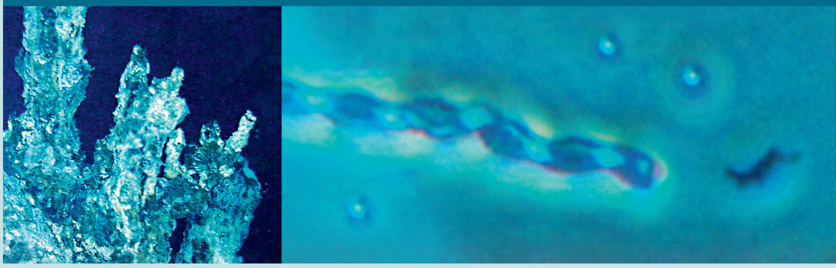
Centre for Geobiology



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

Annual report 2007

Norwegian
Centre of
Excellence

UNIVERSITAS BERGENSIS

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Summary

The Centre for Geobiology (CGB) gradually became operational over the course of 2007. The primary tasks during this 'start-up' process have been developing the organisational structure and centre facilities. Considerable efforts have been taken to secure reasonable autonomy for the new centre while maintaining a tight relationship with its associated departments at the university. The University of Bergen (UiB) has provided premises for the centre on the 4th floor of the "Realfagbygget", and in December 2007 the first researchers moved in - marking the true beginning of the centre almost a year after the Centre of Excellence status was announced.

The development of new research facilities has been another important task during the 'start-up' phase. We have now established geomicrobiology and biogeochemistry laboratories that will be important for the interdisciplinary research at the centre. The centre has also contributed to the establishment and development of proteomics and geochemistry laboratories, as well as to the further development of the deep marine research capabilities at UiB.

In the past year our efforts have also been focused on developing new natural laboratories. In July 2007, the centre organised an international cruise to the Arctic mid-Ocean Ridge to open a new ridge segment for multidisciplinary research in deep-sea geodynamics and life in extreme environments. Furthermore whale carcases have been sunk along the coast of Norway to establish a series of accessible natural laboratories for chemosynthetic life. Finally, the centre has participated in the planning and implementation of deep drilling projects aimed at sampling rock sequences that are critical to the understanding of the evolution of a planet capable of supporting life and the emergence life on Earth.

In 2007 the core group of researchers at the centre published approximately 40 peer reviewed papers and gave 70 presentations at international meetings. One of the highlights was a publication in "Science" that reported the finding of the oldest (3.8 billion years) fragment of oceanic crust on Earth – a discovery that also attracted international media attention. The centre has in 2007 also initiated several outreach activities including a "Teacher at Sea programme".

The most important challenge has been to recruit a team of researchers and students that will enable CGB to address important topics within this area of frontier research in the coming years. Together with the core group of researchers CGB participants are organised in six thematic groups that focus on:

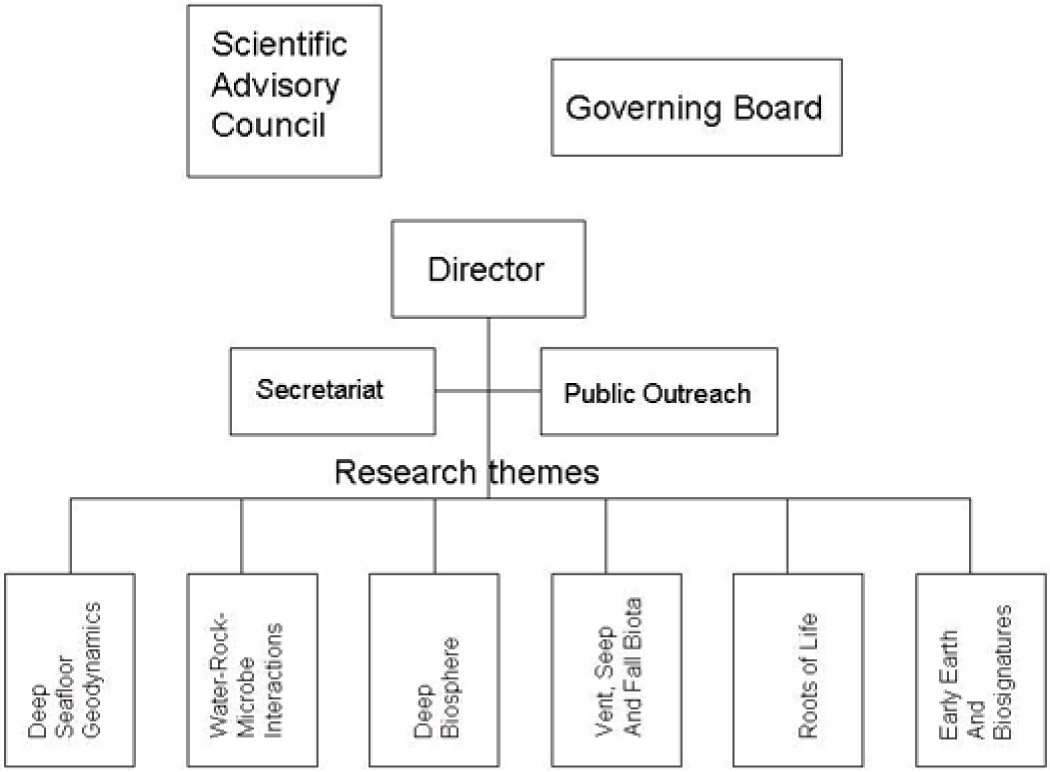
- Geodynamics of the Deep Seafloor
- Water-rock-microbe Interactions
- The Deep Biosphere
- Vent, Seep and Fall biota
- Early Earth and Biosignatures
- Roots of Life

In summary: 2007 has been devoted to the many challenges involved in establishing a new research centre - but by the end of the year, the Centre for Geobiology was ready to begin to address its research activities thanks to the support provided by the Research Council of Norway and the University of Bergen.

ORGANISATION, BOARD AND MANAGEMENT OF CGB

CGB is organised as a unit lying under the Faculty of Mathematics and Natural Sciences, with its research activities integrated within two associated or host departments, the Department of Earth Science and the Department of Biology.

Figure, CGB organisation



Governing board
The Governing board of CGB consisted of the following members in 2007:

Chairman: Vice Dean of The Faculty of Mathematics and Natural Sciences, UiB, Geir Anton Johansen
Head of Department of Biology, UiB, Jarl Giske
Head of Department of Earth Science, UiB, Olav Eldholm
Director of the Department of Research Management, UiB, Kristen Haugland
Employee member Bjarte Hannisdal (substitute: Ingunn Thorseth)
Employee member Ida Helene Steen (substitute: Jørn Einen)

The CGB-board members were appointed by the Board of the Faculty of Mathematics and Natural Sciences in agreement with the central leadership of UiB. The board held its first meeting in 2007.

Scientific advisory council
Members of a Scientific Advisory Council will be appointed by the Board of the Faculty of Mathematics and Natural Sciences in 2008.

Management
Management of CGB is organized in a flat leadership structure, in general based on consensus in a leader team consisting of a centre director (Rolf-Birger Pedersen), a vice-director (Vigdis Torsvik), a centre administrator (Anne Fjellbirkeland) and research theme leaders (Ingunn Thorseth, Lise Øvreås, Christoffer Schander, Ida Steen, Harald Furnes and Rolf-Birger Pedersen).

Further information about organisation and management
Further information about organisation and management of CGB is available in the following web page: http://www.geobio.uib.no/Default.aspx?pageid=829 and http://www.uib.no/mnfa/fakstyret/sakslister/2007/12_19/125.pdf

Main administrative tasks in 2007
- Budgeting and accounting
- Updating the research plan
- Establishing administrative and economic structures/support
- Recruitment of an administrative leader
- Infrastructure planning

PERSONNEL:

Personnel	CGB Activity (%)	Funding
Scientists		
Birkeland Nils Kåre	25	CGB - UiB, Dep.of Biology
Dahle Håkon	50	CGB - NFR
Furnes Harald	50	CGB - UiB, Dept.of Earth Science
Hannisdal Bjarte*	100	External
Kosler Jan	50	CGB - UiB, Dept.of Earth Science
Melezhik Victor	20	CGB - NFR
Pedersen Rolf-Birger	100	CGB - UiB, MN Faculty
Schander Christoffer	50	CGB - Dept.of Biology
Schleper Christa	20	CGB - Dept.of Biology
Steen Ida Helene	100	CGB - NFR
Stokke Runar	100	CGB - NFR
Thorseth Ingunn	50	CGB - UiB, Dept.of Earth Science
Torsvik Vigdis	50	CGB - UiB, Dept.of Biology
Øvreås Lise	50	CGB - UiB, Dept.of Biology
Postdocs		
Bjelland Torbjørg*	100	External
Einen Jørn	100	CGB – UiB, Dept.of Biology
Fliegel Daniel*	100	External
Hellevang Helge*	100	External
McLoughlin Nicola*	100	External
Reigstad Laila*	100	External
Ph.D. students		
Hansen Heidi	75	CGB - UiB, Dept.of EarthSciences
Hocking William	75	CGB – UiB, Dept.of Biology
Steinsbu Bjørn Olav*	100	External
Økland Ingeborg	75	CGB - UiB, Dept.of Earth Sciences
Technical staff		
Almelid Hildegunn	50	CGB - UiB, Dept.of Earth Sciences
Daae Frida Lise	100	CGB - UiB, Dept.of Biology
Jørgensen Steffen Leth	100	CGB - NFR
Kruber Claudia	100	CGB – UiB, Dept.of Earth Sciences
Ronen Yuval	50	CGB - UiB, Dept.of Earth Sciences
Tumyr Ole	50	CGB – UiB, Dept.of Earth Sciences
Administrative staff		
Bartle Elinor	20	CGB - UiB, Dept.of Biology
Berget Tore	20	CGB - UiB, Dept.of Biology
Fjellbirkelland Anne	80	CGB - NFR

* Funding sources for externally financed personnel

Name	Project	Project manager
Bjelland Torbjørg	Hidden Reservoirs of Biological Diversity - Geobiology of Unexplored Endolitihic Communities Associated with Lichens (NFR)	Bjelland Torbjørg
Fliegel Daniel	Life in the volcanic crust of the early Earth: conditions, timing and depth (NFR)	Furnes Harald
Hannisdal Bjarte	Marine Benthic Dynamics Hydro/Statoil	Hannisdal Bjarte
Hellevang Helge	BIODEEP (NFR)	Thorseth Ingunn
McLoughlin Nicola	Life in the volcanic crust of the early Earth: conditions, timing and depth (NFR)	Furnes Harald
Reigstad Laila	Functional Metagenomics to Study Prokaryotes from Arctic/Sub-Arctic Springs of Hydrothermal Origin	Christa Schleper
Steinsbu Bjørn Olav	The deep biosphere of the ocean crust: biomass, diversity, activity and biogeochemical cycles (NFR)	Pedersen Rolf-Birger

ANNUAL ACCOUNTS

Funding

	(1000 NOK)
The Research Council of Norway	7136
University of Bergen	
Department of Biology	1629
Department of Earth Science	1095
The Faculty of Mathematics and Natural Sciences	1731
Total funding	**11591**

Expenses

Salaries (including social benefits)	3732
Facility rental costs	796
External research services	979
Scientific equipment	1625
Other costs	3784
Total expenses	**10916**

ORGANISATION OF INTERNATIONAL CONFERENCES AND SYMPOSIA

9$^{\text{th}}$ International Conference on Thermophiles Research
CGB sponsored the 9$^{\text{th}}$ International Conference on Thermophile Research and CGB scientists were members of the organising committee. Prof. Nils-Kåre Birkeland was conference chair and Prof. Christa Schleper and Research Scientist Ida Helene Steen were members of the international organising committee. The conference was held in Bergen 24$^{\text{th}}$ – 27$^{\text{th}}$ September and the local organisation committee consisted of Nils-Kåre Birkeland, Runar Stokke, Ida Helene Steen, Sidsel Kjølleberg, Elinor Bartle, Christa Schleper, Solveig Hoem, Irene Roalkvam, Anders Schouw.

URL: http://sites.web123.no/AtlanticReiser/uib/Thermophiles2007/

American Geophysical Union (AGU) Fall Meeting
CGB director Rolf-Birger Pedersen and research theme leader Ingunn Thorseth were Co-convenors of the symposium: “Oceanographic Studies in the Eastern Arctic Basin During the International Polar Year II” which was part of the 2007 AGU fall meeting. The meeting was held in San Fransisco, USA, 10$^{\text{th}}$ – 14$^{\text{th}}$ Descember.

URL: http://www.agu.org/meetings/fm07/

PUBLICATIONS

Articles in international peer reviewed journals

1. Banerjee, N., Simonetti, A., **Furnes, H.,** Muehlenbachs, K., Staudigel, H., Heaman, L. M.,, Van Kranendonk, M. J. Direct dating of Archean microbial ichnofossils. Geology 2007;35(6):487-490
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5. Chumakov, N. M.; Pokrovsky, B.G.; **Melezhik, V**. A. Geological history of the Patom Complex, Late Precambrian, Central Siberia. . Izvestiya, Russian Academy of Sciences. Physics of the Solid Earth 2007(413):379-383
6. Dilek, Y., **Furnes, H**. Shallo, M. Suprasubduction zone ophiolite formation along the periphery of Mesozoic Gondwana. Gondwana Research 2007;11(4):453-475

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11. **Furnes, H**., Banerjee, N., Staudigel, H., Muehlenbachs, K. Pillow lavas as a habitat for microbial life. Geology Today 2007(23):143-146

12. **Furnes, H**., Banerjee, N., Staudigel, H., Muehlenbachs, K., **Mcloughlin, N**., de Wit, M., Van Kranendonk, M. Comparing petrographic signatures of bioalteration in recent to Mesoarchean pillow lavas: Tracing subsurface life in oceanic igneous rocks. Precambrian Research 2007;158(3-4):156-176

13. **Furnes, H.,** de Wit, M., Staudigel, H., Rosing, M., Muehlenbachs, K. A vestige of Earth's oldest ophiolite. Science 2007;315(5819):1704-1707

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2. **Schleper, C**. Diversity and ecology of Archaea: Perspectives from microbial ecology and metagenomics.. I: Archaea: Evolution, Physiology and Molecular Biology.. Malden, MA USA: Blackwell Publishing 2007. ISBN 1405144041

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2. Banerjee, N., Simonetti, A., **Furnes, H**., Muehlenbachs, K., Staudigel, H., **Mcloughlin, N**., de Wit, M; Van Kranendonk, M. Direct dating of archean microbial ichnofossils. Geochimica et Cosmochimica Acta 2007;71(15) Suppl 1:A58-A58
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5. De Cock, H., Hertogen, J., **Kosler, J**. Sr-Nd isotope data on diorite-trondhjemite associations from the central Norwegian Caledonides. Goldschmidt Conf.; 20.08.2007 - 24.08.2007
6. **Dahle, H**., Garshol, F., Madsen, M. S., **Birkeland, N-K**. Microbial community structure analysis of produced water from a high-temperature North-Sea oil-field. Thermophiles 2007; 24.09.2007 - 27.09.2007
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12. Faryad, S. W., **Kosler, J**. Incipient eclogite facies metamorphism in a granulite recorded by inclusion pattern and compositional zoning in garnet. Goldschmidt Conf. ; 20.08.2007 - 24.08.2007
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2. **Birkeland, N-K**. Microbial Diversity of Deep and Hot Petroleum Reservoirs. Invited lecture; 22.11.2007 - 22.11.2007
3. **Furnes, H**. Ocean pillow lavas as habitats for microbial life through time (invited talk). Department of Geology and Geochemistry, Stockholm University, Sweden, May 2007.
4. **Furnes, H**. Oceanic pillow lavas and hyaloclastites as habitats for microbial life through time. Institut de Physique du Globe de Paris, France, October 2007.
5. **Hannisdal, B.** Inferring evolutionary patterns in the fossil record by Bayesian inversion. Invited lecture, Centre for Ecological and Evolutionary Synthesis, University of Oslo. March 9, 2007.
6. **Hannisdal, B.** The Community Surface Dynamics Modeling System (CSDMS): an open,community-based modeling framework for earth surface processes. Netherlands Institute of Ecology (NIOO-KNAW), Yerseke, Netherlands. September 5, 2007.
7. **Kosler, J**. (2007): Isotopic dating of accessory minerals by laser ablation ICP-MS: where do we stand? Frontiers in mineral Science abstracts, Cambridge.
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11. **Melezhik, V.A**. ICDP FAR-DEEP: first results and suggestions for the cooperation. 21 December, 2007, Institute of Precembrian Geology and Geochronology, Russian Academy of Sciences, St. Petersburg, Russia.
12. **Pedersen, R. B**., Mid-ocean ridges and hot vents: Chemosynthetic life in the Norwegian Sea. NOSAM, NGU, November 2007
13. **Pedersen, R. B**., Hot-Spots in the Arctic – the 71ºN vent fields. PGP, University of Oslo.
14. **Øvreås, L**. The deep biosphere – a source or a sink of genetic diversity? Environmental workshop 2007. Microbial diversity in the Biosphere: trends and new perspectives. Baeza, Spain. October 4th – 6th , 2007.

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1. **Hannisdal, B.** Geobiologi - jorden som et koblet geologisk-biologisk system. Info-uken, 16. oktober, 2007.
2. **Pedersen, R-B.** Secrets of the Deep Sea, VilVite senteret Bergen
3. **Schander, C**. En uutforsket verden ved Jan Mayen. Veckomøte; 24.01.2007 - 24.01.2007

4. **Øvreås, L**. Dyphavets hemmeligheter. VilVite senteret Bergen. TEKNA familiearrangement. 27th October 2007.
5. Teacher at Sea program, July - 2007

Media presentations

1. **Furnes, H**: Oldest chunk of Earth's crust ever found. 22nd March New Scientist
2. **Furnes, H**: Oldest Known Ocean Crust Found on Greenland 22nd March National Geographic
3. **Furnes, H:** Earth's Oldest Chunk of Crust Found 22nd March Discovery Channel News
4. **Furnes, H**: Found! Oldest chunk of Earth's crust 23rd March abc news
5. **Furnes, H**: Sea floor records ancient Earth 23rd March BBC News online
6. **Furnes, H**: Fant verdens eldste havbunnstruktur 23rd March På Høyden
7. **Furnes, H**: Geophysicists Find Evidence of First Plate Tectonics 23rd March Science Daily
8. **Furnes H**: Canadians find signs of ancient life in Australia 30th May CBC News.
9. **McLoughlin N**: Søker «Marsboere» i urgammel stein 20th August På Høyden
10. **McLoughlin, N.** Steinspising pa Mars. Nysgjerriper (4) 2007
11. **Melezhik, V**: Borer i urtiden. GEO 01/2007
12. **McLoughlin N**: Mikrobeliv på Mars. Hubro 03/07
13. **Pedersen, R-B. Thorseth, I., Furnes H**: Geobiosfæren – et uskrevet kapittel. GEO 8/2007.
14. **Pedersen, R-B**: Nytt SFF-senter til geofagene. GEO 01/2007.
15. **Pedersen, R-B**: "Professoren" GEO 01/2007
16. **Pedersen, R-B**: Leter etter livets røtter. Forskning 03/2007
17. **Pedersen, R-B**: Utforsker livets opprinnelse. Hubro 1/2007
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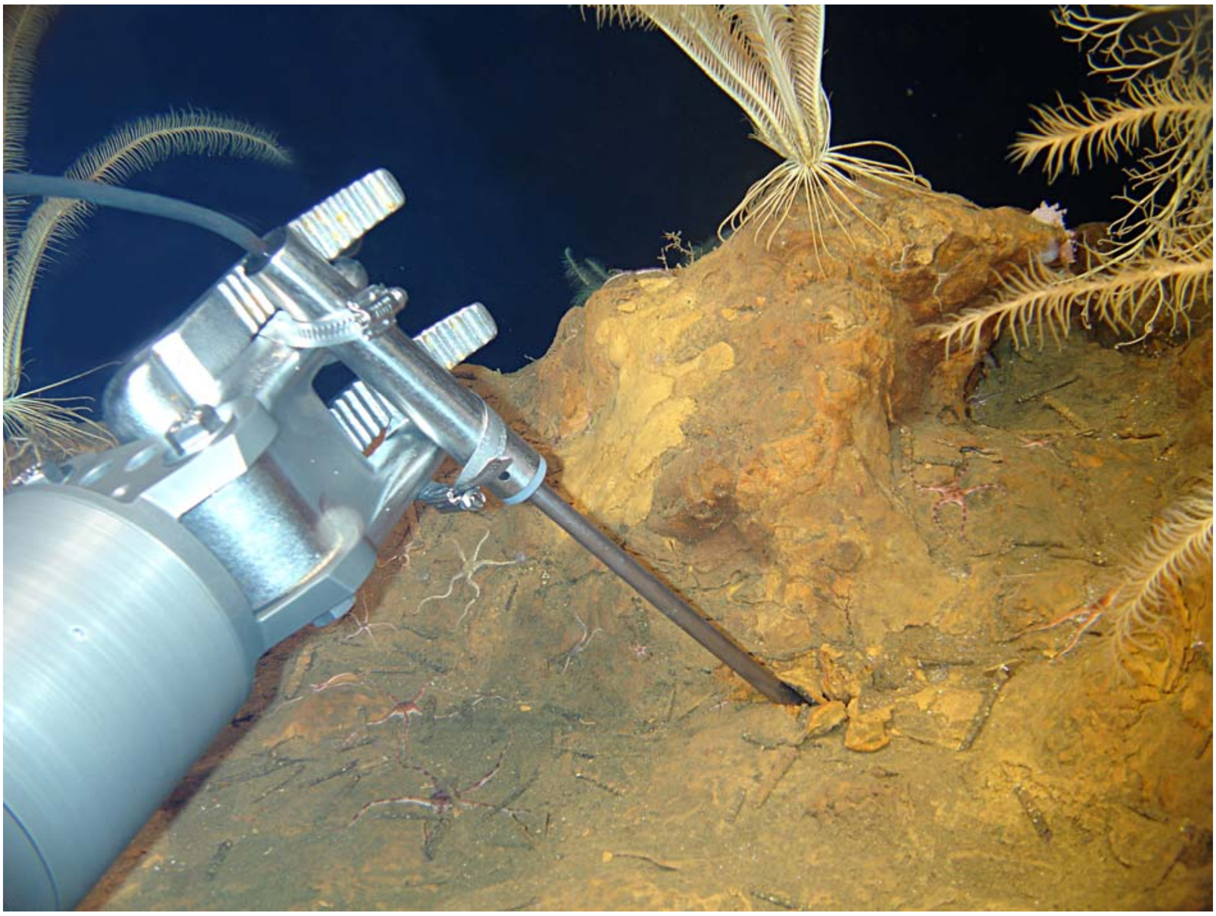

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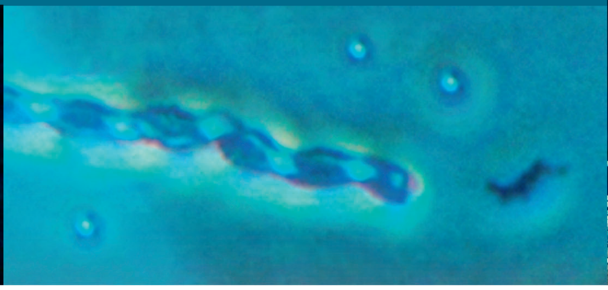
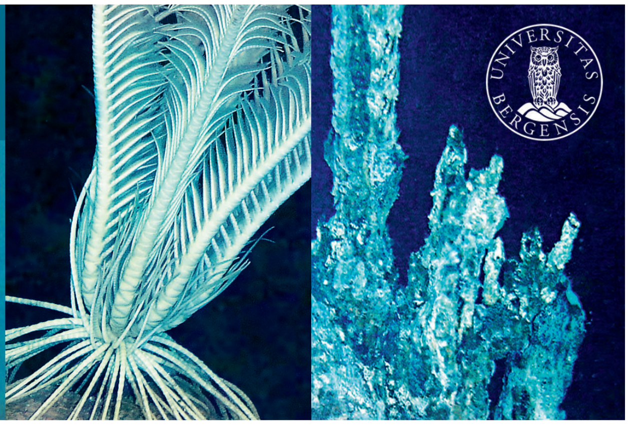
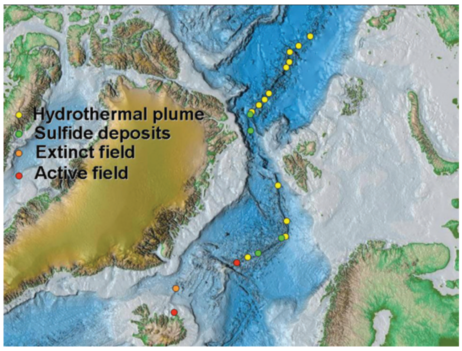


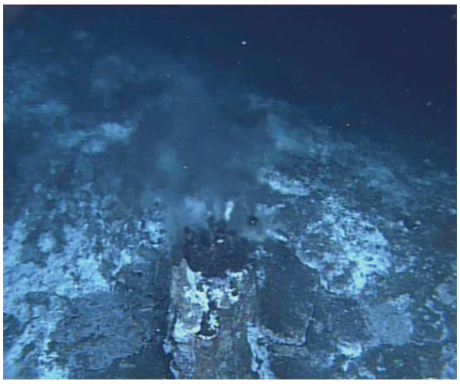


Deep Seafloor • Deep Biosphere • Deep Time & Roots of life

Deep Sea-floor Geodynamics

A new type of hydrothermal system has recently been discovered that may be driven by exothermic rock water reactions that take place when seawater circulates through mantle rocks (peridotite). At ultra-slow spreading ridges such as the Arctic portion of the mid-Atlantic ridge the mantle may become exposed at the seafloor as a result of tectonic processes. These poorly characterized systems may be our closest modern analog to ancient hydrothermal systems that may have been sites for the synthesis of building blocks of life and the earliest life.





Hot water streaming from a hydrothermal vent.

Over the last few years our group has explored the ice-free part of the Arctic Mid-Ocean Ridge; one of the few places where spreading occurs at an ultra-slow rate.

We have discovered two large vent fields at 71ºN. In the deeper waters (~3000m) to the north we have located hydrothermal plumes and have recovered hydrothermal deposits in an area where volcanic activity is scarce, the crust appears to become thin and missing, and where it seems that the mantle is exhumed to the surface by tectonic processes.

Fluids also escape from the seafloor at the continental margins. Whereas the fluids emanating from hydrothermal fields at the ridge are extremely hot (up to 400ºC), the fluids escaping from the sedimentary deposits at the continental margin are much colder – leading to the term ‘cold seeps’. Some cold seeps are associated with mud-volcanoes; areas where the muddy sediments below the seafloor are mobilized and extrude on the surface as a result of the upward flow of fluids.

Our study area in the Norwegian-Greenland Sea covers a variety of geodynamic processes. The mid-ocean ridge comes close to the continental margin southwest of Svalbard. Here, within a limited geographical area, we have hot vents and cold seeps, volcanoes and mud-volcanoes. There are also active fault zones at the ridge and giant submarine landsides from the continental margin.

Investigating subseafloor processes and the deep biosphere ultimately requires seafloor drilling. We may have one of the best localities for seafloor drilling of an ultra-slow spreading ridge because a thick sequence of sediments derived from the continental margin covers the lavas and provide good drilling conditions. The extracted cores will answer first-order questions related to spreading processes, water-rock interactions, hydrogeology and the subseafloor biosphere at the very slow-spreading end of the spreading ridge spectrum.

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Research theme co-ordinator Rolf-Birger Pedersen’s main scientific interests concern the processes responsible for generation and alteration of the earth’s oceanic crust past and present. As Centre leader, he heads an interdisciplinary research team investigating the geobiology of Norway’s unique regions of ultra-slow spreading zones.

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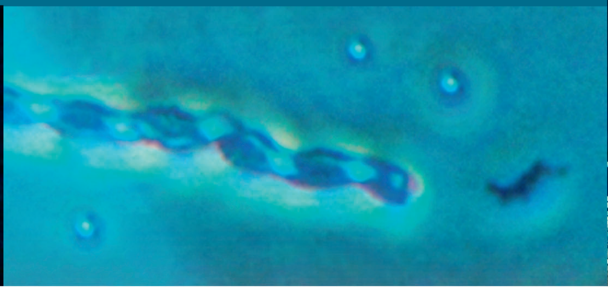
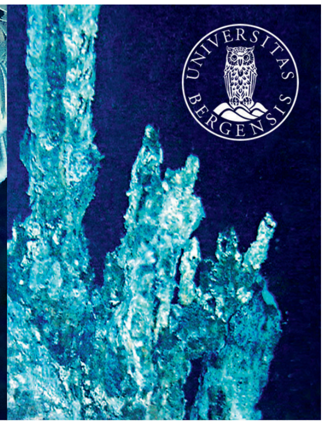




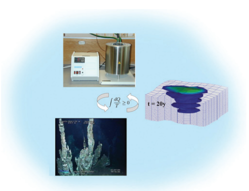
Deep Seafloor • Deep Biosphere • Deep Time & Roots of life

Rocks-Water-Microbe Interactions

Fluids that circulate through the earth's crust and mix with the ocean waters above are responsible for the exchange of elements between the crust and sea water. The processes involved are as yet poorly understood, but are critically important for the development of complete models of marine chemistry and global element cycling. Our research goal is to further our understanding of the influence of microorganisms on the geochemistry of aqueous and solid phases in general.

Alteration of the oceanic crust by circulating hydrothermal fluids is one of the major processes responsible for element exchange between the lithosphere and the ocean. Thus, knowledge of the mechanisms and factors involved is fundamental to understanding and being able to model marine chemistry and global element cycling.

Recently there have been discoveries of indigenous microorganisms in subseafloor rocks and fluids as well as strong biologically-produced chemical signatures in some venting systems. These findings imply that explanations of crust alteration by physical and chemical processes alone are insufficient; water-rock interactions are also strongly influenced by microbial activity and metabolic processes.



Thus, determination of how and to what extent the geobiological processes within the deep biosphere influence alteration of the ocean crust will significantly increase our understanding of the ocean-crust geochemical exchange, the magnitude of the deep biosphere, and its role in carbon cycling and storage in the crust. It is also likely that studied in this area will reveal fundamental information about current and ancient microbial life on Earth and its potential discovery on other planets.

We will carry out detailed textural, mineralogical and chemical studies of hydrothermal deposits and fluids, and altered crustal rocks of different ages - in combination with in situ seafloor, subseafloor and laboratory alteration experiments. We will also develop geochemical models. The specific objectives are to:

This stone, collected from the deep sea, clearly shows the interactions between the rock, water and microbes in its layers.

- determine mechanisms and rates of microbial catalysed dissolution of minerals and rocks
- quantify microbial-induced mineralization and their role in element immobilization
- define textural and chemical biosignatures in rocks suitable for detection of present and ancient microbial life
- estimate the importance of the subseafloor biosphere for carbon storage and cycling

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Research theme co-ordinator Ingunn Hindenes Thorseth's main fields of research are the subseafloor biosphere, weathering and low-temperature alteration of rocks and minerals, microbial degradation of rocks and minerals and biomineralisation, microbial fossilisation and biosignatures in rocks.

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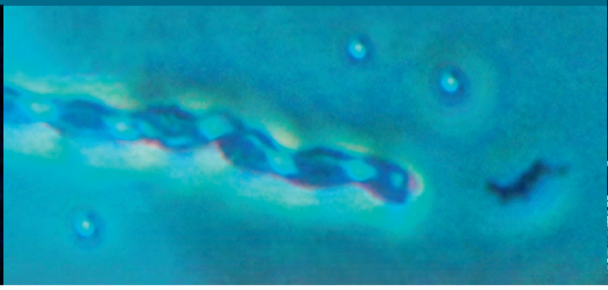
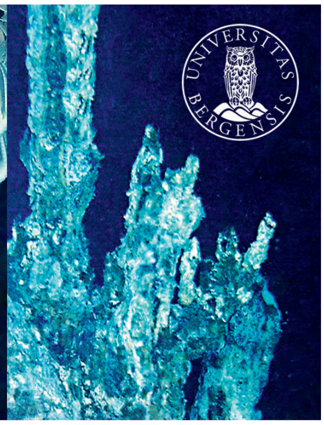




Deep Seafloor • Deep Biosphere • Deep Time & Roots of life

the Deep Biosphere

Microorganisms comprise much of Earth's biodiversity and play critical roles in biogeochemical cycling and ecosystem functioning. Subsurface life offers new and barely explored opportunities to examine the ecological and evolutionary processes that drive microbial diversity, community organisation and microbial interactions. The recognition of large deep biosphere populations raises new, intriguing questions concerning their origin, diversity, resource utilization, activity, adaptation and relationship with the "upper world" biosphere.

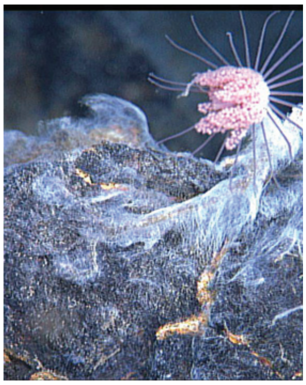
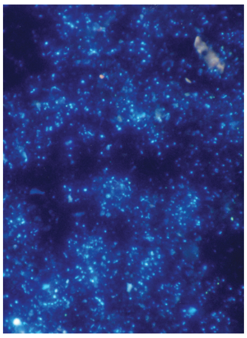


Image showing an example of a bacterial mat on the deep sea floor.

A



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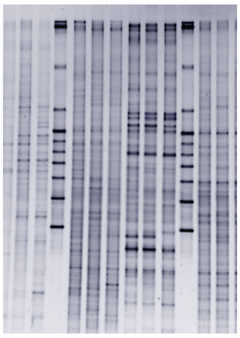

Deeply buried sediments harbor the majority of all prokaryotic organisms (bacteria and archaea) on Earth. Yet, they constitute an almost unexplored part of the global environment.
A)Microscopic impression of bacteria in sediments stained with DAPI and examined under fluorescent microscopy
B) An example of genetic fingeprint of such an unexplored environment

We will apply a holistic approach using whole system biology extending to population dynamics, physiology and phylogenetics. The data we collect will also be coupled to environmental data (rock and fluid chemistry, temperature) to ensure that we can build up complete understanding of the in situ conditions.

In addition to monitoring the diversity in the deep biosphere by 16S rRNA-based technologies, we will employ large-scale metagenomic analyses to reveal the functional potential of indigenous microorganisms, independent of their cultivation.

Questions to address:

1) Are deep biosphere microbes unique and truly isolated from the upper world by slow physical transport mechanisms?

2) Is there a correlation between microbial community structures and the physical/chemical environment?

3) Are there energy sources that are insignificant in the "upper world", which are exploited to sustain life in a minimal-energy deep biosphere?

4) What are the genomic features and adaptations that permit survival and proliferation in this environment?

5) Is the deep biosphere a source or a sink of genetic diversity?

6) How do population size, community isolation and metabolic activity effect genome evolution?

To address these questions, we need to know more about the microbial diversity and function of the deep biosphere.

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Research theme co-ordinator Lise Øvreås' main scientific interests are genetic diversity and population dynamics of microorganisms in their natural environments. She is particularly interested in developing molecular tools to monitor microbial diversity in nature and in which factors that control prokaryotic diversity.

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Early Earth and Biosignatures

Learning about the development of life in the first 3 billion years of our planet's history provides us with information that can be used to help find life on other planets. The earliest life forms on Earth have left biosignatures that can be found in Earth's most ancient rocks.

3800-million-years-old metasediments from Akilia Island, SW-Greenland, containing the oldest evidence of life on Earth.

We aim to provide a global and stratigraphic context to elucidate how ancient microbes became established in the early crust, what environmental factors controlled their development, and how microbes interacted with the volcanic component of the solid Earth through time.

3500-million-years-old pillow lava from the Apex basalt, Pilbara Craton, Australia.

We are addressing four key questions:

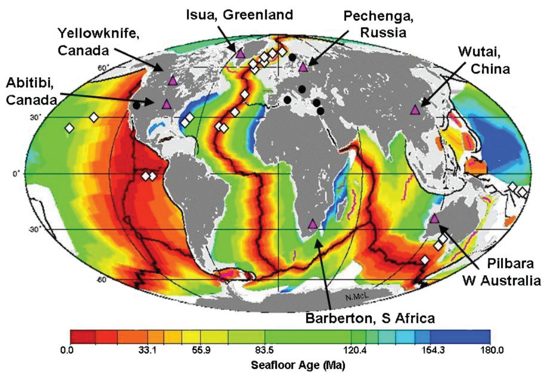
- how far back in time can we trace bioalteration in pillow lavas;
- are bioalteration textures preserved in greenstone belts worldwide;
- what are the key environmental controls on their distribution;
- can we identify and date unique biogeochemical tracers for comparison purposes?

The earliest life forms were simple, single celled micro-organisms and their chemical and morphological traces or biosignatures can be found in the ancient rock record in 3000 to 3500 million-year-old rocks from places in S. Africa and W. Australia.

We use field mapping and sampling followed by microscopy and chemical analyses to understand how these rocks formed. In 3.5 billion year old lavas we have found traces or "rock eating" microbes that made tiny holes in the volcanic glass. We are also studying sedimentary rocks, to seek the remains of the earliest microbial mats or "slime layers".

It is now well established that microbial colonization of basaltic glass leads to the formation of characteristic textural, chemical and isotopic biosignatures that have been discovered in in-situ oceanic and ancient oceanic crust back to 3.5Ga.

FIELD WORK



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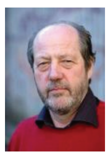
Research theme co-ordinator Harald Furnes studies the development of the oceanic crust both the modern seafloor and ancient fragments of oceanic crust. He is also interested in biogenic and abiogenic processes of basaltic glass alteration, especially as the biogenic alteration processes can provide clues as to the activities of early life-forms on earth.



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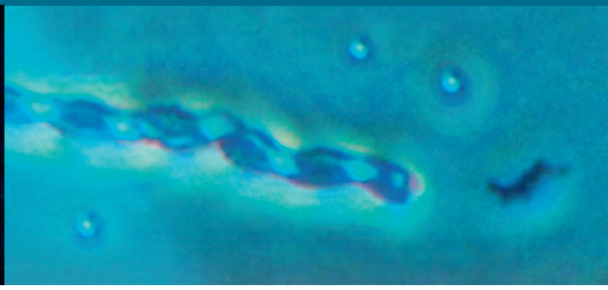

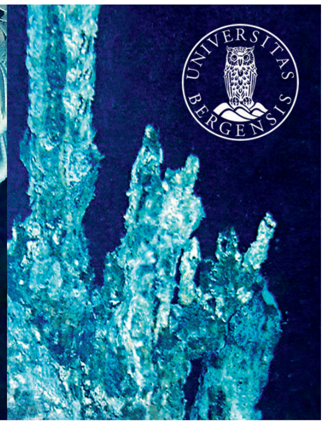

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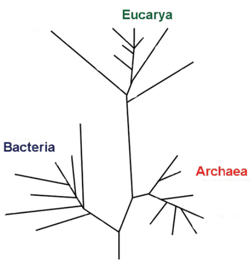
the Roots of Life

Life is thought to have arisen around 3.8 billion years ago. It began with relatively simple one-celled microorganisms. In the late 1970s a new phyla of microorganisms was discovered; the Archaea. Because many Archaea thrive under conditions that seem to re-define the extreme physico-chemical boarders where life can be supported, researchers have wondered if these microorganisms are the descendents or even living fossils of the earliest life forms.



Phylogenetic tree showing three domains of life: Archaea, Bacteria and Eukarya.

In the late 1970s, when biological macromolecules were used for the first time to measure natural evolutionary distances, it was found that the Prokaryotes are deeply divided into two domains; the Bacteria and the Archaea.

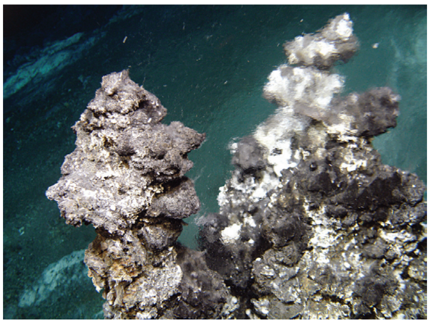
Since the hyperthermophilic organisms of both domains root the phylogenetic trees, it has been widely speculated that the last common ancestors and perhaps the first organisms on earth were indeed hyperthermophiles.

The hypothesis of a hot root of life is still under debate. Hyperthermophiles exhibit specific, highly sophisticated adaptations. The information processing machinery of Archaea is considerably more complex than that in Bacteria, and is clearly related to those of eukaryotes. Study of the Archaea may reveal clues about the evolution of those processes that occur in the eukaryotic nucleus.

Their high abundance indicates that Archaea should be of global ecological significance. However, their phenotypic and physiological properties are still largely unknown.

In the very few studies on communities of deep sea and terrestrial hydrothermal vents, an unexpectedly high diversity of Archaea was detected. Even less is known about Bacteria in hot environments.

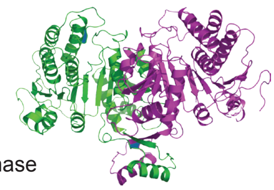
The earliest forms of life may have begun in conditions such as those existing in the water streaming out of this hydrothermal vent.



Learning more about the diversity, genome content, physiological potential and adaptive strategies of the prokaryotes from the deep biosphere will provide fundamental information about the roots of life.

Research activities will concentrate on the following specific objectives:

- determine the evolution of hyperthermophilic microorganisms
- analyze the information processing machineries and adaptive features of some model organisms
- trace remnants of early life forms
- characterize the distribution and diversity of metabolisms



Isocitrate dehydrogenase

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Research theme co-ordinator Christa Schleper studies gene regulation in hyperthermophilic archaea as well as microbial diversity by metagenomic and functional metagenomic techniques. Fellow co-ordinator Ida Steen studies enzymes from extremophile microorganisms.

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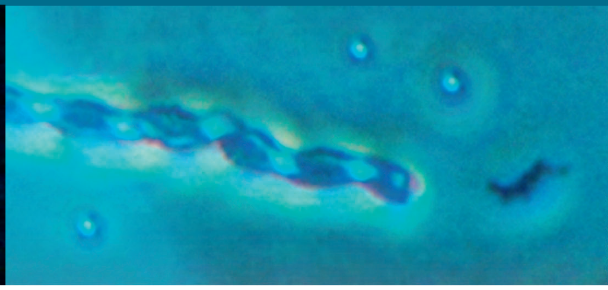

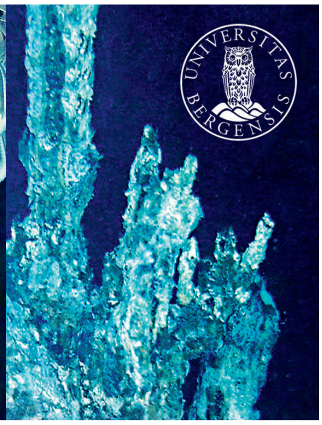

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Vent, Seep and Fall Biota

In extreme deep-sea environments such as those existing around hydrothermal vents and seeps or around nutrient-rich falls, such as whale carcasses, researchers are discovering specialised communities of unusual organisms, most of which are not found anywhere else on earth. The energy system for these unique and relatively unstudied communities of organisms is based on the production of specialised bacteria that are able to reduce chemical compounds to generate the energy required to make biological compounds.

A natural log fall discovered summer 2007 at 3000m.

Vent and seep biota are clearly related to each other and to other chemically-fuelled ecosystems such as whale and wood falls. They differ markedly from the biota found in the surrounding areas.

The trophic structure of these communities is based on chemolithotrophic bacteria that use reduced sulphur compounds as energy to fix inorganic carbon. The communities are characterised by high biomass made up of a few symbiont-bearing species or upon species bearing epibionts, and low biodiversity.

The newly discovered vent fields in the Arctic Ridge system are biologically important in several ways. They are located at high latitude, and are biogeographically isolated from other similar habitats.

Is the fauna found around deep sea hydro-thermal vents, seeps and falls unique, or is it a continuation of communitites found elsewhere?

More importantly, some are found at rather shallow depths, where it has just been shown that the plumes reach all the way up into the photic areas of the ocean. This means that the interaction with the sun-driven ecosystem will be much greater than in many other vent regions.

Such areas will provide us with opportunities to investigate processes that may have been important during Paleoprotozoic and Neoproterozoic ‘snowball earth’ events, when metazoan life may have remained active only within geothermal pockets.

Chemosynthetic ecosystems are by definition disjunctive and offer great possibilities for studying gene flow. The proximity of hot vents at the ridge to the cold seeps at the continental margins makes the Arctic Ocean and the Norwegian Sea ideal for such studies.

Important questions to address are:

- How many species inhabit the vents and what are the relationships between them?
- How do the vent species disperse and colonise in patchy and unstable habitats?
- How do vent species evolve and did their adaptation to extreme conditions play an important part in their evolution?

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Research theme co-ordinator Christoffer Schander’s research use phylogenetic analyses that integrate morphological, ultrastructural and msolecular data to better understand howevolutionary forces and phylogeny have played in creating organismal diversity. The biotic communities living around vents, seep and falls provide unique opportunities to study evolutionary processes in action.