Vol. 8 (1) Spring 1999

InterRidge News

Initiative for international cooperation in ridge-crest studies

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InterRidge Office Updates

Coordinator Update

Steering Committee

There are four new members of the Steering Committee in 1999: Paul Dando (UK), Colin Devey (Germany), Kantaro Fujioka (Japan), and David Kadko (USA). The 1999 InterRidge Steering Committee Meeting will be held June 25-26 in Bergen, Norway.

Publications

The contributions volume from the First International Symposium on Deep-Sea Hydrothermal Vent Biology has been published in *Cahiers de Biologie Marine*, 39(3/4), which came out in February 1999. This volume contains 43 papers dealing with all aspects of hydrothermal vent biology. Contact the InterRidge Office for ordering information.

The report from the InterRidge workshop on *Mapping and Sampling the Arctic Ridges* (Oct., 1998) was finished in December 1998. This report concisely outlines multi-disciplinary plans for sampling this slow spreading ridge system. The text of this report is on the InterRidge web page; a hard copy of the report can be obtained by contacting the InterRidge Office.

InterRidge/BRIDGE Troodos Ophiolite Field Course

InterRidge and BRIDGE will be co-sponsoring a field trip to the Troodos Ophiolite July 11-17, 1999. An international group of 49 scientists from 12 countries (Canada, France, Germany, India, Italy, Japan, Portugal, Russia, Spain, Switzerland, UK and USA) will be participating in this field which will provide an opportunity to gain first-hand knowledge of the geology of the Troodos Ophiolite (Cyprus) and its implications for mid-ocean ridge processes. The field course will concentrate on the upper part of the crustal section, including the volcanics, sheeted dykes, and all elements of the hydrothermal systems. The plutonic crust, upper mantle and a major transform fault terrane will also be studied.

MOMAR

The MOMAR workshop (Long-Term **Mo**nitoring of the **M**id-**A**tlantic **R**idge) was held at the University of Lisbon, Portugal October 28-31, 1998 and attended by 67 participants from 11 countries. The workshop focused on the practical aspects of setting up long-term monitoring south of the Azores on the MAR. The workshop report should be finished shortly and will be sent out in early April, as always contact the InterRidge Office for a copy. The report will also be available on-line on the InterRidge MOMAR web page (http://www.lgs.jussieu.fr/~intridge/momar). This page is still under development; at the moment it has a summary of the MOMAR project, a database of almost 300 scientific references from the MOMAR region, a listing of previous cruises in this area, and articles on recent activities in the MOMAR region.

InterRidge Office Transfer

France's term as host country of InterRidge will end at the end of 1999, and the InterRidge Office will move to the country of another Principal member in January 2000. Bids for the Office will be reviewed by the Steering Committee at the Steering Committee meeting in June.

Coordinator Position

Due to some complicated circumstances I didn't leave the InterRidge Office as planned in February. Currently I plan to stay with InterRidge until October 1999.

Cara Wilson
InterRidge Coordinator
26 March 1999

InterRidge Web Page
http://www.lgs.jussieu.fr/~intridge

BRIDGE Web Pages
http://www.nerc.ac.uk/es/bridge.htm
http://earth.leeds.ac.uk/~bridge

De-Ridge Web Page
http://www.gpi.uni-kiel.de/~cwd/DeRidge/deridge.html

RIDGE Web Page
http://ridge.oce.orst.edu

The InterRidge WWW Electronic Directory is now in database format!

Currently there are ~350 people active in mid-ocean ridge research listed in the database on the InterRidge Home Page (**http://www.lgs.jussieu.fr/~intridge**). This database contains a listing of each researcher's field of interest and expertise as well as their full address information. If you would like to be listed in the database complete this form and send it to the InterRidge Office. Links can also be provided to your personal or departmental web page. You can also use this form to join are regular mailing list to receive the *InterRidge News*, or to be placed on our electronic mailing list.

Indicate whether you would like your name to appear on:

☐ *the InterRidge Electronic Directory* ☐ *the mailing list*
☐ *the electronic mailing list (include your e-mail address)* ☐ *This is a change of address notice.*

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City____________________ **State/County**__________________
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country code area code number country code area code number
E-mail:_______________________________________
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Which InterRidge Program Theme(s) is/are of interest to you?

☐ Active Processes ☐ Meso-Scale Studies ☐ Global Studies

What are your fields of interest/expertise?

☐ Biochemistry	☐ Gravity	☐ Plate kinematics
☐ Biogeography	☐ Heat Flow	☐ Rheology
☐ Biology	☐ Hydrology	☐ Seafloor Morphology
☐ Crustal structure	☐ Hydrothermal vents/plumes	☐ Sedimentology
☐ Ecology	☐ Larval Dispersion	☐ Seismology
☐ Electromagnetism	☐ Magnetism	☐ Structural geology
☐ Engineering/Instrumentation	☐ Microbiology	☐ Sulfide Ores
☐ Event detection and response	☐ Modeling	☐ Tectonics
☐ Genetics	☐ Ophiolites	☐ Volcanology
☐ Geochemistry	☐ Petrology	☐ Other________

Send to (address also on the reverse side): InterRidge Office, Laboratoire de Pétrologie, Tour 26, 3ème étage, Université Pierre et Marie Curie, 4 Place Jussieu, 75252 Paris Cédex 05, France *fold*

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InterRidge Office Updates

InterRidge Publications

All of the following InterRidge publications are available upon request. Fill out our WWW form at **http://www.lgs.jussieu.fr/~intridge/publreq.htm** or contact us by e-mail at **intridge@ext.jussieu.fr.**

InterRidge News:

InterRidge News, 1999, 8, 1, pp. 72
InterRidge News, 1998, 7, 2, pp. 68
InterRidge News, 1998, 7, 1, pp. 72
InterRidge News, 1997, 6, 2, pp. 64
InterRidge News, 1997, 6, 1, pp. 72
InterRidge News, 1996, 5, 2, pp. 68
InterRidge News, 1996, 5, 1, pp. 52
InterRidge News, 1995, 4, 2, pp. 52
InterRidge News, 1995, 4, 1, pp. 72
InterRidge News, 1994, 3, 2, pp. 44
InterRidge News, 1994, 3, 1, pp. 28
InterRidge News, 1993, 2, 2, pp. 4
InterRidge News, 1993, 2, 1, pp. 32
InterRidge News, 1992, 1, 1, pp. 26

Workshop and Working Group Reports:

New! InterRidge **MOMAR (*MO*nitoring the *M*id-*A*tlantic *R*idge)** workshop report, April, 1999.
New! InterRidge **Mapping and Sampling the Arctic Ridges: A Project Plan**, pp. 25, December 1998.
ODP-InterRidge-IAVCEI Workshop Report: **The Oceanic Lithosphere and Scientific Drilling into the 21st Century**, pp. 89.
InterRidge Global Working Group Workshop Report: **Arctic Ridges: Results and Planning**, pp. 78, October 1997.
InterRidge **SWIR Project Plan**, pp. 21, October 1997 (revised version).
InterRidge Meso-Scale Workshop Report: Quantification of Fluxes at Mid-Ocean Ridges: **Design/Planning for the Segment Scale Box Experiment**, pp. 20, March 1996.
InterRidge Active Processes Working Group Workshop Report: **Event Detection and Response & A Ridge Crest Observatory**, pp. 61, December 1996.
InterRidge Biological *Ad Hoc* Committee Workshop Report: **Biological Studies at the Mid-Ocean Ridge Crest**, pp. 21, August 1996.
InterRidge Meso-Scale Workshop Report: **4-D Architecture of the Oceanic Lithosphere**, pp. 15, May 1995.
InterRidge Meso-Scale Project Symposium and Workshops Reports, 1994: **Segmentation and Fluxes at Mid-Ocean Ridges: A Symposium and Workshops & Back-Arc Basin Studies**: A Workshop, pp. 67, June 1994.
InterRidge Global Working Group Report 1993: **Investigation of the Global System of Mid-Ocean Ridges**, pp. 40, July 1994.
InterRidge Global Working Group Report 1994: **Indian Ocean Planning Meeting Report**, pp. 3, 1994.
InterRidge Meso-Scale Working Group Meeting Report, Cambridge, UK, pp.6, 1992.

Workshop and Symposium Abstract Volumes:

InterRidge Workshop: **MOMAR (*MO*nitoring the *M*id-*A*tlantic *R*idge)** Abstract Volume, pp. 82, Oct. 1998.
InterRidge Workshop: **Mapping and Sampling the Arctic Ridges** Abstract Volume, pp. 30, Oct. 1998.
First International Symposium on **Deep-Sea Hydrothermal Vent Biology** Abstract Volume, pp. 118, Oct. 1997.
Fara-InterRidge **Mid-Atlantic Ridge Symposium Results from 15°N to 40°N.** J. Confer. Abs. 1(2), 1996.
ODP-InterRidge-IAVCEI Workshop: **The Oceanic Lithosphere and Scientific Drilling into the 21st Century**, pp. 126, 1996.

Steering Committee and Program Plan Reports:

InterRidge Steering Committee Meeting Report, Barcelona, Spain, 1998, pp. 34, January 1999.
InterRidge Steering Committee Meeting Report, Paris, France, 1997, pp. 17, January 1998.
InterRidge Steering Committee Meeting Report, Estoril, Portugal, 1996, pp. 17, December 1996.
InterRidge Steering Committee Meeting Report, Kiel, Germany, pp. 22, 1995.
InterRidge Steering Committee Meeting Report, San Francisco, USA, 1994.
InterRidge Steering Committee Meeting Report, Tokyo, Japan, 1994.
InterRidge Steering Committee Meeting Report, Seattle, USA, pp. 6, 1993.
InterRidge Meeting Report, York, UK, 1992.
InterRidge Meeting Report, Brest, France, pp. 39, 1990.
InterRidge Program Plan Addendum 1997, pp. 10, January 1998.
InterRidge Program Plan Addendum 1996, pp. 10, April 1997.
InterRidge Program Plan Addendum 1995, pp.10, 1996.
InterRidge Program Plan Addendum 1994, pp.15, 1995.
InterRidge Program Plan Addendum 1993, pp. 9, 1994.
InterRidge Program Plan, pp. 26, 1994.

Updates on InterRidge Projects

Overview of InterRidge Working Groups

More information on the working groups can be found on our website at http://www.lgs.jussieu.fr/~intridge/wg.htm

Arctic Oceans:

Objective: Coordinate planning efforts for mapping and sampling the Arctic Ridges.

Current Activities: see next page.

Chair: Colin Devey (Germany)

WG members: G. A. Cherkashov (Russia), B. J. Coakley (USA), K. Crane (USA), O. Dauteuil (France), V. Glebowsky (Russia), K. Gronvold (Iceland), H. R. Jackson (Canada), W. Jokat (Germany), Y. Kristoffersen (Norway), P. J. Michael (USA), N. C. Mitchell (UK), R. Rihm (Germany), H. A. Roeser (Germany), H. Shimamura (Japan), K. Tamaki (Japan)and C. L. Van Dover (USA).

Back-Arc Basins:

Objectives: Summarize past work on Back-Arc Basins and coordinate future studies.

Current Activities: Compiling report on past work in Back-Arc Basins.

Chairs: H. Fujimoto (Japan) and J.-M. Auzende (France)

WG members: Ph. Bouchet (France), J.-L. Charlou (France), K. Fujikura (Japan), E. Grácia (Spain), P. Herzig (Germany), J. Ishibashi (Japan), R. Livermore (UK), S. Scott (Canada), R. J. Stern (USA), K. Tamaki (Japan), and B. Taylor (USA).

SWIR:

Objective: Coordinate reconnaissance mapping and sampling of the Southwest Indian Ridge.

Current Activities: Coordinating upcoming cruises and proposals

Chair: Catherine Mével (France)

WG members: M. Canals (Spain), C. German (UK), N. Grindlay (USA), C. Langmuir (USA), A. Le Roex (South Africa), C. MacLeod (UK), J. Snow (Germany), K. Tamaki (Japan), and C. L. Van Dover (USA).

Biological Studies:

Objectives: Increase international collaboration in hydrothermal biological studies and work on integrating ridge-crest biological and geological research.

Current Activities: Establishing an electronic database of hydrothermal biological samples, and coordinating the demarcation of ecological reserves at vents.

Chair: L.S. Mullineaux (USA).

WG members: P. R. Dando (UK), J. R. Delaney (USA), D. Desbruyères (France), D. R. Dixon (UK), S. S. Drachev (Germany), A. Fiala-Médioni (France), C. R. Fisher (USA), H. Fricke (Germany), F. Gaill (France), J. Hashimoto (Japan), S. K. Juniper (Canada), R. A. Lutz (USA), Douglas C. Nelson (USA), S. Ohta (Japan), A.-L. Reysenbach (USA), K.O. Stetter (Germany), and V. Tunnicliffe (Canada).

Event Detection and Response & Observatories:

Objectives: Develop detection methods of transient ridge-crest seismic, volcanic and hydrothermal events, and the logistical responses to them through a strategy of international collaboration, and establish a long-term observatory in the Atlantic.

Current Activites: Development of MOMAR project (see page 8).

Chair: Chris Fox (USA)

Undersea Cables:

Objective: Explore the range of science that can be done at ridges with undersea cables and the logistics involved.

Current Activities: Development of MOMAR project (see page 8).

Chair: Alan Chave (USA)

WG members: J. R. Delaney (USA), H. Momma (Japan), M. Kinoshita (Japan), A. Schultz (UK), D. S. Stakes (USA), P. Tarits (France), and H. Villinger (Germany).

Global Digital Database:

Objective: Establish a database of global multibeam bathymetry and other data.

Current Activities: Compiling data.

Chair: Philippe Blondel (UK)

WG members: J. S. Cervantes (Spain), C. Deplus (France), M. Jakobsson (Sweden), M. Ligi (Italy), R. Macnab (Canada), W. Ryan (USA), and W. Weinrebe (Germany).

Global Distribution of Hydrothermal Venting:

Objectives: Target key areas of the global MOR that should be explored for hydrothermal activity and coordinate international collaboration to explore them.

Current Activities: See page 9.

Chair: Chris R. German (UK)

WG members: E. Baker (USA), Y. J. Chen (USA), T. G. Gamo (Japan), E. Grácia (Spain), P. Halbach (Germany), S.-M. Lee (Korea), J. Radford-Knoery (France), D. S. Scheirer (USA), S. D. Scott (Canada), K. G. Speer (France), C. A. Stein (USA), V. Tunnicliffe (Canada) and C. L. Van Dover (USA).

4-D Architecture:

Objective: Promote international efforts to constrain the composition and structure of the oceanic lithosphere, and their along- and across-axis variability.

Current Activities: See page 10.

Chair: Jian Lin (USA)

WG members: S. Allerton (UK), D. K. Blackman (USA), M. Cannat (France), J. Dyment (France), J. E. Escartín (Spain), P. Gente (France), K. M. Gillis (Canada), P. B. Kelemen (USA), L. M. Parson (UK), N. Seama (Japan), M. C. Sinha (UK), and M. Tolstoy (USA).

Updates on InterRidge Projects

Arctic Ridges Update

Report on the Arctic Ridges Workshop, Hannover, Germany 16-17 Oct. 1998

Colin Devey, Chair (cwdevey@uni-bremen.de)

Fachbereich 5 Geowissenschaften, Universität Bremen, Postfach 330440, D-28334 Bremen, Germany

The Arctic Ridges Working group convened a workshop in Hannover, Germany, on 16-17 October 1998 to advance plans to sample and survey the ridge which crosses the Arctic Ocean (formally named the Gakkel Ridge). This workshop was a follow-up to an InterRidge workshop in 1994 during which a series of clear goals for the study of the Gakkel Ridge were drawn up. The aim of the 1998 workshop was to establish a time-frame and methodological approach to achieve at least some of these goals within the next five years. The Gakkel Ridge is of great interest to the InterRidge community for a number of reasons:

- Its spreading rate is appreciably lower than that of any other ridge on Earth.
- In contrast to the slow-spreading Southwest Indian Ridge, for example, ridge offsets on the Gakkel Ridge are rare and spreading is orthogonal.
- The rift valley is extremely deep and appears to be underlain by very thin crust.
- The Gakkel Ridge (and also the Knipovitch Ridge further south) could be the home to unique vent communities due to both the presence of Iceland as a block to migration of hydrothermal-dependent species along the ridge axis into the Arctic and the lack of sedimentation from the surface.

All of these features combine to make the Gakkel Ridge an extremely attractive target for petrological, geophysical, hydrothermal and biological studies. The extreme working conditions presented by the permanent ice cover mean, however, that up to present ridge research here has been restricted mainly to bathymetric mapping from nuclear submarines and some geophysical experiments. The working group´s major priority is to redress this position and facilitate the first sampling and observation programs. This goal has been moved markedly closer through the SCICEX program which has, for the first time, provided bathymetry with sufficient resolution and coverage to make pre-cruise identification of sampling targets possible (see article on pg. 32).

The workshop succeeded in establishing a list of priorities and plans to guide the ridge studies. These are:

- The European end of the Gakkel Ridge (as opposed to the end which abuts the Laptev Sea) should be studied first. The reasons for this are logistical (relatively easy access from the N. Atlantic), diplomatic (international waters), bathymetric (SCICEX has good coverage here) and sedimentologic (the rift valley is apparently relatively sediment-free).
- The Laptev Sea end, in view of its extremely low spreading rates, is interesting in its own right and should remain a high-priority goal. Sampling its volcanics will be a more challenging task both logistically and geologically.
- Two ships will be needed to carry out any reasonable sampling and observational program. Although both ships should have the capability to carry out scientific work, the control of the science plan must be clearly in the hands of one of the vessels.
- Existing technology is sufficient to accomplish most sampling goals in the Arctic, however developments to minimize time in the water would be advantageous and make the program much more cost-effective.

Following the workshop a proposal was submitted by the Alfred-Wegner-Institut, Bremerhaven, Germany to request the *Polarstern* for 2001 to begin this sampling. International support for the *Polarstern* cruise in the form of contributions towards charter costs for the second ice-breaker will be essential for the success of this proposal. Other opportunities for continuing the Arctic sampling program will be presented when the icebreaking reseaarch vessel USCG *Healy* is fully operational in the Arctic, perhaps in 2002.

A workshop report was produced by the InterRidge Office in time for the Fall AGU meeting in December 1998. Copies of this report are available to all interested parties either via contacting the InterRidge Office (intridge@ext.jussieu.fr) or via the InterRidge webpage at http://www.lgs.jussieu.fr/~intridge/arcrep98.htm.

Updates on InterRidge Projects

MOMAR (Monitoring the Mid-Atlantic Ridge)

Pascal Tarits[1] and Maya Tolstoy[2], MOMAR Workshop Convenors

[1]Institut Universitaire Européen de la Mer, UMR 6538 "Domaines Océaniques", Université de Bretagne Occidentale, Place Nicolas Copernic, F-29280 Plouzané, France
[2]Lamont-Doherty Earth Observatory, P.O. Box 1000, 61 Route 9W, Palisades, NY 10964-8000, USA

The objective of the MOMAR project is to promote international cooperation to establish long-term multidisciplinary **MO**nitoring on the **M**id-**A**tlantic **R**idge near the Azores. MOMAR will combine long-term monitoring of biological and physico-chemical activity at hydrothermal vents, with broader scale monitoring of tectonic, volcanic and hydrothermal processes at the ridge axis. The first MOMAR workshop (Lisbon, October 1998) provided a forum for discussion of both the scientific questions to be addressed, and the available technology with which to address them. This workshop was sponsored by InterRidge and included 67 international participants. The workshop report should be finished shortly and will be sent out in early April.

Mid-ocean ridges are environments in which tectonic plates move apart, magma migrates in the subsurface and erupts at the seafloor, seismic and aseismic deformation occurs in the host rock, and seawater-derived hydrothermal fluids circulate. The circulation of these fluids transfers heat within the basement and from the basement to the seawater, extracts and/or deposits metal sulfides and modifies the chemistry of the overlying ocean. The same fluids support a variety of life forms, from thermophilic micro-organisms in the subsurface and hot vents, to macro-organisms on the seafloor. These processes affect the chemical, thermal and biological balance of oceanic environments, and they also provide the best modern insights into primitive earth systems which harbored, and, conceivably, initiated, life. One of the central goals of the community of ridge scientists is to understand the causal links among magmatic, tectonic, hydrothermal, biochemical and biological activities at the ridge crest, as well as the influence of these activities on the chemistry and biology of the Earth's ocean. A prerequisite is to acquire a wide set of data, including data about how a particular ridge environment changes with time.

The time scale for MOMAR should be of the order of 5 to 10 years and monitoring experiments should be designed for a multiscale approach: - large regions (100s of km) must be monitored in order to detect volcanic eruptions, and assess seismic hazard near the Azores Archipelago; - studies of the water column and of seafloor deformations require instruments to be deployed at the segment scale (10's of km); - finally, the study of hydrothermal venting processes and the associated biology should be carried out at a vent field scale (a few meters to 1 km). The Lucky Strike area has been selected by the participants to the MOMAR workshop as the most appropriate site for vent and segment scale monitoring experiments. The Lucky Strike vent field is the largest active hydrothermal site in the present day ocean, it hosts an abundant and diverse fauna, and it is situated close to port within Portuguese EEZ.

The MOMAR project includes the deployment of a variety of monitoring tools, some of which have been successfully deployed in the past, while some will need to be specifically designed. Tools appropriate for monitoring ridge crest events are also potentially adaptable to a range of active underwater environments, for example active margins or intra-plate volcanic edifices (such as the Azores, Canary or Hawaii). The MOMAR program will therefore be an opportunity for technological developments applicable to a wide range of scientific and environmental issues. The use of submarine cables and moored buoys to transmit data and provide the energy necessary for the instruments is also envisioned as part of the MOMAR project and will require coordinated technological efforts on the part of the participating countries.

An international steering committee will be set up in the coming months to help direct the installation of the different components of the MOMAR project. The MOMAR Steering Committee will act in connection with the Portuguese Hydrographic Institute, the agency in charge of oceanographic clearances in Portuguese waters. A second MOMAR workshop (funded by the European Commission through its program "Training and Mobility of Researchers") will be held in the Azores in late 2000 and will serve as a forum to present the early results from MOMAR and to discuss further developments.

InterRidge

MOMAR webpage

http://www.lgs.jussieu.fr/~intridge/momar

Updates on InterRidge Projects

Global Distribution of Hydrothermal Venting

Chris German, Chair (cge@mail.soc.soton.ac.uk)

Southampton Oceanography Centre, European Way, Empress Dock, Southampton, SO14 3ZH, UK

This working group was first established in late 1997 under a working title Global Partitioning of Hydrothermal Activity with an intention to continue in the vein of what is unique about InterRidge - namely to help foster research which can *only* be achieved through international communication and coordination.

During discussions at both the InterRidge Steering Committee meeting in September 1998 and an initial meeting of Working Group members in San Francisco in December 1998 it was decided to make explicit the particular focus of the group by renaming it as indicated above. This name reflects our primary objective: to seek out and investigate new sites of axial hydrothermal venting along previously un-studied sections of the global mid-ocean ridge crest.

A particular objective, in this regard, is to further our understanding of vent biogeography. To a first approximation, the fauna of the Juan de Fuca Ridge/Northern East Pacific Rise (JdF/NEPR) vent-sites are quite distinct from those of the northern Mid-Atlantic Ridge (MAR), but no active vent-sites have yet been visited/observed by manned submersible or ROV anywhere between the S. Pacific Ocean and the low-latitude N. Atlantic. Vast tracts of the global mid-ocean ridge crest system remains unstudied by the hydrothermal research community. While the principal objective of our research, as stated above, has a biological theme, it is also most certainly the case that increasing our coverage of studied hydrothermal areas will also throw new light on the chemical and physical nature of hydrothermal circulation in different geological regimes. As we continue to seek out new sites of venting, therefore, it is to be expected that we will continue to make important new, and as yet unanticipated, discoveries across the disciplines.

As a first stage to implementation of the working group's objectives, and recognising the key role that vent biogeography has to play, a first course of action is to attract additional biological scientists including micro-biologists from across the international community to help steer the scientific agenda for the working group. If you would be interested in making that contribution, please contact me.

Our next step will be to identify key areas where maximum scientific returns can be expected. To that end, an important start has already been made along the Indian Ocean Ridges where hydrothermal plumes and seafloor deposits have recently been reported from all of the Central, SE and SW Indian Ridges. Various proposals from across the international community are now underway and/or awaiting shiptime to follow up with seafloor observations of these ridge crests. Therein lies the most compelling challenge of this working group: many of the sections of ridge-crest most pertinent to our study are remote; they require complex logisitical arrangements to reach them; and the difficulties of working in high-latitude environments should not be underestimated.

To maximise efficiency in an internationally coordinated way, therefore, we have identified the following course of action:

- To expand membership of the WG to accommodate a stronger biological influence.
- To identify key areas of highest priority for biogeographical studies, at the basin scale.
- To identify key ridge sections within those basins where basic underlying geophysical and/or geological datasets (swath bathymetry, sidescan imaging, petrology) have already been collected - this provides a valuable infrastructure and also allows any new hydrothermal discoveries to be placed within a geological context.
- To encourage and support research applications using suitable ships from across the international community to prospect for hydrothermal activity using water column geochemical survey techniques, with or without other related geological/biological investigations, to pinpoint new sites of hydrothermal venting on the seafloor.
- To publicise the results of any such research activities through *InterRidge News* to help stimulate new follow-on proposals, which may be at either the international or the national scale, to conduct first seafloor investigations at these positive targets.

Key target areas for future survey work will include:

The southern MAR and the Arctic ridge crests. The former is of high priority because it will provide improved continuity for vent biogeography studies between the northern MAR and the Indian Ocean (we assume, here, that first successful dives on an Indian hydrothermal site are now just a matter of time...).

The case for the study of the Arctic ridge crests, north of Iceland, is that this is the section of ridge-crest most remote from the well-characterised JdF/NEPR and underlies the most extreme oceanographic conditions. As such, it can be hypothesised that

Updates on InterRidge Projects: **Hydrothermal Venting continued...**

these ridges will host the most unique vent-biota. Additionally the Gakkel Ridge in the Arctic is the slowest-spreading ridge in the world, making it an important end-member for various mid-ocean ridge processes, as such research on this ridge is the focus of another InterRidge working group (see page 7).

There are a number of other remote sections of ridge crest where evolutionary biological studies could be addressed. These include: deep vent-sites of the Mediterranean Sea, the Cayman Trough, the Andaman Sea, the E. Scotia Ridge, the Bransfield Strait and the Gulf of Aden. Perhaps the most intriguing of these is the Cayman Trough. Here (geologically) recent closing of the Isthmus of Panama may have effected late-stage isolation of the Mid-Cayman Rise from the NEPR/JdF ridge system. As such, it will be of great interest to evaluate the relative similarity (or otherwise) of Mid-Cayman Rise vent-fauna when compared to those of (e.g.) the northern EPR, the adjacent cold-seep fauna of the Gulf of Mexico and the high-temperature vent-fauna of the similar latitude MAR.

In future issues of *InterRidge News* we will keep you informed of new developments in many of these work-areas including results from completed cruises as well as the confirmed logistics for future expeditions. Similarly, as more gaps become filled in along the global mid-ocean ridge crest, the scientific questions we wish to address will certainly change and our periodically re-focused objectives will also be reported here. As part of this continuously evolving process, the next opportunity to meet amongst members of the WG will be in Europe, in association with the EGS Open Symposium at Den Haag, April 1999.

4-D Architecture of the Oceanic Lithosphere Update

Jian Lin, Chair (jian@galileo.whoi.edu)

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This working group was established in 1996 to promote international collaboration in studying the structure, composition, and tectonics of the oceanic lithosphere, especially its accretionary processes at mid-ocean ridges. The InterRidge community in this research area has a strong tradition of international co-operation, as shown by frequent occurrence of researchers from one country participating in sea-going programs of the other countries. In the last decade, for example, much of the progress inunderstanding the segmentation processes of the northern Mid-Atlantic Ridge has been the result of research cruises and shore-based programs from multiple InterRidge countries includingthe US, France, UK, Japan, Russia, and others. Clearly such impressive progress could not have been achieved by one or two countries alone.

In 1999 Jian Lin of the Woods Hole Oceanographic Institution (USA) took over as Chair of this working group. The working group would like to express sincere gratitude to the founding Chair Lindsay Parson for his exceptional leadership and dedication during the first three years of the group - thanks, Lindsay! The working meet group met in Dec. 8, 1998 during the Fall AGU meeting in San Francisco, California to discuss several issues related to lithospheric programs in the coming years as detailed below. The group seeks comments, suggestions, feedbacks, and information exchanges from the wide InterRidge community on all issues related to studies of oceanic lithosphere. Comments and information can be submitted to intridge@ext.jussieu.fr and/or jlin@whoi.edu.

InterRidge Theoretical Institute (IRTI)

During discussion within both the 4-D Architecture and Hydrothermal Fluxes working groups, it was felt that the time is ripe for InterRidge to host a focused meeting on the "ThermalRegime of Ocean Ridges and the Dynamics of Hydrothermal Circulation". A 4-day meeting with lectures and discussion was envisioned sometime in year 2000 to gather researchers in the InterRidge community to review, debate, and discuss progress in this active research subject. The

InterRidge Workshop Report:

4-D Architecture of the Oceanic Lithosphere

May 1995, 15 pages

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InterRidge Steering Committee recommended that the meeting be called an InterRidge Theoretical Institute (IRTI) in keeping with the terminology used by the USRIDGE program. Dr. Wil Wilcock of the University of Washington, Seattle, has agreed to lead the organization of this first IRTI. The planning of the meeting is currently underway.

Recent Meetings

The 4-D Architecture working group seeks to actively promote the exchange of the latest results of lithospheric studies at various national and international meetings. Members of the working group has sponsored special sessions on "Magma Focusing and the Segmentation of Mid-Ocean Ridges at all Spreading Rates" at the Fall AGU meeting in Dec. 1998; "Extensional Tectonics in the Oceanic Lithosphere from Continental Margins to Mid-Ocean Ridges" at the EUG meeting in April 1999; and "Evolution of Oceanic Spreading Centers and Their Discontinuities" at the spring AGU meeting in June 1999. In addition, InterRidge will be a co-sponsor (with the Geological Society of London and the Geological Society of America) of a meeting in March 2000 on "The Nature and Tectonic Significance of Fault Zone Weakening".

Drilling the Oceanic Lithosphere

The 4-D Architecture working group is coordinating with ODP in promoting oceanic lithosphere drilling programs. In spring 1998 ODP established a Program Planning Group (PPG) on the "Architecture of the Oceanic Lithosphere" to update and implement the drilling plan outlined in the 1996 Woods Hole Workshop on "The Ocean Lithosphere and Scientific Drilling". J. Cann and R. Batiza are the Co-Chairs of the ODP PPG and three of its members (M. Cannat, K. Gillis, and P. Kelemen) are also members of the InterRidge 4-D Architecture working group. Since its first meeting in May 1998, the ODP PPG has interacted with the PIs of drilling proposals that address lithosphere priorities, and has helped putting together new proposals. It has made recommendations in terms of priorities for ODP technological development. The PPG is also mandated to contribute to the planning process for post-2003 scientific ocean drilling.

The second meeting of the ODP PPG was held in Dec. 1998. In the period up until 2003, the PPG recommends two main thrusts for lithospheric drilling. First, a start should be made on the drilling of an intact section of fast spreading ocean crust. This is likely to take place in three stages, a preliminary stage of pilot drilling, a second stage using current technology that would drill to about 3000 m penetration, and a third stage using riser technology which would complete the task. The first two stages are achievable with current drilling technology and may be planned before 2003. Possible locations for the deep drilling site were considered against a list of 11 essential and 6 desirable criteria. The Guatemala Basin, for which there is already a proposal in the system, fits most of these criteria. The PPG is currently working with the proposal PIs to promote site survey and improve the proposal.

Second, a major thrust should be made before 2003 to develop further our understanding of the dynamics of the plutonic foundations of the oceanic lithosphere. In fast spreading crust, the plutonic foundations are rarely brought close to the surface. Hess Deep is one place where this happens, and results from a previous drilling leg are now the basis for petrological interpretations of magmatic processes in fast spreading oceanic crust. A letter of intent has been submitted for further drilling. But new site surveys are required to unravel the complex tectonic history of the proposed drill sites. The PPG is currently interacting with PIs of both the drilling letter of intent and the site survey cruise proposals in order to improve and promote both. In slow spreading crust, there are a number of drilling proposals in the ODP system. A proposal for drilling an area close to 15°N in the Atlantic, where peridotite seems to make up a large part of the surface layer, has recently received good reviews in the ODP system and is in good position for drilling before 2003. A proposal for new drilling around site 735B in the SW Indian Ocean Ridge is also in good shape.

Three preliminary proposals and letters of intent were submitted to ODP for drilling detachment faults of the Atlantic and Indian Oceans. This generic objective is seen as a very high priority by the ODP PPG for pre-2003 drilling of the oceanic lithosphere. The PPG is in contact with PIs to help produce at least one good full proposal by the end of 1999 in order to have it ranked and scheduled prior to the end of ODP in 2003.

ODP-InterRidge-IAVCEI Workshop Report:

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International Ridge-Crest Research: **Biological Studies**

Finding of *Luckia striki* (Amphipoda: Eusiridae) at the Rainbow Hydrothermal Field (MAR)

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Amphipods are a common component of many Eastern Pacific hydrothermal vent communities (see reviews in Vinogradov (1996) and Bellan-Santini (1998)), but they are significantly less numerous in Mid-Atlantic Ridge (MAR) hydrothermal vent communities. For a long time the only known specimens from MAR vent communities were *Andaniotes* cf.*ingens* (Stegocephalidae) from the Snake Pit site (Segonzac, 1992, named after Bellan-Santini, 1998) and the widely distributed *Hirondellea brevicaudata* Chevreux, 1910 (Lysianassoidea) from the Broken Spur site (Vinogradov, 1996). In 1996 the first more or less complete collection of endemic Atlantic vent amphipods was described (Bellan-Santini and Thurston, 1996). This collection includes one numerous species (*Steleuthera ecoprophyceaa* Bellan-Santini and Thurston, 1996, Stegocephalidae) from the Snake Pit and three species from the Lucky Strike site. The two Eusirid species, *Bouvierella curtirama* Bellan-Santini and Thurston, 1996 and *Luckia striki* Bellan-Santini and Thurston, 1996, are numerous at the Lucky Strike site. These amphipods are considered to be benthic in habitat and they are present on both mussel beds and over patches of sulfides which are barren of mussels (Van Dover et al., 1996). These species have been descibed as an unique feature of the Lucky Strike vent fauna (Van Dover et al., 1996).

New material

During the 41st cruise of the R/V *Akademik Mstislav Keldysh* with the two *Mir* submersibles (Fall 1998) six dives were made at the Rainbow hydrothermal field. One of the experiments carried out was a 24 hour deployment of a baited trap. The trap was placed on the slope of the hydrothermal structure about 7 m from the active "black smoker" (36°13.78' N, 33°54.15' W, 2350 m) in a region of mussel beds and the first occurence of the shrimp *Rimicaris exoculata*. When the trap was recovered it retained a portion of the soft sediments underneath it. Thus, both bait-attracted and sediment species were collected by the trap. Among the animals recovered in the trap there were 4 amphipods specimens (all were identified as different species), however one of them was badly damaged. Two species (*Paracentromedon sp. (n.?)* (Lysianassoidea: Lysianassidae), and the female of Harpiniinae gen. sp. (Phoxocephalidae)) seem to represent a background fauna and will be described in separate paper. However, the third species is of interest as it is undoubtedly *Luckia striki*. It is a 8.5-mm long female with seven 1.5-mm hatchlings in marsupium and it matchs the description and figures of *Luckia striki* given in Bellan-Santini and Thurston (1996) with only one insignificant difference – in our specimen the posteriodistal corners of epimeral plates I and II were more distinct. Thus, the Rainbow vent site must be included in the area of this hydrothermal vent species.*

Bellan-Santini and Thurston (1996) presumed that in the Atlantic, with episodic and widely separated vent fields, amphipods have little chance to disperse because they lack planktonic larvae. However, a significant number of "benthic" amphipods (including Eusiridae) are good swimmers and in reality they should be considered benthopelagic animals (Vinogradov, 1996). *Luckia striki* clearly seems to be able to overpass the ~200 km distance between the Lucky Strike and Rainbow vent sites.

Acknowledgements

I thank Dr. A. L. Vereshchaka, Ac. M. E. Vinogradov and the *Mir* group for the collection of the material.

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*Editor's note: This article does not constitute a formal range extension for this species since it has not been peer-reviewed.

A Submarine Eruption west of Terceira Island (Azores Archipelago)

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Sea surface manifestations of a submarine eruption near Terceira Island were observed by some fishermen on Dec. 18, 1998, and the local Azorean seismic network registered micro-seismic activity which started shortly before the sea surface observations. This activity, located at 38°46.8'N, 27°28.6'W, is confined to a small region (known as "Serreta High") 10 km west of Terceira Island (Fig. 1). The first phase of the eruption was focused in three different areas and later it spread into six different locations. All the manifestations are consistently aligned along a NE-SW direction. They comprise plumes of smoke emanating from cooling floating lava debris, up to 3 m in length, consisting on vitreous basalt (Fig. 2). The eruption has an high volatile content, indicated by the empty cavities, formed by gas accumulations, which are visible in the surface debris. As cooling occurs, seawater enters through cracks and gas liberation results in the subsequent sinking of the debris. On average the debris floats at the surface for about 15 minutes. The eruption is not continuous - it pulses between periods of moderate activity and periods of relative quietness with an absence of surface manifestations of volcanic activity.

During the 500 years of human settlement in the Azores, a significant number of submarine eruptions have occurred, sometimes evolving into ephemeral islands (a complete synthesis of Azores eruptions may be found in the paper of Weston, 1964). The new submarine eruption occurs close to the site where a catastrophic submarine eruption took place in 1867. This historic eruption was preceded by premonitory tremors that lasted five months and culminated with violent earthquakes and explosive volcanism that for a week severely damaged Terceira Island. The present eruption has lasted for a longer time and seems to be much more effusive in character and, given the geometry of the seafloor manifestations, of a fissural nature. However, because the eruption is still going on at the time of this writing, these characteristics may change. For the time being, the associated seismicity level is very low.

The depth of the 1998/1999 Serreta eruption probably lies between 300 and 700 m according to pre-eruption data, but recent echo-sounding surveys suggest a massive volume for the different flows and a significant change of seafloor topography. A new detailed bathymetric survey has not yet been made due to a lack of navigation security. A bathymetric compilation (Lourenço *et al*, in press) of swath data from a fiber-optic cable festooning survey made with a SIMRAD EM12 indicates that the eruption site is located in the southern flank of a major E-W striking volcanic ridge. This structure, the Serreta Volcanic Ridge, is a quite narrow feature with a length of approximately 20 km. It borders the southern flank of the East Graciosa Basin (see Fig. 1). On the northern side of this ridge it is possible to observe numerous small seamounts punctuating the sea floor. However, the magnetic anomaly map of the Azores Plateau (Luis, 1996) shows that they are located in a zone of inverse magnetic polarity thus suggesting a much older age for these formations. Strikingly the present eruption seems to have developed along an orientation transverse to that of the Serreta Ridge. If this conclusion is true it would be the first time that such a direction, which roughly corresponds to that of small circles

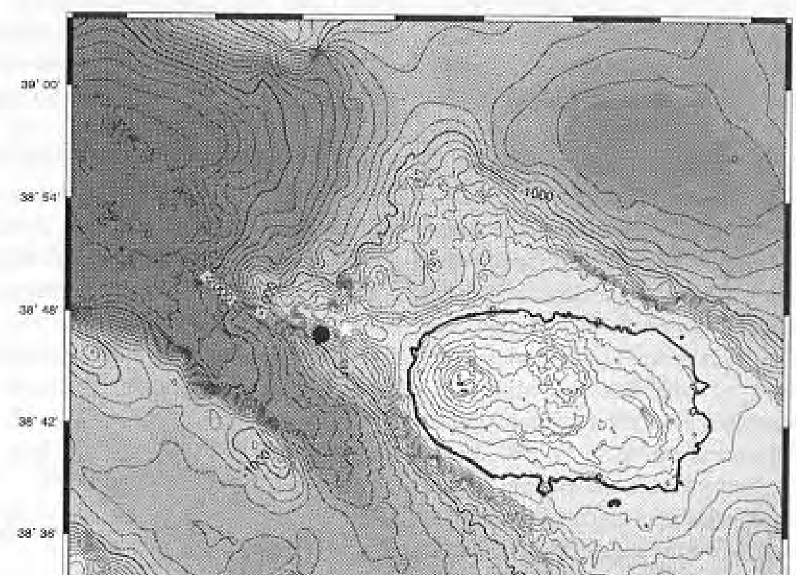

Figure 1. Location of the Serreta Volcanic eruption (black dot) and the 1860 eruption (white star). The thick black line is the shoreline of Terceira Island (Azores).

International Ridge-Crest Research: **Mid-Atlantic Ridge:** Luis et al continued...

about the Euler poles for Eurasia and Africa, has been identified.

The overall Azores morphology consists of numerous linear submarine ridges that seem to have a tectonic origin. Some islands (e.g. S. Jorge, Pico and Faial) are made up of huge linear volcanic ridges. It is not clear how these ridges have developed. Different hypotheses include propagation due to stress concentration at the ridge tips and growing along pre-existent crustal lineaments from inherited tectonics. A detailed study of the Terceira structure is essential for clarifying the roles of small scale accretion processes and tectonics in the Azores Ridge, and to understand the interdependencies between these two factors in the development of the Azores segmentation pattern.

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WWW sites of interest

http://www.virtualazores.com/crise99/ (in Portuguese, can be translated to English with Altavista) - Photographs and daily reports from local radio and TV stations

http://www.discovery.com/news/earthalert/990111/volcanoazores.html

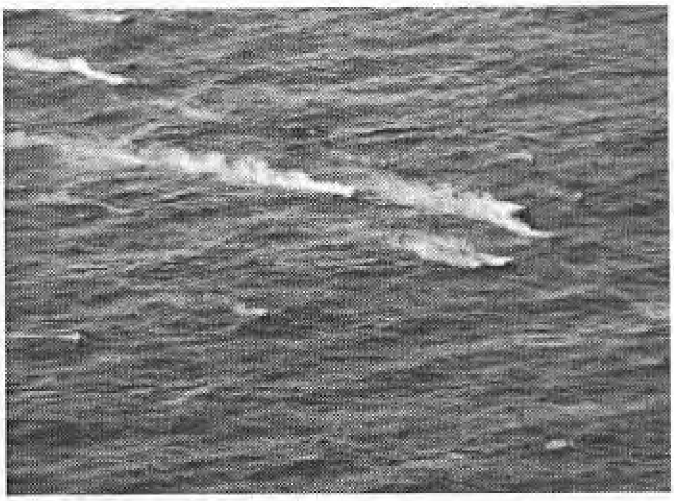

Figure 2. Sea surface manifestations of the submarine volcanic eruption near Terceira Island.

Acoustic Monitoring of the Mid-Atlantic Ridge Begins

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Seismo-acoustic monitoring of the Mid-Atlantic Ridge (MAR) began in February, 1999 with the deployment of six long-term hydrophones from the *R/V Maurice Ewing*. The first instrument was deployed on February 6 and the final (sixth) instrument deployed on February 20. Figure 1 shows the *Ewing*'s tracks and the deployment sites.

The hydrophones are designed to continuously record acoustic signals from 1-55 Hz for periods of over one year and should provide accurate detection of low-level seismicity for most of the region from 10°N to 40°N and the MOMAR site at Lucky Strike. The recent volcanic activity at Terceira Island in the Azores will provide an interesting test of the capabilities of the hydrophones. Due to generally good weather, time was found to collect exploratory multibeam bathymetric surveys of the MAR axis between 17°N and 22°N and over the Royal Trough.

Principal scientists on the cruise were Debbie Smith (WHOI), Maya Tolstoy (LDEO), and Chris Fox (NOAA), and the project is funded by the US RIDGE program. The first year's data will be recovered in early 2000 with an additional year's deployment already funded.

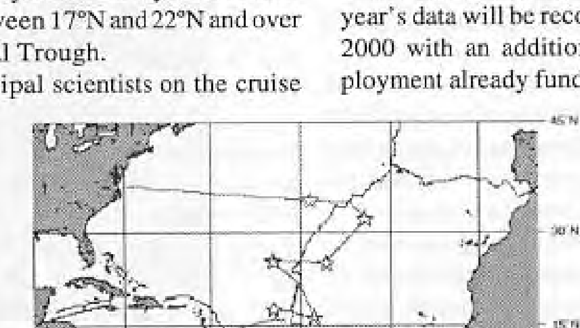

Figure 1. The ship tracks of the *Ewing* cruise and the locations of the hydrophones.

The Northern Chile Ridge Revealed: Preliminary Cruise Report of PANORAMA Expedition Leg 04

(R/V Melville Panorama Expedition Leg 04, January 15 - March 2, 1998)

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Introduction

The Chile Ridge (Fig. 1) extends from the Chile Fracture Zone (~36°S) to the Chile Margin Triple Junction (~47°S) and separates the Nazca and Antarctic plates. Until recently, the first-order behavior of the Chile Ridge was poorly defined. Aeromagnetics coverage and satellite altimetry-based gravity and predicted bathymetry (Smith and Sandwell, 1994) have defined the recent kinematic history, gross segmentation and morphological character of the ridge axis (Tebbens and Cande, 1997; Tebbens et al., 1997, and references therein). For the past 14 m.y., convergence between the South American margin and the southernmost Chile Ridge has caused subduction of the ridge axis and progressive northward migration of the triple junction. Clockwise rotation in the pole of opening about 10-12 m.y. ago caused rapid northward extension of the axis into its present configuration. The spreading center is now broken into two main provinces by the ~700 km long Valdivia Fracture Zone (VFZ) system: the ~550 km long Northern Chile Ridge (NCR) and the ~650 km long Southern Chile Ridge (SCR). Transform offsets further sub-divide the NCR and SCR axis into several first-order ridge segments and the VFZ into six short (~10 km long), intra-transform spreading centers (ITSCs). Satellite gravity and aeromagnetic data suggest that the large fracture zones which offset these segments have been stable for long time periods (>10 m.y.). The spreading rate is intermediate (~53 mm/yr), based on aeromagnetics data, and is uniform over most of the axis (Tebbens and Cande, 1997).

Several recent expeditions to the SCR have focused on ridge-trench interactions and their consequences for spreading center magmatism, forearc processes (e.g., ODP Leg 141), and ophiolite obduction. The only previous cruise to the NCR, however, was a 1985 *Sonne* cruise (SO-40) which conducted limited Hydrosweep bathymetry mapping and dredging at 16 sites (mostly off-axis) on the central portion of the NCR axis (e.g., Marienfeld and Marchig, 1992). Mid-Ocean Ridge Basalts (MORB) recovered during SO-40 have compositions that are uniform, generally very depleted in incompatible trace elements (Bach et al., 1996), and quite unlike the highly diverse and unusually enriched lavas found farther south on the SCR (Klein and Karsten, 1995; Sturm et al., 1999). Mineralized greenstone breccias with high Pb contents (~3000-fold enrichments over oceanic basalts) were also recovered during SO-40 (Marienfeld and Marchig, 1992; Mühe et al., 1997).

Our highly successful 47-day *R/V Melville* cruise (PANORAMA Leg 4) in early 1998 conducted reconnaissance-scale mapping and sampling of the entire NCR axis, VFZ and northern SCR, for the first time (Fig. 1). This expedition had two major goals:

(1) Investigating thermal effects of large, long-lived transform offsets on axis depth and morphology, faulting characteristics, crustal structure and thickness, and magmatism. Transform fault effects (TFEs) studied previously at other sites have yielded ambiguous results, largely owing to contributions from other tectonic complexities at those sites. From preliminary observations, it appears that segmentation geometry (axis length, offset length) is the main tectonic variable changing at the NCR (i.e., no regional thermal gradients). The combination of tectonic simplicity and the intermediate spreading rate, which should make the axis particularly sensitive to small thermal changes (e.g., Phipps Morgan and Chen, 1993), makes the NCR an ideal site for study of TFEs.

(2) Exploring the spatial extent of MORB with unusual and distinct geochemical anomalies seen previously on the SCR. Klein and Karsten (1995) recovered MORB from SCR segments nearest the trench with highly unusual trace element characteristics that had enrichments trending toward compositions more commonly associated with arc or back-arc lavas (i.e., a supra-subduction zone signature), indicating that they had been contaminated with recycled components. Samples from the unexplored northernmost SCR and the VFZ ITSCs can be used to assess whether these unusual lavas are spatially restricted to the near-trench environment (and thus

International Ridge-Crest Research: **Northern Chili Ridge:** Karsten et al. continued...

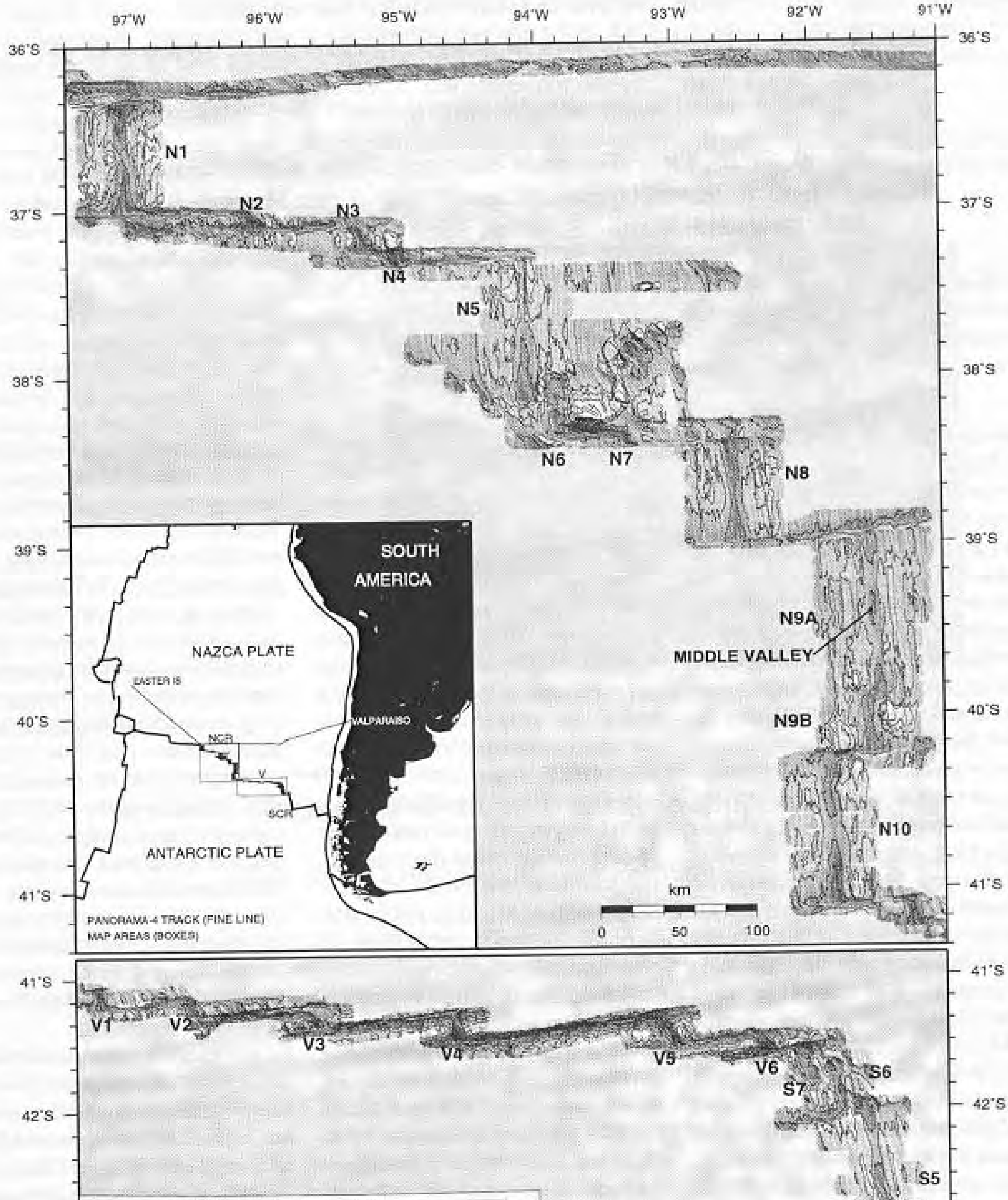

Figure. 1. Shaded relief SeaBeam bathymetry of the Northern Chile Ridge (NCR; top panel) and Valdivia Fracture Zone (V) -Southern Chile Ridge (SCR) region (bottom panel) from PANORAMA Leg 4, merged with predicted bathymetry of Smith and Sandwell (1994). Labeling (e.g., N1) identifies first-order ridge segments. Contours given every 250 m for depths <3000 m and every 500 m for depths >3000 m. Inset shows location of the ridge axis and the PANORAMA Leg 4 trackline relative to other major Southeast Pacific features.

likely associated with recent subduction processes). Additionally, the low magma supply environment of the ITSCs, which prevents extensive magma mixing, means that these melts may better represent the range of heterogeneity in the sub-ridge mantle.

PANORAMA Leg 4 (Valparaiso, Chile to Easter Island) mapped southward along the axis and then sampled northward on the return. We imaged over 22,000 sq. mi. of seafloor with SeaBeam 2000, shipboard magnetics and gravity, covering >700 km of ridge axis out to at least past the Brunhes-Matuyama magnetic reversal boundary (~0.78 Ma crust). Rock sampling of the axial valleys and ITSCs was conducted at 112 dredge stations and 23 wax core stations (average sampling density of ~6-7 km along-strike); rocks or glass were recovered at all but one station. Although not funded for hydrothermal studies, we were able to make a preliminary assessment of hydrothermal activity for all but the last 7 stations, by using a Miniature Autonomous Plume Recorder (MAPR), kindly donated by Dr. Ed Baker (NOAA-PMEL), positioned ~150 m above the dredge or wax core (Baker and Milburn, 1997). MAPRs collect temperature, nephelometer and pressure readings which can indicate water column anomalies associated with nearby hydrothermal plumes.

Preliminary Results

Ridge Axis Segmentation and Morphology

SeaBeam 2000 data (Fig. 1) fully defined the segmentation of the study area and revealed several short (<10 km long) segments not previously identified (Karsten et al., 1998a). From the north, we have named these segments N1 through N10 (NCR), V1 through V6 (VFZ) and S7 through S5 (SCR). With the exception of segments N5-N6 and S6-S7, all of these segments are bounded by stable, long-lived transform offsets. Segments S6 and S7 overlap and are separated by an unusual, apparently unstable, offset. Segment N5 has been propagating to the south, at the expense of N6, for about 4 m.y. The pseudofault terrain to the east of N5 is complex, suggesting episodes of dueling propagators or overlapping rift segments. Several steep, tectonized blocks in the pseudofault provide crustal exposures of over 2 km; the east side of the tectonized block in the overlap zone between N5 and N6 is the site where SO-40 recovered Pb-rich greenstone breccias (Mühe et al., 1997).

Average axial depth (Fig. 2) is remarkably uniform along the entire ~750 km of plate boundary for both on-axis and off-axis profiles and subsidence rate is generally symmetric about the axis. [Note that this is in marked contrast to the South-east Indian Ridge, where average axial depth deepens by 1000 m between 80°E and 120°E, due to the mantle cooling at the AAD (e.g., Sempere et al., 1996).] Axial depth varies locally along-strike from ~3300 m near segment summits (usually near the segment center) to >4000 m near ridge-transform intersections (RTIs), consistent with thermal model predictions. Segments that are very short (e.g., N2), and thus strongly influenced by the transform cold edge effect, or abutted by longer (and thus colder) transform offsets (e.g., N1), are systematically deeper.

Ridge axis morphology (Mart'nez et al., 1998) is characterized by a broad axial valley, similar to the slower Mid-Atlantic Ridge (MAR) morphology (e.g., Kong et al., 1988) and three main axial valley styles, described here briefly, are observed:

Hourglass segments (N1, N8, N10) are of medium length (55-90 km) and display the morphology commonly seen on the MAR, with a narrower (~5-7 km wide) and shallower axial valley near the segment middle (summit region) and broader (~10-12 km wide), deeper valley at the distal ends (e.g., Fig. 3). Near segment ends, the valleys show across-axis asymmetry in their bathymetric profiles (i.e., high inside corners), commonly seen at other axial valley settings (e.g., Severinghaus and Macdonald, 1988). Away from RTIs, flanking abyssal hills are generally very symmetrically distributed about the axial valley; fault relief and spacing decrease away from the segment ends (e.g., Shaw, 1992). Although axial valley width varies 2-fold along-strike within one of these segments, the flanking abyssal hill lineations are extremely continuous along-axis over the entire segment, at least in the bathymetry data, raising interesting questions about how structures formed within the valley evolve off-axis. Narrow, ~200 m high, central ridges, which yielded young, volcanic rocks upon sampling, lie in the middle of the axial valley; these central ridges, which may be the neovolcanic zone, are most prominent at the distal ends of the segment.

Pinch-and-Swell segments. Segments N9 and S5, the longest (~150 km) ones, are the only segments to show clear development of higher order offsets in the bathymetry (Fig. 4). For example, in addition to a ~7 km wide, non-migrating, non-transform offset at 38°55'S, which separates the ridge into sub-segments N9A and N9B, a DevAL (deviation in axial linearity of the central ridge) occurs near 39°28'S. Axial valley width and depth undulate along segment N9A and it has two summit regions, separated by a broad, deep basin which we refer to here as "Middle Valley". As was seen at the "hourglass" segments, the axial valley deepens and widens near the RTIs, but the flanking abyssal hills do not appear to reflect these axial valley undulations.

Short Segments (Megamullions). The very short (<15 km) segments (N2, N3, N4 and the VFZ ITSCs), are characterized by deep (>4300 m), rhomboid-shaped basins with a narrow, ~200 m high ridge either centered in the middle of the basin or displaced obliquely to the side (Fig. 5). Volcanic rocks recovered from the central ridges suggest they may be constructional, but their steep-sided morphology indicates they may represent uplifted crustal blocks (e.g., "razor-back" ridges). One of the most exciting discoveries was the recognition of lineated domal

International Ridge-Crest Research: **Northern Chili Ridge:** Karsten et al. continued...

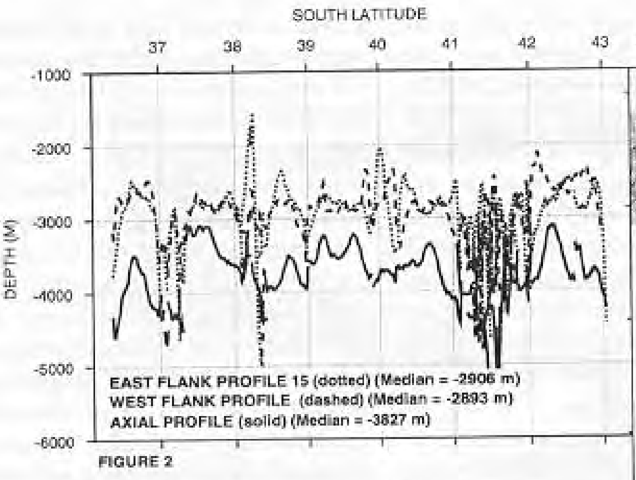

FIGURE 2

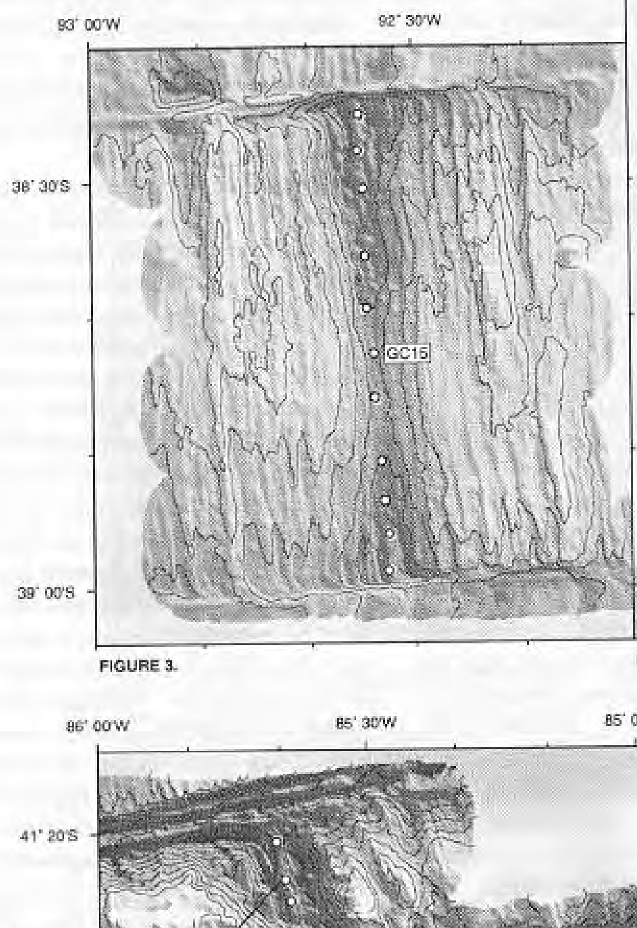

FIGURE 3.

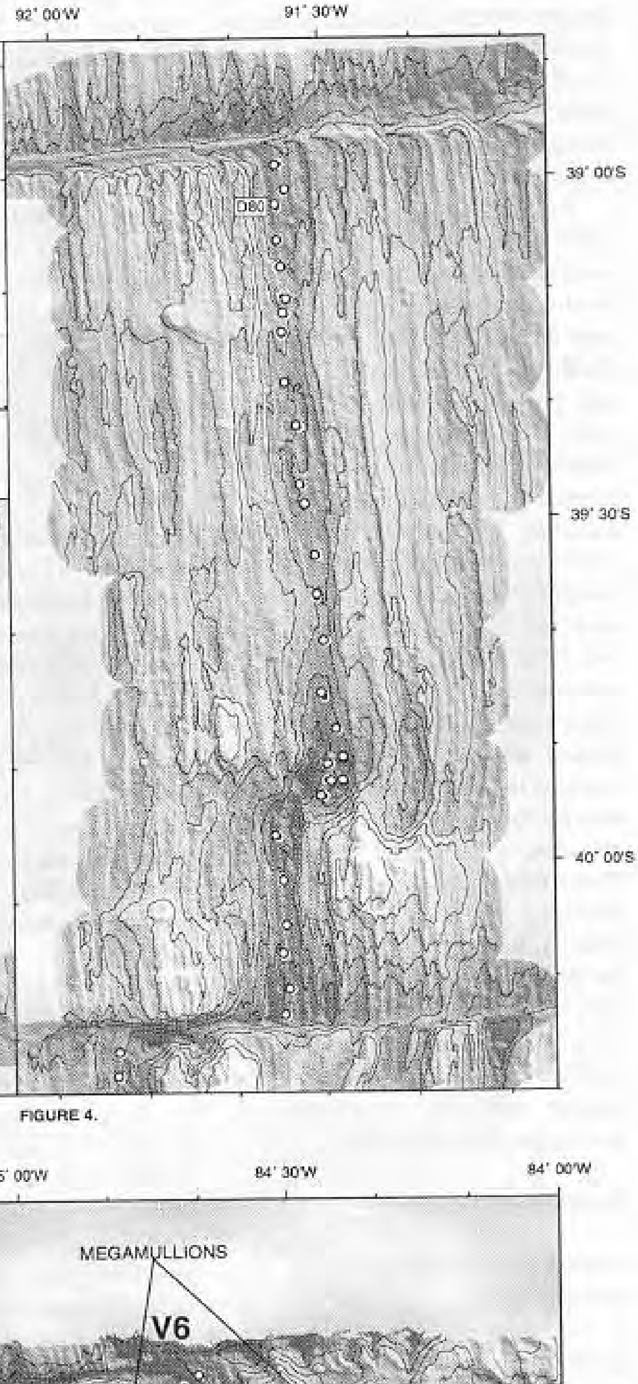

FIGURE 4.

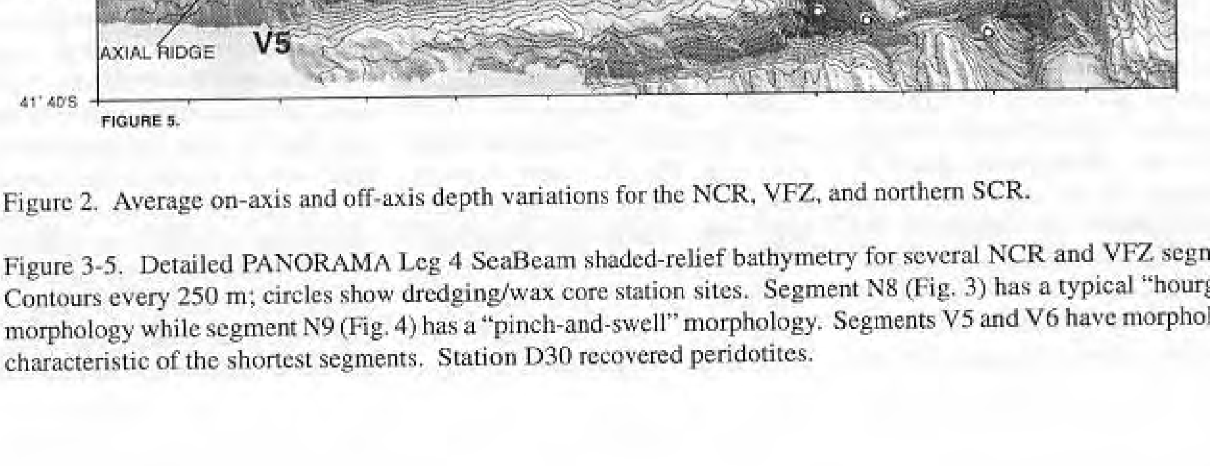

FIGURE 5.

Figure 2. Average on-axis and off-axis depth variations for the NCR, VFZ, and northern SCR.

Figure 3-5. Detailed PANORAMA Leg 4 SeaBeam shaded-relief bathymetry for several NCR and VFZ segments. Contours every 250 m; circles show dredging/wax core station sites. Segment N8 (Fig. 3) has a typical "hourglass" morphology while segment N9 (Fig. 4) has a "pinch-and-swell" morphology. Segments V5 and V6 have morphologies characteristic of the shortest segments. Station D30 recovered peridotites.

features on the flanks of segment V6 (Fig. 5; Martínez et al., 1998), which strongly resemble "megamullion" or "oceanic core complex" structures seen recently at predominantly slower or colder spreading centers, such as the MAR (Tucholke et al., 1998) and SEIR near the AAD (Christie et al., 1998). These ~25-30 km long features consist of crustal blocks with transform-parallel striations in the bathymetric data that are markedly different from normal, axis-parallel abyssal hill lineations. Here, they are found on both flanks of V6, which has only been seen previously at the 15°20'N MAR area (Casey et al., 1998). The origin of such features and their role in crustal accretion is still the topic of intense discussion. They have been interpreted as blocks of lower crust or upper mantle exhumed by detachment faulting during amagmatic extension (e.g., Tucholke et al., 1998).

Gravity and Magnetics Data

Mantle bouguer anomalies (MBAs) derived from the PAN4 shipboard gravity data (after Kuo and Forsyth, 1988) show pronounced negative MBA "bull's-eye" features of ~25-30 mGal only at the centers of the longest segments (N5, N9A, N10, S5), while the "hourglass" segments have relatively weak (~10-15 mGal) MBA lows at segment mid-points. The largest MBA "bull's-eye" lies beneath the summit of the propagator segment (N5), most likely due to increased crustal thickness and/or hotter mantle temperatures associated with the seamount volcanism in this area. Separate MBA lows occur over sub-segments N9A and N9B. Interestingly, the MBA low at segment N9A is elongate along-axis, straddles the two bathymetric summits found on this segment, and actually is centered over the deep ("Middle Valley"), quite unlike the behavior seen at the MAR (e.g., Kuo and Forsyth, 1988). The gravity signature of the short segments and their flanks are poorly defined, owing to the fact that the tracks primarily crossed the fracture zones; however, the "mega-mullion" flanks of V6 appear to have relative MBA highs, which could indicate thinner crustal thickness and/or exposure of denser, lower crustal rocks at these sites, like the SEIR (Christie et al., 1998). Our magnetic anomaly data confirm a ~53 mm/yr spreading rate and indicate largely symmetric accretion during the last 0.78 m.y. (Martínez et al., 1998)

Axial Lavas, Serpentinized Peridotites, and Greenstone Breccias

Three types of lithologies were recovered during our sampling program. Most samples were MORB with more than 50% of the rock types described being crystal-rich, plagioclase phyric and porphyritic lavas (Karsten et al., 1998b). Available major and trace element data for these samples indicate that most of the NCR lavas are extremely uniform, have restricted and relatively high MgO contents, and have generally very depleted trace element characteristics. These observations suggest very limited mantle source heterogeneity beneath most of the NCR axis and limited modification by low pressure fractionation prior to eruption. The only exception to this homogeneity is found in the vicinity of the northern end of propagator segment N5, where very alkalic lavas (K2O > 1.5 wt%) were recovered from the summit region and the seamounts just west of the axis in this region. Unlike the NCR, the northern SCR lavas are very heterogeneous and span a much greater range of MgO contents. However, enriched MORB compositions do not appear to show the unusual "supra-subduction zone" trace element characteristics seen farther south on the SCR (Sturm et al., 1998), which suggests this anomalous contamination is restricted to the near-trench setting. The VFZ (which has intermediate levels of heterogeneity) thus delimits a major compositional boundary in the mantle between the NCR and SCR. VFZ lavas also have systematically higher Na2O contents at the same MgO content, like other ITSC settings (e.g., Hekinian et al., 1995), compatible with the interpretation that they represent generally lower degree partial melts (Karsten et al., 1998b).

Serpentinized ultramafics were dredged from one site (D30) at the southern end of V5, where the central ridge intersects the western valley wall (Fig. 5). Most of these samples have been significantly serpentinized and deformed, but some harzburgites were found that contain fairly pristine phenocryst cores (>Fo90 olivines and ~En85 orthopyroxenes) and interstitial plagioclase-rich zones that likely represent trapped melt. It is highly probable that lower crustal rocks are extensively exposed in the low magma supply VFZ ITSCs and the "megamullion" zones, although we did not have time to thoroughly explore those sites. Mineralized greenstone breccias and serpentinized ultramafics were also recovered from a site located on the western side of the tectonized block which lies in the overlap zone between segments N5 and N6. They are variably altered metabasalts and metadolerite breccias, with chlorite-smectite, chlorite-epidote, quartz, pyrite, chalcopyrite and sphalerite as the dominant minerals. Our preliminary interpretation is that these greenstones are samples from the upflow zone of a fossil hydrothermal system (Mühe et al., 1998). The recovery of greenstone breccias on both sides of this edifice on two different cruises (SO-40 and PAN4) suggests that they occur extensively in this region.

Evidence of Hydrothermal Activity

The MAPR data provide some intriguing indications regarding the presence of possibly extensive hydrothermal plume activity on the NCR and northern SCR axis. We cannot correct our MAPR temperature (T) data to potential T (no conductivity data), but the raw profiles reveal two very distinct types of T anomalies. First, over the shallower, summit regions of several segments, particularly the longer ones, we see more traditional T anomalies, which occur as small (<0.02¡C), but distinct, T spikes or broad T peaks superimposed on the water column gradient (e.g., Fig. 6A); these T peaks are often, but not always, associated with

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increases in light scattering (indicating higher particle contents), although the nephelometer data often do not define a sharp peak. These anomalies are found between 100-300 m above the seafloor, which is the typical rise height for hydrothermal plumes at other spreading centers (e.g., Baker et al., 1995). Association of hydrothermal plume activity with the shallowest, more magmatically active part of the ridge segment is consistent with the distribution seen along faster spreading ridges (Baker et al., 1995).

The second type of T anomaly we see (e.g., Fig. 6B) is quite different and is characterized by a systematic "up-turn" within ~600 m of the seafloor, sometimes reaching anomalies of up to 0.07°C relative to the normal T-P gradient. These T gradient "tails" often correspond to regions of increased particle abundances inferred from the nephelometer data and are found principally at deeper sites near RTIs and along the short and deep ridge segments. These T anomalies cannot just reflect pressure effects, as the "hinge depth" where the up-turn begins varies along-axis and shows good correlation with the average depth of the flanking valley walls. We believe these anomalies may indicate the presence of accumulated hydrothermal plumes which, due to the the surrounding seafloor relief (>500 m) and their "closed basin" geometry, are not rapidly flushed by prevailing bottom currents.

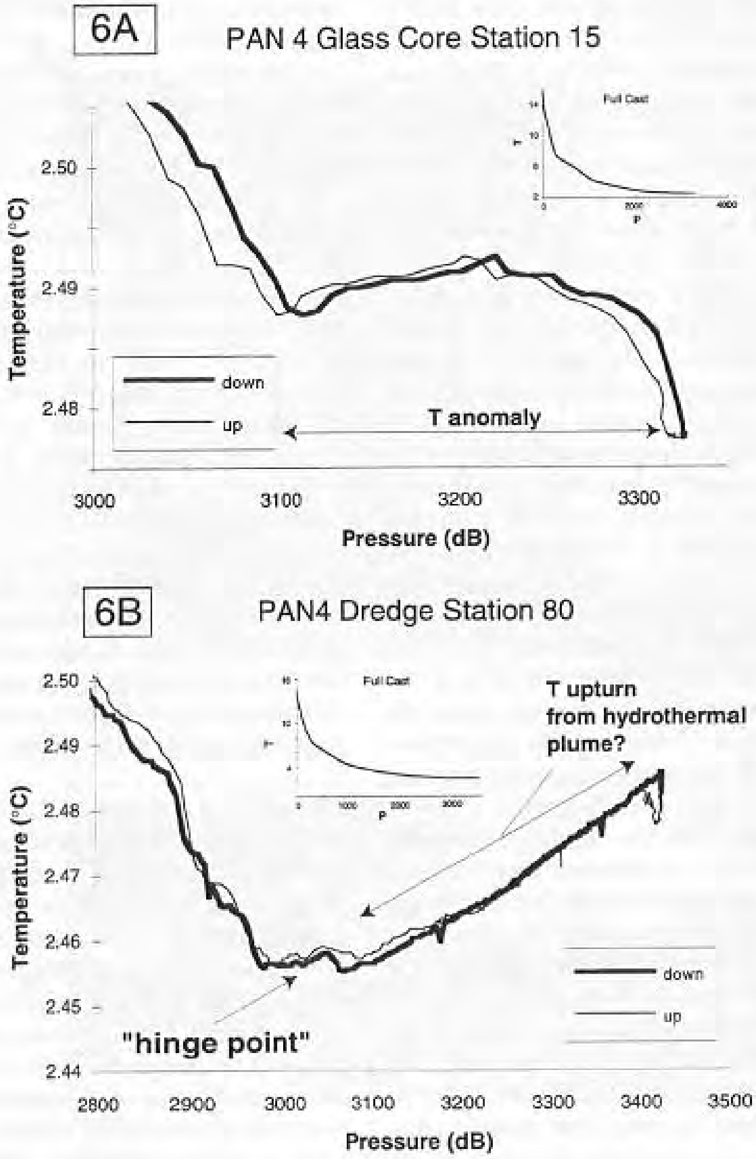

Figure 6. Examples of PANORAMA Leg 4 MAPR temperature anomalies showing details of the near-bottom profile (inset shows the full water column cast). A) More typical temperature "spike" relative to the background P-T gradient associated with hydrothermal plumes; B) Temperature "tail" anomalies where T increases systematically over the last few hundred meters, possibly due to closed basin accumulation of plumes (see text).

Following the recent SEIR work of Scheirer et al. (1998), we have used the MAPR data to make preliminary estimates on the incidence of plume activity for the region. Our estimate ranges from as low as 13% (using only those sites which have both T spikes and nephelometer anomalies), to as high as ~76% (when we include the second type of T anomalies). This huge range in the PAN4 MAPR data clearly demonstrates the need for a follow-on field program in this area in order to assess whether these T "tails" represent trapped plumes associated with high T venting in the basins, or some other phenomenon. If we can confirm that this second type of MAPR anomaly really does correspond to active venting, it suggests that there is significant hydrothermal activity in the tectonized portions of the axis, which may have important implications for the global hydrothermal heat budget.

Acknowledgments

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International Ridge-Crest Research: **Indian Ridges**

First Submersible Investigations of mid-ocean ridges in the Indian Ocean

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Introduction

The first submersible investigations of the mid-ocean ridges in the Indian Ocean were carried out in September-October 1998 during the INDOYO cruise with the submersible *Shinkai 6500* and the *R/V Yokosuka*. The cruise objectives were to obtain detailed information about accretionary processes along the Southwest Indian Ridge (SWIR) and to locate hydrothermal vent sites in the Indian Ocean.

The SWIR, separating the African and Antarctic plates, opens at the ultra-slow half rate of 7 to 8 mm/year, and represents an end-member of the global ridge system in terms of spreading rate. For this reason, it has been selected by the InterRidge program as an important target of global ridge studies. This portion was intensively investigated in 1997 during two cruises on the *R/V Marion Dufresne*. The EDUL cruise comprised a systematic sampling of the axis between 49°E and 68°E, and confirmed that the amount of melting is particularly low in this portion of the SWIR (Mével et al., 1997). During the FUJI cruise, a TOBI deeptow sidescan survey was conducted for the mapping of magmatic and tectonic activity (Mével et al., 1998). A series of transmissometers mounted on the TOBI and the tow cable documented several signals interpreted as hydrothermal plumes (German et al., 1998). We carried out diving surveys on the SWIR based chiefly on the TOBI images and the transmission anomalies. Three-component measurements of the magnetic field was made during most of the dives.

Although many active hydrothermal vent fields with biological communities have been found and sampled on the Mid-Atlantic Ridge (MAR) and on the East Pacific Rise (EPR), no active sites have been located in the Indian Ocean yet (cf. Plüger et al., 1990). The species of vent fauna on the MAR are different from those on the EPR (Tunnicliffe, 1991). The Indian Ocean Ridges are important as they are in the main propagation pathway between the Atlantic and the Pacific vent fauna. From this viewpoint, we also investigated a site in the first segment of the Central Indian Ridge (CIR) north of the triple junction near to where geochemical anomalies were observed in 1993 (Gamo et al., 1996).

Crustal accretionary processes at the ultra-slow spreading ridge

To characterize the accretionary processes in the ultra-slow spreading environment we concentrated 7 dives on Segment 11 (~64°E), two on the axial volcanic ridge (AVR), three on a "megamullion" and two in the non-transform discontinuity (NTD) (Fig. 1).

The center of Segment 11 is characterized by the presence of a large magmatic construction that fills the axial valley (Mount Jourdanne). A series of extrusive units, principally alternating sheet flows and pillow/lobate flows, comprise the main outcrop of the eastern AVR of Mount Jourdanne. Pillow mounds and flow units are more common on the uppermost, shallowest parts of the summit. Most of the seafloor was covered with sediment of varying thickness. The eastern AVR is cut by faults, and in some cases, pervasive fissures with E-W strikes; some of them formed hydrothermal precipitates.

The relatively small volcanic AVR (ca. 64°30'E) of Segment 10 was significantly different from that of Mt Jourdanne. Most of the Segment 10 AVR was buried by pillow fragments and basaltic talus. Sheet flows were not observed. The AVR is cut by a series of approximately E-W scarps and grabens reflecting extensional movement. In contrast to Segment 11, tectonic processes appear dominant in this segment.

To determine the evolution of the crustal accretion processes in the SWIR, we extended sea surface geophysical mapping to anomaly 5 in Segment 11 and in Segment 9, where the TOBI images indicate the least magmatic supply. Off-axis topographic data across Segment 9 show striking asymmetry across the spreading axis.

The first sulfide chimneys from the SWIR

Some of the larger fissures on the eastern AVR of Mt. Jourdanne show a strong spatial relationship to the location of extinct hydrothermal sites. Favored by both volcanic (heat source) and tectonic activity (pathways for fluid convection) several exitinct hydrothermal sites were found within an area of approx. 0.5 km^2 at a water depth of about 2941 m (27°50.97'S 63°56.15'E). All of exitinct hydrothermal sites were related spatially either to the graben or to smaller fissures. They are the first known sulfide deposits along the ultra-slow spreading SWIR.

Hydrothermal precipitates consist of sulfide impregnated basalts, and massive sulfides dominated by pyrite, sulfates and oxides. Hydrothermal products occur on the ocean floor as mounds with an average size of about 5 m^3; the mounds are usually cracked and highly weathered at the surface. Besides mound-like structures, small chimneys were observed on the ocean floor. During the INDOYO cruise it was possible for the first time to sample sulfide chimneys from the SWIR. These chimneys have a tube-like shape and consist possibly of sphalerite, some chalcopyrite as well as pyrite and minor amounts of sulfates. Silica seems to be more or less absent in chimney samples, which might explain the fragility of chimney edifices. The chimneys are totally encrusted by manganese.

Detachment fault surface (FUJI Dome)

The TOBI images also showed a large striated surface ("megamullion") 20 km south of the axis in Segment 11, inferred to be a major detachment surface resulting from long-lasting asymmetric extension (the FUJI Dome in Fig. 1).

Three dives were made on the FUJI Dome. The detachment surface represents a distinct formation that is different from those adjacent to it. Except at the steep southern slope near the inferred breakaway, the surface is very smooth and sediment-covered surface with frequent deposits of basaltic debris. Two gabbro samples were recovered from the crest of the dome, and one serpentinite peridotite boulder (not *in-situ*) was recovered from its northern (younger) flank. No other evidence of lower crustal or mantle lithologies was seen. *In-situ* metamorphosed basalt was recovered from a probable thin faulted sliver on the lower northern flank of the detachment. Preliminary analysis of seafloor gravimetry during the three dives indicates mostly the same subterranean density structure.

Extinct clam colonies near the Rodriguez Triple Junction

We could not find any indication of hydrothermal activities other than the extinct sites on the Mt. Jourdanne, and we moved to the CIR near the triple junction. Two dives were focused on a spur extending to the NW from the crestal ridge at 25°19'S, 70°03'E (Fig. 2), where the most fresh

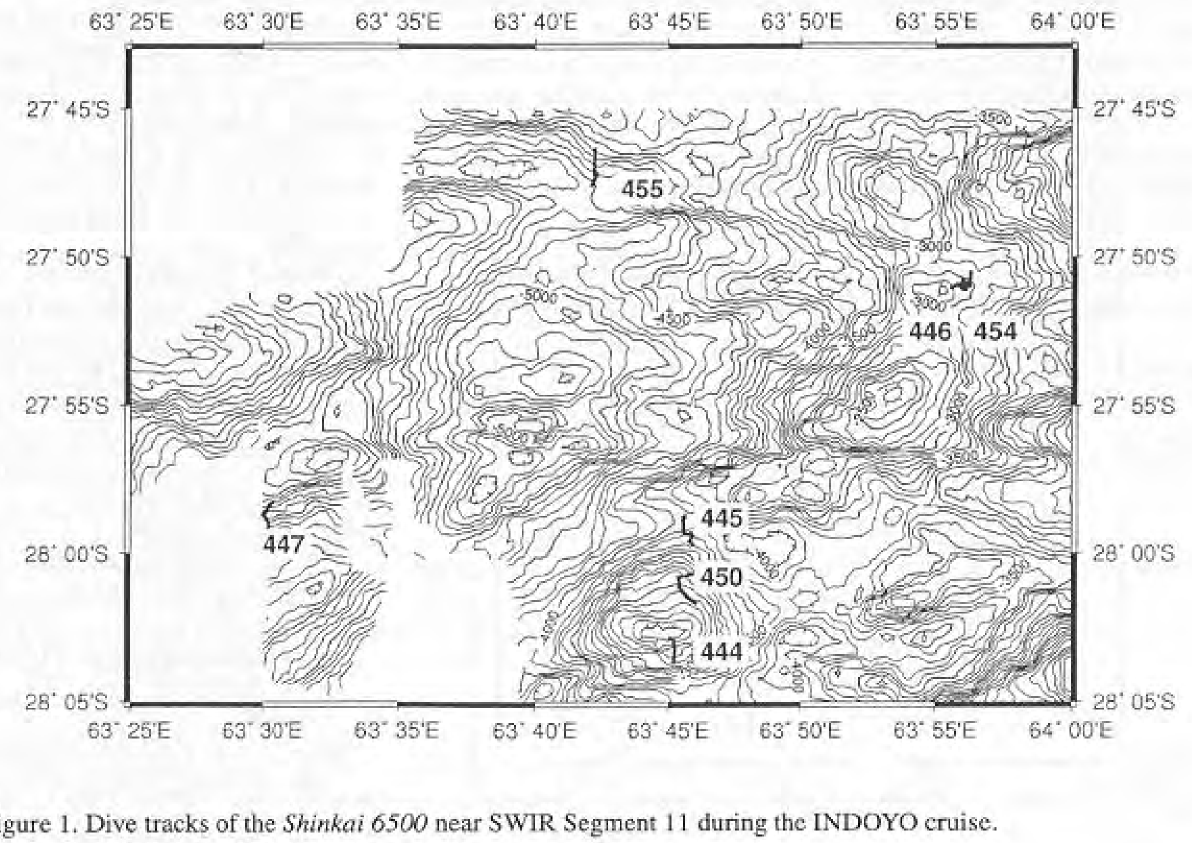

Figure 1. Dive tracks of the *Shinkai 6500* near SWIR Segment 11 during the INDOYO cruise.

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hydrothermal plume observed in 1993 had been expected to converge from the analysis of CH_4/Mn ratio (Gamo et al., 1996).

Heaps of dead shells were found just on the landing site of the first dive. We successfully sampled shells of two species of Calyptogena. The heaps can safely be regarded as *in situ* biological communities related to former or possibly recent hydrothermal activity. The finding and characterization of hydrothermal vent communities has been highly expected by most marine biologists to depict the global distribution map of chemosynthetic communities and their propagation mechanisms and evolution. This is the first demonstration of *in situ* biological communities associated with hydrothermalism along the Indian Ridge.

Groups of the giant white clams are main constituents of hydrothermal vent communities along spreading centers, especially in the Pacific (Hessler and Lonsdale, 1991; Tunniclife, 1991). Occurrence of Calyptogena on the CIR suggests the idea that the lineage of vent communities on the Indian Ridge might be more related to those of the Pacific than to those of the Atlantic, because so far there has been no report of the occurrence of Calyptogena along the Mid-Atlantic Ridge. Main propagation route of possible Indian vent organisms might be via the mid-ocean ridge connecting the Southeast Indian Ridge and the East Pacific Rise.

During the last dive, transmission anomalies of 0.5% were observed at the end of the dive. This anomaly is significant, about 5 times larger than those observed in 1993, probably because the surveyed area is much closer to a venting site. In addition, the CTD attached to *Shinkai 6500* detected bottom temperature anomalies of about 0.05°C at a location close to that of the observed transmission anomalies. These observations suggest the existence of current hydrothermal activity around the survey area.

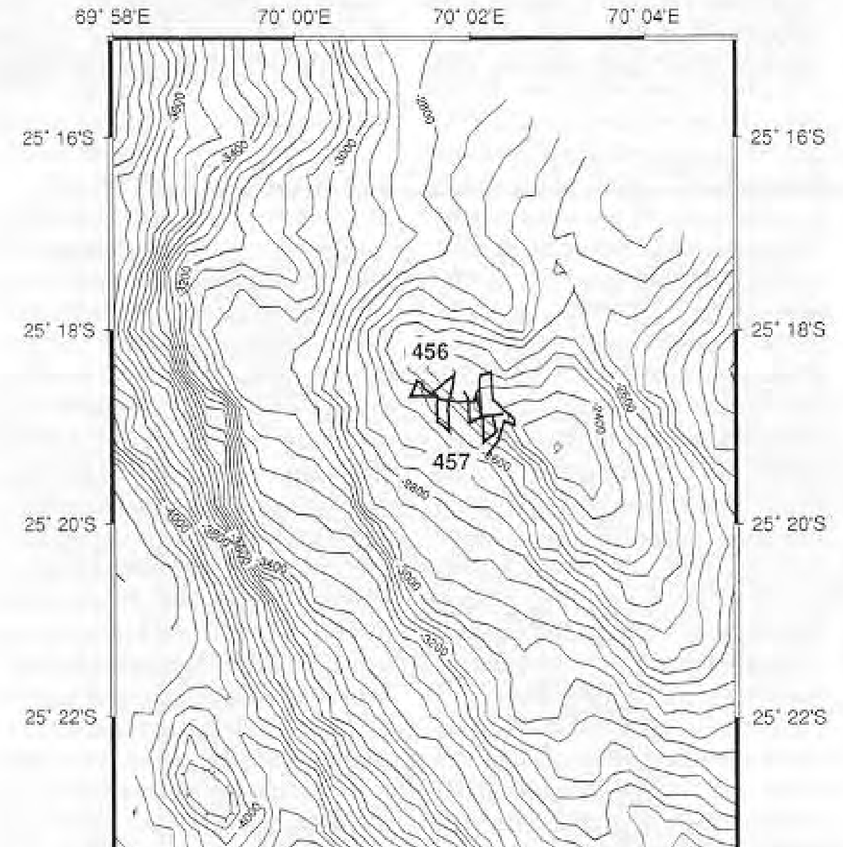

Figure 2. Dive tracks of the *Shinkai 6500* on the CIR north of the Rodriguez Triple Junction during the INDOYO cruise.

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International Ridge-Crest Research: **Indian Ridges**

The Magofond 2 cruise: a surface and deep-tow survey on the past and present Central Indian Ridge

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Introduction

Tremendous efforts have been recently focused on the study of the Indian Ocean mid-ocean ridge system. The Southeast Indian Ridge, an intermediate spreading center, displays different types of axial morphology and geophysical signature in relation to variations of the underlying mantle temperature (e.g., Cochran et al., 1997; Sempéré et al., 1997; Christie et al., 1998). The Southwest Indian Ridge offers an almost unique opportunity to study the end-member case of ultra-slow seafloor spreading (e.g. Grindlay et al., 1996; Mével et al., 1997, 1998; see also Marine Geophysical Research, special issue: the Southwest Indian Ridge, December 1997). The Rodrigues Triple Junction, where these ridges intersect, has been the subject of several studies (Honsho et al., 1996). In contrast, the more accessible Central Indian Ridge (CIR) has been poorly studied and no systematic bathymetric and geophysical data coverage exists north of 21°S, although it is an attractive target for mid-ocean ridge studies for several reasons. The drastic changes in spreading rate and direction encountered by the CIR during its history, and the geophysical, morphological, and geochemical evidence of a ridge-hotspot interaction in a narrow corridor in the vicinity of the Rodrigues Ridge have partly motivated the Magofond 2 cruise, as has the desire to acquire high-resolution magnetic anomaly records with deep-tow measurements to investigate detailed time variations of the geomagnetic field and the magnetic structure and properties of the oceanic lithosphere.

Cruise operation

The Magofond 2 cruise of *R/V Marion Dufresne* took place between Oct. 11 - Nov. 9, 1998. Operations took place in two areas in the Exclusive Economic Zone of the Republic of Mauritius (Fig. 1), one located on the present CIR axis east of Rodrigues Island, between 18°30'S and 20°S, and the other southeast of Mauritius Island, on oceanic crust created between 50 and 30 Ma at the CIR axis and including a major change of spreading rate and direction and a fossil ridge segment, the Mauritius Fossil Ridge (Patriat, 1987). Data acquired routinely throughout the cruise include multibeam bathymetry and imagery, gravity, scalar and vector surface magnetics. Following recent improvements, the Thomson Marconi Sonar TSM 5265 multibeam echosounder of *the R/V Marion Dufresne* provided remarkable data in terms of spatial resolution and efficiency (about 20 m for a depth of 3000 m at the optimal speed of 15 knots). Data were processed onboard

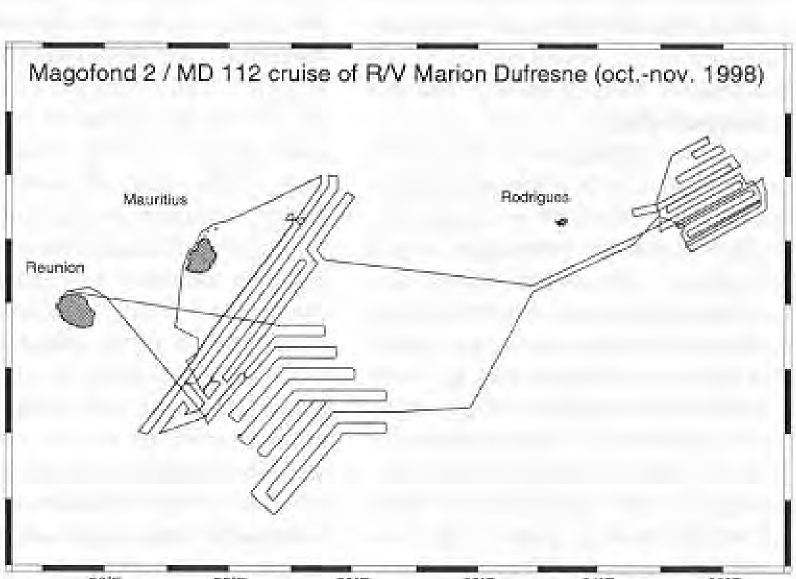

Figure 1: Tracks of the Magofond 2 cruise of *R/V Marion Dufresne*

using the Caraïbes software developed by IFREMER. Gravity measurements obtained by the Lacoste & Romberg marine gravimeter were tied to the reference base of Le Port at Reunion Island using a Scintrex gravimeter, courtesy of colleagues at Université de La Rochelle, France. A proton magnetometer towed 350 m behind the ship at the sea surface provided absolute measurements of the magnetic field intensity and scalar magnetic anomalies. A shipboard three-component magnetometer (STCM) from Ocean Research Institute (ORI), University of Tokyo, Japan, provided vector magnetic anomalies, useful to determine the dimensionality of the magnetized bodies and eventually the direction of the 2D bodies. The surface-towed and shipboard magneto-meters provide complementary information, as the STCM is unable to provide absolute measurements of the magnetic field due to the difficulty to correct adequately for the slowly time-varying viscous magnetization of the ship body. A deep-tow proton magnetometer from ORI was towed about 300-900 m above the seafloor on selected profiles navigated at slow speed (2.5 knots), for a total duration of about 8 days. A new deep-tow Overhauser magnetometer recently purchased by CNRS was also tested during the cruise. Finally, two successful dredge hauls provided about 500 kg of rock samples and sediments.

Detailed history of the Earth's magnetic field

The simplistic view of a binary sequence of alternating polarity and constant intensity is no longer sustainable for the geomagnetic field evolution. The observation of consistent patterns of low-amplitude, short-wavelength anomalies, the tiny wiggles, superimposed on the well-known Vine-Matthews-Morley magnetic anomalies, has been interpreted as reflecting either short polarity reversals or geomagnetic field intensity fluctuations (e.g., Cande and Kent, 1992; Gee et al., 1996). Measurements of geomagnetic field relative paleointensity in sediment cores has also revealed consistent variations for the recent period (e.g., Roberts et al., 1997) and has raised the strongly debated question of the "saw tooth pattern" of the field intensity (e.g., Valet and Meynadier, 1993; Kok and Tauxe, 1996). A good knowledge of the field behavior, both within a given polarity period and in terms of time distribution of the polarity reversals, is essential to investigate the mechanisms of the geodynamo and the dynamics of the Earth core (e.g. Gallet and Courtillot, 1995). For mid-ocean ridge investigators, better constraints on the fine-scale evolution of the geomagnetic field will allow more accurate and unambiguous ages of the seafloor (see, for example, Dyment, 1998), although a limitation may arise from the ability of the oceanic crust to preserve the record of the fine geomagnetic fluctuations.

Surface magnetic anomalies lack the resolution required to unambiguously discriminate the origin of the tiny wiggles, i.e. short polarity reversals or intensity fluctuations, and to obtain a detailed record of the geomagnetic variations. A better resolution can only be achieved by getting measurements closer to the seafloor, using a deep-tow magnetometer. A major objective of the Magofond program is to test the practicality of this approach and to evaluate the potential of such deep-tow magnetic studies for geomagnetic studies. For the sake of comparison with relative paleointen-sity records obtained from sediments, the period investigated spans the last three millions years, i.e. the profiles are collected at a mid-ocean ridge. Another advantage of such a choice is to allow the collection of conjugate profiles and therefore the identification of tectonic complexities unrelated to geomagnetic fluctuations. As for the selection of a target area, a faster spreading rate would insure a better resolution, a slower spreading rate a longer time interval surveyed for the available ship time. In addition, previous works on surface magnetic anomalies suggest that the magnetic structure of the oceanic crust is more complex at a slow/cold spreading center than at a fast/hot one (e.g., Dyment and Arkani-Hamed, 1995; Dyment et al., 1997; Dyment and Fulop, 1997). Despite a relatively slow (full) rate of 45 km/m.y., the part of the CIR located between 18 and 20°S is characterized by a low roughness both on the few available bathymetric profiles and on gravity anomaly maps derived from satellite altimetry (Sandwell and Smith, 1995), typical of oceanic crust formed at a hot, magmatic spreading center. Three deep-tow profiles have been run across the CIR in this area up to about 3 Ma on both flanks, providing six records of the geomagnetic history for the last three millions years.

Fig. 2 shows surface and deep-tow magnetic data collected on Deep Tow Profile 5, which crossed the CIR axis at 19°10'S. The raw magnetic measurements have been reduced for the provisional IGRF model. No correction has been made for the varying altitude of the instrument, the topographic effect, the inclinations of both geomagnetic field and magnetization vectors (which result in the skewness of the anomalies), or time variations such as the diurnal solar quiet variation. Despite these effects, to be corrected in future works, and considering a high on one flank to be matched with a low on the other flank to account for the skewness of the anomalies, a good correlation is observed between both major anomalies and tiny wiggles on conjugate flanks, as suggested by lines connecting various features of the Brunhes anomaly. The best resolution for these conjugate features is 50-100 k.y. for the altitude of 300 m. The Cobb Mountain event is observed on both flanks in the surface and deep-tow data, the Reunion event is well-marked on the northeastern flank and is more subdued on the southwestern one. Spreading is clearly asymmetrical during the Brunhes and Matuyama periods on this profile, with 45% of the crust formed on the African plate and 55% on the Indian plate, but this asymmetry does not affect the correspondence observed between conjugate magnetic features. The data collected on Deep Tow Profiles 3 and 4 are very similar to those of Fig. 2. These data await further processing in order to be compared to relative paleointensity records deduced from the analysis of sediment cores.

Additional deep-tow magnetic data were collected during the Magofond 2. The short Deep Tow Profile 6 surveyed anomalies 4A, 5 and 5A about 1000 m above the seafloor on the African plate. It shows tiny wiggles consistent with those described by Blakely (1974) and, more recently, by Cande et al. (1995) from data collected in the Pacific Ocean off North America, suggesting that global geomagnetic events were responsible for these tiny wiggles. The long Deep Tow Profile 1-2 cut across the Mauritius Fossil Ridge (MFR) and surveyed conjugate anomalies 22 reversed to 20 reversed about 1000 m above the seafloor. No definitive evidence has been found on the unprocessed data for a short normal event within anomaly 22 reversed, as suggested by Patriat (1987) from the observation of a clear tiny wiggle within this anomaly.

Structure and magnetic properties of the oceanic crust

The classical view of rectangular prisms bearing constant magnetization has given place to more complex models, including a geometry of the extrusive basalt layer which results from spreading and lava flow piling (e.g., Kidd, 1977; Macdonald et al., 1983; Tivey, 1996), deeper magnetized layers gently sloping away from the ridge (e.g., Kidd, 1977; Cande and Kent, 1978; Arkani-Hamed, 1989; Dyment et al., 1997), magnetization intensity varying with iron content and fractionation at regional and segment scale, or with alteration at faulted areas or hydrothermal sites (e.g. Hussenoeder et al., 1996; Tivey, 1996). The collection of magnetic data at the sea surface and near the seafloor can help to resolve the structure and magnetic properties of the oceanic crust.

The anomalous skewness of surface magnetic anomalies decreases with spreading rate, from a negligible value above 50 km/m.y. (half rate) to as much as 40° at about 10 km/m.y. (Dyment et al., 1994). This observation suggests that the source of the anomalies is almost exclusively made of a thick layer of iron rich, strongly magnetized extrusive basalt for fast-spreading centers. Conversely, a deeper magnetic layer, possibly made of partly serpentinized lower crustal rocks, would increasingly contribute to the anomalies as the extrusive basalt gets thinner, more pervasively altered, and less magnetized with decreasing spreading rate (Dyment and Arkani-Hamed, 1995; Dyment et al., 1997). In order to test this model and investigate the relative contribution of the shallower and deeper magnetized layers at different spreading rates, a long deep tow magnetic profile has been navigated across the MFR between conjugate anomalies 23 (young side, 51 Ma) and anomaly 20 reversed (43 Ma), which marks the end of spreading activity. The advantage of such a fossil ridge is twofold: the proximity of conjugate anomalies makes the anomalous skewness easier to evaluate, and the progressive decrease of spreading rate allows to investigate the effect of this parameter. Magnetic measurements at the sea surface, 4000 m above the seafloor, detect with four times more intensity a magnetized source located in the extrusive basalt layer than the same source in the lower crust; this ratio increases to twenty for deep-tow magnetic measurements made 1000 m above the seafloor. The joint analysis of surface and deep-tow data (after altitude and topography corrections, see above) for both skewness and amplitude should provide better constraints on the relative contribution of shallower and deeper magnetized layers, and therefore on the source of marine magnetic anomalies at different spreading rates. Preliminary results indicate is a sharp decrease in the anomaly amplitude at anomaly 21r, which corresponds to spreading rates falling from 40 to 20 km/m.y. and a rapid transition between smooth and rough bathymetry (Fig. 3). A similar observation has been obtained from a systematic analysis of anomaly 25 in the world's ocean basins (Dyment and Fulop, 1997), with a clear separation of low and high anomaly amplitudes at a spreading rate of 30 km/Ma. This threshold, which roughly corresponds to the morphological transition between axial valleys and axial domes, may reflect changes in the extrusive layer

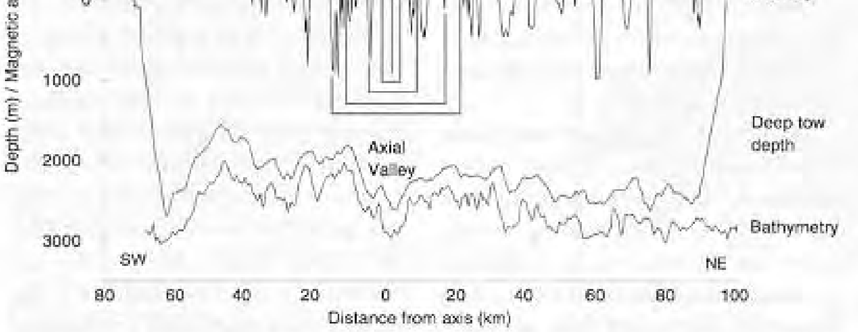

Figure 2: Surface and deep tow magnetic anomalies, deep tow depth and bathymetry across the Central Indian Ridge at 19°10'S. Normal (reversed) magnetic polarity intervals are shown in black (white), with J: Jaramillo, O: Olduvai; possible short events marked by tiny wiggles are shown by arrows, with R: Reunion, C: Cobb Mountain. Thin lines connect short-wavelength conjugate features inside the Brunhes period.

International Ridge-Crest Research: **Indian Ridges:** Dyment et al. continued...

thickness, in the degree of alteration, or in the iron content of the extrusive basalt.

A drastic change of spreading direction between 45 and 40 Ma

A major reorganization of the Indian Ocean mid-ocean ridge system occurred between 45 and 40 Ma (anomalies 20 to 18) as a possible consequence of the collision of India with Eurasia (e.g., Patriat and Achache, 1984). On the CIR this event is marked by a rapid decrease of spreading rate followed by a 50° clockwise change of spreading direction. In an attempt to understand the detailed evolution of such a large reorganization, we surveyed two key-areas on the African plate southeast of Mauritius (Fig. 4). Data on parts of the conjugate area on the Indian plate have been acquired by our Indian colleagues of the National Institute of Oceanography, Goa, India.

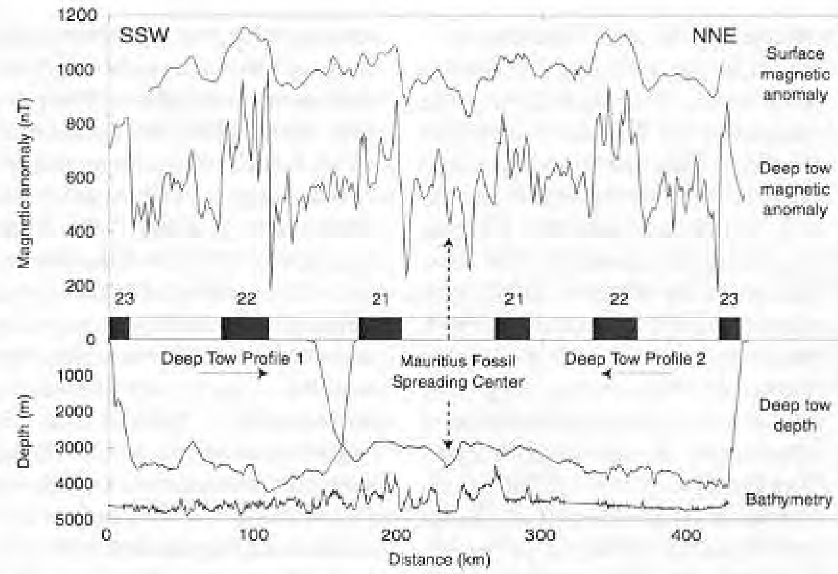

Figure 3: 30° phase-shifted furface and deep tow magnetic anomalies, deep tow depth and bathymetry across the Mauritius Fossil Ridge. Normal (reversed) magnetic polarity intervals are shown in black (white). Note the symmetry of the conjugate flanks and the decreasing anomaly amplitude for anomalies younger than 21 reversed.

The first area is located southeast of the Mauritius Fracture Zone. Prior to anomaly 20 reversed (43 Ma), it was part of a relatively narrow compartment, about 100 km wide, bounded by large offset transform faults. In this area, the reorganization is marked by a sharp decrease of spreading rate at anomaly 21 reversed (48 Ma; see above and Fig. 3), clearly seen in the increasing roughness of the bathymetric fabric (Fig. 4), and the cessation of spreading at anomaly 20 reversed (44 Ma) on a 80 km long section of the CIR, now the MFR, which displays a large and deep axial valley filled with sediments. Deformation, breakup and finally the initiation of a new spreading center occurred along a N30°E lineament, which isolated and transferred a 300 km-long, 80 km-wide sliver of oceanic crust originally formed on the Indian plate to the African plate. The linearity and morphology of this feature as well as its direction may have led some confusion with a fracture zone; this interpretation is however not sustainable, as no conjugate feature exists on the southern flank of the MFR. The N120°E fabric of the older crust, clearly seen on the southeastern part of the transferred crust sliver although it is covered by sediments on most of its extent, is cut across by N170°E deformational features. The "scar" between the old and new oceanic crust is made of a trough, filled by sediments, and a linear, quite continuous ridge, suggesting a strike-slip motion component in the early stage of its evolution. The new oceanic crust displays a complex structure, with at least four irregular alignments of most likely volcanic mounds separated by depressions. These features trend about N50°E and seem to curve southward and tangent the "scar". Our preliminary interpretation considers the mounds as short ridge segments offset by discontinuities (the depressions) to account for the obliquity of the "scar" with respect to the new spreading direction.

Prior to the spreading reorganization, the second area, located further southeast, represented a continuous section of a fast-spreading center, more than 300 km-long, only affected by small offset discontinuities. The decreasing spreading rates are associated with a more segmented bathymetric fabric and a rougher bathymetry, although the change appears more progressive than on the first area. Although the detailed interpretation of the magnetic anomaly is not yet available, the various trends of the bathymetric fabric clearly show that the change of direction is not synchronous. New segments, about 10 to 20° oblique to the previous direction, appears in the vicinity of the fracture zones and propagate at the expense of the older fabric or areas with complex structures, quite similar to the model proposed by Hey et al. (1988). This process is reiterated 3 or 4 times to achieve the 50° total rotation, as seen in the central part of the survey area (Fig. 4). The first-order segmentation is also drastically affected by the reorganization. The major fracture zone system at 22°S, 58°E, named La Boussole FZ by Patriat (1987), is actually made of two nearby fracture zones between anomalies 23 and 21. The southern fracture zone disappears after a 20° rotation of the nearby fabric has been achieved, and the northern one evolves to a second-order discontinuity after 40°. This observation possibly reflects the progressive decrease of the offset across this feature as a result of the ridge segment clockwise reorientation revealed by the bathymetric fabric. At the same time, the coalescence of several oblique discontinuities, which becomes more or less parallel to the spreading direction due to the progressive rotation of this direction, results in the creation of a new N80°E fracture zone. Such a fracture zone may be required by the increasing offset induced by the clockwise reorientation of the segments.

The establishment of a more detailed evolution of these events and its chronology awaits further structural analyses and the integrated analysis of the new and previous surface magnetic anomaly data available in the area.

Ridge-hotspot interaction: the CIR at 19°S

The CIR presents morphological and geophysical evidence of a hotter mantle in the vicinity of Rodrigues Ridge, between the Marie-Celeste and Egeria Fracture Zones (18°S-20°S). Geochemical analyses of the few available samples along the CIR also suggest a narrow corridor where the MORBs are contaminated by hotspot material showing affinities with the Reunion hotspot (Mahoney et al., 1989; Humler, pers. comm.). These inferences are most likely related to the nearby Rodrigues Ridge, an off-axis bathymetric structure which extends continuously from the Mascarene Plateau to the Rodrigues Island area along a roughly N105°E direction and overlays oceanic crust created from 40 to 7 Ma. Samples dredged on the ridge have provided rather uniform ages of 7-9 Ma (Baxter, pers. comm.). Our investigation on the CIR at 19°S, triggered by a favorable setting to collect deep-tow magnetic data, provides an opportunity to study a slow-spreading center (half spreading rate 2.2 km/m.y.) in a hot mantle environment and, more generally, the interaction of this ridge with the hotspot from which the Rodrigues Ridge originated.

We have collected the full bathymetric coverage of a 150 km-long section of the CIR from the ridge axis to anomaly 2A included (4 Ma) on both flanks, with extension to anomaly 3A (7 Ma) in the close vicinity of the Rodrigues Ridge (Fig. 5). The ridge axis is made of a shallow axial valley, with inner floor 3000 m deep and crests 2200 m deep. The

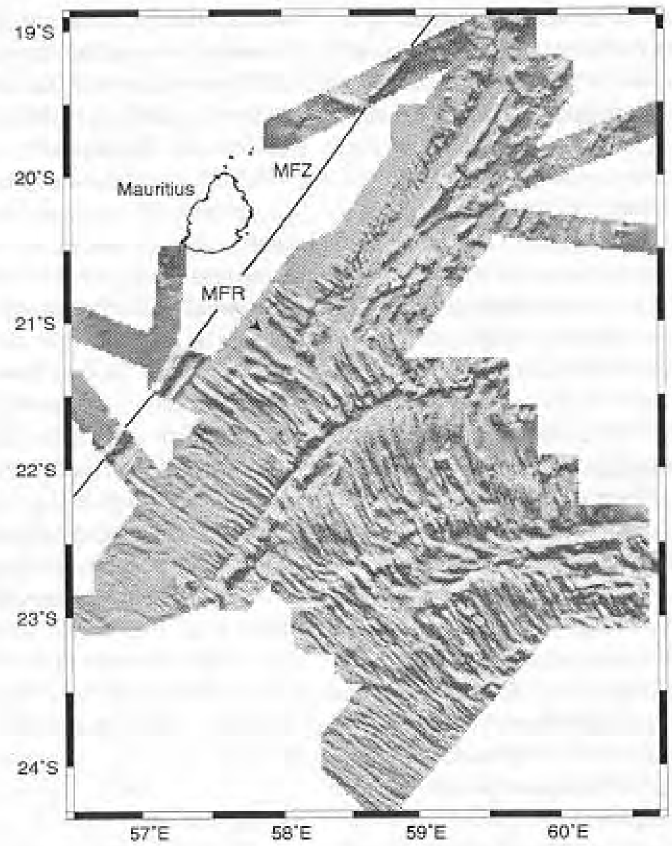

Figure 4: Shaded bathymetry of the Mauritius Fossil Ridge (MFR) and the change of spreading direction, dated 40-45 Ma, in the vicinity of Mauritius and Reunion Islands (illumination from North). MFZ: Mauritius Fracture Zone. See text for details.

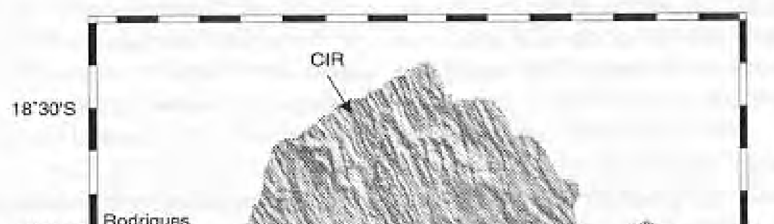

Figure 5: Shaded bathymetry of the Central Indian Ridge (CIR) in the vicinity of the Rodrigues Ridge (illumination from N60°W) from *R/V Marion Dufresne* Magofond 2 cruise and *R/V L'Atalante* Larjaka transit data. Note the shallow axial valley, the continuous abyssal hills, the discontinuity at the northern end of the survey, and the Three Magi and Gasitao Ridges which connect the easternmost end of the Rodrigues Ridge with the CIR axis.

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off-axis abyssal hills are quite regular and monotonous along the survey area, with hills extending continuously on as much as 130 km. The axial valley floor presents a succession of highs and lows at intervals of about 10-20 km, which have previously been interpreted as segment centers and ends (Briais and Sauter, 1998). However, the off-axis bathymetry does not show the corresponding pattern of rhombohedrons bounded by continuous traces of discontinuities as seen, for instance, between neighboring segments on the Mid-Atlantic Ridge (e.g., Gente et al., 1995), suggesting that no stable short-wavelength segmentation exists in most of the survey area. The only continuous discontinuity is observed at the northern end of the survey area and bounds a segment longer than 130 km (its southern limit is outside the survey area). The varying trend of this discontinuity suggests that the segment has been growing between 3.5 and 0.7 Ma and may have recently started to recede. This pattern of segmentation, with long segments and minor, transient discontinuities inside, may reflect a better magma supply and hotter asthenosphere, in contrast with the smaller segments, 80 km long in average, observed on the CIR axis to the north and the south of the survey area (Parson et al., 1993).

One of the most striking discovery of the Magofond 2 is a series of small bathymetric ridges which continues the Rodrigues Ridge eastward up to the CIR on the African flank. Immediately east of the Rodrigues Ridge, three parallel ridges trend about N80°E on oceanic crust 6.5 to 4 Ma old. These ridges, 20-40 km long and 1500 m higher than the neighboring seafloor, have been named "The Three Magi Ridges" to emphasize their linear and parallel appearance, similar to the paths of the Three Wise Men following the Star. Further east, another ridge, parallel to the previous ones and also remarkably linear, lies on oceanic crust 3.5 to 0.5 Ma old and ends on the western crest of the CIR axial valley. This ridge, 50 km long and 700 m higher than the neighboring seafloor, has been named "Gasitao Ridge" in memory of a cyclone encountered in 1988 by the first *R/V Marion Dufresne* a few hundreds nautical miles north of the area. An alignment of volcanic edifices, parallel to the Gasitao Ridge, is observed 30 km northward, on oceanic crust of the same age. Our bathymetric survey shows unambiguously that these features have no conjugate on the Indian plate, which suggests an off-axis formation although the proximity of the axis implies some relationship to be determined. Two successful dredge hauls on the Gasitao and Three Magi Ridges have provided relatively fresh basalt, including glass. These samples will be dated and analyzed to decipher the history of their emplacement (near the ridge axis or on older crust?) and the influence of the ridge and the hotspot on their geochemical composition.

Conclusions

The Magofond 2 cruise has provided a collection of excellent data which, after only a preliminary analysis, lead to the following results:

1) Although this inference awaits further processing to correct for the effects of topography and varying immersion of the magnetometer, our deep-tow magnetic measurements record a coherent signal (as illustrated by the comparison of conjugate profiles, see Fig. 2. which partly reflects time-variations of the geomagnetic field at a scale of 100 k.y.

2) Surface and deep-tow magnetic anomalies across the MFR reveal a strong decrease in the anomaly amplitude at a (half) spreading rate of about 30 km/m.y. which reflects important differences in the thickness, degree of alteration, or iron content of the extrusive basalt between fast- and slow-spreading centers.

3) Our off-axis bathymetric survey of the MFR and the nearby remnants of the 40-45 Ma spreading reorganization reveals the reaction of a spreading center to the remote collision of India with Eurasia and its effect on plate kinematics. In the western area, a ridge section died and a new one was initiated, while in the eastern area, a progressive readjustment ocurred through propagating ridge segments, eliminating a fracture zone and creating a new one.

4) The CIR at 19°S is a slow and hot spreading center, with morphological, geophysical and geochemical characters contrasting with those observed elsewhere on the CIR. Despite the unclear origin of the Rodrigues Ridge, ridge-hotspot interaction still exists in this area, as suggested by the newly discovered Three Magi and Gasitao Ridges which continue the Rodrigues Ridge eastward up to the CIR axis.

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International Ridge-Crest Research: **Arctic Ridges**

Mapping the Gakkel Ridge: SCICEX 98 achievements and plans for SCICEX 99 on the *USS Hawkbill*

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Since 1995 the US Navy has provided a Sturgeon-class fast attack submarine for an annual unclassified scientific cruise in the Arctic Ocean. The SCICEX program has utilized the mobility of the submarine, which is independent of surface conditions, to explore this largely unknown ocean basin. Designed to be quiet and stable, the submarine provides an ideal platform for the efficient acquisition of underway sonar data, particularly swath mapping and sub-bottom profiler data. Due to the constraints imposed by the circulating ice pack, this information cannot be efficiently collected by any other means in the Arctic.

In 1996, the Arctic Natural Sciences Program of the National Science Foundation, with support from the Palisades Geophysical Institute, the Geological Survey of Canada and Lamont-Doherty Earth Observatory (LDEO), funded the fabrication of a unique set of active sonar instruments for future SCICEX missions. The Seafloor Characterization and Mapping Pods (SCAMP) includes an Arctic optimized SeaMARC™-type Sidescan Swath Bathymetric Sonar (SSBS), a swept frequency ("chirp") High Resolution Sub-bottom Profiler (HRSP), a Bell BGM-3 gravimeter and a Data Acquisition and Quality Control System (DAQCS). SCAMP is an integrated geophysical data acquisition system for underway mapping of the seafloor derived from proven technologies, optimized for under hull operation on a submarine in ice covered waters. SCAMP was installed and tested on the *USS Hawkbill* for SCICEX 98.

The Gakkel Ridge is the slowest spreading section of the global mid-ocean ridge system (total rates of 0.6-1.3 cm/yr), and is an important end-member for the study of magmatic and tectonic processes at ridge. It may be a unique hydrothermal and biological environment as well. Although the development of the Eurasian basin is well-understood in the context of global plate tectonics, we know very little about the morphology, structure, magmatism, petrology or distribution of sediments on the Gakkel Ridge. We have no information on the existence or distribution of magmatic activity, hydrothermal vents or benthic vent communities. To remedy this situation, one of the primary

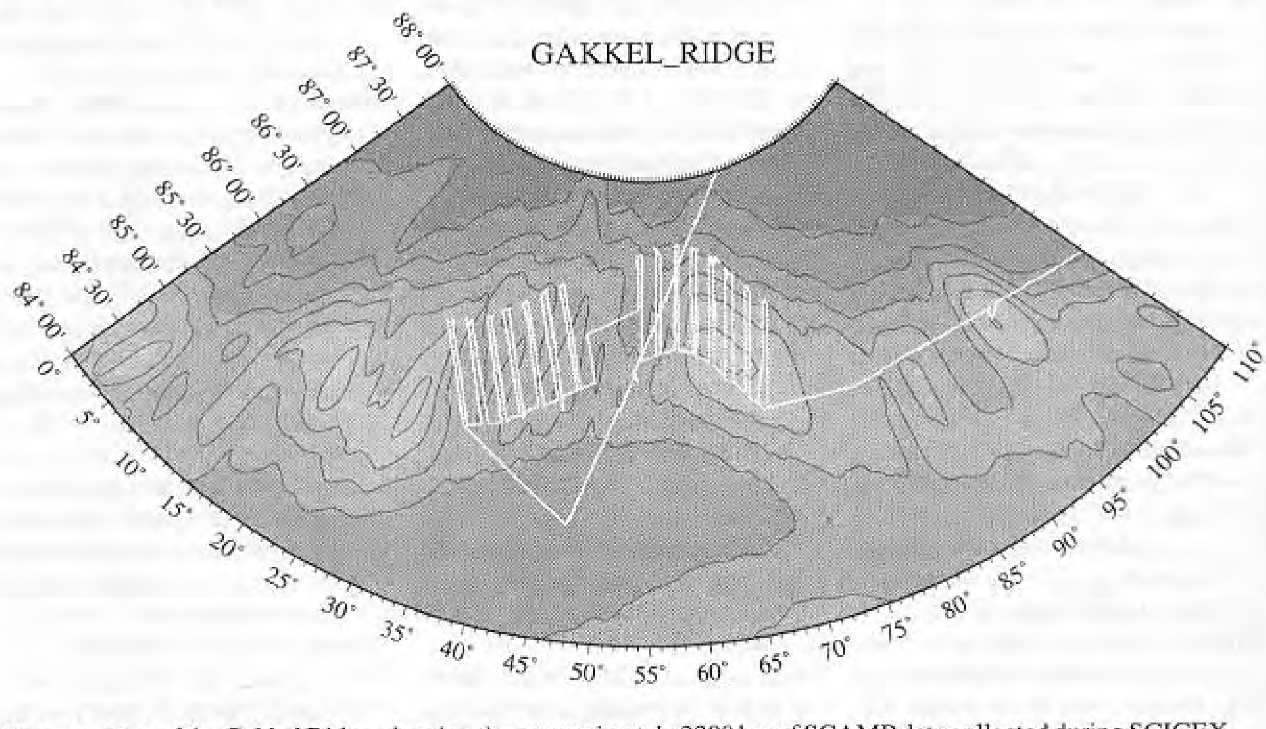

Figure 1. Map of the Gakkel Ridge, showing the approximately 3300 km of SCAMP data collected during SCICEX 96 on the *USS Pogy*. The contour interval is 250 m.

objectives for SCICEX 98 and 99 has been SSBS mapping of the Gakkel Ridge.

Building on work that was done during SCICEX 96 from the *USS Pogy* (Coakley and Cochran, 1998), approximately 3300 track km of data were collected along axis of the Gakkel Ridge during SCICEX 1998 (Fig. 1) using SCAMP. Two segments of the ridge, totaling about 250 km in length, were mapped out to 50 km on either side of the axis (approximately anomaly 5). One segment from this data set, showing roughly 120 km of data along the axis was shown at Fall 98 AGU (Chayes et al., 1998) and reproduced on the back cover of the recent InterRidge report on the meeting of the Gakkel Ridge working group (Wilson, 1998). In this data, the pattern observed in the 1996 narrow-beam profile data (Coakley and Cochran, 1998) is evident. The ridge axis is quite deep, more than 5000 meters in some locations and segmented by inter-axial highs. The flanks are characterized by a blocky morphology with high relief. There may be persistent asymmetry across the axial zone, but there are no obvious transform offsets.

This quality of the data, collected during the first deployment of the SSBS, is encouraging. Additional processing is underway at the University of Hawaii to elimnate artifacts in the grid shown last fall.

There were also some problems with the SSBS hardware during SCICEX 98, which prevented acquisition of the starboard-side data and may have diminished the quality of the port side data as well. Dale Chayes from LDEO spent much of early January working on these problems, identifying the primary cause as flooding in four of the 10 sub-arrays that make up the transducer arrays of the SSBS. Repositioning two of the failed sub-arrays into the fore and aft positions in the transducer pod to maintain the weight distribution and pod fairing results in a slight reduction in transmit power and along-track resolution, compared to the design specifications for the SSBS. Data collected off Hawaii during a recent shake-down cruise demonstrate that the repair of the SSBS was successful. We expect to have very good swath bathymetry and backscatter data to complement the excellent gravity anomaly and HRSP data that will be collected again this year.

The SCICEX 99 cruise, again on the *USS Hawkbill*, will sail on March 15, 1999 from Pearl Harbor for approximately 40 days of oceanographic and geophysical data acquisition in the deep Arctic Basin. Margo Edwards will be chief scientist. During SCICEX 1999 cruise, we plan to sail along the axis of the Gakkel Ridge east to the edge of the SCICEX operational area to image the youngest seafloor formed at the slowest spreading rates in the submarine's operational area. We also plan to complete the mapping begun during SCICEX 98 further to the west along the ridge axis. This will result in complete coverage of the axial zone in the operational area as well as roughly 600 km of continuous swath mapping data along the faster spreading portions of the ridge to 50 km on either side of the axis. This data will help answer questions about seafloor spreading (Coakley and Cochran, 1998) and magmatism (Reid and Jackson, 1981) at ultra-slow rates as well as providing the basis for planning a proposed cruise for geophysics and seafloor sampling on the German icebreaker *Polarstern* in 2001.

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International Ridge-Crest Research: **Scotia Ridge**

JR39b: Deep-towed Sonar and Seismic Survey on the East Scotia Ridge

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The deep-towed sonar, TOBI (Flewellen et al., 1993), incorporating 30 kHz sidescan and phase bathymetry subsystems, was deployed on two segments of the East Scotia Ridge, an intermediate-rate (65-70 km/Ma) spreading centre behind the South Sandwich Arc (Fig. 1), during a 28-day leg by *RRS James Clark Ross* in February and March 1999. The two segments lie at the northern and southern extremities of the ridge, and are both anomalously shallow in comparison with the intervening segments.

The entire ridge, including all Brunhes age crust, was mapped in 1995, using the HAWAII-MR1 shallow-towed sonar. That work showed that the ridge consists of nine principal segments (E1 - E9) separated by non-transform offsets (Fig. 2). Since then, further investigations, including high-resolution rock sampling and deep-crustal seismic studies, have been carried out, confirming a view of the ridge involving enhanced mantle melting towards the ends of the ridge, perhaps resulting from influx of South Atlantic mantle. Spreading rates, at 65-70 km/Ma, are close to that at which a transition from rifted valley to volcanic ridge morphology occurs on ridges elsewhere, so that the ridge is particularly sensitive to small changes in magma supply.

Mermaid's Purse

Segment E2 is propagating southward at the expense of E3, and varies in its morphology, from a shallow median valley at a depth of 4000 m near the propagator tip, to a narrow, steep-sided topographic high at approximately 2650 m near its centre. Beneath this feature, known as the 'Mermaid's Purse' an axial magma chamber (AMC) reflector was observed by seismic profiling in 1995 and 1997, (Livermore et al., 1997). This segment, and its southern counterpart E9, were the targets for deep-towed sonar mapping and hydrothermal plume detection this year, the latter following the methodology of German et al. (1996, 1998) using the Southampton Oceanography Centre's newly developed optical backscatter sensor string which was suspended beneath the TOBI deep-tow sidescan vehicle.

The new sonar data (Fig. 3) reveal a rough seafloor texture at the summit of the mermaid's purse, flanked by the much smoother texture of flows on the ridge flanks. The image was ground-truthed using the SHRIMP deep-sea camera system, confirming the presence of extensive undeformed and unsedimented pillows.

The biggest surprise was the form of the axial high, which, to the north and south of the Mermaid's Purse, was bounded on its western and eastern flanks by steep, narrow and rugged ridges, rising in places to 2300 m, some 300 m shallower than expected from previous mapping. Its extremely rugged nature can be divined from the long shadows cast on the TOBI sonograph. Numerous fissures extend

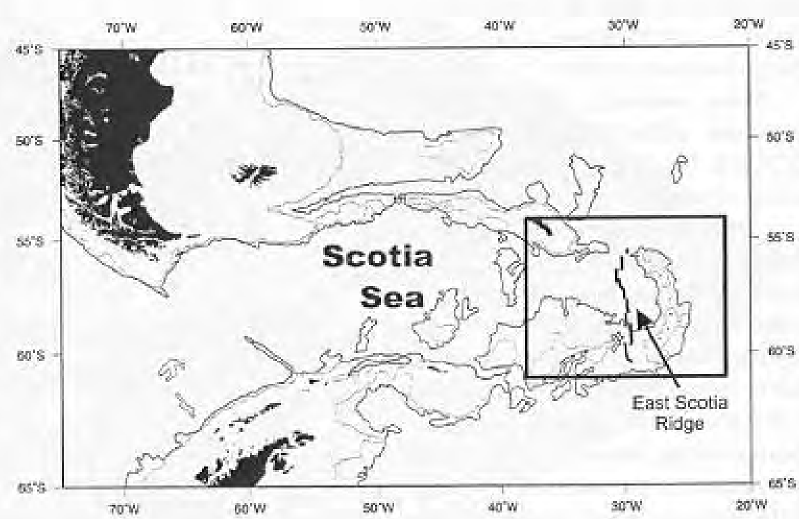

Figure 1. Location of the East Scotia Ridge in the South Atlantic.

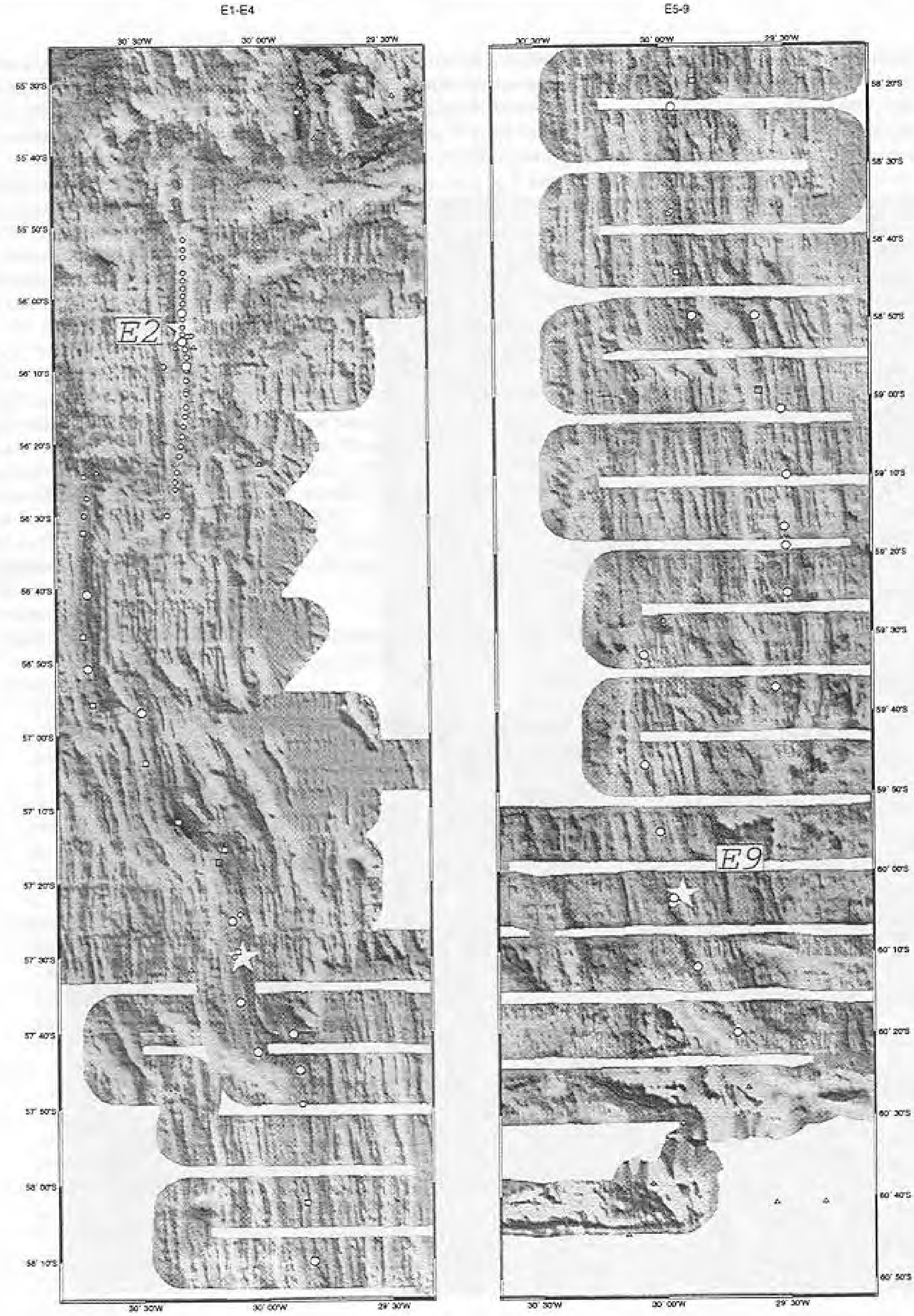

Figure 2. HAWAII-MR1 bathymetry of the East Scotia Ridge, showing wax core sites (large circles) occupied during cruise JR39b; stars indicate approximate locations of hydrothermal plumes detected using PMEL MAPRs (see text).

International Ridge-Crest Research: **Scotia Ridge:** Livermore et al. continued...

northward and southward from the summit, within narrow (3-4 km) summit grabens. More than twenty new volcanoes were imaged during the survey, several of them over 1 km in diameter. All were isolated, conical edifices lying on crust formed during the Brunhes epoch.

Segment E9

Segment E9 shows a high degree of curvature in plan view, and has a shallow median valley throughout its length. However, a pronounced, smooth-topped, axial high in its central section attests to a higher than average magma supply. Although previous seismic profiling revealed no crustal AMC reflection, the existence of a summit caldera was suspected. This was imaged by TOBI (Fig. 4), which showed a sub-circular, steep-sided collapse feature, 280 m deep, atop the smooth, low-backscattering sea floor of the axial ridge. Linear and persistent fissures emerge from the summit caldera, extending for 5 km or more to both north and south. Comparable caldera collapse features have been observed on Iceland (e.g. Sigurdsson and Sparks, 1978) and Hawaii (e.g. Ryan et al., 1983), following magma withdrawal.

Hydrothermal Plumes

Optical back-scatter data from the TOBI sensor string has revealed evidence for hydrothermal activity in the form of particle-laden mid-water plumes overlying the centres of both segment E2 and segment E9. In addition, evidence for a third plume was obtained in the centre of the E5 segment from a series of MAPR (miniature autonomous plume recorder; Baker and Milburn, 1997) deployments. The locations of the three sites are shown schematically in Fig.2.

Wide-angle Seismic Investigations

Ocean bottom hydrophones, supplied by GEOMAR, were used to record wide-angle P-wave arrivals from beneath the mermaid's purse (Fig. 2). Two lines were shot, one along and one across the axis of E2, using an eleven-airgun source with a total capacity of 7330 cu in. Initial results show clear crustal arrivals to an offset of 35 km. Stations on the ridge axis show attenuated arrivals suggesting the existence of a low velocity zone.

Rock Sampling

During the cruise, the opportunity was taken to sample most ridge segments, some for the first time, using a wax corer. Fresh glassy material was obtained at 28 sites from E2 to E9 (Fig. 2) which, when combined with previous sampling by the British Antarctic Survey and the University of Kiel, provides complete coverage of the East Scotia Ridge. Particular attention was paid to the axial highs at the centres of segments E8 and E9.

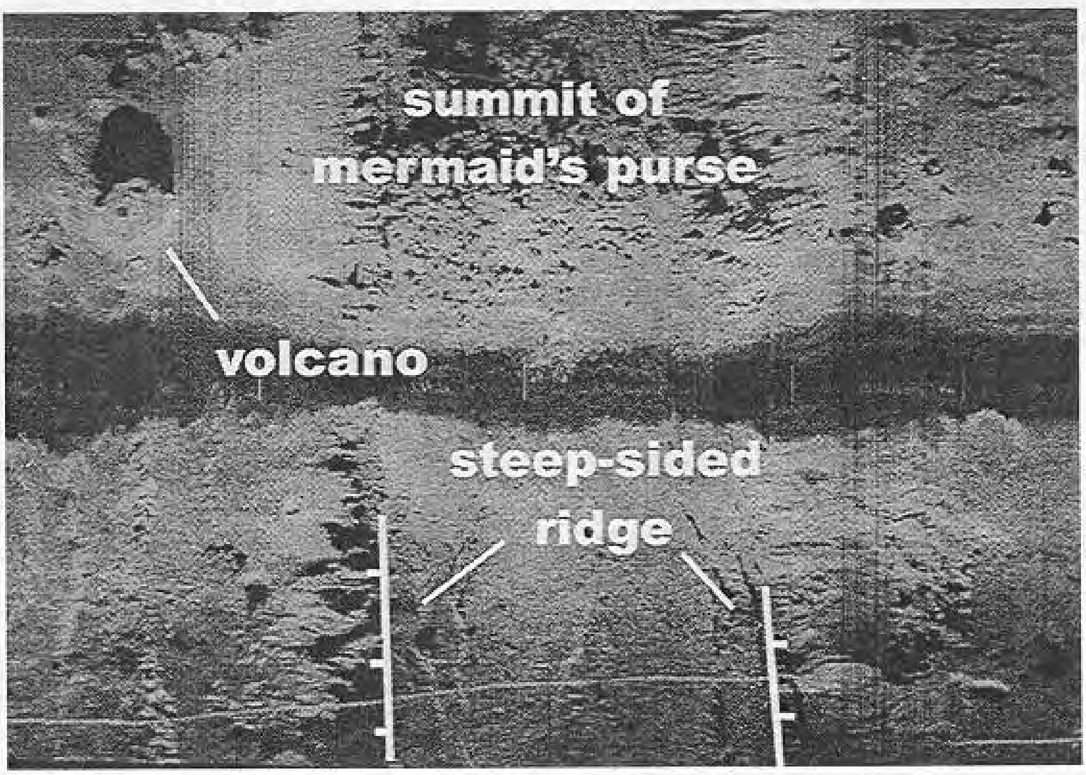

Figure 3. TOBI sidescan image of the Mermaid's Purse on segment E2.

Previous high-density sampling on segment E2 showed a clear relationship between depth and trace element geochemistry (Leat et al., submitted).

Mantle Inflow Model

These preliminary results seem to confirm that enhanced magmatism occurs towards the ends of the East Scotia Ridge, causing in one case (E9) a partial, and in the other (E2), a total transformation from rifted valley to volcanic ridge morphology. Both segments appear to be propagating into the back-arc region. We are presently testing the hypothesis that these variations may reflect inflow of mantle from beneath the eastward-migrating subducting slab (Livermore et al., 1997).

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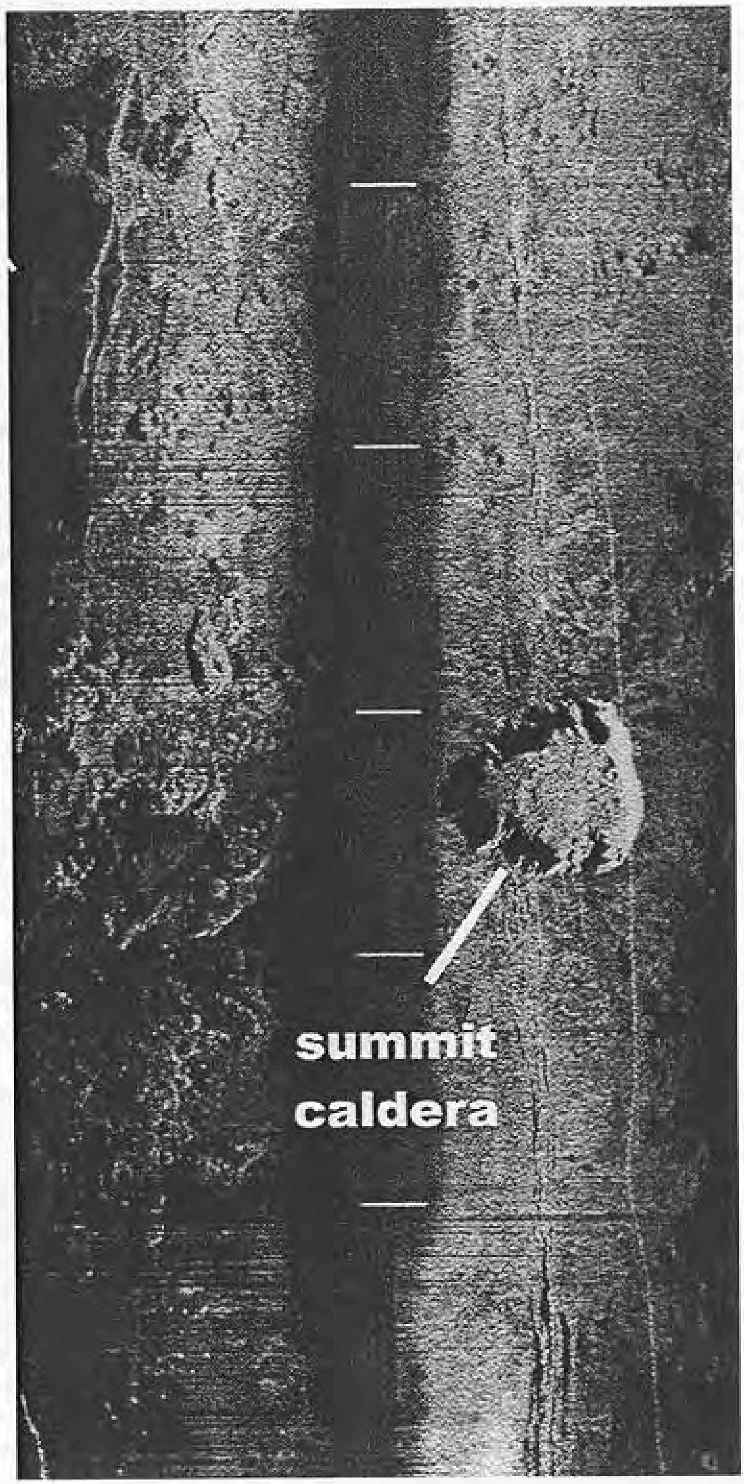

Figure 4. TOBI sidescan image of summit caldera on segment E9.

International Ridge-Crest Research: **Back Arc Basins**

Diffuse Hydrothermal Fluid Activity, Biological Communities, and Mineral Formation in the North Fiji Basin (SW Pacific): Preliminary Results of the *R/V Sonne* Cruise SO-134

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Introduction

The research cruise SO 134 in the North Fiji Basin was part of the HYFIFLUX II project. The objectives of this interdisciplinary, cooperative project are the investigations of the hydrothermal activity in areas of the Central Fiji Ridge (CFR) and the related geochemical fluxes, mineral precipitations and biological characteristics. The investigations of material transport, mineral precipitation (ore formation and zonation) and biological activity, which started during the SO 99-cruise (HYFIFLUX I; Auzende et al., 1995a, 1995b; Halbach et al., 1995a, 1995b) in the North Fiji Basin, were continued and intensified, especially by a well-aimed sampling method for the fluids. Geological and geochemical-mineralogical studies were carried out on mineral precipitates, basaltic rocks (including alterites), sediments and hydrothermal fluids; from the biological point of view, the structure and the interrelationships between the bacterial and zoobenthic communities correspond to the evolutionary stage of the hydrothermal activity.

Each hydrothermal convection cell, in general, may have a diameter in the range of km's. Thus we can expect zonations which, at a certain stage, should exhibit lower temperatures in the outer range (e.g. comparable to the initial stage) and higher temperatures in the central part (corresponding to the main stage of activity). On the seafloor, these conditions are laterally documented by characteristic mineralisations and/or different types of mixed vent fluids. The sampling of non-endmember fluids, especially of low-temperature diffuse outflow is particularly important for the definition of the geo-bio-interfaces. The consideration of the fluid matrix-biota interaction is one crucial objective of the HYFIFLUX II project. Such a project is best carried out in a marine area, where the geology, tectonics, local morphology and hydrothermal phenomena have previously been well studied: this is the case in the North Fiji Basin. The newly discovered SO 99-Field (HYFIFLUX I-cruise), the Père Lachaise-Field, as well as the highly active White Lady- and LHOS-Fields of the CFR are regions with well known geology. The local hydrothermal circulation is linked to the magmatic accretion and extension of the ridge which has divergence rates between 5 and 8 cm per year in the study area. The hydrothermal fields known so far are concentrated south of a triple point.

We investigated geochemical

anomalies (Mn^{2+}, H_2S, CH_4 and further physico-chemical parameters like temperature, pH, Eh and salinity) in the water column and in the near-bottom-water layer and studied their relationship to the local morphology in an area south of the Triple Junction where indications for hydrothermal activity are frequent. The use of the Hydro-Bottom-Station (HBS), our main device for fluid measurements and sampling on this cruise, allowed the step-wise analyses of the suprabenthic water layer (mixing layer, 0-1 m). Together with the benthic biological research, this enables us to model the material transport as well as the mixing and precipitation processes in the study area.

The micro- and macrofauna of the hydrothermally very active region were studied in correlation with the local bottom-water chemistry. Since the geochemical and microbiological studies were carried out on the same fluid samples, these investigations allow the identification of geo-bio-interfaces of the hydrothermal system; one specific aspect is the quantification of the different dissolved sulphur species in relation to primary bioproductivity. An important characteristic of the specific hydrothermal fauna is the formation of bacteria-animal symbioses. Detailed structural and molecular analyses focus on the functional variability of these symbioses under the possible influence of divergent hydrothermal conditions. Community structure of hydrothermal fauna is studied as an indicator of local vent conditions.

Geological Setting

The first study area (area D; Fig. 1) is located on the N-S segment of the Central Fiji Ridge. The fast spreading ridge (8 cm/yr) has the corresponding morphology typical for a volcanic stage with a flat axial elongated dome at a water depth of about 2730 m. Very fresh lava with no or very little sediment cover and often glassy surfaces indicate the young volcanic activity. Tectonisation is not pronounced, and consequently no active or recent high-temperature hydrothermalism was observed; however, the observed low-temperature mineral precipitates of yellowish to brownish colour are due to lava cooling processes.

Most of the sampling and measuring programme, however, was carried out in area A (Fig. 1) This study region lies farther to the north in the N15° segment, where intense tectonisation and various types of recent and subrecent hydrothermal activity exist. With a spreading rate of about 6 cm/yr this segment consists of a volcanic dome which in the north, i.e. in the study area, is subdivided into a 1980 m deep and 2 km wide axial valley and into two bordering neovolcanic ridges which rise about 100 m higher; in the southern part the floor of the graben reaches 2200 m water depth, and the ridges there have an elevation of 2075 m.

Tectonic activity increases from the south to the north, most lineaments are horst and graben structures aligned parallel to the main strike of N15°, but close to the nodal basin which defines the northernmost part of the N15° segment where it meets with the N160° axis and the North Fiji Fracture Zone in a triple junction, the strike of the faults becomes more diffuse.

In addition to fossil chimneys, there are several types of active vents in the axial zone of the N15° segment. A high-temperature fluid vents out of sulphate chimneys (White Lady) with temperatures up to 290°C, but with a salinity of only half that of seawater. At other sites there is diffuse outflow of low-temperature venting, some with precipitation of iron-silicate minerals without any biological activity, and others without recent mineral precipitation but with high bioproductivity. In a southern extension of the LHOS Field we found several small sites and one larger site (which we called 'Mussel Hill' (Fig. 2) because of its high abundance of biological activity with up to 300 individuals of mussels and snails per m^2, and white bacteria and silica mats covering the substrate as well as the shells of snails and clams) with intense low-temperature hydrothermal activity. These sites are concentrated in the western part of the rift graben on highly fractured basaltic mounds which rise 1-2 m above the sea floor, having a width of 2-3 m and are often elongated to a range up to 10 m length.

Another stage of tectonic defor-

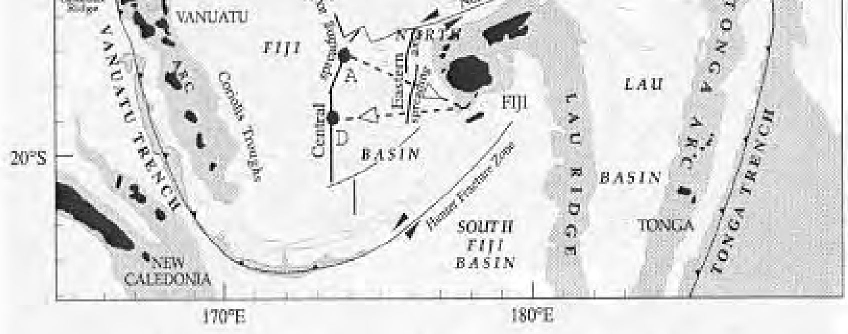

Figure 1. Map showing the course of the SO 134 cruise and the locations of the investigated areas A and D.

International Ridge-Crest Research: **Back Arc Basins:** Halbach et al. continued...

mation with opening of cracks was also observed in the form of young fissures in the seafloor with a width between several cm and several dm (Fig. 4). Sometimes clams were settled on the edges and within these fissures, indicating that venting of reduced fluid has already started. However, the main activity of diffuse venting takes place within the much more fractured basaltic mounds which seem to be young basaltic extrusions through older fractures.

Preliminary Results

Aspects of the HBS deployment

Since the currently used water sampling and measurement systems do not allow precisely controlled water sampling directly from hydrothermal emanation sites, we have developed a technical system for sampling and monitoring low-to-medium temperature fluids from diffuse emanation sites: the Hydro-Bottom-Station (HBS, Fig. 3). The system consists of six main components: an instrument cage/frame, an adjustable fluid sampling system with PTE-sampling bags, adaptation system for sampling of hydrothermal sediments (geolance), a multi-functional sensor system (pH, Eh, O_2, CO_2, temperature, conductivity, pressure), an online data transmission system for coaxial and optical cables, and an online black and white as well as colour video-camera system (Halbach and shipboard scientific party, 1998). The most important component of the HBS is the mobile hydrolance which can be lowered to the seafloor in cm steps after video-controlled positioning of the device. It can also take samples from some decimetres below the seafloor within cracks, soft sediments or below animal beds (Fig. 4 and 5).

The HBS was successfully deployed in the North Fiji Basin during the cruise SO 134 with the German research vessel *R/V Sonne*. The precise measurement of local conditions over a significant time interval was made by deploying the hydrolance through the mussel or snail beds. Used in this way it was possible for the first time to sample hydrothermal fluids

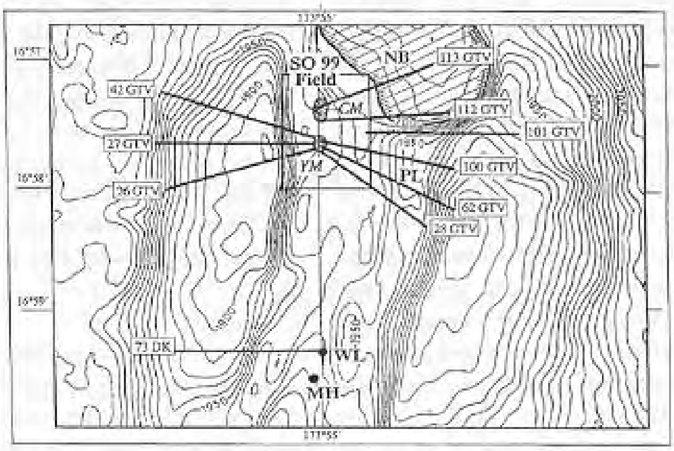

Figure 2. Bathymetric map of area A (SO 99 field) in the northern part of the Central Fiji Ridge with the massive sulphide sample locations. NB = Nodal Basin, CM = Corner Mound, YM = Yogi Mound, PL = Père Lachaise, WL = White Lady, MH = Mussel Hill.

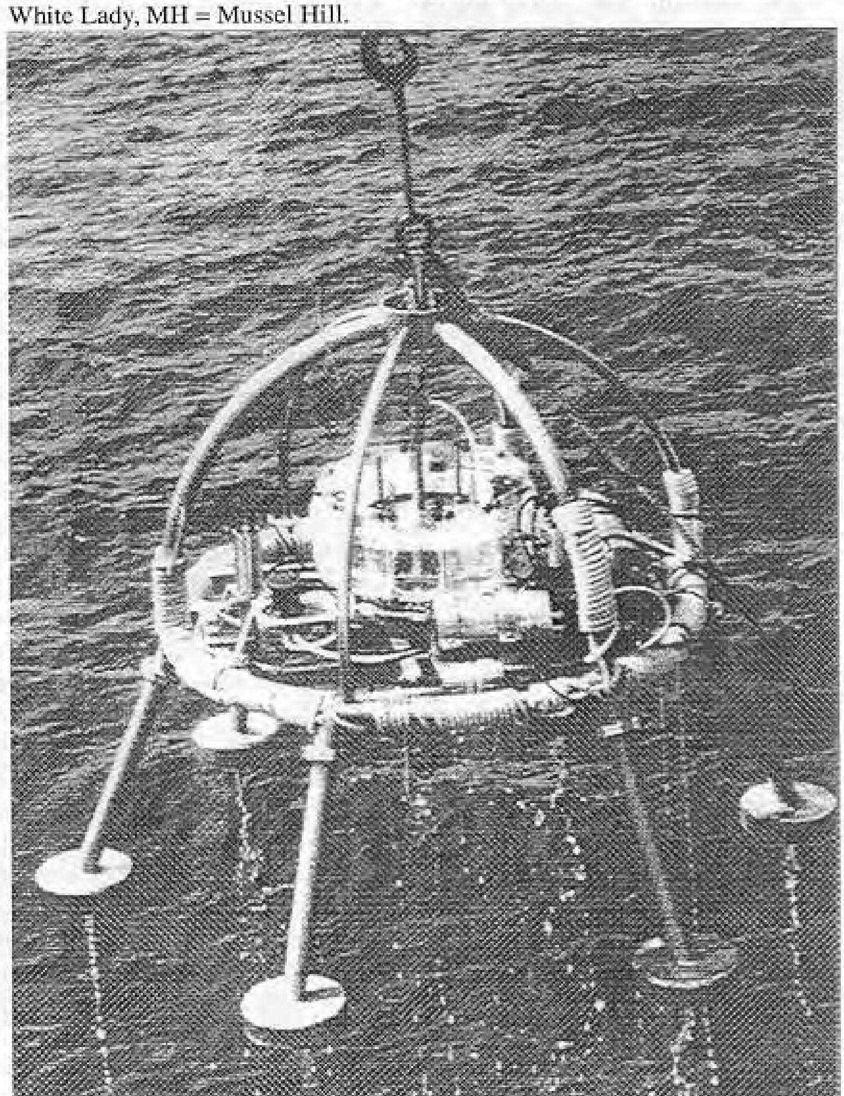

Figure 3: Hydro-Bottom-Station; see text for technical details.

before they were used by the local benthic fauna. We also observed that the diffuse emanations discharge in pulses at intervals of several minutes.

Water chemistry

Most water samples were taken in area A (Figs. 1, 2) using a rosette water sampler with a CTD and the HBS. While the rosette water sampler was used to take profiles in the water column down to about 1 m above the seafloor, the HBS provided detailed samples from the bottom mixing layer, either in a time series profile, or in a distance profile between 50 cm above the seafloor and 15 cm below the seafloor. The highest temperature anomaly measured with the HBS temperature sensor was about 11°C above the background temperature of 2.2°C. The warm water diffuse outflow is explained by subsurface mixing of hydrothermal endmember fluids with normal seawater. According to our temperature measurements and considering the 350°C hot OBS solution (EPR 21°N; Von Damm et al., 1985) or the hot solutions from the North Fiji area (Ishibashi et al., 1994) as an endmember model fluid we obtain a mixing ratio of 33 parts of seawater with one part of hot fluid. A weak decrease in salinity measured in our warm water samples indicates that after phase separation condensed vapour has possibly also contributed to the non-endmember fluid composition. Over 40 hours of video recording, which will also be evaluated by the biologists, gave indications that the diffuse fluid emission is pulsating in a 2-6 minute rhythm.

Dissolved sulphur species, manganese, silica and methane concentrations of the water samples were determined on board. The sulphur species, sulphide, thiosulphate and sulphite, and Mn were determined by voltammetric methods, silica by a photometric procedure, and methane by gas chromatography (see Halbach and shipboard scientific party, 1998) These typical hydrothermal tracers correlate positively with each other and with the fluid temperature (Fig. 6). Maximum concentrations of 49 μg/l Mn^{2+}, 4 mg/l total S^{2-}, 9.8 mg/l Si and more than 30,000 nl/l methane were measured in the HBS samples. Increasing concentrations of these parameters with decreasing Eh values were observed, with lowest Eh values around -75 mV. Only the logarithmic values of the total S^{2-} concentrations exhibit a linear relationship with Eh, indicating that the reduced sulphur may be the determining factor for the redox potential. Also the ratio of Cr(III) to Cr(VI) species indicated the reducing environment by correlating with the Eh values. Further heavy metals like Zn, Cu, Cd, Pb, Co, Ni, Ti, Tl, V, Mo, and U were determined in our on-shore laboratory. While in the Mn- and methane-rich samples the other heavy metals are not significantly enriched, we found a pronounced heavy metal enrichment in a few water samples with somewhat higher Na, K and Cl concentrations. We regard this as an indication that two types of hydrothermal fluids emanate in the investigated area as a result of subbottom boiling.

Methane enrichment could also be detected in the water column, with maximum values of up to 248 nl/l about 10 m above the seafloor. This methane anomaly obviously originates from a thermal fluid of low salinity, as it correlates with positive temperature and negative salinity anomalies in the CTD profiles. Calculations using a non-saline condensed vapour phase result in a temperature end-member between 322 and 376°C. This is approximately consistent with the theoretical boiling temperature of 360°C at 2000 m water depth for sea water (Bischoff and Rosenbauer, 1984) and supports the idea that the emanating fluids are formed by shallow subbottom boiling. Also the strong segregation of the observed anomalies and the pulse-like outflow of the fluids as observed by the HBS camera and the temperature sensor are in agreement with this argument.

The successful fluid sampling

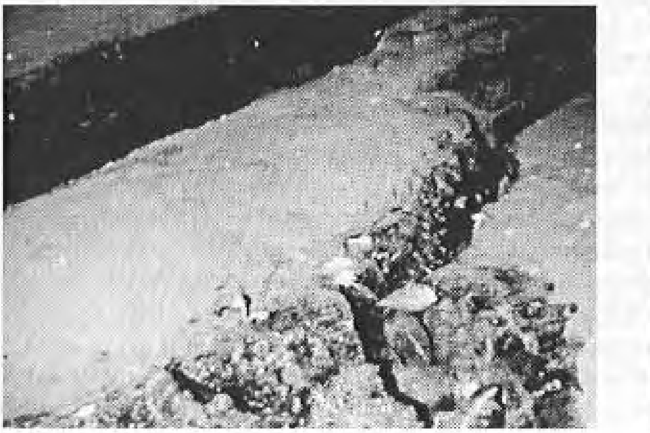

Figure 4. Seafloor photograph taken with HBS showing very young cracks along which hydrothermal fluids are emanating. These emanation sites are populated by hydrothermal fauna.

Figure 5. HBS on the seafloor of the North Fiji Basin. The hydrolance has been pushed through the mussel bed to take fluid samples before they are used by the biology.

combined with the exact *in-situ* observations and measurements could only be carried out using the new system of the HBS. The fluid samples were studied geochemically, and will also be subject to microbiological investigations. For the microbiological research the identification of methanotrophic and sulphur-oxidising bacteria, as well as their contribution to the bioproductivity is of primary importance. High sulphur concentrations in the bottom water correlate with high numbers of living cell numbers of sulphur-oxidising bacteria. The bacteria isolated under autotrophic conditions were slightly enriched in the bottom water compared to higher water layers and showed a different colony morphology. The largest part of the microbiological work still has to be done.

Fauna of Hydrothermal Vents in the North Fiji Basin and Variability in Population Structure and Symbioses

The video and photo inspection showed a rich and diverse fauna which differs from that of the East Pacific Rise. A rich variety of fauna could be retrieved from "biological stations" taken with the TV grab. The mussle *Bathymodiolus brevior* and the *snail Ifremeria nautilei* usually were the dominant components. Also barnacles (Eochionelasmus) and shrimps (Bresiliidae) lived in dense populations right in the efflux of vent water. Small tubes of pogonophoran worms (c.f. Lamellibrachiidae) covered the rocks in dense colonies, numerous species of other polychaetes (Terebellomorpha, Paralvinella) and crabs (Bythograea, Paromola) found shelter in the crevices. Many other rarer components of the fauna remain to be identified.

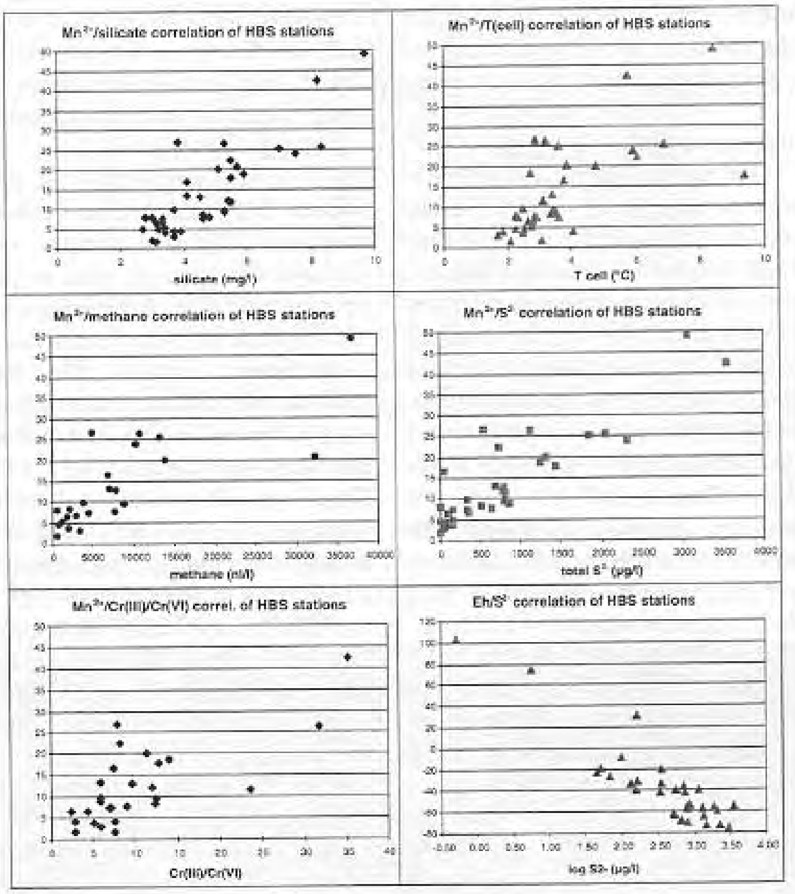

Figure 6. Scatter diagrams showing the relationships of dissolved Mn, methane, sulphide, silica, Cr species, and temperature in the low-temperature hydrothermal fluids sampled with the HBS

On a local scale, from one vent site to the next, there existed considerable differences regarding species composition and population status. Although the population structure of *Bathymodiolus brevior* and *Ifremeria nautilei* from adjacent sites were different they have in common skewed or bimodal size curves. Dead assemblages were found close to settlements of juveniles. This points to variations in the key factor of this ecosystem, the venting of hydrothermal water.

Using these findings we suggest a model based on the impact of water emanation on the fate of populations: Vents are short-lived islands for a rich and specialised animal life. Their fauna largely depends on the duration and activity of the hydrothermal outflow. A young vent is an attractive site for bacteria and subsequently for animals (molluscs) colonising it by larvae. Subsequent development of increasingly diverse assemblages follows pathways largely controlled by the venting activity and the ecological niche width. A weakening or ceasing water flow will reduce recruitment and growth of populations and contribute to the death of the obligate vent animals living in symbiosis with chemoautotrophic bacteria. If supported by further age analyses, size-related population analyses might attain an indicator function for estimating the course of hydrothermal activity on a biological time scale. Covering the short-term time segment, this could represent a valuable tool supplementing the available geological time scales.

Another aspect of variability is reflected in potential differences in the symbiotic pattern of the hydrothermal animals living in obligate symbiosis with chemoautotrophic bacteria. The gill symbionts of *Bathymodiolus brevior* and *Ifremeria* *nautilei* will undergo ultrastructural and molecular biological analyses. Comparison with results from other regions and former cruises (Windoffer and Giere, 1997; Dubilier et al., 1998) will reveal whether there exists a relation between bacterial type and geographical distribution. Also a possible relation between the chemical nature of vent emanations and the symbiotic bacteria metabolising the fluids is the focus of our studies currently in progress.

Basalts and mineral precipitates

The TV-grab stations in area A south of the triple junction allowed us to obtain a representative collection of the volcanic rocks. Throughout the entire area the volcanic rocks are essentially aphyric basalts with fresh glass. They have no phenocrysts, are dense, and of equal grain size. The basalts collected show different geochemical signatures: N-MORB, OIB and less frequent E-MORB (Seifert et al., 1998). Basaltic samples in particular from the eastern zone of the N 15° graben structure are depleted in LIL elements and have low to moderate trace element concentrations, for example, of Sr, Rb, Zr, and Ba, which is characteristic for N-MORB. Basalts from S and SW of the triple junction, where the fields with young chimneys and mound deposits were found, have geochemical signatures with a strong trend to alkali OIB. These basalts are significantly enriched in K_2O, TiO_2, Sr, Rb, Zr, Nb, and Ba. These aphyric basalts are also characterised by degassing channels, indicating their origin from volatile-rich magmas. These OIB-type basalts in area A probably indicate a local hot-spot magmatism. It is possible that the formation of the younger generation massive sulphides is connected to this specific volcanism.

W and NW of Père Lachaise the new SO 99 hydrothermal field was discovered between 16°58´S and 16°57´S (Halbach et al. 1995). It is an elongated field 500 m wide and about 800 m long, representing the western part of the axial graben system (Fig. 2). It contains numerous fossil (older generation) and younger chimney structures (younger generation), some of which are on top of several hydrothermal mounds which are up to 10 m high in places. Young chimneys are often located on the slopes or at the foot areas of the normal fault plains. Relics of the older generation chimneys were occasionally observed at the upper edges of the fault slopes. One remarkable mound deposit was detected during the SO 134 cruise and is located in the NW corner of the SO 99 Field (Corner Mound, Fig. 2) and is about 100 m long and 50 m wide.

Our results show that in the area of the SO 99 Field hydrothermal activity still exists and that the respective chimneys are much younger than the chimneys of the Père Lachaise Field. On the other hand, we also recovered large fragments of strongly oxidised sulphide material from the SO 99 Field, which might have a similar age as the Père Lachaise sulphide chimneys. Thus, we can clearly distinguish between at least two major hydrothermal episodes.

Most of the massive sulphides recovered (more than 2000 kg) were fragments of chimneys and mound structures (pieces of older chimneys already disintegrated and partly oxidised or superimposed by younger hydrothermal processes). Larger fragments (up to 2 m high) show multiple chimney intergrowth with several feeder channels.

The principal sulphide minerals observed were: chalcopyrite, cubanite, bornite, covellite, pyrite, marcasite, sphalerite (with varying Fe contents), wurtzite, greenockite and fahlore. Gangue minerals were anhydrite, barite, and amorphous silica. In general, we can distinguish between 5 types of mineralisations: 1. Fe-rich sulphides ('Kies'-type), 2. Cu-rich sulphides, 3. Zn-rich sulphides, 4. silica-rich Zn sulphides and 5. anhydrite-rich Cu-Fe sulphides. The Fe-rich 'Kies'-type sulphides typically form the outer parts of the chimney structures; these sulphides are dominated by pyrite and marcasite, often replacing each other. The relics of the older generation chimneys from the Yogi mound in particular consist of Cu minerals (chalcopyrite, bornite, and covellite) and recrystallised Fe sulphides (pyrite and marcasite); the corresponding Cu concentrations vary between 17 and 36 %. The Zn-rich sulphides (Zn concentrations vary between 12 and 61 wt. %) show a great variability with respect to the admixed amorphous silica content. Since higher silica concentrations are associated with an increase in precious metal content, we defined an individual type of mineralisation; in one sample we measured 600 ppm Ag and 15 ppm Au, which could be explained with a nugget effect. Nevertheless Ag and Au enrichments in the Zn-sulphides are mostly combined with silica increase. The anhydrite-rich sulphides are particularly abundant in the Corner Mound deposit.

Conclusions and Outlook

The study areas of the North Fiji Basin are characterised by different types of hydrothermal activity. A, the Geological conditions and hydrothermal activity vary according to the position of the different locations, particularly within the N15° segment. Among the active hydrothermal vents, the temperatures of the emanating fluids range from about 280°C (White Lady) to low-temperature emanations of about 14°C (Mussel Hill) and to regions with fluids only some degrees above background (SO 99 Field). Some low-temperature vents are characterised by iron-silicate precipitates, others by high abundance of hydrothermal fauna. Two new hydrothermal mound deposits with chimney fragments of an older massive sulfide generation, which were topped by younger generation chimneys, were found in the W and NW part of area A of the NFB. Five different types of mineralisations could be distinguished on the basis of the major metal composition and on their local occurrence. The older episode of hydrothermal activity probably took place 3 to 4 ky ago and dominated in particular the eastern part of the axial graben. Because of changes in the tectonic deformation, the younger episode of hydrothermalism (younger than 1 ky) migrated to the W and NW section of the graben structure. The mineralisation assemblages within one chimney mound sample show characteristic zonation and replacement structures with the changes in mineral composition caused by fluid variability.

Enough massive sulphide assemblages from different localities and varying types now exist for mineralogical-geochemical evaluation like microscopy, specific trace element analyses, fluid inclusion studies, S- and O_2-isotope studies. Thus we will be able to model the hydrothermal processes in the NFB region from the initial to the final phase, possibly with various cycles, and to determine the origin of the mineral-forming fluids in the different locations.

The grab stations were successful for the biologists and the geologists. Enough material was recovered for the determination and statistical evaluation of specific vent fauna parameters and to identify the origin of the non-endmember diffuse fluids. Biological investigations include the determination of the species-specific age and growth structures from which conclusions can be drawn regarding the local hydrothermal activity variations. DNA-analysis of the symbiontic bacteria will reveal the bacterial species and their respective functions. This in turn will give indications regarding the energy and material transfer from the geochemical to the biological level.

Apart from the 'conventional' systems used on research ships like bathymetric mapping, OFOS observation of the ocean floor, CTD sampling of the water column, piston coring of sediments and TV-grab sampling of hard rocks, we successfully deployed the newly constructed HBS in order to monitor and sample diffuse low-temperature vent fluids at locations with especially high biological activity. Thus, in addition to the above-mentioned data and samples, HBS *in-situ* measurements and about 60 samples of low-temperature fluid profiles as well as more than 40 hours of video recording now exist. Some parameters of the fluid samples were determined on board, but most metal analyses will be done in our onshore laboratories. Enough material exists for an integrated study of the geochemical and microbiological parameters, which will be an important aspect of the analysis of the individual fluid samples.

Analysis of the ash layers and basalt samples will help to identify the surrounding volcanic cycles and to identify the origin of the basaltic seafloor material.

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International Ridge-Crest Research: **Back Arc Basins**

Longitudinal Transect of the Kermadec – Havre Arc – Back-Arc System: Initial Results of *R/V Sonne* Cruise SO-135

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Introduction

Cruise SO-135 of *RV Sonne* completed an extensive mapping and sampling program at selected sites along a longitudinal transect of the active Kermadec arc – Havre back-arc system (SW Pacific), and its southern extension into the offshore Taupo Volcanic Zone (TVZ) of central North Island, New Zealand (Fig. 1). To the north the Lau Basin back-arc, and volcanism of the Tofua arc, are associated with subduction at the Tonga Trench. The *RV Sonne* cruise was a collaborative German – New Zealand project involving a consortium of five German universities, three New Zealand research groups, and other invited researchers. SO-135 was the second of a series of recently completed and/or planned cruises, to this arc – back-arc system. The underlying theme of these cruises is to characterise longitudinal variations of tectonic and magmatic processes along the arc – back-arc system at different crustal settings, and to identify sites of associated hydrothermalism. The cruise (Sept.-Oct. 1998) comprised two legs from Suva-Auckland-Wellington, with the first completing a series of detailed mapping and sampling studies along the Kermadec arc, and central Havre Trough, while the second leg consisted of sampling, including manned JAGO submersible dives at shallow hydrothermal vents of the offshore TVZ.

Geological Setting

The Tonga-Kermadec-Taupo (TKT) arcs, and the ssociated Lau-Havre-Taupo (LHT) back-arc system, form an active, contiguous arc–back-arc system extending over 2000 km between Tonga and New Zealand along the Pacific–Australian convergent margin. The general structure comprises the LHT back-arc, and to a lesser degree the TKT arc, progressing southward through different crustal settings (Parson and Wright, 1996), although collision of seamount chains, and possibly submarine plateaus, into the subduction margin overprint the system along its length. The LHT propagates southwards with spreading oceanic propagation into oceanic crust (central Lau Basin), oceanic propagation into arc crust (southern Lau Basin), rifting within arc crust (Havre Trough), and rifting within continental crust (central North Island, New Zealand).

The continuum of an arc–back-arc system through full oceanic spreading to continental crustal rifting raises a number of fundamental issues including:

(1) What tectonic and magmatic processes are involved in the development of a mature arc spreading back-arc from an immature arc rifting back-arc system?
(2) Do these processes vary spatially and temporally (including longitudinally and across the arc)?
(3) Does proximity to a subduction zone modify the underlying tectonic and magmatic processes?
(4) Does rift and arc magmatism (in-

cluding associated hydrothermalism) vary between continental, arc, and oceanic crustal settings?

Specific sectors of the LHT system are becoming comparatively well-studied. Considerable data exists for the (1) central and southern Lau oceanic spreading ridge propagation (Parson et al., 1990; Wiedicke and Collier, 1993; Parson and Hawkins, 1994) and southern Lau rift (Matsumoto et al., 1997), (2) the northernmost Havre Trough (Matsumoto et al., 1997), and (3) the southernmost Havre Trough (Wright et al., 1996) and onshore Taupo continental rifting segment (Wilson et al., 1995). However, critical gaps along the system are the central Havre Trough – Kermadec Ridge sector (between 28-32°S); and the offshore TVZ. Additionally, the character and distribution of hydrothermalism is poorly established along the Kermadec – Havre sector, although active hydrothermal systems are known at both the northern and southern extensions from the Lau Basin (Fouquet et al., 1991) and TVZ (Hedinquist, 1986). Hydrothermal sites within the Kermadec–Havre sector have been recently discovered at Brothers and Rumble II West arc calderas (Wright et al., 1998), however, it is uncertain whether they are presently active.

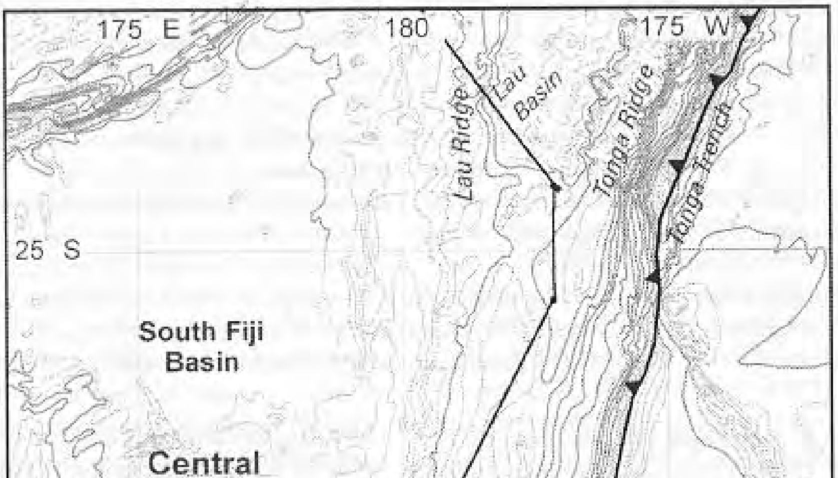

Figure 1. Regional structure (SW Pacific) and the ship track of *RV Sonne* cruise SO-135.

Cruise Objectives

The underlying scientific objectives of SO 135 were to:

(1) Determine the characteristic morphology and volcano-tectonic fabric of back-arc rifting and associated volcanism within the central Havre Trough, including spatial and temporal variations,

(2) Establish the petrogenetic characteristics and relationships of rifting magmatism and arc volcanism, and possible longitudinal variations in magmatism along the modern Kermadec arc front between arc and continental crust,

(3) Locate, quantify, and determine the setting of possible hydrothermalism and active venting along targeted sectors of the Kermadec – Havre arc–back-arc system, and

(4) Further characterize and sample submarine hydrothermal vents within the continental offshore TVZ, near the active White Island arc volcano.

Central Havre Trough Rifting

The central Havre Trough forms an archetypal segment of an arc–back-arc system (Karig, 1970, Taylor and Karner, 1983) comprising the remnant Colville arc, Havre Trough back-arc complex, and the active Kermadec arc and frontal ridge. The latter including the partially emergent island volcanoes of Macauley, Curtis Islands, and Raoul Islands. The back-arc complex consists of a central volcanic basement high, flanked by western and eastern sedimentary sub-basins. Hydrosweep multibeam and magnetic anomaly data, and multichannel seismic (MCS) profiles (145-165 km in length) reveal the back-arc rifting fabric between 30-30°40'S (Fig. 2).

The remnant Colville arc comprises volcanic basement with overlying sequences of volcaniclastic sediments that are down-thrown by a series of listric normal faults to the east. The basal sequences are extensively faulted at depth, and record both the early phases of arc volcanism, and the earliest phases of arc rifting. The border fault zone, between the remnant arc and western sub-basin, has an apparent *en echelon* configuration, generally striking between 019 and 038. Syntectonic volcanism is evinced by volcanic edifices along the fault zone.

The western sedimentary sub-basin consists of a sedimentary sequence (with thickness of 0.4 - 0.8 sec TWT) partially mantling volcanic basement. Out-of-plane seismic reflections and isolated knolls observed within the multi-beam data indicate that the underlying basement has a variable morphology. The basement fabric, where observed, is orientated 041-043. The overlying sedimentary sequence shows basin infilling was dominantly from the west, with little evidence of subsequent extensional faulting.

The central volcanic high has a 12-35 km wide basement block, with minor or no sediment cover, which rises ~200-800 m above the flanking sediment basins. It has a strong linear fabric with bimodal structural trends of 021-031 and 063. Such trends are consistent with other oblique Havre Trough rifting basement fabrics (Caress, 1991; Wright, et al., 1996). The more oblique orientations appear to occur along the eastern margin of the central volcanic block. The eastern sedimentary sub-basin is the main site of present-day extensional faulting, with a pervasively faulted sedimentary sequence of variable thickness of up to at least 1 sec TWT. Faults predominantly dip west, with the larger having seafloor relief and late Quaternary syntectonic deposition on the hanging-wall. In the south, where the basin narrows to a 10 km wide rift, flanking basement horsts have strike orientations of 043-055.

The Kermadec Ridge is interpreted to comprise a basement core of the older proto-Colville-Kermadec arc and associated volcaniclastic sequences possibly 10-5 Ma in age, capped with arc volcanoes of the present-day arc front. The entire volcaniclastic sequence consists of an upper sedimentary section overlying a chaotic sequence of discontinuous reflectors that in part may represent intercalated sequences of old volcaniclastic sediments and true acoustic basement. The lower section may be better imaged following processing of the MCS data. Border faults along the lower western flank, generally orientated 025, are interpreted as a series of low-angle normal faults with seafloor relief of 100-300 m. These faults dip west and show evidence of back-tilting and syntectonic deposition.

Rock samples dredged from across the entire arc–back-arc system comprise mostly highly vesicular, aphyric

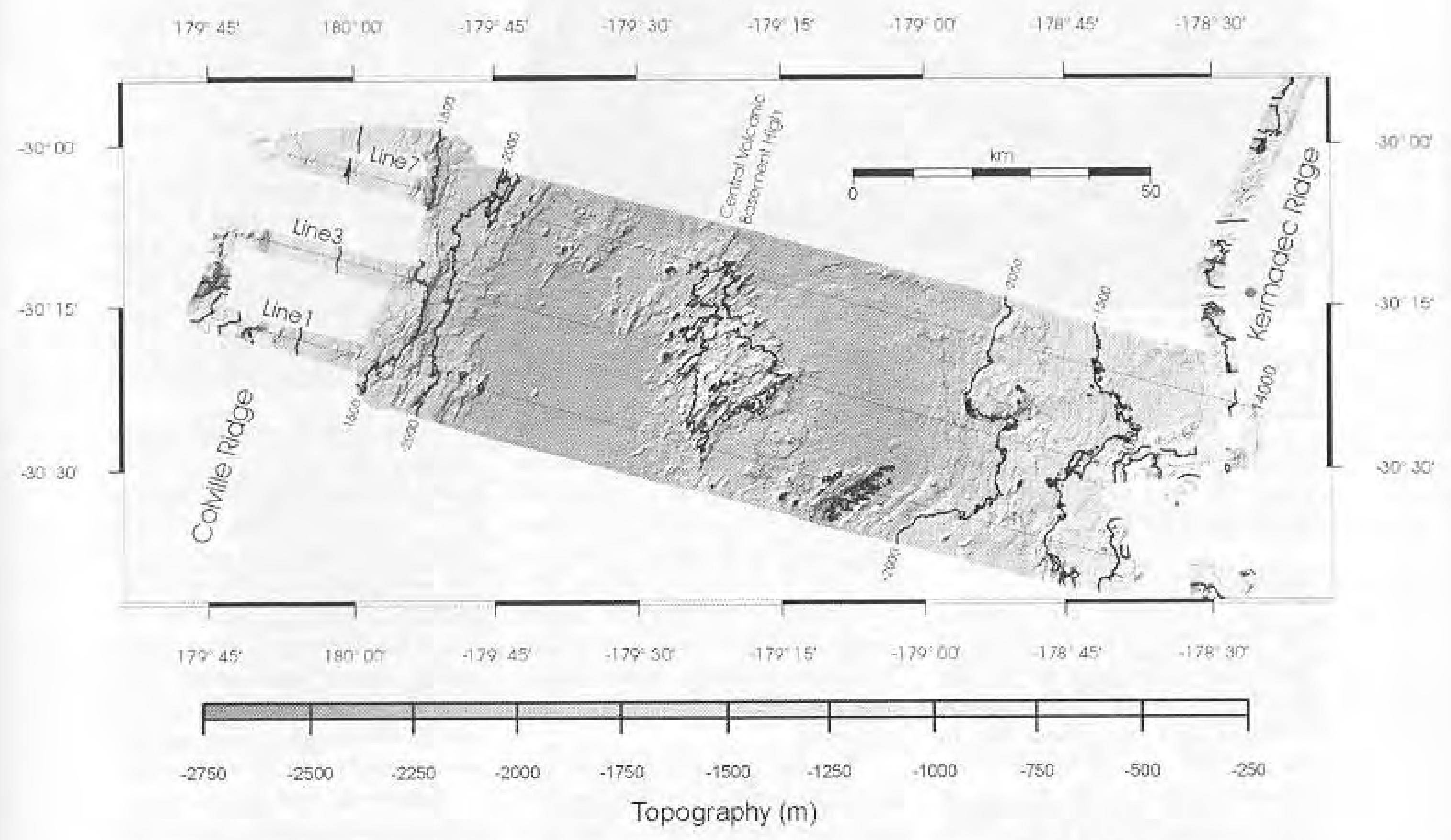

Figure 2. Shaded bathymetry and location of MCS profiles within the central Havre Trough back-arc basin.

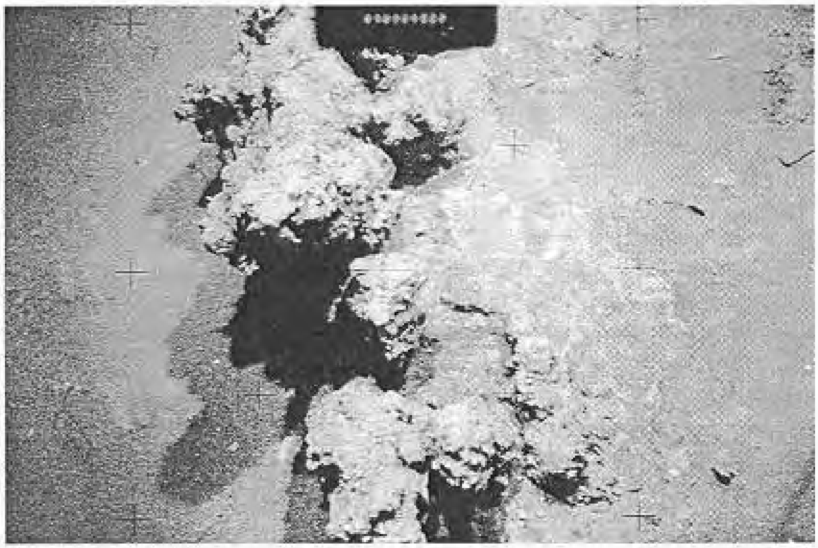

Figure 3a. Chimney and associated massive sulfides and talus from the inner north wall of Brothers caldera.

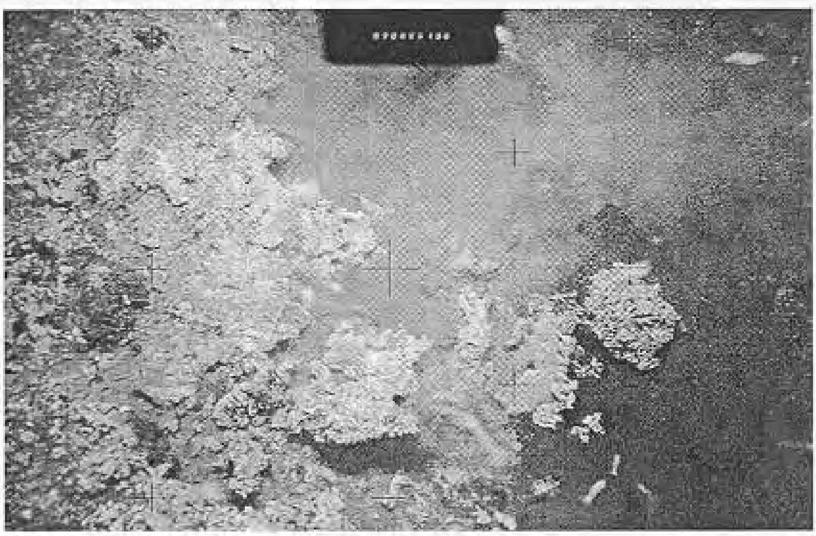

Figure 3b. Shrimps near the vicinity of black smoker vents on the lower north wall of Brothers caldera.

lavas, with 2 cm Mn encrusting, palagonite, and rock "weathering" increasing to the west.

Brothers Arc Caldera

The Brothers arc caldera (34°52'S, 179°04'E), a volcano of the southern Kermadec arc initially discovered with MR1 swath mapping, is one of only two known sites of deep-water, high-temperature hydrothermalism in the Kermadec-Havre system (Wright et al., 1998). Prior to cruise SO-135 two sites of sulfide mineralisaton associated with hydrothermal venting on the caldera wall, and the recovery of two partial specimens of the caridean vent shrimp suggested that Brothers caldera was an active hydrothermal system. SO-135 studies at the Brothers caldera entailed multibeam mapping, seafloor video/camera surveys, rock sampling, and reconnaissance water-column sampling.

The volcano is part of larger volcanic arc complex comprising elongate ridges/extensional fractures and depressions orientated 050-060. The edifice proper rises to a general caldera rim water-depth of 1560 m, although locally the northwest caldera rim shoals to 1320 m. The elongate-cresentic caldera partially encircles an elongate 1.5-2 km wide, and 350 m high, resurgent dome cone that, in part coalesces with the inner, southern caldera wall. The caldera varies between 3-3.5 km in diameter, with the caldera wall rising some 350-450 m above the caldera floor. Evidence of faulting and mass-wasting of the caldera wall are common.

The seafloor imaging and sampling revealed the presence of extensive hydrothermal mineralization, active high-temperature "black smoker" venting, and localized vent fauna on the north and southern caldera walls, and on the resurgent dome.

North Wall

Coincident with the original massive sulfide discovery a significant site of sulfide mineralisation and active hydrothermal venting occurs on the northern caldera wall along escarpments in water-depths of 1550-1650 m. Four active black smoker vents (with 1-2 m high chimneys) were observed. The largest contiguous zone of sulfide mineralization, 50 m in width and nearly 500 m in strike length, occurs along a narrow escarpment at about 1650 m water depth. Numerous, free-standing chimneys, measuring 1-5 m in height and having abundant sulfide talus and massive sulfides, were observed (Fig. 3a).

Black smoker vents and inactive chimneys also occur higher up on the northern caldera wall (small fields up to 25 m across), while a partially buried relict vent field occurs on a low escarpment near the sediment-covered caldera rim. The latter consists of discontinuous zones of eroded sulfide material and standing chimneys with a total strike length of about 400 m. Shimmering water was observed locally near the caldera rim.

Recovered hydrothermal rocks include 6 main sample types: (1) pyrite-anhydrite breccias; (2) a massive sphalerite chimney, (3) massive pyrite crusts, (4) massive pyrite breccias, (5) pyritic stockwork material, and (6) Fe-oxide-silica crusts.

The massive anhydrite breccias consist of crystalline anhydrite and minor disseminated pyrite. Complex breccias containing large clasts of pyrite and anhydrite in a matrix of coarser-grained anhydrite are interpreted to be the erosional remnants of anhydrite mounds and/or chimneys.

A single, intact sphalerite chimney was recovered by dredging of the lower caldera wall. The interior of the chimney is distinctly zoned, with an inner core of porous sphalerite and pyrite and an outer zone of amorphous silica, pyrite and marcasite. Minor chalcopyrite lines an internal conduit, with macroscopic galena intergrown with the sphalerite.

Pyritic stockwork-like consists of massive pyrite-cemented breccias, containing pyrite and clasts of intensely altered dacite, and pyrite-silica breccias comprising large clasts of silicified dacite with abundant disseminated pyrite in the matrix. The former contain traces of sphalerite and chalcopyrite, and euhedral anhydrite.

Large areas of the upper caldera wall and rim are covered by delicate Fe-silica crusts which appear to have formed at low-temperature vents and along fractures in the more massive dacite flows. Most of the crusts consist of brecciated fragments, probably formed by the repeated growth and collapse of small Fe-silica chimneys at the deposit margins.

Although vigorous venting of black smoke was observed, obvious vent-specific macro-fauna were not abundant. The presence of clam shells, bacterial floc, and stalked barnacles suggests that a vent fauna assemblage was once present, but is now sparse. A few barnacles, galatheid crabs, minor filamentous bacteria, and shrimps (Fig. 3b) were the only living fauna associated with the current hydrothermal activity.

South Wall

Grey altered talus occurs at the base of the south wall, suggesting that much of this portion of the caldera may have been exposed to hydrothermal fluid. No obvious sulfide mineralization was observed and no samples were recovered from this location.

Resurgent Dome

The resurgent dome comprises extensive glassy dacite talus and a large 300 m zone of Fe-oxide staining and alteration at the crest. A large near-bottom plume was observed near the dome crest, but an obvious vent source could not be located. Fresh, glassy, vesicular dacite dredged from the northern flank of the dome was locally encrusted with native sulfur and Fe-oxides. Vent-related fauna include sulfide worms, limpets, white filamentous bacteria, shrimp, and several large fields of stalked barnacles.

Offshore TVZ (SW White Island)

The offshore TVZ, southwest of the active White Island volcano, forms a region of known submarine hydrothermal venting with observations of gas bubbling, metalliferous sediments, and anhydrite mounds (Duncan and Pantin, 1969; Glasby 1975; Sarano et al., 1989). Known sites of hydrothermal venting (including the Calypso vents) occur within a zone of late Quaternary extensional faulting (the offshore segment of the Whakatane Graben), and appear to be associated with active normal faults (Pantin and Wright, 1994). SO-135 studies at these sites entailed multibeam mapping, seafloor video /camera surveys, rock sampling, and JAGO submersible sampling and observations.

Multibeam mapping reveal that the outer continental shelf is disrupted by a series of TVZ faults (including the White Island fault zone) striking 044°-053. Typically the faults have seafloor expression comprising elongate depressions, tilted blocks, and raised ridges, all of which have vertical relief of 5-20 m. The faults appear to be segmented over strike lengths of 5-7 km. Three major hydrothermal vent site areas, initially identified by acoustic back-scattering from columnar bubble zones streaming to the sea-surface were identified at 37°41.7'S, 177°06'E; 37°41.3'S, 177°07.4'E; 37°35.8'S, 177°06.2'E (the Calypso vents).

Northern Vent Area (Calypso Vents)

The northern vent area comprises a number of vent sites within a 1.5 km^2 area. Most recovered samples comprise altered pumiceous ash and sulfur-cemented breccias, and localised anhydrite. Disseminated pyrite (as < 1 mm grains) is abundant in the clay-altered pumiceous ash. The massive anhydrite shows evidence of corrosion, dissolution, and extensive reworking, and is interpreted to be the eroded remnants of an anhydrite mound or chimney, possibly that described by Sarano et al. (1989).

Southern Vent Area

Vents in the southeast and southwest areas generally occur as individual vent outlets occupying small depressions (1-5 m in diameter) adjacent to the faults, and clustered within ~500 m^2 areas. Specific vent sites appear to be localized by collapse features along fault scarps, and zones of intense silification which focus fluid flow. Venting fluid temperatures are 180-201°C. The silicified sediments occur as large, flat-lying and sometimes tilted slabs that are exposed along the fault scarps, and mantled with bacterial filaments, sponges and anemones.

Within the vent areas most recovered samples contain abundant native sulfur, and locally pyrite. In more silicified rocks, veins of pyrite up to 1 cm wide are observed and cut silicified ash beds. Black, sulfide-stained blocks of pumiceous ash and volcanic breccia were also recovered, many of which were impregnated with light hydrocarbons in fractures and pore spaces. Some 30-40% of samples are intensely mineralized containing abundant pyrite, orpiment, realgar, mercury (cinnabarnative mercury), and native sulfur.

Acknowledgements

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International Ridge-Crest Research: **Back Arc Basins:** Stoffers et al. continued...

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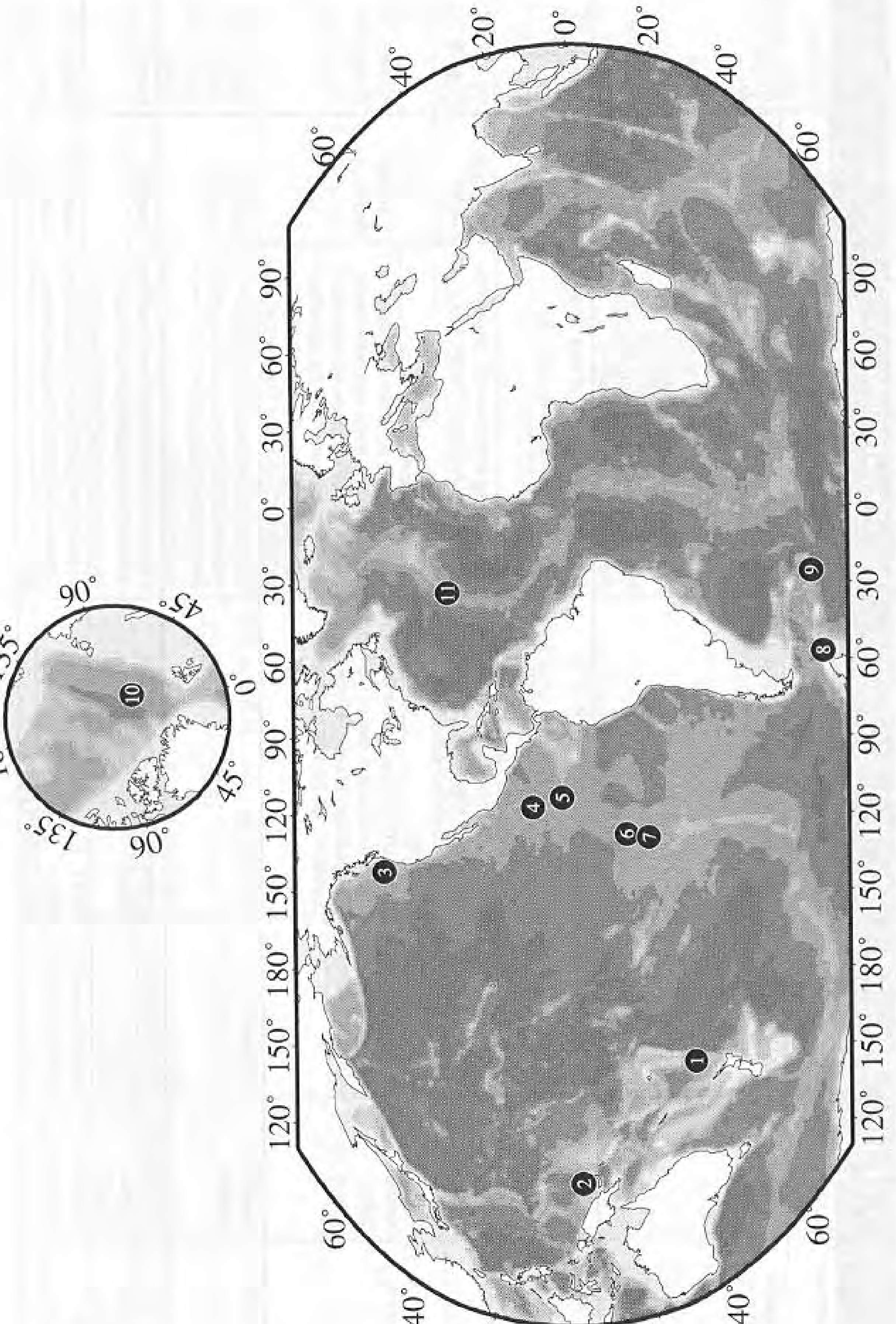
The deadline for *InterRidge News* 8(2) is:

Friday, October 1, 1999

- Format specifications can be found at **http://www.lgs.jussieu.fr/~intridge/irn.htm**
- Send submissions by e-mail (intridge@ext.jussieu.fr) or by diskette via the post
- Please do no send articles in formats higher than Word 6!

World Ridge Cruise Map, 1999-2000



InterRidge Projects, 1999-2000

World Ridge Cruise Schedule, 1999-2000

Map No.	Country	PI	Institution	Name/Location	Research Objectives	Ship	Dates
2	Australia	Binns	CSIRO	Pacmanus	Deploy PROD seafloor diamond rig to drill shallow (100 m) holes at Pacmanus	Franklin	Nov.-Dec. '99
3	Canada/ USA	Juniper, Delaney	UQAM, U. Wash.	Endeavour Segment - High Rise 1999	acquire high-quality video and photo documentation of the Endeavour vent species in their natural habitat; collect samples for intensive sorting and species identification to develop quantitative bio-diversity information for the site. Will also recover moored instruments and participate in a public outreach effort.	Thompson, ROPOS	16 Jul - 23 Jul '99
4	France	Lallier	CNRS, IFREMER, UPMC	East Pacific Rise 13°N, 9-10°N - **HOPE'99** http://www.sb-roscoff.fr/Ecophy/hope99.html	Ecology and physiology of vent organisms.	L'Atalante, Nautile	7 April - 22 May '99
4	France	Prieur	UBO, Roscoff	East Pacific Rise 13°N - **AMISTAD** (**A**dvanced **Mi**crobiological **St**udies on Thermophiles: **A**daptations and **D**iversity) .	Microbiology cruise to study procaryotic thermophiles and hyperthermophilic communities	L'Atalante, Nautile	May 23 to 15 June '99
2	France, Japan	Auzende, Urabe	IFREMER, Geological Survey of Japan	**MANAUTE** cruise, Manus Basin in Papua New Guinea, part of the New STARMER (1994-1999) French-Japanese bilateral joint program	Study spreading processes characterising the three axes in terms of tectonic and magmatic manifestation and study the processes associated with the spreading such as active hydrothermal venting, fossil and active deposits and fauna colonization	L'Atalante, Nautile	22 Dec - '99 - 27 Jan. '00
6	Germany	Devey, Villinger	U. Bremen	EXCOII Leg 1 and 2, EPR at ca. 13°S	Geophysics (mapping, simple seismics and heat flow) and rock, sediment, and pore water sampling on the EXCO corridor from 0-8 Ma	Sonne	Dec. 29 '99 Jan. 27 '00; Jan. 28 - Feb 29' 00
1	New Zealand, USA	De Ronde, Massoth, Wright	IGNS, NOAA, NIWA	southern Kermadec arc - Wright Island	CTD and SUAVE mapping and sampling of hydrothermal plumes along the southern Kermadec and around White Island	Tangaroa	Mar '99
9	UK	Livermore	British Antarctic Survey	JR39 - East Scotia Ridge see article on page 34	Locate hydrothermal vents. Map selected segments with TOBI. Geochemical sampling.	James Clark Ross	Jan/Feb '99

World Ridge Cruise Schedule, 1999-2000, continued...

6, 7	USA	Vrijenhoek, Lupton	Rutgers, NOAA	SEPR, 13°-21°S	Test hypothesis that dispersal of vent-endemic fauna is unimpeded between the NEPR and the SEPR; extend previous studies of hydrothermal venting rates	Atlantis, Alvin	Dec. 16 '98- Jan. 21 '99
11	USA	Smith, Tolstoy, Fox	WHOI, LDEO, NOAA	MAR, 10°-40°N see article on page 14	install six autonomous underwater hydrophone moorings to monitor the MAR from 10°-40°N for two years	Ewing	Jan. 30 - Feb 24. '99
7	USA	Sinton, Van Dover	U. Hawaii, College William & Mary	SEPR, near 17°26'S, 18°10'-18°20'S, and 18°37'S	Conduct volcanological investigations of single eruptive sequences using deep towed 120 KHz surveys, ALVIN dives, rock dredging and wax coring.	Atlantis, Alvin	Jan. 25 - Mar. 6 '99
5	USA	Karson, Klein, Hurst	Duke, U. Illinois	Northern wall of the Hess Deep Rift	Focus on a section of the uppermost oceanic crust using AMS-120 side-looking sonar; ARGO II imaging of selected areas; Alvin sampling and observations	Atlantis, Alvin, ARGO (15 dives)	Mar 12- Apr. 12 '99
10	USA	Edwards	U. Hawaii	SCICEX- Arctic Ocean - Gakkel Ridge see article on pg. 32 and http://www.ldeo.columbia.edu/SCICEX	Oceanography and geophysical mapping with SCAMP	USS Hawkbill	Mar. 15- Apr. 25 '99
8	USA	Klinkhammer	Oregon State Univ.	Deception Island & Bransfield Strait, Antarctica	Search for hydrothermal vents using ZAPS sled	N. B. Palmer	Apr. 14 - May 10 '99
4	USA	Mullineaux, Cavanaugh	WHOI, Harvard	EPR, 9-10°N	Community development and structure at Hydrothermal Vents: Life After Recruitment: final in a series of five cruises investigating biological interactions during colonization of hydrothermal vents.	Atlantis, Alvin	Apr. 17 - May 4 '99
3	USA	Menke, Webb	LDEO, SIO	Juan de Fuca Ridge	Active-source imaging of the crustal magma system of Axial Volcano, using airgun sources to already-deployed Scripps OBS's.	Ewing	17 Apr. - 3 May '99
4	USA	Cary, Luther, Lutz	U. Delaware, Rutgers	EPR, 9-10°N (LEXEN)		Atlantis, Alvin	8 May - 6 Jun '99

World Ridge Cruise Schedule, 1999-2000, continued...

Map No.	Country	PI	Institution	Name/Location	Research Objectives	Ship	Dates
3	USA	Embley	PMEL/NOAA	Juan de Fuca Ridge - NeMO 1999 (VENTS program)	Interdisciplinary investigation using ROPOS to continue a time series/mapping program over the 1998 eruption site in Axial Caldera. Several instruments will be recovered and redeployed.	Thompson, ROPOS	Jun 17 - Jul 15 '99
2	USA	Mutter	LDEO	Woodlark Basin	Study late stage continental rifting in the Woodlark basin using airguns, OBS	Ewing	28 Aug - 10 Sept '99
2	USA	Martinez	HIG	Woodlark Basin	Study lithospheric deformation at different stages of rifting and possible dynamic mantle effects via a series of marine heat flow measurements in continental basement areas in different stages from rifting to incipient seafloor spreading to young conjugate margins.	Ewing	Sept. 13 - Oct. 16 '99
3	USA	Chadwick	PMEL/NOAA	Juan de Fuca Ridge	Deploy an array of acoustic extensometers to measure seafloor spreading events. Part of the south Cleft observatory effort.	Thompson, JASON	24 Aug - 2 Sept '99
3	USA	Cowen	U. Hawaii	Juan de Fuca		Thompson, JASON	Sept. 3- 16 '99
3	USA	Fisher, Cavanaugh	U. Penn., Harvard	Endeavour Segment of the Juan de Fuca Ridge	Long term studies of vestimentiferan growth and nutritional interactions; examining the molecular and biochemical basis for the tissue stable C isotope signature of vesicomyid clams.	Atlantis, Alvin	Aug. 23 - Sep 7. 1999
3	USA	Seyfried, Becker, Kastner, Wheat	U. Minnesota, U. Miami	Juan de Fuca Ridge (LEXEN)	Test performance of solid state chemical sensors to measure pH and the dissolved concentration of H_2 and H_2S in vent fluids; monitor of vent fluidchemistry over a time period from hours to days	Atlantis, Alvin	Sept. 12 - Oct. 1 '99

World Ridge Cruise Schedule, 1999-2000, continued...

1	USA	Harding	SIO	Lau Basin - all the major seafloor spreading centers of the Lau Basin from the Central Lau Spreading Center to the Valu Fa Ridge.	Collect reflection data to determine how the style of crustal accretion varies within the Basin and to compare it with mid-ocean settings	Ewing	27 Nov-21 Dec '99
4	USA	Lutz, Van Dover	Rutgers, College William & Mary	EPR, 9-10°N	Continue time-series analyses of biological and geological changes; Replicate mussel sampling for a regional and global comparison of biodiversity at hydrothermal vents; Sample for phototrophs	Atlantis, Alvin	10 Nov - 3 Dec. '99
4	USA	Manahan, Deming	USC, UW	EPR, 9-10°N, LARVE Project and LEXEN	Collect for studies of the biology of their larvae and to collect larvae from the field ear vent sites.	Atlantis, Alvin	7-28 Dec. '99
4-7	USA	Fornari	WHOI	**AHA** cruise (Autonomous Hydrophone Array), East Pacific Rise, 20°N-26°S	Carry out near-bottom investigations using Seabeam, DSL-120 sonar, Argo-II, dredging, rock coring, and CTDs over 4 -5 areas suspected of having recent volcanic eruptions based on NOAA Autonomous Hydrophone Array	Melville	Feb/Mar '00
8	USA	Christeson, Dalziel, Nakamura	UTIG	Bransfield Strait, Antartica	Ocean Bottom Seismograph refraction profiling for crustal structure in Bransfield Strait, West Antarctica	N.B. Palmer	April '00
11	USA	Blackman	SIO	Mid-Atlantic Ridge - 30°N	Use submersible, sonar & video mapping, deep-tow gravity profiles and oriented samples to determine the structure and evolution of the oceanic core complex on the inside corner of the RTI	Atlantis, Alvin	Aug/Sep '00

If you have a ridge-related scheduled or proposed cruise that is not listed here, please inform the InterRidge Office at intridge@ext.jussieu.fr.

National News....

Canada: CanRidge

A Pilot Marine Protected Area on the Juan de Fuca Ridge

On December 8, 1998, Canada's Minister of Fisheries and Oceans announced that the Endeavour Segment hydrothermal vent fields on the Juan de Fuca Ridge were to become a Pilot Marine Protected area. The Endeavour Hot Vents Area is one of 3 pilot offshore Marine Protected Areas (MPAs) located within Canada's EEZ. The choice of the Endeavour Segment vents was made in consultation with Canadian scientists actively involved in research on the Juan de Fuca and Explorer Ridges, both of which lie at least partially within Canadian waters. The Endeavour Segment vent fields were chosen for their spectacular physical environment and, more importantly, for the variety and abundance of vent habitat and vent species found there. The abundance and long-term stability of venting at this site likely make it an importance source of propagules for the regional species pool.

The Endeavour Hot Vents are the first area of the global ridge system to be identified for official protection and conservation. The progression from a Pilot Marine Protected Area to official protection and development of a management plan is expected to take 2 years. This process involves extensive consultation with users of the area. The Endeavour site is unusual in that it was identified for MPA status because of its considerable scientific interest, rather than to protect it from commercial exploitation. The major users of the site are scientists. Although there was some initial concern among scientific groups about liberty of access to the area, Department of Fisheries and Oceans (DFO) officials have emphasized that it is their intent to encourage research at the site rather than restrict it. This intent was recently reiterated at a DFO sponsored Endeavour MPA Ecosystem Overview workshop held at the University of Victoria on March 17 and 18, 1999.

A joint DFO-universities biodiversity cruise to the Endeavour MPA site was also announced at the March workshop. The submersible expedition will acquire high-quality video and photo documentation of the Endeavour vent species in their natural habitat and collect samples for intensive sorting and species identification to develop quantitative biodiversity information for the site. See below.

This new status for the Endeavour Hot Vents is likely to provide a boost to research in the area by encouraging collaboration and coordination among research groups, by providing a new research focus around the themes of biodiversity and marine conservation, and by providing or facilitating funding for both basic research and public education. An entire session of the March workshop focused on public education questions. Scientists, educators and DFO managers all participated enthusiastically in this forum, recognizing that there is tremendous potential for public interest in deep-sea research. It was also pointed out that there is a certain urgency to inform the public now of the resources and environmental issues that are particular to the deep ocean, since technology and market forces are already leading wealth creation activities into abyssal depths.

Upcoming Cruises

Canadian ridge scientists will be involved in two joint submersible cruises to the Juan de Fuca Ridge this coming summer, in collaboration with different US institutions. Both cruises will use the Canadian submersible ROPOS with the *R/V Thomas G. Thompson* from the University of Washington serving as the support vessel.

NeMO 1999

This 21 day cruise will take ROPOS to Axial Seamount on June 18, where NOAA, University of Washington and Canadian university scientists will undertake the second year of the NeMO (NEw Millenium Observatory) time series study of the response of the hydrothermal system to the January 1998 eruption. Canadian university scientists will include personnel from laboratories at the University of Toronto (Steve Scott), the University of Victoria (Verena Tunnicliffe) and the Université du Québec à Montréal (Kim Juniper). See the Fall 1998 InterRidge News (Vol. 7 (2), p. 54) for details of the NeMO scientific program.

High Rise 1999

This 8 day cruise will follow the NeMO cruise and will take ROPOS/Thompson to the Endeavour Segment hydrothermal vents to acquire high-quality video and photo documentation of the Endeavour vent species in their natural habitat and collect samples for intensive sorting and species identification to develop quantitative biodiversity information for the site. This will also be a collaborative venture with U. Washington (J. Delaney) and Penn State University (C. Fisher) scientists who will recover moored instruments and participate in a public outreach effort. During the cruise we will also mount an Imagenex scanning sonar system on ROPOS to create a high resolution acoustic map of the Main Endeavour vent field. Canadian university scientists will include personnel from laboratories at the U. Toronto (S. Scott), the U. Victoria (V. Tunnicliffe), the U. New Brunswick (L. Mayer) and the Université du Québec à Montréal (K. Juniper).

continued on next page...

Canada continued...

New Cable and Winch for ROPOS

During the past year the Canadian Scientific Submersible Facility has been able to secure funding for the acquisition of a new deep-sea winch and cable for the ROPOS remotely operated vehicle. Both winch and cable are presently being fabricated and will allow ROPOS to dive to its full operational depth of 5000 m. Delivery of both cable and winch are anticipated for early summer 1999. New funding has also permitted an upgrade of the ROPOS fibre optic telemetry and video distribution systems and the development of a state-of-the-art dive logging system for scientific users.

For more information on CanRidge contact Kim Juniper (juniper.kim @uqam.ca).

France: Dorsales

1998 programs

In 1998, the Dorsales program funded three major programs proposed by some of the working groups set up by the Dorsales Steering Committee (see *InterRidge News*, 7(2)) :

High pressure container for biological samples (IPOCAMP project)

This equipment is under development and will be ready for NAUTILE biological cruises that will take place in the spring of 1999 on the East Pacific Rise (HOPE99 and AMISTAD). The next step will be to develop a system to recover the samples under pressure.
contact: Bruce Shillito
Bruce.Shillito@snv.jussieu.fr

MORB petrogenesis: experimental petrology

Two sets of experiments will be conducted for a better understanding of natural samples, the partial melting of an already depleted mantle and assimilation of oceanic crust by primitive liquids.
contact: Mike Toplis
mtoplis@crpg.cnrs-nancy.fr

Geophysical database

The objective is to generate a database with the bathymetric and geophysical data collected using French research vessels. This database will be the French contribution to the InterRidge database. On the basis of the existing multibeam bathymetric data, seven areas have been selected to concentrate the efforts:

• Mohns Ridge
• Central MAR (10-40°N)
• East Pacific Rise (40°S-25°N)
• Indian Ocean ridges
• Pacific Antarctic Ridge
• Red Sea/Gulf of Aden
• Fiji and Lau Basins

contact: Christine Deplus
deplus@ipgp.jussieu.fr

1999 programs

Early this year, a call for proposals was issued for funding in 1999 and proposals are currently being reviewed. Emphasis is being placed on three major themes:

• Geophysical imagery of the lithosphere and mantle beneath ridges. The objectives are: 1) a better characterization of the physical properties of samples, possibly in *in-situ* conditions, for a better interpretation of geophysical measurements 2) the use of existing geophysical data to construct regional or local images using physical parameters 3) the development of models for a better understanding of mantle and crustal processes

• MORB petrogenesis: experimental petrology

• Symbiosis. Two major aspects are favored, the symbiotic associations between invertebrates and bacteria, and the procaryotic thermophile communities.

The French community wants to be involved in the MOMAR project for long-term observation of the Mid-Atlantic Ridge south of the Azores. About ten French scientists attended the MOMAR workshop last October. The Dorsales program is supporting a cruise proposal to map the precise location and regional environment for the observatory that will be designed for long-term monitoring of the Lucky Strike segment.

A major experiment (MAGMA) is also proposed for a geophysical study of the crust and mantle beneath as segment of the Mid-Atlantic Ridge around 29°N. This MELT type experiment on a slow-spreading ridge will combine efforts from France, USA, Germany, Japan and Australia.

Sea trials of the ROV VICTOR

IFREMER is developing an ROV, the VICTOR, with a depth capability of 6000 m. The VICTOR PREMIERE cruise (chief scientist A.M. Alayse), which occurred last summer on the *R/V Thalassa*, was dedicated to the first sea trials of this new tool in different seafloor environments. Besides the engineers responsible for the ROV development, a few scientists were invited to evaluate VICTOR's capabilities with respect to their scientific requirements. 5 dives of the cruise took place on the Lucky Strike hydrothermal field on the Mid-Atlantic Ridge. The video systems as well as the rock, biological specimen and hydrothermal fluid samplers were successfully tested. All the scientists on board were favorably impressed by the performances of VICTOR. There is no doubt that when completely finished it will be a poweful tool for investigating mid-ocean ridges.

For more information about Dorsales contact Catherine Mével, Dorsales Chair (mevel@ccr.jussieu.fr).

National News....

Russia-Ridge

The Russian-Ridge program has continued along several scientific directions despite the serious funding difficulties resulting from the 1998 financial crisis in Russia. The current ridge-related research projects in Russia are summarized below:

Residual Peridotites of the mid-oceanic ridge and their petrological characteristics used as indicators of the petrogenesis conditions at ridge crests, *Vernadsky Institute of the Russian Academy of Sciences*

A comparison of the petrological characteristics of subsolidus metamorphism of the mid-ocean ridge residual peridotites with mantle peridotites from different geodynamic settings was carried out in 1998. This study was based on both new data and on half-quantitative estimations of subsolidus metamorphism conditions obtained from different physical models of the cooling of mantle peridotites. The approach established a link between the distribution character of closure temperatures of exchange reactions for two Pyroxenes (Ca-Mg) and Olivine-Spinel (Fe-Mg) pairs and geodynamic style of formation of host mantle peridotites. Hence these parameters provide a useful petrological indicator for geodynamic conditions. The calibration of subsolidus metamorphism temperature against physical models of rock cooling provides an independent estimation of both the lithosphere thickness in oceanic spreading zones and the time interval between melt separation and the appearance of residual peridotites on the oceanic floor.

The geochemistry of the mantle substratum in the region of the large geochemical anomaly in the Central Atlantic (14°48'N) was interpreted from new Sr, Nd and Pb isotope composition data from 18 samples of residual peridotites from between 13-16°N obtained in 1998. The distribution of the $^{143}Nd/^{144}Nd$ isotope ratio values from residual peridotites along the rift valley strike between 14° and 16°N demonstrates that mantle sources south of the 15°20' Fracture Zone are plume-type (enriched mantle) while mantle sources north of the fracture zone are normal-type mantle sources produced Atlantic MORB and conforming to mixing trend between depleted oceanic mantle and mantle with HIMU (high $^{238}U/^{204}Pb$ ratio) isotope characteristics.

A detailed geochemical and petrological study of the MAR plutonic complex (13-17°N) identified four major rock types: normal gabbro, gneissic gabbro, trondhjemites, and amphibolites. Intrusion of trondhjemite into gabbro causes the formation of hybrid gabbro varieties. The metamorphic transformation of plutonic rocks is closely related to the emplacement of residual peridotites at upper crustal levels.

PIs: S.A. Silantyev, B.A. Bazylev, L.V. Dmitriev.

Publications: S.A. Silantyev, J.F.Casey, H.J.B. Dick et al. Compositional Range of the Residual Peridotites at MAR between 14 and 16°N as Indicators of Mantle Sources Variety. *6th Zonenshain Conference on Plate Tectonics*, Moscow, p.23, 1998. (In English)

S.A.Silantyev. Origin Conditions of the Mid-Atlantic Ridge Plutonic Complex at 13°-17°N. *Petrology*, 6, 351-387, 1998.

Geochemical and Petrological characteristics of Mid-Ocean Ridge Basalts (MORB) and their relationship with mantle melting conditions and the nature of mantle sources, *Vernadsky Institute of the Russian Academy of Sciences*

The compositional diversity of MORB abyssal glass from MOR axial zones has been statistically analyzed and six groups of MORB were identified and their distribution along ridges was established. The conditions of the parental melt of each group's formation were reconstructed from experimental data on the basaltic melt petrology.

A model of deep mantle movements and the formation of the main MORB groups was developed on the basis of the reconstruction of the adiabatic mantle upwelling from the geotherm to solidus intersection. This model explains the origin of geodynamic ridge segmentation but requires the correlation with mantle convection constraints. The spatial distribution of petrological variations suggests that the most unstable geodynamic conditions occurs near the boundaries between first-order ridge segments next to large long-lived fracture zones. The hydrothermal vents of these ridge crest zones areas were formed from MORB enriched in water.

PI: L.V. Dmitriev

Publication: L.V. Dmitriev. Chemical Variability of Mid-Ocean Ridge Basalt as a Function of the Geodynamic Setting of their Formation. *Petrology*, 6, 314-334, 1998.

Comparison of the South Atlantic and the Indian Ocean Ridge Systems, *Vernadsky Institute of the Russian Academy of Sciences*

Geochemical data indicates that the generation of basaltic melts at the Rodriges Triple Junction occured from shallower mantle sources than those from melts from the Bouvet Triple Junction (BTJ). Petrological and geochemical data show that BTJ basalts formed at high-temperature conditions. The geochemistry of the enriched basaltic suites from the eastern part of the Indian Ocean suggest the ancient metasomatized mantle substratum participated in the melting process and gave rise to the considerable enrichment of basalts in light

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National News...

Russia continued...

REE, K, H_2O, U, and Th.
PI: N.M. Suschevskaya
Publication: N.M. Suschevskaya, T.I. Tsekhonya, A.A. Peyve. The specific signs of magmatism at the intersection of the Mid-Atlantic Ridge, the Africa-Antarctic Ridge and the America-Antarctic Ridge. *Geokhimia*, 3, 250-263, 1998 (in Russian), will be translated in English in *Geochemistry International.*

Gravity and magnetic anomaly maps from the Gakkel Ridge, *VNIIOkeangeologia St. Petersburg*

A coherent digital potential field data base has been compiled for the Gakkel Ridge (Arctic Ocean) on the basis of Russian gravity maps and digitized aeromagnetic data collected during the past decades. The resulting gravity and magnetic anomaly maps showing the segmentation of the Gakkel Ridge were presented at the InterRidge Mapping and Sampling the Arctic Ridge Workshop in Hannover, Germany in October 16-17, 1998 and were used for the development of future field work in the Arctic.
PIs: Sergei Maschenkov and Vladimir Glebovsky

Geophysical studies of the Mid-Atlantic Ridge (MAR), *The Shirshov Institute of Oceanology of the Russian Academy of Sciences*

A new petromagnetic model for this slow-spreading ridge has been proposed from an analysis of the magnetic anomalies variations at the MAR axial zone and adjacent areas. The model results show that a close spatial correlation exists between the effective magnetization of the oceanic crust and its petrographic construction.
PIs: A.M. Gorodnitsky, K.V. Popov and S.V. Lukyanov

The monograph *The deep structure and evolution of the lithosphere in the Central Atlantic (Results of investigations on the Canary-Bahamas geotransect)* (editors S. Maschenkov and Yu. Pogrebitsky), has been published under financial support of Russian Foundation for Basic Research, Grant # 98-05-78013. This monograph, accompanied by a CD-ROM with geophysical maps and cross-sections between 23°-29°, describes the spatial and temporal variations of the spreading process during the past 50 Ma and the concept of a long-lived medium scale segmentation of the MAR is substantiated. To obtain a copy contact Dr. S. Maschenkov at mascha@vniio.nw.ru.

Correlation between bathymetric and geophysical structures of the MAR, the Structural-Tectonic Ensembles of the Equatorial Atlantic Ocean, *Geological Institute of the Russian Academy of Sciences*

An electronic atlas of the Equatorial Atlantic between 15°S-25°N and 60°W to 10°E has been compiled. The atlas includes the following data:
- Tracklines and stations made by the Geological Institute RAS with the R/V *Akademik Nikolaj Strakhov* between 1995 - 1998 (http://geo.tv-sign.ru/tectonic/marine/map1.gif)
- Physical-geographical map with the names of ocean bottom features
- Predicted topography relief with land topography and hydrological features
- Joint free air anomalies from ocean altimetry and continental measurements
- Sediment thickness and ages
- Mesozoic-Cenozoic magmatism and crust age
- Magnetic anomalies, seismicity and heat flow
- Earthquake focal mechanisms and geoid surface
- Bouguer anomalies
- Mantle Bouguer anomalies
- Isosatic anomalies
- Rock types from dredge stations
- Alterations of rocks and sulphides
- Tectonic map

This MS Access database (10 Mb) has 839 records of radiometric ages of magmatic rocks and data from 1816 dredges (1153 Russian). The database also includes a glossary of 370 marine geologic terms in field of Marine Geology (English-Russian, Russian-English) with detailed descriptions. Multibeam echosounder and single-channel seismic reflection digital data collected on the *R/V Akademik Nikolaj Strakhov* have been recorded on CD's. The next step of the project will be to compile digital maps of all the multibeam data from the the *R/V Akademic Nikolaj Strakhov* (see http://geo.tv-sign.ru/tectonic/marine/map1.gif) at a scale of 1:200000. For more information contact marine@geo.tv-sign.ru or geophys@geo.tv-sign.ru.
PIs: A.O.Mazarovich, S.Y.Sokolov
Publications: A. O. Mazarovich and S. Yu. Sokolov, The Tectonic Position of Hydrothermal Fields on the Mid-Atlantic Ridge. *Lithology and Mineral Resources*, Vol. 33, 391-394, 1998.

A. O. Mazarovich. Geology of the Central Atlantic: Fractures, Volcanic edifices and Oceanic Bottom Deformations, Ph. D. Thesis, 400 pp., 1998. (abstract: http://geo.tv-sign.ru/personal/mazarovich/autoref.htm, in Russian)

Expeditions to hydrothermal sites on the MAR and the Knipovich Ridge

A cruise of the *R/V Professor Logachev* (St-Petersburg, Polar Expedition, VNIIOkeangeologia, Sevmorgeo) visited two hydrothermal sites on the MAR: 24°30'N and 14°45'N (Logachev hydrothermal field) in March, 1998. Deep-tow profiling by a RIFT system equipped with geochemical and geoelectrical sensors, and sampling of sediments, rocks and hydrothermal deposits by both cores and a heavy TV-equipped grab were conducted during this cruise. Two sites on the MAR (Rainbow and Logachev) and one on the Knipovich Ridge (76°47'N) were visited during two diving cruises of the *R/V Academic Mstislav Keldysh* (Shirshov Institute, Moscow). The Knipovich Ridge diving program was funded by NRL and National Geographic (USA), GEOMAR (Germany), University of Bergen (Norway) and the Russian Academy of Science. A brief report on the Knipovich Ridge cruise was published in the last issue of *InterRidge News*.

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National News...

Russia continued...

Work in the ODP program

Russian scientists from the Vernadsky Institute are contributors to Experiment B of the Slow-Spreading Ocean Ridges working group established during the ODP-InterRidge-IAVCEI Workshop "The Oceanic Lithosphere & Scientific Drilling into the 21st Century" in May 1996 at Woods. The experiment calls for drilling into a serpentine belt along the MAR at 15°N. S.A. Silantyev, L.V. Dmitriev and A.V. Sobolev were co-proponents in an ODP proposal for drilling mantle peridotite along the MAR from 14°-16°N, submitted October 1998.

Cruises

The number of Russian cruises has dropped sharply during the last few years because a lack of funding. The rare cruises are organized on a commercial base only, and thus scientific objectrves do not have a decisive role in planning these cruises. For more informtion contact either Sergei A. Silantyev (silant@chat.ru) or Sergei P. Maschenkov (ocean @sovamsu.sovusa.com).

Denmark

Solid earth research in Denmark is generally not directly concerned with ridges and ridge processes. Nevertheless there is an interest within the Danish community to stay informed about ridge research which is why Denmark maintains correspondence status with InterRidge. In particular, ongoing research on the N. Atlantic rifted margins by various groups within Denmark have highlighted the need to study more closely present-day ridge processes on and around Iceland. This brief report focuses on several research initiatives within the Danish Lithosphere Center in Copenhagen that are relevant to ridge studies. It should be emphasized that there is no intent to exclude research from other institutes within Denmark and that Danish researchers who wish to be included in future summaries are welcome to contact one of the two InterRidge correspondents in Denmark, John R. Hopper (jrh@dlc.ku.dk) at the Danish Lithosphere Center, Copenhagen, or Stefan Bernstein (sb@dlc.ku.dk) at the Arctic Station, Qeqertarsuaq, Greenland.

David Peate (dwp@dlc.ku.dk) is looking at the systematics of U-series nuclides (^{238}U-^{230}Th-^{226}Ra and ^{235}U-^{231}Pa) in ridge-related samples to provide constraints on the processes of melt extraction and mantle dynamics. Work is continuing on samples from the Reykjanes Ridge and Iceland, and our existing data indicate that: (i) there is active mantle upwelling associated with the Iceland plume, and (ii) this can not extend more than perhaps 100 km from Iceland so that plume-related com-positional signatures in lavas further south along the Reykjanes Ridge must be largely a result of lateral transport. A second study has focussed on melt generation at back-arc spreading centres, and U-series data from the Lau Basin have yielded important information as to the role of water during melt generation at a ridge setting. These studies involve collaboration with colleagues from the Open University (UK), Vrije Universiteit (Amsterdam), Southampton Oceanography Centre (UK), and Durham University (UK).

Recent isotopic studies by Ole Stecher (stecher@dlc.ku.dk) on basaltic to rhyolitic rocks from Torfajökull, the largest central volcanic complex in Iceland, have revealed that they represent the most radiogenic Pb-isotope signature from Icelandic rocks. This radiogenic end-member has the isotopic characteristics of a common isotopic component that has been coined "FoZo" mantle and is the most prominent component of the Iceland mantle plume (see Stecher et al., 1999, EPSL 165, 117-127). Ole has also looked at fluorine in comparison to other incompatible elements (K,P, Zr, Ti) in basaltic rocks from the Reykjanes Peninsula, localities in central Iceland, and Jan Mayan Island. The data show that the mantle source of Jan Mayen lavas contains nearly 4 times as much K compared to the mantle source giving rise to the Reykjanes Peninsula lavas (see Stecher, 1998, GCA 62, 3117-3130).

In addition, the DLC has two Ph.D. students who are currently working on volcanic rocks from Iceland. A study by Anna Cecelie Skovgaard (acs@dlc.ku.dk) is looking at the covariation of Os isotopes with Pb-, Sr-, and Nd-isotopes within the neo-volcanic zone of Iceland. High Mg-lavas are being analyzed to constrain contributions from different mantle reservoirs and recycled crustal components in the Iceland Plume. A study by Kresten Breddam Dupont (kbd@dlc.ku.dk) is utilizing primitive tholeiitic glasses from large volume subglacial eruptions in the Northern and Eastern Rift-Zones of Iceland, in order to geochemically characterise the source regions of the Iceland mantle plume as well as its lateral dimensions in the upper mantle. Samples were collected away from volcanic centres to favour melts unmodified by residence in crustal magma chambers and only from lower units of subglacial eruptions where high contents of noble gases might be expected. Helium isotopic ratios are used as the basic tool for tracking melts derived from lower mantle material which are then further characterised by a variety of other isotope systems and trace element ratios.

For more information on these projects, visit the DLC website at http://www.dlc.ku.dk or e-mail any of the above people.

UK: BRIDGE

End of BRIDGE

The BRIDGE Programme has now entered its final year. The BRIDGE Dataset will be made available in due course (probably during the year 2000) after the principal scientists who collected the data have had a chance to work up their results and research students relying on the data have been allowed a reasonable period of exclusive access. However the BRIDGE programme itself will formally end in November 1999. Planning is currently underway to present BRIDGE achievements in a coherent way to decision makers and the public, to feed the results into the education system at school level, and to summarise the scientific output at a range of high profile science meetings.

Despite the widely recognised success of the programme, it is not the policy of the UK's Natural Environment Research Council to extend the life of existing programmes. The funding that has been allocated to BRIDGE over the last six years will now be used to fund other NERC research priorities in the broad environmental field. BRIDGE researchers will either continue their interdisciplinary work within a European - or broader international - funding context, or will submit individual research proposals to the general 'non-thematic' funding mode of the NERC. Hopefully the networks of multidisciplinary teams that have formed within the programmatic structure will survive, to the continued benefit of all sides.

Some lines of deep ocean research formerly supported through BRIDGE are already leaving home to start new lives elsewhere and the UK's commitment to, and enthusiasm for, the InterRidge community will hopefully be undiminished.

Future BRIDGE publications

BRIDGE, of course, will live on in spirit and scientific journals. A recent UK report considered the publication output from two UK cruises funded by science awards. In neither case were any scientific publications produced during the lifetime of the award; in both cases the publication output did not peak until 5-6 years after the cruise. This pattern is supported by other studies and is important to remember when assessing the scientific output from research involving shiptime. The often multidisciplinary work requires greater collaboration, and hence time, in the analysis and writing. The difficulty and expense of deep sea work also ensures a higher rate of secondary use of data and samples (i.e. later use by workers not involved in the original project) than occurs in other environmental sciences. BRIDGE results will be appearing in the literature for many years and the data collected will hopefully continue to be used in novel and informative ways well into the next century.

Closure of the BRIDGE Office

With the end of the programme in sight, the BRIDGE Office at Leeds University has closed and all remaining administration has passed to the NERC. The new contact details are provided below. The BRIDGE Newsletter should appear as normal during 1999, although it is planned to give the Autumn 1999 issue a new look to coincide with the end-of-programme promotions. Hopefully the BRIDGE website can be retained.

And finally...

The idea for a British mid-ocean ridge initiative sprang from the meeting in Oregon in April 1987 that launched the RIDGE proposal (we're not ashamed to steal good ideas). As BRIDGE retires it is heartening to hear David Christie, in the impressive new technicolor 'RIDGE Events', talking about the next ten years of RIDGE. We at BRIDGE wish RIDGE and all other national InterRidge programmes continued success in the new millennium.

Keith Harrison
BRIDGE Programme Manager (retd)

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National News...

RIDGE

USA: RIDGE

Coming Attractions:

RIDGE 2000 Meeting

In the spirit of the Salishan meeting that led to the establishment of the RIDGE Program, this conference will review RIDGE accomplishments, and set the course for the RIDGE Program into its second decade. September 22-25, 1999 in Newport, Oregon.

Troodos Field School

The third RIDGE Field School will focus on the Troodos Ophiolite. The School is designed to promote interaction among younger scientists working on mid-ocean-ridge-related problems, to provide first-hand knowledge of the geology of the Troodos Ophiolite, and to encourage discussion of its implications for mid-ocean ridge processes. Three classroom days will be interspersed with six field days. Announcement of the Field School generated considerable interest in the RIDGE community. Unfortunately, funding and logistics restricted this field school to US participants. The field school will be held July 1-11, 1999 in Larnaca, Cyprus. A second, field-only school will be sponsored by InterRidge and Bridge immediately following.

Juan de Fuca Results Symposium

This conference will summarize past results and identify future objectives in JdF Ridge research. It is tentatively scheduled for November 7-9, 1999 in Seattle, Washington.

Recent Attractions:

Newsletter

The first newsletter produced by the RIDGE Office since it moved to Oregon State University was published in December 1998. Copies of the newsletter were mailed to U.S., Canadian, and Mexican addresses. The newsletter is available on the RIDGE website or by request to the RIDGE Office.

New Science Plan

The new RIDGE Science Plan is now online at http://ridge.oce.orst.edu /sciplan/. This new Plan highlights six 'scientific questions' to help focus scientific endeavor on important, but potentially solvable problems, while leaving adequate latitude for individuals. This Science Plan is expected to have a short life, as a new Plan will be developed from the proceedings of the upcoming RIDGE 2000 Conference.

Steering Committee

At the October 1998 RIDGE Steering Committee meeting it was agreed that certain STCOM activities could be conducted more efficiently by focused subcommittees. STCOM then creating four subcommittees: Database/Synthesis, Event Detection and Response/Observatory, Education and Outreach, and Meetings. Members and functions of these new subcommittees were published in the December 1998 RIDGE Events newsletter available on the RIDGE website.

Sessions and Meetings at AGU

RIDGE sponsored a Union review session "RIDGE - approaching a decade of multi-disciplinary science". Thirty-eight invited papers reviewed a decade of progress across the spectrum of RIDGE science.

RIDGE also sponsored a series of organizational meetings at the Fall AGU meeting including: Juan de Fuca Observatory coordinating meeting, Discussion of a proposal to drill the EPR at 9° North, and an Editors meeting for the report from the "Monitoring the Mid-Atlantic Ridge" (MOMAR) Workshop.

And one dis-organizational meeting – the RIDGE Smoker attracted the usual large crowd. Highlight of the meeting was the Davy Jones Award to Chris Fox for significant contributions to the permanent instrumentation of the deep ocean. Nominations for next year's award ceremony are eagerly sought.

Finally, we welcome the new RIDGE Office Program Assistant, Chris LeBoeuf who brings to the position extensive experience in office management, meeting organization, and web page design, and a great sense of humor.

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Upcoming Meetings and Workshops

Calendar

More details about all of the following meetings can be found via the Calendar Page on the InterRidge web site.

Apr. 19-23 1999
European Geophysical Society, 24th General Assembly
The Hague, The Netherlands

Apr. 27-30 1999
The Oceanography Society 1999 Scientific Meeting: Extreme and Unexpected Phenomena in the Ocean
Reno, Nevada, USA

May 26-29 1999
COMPLEX - Conference on Multiple Platform Exploration
Vancouver, Canada

May 31-Jun. 4 1999
AGU 1999 Spring Meeting
Boston, MA, USA

Jun. 10 1999
IEE Colloquium on Deep Sea Vehicle Positioning and Navigation
Savoy Place, London, UK

Jun. 20-22 1999
Large Engineering Systems Conference Series, including a Conference on Autonomous Underwater Vehicles (LESCOAUV'99) and a Conference on Underwater Cables (LESCOCABLE)
Halifax, Nova Scotia, Canada

Jun. 25-26 1999
InterRidge Steering Committee Meeting
University of Bergen, Norway

Jul. 1-11 1999
RIDGE Field Trip to the Troodos Ophiolite
Larnaca, Cyprus

Jul. 11-17 1999
InterRidge Field Trip to the Troodos Ophiolite
Larnaca, Cyprus

Jul. 18-30 1999
XXII General Assembly of IUGG (International Union of Geodesy and Geophysics)
University of Birmingham, UK

Aug. 22-25 1999
11th International Symposium on Unmanned Untethered Submersible Technology (UUST99)
Durham, New Hampshire, USA

Sep. 12-15 1999
3rd International Workshop on Orogenic Lherzolites and Mantle Processes
Pavia, Italy

Sep. 13-17 1999
34th European Marine Biology Symposium
Universidade dos Açores, Ponta Delgada, Açores, Portugal

Sep. 22-25 1999
RIDGE 2000 Meeting
Newport, Oregon, USA

Nov. 7-9 1999
Juan de Fuca Results Symposium
Seattle, Washington, USA

Dec. 13-17 1999
AGU 1999 Fall Meeting
San Francisco, CA, USA

Jan. 24-28 2000
Ocean Sciences 2000 Meeting
San Antonio, TX, USA

Mar. 8-9 2000
The Nature and Tectonic Significance of Fault Zone Weakening - A joint Geological Society of London/ Geological Society of America/ InterRidge meeting
Geological Society, London, UK

Apr. 17-20 2000
GEOSCIENCE 2000
University of Manchester, UK

May 23-26 2000
Underwater Technology 2000 (UT'00)
Tokyo, Japan

Aug. 6-17 2000
31st International Geological Congress
Rio de Janeiro, Brazil

Aug. 28-Sep. 2 2000
The XVIIIth (New) International Congress of Zoology
Athens, Greece

Dec. 15-19 2000
AGU 2000 Fall Meeting
San Francisco, CA, USA

Upcoming Meetings and Workshops

Special Sessions of upcoming meetings relevant to the international ridge community

European Union of Geosciences: EUG 10 Meeting

28th March - 1st April 1999, Strasbourg, France

http://eost.u-strasbg.fr/EUG/Meeting.htm

Symposium B13: Methane hydrates and the deep subseafloor biosphere The recent resurgence of interest in methane hydrates has resulted from the recognition that they may play important roles in the global carbon cycle and rapid climate change through emissions of methane from marine sediments and permafrost into the atmosphere, and in causing mass failure of sediments and structural changes on the continental slope. A deep microbial source for the methane links the formation of hydrates with an actively metabolising deep sub-seafloor biosphere, which has been recognised during ODP cruises. Methane seeps are also associated with diverse biota in the deep ocean, not unlike the assemblage associated with hydrothermal vents. The methane hydrate role in modulating climate and slope-stability, as well as the related biological activity in the sub-surface and on the seafloor, will be examined.

Symposium C5: The deep biosphere The rapid growth of interest in the existence of a microbial life in the seafloor and continental subsurface has created needs for information synthesis to guide the development of research strategies and programs. The existence of a deep biosphere amounted to speculation only a few years ago. Whatever their origin, bacteria in the deep biosphere are uniquely adapted to survive in exceedingly harsh environments. This knowledge, in conjunction with other recent research into the role that bacteria play in global biogeochemistry, is beginning to influence ideas about nutrient cycling, dolomite formation, biomineralization, biological adaptation and the size of the biosphere beneath the surface of the lithosphere.

Symposium F2: Magmatic, tectonic and hydrothermal processes at mid-ocean ridges and back-arc basins Mid-ocean ridges are commonly divided into "fast" and "slow" spreading centres. However, recent studies from the Southwest Indian and Arctic ridges, from portions of the Mid-Atlantic Ridge that are near hot spots, from the intermediate spreading Southeast Indian Ridge, and from various spreading centres in back-arc basins, emphasise the potential effects of ultra-slow spreading rates, of variations in mantle temperature, and of complexities in plate kinematics, on mantle melting and on axial magmatic, tectonic and hydrothermal processes. This session is sponsored by InterRidge.

European Geophysical Society, XXIV General Assembly

19-23 April 1999, The Hague, The Netherlands

http://www.copernicus.org/EGS/egsga/denhaag99/denhaag.htm

SE58: Composition and structure of the oceanic crust: constraints from seismic, gravity, geological and petrological observations Studies of oceanic crustal structure have provided us with important insights into the composition, physical state, and dynamics of the mantle. While the first order processes governing oceanic crust formation are understood, the detailed mechanism of magmatic accretion and the interplay of magmatism and tectonism are still not well known. In addition, many important parameters - such as spreading rate, potential temperature, proximity to a hot spot, etc. - have expressions which have not been fully characterized and influences which are not well understood. Research is very active in this area, and this session will bring together results from recent studies aimed at characterizing oceanic crust composition and structure with the goal of better understanding the processes of oceanic crustal accretion under a variety of conditions.

SE59: Extensional tectonics in the oceanic lithosphere; from continental margins to mid-ocean ridges The session will focus on the modes of tectonic extension at passive continental margins (continent to continent-ocean transition) and mid-ocean ridges. We seek contributions on brittle and ductile deformation mechanisms, rheology, quantification of strain, and on the interactions between extensional tectonics and magmatic/ hydrothermal processes. Contributions addressing the origin and modes of formation of low angle detachment faults and the geophysical (gravity, seismics and magnetics) signature of tectonic structures are particularly encouraged. This session is sponsored by InterRidge.

SE60: Strain partitioning from continental margins to mid-ocean ridges The more closely we look at areas of continental and oceanic extension, the more we see that all rifts are not created equal. Some from slowly, some

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EGS continued...

quickly. In areas of continental extension, there are wide rifts, narrow rifts, volcanic rifts and failed rifts. Areas of oceanic extension are markedly different in accordance with their spreading rates: fast spreading centers are marked by axial highs, slow spreading centers by axial valleys and intermediate spreading centers by both axial highs and valleys. For both oceanic and continental domains, the pattern of faulting is seen to vary between different extended areas. In addition, the transition from continental rift to oceanic rift and seafloor spreading is highly variable: some are defined as sharp boundaries while others are transition zones that span several 10's of km. Several processes have been implicated in the production of this rift diversity from continent to ocean. These include: pre-existing strength heterogeneity, the initial thermal structure and crustal thickness in a rifting region, strain rate dependent changes in strength of rifts, and magmatism during rifting.

SE62: Melt generation beneath mid-ocean ridges and hotspots Melt generation beneath mid-ocean ridges and hotspots, fundamental processes closely related to the geodynamic and geochemical evolution of the Earth, continue to challenge geoscientists. Recent geophysical, petrological, and geochemical observations have improved our knowledge on melt extraction and mantle flow beneath mid-ocean ridges, and on the deep origin of mantle plumes and its implications for models of mantle convection and the evolution of mantle instabilities. The purpose of this session is to bring together researchers from all geoscience disciplines (seismology, electromagnetic methods, geodynamic models, petrology, geochemistry) to present and discuss their latest results on upwelling and mantle flow, generation, extraction, and distribution of melt beneath mid-ocean ridges, and on the origin and evolution of mantle plumes.

OA8: The chemistry of hydrothermal systems and interactions with the water column This symposium aims to address current issues in submarine hydrothermal circulation. New insights have emerged in recent years, at the European and wider international scale, concerning the relative importance of three "end-member" types of hydrothermal venting: spectacular high- temperature venting on mid-ocean ridge axes; lower temperature, ore-forming diffuse flow along ridge-axes; and wide-spread low-temperature on- and off- axis circulation. All these styles of venting affect both thermal and chemical exchanges between the solid earth and the overlying oceans and also support unique ecosystems. The purpose of this symposium is to bring together presentations on state-of-the-art research from around the world's ridge-crests in this multi-disciplinary field. Papers are invited which address the physics, chemistry and geology of hydrothermal systems themselves as well as the fate of material discharged from hydrothermal venting, in terms of physical, chemical and biological processes in the oceans.

American Geophysical Union

May 31 - June 4, 1999, Boston, MA, USA

http://www.agu.org/meetings/sm99top.html

U04: Earth's Deep Interior and Surface Observations: How Are They Linked and What Can We Learn? The complex thermo-chemical processes occurring deep in the Earth's interior are intimately linked to surface observables such as gravitational and magnetic fields, composition of erupted magmas, and seismic waves, and to all large scale geological processes occurring at the surface, including global tectonics. The aim of this session is to explore these links, bringing together an interdisciplinary group of scientists with a common interest in bridging the gap between what is observed at the surface or near the surface (i.e., in the crust/lithosphere), and what is occurring in the deep interior, including mantle and core. This theme follows logically from the Gordon Conference on Earth's Interior held in July 1998.

OS07: Melt Migration Mechanisms in the Upper Mantle and Lower Crust A variety of central questions regarding melt transport in the Earth remain unresolved: Under what conditions is flow reactive or chemically isolated? Where is melt flow distributed, and where is it localized? For porous flow mechanisms, how does permeability vary with porosity, grain size, and stress state? What role do high temperature fractures play in melt migration? What physical properties need to be defined and/or measured (e.g., "cohesive strength," "fracture toughness") to achieve quantitative understanding of the transition from porous to fracture flow? What results from related fields, such as hydrology and oil field characterization, can be brought to bear on these problems?

T03: Evolution of Oceanic Spreading Centers and Their Discontinuities Detailed mapping at slow, intermediate, and fast spreading mid-ocean ridges has revealed that stable ridge-transform configurations comprise only a small subset of the behavior observed at spreading center offsets. Whereas transform faults appear to be relatively

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Upcoming Meetings and Workshops

Spring AGU continued...

long-lived and stationary features, so-called higher-order discontinuities (such as overlapping spreading centers at faster-spreading centers and non-transform offsets at slower-spreading centers) appear and disappear on time scales of one million years or less, offset the ridge axis at irregular intervals, migrate along spreading segments at rates comparable to the local spreading rate,and leave basins, ridges, and tectonized fabric in their wakes. The goal of this session is to bring together scientists interested in the long-term, time-dependent evolution of individual spreading segments and their discontinuities.

T09: New Magnetic, Gravity, and Seismic Studies in the Arctic Ocean After an initial burst of exploration in the 1960s and 1970s, relatively little geophysical work was done in the high Arctic in the 1980s except for the Canadian ice island experiments. In the 1990s, a new series of explorations has been done using surface ships, submarines, aircraft and satellites. This session will showcase data collected in the past few years and their bearing on our understanding of the tectonic development of the region.

T11: Deformation Associated With Oblique Rifting The goal of this session is to bring together researchers who have conducted studies of the deformation associated with oblique rifting. Most of our understanding of extensional tectonics comes from studies that have considered the simplest boundary conditions (i.e., extension perpendicular to a rift/discontinuity/plate edge. However, thecombination of extension and shear that results when a rift is oriented obliquely to the direction of absolute plate motion produces a complex pattern of brittle and continuous deformation that cannot be explained by simpleextensional models. Oblique rifts can be grouped into those controlled by fault reactivation above a decollement, or by those characterized by formation of new faults in a relatively homogeneous brittle layer. Why do some rifts have vertical-axis block rotation and transverse strike-slip faults, while others accommodate strain predominantly along normal faults? How is strain partitioned in oblique rift zones?

T12: The Plan View of Spreading: From Kinematics to Dynamics Recorded in Ridges and Ophiolites
The past decade has seen leaps in the quality and resolution of geophysical data from active spreading centers. Concomitant development in the images of spreading fossilized in ophiolites pushed the understanding of the underlying processes to new levels. The analyses of these processes are typically restricted to a vertical cross section. The revealed spatial and temporal variability of plan view features (i.e., types of discontinuity, segments and their relative orientations, hotspot influence) calls for integration with the deep processes. This session will address new opportunities to link surficial geometry, deep structure, and governing processes. Issues will include magmatic and tectonic features, hotspot influence, spatial and temporal variations, and driving forces. We particularly encourage contributions that will emphasize dynamic implications of plan view elements beyond the kinematics of spreading.

XXII General Assembly of IUGG (International Union of Geodesy and Geophysics)

18-30 July 1999, University of Birmingham, Birmingham, UK

http://www.bham.ac.uk/IUGG99

IAVCEI (International Association of Volcanology and Chemistry of the Earth's Interior) Symposia VS1 Subglacial Eruptions and Sedimentation in Iceland and Elsewhere *(Monday July 26)* Mid-ocean ridge magmatism and superposition of a mantle plume make Iceland one of the most productive volcanic regions in the world. Consequently, Iceland is of great significance to study aspects of volcaniclastic sedimentation through time. The purpose of this special session will be to highlight the various studies on sediment deposits and sedimentation processes related to the 1996 eruption in Vatnajokull, as well as aspects of sedimentation related to older deposits.

JWA34 Long Term Ocean Bottom Geophysical Observatories *(Tuesday July 27)* The global coverage of land-based seismic, geomagnetic, geodetic and other geophysical observatories is not adequate to address many important scientific issues related to plate tectonics, reference geomagnetic models, and the deep structure and dynamics of Earth. Geophysical observatories on the ocean bottom are required, but theseobservatories present technological challenges including deployment, power access, data collection/retrieval, and maintenance. These observatories must be deployed for operation over many years, and must address concerns such as baseline control

Upcoming Meetings and Workshops

IUGG continued...

for geomagnetic observations or broadband coverage for seismic observations. Pilot programs for geophysical measurements include the Global Seismic Network site H2O (IRIS), Japanese cable programs, and those coordinated through the International Ocean Network (ION).

IAPSO (International Association of Physical Sciences of the Oceans) Symposium P16: Recent Improvements to Deep-Sea Research through use of Submersibles, Acoustic Tomography and In-situ Long Term Observations (*Thursday July 29 and Friday July 30*) This Symposium will focus on recent progress in understanding phenomena occurring in the deep oceans through use of manned research submersibles, remotely operated vehicles (ROV and AUV), acoustic tomography and in-situ long-term observatories. For example, venting of both hydrothermal and cold fluids from the deep ocean floor has provided a new picture of the mass and heat fluxes between the ocean and crust with possible implications for oceanography. In-situ observations by underwater cables are emerging to be important tools for monitoring time-variations of oceanic processes (whether periodic or sporadic). Acoustic tomography is capable of yielding 3-D snapshots of oceanographic conditions. We aim to synthesize the present status of research and to establish a new vision of oceanography in the next century.

JSM41 The Contribution of Satellite Observations to Global Climate, Ocean, and Terrestrial Monitoring (*Thursday July 29*) By virtue of their global coverage, increasing record lengths, and sophisticated instrumentation, environmental satellites are playing an expanding role in monitoring global change and climate variations. This symposium will focus on the contributions of satellites to measuring variations on time scales ranging from seasonal-interannual to decadal. Topics include: Requirements for monitoring global change/climate variations; Observational results for all components of the Earth system - atmosphere, oceans, land, cryosphere - and on global change/climate forcings -solar, terrestrial, and anthropogenic; and plans for relevant future satellite observations will be presented.

The Nature & Tectonic Significance of Fault Zone Weakening

A joint Geological Society of London/Geological Society of America/InterRidge meeting

Abstract Deadline: **September 30, 1999**

8-9 March 2000, Geological Society, Burlington House, London

Many faults appear to form persistent zones of weakness that fundamentally influence the distribution, architecture and kinematic patterns of crustal-scale deformation and associated geological processes in continental and oceanic regions. To date, however, our understanding of the mechanisms that lead to changes in fault zone rheology, their many geological consequences and the larger-scale implications that they may have for lithosphere dynamics are still poorly understood. This meeting aims to brings together an international group of earth scientists working in both continental and oceanic regions to discuss a broad range of topics centred around the role of weak faults during crustal deformation.

Possible thematic sessions include:

- The nature of shear localisation and fault zone weakening mechanisms
- The detachment fault problem in continental and oceanic regions
- Fluid- and magma-induced changes in fault zone rheology
- Reactivation and seismic hazard assessment
- Weak faults and lithosphere dynamics

Contributors are invited to submit titles or abstracts (one sheet of A4) to the convenors. Deadline for the submission of abstracts will be **Sept. 30, 1999**. We hope to compile a thematic set of papers arising from this meeting and the deadline for the submission of completed manuscripts will be 8th March 2000 (i.e. at the meeting) in order to facilitate rapid publication.

Convenors:
Dr. Bob Holdsworth *R.E.Holdsworth@durham.ac.uk*
Dr. Jerry Magloughlin *jerrym@cnr.colostate.edu*
Prof. R.J. Knipe *r.knipe@rdr.leeds.ac.uk*
Dr. R.A. Strachan *rastrachan@brookes.ac.uk*

Upcoming Meetings and Workshops

RIDGE 2000 Conference: RIDGE into the Next Millennium

September 22-25, 1999, Newport, Oregon, USA

In September, 1999, the RIDGE 2000 Conference will convene at the Hatfield Marine Science Center in Newport, Oregon, to review the first decade of the RIDGE Program and to establish directions and priorities for RIDGE in the next decade. This meeting is intended to match the breadth and stature of the 1987 Salishan meeting, which recognized the need for inter-disciplinary collaboration and coordination, and led directly to the establishment of the RIDGE Program.

After a decade of remarkable progress, a second meeting of this stature is essential if the RIDGE Program is to remain viable for a second decade.

- We must respond to, and be part of, the millennial review and refocusing that is currently taking place across NSF and elsewhere.
- We must respond to, and allay, concerns at NSF and elsewhere, that RIDGE has run its course.
- We must refocus our program around those efforts that are truly not possible within the traditional core funding structure.
- We must provide a new, relevant, vital document that can convey our scientific goals and priorities to NSF, the National Academy, and others who are influential in guiding or controlling funding. Our plan must be credible to this audience and it must be seen to have strong community support.

Your comments and suggestions are welcome at any time.

Regards,
David Christie
Chair, RIDGE Steering Committee

For more information see:
http://ridge.oce.orst.edu/meetings/RIDGE2000/

Cahiers de Biologie Marine

Volume 39: 3/4, 1998

The proceedings from the **First International Symposium on Deep-Sea Hydrothermal Vent Biology** have been published in this special issue of *Cahiers de Biologie Marine.* This volume contains 43 papers devoted to hydrothermal biology and spanning the following topics:

- Ecology/Microdistribution/Temporal Evolution
- Physiology/Adaptation
- Cold Seep Communities
- Biogeography/Evolution/Genetics/Taxonomy
- Microbiology/Ultrathermophiles/Bacterial Symbiosis
- Biological Cycles/Larval Dispersion/Plankton

Guest Editors: Manuel Biscoito, Craig Cary, David Dixon, Heather Sloan and Cara Wilson

Contact the InterRidge Office for ordering information.

Upcoming Meetings and Workshops

The XVIIIth (New) International Congress of Zoology

28 August - 2 September 2000, Athens, Greece

Special Symposium B7:
Zoological implications of the discovery of geothermally-driven commmunities

Convener: Françoise Gaill, Université Pierre et Marie Curie, francoise.gaill@snv.jussieu.fr

The discovery of deep-sea vent fauna has given new insights into several important zoological aspects. These hydrothermal vents are one of the most unusual habitats found on earth. Vents are surrounded by a dense community which is supported by primary production through chemoautotrophic bacteria. Most of this fauna is composed of sessile animals that harbor these bacteria as intracellular symbionts. Such geothermally-driven commmunities are dependant on the reduced sulfur compounds found in the emerging hot hydrothermal fluid (up to 400°C) which are the main energy source for free-living and symbiotic bacteria.

Since the primary food source of the vent community is locally produced in the deep sea, it has been suggested that these communities are largely independant of environmental changes at the surface and not subject to the same evolutionary pressures as other organisms. Supporting this hypothesis is the fact that most of the organisms found at the vents are endemic. This observation raises the question of how old these ecosystems are and when animals first started to be associated with vents. These communities may have escaped the mass extinctions affecting surface dwelling organisms. Even though our knowledge about the zoology of this fauna is increasing, we still do not know what are the life cycles of these animals, what their larvae look like and where they are found.

Some spectacular organisms are found in these communities such as the polychaetous annelid *Alvinella pompejana* which is the most thermophilic metazoan known today and which could harbor the most eurythermal symbiosis of our planet. Vestimentiferans are unusual animals discovered in these areas and their taxonomical position is still in debate. These giant gutless organisms inhabit both vent and cold seep sites as do the bivalves. Understanding the dispersal, colonisation and succession of species in vent and cold seep habitats is a great challenge for the future and will shed light about major questions such as the origin of life, evolution of symbiotrophy, diversity of physiological adaptations and molecular phylogeny.

For more details see: http://www.ims.usm.edu/~musweb/icz_xviii/icz_home.html

11th International Symposium on Unmanned Untethered Submersible Technology (UUST99)

August 22-25, 1999, University of New Hampshire, Durham, New Hampshire, USA

The symposium will cover the following topics:

- Applications of AUV Technology
- Autonomous Manipulation
- Bioengineering
- Communications
- Distributed Control
- Energy
- Hydrodynamics
- Modeling
- Navigation
- Reliability
- Underwater Imaging
- Operational Systems Experience
- Sensor Systems and Processing
- Intelligent Systems and Technologies
- Guidance and Control Systems

For more information see http://www.uust.org/

Upcoming Meetings and Workshops

1999 Large Engineering Systems Conference Series

20-22 June 1999, Halifax, Nova Scotia Canada

Conference on Autonomous Underwater Vehicles (LESCOAUV'99)

This Conference will provide an international forum for participants to share knowledge, experience, new ideas and to discuss recent developments with practical applications in all aspects of Autonomous Underwater Vehicles. Original papers and proposals for invited sessions are solicited on topics related to new developments in the application, operating experience, field testing, theory, design, and analysis, in all areas of AUV Engineering. Areas of interest to the Conference include, but not limited to:

- Navigation for Underwater Vehicles
- Signals & Information Processing
- Communication and Telemetry
- Computational Intelligence Applications
- Hardware Trends
- Modelling and Simulation
- Instrumentation
- Vehicle Control
- Design Aspects

Conference on Underwater Cables (LESCOUCABLE'99)

This Conference will provide an international forum for participants to share knowledge, experience, new ideas and to discuss recent developments with practical applications in all aspects of underwater cables and connectors. Original papers and proposals for invited sessions are solicited on topics related to new developments in the application, operating experience, field testing, theory, design, and analysis, in all areas of underwater cables and connector engineering. Areas of interest to the Conference include, but are not limited to:

- Design of undersea cables
- Manufacturing Process for undersea cables
- Communication cable applications
- Oceanographic applications
- Fibre optic cables
- Instrumentation Cables
- ROV applications
- Modelling and analysis
- Computer-aided design

Further information (for both conferences) is available from Dr. Ferial El-Hawary, elhawary@dal.ca

Underwater Technology 2000 (UT'00)

"Advanced Underwater Technologies for the 21st Century"

23-26 May 2000, New Sanno Hotel, Tokyo, Japan

Abstract Deadline: November 19, 1999 see: http://manta.iis.u-tokyo.ac.jp/ut00/

Sessions will cover various technologies and applications in the underwater environment. Topics may include, but are not limited to, the following areas:

Underwater Acoustics
- Global Acoustics, Tomography
- Acoustical Oceanography
- Sound Propagation & Scattering
- Transducers & Arrays

Underwater Construction
- Harbor & Tunnel Construction
- Deep Sea Construction
- Diving Operations
- Saturation Diving

Underwater Vehicles & Robotics
- ROVs
- AUVs
- Manned Submersibles
- Underwater Robotics

Underwater Observation
- Imaging Systems
- Sensors
- Instrumentation Systems
- Underwater Cable Systems

Underwater Positioning
- Mapping & Guidance Systems
- Navigation & Tracking Systems
- Geodetic Measurement Systems
- Underwater Telemetry

Signal & Information Processing
- Detection & Estimation
- High Resolution Processing
- Image & Signal Compression
- Neural & Fuzzy Systems

For further information see the web page or contact Tamaki Ura, ura@iis.u-tokyo.ac.jp, or Robert L. Wernli, wernli@nosc.mil.

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