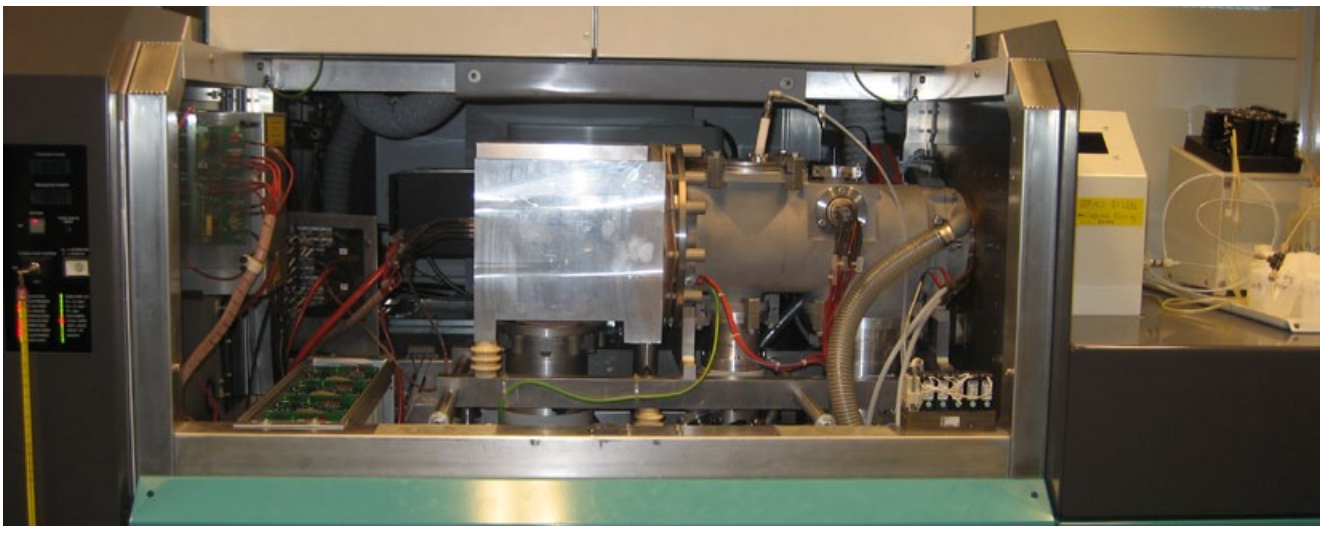
Researchers often need to study the chemical and isotopic composition of solid samples on sub-microscopic scales. This is because many minerals and biological samples are heterogeneous and it is those small scale variations that provide the most valuable information about the sample's formation and history. One such technique uses energetic laser beams to ablate small volumes of solid sample for isotopic analysis by plasma source mass spectrometry (LA ICP-MS).

Researchers associated with CGB are involved in the development and distribution of internationally recognized reference materials for U-Pb microanalysis and, in collaboration with the International Association of Geoanalysts (IAG) and the EARTHTIME programme, they contribute to establishing the common and internationally recognized analytical procedures.

Recent projects in sedimentary provenance include studies of the Norwegian continental margin, the origin and evolution of the Jan Mayen microcontinent, the provenance of sedimentary rocks in eastern Greenland, the evolution of the Gondwanan margin in the north-central Andes and the tectonic history of northern Graham Land in western Antarctica.

In 2009 laser ablation ICP-MS was used to constrain the age of the oldest directly dated morphological evidence for life on the Earth. Tubular channels formed by microbial activity in ancient volcanic glass from the Barberton Greenstone Belt in South Africa are filled with mineral titanite and its U-Pb dating confirms the antiquity of these trace fossils attesting to the existence of a sub-oceanic biosphere in the early Archean (at least 3.34 Ga ago).

Specialists in lasar ablation at the Bergen Geoanalytic Facitility aim in the future to focus more on the fundamental research of the laser ablation process. Their goal is to improve the spatial resolution of laser ablation analyses so that even smaller domains in mineral grains and biological samples can be analyzed. This will extend our capabilities in isotopic dating, improve time resolution in geological and environmental studies and lead to new projects on elemental and isotopic partitioning in minerals, fluid inclusions and biological compounds. Ultimately it will result in better data quality and more exciting projects for users of the BGF laboratories.



Confocal Laser Raman Microscope in place!

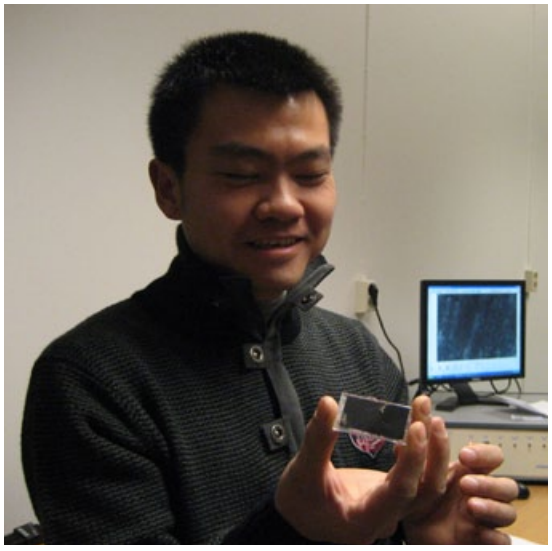
This autumn the Bergen Geoanalytical Facility installed a new Raman spectrometer. The Labram-HR of Horiba Jobin-Yvon consists of a high-resolution confocal Raman spectrometer with three laser wavelengths in the visual range, attached to a petrographic microscope with a motorized mapping stage. This system measures the molecular vibrational energy of substances, and can thus be used for the identification of various materials. Since vibrational energy is related to molecular bond strength, certain molecular characteristics can be studied, such as stress patterns in solids or isotopic variation in e.g. ^{13}C-labelled biologic compounds.

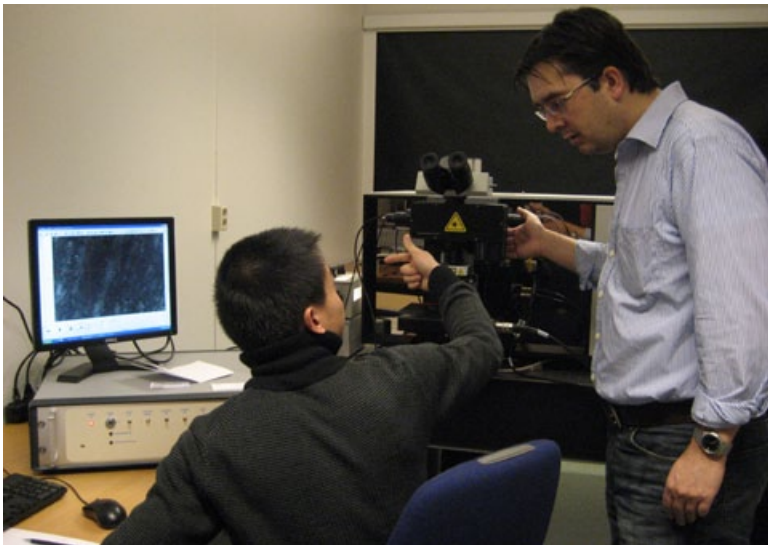
Laser Raman spectroscopy will be used in the Centre for Geobiology as a rapid tool for mineral identification and characterization of microfossils in geological samples. In addition it is envisioned that this technique will be used for the characterization of fluid inclusions, biologic compounds, and products of biomineralization.

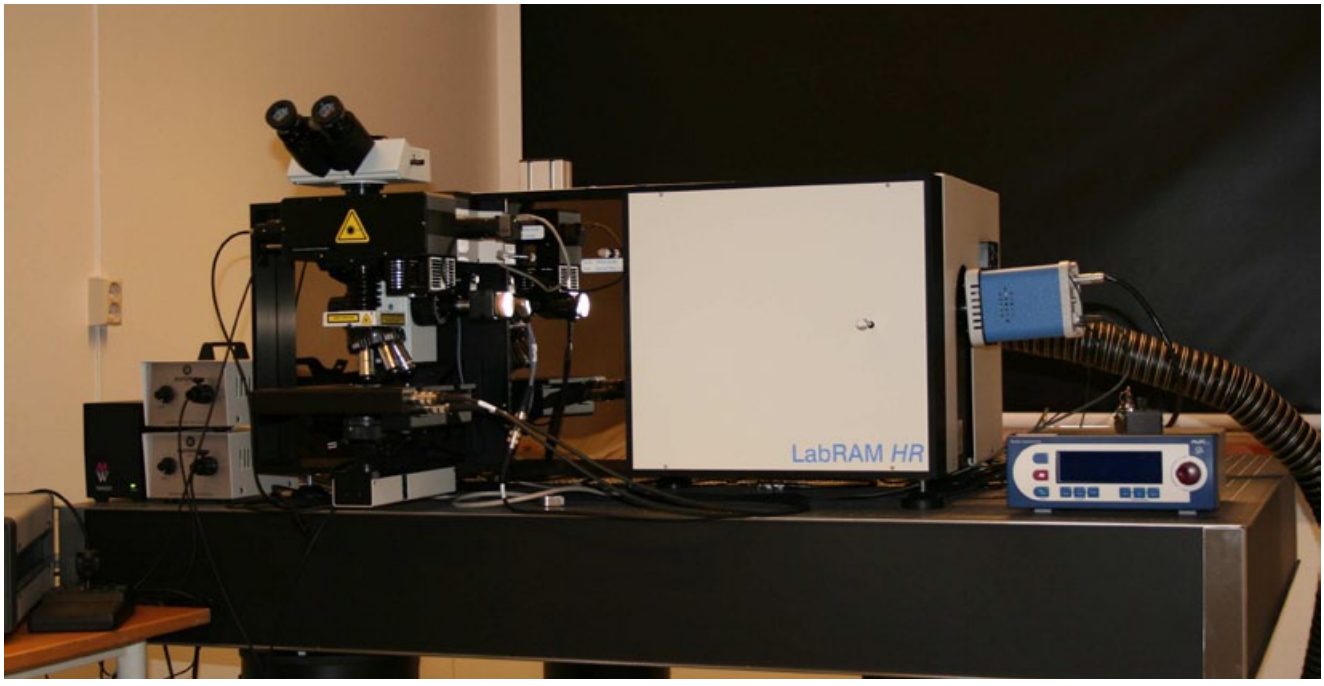
For geologic samples one typically works with 30 µm thin-sections, although larger samples can be analyzed as well. For fluid inclusion studies 100 µm thinsections are preferred. A typical analysis is entirely nondestructive, requires no further sample preparation, and takes place in a matter of seconds. Raman maps (2D- or 3D-maps) and depth profiles can be constructed in a matter of minutes to hours, depending on resolution (down to 0.3 µm) and area (up to centimetres).

While the main focus is on geological and biological samples, Raman spectroscopy can be applied to a wide variety of materials. Some interesting examples are: paintings and archaeological artefacts, stress patterns in silicon wafers, synthetic diamonds, real time reaction analysis in micro-reactors, cryogenic samples such as gas hydrates in ice.

CGB researcher Mark Van Zuilen was in charge of the installation and he will be central in further development of the instrument.

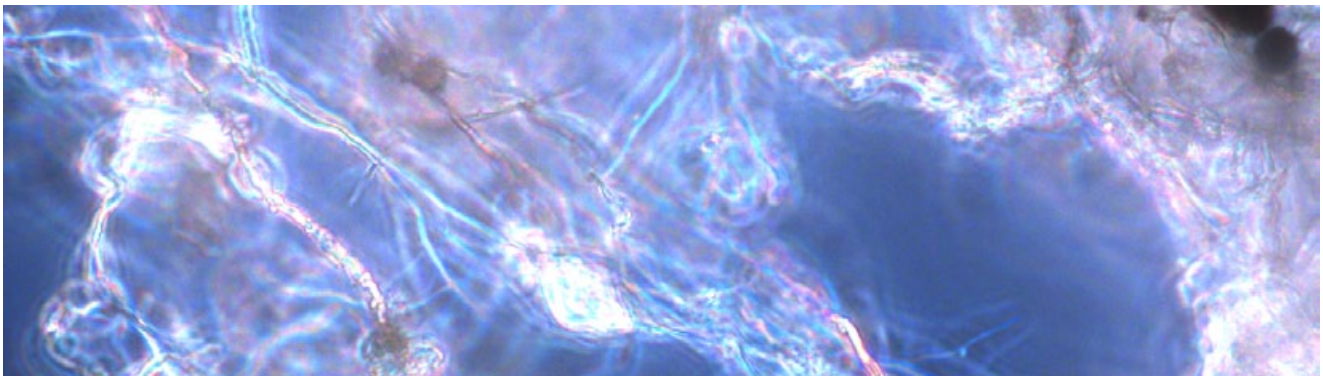






Workshops and conferences

In 2009 a number of researchers were involved in organising workshops or conferences and convened conference sessions.



Geological Society of Norway, Winter Conference, Bergen, Norway, 13-15 January 2009,

Ingunn Thorseth was a member of the Organizing Committee

The conference presents a cross-section of the great diversity of activity ongoing in Norway's geology milieu.

The opening key note lectures highlighted different geological aspects of the Earth in light of the completion of the United Nations Year of the Planet. Researchers from all six themes within the Centre gave talks and were involved in poster presentations. These were presented in a special geobiology session which was co-chaired by CGB researcher **Bjarte Hannisdal**.

10th International Conference on Bacterial Genetics and Ecology, Uppsala, Sweden, 15-19 June 2009

Vigdis Torsvik was a member of the International Scientific Committee

The 10th International Conference on Bacterial Genetics and Ecology (BAGECO-10) brought together approximately 250 participants from all over the World. The Conference had the title "Coexisting on a Changing Planet". The major topics of the conference were on microbe-microbe and microbe-macrobe interactions and how microbial community and complex interacting consortia are influenced by environmental changes. Advances in analytical tools such as metagenomics, transcriptomics and other "omics" approaches to better understand microbial community diversity, composition and function in different ecosystems were highlighted.

Vigdis Torsvik gave an opening presentation at the first session on Climate change and microbial communities. **Tim Urich** presented some work performed at CGB in his talk on the double RNA approach, and **Christa Schleper** gave the closing Key note lecture on Evolution and Ecology of ammonia oxidizing bacteria.

Convenor at the Goldschmidt 2009 Conference

Reynolds B, Mason P, **Schoenberg R**. Session 18f at the Goldschmidt 2009 Conference, Davos,
Switzerland, Pushing Precision and Accuracy in Radiogenic, Radioactive, and Non-Traditional Isotope Ratio Measurements. June 20-25 2009.

Convenor at the 3rd Congress of European Microbiologists

Schleper C. FEMS 2009: 3rd Congress of European Microbiologists, Göteborg, Sweden. 28 June -3 July 2009

Convenor at the annual meeting of the Geological Society of America

Dilek Y, **Furnes H**, De Wit M. Greenstone Belts, Archean Earth, and Early Life. Session 89 at the annual meeting of the Geological Society of America, Portland, Oregon, USA, 18-21 October 2009.

19-23 October, Vent, Seep and Fall Biota thematic group hosted a taxonomy workshop

During 2009 a substantial amount of invertebrate material from the vents and seeps was sorted by the staff at Bergen Museum and a workshop was arranged 19-23 of October to undertake most of the identification work. Some of the material remaining to be identified has been sent out to taxonomic experts while other parts being studied here in Bergen.

Nordic-NASA Astrobiology Summer School in Iceland in June/July 2009

CGB researchers are partners in the Nordic Network of Astrobiology graduate Schools and CGB researchers **Ingunn H. Thorseth**, **Ida H. Steen** and **Nils Kåre Birkeland** were involved in the organization and teaching at the NASA Astrobiology Summer School in Iceland in 29 June – 18 July 2009. Several of the CGB PhD students participated in the school.

Seed Projects

In 2009 the CGB leader group decided to initiate a Seed Project programme whereby Centre researchers engaging pilot / short-term research initiatives could apply for funding for 1-year.
This initiative has proven so successful that the CGB leader group has decided to continue the practice in 2010. The following seed projects were funded by CGB in 2009:

- Adaptation of Archaeoglobus species to environmental changes
- AEON-CGB Barberton Scientific Drilling Programme
- Gas composition of the Loki's Castle vent fluids
- Diversity and functioning of archaea in marine methane enriched sediments
- Hot Vents Webs
- Macrofauna on hydrothermal vents and cold seeps in the northernmost Atlantic ocean
- Probing the community structure and function of hydrothermal vent microbial mat communities using an integrated "Omics" approach
- Serpentinisation and abiotic formation of hydrogen and organic compounds
- Hydrothermal bacterial mats - proteomics
- Hydrothermal bacterial mats - diversity
- Low-temp hydrothermal biodiversity
- Redox-changes of the deep oceans since the early Proterozoic; a transition metal isotope study of ancient and modern FeSi-deposits
- Seafloor ironoxide deposits present and past
- Sponge-microbial interactions; key functional genes for sulfur cycling microorganisms in the cold water sponge *Geodia baretti*.
- The Macrofauna of the Schulz massive, North Atlantic (73° N)
- Terrestric ironoxide deposits
- Whalefalls

Public Outreach

Web site

The University of Bergen (UiB) launched a new external web site. As a Centre of Excellence that is completely under the UiB umbrella, the Centre for Geobiology (CGB) was asked to move its web pages to the new UiB site. As there were several hundred pages involved, this process took some time, but the work is now complete and as much as possible of the previous Centre web site has been integrated into the new UiB web content management system using a redirect so that the old address continues to be functional. In addition, the new web pages followed along with daily reports of this summer's cruise.

Documentaries

A film crew from Discovery was aboard the G.O.Sars with CGB researchers this summer. They were filming researchers "in action" on the Sars as a state-of-the-art research ship for their Mighty Ships series. The final film will be part of the third series and will be released summer 2010. In addition in 2009, two different independent film producers made short documentaries about CGB field activities. Rehana Dada, a South African science and environmental journalist, produced "Bedrock for life on a young Earth - searching for our planet's earliest life forms", which dealt with the drilling project in the Barberton Mountains, sampling rocks that are ~3.4 billion years old. The other short documentary, entitled "Searching for Black Smokers" dealt with the discovery of Loki's Castle.

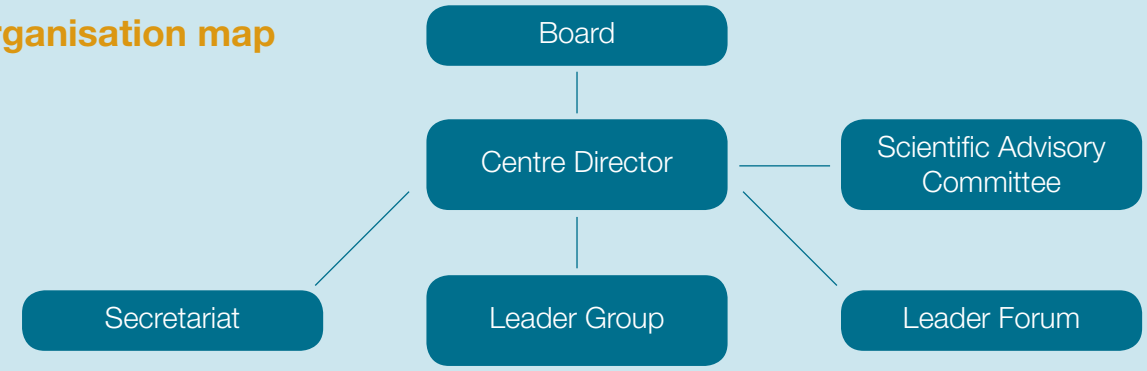
Popular lectures and interviews

CGB researchers have been active in Public Outreach. In addition to participating in two UiB initiatives, the Research Council of Norway's annual Science Week (Forskningsdagene) and Darwin's Bicentennial celebrations, several have been interviewed on a National Radio programme, Verdt å Vite, and a number have given popular lectures in a variety of contexts.

Organisation

The Centre for Geobiology (CGB) is part of the Faculty of Mathematics and Natural Sciences at the University of Bergen and is primarly a collaboration between the Departments of Biology and Earth Sciences.

Organisation map



	Research Theme 1	Research Theme 2	Research Theme 3	Research Theme 4	Research Theme 5	Research Theme 6	Research Labs	Marine Infrastructure
Project A	x		x	x			x	
Project B		x	x	x			x	
Project C					x	x		x
Project D	x		x	x	x			
Project E	x	x	x	x	x	x	x	x

Matrix model and establishment of Leader Forum

Although CGB is based on six main research themes, in practice researchers are collaborating in projects across themes and with external partners. Resources and infrastructures are not linked to particular themes but also are used across themes. Therefore in 2009 a Matrix model was proposed as a new organisational model for CGB's research activity, based on projects and resources. This model was approved for a one-year pilot by the CGB Board February 2009. The Matrix model provides a structure whereby CGB can grant research funding to multi-disciplinary, cross-theme projects – the seed projects. As a direct result of the new model, a new leader group was formed called the leader forum consisting of all project leaders, lab leaders and thematic leaders. Not only will such a structure contribute to coherence and team-building at the Centre, but it will also provide valuable leadership training to more individuals at CGB, particularly younger scientists. CGB's leader group consisting of the Centre leadership and the theme leaders will continue to play a valuable leadership role for CGB overseeing the entire project portfolio and ensuring that the necessary infrastructures and resources are in place for the portfolio research activity.

The first meeting in the CGB leader forum took place August 2009. The special theme for the meeting was management. Topics included group dynamics, challenges of cultural perceptions etc.

Science Advisory Committee:

Antje Boetius	Max-Planck-Institut für Marine Mikrobiologie, Bremen, Germany
Chris German	Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA
Cindy Van Dover	Duke University Marine Laboratory, Beaufort, North Carolina, USA
Frances Westall	Le Centre de Biophysique Moleculaire, CNRS, Orléans, France

The Governing Board:

Geir Anton Johansen (chairman)	Vice Dean of The Faculty of Mathematics and Natural Sciences, UiB
Gunn Mangerud/Olav Eldholm	Head of Department of Earth Sciences
Jarl Giske	Head of Department of Biology
Kristen Haugland	Director of the Department of Research Management
Ole Tumyr	Employee representative Department of Earth Sciences
Runar Stokke	Employee representative Department of Biology

Research projects

Projects Funded by the Research Council of Norway

Duration	Title	Leader*/Partner**
2004 – 2009	The deep biosphere of the ocean crust: biomass, diversity, activity and biogeochemical cycles	Rolf Birger Pedersen*
2006 – 2009	Life in the volcanic crust of the early Earth: conditions, timing and depth	Harald Furnes*
2006 – 2009	The Jan Mayen micro-continent - searching for new knowledge on prospectivity, basin evolution and sediment provenance	Rolf Birger Pedersen*
2006 – 2010	Funcional Metagenomics to Study Prokaryotes from Arctic/Sub-arctic Springs of Hydrothermal Origin	Christa Schleper*
2007 – 2009	Hidden reservoirs of Biological diversity – geobiology of unexplored endolithic communities associated with lichens	Torbjørg Bjelland*
2007 – 2010 ”SylfoSYS”	Silicon cell model for the central carbohydrate metabolism of the archaeon Sulfolobus solfataricus under temperature variation.	Christa Schleper*
2007 – 2010	Metagenomics and gene discovery in Antarctic terrestrial habitats.	Nils-Kåre Birkeland*
2008 – 2011 “H2DEEP”	Ultra-slow spreading and hydrogen-based biosphere: A site survey proposal for zero-age drilling of the Knipovich Ridge	Rolf Birger Pedersen*
2009 – 2010 ”NOON”	Pre-project for Cable-based Ocean Observatory	Rolf Birger Pedersen**
2009 – 2012 ”FARDEEP”	The Emergence of an Aerobic World – Drilling Early Earth Project	Victor Melezhik*
2009 – 2017 ”SUCCESS”	Subsurfac CO2 storage – Critical Elements and Superior Strategy	Rolf Birger Pedersen**/ Ingunn H Thorseth**
2010 – 2012 ”CryoCARB”	Long-term Carbon Storage in Cryoturbated Arctic Soils	Christa Scleper*/ Tim Urich**/Vigdis Torsvik**
2010 – 2013	Hotspot Rift Interaction & Geochemistry of the North Atlantic Mantle: the Aegir Ridge ‘Hole’ in the Iceland Hotspot	Rolf Birger Pedersen**

International projects funded through the European Science Foundation (ESF)/Era-Net

Duration	Title	Coordinator*/Principal Investigator**/ Collaborator***	Programme
2007 – 2010 ”SylfoSYS”	Silicon cell model for the central carbohydrate metabolism of the archaeon Sulfolobus solfataricus under temperature variation. International consortium of x groups	Christa Schleper* (Main Coordinator)	Era-Net/SysMO
	WP1: Fermentation/Perturbation	Christa Schleper***	
	WP2: Biochemistry	Nils Kåre Birkeland***	
	WP3: Transcriptomics /Metabolomics/ Proteomics/ Comp. Genomics	Christa Schleper***	
2008 – 2011 “H2DEEP”	Ultra-slow spreading and hydrogen-based biosphere: A site survey proposal for zero-age drilling of the Knipovich Ridge	Rolf Birger Pedersen* (Main Coordinator)	ESF/ EuroMARC (EUROCORES)
	Project 1: The Magmatic, Tectonic and Hydrothermal Architecture of the Southern Knipovich Ridge: Geophysical Survey and Geological/ Geomicrobiological sampling.	Rolf Birger Pedersen**/ Ingunn H. Thorseth***	

	Project 2: Core complex formation and evolution: Geodynamic synthesis, Knipovich Ridge	Rolf Birger Pedersen***	
	Project 3: Linking Hydrothermal Alteration, Serpentinization, and Fluid Fluxes to Biological Niches at the Knipovich Ridge	Rolf Birger Pedersen***	
	Project 4: Sulfide Petrology, Ore Genesis and the Deep Biosphere at Knipovich Ridge	Rolf Birger Pedersen***/ Ingunn H. Thorseth***	
	Project 5: Geomicrobiology: microbial communities and processes associated with basement alteration at the ultraslow spreading Knipovich ridge	Ingunn H, Thorseth**/ Rolf Birger Pedersen***/ Lise Øvreås***	
2010 – 2012 "CryoCARB"	Long-term Carbon Storage in Cryoturbated Arctic Soils	Coordinated by Universitty of Vienna	ESF/ PolarCLIMATE
	Individual project 5: High-resolution Microbial Community Structure	Christa Schleper**/ Vigdis Torsvik***/ Tim Urich***	

Projects funded by other sources

Duration	Title	Leader*/Partner**	Funder
2007 – 2011	Biotechnology and microbial diversity of Ethiopian soda lakes	Lise Øvreås*	SIU
2008 – 2009	Comparative genomics of Archaeoglobus fulgidus	Nils Kåre Birkeland*	UiB/Friforsk
2008 – 2009	Mikrobiell studie av Kristin/Morvin-feltet	Nils Kåre Birkeland*	Statoil
2008 – 2009	SPONGRAM Sponge Risk Assessment and Monitoring	Hans Tore Rapp*	Statoil
2009 – 2011	Preparing for sub-sea storage of CO2	Rolf Birger Pedersen**	Gassnova
2009 – 2012	Direct dating of diagenic processes by in-situ analysis of U-Th-Pb isotopes in authigenic phosphate minerals by laser ablation ICP-MS	Jan Kosler*	Statoil
2009 – 2012	Metagenomics and metaproteomics of deep arctic hydrothermal systems	Ida Helene Steen*	VISTA
2009 – 2012	Subsurface metagenomics, functional microbial diversity analysis and gene discovery in deep and hot petroleum reservoirs	Nils Kåre Birkeland*	VISTA
2009 – 2114	Earth System Modelling	Jan Kosler**, Bjarte Hannisdal**, Jiri Slama**	Statoil

Selected Publications 2009

In 2009 CGB researchers and students published 49 papers in peer-reviewed journals and 84 conference proceedings. Below is a list of some selected publications:

1. Albers SV, **Birkeland NK**, Driessen AJM, Gertig S, Haferkamp P, Klenk H-P, Kouril T, Manica A, Pham TK, Ruoff P, **Schleper CM**, Schomburg D, Sharkey KJ, Siebers B, Sierocinski P, Steuer R, van der Oost J, Westerhoff HV, Wieloch P, Wright PC, Zaparty M (2009). SulfoSYS (Sulfolobus Systems Biology): towards a silicon cell model for the central carbohydrate metabolism of the archaeon Sulfolobus solfataricus under temperature variation. Biochemical Society Transactions 37: 58-64.
2. **Baskar S**, **Baskar R** (2009) Geobiology and geomicrobiology: importance and need for studies in the Indian context. Current Science 96:200-201
3. **Bruvoll VB**, Breivik AJ, Mjelde R, **Pedersen RB** (2009). Burial of the Mohn-Knipovich spreading ridge by the Bear Island Fan: Time constraints on tectonic evolution from seismic stratigraphy. Tectonics 28, TC4001, doi:10.1029/2008TC002396
4. Cohen PA, Bradley A, Knoll AH, Grotzinger JP, Jensen S, Abelson J, Hand K, Love G, Metz J, **McLoughlin N**, Meister P, Shepard R, Tice M, Wilson JP. (2009) Tubular Compression Fossils from the Ediacaran Nama Group, Namibia. Journal of Paleontology 83:110-122
5. Dilek Y, Furnes H (2009) Structure and geochemistry of Tethyan ophiolites and their petrogenesis in subduction rollback systems. Lithos 113:1-20
6. Dipippo JL, Nesbo CL, Dahle H, Doolittle WF, Birkeland NK, Noll KM (2009) Kosmotoga olearia gen. nov., sp. nov., a thermophilic, anaerobic heterotroph isolated from an oil production fluid. Int J Syst Evol Microbiol 59:2991-3000
7. **Eickmann B**, Bach W, Rosner M, Peckmann J (2009) Geochemical constraints on the modes of carbonate precipitation in peridotites from

the Logatchev Hydrothermal Vent Field and Gakkel Ridge. Chemical Geology 268:97-106

8. **Eickmann B**, Bach W, Peckmann J (2009) Authigenesis of Carbonate Minerals in Modern and Devonian Ocean-Floor Hard Rocks. Journal of Geology 117:307-323

9. **Fliegel D**, Gunther D (2009) Laser ablation particle beam glow discharge time of flight mass spectrometry for the analysis of halogenated polymers and inorganic solid material. Spectrochimica Acta Part B-Atomic Spectroscopy 64:399-407

10. Frols S, White MF, **Schleper C** (2009) Reactions to UV damage in the model archaeon Sulfolobus solfataricus. Biochem Soc Trans 37:36-41

11. **Furnes H**, Rosing M, Dilek Y, de Wit M (2009) Isua supracrustal belt (Greenland)-A vestige of a 3.8 Ga suprasubduction zone ophiolite, and the implications for Archean geology. Lithos 113:115-132

12. Godard M, Awaji S, **Hansen H**, Hellebrand E, Brunelli D, Johnson K, Yamasaki T, Maeda J, Abratis M, Christie D, Kato Y, Mariet C, Rosner M (2009) Geochemistry of a long in-situ section of intrusive slow-spread oceanic lithosphere: Results from IODP Site U1309 (Atlantis Massif, 30 degrees N Mid-Atlantic-Ridge). Earth and Planetary Science Letters 279:110-122

13. Grosch EG, **McLoughlin N**, De Wit M, **Furnes H** (2009) Deciphering Earth's Deep History: Drilling in Africa's Oldest Greenstone Belt. EOS, Transactions, American Geophysical Union, 90:350-351

14. Haloda J, Tycova P, Korotev RL, Fernandez VA, Burgess R, Thoni M, Jakes P, Gabzdyl P, **Kosler J** (2009) Petrology, geochemistry, and age of low-Ti mare-basalt meteorite Northeast Africa 003-A: A possible member of the Apollo 15 mare basaltic suite. Geochimica Et Cosmochimica Acta 73:3450-3470

15. **Hoffmann F**, Radax R, Woebken D, Holtappels M, Lavik G, **Rapp HT**, Schläppy M-L, **Schleper C**, Kuypers M (2009) Complex nitrogen cycling in the sponge Geodia barretti. Environmental Microbiology 11:2228-2243

16. Op den Camp HJM, **Islam T**, Stott MB, Harhangi HR, Hynes A, Schouten S, Jetten MSM, **Birkeland NK**, Pol A, Dunfield PF (2009) Environmental, genomic and taxonomic perspectives on methanotrophic Verrucomicrobia. Environmental Microbiology Reports 1:293-306

17. Jensen S, Frost P, **Torsvik VL** (2009) The nonrandom microheterogeneity of 16S rRNA genes in Vibrio splendidus may reflect adaptation to versatile lifestyles. FEMS Microbiology Letters 294:207-215

18. Klotzli U, Klotzli E, Gunes Z, **Kosler J** (2009) Accuracy of Laser Ablation U-Pb Zircon Dating: Results from a Test Using Five Different Reference Zircons. Geostandards and Geoanalytical Research 33:5-15

19. Koepke J, Schoenborn S, Oelze M, Wittmann H, Feig ST, Hellebrand E, Boudier F, **Schoenberg R** (2009) Petrogenesis of crustal wehrlites in the Oman ophiolite: Experiments and natural rocks. Geochemistry Geophysics Geosystems 10, Art.Q10002

20. **Kosler J**, Magna T, Mlcoch B, Mixa P, Nyvlt D, Holub FV (2009) Combined Sr, Nd, Pb and Li isotope geochemistry of alkaline lavas from northern James Ross Island (Antarctic Peninsula) and implications for back-arc magma formation. Chemical Geology 258:207-218

21. **McLoughlin N**, **Furnes H**, Banerjee NR, Muehlenbachs K, Staudigel H (2009) Ichnotaxonomy of microbial trace fossils in volcanic glass. Journal of the Geological Society 166:159-169

22. **Melezhik VA**, Fallick AE, Filippov MM, Lepland A, Rychanchik DV, Deines JE, Medvedev PV, Romashkin AE, Strauss H (2009) Petroleum surface oil seeps from a Palaeoproterozoic petrified giant oilfield. Terra Nova 21:119-126

23. **Melezhik VA**, Pokrovsky BG, Fallick AE, Kuznetsov AB, Bujakaite MI (2009) Constraints on Sr-87/Sr-86 of Late Ediacaran seawater: insight from Siberian high-Sr limestones. Journal of the Geological Society 166:183-191

24. Meyer R, Hertogen J, **Pedersen RB**, Viereck-Gotte L, Abratis M (2009) Interaction of mantle derived melts with crust during the emplacement of the Voring Plateau, NE Atlantic. Marine Geology 261:3-16

25. Mikova J, **Kosler J**, Longerich HP, Wiedenbeck M, Hanchar JM (2009) Fractionation of alkali elements during laser ablation ICP-MS analysis of silicate geological samples. Journal of Analytical Atomic Spectroscopy 24:1244-1252

26. Nesbø CL, Bapteste E, Curtis B, **Dahle H**, Lopez P, Macleod D, Dlutek M, Bowman S, Zhaxybayeva O, **Birkeland NK**, Doolittle WF (2009) The Genome of Thermosipho africanus TCF52B: Lateral Genetic Connections to the Firmicutes and Archaea. Journal of Bacteriology 191:1974-1978

27. O-Thong S, Huub JMOdC, Prasertsan P, **Birkeland NK** (2009) Evaluation of methods for preparing hydrogen-producing seed inocula under thermophilic condition by process performance and microbial community analysis. Bioresour Technol 100:909-918

28. Pertoldova J, Tycova P, Verner K, Kosulicova M, Pertold Z, **Kosler J**, Konopasek J, Pudilova M (2009) Metamorphic history of skarns, origin of their protolith and implications for genetic interpretation; an example from three units of the Bohemian Massif. Journal of Geosciences 54:101-134

29. Quince C, **Lanzén A**, Curtis TP, Davenport RJ, Hall N, Head IM, Read LF, Sloan WT (2009) Accurate determination of microbial diversity from 454 pyrosequencing data. Nature Methods 6:639-641

30. Schauss K, Focks A, Leininger S, Kotzerke A, Heuer H, Thiele-Bruhn S, Sharma S, Wilke BM, Matthies M, Smalla K, Munch JC, Amelung W, Kaupenjohann M, Schloter M, **Schleper C** (2009) Dynamics and functional relevance of ammonia-oxidizing archaea in two agricultural soils. Environmental Microbiology 11:446-456

31. **Schoenberg R**, Marks MAW, Schuessler JA, von Blanckenburg F, Markl G (2009) Fe isotope systematics of coexisting amphibole and pyroxene in the alkaline igneous rock suite of the Ilimaussa Complex, South Greenland. Chemical Geology 258:65-77

32. Schotter S, **Hoffmann F**, Wild C, **Rapp HT**, Boetius A, Ramette A (2009) Inter- and intra-habitat bacterial diversity associated with cold-water corals. ISME Journal 3:756-759

33. Schuessler JA, **Schoenberg R**, Sigmarsson O (2009) Iron and lithium isotope systematics of the Hekla volcano, Iceland - Evidence for Fe isotope fractionation during magma differentiation. Chemical Geology 258:78-91

34. Tajcmanova L, Konopasek J, **Kosler J** (2009) Distribution of zinc and its role in the stabilization of spinel in high-grade felsic rocks of the Moldanubian domain (Bohemian Massif). European Journal of Mineralogy 21:407-418

35. Todt C, Cardenas P, **Rapp HT** (2009) The chiton Hanleya nagelfar (Polyplacophora, Mollusca) and its association with sponges in the European Northern Atlantic. Marine Biology Research 5:408-411

36. Von Proschwitz T, **Schander C**, Jueg U, Thorkildsen S (2009) Morphollology, Ecology and DNA-barcoding distinguish Pupilla Pratensis (clessin, 1871) from Pupilla Muscorum (Linnaeus, 1758) (Pulmonata: Pupillidae). Journal of Molluscan Studies 75:315-322

Staff

Scientists

Birkeland, Nils Kåre
Furnes, Harald
Kosler, Jan
McLoughlin, Nicola
Melezhik, Victor
Pedersen, Rolf Birger
Rapp, Hans Tore
Schander, Christoffer
Schleper, Christa
Schoenberg, Ronny
Steen, Ida Helene
Thorseth, Ingunn H.
Torsvik, Vigdis
Urich, Tim
van Zuilen, Mark
Øvreås, Lise

Post-docs

Bjelland, Torbjørg
Dahle, Håkon
Drost, Kerstin
Eickmann, Benjamin
Fliegel, Daniel
Garcia-Moyano, Antonio
Hannisdal, Bjarte
Huang, Shanshan
Keen, T. Jeffrey
Reigstad, Laila
Slama, Jiri
Stokke, Runar

PhDs

Bengtson, Mia
Flesland, Kristin
Hansen, Heidi
Hocking, William
Jørgensen, Steffen Leth
Lanzén, Anders
Möller, Kirsten
Olsen, Bernt Rydland
Roalkvam, Irene
Yuangao, Qu
Økland, Ingeborg

Technical staff

Almelid, Hildegunn
Daae, Frida Lise
Hoem, Solveig
Hjort Dundas, Siv
Johannessen, Torill Vik
Norheim, Marianne
Ronen, Yuval
Storesund, Julia
Tumyr, Ole

Administration

Bartle, Elinor
Fjellbirkeland, Anne

Personnel summary

Category	Person-years	Foreigners (% person-year)	Women (% person-year)
Scientists	9,9	34	30
Post-docs	9,2	57	34
PhDs	9,9	48	50
Technicians	4,9	0	80
Administration	1,4	29	100
Total	35,3	39	46

Funding and expenses

Funding

	(1000 NOK)
Research Council of Norway	15 210
University of Bergen	15 196
Total funding	**30 406**

Expenses

Salaries and indirect costs	18 402
Research equipment	3 785
External research services	483
Other costs	3 183
Total expenses	**25 853**