Photo courtesy of G. De Lange

ESF Magellan Workshop on Exploring the Deep Biosphere with Scientific Ocean Drilling

Kartause Ittingen, Warth, Switzerland
26-29 January 2006

Workshop Report

Compiled by J. A. McKenzie, ETH Zürich

SWISS NATIONAL SCIENCE FOUNDATION

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Table of Contents

I. ESF Magellan Workshop Program

Exploring the Deep Biosphere with Scientific Ocean Drilling
Kartause Ittingen, Warth, Switzerland

Thursday, 26 January 2006

Late afternoon/early evening arrival

Welcoming Aperó - (1700) Informal gathering of participants followed by Dinner (1800)

After-Dinner Keynote Speaker: John Parkes, "Historical Perspective on the Study of the Deep Biosphere"

Friday, 27 January 2006

Breakfast after 7:00
Morning Session 9:00

Welcome & Introduction of Participants: J. McKenzie

Review of Workshop Goals: Co-Chairs S. Kasten & C. Vasconcelos

Round Table Discussion: "Techniques and Methods to Study the Deep Biosphere"
H. Cypionka (ODP Leg 201), C. Vasconcelos (IODP Exp. 310), B. Horsfield (ICDP)

Coffee Break (10:00)

Drilling Results and Prospects for Future Drilling

Short presentations to define specific areas/topics for drilling proposals:

Argentine Basin - Leader S. Kasten
Mediterranean Sea - Leader G. de Lange
Bay of Cadiz – Leader D. Depreiter
Great Australian Bight – Leader U. Wortmann
MOR & Hydrothermal Venting – Leader N. Holm

Other areas or specific topic, e.g., Deep Biosphere Borehole Observatories, Drilling Methane/Sulfate Transition, etc.

Lunch Break 12:30

Afternoon Session 13:30

Keynote Speaker: A. Boetius – "Methane as Energy Substrate for Microbial Life: News and Views"

Review Initial Science Plan (ISP) Deep Biosphere Initiative – J. McKenzie

Define Deep Biosphere Mission – J. McKenzie

Coffee Break (16:00)

Brainstorming sessions in breakout groups

Dinner 18:30
Concert by Mahmoud Turkmani-Merz (Begins at 20:15)

Saturday, 28 January 2006

Breakfast after 7:00
Morning Session 9:00

Working groups meet

Coffee Break (10:15)

Presentation: ECORD ERA-Net Work Package 1: Geo-microbiology Database
T. Bingham Mueller & F. Tamburini

Lunch 12:30

Afternoon Session 13:30

Preparation of Working Group Reports

Coffee Break (16:00)

Presentation of Working Group Reports

Cultural Event (18:00-19:30): Guided Tour "The History of the Kartause Ittingen"
Dinner (19:45)

Continued discussion and completion of reports

Sunday, 29 January 2006

Breakfast (after 7:00) & farewell discussion – morning departure

II. Introduction

The Initial Science Plan (ISP) formulated to drive the first 10 years (2003-2013) of the Integrated Ocean Drilling Program (IODP) identifies the study of the deep, subseafloor biosphere as one of eight high-priority initiatives for scientific ocean drilling. In spite of this emphasis on the deep biosphere and being more than two years into the new IODP, Ocean Drilling Program (ODP) Leg 201 remains the first and only drilling expedition that was dedicated to the study of the deep biosphere. Although microbiology has been introduced as a routine component in many of the IODP drilling expeditions, the involvement of the microbiology community into IODP has been very limited. In particular, major areas of microbiology, such as genomics and microbial ecology, do not factor strongly in existing IODP proposals. The problem of achieving the goals of the Deep Biosphere Initiative, as defined in the ISP, has been widely recognized within the IODP Scientific Advisory System and the national agencies funding IODP.

To capitalize on the knowledge gained during the Ocean Drilling Program and specifically build on the unqualified success of ODP Leg 201, the Deep Biosphere Workshop was proposed to bring together a diverse group of European scientists to develop ideas, evaluate current technology and formulate new drilling proposals to study the deep biosphere in sedimentary sequences, as well as in crustal environments. Although financially sponsored by grants from ECORD and the Swiss National Science Foundation, the workshop was considered to be part of the official ESF Scientific Program for "Workshops on Marine Research Drilling", the so-called Magellan Workshop Series, which came into formal existence in February 2006.

During the Deep Biosphere Workshop, held in the cloistered setting offered at Kartause Ittingen from 26-29 January 2006, 28 participants from the ECORD community gathered to discuss the key scientific issues surrounding the investigation of the deep biosphere through drilling and the concept of defining a Deep Biosphere Mission within IODP was presented. The Kartause Workshop was a first step towards defining a global, long-term drilling strategy and identifying some of the technological requirements for addressing the proposed objectives. This report represents the results of the general group discussion and contributions of specific sub-groups and individuals. See Appendix I for list of participants.

III. Drilling the Deep Biosphere Mission

The participants proposed that progress towards achieving the goals outlined in the ISP would only be made when dedicated expeditions to investigate the deep biosphere are routinely scheduled in IODP. For the second phase of IODP drilling representing the period 2007-2013, the participants recommend that a minimum of one dedicated deep biosphere expedition per year, i.e., up to six expeditions, should be undertaken. If a microbiology program is to ever become a major part of the IODP research, more scientific and technologic input must come from the microbiology community. To generate a stronger microbiologic component in IODP will require increasing the number of microbiologists serving on the SAS panels. In addition, the workshop participants recommended that more flexible programs conducive to the research needs of microbiologists would encourage greater participation in the shipboard work. For example, microbiologists may not need to remain onboard for the entire period of an expedition, but they could be shuttled on and off the ship using helicopters or crew-change boats, as has been done in the past for other specialists, such a downhole loggers. It was suggested that the establishment of a standing Microbiology Working Group, in IODP SAS or within the European ECORD community, would be useful to ensure that the microbiology program was being carried forward.

The technological requirements and needs for microbiological studies to be conducted on IODP platforms were evaluated. Topics of discussion included the following items:

(1) Shipboard sampling on dedicated deep biosphere legs - Minimum measurements should be extracted from ODP Leg 201 protocols e.g. cell counting, sample conservation. The protocols will be circulated for review and discussion (Axel Schippers).

(2) Portable microbiology laboratory – A portable container, adapted from plans formulated by Steve D'Hondt was presented by Brian Horsfield. The same container is outfitted for both microbiology and geochemistry studies. UV/V photometry and ATP luminometer are included. See attached presentation from B. Horsfield in Appendix II.

(3) Rhizon samplers should be available for pore water extraction. These porous (average pore diameter 0,1 μm) polymer tubes which were initially designed for the sampling of soil moisture have already been successfully applied during IODP Expedition 302 (ACEX). Rhizons have the advantage of causing a minimum disturbance of the sediment structure and ensuring the extraction of microbial- and colloidal-free pore water into evacuated and thus anoxic sample vials.

(4) Quantification of biomass / diversity by Qpcr (96 samples plates) adaptable resolution and CARD-Fish. Split DNA samples directly in Bacteria, Archaea and functional genes. At present there are considerable contradictions between biodiversity estimates obtained from different groups using similar methods hence it is essential that a range of molecular genetic and biomarker approaches are used on the same sediment to resolve this apparent contradiction. We also need more information about the degradation and preservation of biomolecules so that those indicative of active populations can be differentiated from those measuring dormant, dead or ancient communities.

(5) A range of successful DNA extraction procedures needs to be collated so that these are available to test with new sediments and ultimately establish a "standard DNA/cells extraction protocol".

(6) A feasibility study should be conducted to determine if automated DNA extraction with a joint venture company, e.g. Diversa, would be possible (Eric Allen).

(7) In situ experiments in bore hole laboratories should be designed.

IV. Potential Deep Biosphere Drilling Targets

The workshop participants outlined several geographic areas and/or topics where ocean research drilling would be suitable to drive the exploration of deep biosphere. Dedicated expeditions were proposed as an outcome of topical discussions among sub-groups of workshop participants for the following areas and/or topics:

(1) Moroccan Margin

A preliminary IODP proposal was submitted for the Moroccan Margin for the 1 April 2006 deadline. This is IODP Preproposal 689-Pre: Mud Volcanoes as a Window into the Deep

Biosphere, D. Depreiter et al., the cover sheet of which is appended to this report as Appendix III. The full document can be obtained from D. Depreiter (Davy.Depreiter@UGent.be).

(2) Great Australian Bight

A preliminary IODP proposal was submitted for the Great Australian Bight for the 1 April 2006 deadline. This is IODP Preproposal 701-Pre: Microbial Carbon and Sulfur Cycling in the Deep Biosphere of the Great Australian Bight, U. Wortmann et al., the cover sheet of which is appended to this report as Appendix IV. The full document can be obtained from U. Wortmann (uli.wortmann@utoronto.ca).

(3) Slow-spreading ridge Greenland Sea

I. Thorseth prepared and presented an IODP Preproposal outline entitled "Hydrothermal Systems at Ultra-Slow Spreading Ridge: Basalt/Peridotite hosted Deep Biosphere". The outline with the timeframe for preparation of a full IODP proposal is attached as Appendix V.

(4) Dedicated Expedition to the Eastern Mediterranean

The Eastern Mediterranean offers a set of environments that are unique for the deep biosphere. These include regularly occurring layers of sapropels, active mud volcanoes and brine lakes derived from evaporites and relict brines. Sapropels are distinct organic rich, cyclic units interbedded with organic-lean layers ranging from more than 5 million to approximately 8,000 years old. The cyclical occurrence is related to astronomical processing cycles occurring approximately every 22'000 years. It was proposed to return to reoccupy ODP Leg 160 sites, where initial microbiological results demonstrate that microbial populations and activity are elevated in sapropel layers. Remarkably, total populations appeared to increase in each sapropel layer with increasing depth. Questions to be answered include: Do the microbial communities continue to grow with depth in the sediment? How do they change with depth and age of the sediment? As each sapropel can be accurately dated, this gives a unique opportunity to quantify growth rates in the deep subsurface. There are also indications that the communities differ between the sapropel and non-sapropel layers. This gives a unique opportunity to look at the development of subsurface communities in organic-poor and organic-rich layers over millions of years. At the base of the sequence are the Messinian evaporites, which themselves may contain a unique hypersaline community. With the potential of drilling into and beneath the Messinian evaporates, it may be possible to discover even more ancient communities.

Furthermore, the Eastern Mediterranean is a region with a high density of active, hydrocarbon-expelling mud volcanoes. A direct comparison is possible between the microbial communities and biogeochemistry of mud volcanoes of active and passive continental margin settings. It has been proposed that mud volcanoes are windows to the deep biosphere because muds, fluids and gases are rising from deep subsurface reservoirs to the seafloor. However, changes in the microbial community structure and activity with depth have never been tested. Evidence has been found that the surface sediments of mud volcanoes contain some unique microbial populations. They also potentially contain unique deep-sourced energy supplies. Furthermore, they represent spatially and temporarily highly dynamic systems influencing microbial populations by varying fluid and gas flow, hydrate formation and decomposition, sediment compaction and mixing and other processes. There are several mud volcanoes providing both deep source electron donors (e.g., hydrocarbons) and electron acceptors (e.g., sulfate) thus providing potential of a deep microbial bioreactor.

Finally, Eastern Mediterranean sediments deposited in deep hypersaline brine lakes, may represent one of the most extreme environments on Earth. Drilling within this environment provides an opportunity to discover whether microbial life exists in this setting and, if so, to characterize this potentially unique community. Development of an IODP preproposal for Eastern Mediterranean drilling is anticipated for the near future (1 October 2006 deadline).

(5) Dedicated Expedition to the Black Sea

Because of its hydrological isolation from the global oceans, the Black Sea has experienced extreme variations of salinity in the past 2 million years. Different from most marine sediments, those of the Black Sea were formed under conditions changing among limnic, marine and hypersaline settings. Due to the high sedimentation rates, the porewaters have retained their initial salinity (ranging from brine to brackish) to a great extent. The influence of these changes on the microbial communities should be investigated. Today, the Black Sea hosts a variety of active shallow and deep hydrocarbon seeps, which expel fluids and gases to the anoxic water column. We consider these systems ideal natural laboratories to study methanogenesis, anaerobic oxidation of methane, sulfate reduction, iron- and sulfur cycling and microbe-mineral interactions (e.g., authigenic carbonate precipitation, barite precipitation and dissolution etc.). Nothing is known about the deep biosphere of the Black Sea, but we expect highly active communities degrading the high organic input by fermentation, coupled to sulfate reduction, methanogenesis, or perhaps acetogenesis. These sediments represent the closest and largest modern-day analogue to ancient anoxic microbial ecosystems. Oxidation of the surface environment might have had profound impact on biosphere-geosphere coupling.

The Black Sea provides unique access to sediments subject to significant environmental change including dramatic salinity changes, variation in organic matter supply from a limnic to marine setting, as well as mud volcanoes and very deep sedimentary sequences to be drilled. Development of an IODP preproposal for Black Sea drilling is anticipated for the near future.

Other geographic areas or topics were proposed and are awaiting further development as follows:

(6) Guymas Basin

(7) How deep is the deep biosphere? South Pacific Gyre and Atlantic compliment

(8) How old is the deep biosphere? Somali Basin

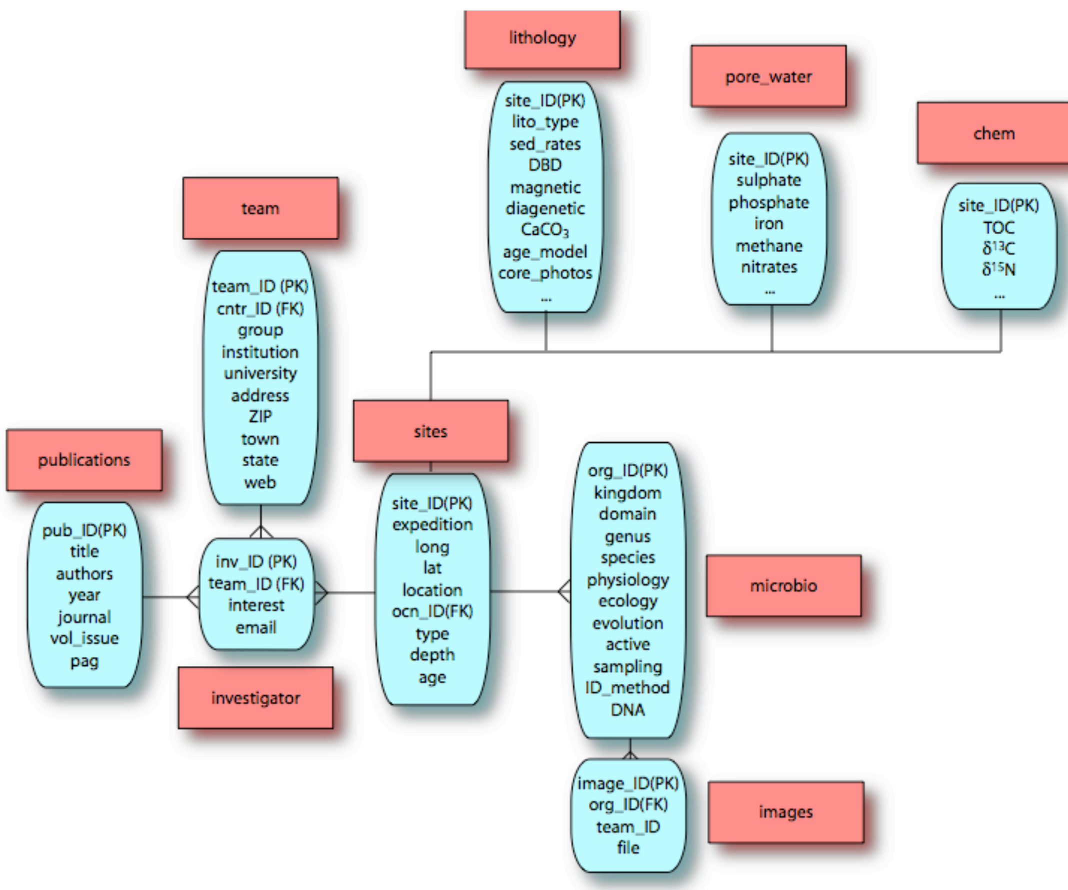
(9) How hot is the deep biosphere?

(10) MSP proposals – In situ Experiments, e.g. in European waters, Walvis Bay, Tahiti etc.

V. Geomicrobiology Data Base

Teresa Bingham and Federica Tamburini presented the ECORD-Net: WP 1: Toward a Geo-microbiology discovery database system. The goal was to establish contact with experts in the field of geomicrobiology to direct and finalize the efforts to construct a scientist-oriented meta-database and determine the usefulness of a ground-up database. The existing meta database was presented to the workshop participants in order to determine if the chosen structure was appropriate and provide further input.

The following diagram shows the various categories that will be included in the meta database. At the moment, information about the scientists working in the field of geomicrobiology is included in the meta database and can be searched by name and country. The relevant available data on ODP and IODP sites can be looked at according to ocean and the links to the JANUS database are given, where available. The information on the microbiology section will be developed in the near future. Information gained from the workshop participants will facilitate the development of the future database system.



Appendix I: Workshop Participants

1. Austria	Henry Mueller	University of Graz
2. Belgium	Davy Depreiter	University of Ghent
3. Canada	Uli Wortmann	University of Toronto
4. Denmark	Donald Canfield	University of Southern Denmark
5. France	Giovanni Aloisi	Université Claude Bernard, Lyon
6. France	Bénédicte Menez	Institut de Physique du Globe, Paris
7. Germany	Antje Boetius	Max Planck Institute of Mar. Microbiology, Bremen
8. Germany	Heribert Cypionka	Institut für Chemie u. Biologie, Oldenburg
9. Germany	Brian Horsfield	GeoForschungsZentrum Potsdam
10. Germany	Kai-Uwe Hinrichs	University of Bremen
11. Germany	Sabine Kasten	AWI-Bremerhaven
12. Germany	Axel Schippers	Federal Institute for Geosciences, Hannover
13. Iceland	Viggo Marteinsson	University of Iceland, Reykajavík
14. Italy	Roberto Barbieri	University of Bologna
15. Japan	Fumio Inagaki	JAMSTEC
16. Netherlands	Gert De Lange	University of Utrecht
17. Netherlands	Fons Stams	Wageningen University
18. Norway	Ingunn Thorseth	University of Bergen
19. Portugal	Vitor Magalhães	Natl. Inst. of Eng., Technology & Innovation, IP
20. Spain	Ricardo Amils	Centro de Bio. Molecular, Madrid
21. Sweden	Nils Holm	Stockholm University
22. Switzerland	Christophe Dupraz	University of Neuchâtel
23. Switzerland	Judith A. McKenzie	ETH-Zürich
24. Switzerland	Crisogono Vasconcelos	ETH-Zürich
25. Switzerland	Rolf Warthman	ETH-Zürich
26. U.K.	Ian Head	University of Newcastle
27. U.K.	John R. Parkes	University of Cardiff
28. U.S.A.	Eric Allen	University of California, San Diego

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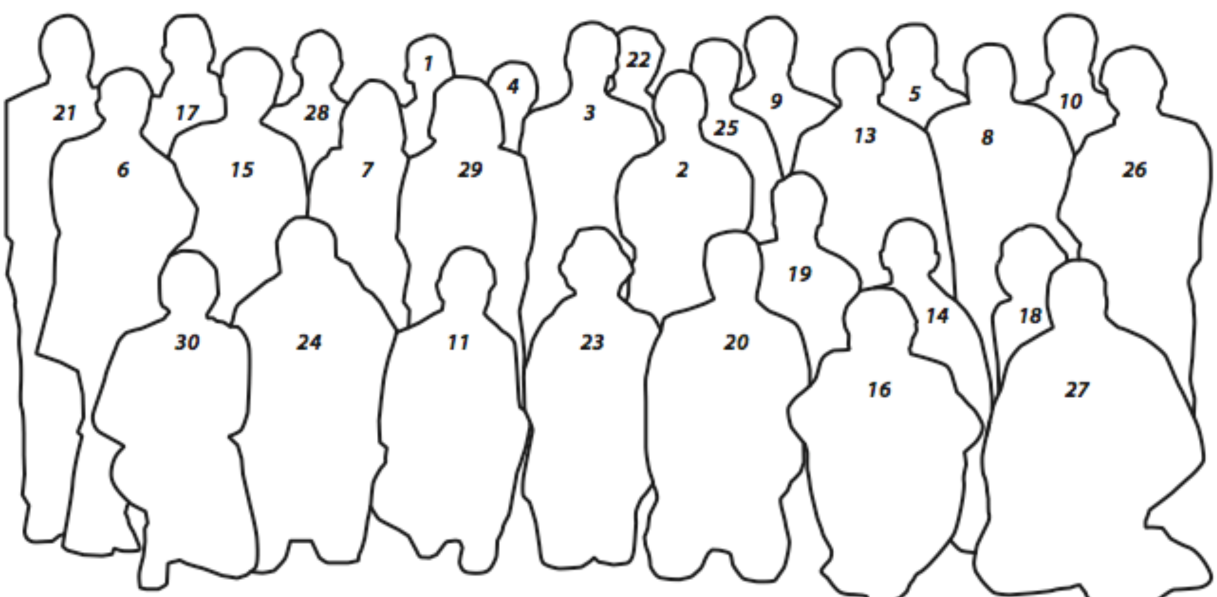
29. Switzerland	Teresa Bingham Müller	Swiss National Science Foundation
30. Switzerland	Federica Tamburini	ETH-Zürich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Appendix II - ppt by B. Horsfield

Microbiology and Geochemistry at ICDP

- Protocols should be same: IODP/ICDP
- Drilling operations will use different platforms
- Laboratory has to be flexible to accommodate different projects/environments

Mobile Lab

Built on experience – Rhode Island unit.
In consultation with an Advisory Group from the geomicrobiological community

- Highly modular to allow for different drilling locations and scientific objectives
- Minimum fixed equipment
- Everything else will be added according to project objectives

The container

- 40 ft, standard shipping size
- Good thermal insulation
- Air condition, heating
- Std. electricity connection (110 - 400 V)

Permanent equipment

- Fume Hood
- Laminar Flow
- Ultra-pure water supply
- Fridge
- -20° C and -80° C Freezer
- Autoclave
- Balance, Centrifuge, Shaker etc.

Sampling Equipment

- Anaerobic Glove Box
  - For anaerobic sampling and sample handling
- Titanium Pore Water Squeezers
  - For contamination-free PW extraction

Aqueous Geochemistry Equipment

- Ion Chromatography
  - For major Cations and Anions
- Microelectrode System
  - For transient parameters e.g. pH, Redox, O_2, $Fe^{2+/3+}$, reduced sulfur species

Gas Geochemistry Equipment

- Gas Chromatographs
  - One for methane and light hydrocarbons, one for Fluorocarbon tracer
- Reduced Gas Analyzer
  - For Hydrogen determination

Microbiology Equipment

- Scintillation counter
  - For turnover and incorporation rate measurements
- Fluorescence Microscope w/digital camera
  - For particle tracer contamination assessment, cell counts, quick visualization of samples to guide sampling

Incubation Equipment

- High pressure incubators
  - For incubation under in-situ pressure
- 2 Thermal incubators

Received 13 March 2006

IODP Proposal Cover Sheet

689-Pre

☑ **New** ☐ **Revised** ☐ **Addendum**

Please fill out information in all gray boxes

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Title:	Mud Volcanoes as a Window into the Deep Biosphere
Proponent(s):	D. Depreiter, J.P. Henriet, J. Poort, A. Foubert and P. Van Rensbergen (Renard Centre of Marine Geology, Ghent University, Belgium); R.J. Parkes, A.J. Weightman, H. Sass and J. Sas (School of Earth, Ocean and Planetary Sciences, University of Cardiff, UK) W. Verstraete, L. Maignien and N. Boon (Laboratory for Microbial Ecology and Technology, Ghent University, Belgium) K. Hinrichs (Research Centre Ocean Margins, Marum, Germany) K. Mangelsdorf, K. Zink (GFZ Potsdam, Germany) J. Sinnighe Damsté (Marine Biogeochemistry & Toxicology, NIOZ, The Netherlands) H. Cypionka (Institut für Chemie und Biologie des Meeres, University of Oldenburg, Germany) R. Amils (Centro de Biología Molecular, Universidad Autónoma de Madrid, Spain) R. Swennen (Geology, Catholic University of Leuven, Belgium) S. Kasten (AWI Bremerhaven, Germany) N. Holm (Marine Research Center, Stockholm University, Sweden) G.G. Ori (Int'l Research School of Planetary Sciences – Universita d'Annunzio, Pescara, Italy) L.M. Pinheiro (Department of Geosciences, University of Aveiro, Portugal) W. Brückmann (IFM Geomar, Kiel, Germany) S. Louwye (Research Unit Paleontology, Ghent University, Belgium) S. Spezzaferri (Dept. of Geosciences, University of Fribourg, Switzerland)

Keywords: *(5 or less)*	Mud volcano, deep biosphere, anaerobic methane oxidation, gas hydrates, geomicrobiology	Area:	Moroccan Margin

Contact Information:

Contact Person:	Davy Depreiter		
Department:	Renard Centre of Marine Geology (RCMG)		
Organization:	Ghent University		
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Tel.:	0032 9 264 4591	Fax:	0032 9 264 4967
E-mail:	Davy.Depreiter@UGent.be		

Permission to post abstract on IODP-MI Web site: ☑ Yes

Abstract: (*400 words or less)*

The deep biosphere is potentially the largest prokaryotic habitat on Earth, however it is largely unexplored. Mud volcanoes could represent an important deep biosphere habitat as there is a potential supply of deep sourced energy and microorganisms from below. Hence, mud volcanoes may be windows into the deep biosphere and related processes.

Mercator mud volcano, situated at a depth of 350-450 meters below sea level on the NW Moroccan continental margin, has been selected as a drilling target for a number of reasons: the presence of an enigmatic seismic reflection which could indicate the presence of a shallow gas hydrate layer, an increased heat flow (modeled), evidence for episodic mud volcano activity through the Cenozoic based on seismic data, small scale fluid venting on the mud volcano slope, bubble escape and the presence of methane related carbonate crusts in the crater area. Many interesting topics and fundamental questions can be addressed by drilling Mercator mud volcano and its environment, which thus represents it as a valuable target for a microbiology-dedicated expedition.

We propose to drill along a transect from an off-mud volcano site towards the crater, to a depth of about 300 m in each location. The off mud volcano site is needed for geochemical and microbiological background analyses, for biostratigraphy and sedimentology, giving a temporal dimension to the activity episodes of the mud volcano. A second near mud volcano site drills the alternation of sediments and extruded mud flows, giving an insight in episodicity and geochemistry and microbiology of the mud lobes and background sediments. The third site is located in an area where an anomalous seismic reflector, possibly indicating gas hydrates, is well developed. The fourth site is located in the mud volcano crater, for assessment of the potential of mud volcanoes as a window into the deep biosphere.

The drilling and logging procedure will address deep biosphere geomicrobiology and biogeochemistry, gas hydrates and carbonate diagenesis, lithological and physical parameters, microfossil dating and paleoceanographic analysis.

We propose to install CORK borehole observatories in order to measure the internal fluid flow regime over longer time spans. A series of CORK observatories also would allow for unique in situ microbial and geochemical experiments and long-term sampling. Targeted coring using a high pressure coring system (e.g. HYACINTH) will be deployed to preserve in situ environmental conditions and microbial activities.

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Scientific Objectives: (*250 words or less*)

- Diversity, Ecology and Physiology of the Deep Biosphere: a transect of drill cores across an active mud volcano into a non-volcano reference site will sample a range of subsurface habitats not previously studied. Molecular and cultivation approaches will help to understand the ecology and environmental interactions by assessing biodiversity, poplution size and function.
- Fluid Migration and Microbial Activity: detailed geochemical analysis of deep mud volcano sediments, interstitial pore water analysis, analysis of microbial populations activities allow assessment of mud volcanoes as deep biosphere hotspots.
- Mud volcanoes may be natural conduits for deep biosphere microorganisms. Gradations in communities may reflect a combination of different conditions, e.g. geochemical, lithological, age and nature and composition fluid flow.
- Drilling the slope of the mud volcano will explain the real nature of an anomalous seismic reflection in the mud volcano, which is believed to represent a gas hydrate layer. Many open questions related to gas hydrate microbial ecology can be addressed if gas hydrates are present.
- Drilling and dating mud lobes and the stratigraphic record next to the mud volcano will give insight into the driving factors of mud volcano activity and help constrain their apparent episodicity.
- Thermal field and fluid flow regime in mud volcanoes can be best constrained by drilling. CORK borehole observatories will allow for long-term fluid flow observations, as well as in situ microbial experiments.

Please describe below any non-standard measurements technology needed to achieve the proposed scientific objectives.

Pressure core sampling (PCS), heath flow measurements, CORK Borehole Observatories (long-term pressure, temperature, in situ microbiology experiments), fluid sampling tools

Proposed Sites:

Site Name	Position	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
MOMV-01A	35N 18.202’ 6 W 40.717’	485	300	0	300	Sedimentology, Biostratigraphy, Off mud volcano site Geochemical/Microbiological Background, Deep Biosphere
MOMV-02A	35N 17.821’ 6W 39.687’	480	300	0	300	Near mud volcano site Geochemical/Microbiological Background,Biostratigraphy, Sedimentology, Deep Biosphere, Mud lobe properties
MOMV-03A	35N 17.743’ 6W 39.482’	455	300	0	300	Mud volcano slope site Gas hydrates, Deep Biosphere, Fluid Flow, Thermal Field, Mud Lobes
MOMV-04A	35N 17.863’ 6W 38.750’	350	300	0	300	Mud volcano crater site Deep Biosphere and Geo(bio)-chemistry, Fluid Flow, Thermal Field

Received 31 March 2006

701-Pre

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IODP Proposal Cover Sheet

☑ **New** ☐ **Revised** ☐ **Addendum**

Please fill out information in all gray boxes

Title:	Microbial carbon and sulfur cycling in the deep biosphere of the Great Australian Bight		
Proponent(s):	Ulrich. G. Wortmann, Fumio Inagaki, Heribert Cypionka, Donald E. Canfield, Kai-Uwe Hinrichs, Sabine Kasten, Verena Heuer, Alfons J. M. Stams and Peter K. Swart		
Keywords: *(5 or less)*	Geomicrobiology, Deep Biosphere, Hydrogeology of passive continental margins	Area:	Australian shelf124-134° E 32-34·°S

Contact Information:

Contact Person:	Ulrich Georg Wortmann		
Department:	Geology		
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Permission to post abstract on IODP-MI Web site: Yes

Abstract: (*400 words or less)*

Interstitial water data retrieved by ODP Leg 182 indicates that the south Australian shelf harbors a unique deep biosphere ecosystem. The available evidence suggests that unlike anywhere else, a) methanogenic archea co-exist with sulfate-reducing bacteria, b) sulfate-reducing bacteria fractionate sulfur to a much higher degree than previously thought possible, and c) that high metabolic rates can be sustained to considerable depths. These discoveries raise fundamental questions with regard to our understanding of a) deep biospheric processes in general, b) our current understanding of the metabolic processes in sulfate-reducing and methanogenic and methane oxidizing archea, and in consequence) for our interpretation of the global cycles of carbon, sulfur and oxygen. However, Leg 182 did not include a microbiological objective, and consequently, little attention was paid to the above problems, nor were samples suitable for microbiological work retrieved. We therefore propose a dedicated microbiology leg to investigate this outstanding deep subsurface ecosystem.

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Scientific Objectives: (*250 words or less*)

- What are the metabolic processes facilitating accumulation of large amounts of methane at high sulfate concentrations?
- Why does the anaerobic oxidation of methane (AOM) with sulfate as electron acceptor not lead to depletion of either the electron donor or acceptor. What are the limiting factors for AOM and which groups of anaerobic methane oxidizers (ANME phylotypes) are present?
- Is sulfate reduction coupled to methane oxidation or organic matter degradation?
- Are the functional groups and activities of the microbial community principally different from non-carbonate continental margin sites?
- Is the microbial ecology of this system fundamentally different from other marine deep biosphere sites (i.e., ODP Leg 201, IODP Exp 301, 311)?
- Are there differences in the community composition, of of layers with the same age and similar geochemical settings at different depths?
- Can we identify genetics trends along chemical gradients, i.e., are there evolutionary trends between different environments of similar age in response to e.g. increasing/decreasing hydrogen sulfide, sulfate, methane concentrations?
- Obtain high resolution and wide aperture interstitial water data from the south Australian shelf break and shelf slope to investigate the hydrogeology of this brine dominated passive continental margin

Please describe below any non-standard measurements technology needed to achieve the proposed scientific objectives.

Pressure coring to take pressurized samples for microbiological work and and to quantify methane and hydrogen sulfide concentrations.

Proposed Sites:

Site Name	Position	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
GABB-1A	128:28.85 -33:16.8	170	700		700	Hydrogeology/Microbiology
GABB-2A	128:28.85 -33:18.5	260	700		700	Microbiology
GABB-3A	128:28.85 -33:20.5	400	700		700	Microbiology
GABB-4A	128:28.85 -33:22.3	600	700		700	Microbiology
GABB-5A	128:28.85 -33:24	805	700		700	Microbiology
GABB-6A	128:28.85 -33:25.2	900	700		700	Hydrogeology/Microbiology
GABB-7A	128:28.85 -33:26.8	1000	700		700	Hydrogeology/Microbiology

Hydrothermal Systems at Ultraslow Spreading Ridge: Basalt/Peridotite hosted Deep Biosphere

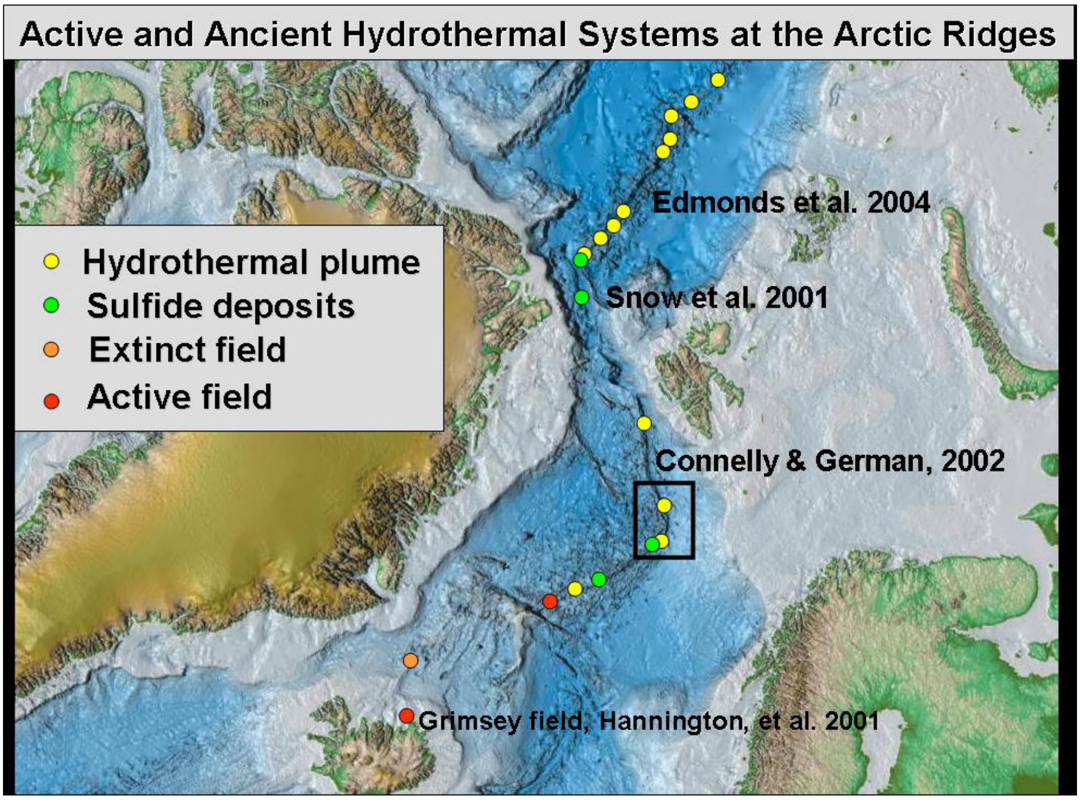
Zero age drilling of the Knipovich Ridge (Norwegian-Greenland Sea)

Objectives

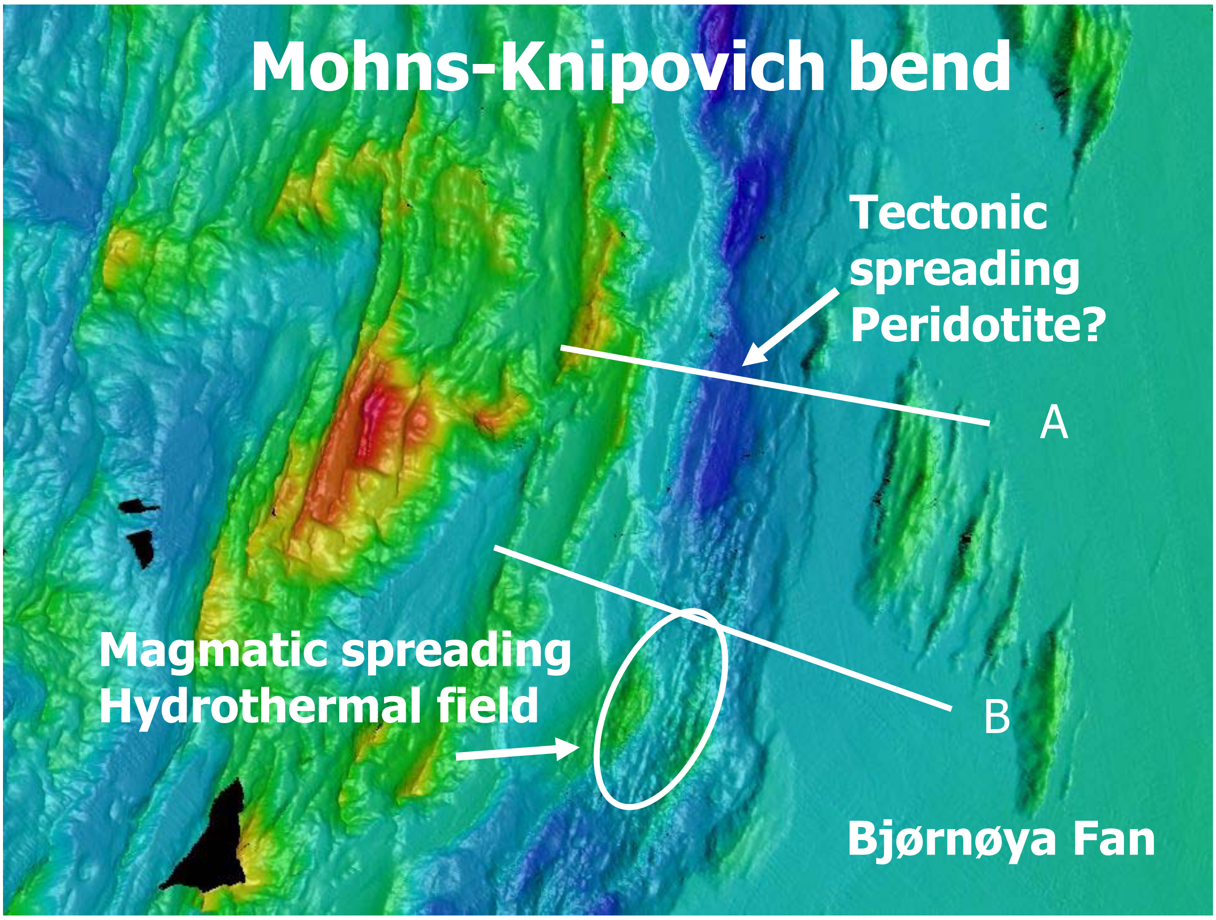
- Drill the first hydrothermal field at an ultraslow spreading ridge
- Sample the deeper parts of composite (peridotite/basalt hosted) hydrothermal systems by drilling zero age crust and mantle
- Study accretionary, hydrothermal and H_2-producing processes at an ultraslow spreading ridge
- Characterise the deep H_2-based biosphere
- Study synthesis of organic components in basalt/peridote hosted systems based on the occurrence of H_2

Why Southern Knipovich Ridge

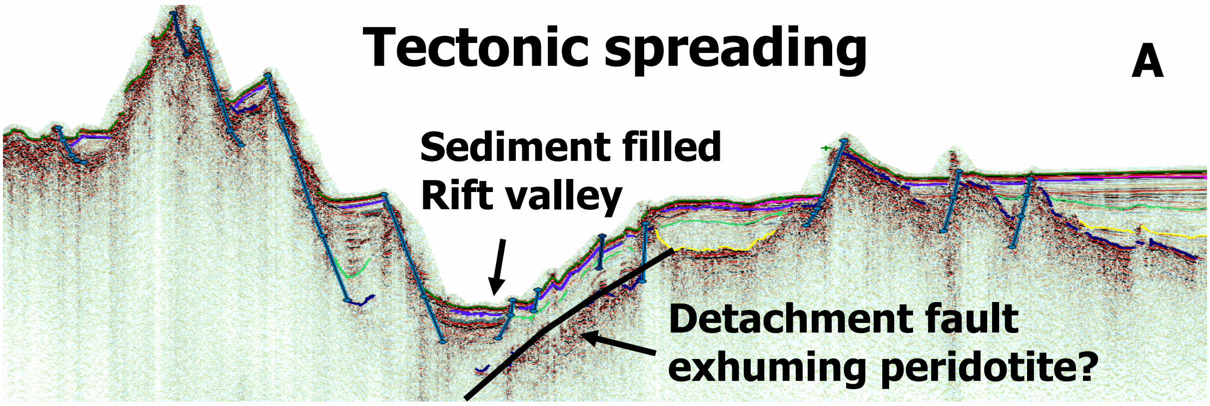
- One of the slowest-spreading segments present
- Hydrothermal activity documented in the area
- Ice free conditions
- Sediment filled rift valley - allowing zero-age drilling, and potentially hosting hydrothermal deposits
- Seismic data show anomalous low ìcrustalî ve locities below rift valley ñ potentially due to serpentinites
- Basalt petrology suggests intra-mantle magma reservoirs (heat source for peridotite-hosted hydrothermal systems)

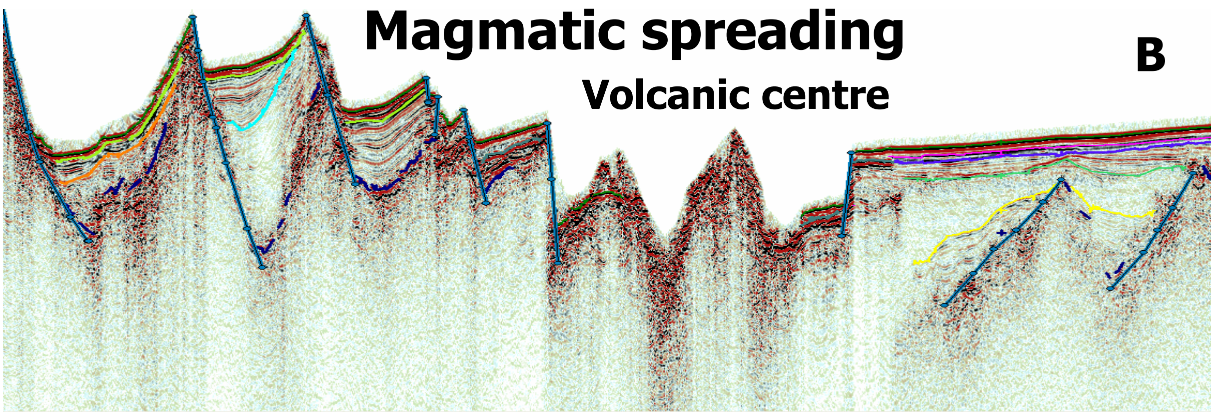


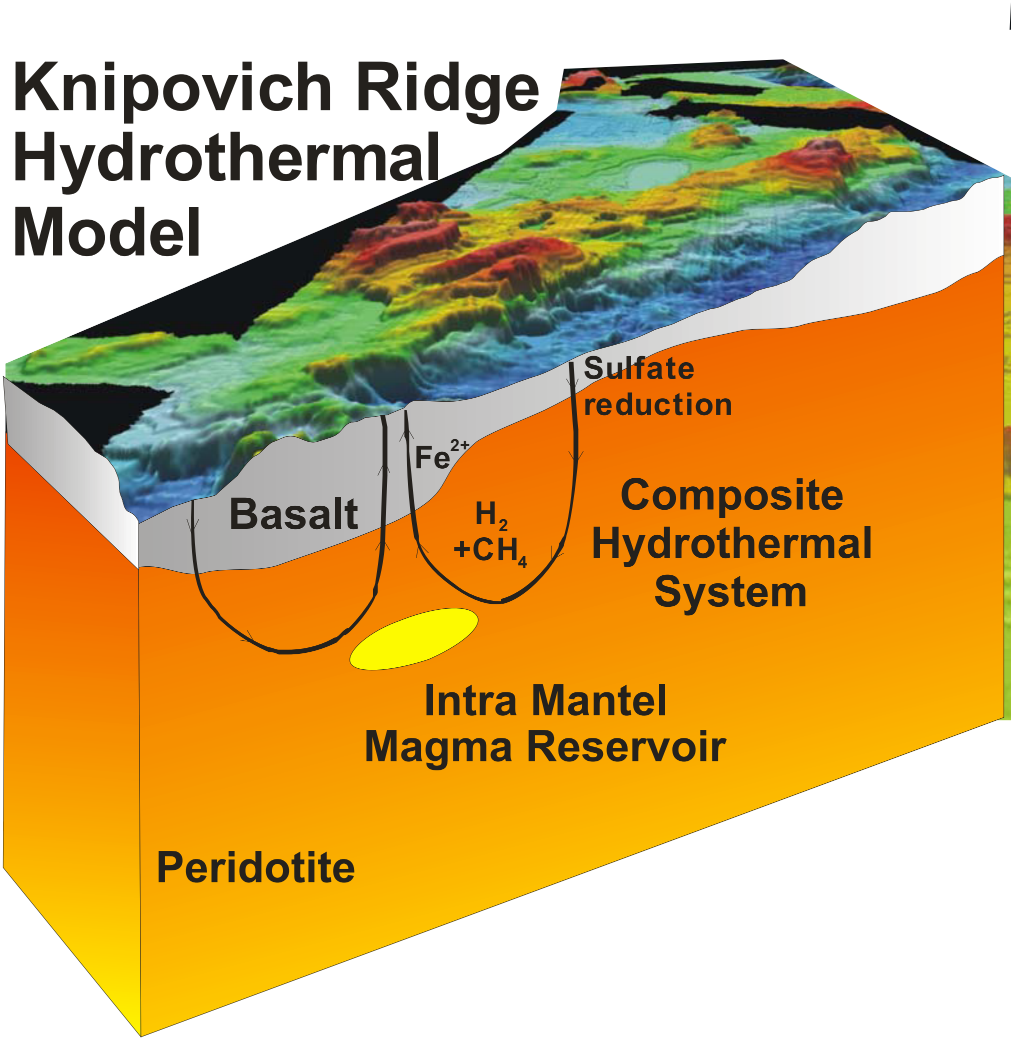
Proposed area for drilling is marked with black frame.



Southern part of proposed area for drilling.







Time Line

- May-06: Submission of EUROMARC-proposal for funding of further site survey
- June-06: Norwegian lead cruise to locate and visit active vent field(s)
- Summer-07: Site survey cruise, multibeam mapping of northern area, and additional seismic studies
- Summer-07: Norwegian lead IPY (International Polar Year) cruise to hydrothermal field(s)
- Fall-07: Submission of IODP-proposal

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