

InterRidge News

vol. 3, no. 2

Fall/Winter 1994

InterRidge Update

As 1994 draws to a close, so does Phase I of the InterRidge Program Plan. This first phase in the decadal program was dedicated to improving co-ordination of on-going independent national and international co-operative projects. InterRidge set out to achieve this goal by enhancing, encouraging and actively facilitating exchange of ideas and information at a series of workshops attended by a broad spectrum of the international ridge-crest research community. These workshops fostered interdisciplinary, international approaches to problems in ridge-crest study. Their aim was to bring the best available expertise to bear on problems too large or logistically complex to be within the capabilities of any single national programme. The success of this effort is partly reflected in the number of national ridge-crest study programmes which have sprung into being over the last few years. These programmes are now helping to co-ordinate research on both national and, in conjunction with InterRidge, international levels.

In 1994, InterRidge has become the community-supported international research initiative envisaged by scientists from 11 nations who attended the first formal InterRidge meeting held in France in 1989. InterRidge now counts 4 principal Member Nations: France, Japan, the United Kingdom and the United

States. Germany has also indicated its intention to join as a Principal Member this year and Spain is expected to become a Principal Member in 1995. Canada, Iceland and Portugal have expressed their intention to join as Associate Members. In addition, InterRidge maintains an active correspondence with ridge-crest researchers in Australia, Italy, Korea, Mexico, Norway, Russia and Sweden. It is hoped that India and Switzerland will soon enter into this correspondence and eventually become InterRidge Members. InterRidge is also being brought to the attention of ridge workers in other countries as opportunities arise.

InterRidge, SCOR and ODP

In addition to cultivating contacts with national ridge research programmes, InterRidge has been actively pursuing its links with such international programmes as the Scientific Committee on Ocean Research (SCOR) and JOIDES/ODP. The SCOR Working Group 99 "Linked Mass and Energy Fluxes at Ridge Crests" held its first meeting in Cambridge, UK, 10-12 October 1994. The Working Group was established by SCOR in 1992, following a proposal made by John Delaney and David Needham, then InterRidge Co-Chairs. Martin Sinha, as Working Group Chair, has since overseen selection of its members and directed its activities.

Contents

InterRidge Update.....	1
What is InterRidge?.....	3
InterRidge Provisional Calendar.....	4
JOIDES/ODP at the Ridge Crest.....	7
A Seismic and Geochemical Study of the Southwest Indian Ridge / T. A. Minshull <i>et al.</i>	9
International Co-operative Research Indian Ocean Column.....	10
Indian Ocean Planning Meeting Report / J.-C. Sempère.....	10
FARA.....	13
FARA Cruise Update / D.H. Needham.....	13
A Detailed Study of the Lucky Strike Hydrothermal Site and Discovery of a New Hydrothermal Site: Menez Gwen; Preliminary Results of the DIVA1 Cruise / Y. Fouquet <i>et al.</i>	14
New Information on the Ecology of Deep- sea vent Communities in the Azores Triple Junction Area: Preliminary Results of the Diva 2 Cruise / D. Desbruyères <i>et al.</i>	18
MODE '94	20
Diving and Surface Surveys of the Western Part of the Kane Transform Fault / H. Fujimoto <i>et al.</i>	20
Shinkai-Yokosuka MODE '94 Leg 2 Cruise Summary: Studies of an Active Hydrothermal Mound at the TAG Area on the Mid-Atlantic Ridge / Kantaro Fujioaka <i>et al.</i>	21
A Biological Observatory at Endeavour Segment, Juan de Fuca Ridge / Kim Juniper <i>et al.</i>	23
High rates of hydrothermal activity at the West Rift of the Easter Microplate deduced from metalliferous sediment composition / G.S. Roonwal <i>et al.</i>	26
Vector Geomagnetic Field Measurements over Mid-Ocean Ridges with Ship- board Three-Component Magnetometers / N. Seama <i>et al.</i>	28
World Ridge Cruise Schedule.....	30
GEBCO Digital Atlas Update.....	34
News from National Ridge Crest Research Programmes.....	35
Announcements and Notices.....	40
National Correspondents.....	43
InterRidge Steering Committee.....	44
National Admin. Representatives.....	44

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Dr. Heather Sloan, Editor.

The final membership of the SCOR Working Group 99 is:

Martin Sinha, Chair	UK
Henri Bougault	France
John Delaney	USA
Pall Einarsson	Iceland
Hiromi Fujimoto	Japan
Nils Holm	Sweden
Kim Juniper	Canada
Charles Langmuir	USA
David Needham	France
Anatoly Schreider	Russia

The Executive Reporter to SCOR is Nick McCave (UK). A full report of the Working Group's progress will be published in the next issue of *InterRidge News* in April 1995.

The recent shift in emphasis of the Ocean Drilling Program towards thematic science projects provides the ridge crest research community with the opportunity to benefit from the capabilities of this proposal-driven organisation. InterRidge considers ocean drilling an integral part of both its Meso-Scale and Active Processes programmes and encourages the community to explore the possibilities and advantages it presents. A summary of ODP's 1995 objectives and ridge crest related legs are given on page 7, followed by a brief report of a seismic and geochemical study centered on ODP site 735B. A brief summary of the ODP proposal submission guidelines and evaluation procedure appears on page 8 of this issue.

An International Database

As InterRidge enters into its second phase, the scope of its activities will broaden to include planning for international and interdisciplinary InterRidge Projects focusing on temporal variability and spatial characterisation of the ridge crest. In addition to information made available to the community through the publication of *InterRidge News* and workshop reports, InterRidge will establish an electronic database catalogue accessible via the Internet. The ultimate goal of this project is to link various national data archives via an InterRidge World Wide Web home page, which would allow users to access data maintained in several

databases around the world with a single query.

International Ridge Researcher Directory

The InterRidge Office is in the process of establishing an electronic international directory of ridge crest researchers accessible via the Internet on the InterRidge World Wide Web home page. It is expected that the directory will be on-line by February 1995. The directory will list the fields of interest of each researcher as well as their full coordinates (address, telephone, fax, e-mail). Individuals wishing to be included in the directory should complete the form on page 5 of this issue and send it to the InterRidge Office no later than 31 December 1994.

Workshops and Meetings

Following on from the 1993 Meso-Scale and Global Workshops, three new InterRidge Workshops have been held or organised in 1994. Each is designed to pursue questions or themes identified at a previous workshop. Themes for two workshops came out of the Global Meeting held in Paris in 1993, "Indian Ocean Planning Meeting" and "Arctic Ridges: Results and Planning". The Meso-Scale Workshop held in Durham, UK, generated the subsequent "4-D Architecture of the Oceanic Lithosphere Workshop". Reports from the 1993 Meso-Scale and Global workshops have been published and are available in hard copy upon request from the InterRidge Office. Alternatively, they may be imported from the InterRidge Gopher (piglit.dur.ac.uk).

One of the main objectives of the "Indian Ocean Planning Meeting" held in Baltimore, USA on 22 May, was the dissemination of information concerning scheduled field programs and further development of project co-ordination in the Indian Ocean. The other aim was to encourage interaction between geophysical/geochemical and biological/hydrothermal research communities. One of the outcomes of this meeting is the initiation of an "Indian Ocean Column" which will appear in the

InterRidge News starting with this issue.

The second spin-off from the 1993 Paris Global Workshop is the "Arctic Ridges: Results and Planning Workshop" to be held in Kiel, Germany on the 15-17 November. The principal foci will be to familiarise the community with existing Arctic datasets, identify data gaps, and to define approaches and implementation plans to meet the scientific and logistical challenges presented by this region.

The "4-D Architecture of the Oceanic Lithosphere Workshop" held in Boston, USA on 23 & 24 September, was an expansion on the theme of spatial and temporal characterisation of second-order ridge segmentation. The principal objective for this follow-up workshop was to draft a plan for co-ordinated segment-scale experiments over the next five years. It was decided that a geophysical/geochemical/petrological experiment should be carried out at both a fast- and a slow-spreading ridge. Agreed sites included Hess Deep (to study fast-spreading lithosphere formed at the EPR) and a short-list of four potential sites from the slow-spreading Mid-Atlantic Ridge: MARK, TAG, 29°N and 35°N. It is anticipated that work involving the resources of the Ocean Drilling Program will play an important role in the design of this project. A full report of the workshop will be available from the InterRidge Office in December 1994. National programmes have been asked to comment on these sites. A RISES Workshop convened by RIDGE immediately following the InterRidge Workshop represented the first such national discussion.

Heather Sloan
InterRidge Co-Ordinator

What is InterRidge?

InterRidge is an international and interdisciplinary initiative concerned with all aspects of mid-ocean ridges. It is designed to encourage scientific and logistical co-ordination, with particular focus on problems that cannot be addressed as efficiently by nations acting alone or in limited partnerships. Its activities range from dissemination of information on existing, single-institution experiments to initiation of fully multi-national projects.

Principal InterRidge activities are grouped under three major themes, or Integrated Projects, the objectives of which are:

- **Global Studies:** To acquire a balanced set of global-scale data on the entire mid-ocean ridge system, which implies notably a concerted effort of exploration in high latitudes where data are extremely sparse.
- **Meso-Scale Studies:** To investigate the interplay of mantle processes at temporal and spatial scales that bridge the gap between the global perspective and fine-scale studies of active processes. These "meso-scale" studies focus on processes that control magmatic and tectonic segmentation; quantification of mass, energy and chemical fluxes on the segment scale; and include a specific effort on ridges in marginal (back-arc) basins.
- **Active Processes/Temporal Variation Studies:** To observe, measure and monitor active processes at individual ridge sites in order to begin to quantify the fluxes of mass and energy involved and their biological consequences; and to understand the evolution, reproduction strategies and dispersion paths of hydrothermal vent biota and determine their relevance to and interaction with physical, chemical, and geological processes at the ridge crest. InterRidge activities are initiated within the international ridge crest research community, overseen by the InterRidge Steering Committee and the InterRidge Chair (see page 44) and co-ordinated through the InterRidge Office.

Who Does InterRidge Serve?

InterRidge is designed to serve national and international programmes, individuals and groups around the world engaged in ridge crest research.

What Services Does InterRidge Provide?

- **Promotion of communication and exchange of information and ideas amongst members of the international ridge crest research community.** By organising and facilitating meetings and workshops around the above scientific themes, InterRidge provides a venue for identification and discussion of the scientific issues of chief concern to the community.
- **Dissemination of information.** InterRidge edits and publishes:
 - Meeting and Workshop Reports - These reports serve not only to communicate the proceedings of workshops and meetings to members of the community, but also as a vehicle for their recommendations to various national and international research and funding agencies.
 - InterRidge News - This semi-annual newsletter is distributed free to members of the ridge crest research community. It contains:
 - reports on recent ridge crest cruises
 - updates on international co-operative research projects
 - news from national and international research programmes
 - various announcements and notices pertaining to ridge crest research
 - an up to date schedule of ridge crest cruises for 6 countries.
- **International Electronic Database.** The ultimate goal of this project currently being undertaken by the InterRidge Office, is to link various national and institutional data archives via an InterRidge World Wide Web home page, which would allow users to access data maintained in several databases around the world with a single query.
- **International Ridge Researcher Directory.** The InterRidge Office is in the process of establishing an electronic international directory of ridge crest researchers accessible via the Internet on the InterRidge World Wide Web home page. The directory will list the fields of interest of each researcher as well as their full coordinates (address, telephone, fax, e-mail).

Taking Part in InterRidge

Any individual engaged in ridge crest research may contact the InterRidge Office to request that their name be put on the InterRidge maillist and/or electronic directory. They will then receive *InterRidge News* as well as workshop announcements and other information. If your country would like to become an InterRidge Member Nation, a National Correspondent should be appointed in agreement with your national ridge crest research programme and funding agency. This correspondent should then contact the InterRidge Chair at the InterRidge Office for further information. InterRidge Member Nations are entitled to representation on the Steering Committee and participation in the direction of the InterRidge Initiative.

Provisional InterRidge Calendar

1994

4-D Architecture of the Oceanic Lithosphere
Boston, MA, USA; 23 & 24 September, 1994

SCOR 99 Working Group Meeting: Mass and Energy Fluxes at Ridge Crests
Cambridge, UK; 10-12 October, 1994

Arctic Ridges: Results and Planning Workshop
Kiel, Germany; 15-17 November, 1994

Steering Committee Meeting
San Francisco, CA, USA; 6 December, 1994

1995

Active Processes Workshop: "Event Detection and Response & A Ridge Crest Observatory"
Paris, France; 16-18 January, 1995

Biological Studies Workshop
January/February, 1995

Meso-Scale Workshop:
"Quantification of Fluxes at Mid-Ocean Ridges: Design/Planning for the Segment-Scale Box Experiment."
May/June, 1995 (provisional)

InterRidge Steering Committee Meeting: End of Phase I - Beginning of Phase II
to be held in parallel with a Meeting of DeRidge
Kiel, Germany; October/November, 1995

InterRidge Publications

InterRidge News:

InterRidge News, 1992, 1, 1, pp. 26.
InterRidge News, 1993, 2, 1, pp. 32.

InterRidge News, 1993, 2, 2, pp. 4 (bulletin)
InterRidge News, 1994, 3, 1, pp. 28
InterRidge News, 1994, 3, 2, pp. 48

Meeting and Workshop Reports:

InterRidge Program Plan, pp. 26, 1994.
InterRidge Program Plan Addendum 1993, pp. 9, 1994.
InterRidge Program Plan Addendum 1994, in prep.
InterRidge Meeting Report, Brest, France, 1990.
InterRidge Meeting Report, York, UK, 1992.
InterRidge Meso-Scale Working Group Meeting Report, Cambridge, UK, 1992.
InterRidge Steering Committee Meeting Report, Seattle, USA, 1993.
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 Steering Committee Meeting Report, Tokyo, Japan, in prep.
InterRidge Global Working Group Report 1994: Indian Ocean Planning Meeting Report, 1994.
InterRidge Meso-Scale Workshop Report: 4-D Architecture of the Oceanic Lithosphere, in prep.

These publications are available from the InterRidge Office upon request.

InterRidge Researcher Electronic Directory

This form may be used to add your name to the InterRidge Researcher Electronic Directory, the maillist, the electronic maillist and/or as notification of change of address.

The InterRidge Researcher Electronic Directory will contain a listing of each researcher's field of interest and expertise as well as their full coordinates. The Directory will be accessible on the World Wide Web via the InterRidge Home Page making it possible to carry out effective searches quickly and easily.

If you would like to be part of the first issue of the directory please complete this form and send it to the InterRidge Office no later than 31 December, 1994. It is expected that the full directory will be on-line by February 1995.

Please indicate whether you would like your name to appear on International Ridge Researcher Electronic Directory, the maillist, the electronic maillist (be sure to include your e-mail address). This is a change of address notice.

Name _____

Address _____

City _____ State/County _____

Post Code _____ Country _____

Tel.: _____ Fax.: _____

country code area code number

country code area code number

e-mail: _____

Name of your national ridge research program: _____

Which InterRidge Program Theme(s) is of interest to you?

Active Processes Meso-Scale Studies Global Studies

What are your fields of interest/expertise?

Biogeography

Geochemistry

Rheology

Biology

Gravity

Seafloor Morphology

Crustal structure

Magnetism

Sedimentology

Ecology

Microbiology

Seismology

Electromagnetism

Modelling

Structural geology

Engineering/Instrumentation

Petrology

Tectonics

Event detection and response

Plate kinematics

Volcanology



cut

fold

fold

affix
postage

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cut

JOIDES - Ocean Drilling Program at the Ridge Crest

Ocean Drilling Program 1995 Objectives

In April, the JOIDES Planning Committee finalized objectives for seven legs of drilling for the Ocean Drilling Program. The planned legs will be located in areas ranging from the equatorial Atlantic to the Arctic Ocean. Specific objectives of the legs include: characterizing the nature of tectonism at transform and collisional margin settings; Arctic glaciation, and gas hydrates. Presented here are those legs concerned with the ridge crest.

Leg 158: TAG Hydrothermal System

Leg 158 is planned to investigate ridge-crest hydrothermal systems, which play a fundamental role in transferring heat from the Earth's interior to its surface. The leg runs from September 28 to November 23, 1994, at the TAG hydrothermal mound at 26°N on the Mid-Atlantic Ridge. The drilling and logging program at TAG will attempt to characterize the fluid flow, geochemical fluxes, and associated alteration and mineralization of an active hydrothermal system on a slow-spreading ridge.

Leg 164: DCS Test - Vema Fracture Zone

Leg 164 is scheduled to test the diamond coring system (DCS). The test will be at the Vema Fracture Zone from November 6 to January 1, 1996. Throughout the past six years, ODP has expended considerable effort to enhance core recovery in difficult lithologies. Much of this effort has focused on the design and development of a diamond coring system (DCS). Land-based diamond coring is a proven technology. However, to use such technology on a

highly dynamic platform such as the JOIDES Resolution, the vertical motion (heave) must be compensated for to reduce weight on the drill bit. The secondary-heave compensation system is currently under development at ODP-TAMU. The Planning Committee recognizes that the development of the DCS is important to the completion of ODP long-range plans and has, therefore, tentatively scheduled an engineering leg to test DCS and the secondary heave compensation system.

ODP is currently staffing Legs 160 onward. Shipboard participation is by invitation from ODP's science operator at Texas A & M University. Information can be obtained by contacting Jack Baldauf, Manager of Science Operations, Ocean Drilling Program, Texas A&M University, 1000 Discovery Drive, College Station, TX 77845-9547, phone: (409) 845-2673, fax (409) 845-4557, Internet: baldauf@nelson.tamu.edu.

ODP Open Discussion Bulletin Board

The ODP LISTSERVER is a discussion bulletin board service to which individuals may subscribe via Internet. It permits exchange of information among all subscribers. Currently the list administrator, Linda Weatherford, sends a report of the previous week's shipboard scientific and operations activities to all subscribers. Site summaries are distributed as soon as they are received at ODP from the ship. Periodically, an updated cruise schedule and brief descriptions of upcoming cruises are sent out. Any subscriber may send files to the list administrator for distribution. A file sent to the list ad-

dress will be reviewed before being distributed. Anyone with an Internet address can subscribe. At present there are subscribers in the US, Canada, Europe, Australia and Japan. There is no charge for subscribing to the listserver.

To subscribe, send a brief message to Linda Weatherford (Weatherford@nelson.tamu.edu) requesting that you be added to the ODP-L subscription list.

JOIDES OFFICE RELOCATION

As of October 1, 1994, the JOIDES Office moves to the University of Wales, Cardiff. This is the first time that the JOIDES Office has been hosted by a non-US partner. As the new Planning Committee Chair, Rob Kidd will head the JOIDES Office, he will be assisted in running the office by: Colin Jacobs, Science Co-ordinator; Katherine Ellins, US Liaison; and Julie Harris, Office Co-ordinator.

After September 30th, please send all correspondence to the JOIDES Office at:

JOIDES Planning Office
Department of Earth Sciences
University of Wales, Cardiff
P.O. Box 914
Cardiff, Wales CF1 3YE (UK)
Tel: 44 (222) 874-541
Fax: 44 (222) 874-943
Internet: joides@cardiff.ac.uk

Next Proposal Deadline: JANUARY 1, 1995

Proposals or Letters of Intent (10 copies) must be submitted to the JOIDES Office by January 1, 1995 for review and ranking by the JOIDES Thematic Panels in the Spring. Contact the JOIDES Office for proposal guidelines.

JOIDES PROPOSAL SUBMISSION

There are two options to get your ideas into the system.

LETTER OF INTENT

A Letter of Intent is a three to four page outline of your idea(s) for scientific ocean drilling. It may be submitted as an alternative to a full proposal and will be forwarded to the panels for comments. Based on panel response, the preparation of a formal proposal may be recommended.

FULL PROPOSAL

An ODP drilling proposal must contain an abstract (400 words or less) and the following information to be accepted and forwarded to the four thematic panels for review:

- Scientific objectives preferably linked to COSOD or ODP Long Range Plan (LRP) themes (COSOD and ODP LRP documents are available from the JOIDES Office).
- Drilling sites that are tied to the stated scientific objectives and justified by appropriate site survey data.
- Completed ODP Site Survey Summary Forms (blanks are available from the JOIDES Office on disk or in hard copy).

In addition:

Ten hard copies of the entire proposal must be sent to the JOIDES Office. The JOIDES Office would also appreciate receiving a copy of the proposal via electronic mail or on floppy disk.

JOIDES REVIEW AND PLANNING CYCLES

SITE SURVEY DATA PACKAGE

The JOIDES Office will ask proponents of proposals that have been highly ranked to submit a site survey data package to the ODP Data Bank at LDEO by a July or November deadline. The guidelines for submission of site survey data are available from the JOIDES Office at any time.

JOIDES PROPOSAL REVIEW DEADLINES

JANUARY 1

A proposal or letter of intent submitted for this deadline will be reviewed in the Spring. The JOIDES Office will return comments, recommendations and data package requirements to proponents in April.

JULY 1

A letter of intent or proposal submitted for this deadline will be reviewed in the Fall. The JOIDES Office will return comments, recommendations, and data package requirements to proponents in October.

JOIDES PLANNING MILESTONES

APRIL

All "active" proposals (those submitted within the past 3 years) are considered and ranked by the Thematic Panels. A four year outlook is determined by the Planning Committee.

AUGUST

Based on proposal maturity and scientific priority, a short list of 10-12 proposals is compiled into a proposal prospectus by the Planning Committee.

DECEMBER

Following a review and ranking of proposals in the prospectus, and any other proposals added to the prospectus in the Fall by the Thematic Panels, PCOM sets the drilling schedule for the next fiscal year.

JOIDES Planning Office

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A Seismic and Geochemical Study of the Southwest Indian Ridge at ODP Site 735B

*T. A. Minshull, M. Muller and R. S. White
Bullard Laboratories, University of Cambridge*

The Southwest Indian Ridge is the longest segment of very slow-spreading ridge, and has been identified as a region of particular interest to InterRidge. In April-May 1994, aboard RRS *Discovery*, we conducted an extensive program of geophysical and geochemical sampling of two areas of the ridge, at the Atlantis II Fracture Zone and in an area of pre-existing swath bathymetric coverage around 66°E. Here we focus on the first of these areas, where our geophysical work was centered on Ocean Drilling Program Site 735B on the transverse ridge of the fracture zone. We ac-

quired a grid of wide-angle seismic profiles using ocean bottom seismometers (OBSs) and sonobuoys (Figure 1), with coincident 8-channel seismic reflection profiles, and underway gravity and magnetic data. Our seismic source was a tuned 10-gun, 4346 cu in (71 l) airgun array.

We recovered fresh basalts from the ridge segment immediately to the east of the fracture zone, and also sampled basalt from the region adjacent to 735B. The OBS data show good crustal P-wave arrivals, and clear mantle arrivals on some instruments. Two instruments placed on the uplifted block around

site 735B show high upper crustal velocities, as expected where gabbro is exposed at the seafloor. The location of the Moho triplication in this data suggests that the crust may be thinner than normal in this area. The seismic data should ultimately allow us to determine detailed variations in the P-wave velocity structure and thickness of the crust both along the transverse ridge and across the fracture zone, including the whole length of the ridge segment immediately east of the fracture zone to a small offset near 57°35'E.

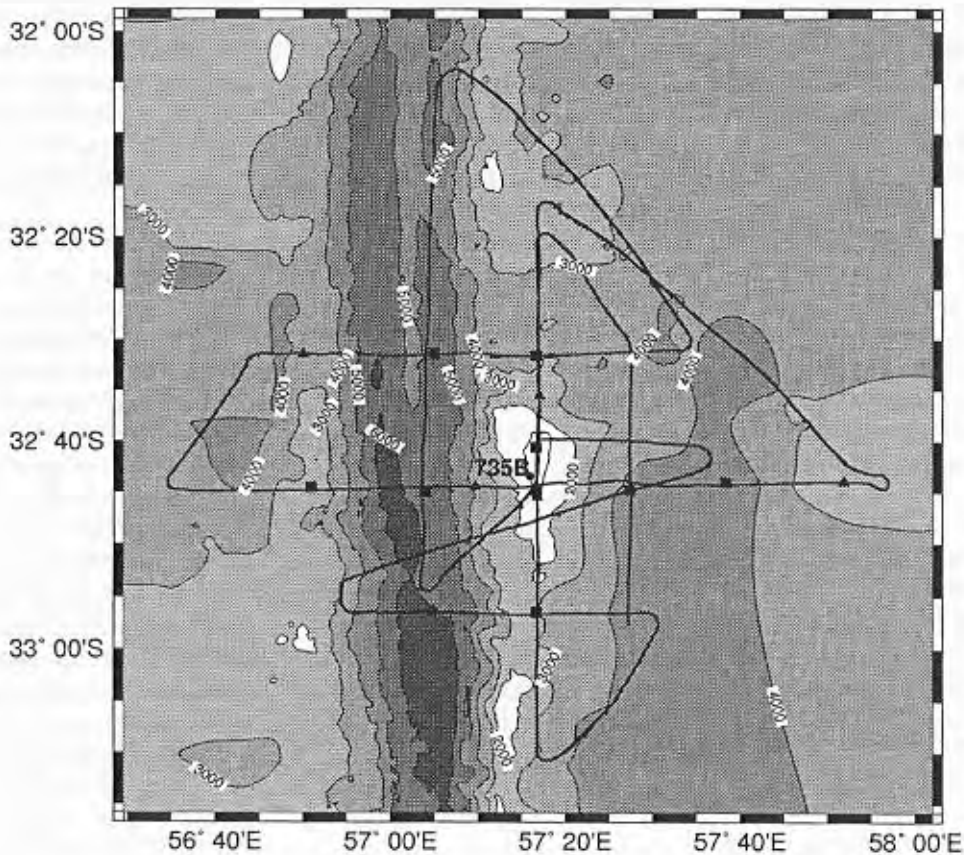


Figure 1. Layout of the seismic experiment at the Atlantis II fracture zone, overlain on bathymetry. Lines mark airgun shooting tracks, squares mark OBS locations, triangles mark sonobuoys from which good records were obtained, and the circle marks the Ocean Drilling Program borehole.

International Co-Operative Research

Indian Ocean Column

Indian Ocean Planning Meeting Report to InterRidge

Jean-Christophe Sempéré, University of Washington

Introduction

The Global Structure and Fluxes program of InterRidge focuses on the large percentage of mid-ocean ridges which have remained poorly characterized. At least two types of scientific problems concerning mid-ocean ridges require a global approach. First, the accretion and evolution of oceanic crust are multi-dimensional processes which necessitate the investigation of distinct, representative survey areas to separate the influence of different parameters (e.g. spreading rate, mantle temperature, proximity to hotspots,...). Second, some problems are global in scale and require survey areas which are very large compared to more conventional field programs (e.g. the characterization of global mantle reservoirs). These two factors explain why global scale studies of mid-ocean ridges are an important component of the InterRidge program.

The Indian Ocean includes three major mid-ocean ridges which are, for the most part, uncharted and unsampled. Thus, this region is of prime importance to the global component of InterRidge. The important scientific problems to be addressed in the Indian Ocean have been summarized in the report of the Global Working Group of InterRidge. This

report can be obtained by request from the InterRidge Office. The availability of several ships from several nations in the next 2-4 years in the Indian Ocean makes this region a natural focus of InterRidge. With this in mind, a meeting was held in Baltimore on May 22, 1994 to plan and co-ordinate international efforts in the Indian Ocean over the next few years.

Objectives of the meeting

The InterRidge Indian Ocean Planning Meeting had two main objectives. The first was to disseminate information regarding scheduled field programs in the Indian Ocean, as well as to plan and co-ordinate the future efforts of investigators or groups of investigators in this region. The number of funded and proposed projects presented in Baltimore attests to the health of the global program of InterRidge and to the high interest level of many scientists in working in the Indian Ocean. The second objective of this meeting was to allow the geophysical/geochemical communities and the biological/hydrothermal communities to interact. The success of the global program rests not so much on mapping remote spreading centers, but on obtaining an interdisciplinary dataset

over one or several supersegments. Inclusion of the hydrothermal and biological communities is an important component of our program. A large component of the discussion at the meeting was devoted to devising realistic strategies to achieve this goal.

Planned and proposed field programs in the Indian Ocean

Approximately half of the meeting was spent discussing planned and proposed field programs in the Indian Ocean. Individual investigators, already funded to work in the Indian Ocean, outlined the scientific objectives of their field programs and discussed their survey strategy. Table 1 lists the programs which are currently funded for the 1994, 1995 and 1996 field seasons. It is expected that ship tracks and sampling sites will be made widely available within a few weeks after each cruise, and that interested parties will be able to obtain more detailed information necessary for proposal writing or cruise planning (i.e. bathymetric grids, sample composition) by contacting the principal investigators.

In addition to the funded studies, at least two programs have been proposed in 1994 to various funding agencies. Table 2 lists the programs

Table 1: Funded Programs		
Dates	Objectives	Investigators
Dec 94 - Mar 95	Geophysical and geochemical study of the Southeast Indian Ridge between 90°E and 120°E	D. Christie (OSU) J. Cochran (LDEO) F. Frey (MIT) D. Graham (OSU) J. Mahoney (SOEST) J.-C. Sempéré
TBA	Geophysical study of the Southwest Indian Ridge between 15°E and 35°E	N. Grindlay (UPR) J. Madsen (UD) K. Macdonald (UCSB) J. Sclater (SIO)
TBA	Mantle composition and ridge dynamics of the Southeast Indian Ridge near the Amsterdam/St. Paul hotspot	K. Johnson (Bishop Museum) D. Forsyth (Brown) D. Scheirer (UCSB) D. Graham (OSU)
Oct 95 - Nov 95	Geophysical study of the Southwest Indian Ridge near the Galliéni Fracture Zone	P. Patriat (IPG)

that were discussed at the Baltimore meeting. Additional information regarding funded and proposed field programs in the Indian Ocean can be obtained directly from the principal investigators (see list of e-mail addresses at the end of this article).

Biological studies in the Indian Ocean

Biogeographic patterns of vent faunas are a priority for understanding the origins of vent communities. The Indian Ocean represents one of several areas remote from known hydrothermal communities. Thus, ridge-crest biological communities in the Indian Ocean should provide an important datum in our studies of global vent biogeography. Unfortunately, virtually nothing is known about hydrothermal activity in the Indian Ocean. Two hydrothermally-

active segments of the Central Indian Ridge have been identified. However, the exact location of the sources of these plumes is not known. Characterization of the hydrothermal setting of these segments of the Central Indian Ridge is viewed as a priority for initial hydrothermal investigations in the Indian Ocean. C. Van Dover has agreed to take the lead in getting an interdisciplinary/international group of investigators together to study one of these hydrothermal areas. We expect this work to spark a strong interest from the hydrothermal groups in InterRidge countries.

During the meeting, A.-L. Reysenbach discussed the use of biological films mounted on deep-sea instruments to obtain microbiological samples. Investigators planning to deploy instruments near Indian Ocean spreading centers are encour-

aged to contact Dr. Reysenbach for further information. This technique will be used this Fall in conjunction with the deployment of ocean bottom seismometers along the Southeast Indian Ridge. The preservation of deep-sea animals fortuitously sampled during dredging operations, was also discussed. The InterRidge Office will ensure that global investigators have access to the necessary items to preserve biological samples. Investigators planning to carry out dredging operations in the Indian Ocean should contact the InterRidge Office to obtain the items.

Future activities

The role of InterRidge in the characterization of Indian Ocean spreading centers was discussed several times during the meeting. A few specific tasks for the InterRidge Of

Table 2: Proposed Programs	
The distribution and character of hydrothermal tracers along the Southeast Indian Ridge	G. Klinkhammer (OSU) R. Collier (OSU) J.-L. Charlou (IFREMER)
Geophysical study of the Central Indian Ridge between 14°S and 20°S	A. Briais (CNES)

files were suggested.

Data archiving and dissemination are two important functions that are at present not overseen by any organization. The ready availability of basic information about Indian Ocean spreading centers was viewed by all participants as important. It was felt that InterRidge should take the lead in creating a database, accessible via Internet, and ultimately,

publishing an atlas of the data to be collected in future field programs.

The Baltimore meeting was a good example of the important role that InterRidge can play. The information disseminated at the meeting appears to have been beneficial to all participants. An annual Indian Ocean meeting organized by InterRidge in the next few years will continue to ensure proper dissemi-

nation of information and data. The next meeting will probably be held in Europe to facilitate the participation of European scientists who were under-represented in Baltimore. In addition, an "Indian Ocean Column" in the *InterRidge News* will be created to further facilitate the exchange of information regarding activities in the Indian Ocean.

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FARA

FARA CRUISE UPDATE

(*Project Franco-Américain d'étude de la Ride Atlantique;*
French-American Ridge Atlantic Project).

As endorsed under the US-France co-operation in oceanography, the FARA project concerns the study of the structure, dynamics and biological populations of the crest of the Mid-Atlantic Ridge in the Central North Atlantic between 15°N and 40°N.

There were 10 successful cruises during 1991-1992 (see *InterRidge News* vol. 2, no. 1, Spring/Summer 1993) and five in 1993. Two successful cruises have been conducted this year (1994) and at least three are provisionally planned for 1995, including a rescheduled, unsuccessful 1993 Alvin program to the

South Kane segment (see table).

Most of the 1993-1994 and currently planned 1995 activity focuses on detailed, Phase 2 investigations of specific areas following Phase 1 studies which were aimed at establishing the broad-scale variations in the overall architecture of the ridge crest. Research in 1993 and 1994 concerning hydrothermal systems, has included geological and biological submersible expeditions to the 37°15'N (Lucky Strike) site, discovered in 1992, and discovery and preliminary investigation of the 37°50'N (Menez Gwen) site in the summer of 1994 (see report in this

issue).

In parallel to the 1993-1994 sea-going activities under FARA, UK scientists have continued to work under the BRIDGE project between the Kane and Atlantis fracture zones, Japanese scientists have visited the western end of the Kane fracture zone and the TAG area, and a number of ODP related studies have been carried out in the TAG area in advance of the ODP drilling this Autumn.

It is anticipated that FARA fieldwork will be completed by the end of 1995 and a science symposium scheduled for mid 1996.

D.H. Needham

1993 and 1994 FARA Projects and Future Objectives

	Vessel	Cruise	P/I	Observations
1993	Noroît	Géofar	G. Auffret	Sediment sampling 37°-39°N for history of hydrothermal activity
	Noroît	Seadma II	M. Cannat C. Mével	Rock sampling south of Kane FZ, on- and off-axis
	Alvin+Suroît Atlantis II	MAR	C. VanDover A. Fiala-Médioni	TAG and Snake Pit biology
	Alvin+ Atlantis II	Lucky Strike	J. Dubois	Seafloor gravity measurements south of Kane FZ
1994	Nautil + Nadir	DIVA 1	Y. Fouquet	Further studies of 37°15'N (Lucky Strike) hydrothermal site, exploration of 37°50'N and 38°20'N axial volcanoes
	Nautil + Nadir	DIVA 2	D. Desbruyères	Biology of 37°15'N and 37°50'N
1995	Alvin + Atlantis II	-	J. Karson	Structure and petrology of South Kane segment
	*Nadir + Nautil	Oceanaut	D. Bideau R. Hékinian	Petrology and structure of South Oceanographer and North Hayes segments
	*Nadir Nautil	Microsmoke	D. Prieur	Microbiology of the TAG
	*Ewing	-	R. Detrick	Seismic structure of South Oceanographer segment (refraction + reflection) scheduling unlikely in 1995

*Provisional: not scheduled.

A Detailed Study of the Lucky Strike Hydrothermal Site and Discovery of a New Hydrothermal Site: Menez Gwen; Preliminary Results of the DIVA1 Cruise (5-29 May, 1994)

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Nineteen dives were completed with Nautile on three different volcanic segments located between 37°17'N and 38°20'N on the Mid-Atlantic Ridge (MAR) near the Azores. Cruise participants included scientists from IFREMER (France), University of Lisbon (Portugal) and Woods Hole Oceanographic Institution (USA). The cruise was part of the French-American FARA program on the Mid-Atlantic Ridge. The objectives of the cruise were to survey and sample the Lucky Strike (37°17'N) site in detail, and to extend exploration efforts to two other volcanic segments further north, in order to study the influence of water depth on volcanic and hydrothermal processes. The three dive sites investigated during the DIVA1 cruise, are located at the topographic highs of the volcanic segments which are called, respectively from south to north, the Lucky Strike segment (37°17'N), the Menez Gwen segment (38°50'N), and the 38°20'N segment (Fig. 1). Detailed geological mapping and rock and hydrothermal fluid sampling were carried out at Lucky Strike and the newly discovered Menez Gwen sites (Fouquet et al., 1994).

Since 1991, this area of the MAR has been extensively surveyed during five cruises conducted as part of the French-American co-operative agreement (FARA). The first bathymetric maps of the area were obtained using the EM12 system during the FARA-SIGMA cruise (H.D. Needham, IFREMER, Chief Scientist) in 1991. In 1992, during the 2 FAZAR survey cruises, (C. Langmuir, LDEO, and G.

Klinkhammer, OSU, Chief Scientists) sulphides were dredged from the top of the Lucky Strike segment (FAZAR Scientific Team, 1992; Langmuir et al., 1993a), and Mn and CH₄ chemical anomalies were identified in the seawater column (Charlou et al., 1992). Sediments were sampled on both sides of the ridge during the GEOFAR cruise (G. Auffret; IFREMER, Chief Scientist). Six dives were carried out with Alvin in 1993 on the Lucky Strike site (Langmuir et al., 1993a-b). Eight discrete active vents were found. Massive sulphides, basalt, hydrothermal fluids and biological samples were collected (Langmuir et al., 1993a-b; Humphris et al., 1993; Colodner et al., 1993).

Lucky Strike

The Lucky Strike segment is located between 37°00'N and 37°35'N. The rift valley is 15km wide and up to 950m deep. At its central part is a composite volcano 13km long, 7km wide, and 430m high, and divided into two parts separated by a N-S valley. The western part is an elongated narrow ridge while the eastern part has a semi-circular shape with three volcanic cones at its summit. The hydrothermal site is located in a depression between these three cones.

One of the major results of the DIVA1 cruise, is the discovery of a lava lake at the central depression among the three summit cones. The lava lake has a circular shape and is about 300m in diameter and up to 6m deep at water depths of between 1730m and 1736m. Very fresh lavas, exhibiting low vesicularity, are

present at the bottom of the lake (pillars up to 3 m high, collapsed lobate lava flows). In contrast, most of the three volcanic cones are composed of older, highly vesicular volcanic breccia. This lava lake was visible on the EM12 images as a black area contrasting with the grey color of the volcanic breccia on the three volcanic cones.

Active vents surround the lava lake, with the most active venting (dominated by large areas of low temperature diffuse flow) present on the western side. A large amount of older, inactive massive sulphide occupies ~80% surface area of the square kilometer surface area of the lava lake. These deposits are observed at water depths of 1730m to 1645m. They do not occur as a discrete, localised mound, but as an area of extended sulphide deposits around a circular depression which, at its base, is occupied by the lava lake. The sulphide deposits clearly correspond to several hydrothermal episodes spatially controlled by the lava lake. Hydrothermal discharge occurs through high temperature, active black smokers with anhydrite (324°C) flanges rich in barite and iron and zinc sulphides (170°C), and as low temperature diffuse flow with deposition of amorphous silica. Inactive portions of the deposits include iron and copper-rich massive sulphides and an unusual type of deposit termed hydrothermal slab, rarely observed but typical of this site. These slabs form very flat, layered deposits which are up to 10m thick in some places. Composition of the slabs vary, and include: breccia of massive sulphides cemented by silica, volcanic

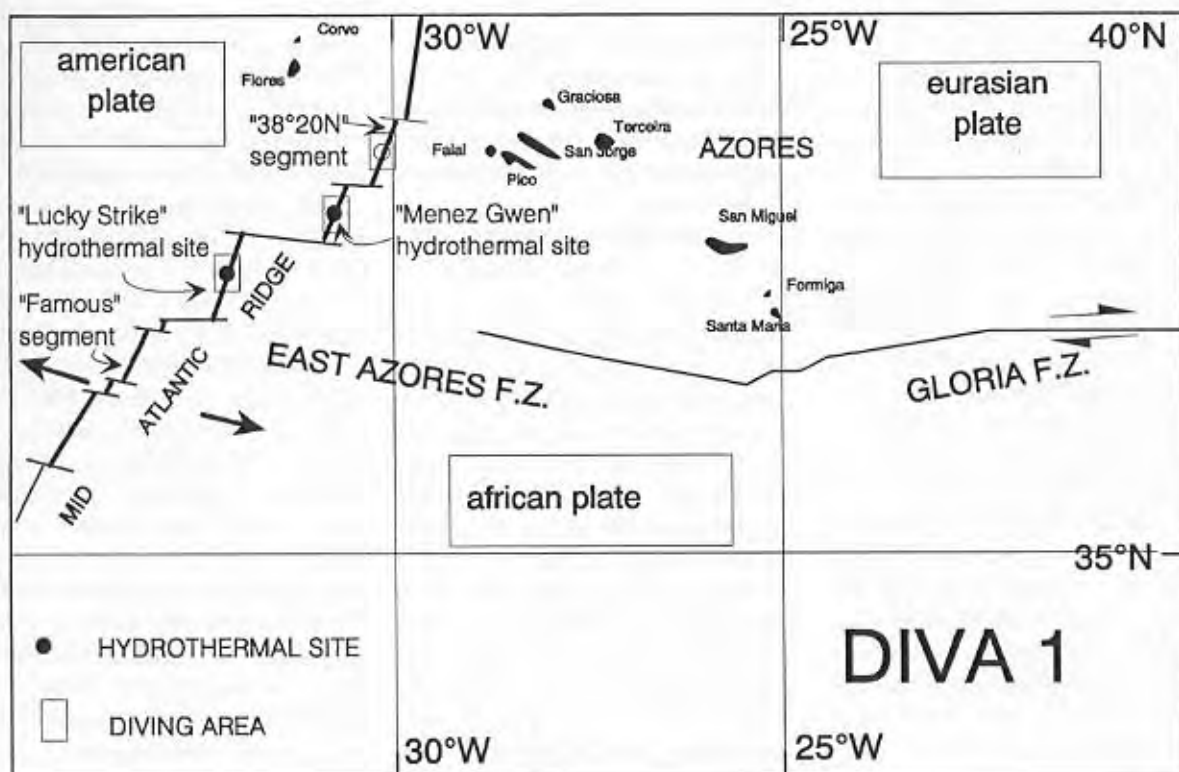


Figure 1

breccia cemented and altered by silica and sulphides, or silica and iron oxides, or iron oxides and iron/manganese. We confirm the dispersed nature of hydrothermal discharge at the Lucky Strike site compared to focused black smoker activity observed at the top of the sulphide mounds at the Snake Pit and TAG sites, also in the Atlantic.

Temperature anomalies associated with salinity anomalies were detected in the seawater column 100 m above the seafloor. A distribution map was made of H_2S and CH_4 at 2-5 m above the bottom (Radford-Knoery et al., 1994). At the active vents, temperatures measured in 1994 were similar to those measured in 1993. A temperature probe left in May 1993 and recovered in May 1994 revealed a remarkable stability for the same vent throughout the year (D. Fornari, pers. comm.). Temperature probes left for 18 days during the DIVA1 cruise, likewise all revealed stable temperatures. The highest recorded measured temperature ($324^\circ C$) is close to the boiling point of seawater at 1700 m water depth ($356^\circ C$; Bischoff and Rosenbauer,

1985).

During exploration dives to the west and north of the vent field, volcanic cones of very fresh pillows were observed at the top of the western ridge. This contrasts with the volcanic breccia observed on the three cones near the lava lake. The northern part of the 150 m deep, 1 km wide valley between the two volcanic systems is covered with very fresh sheet flows. This may indicate that the present-day axial valley is in this depression. However, the abundance of sediments in the southern part of the valley indicate that volcanic activity is not continuous along strike.

Menez Gwen Site

The Menez Gwen site, discovered during the cruise, is on the volcanic segment just north of the Lucky Strike segment (between $37^\circ 35'$ and $38^\circ N$). One of the particular characteristics of the segment is the absence of a central rift. EM12 sonar images indicate that relatively fresh lava occurs all along the segment. However, the main volcanic system is a circular volcano at the central part of the segment. This

volcano is 700 m high with a diameter of 17 km. At its top is an axial graben 6 km long, 2 km wide and 300 m deep. The graben is open both at its northern and southern part, and thus cannot be considered as a simple caldera system. A new volcano (600 m in diameter, 120 m high) is growing at the northern end of the graben.

Five dives were conducted to examine the central graben at water depths between 1000 m and 700 m. Most of the graben bottom is comprised of relatively fresh to very fresh lava. At the deepest part (1045 m) is a 1400 m long, 400 m wide and up to 8 m deep lava lake where very fresh lavas were sampled (as fresh as on super-fast spreading ridges). Lava pillars form at two to three distinct levels, each 1-3 m high. On both sides of the lava lake are fresh lobate flows. The northern extension of the lake is comprised of fresh pillows in a highly fissured area. On a 400 m high cross-section on the western central side of the graben, different types of volcanic products were seen. At the very base is the lava lake, and lobate and pillow flows corresponding to the recent

volcanic episode. Proceeding upward, there are two well separated units corresponding to a section across the older split volcano. The first unit at the core of the volcano is 60m high and comprised of several massive prismatic lava flows up to 3m thick. Very often the tops of these lava flows are composed of brecciated lava. At the top of the section is a 240m thick unit of volcanic ejecta starting at a water depth of 939m. This unit consists of variably layered volcanic ash, sand and lapilli. The contact with massive lava is sharp, and no lava flow was observed within the unit.

A new strategy to search for hydrothermal activity with the submersible was developed for the DIVA1 cruise. This strategy combines CTD measurements and mini-rosette water samples where both CH_4 and H_2S concentrations were measured. Sulphide concentrations range from <2-15mmol/L in vent fluids, while background sulphide concentrations are "zero" in deep water unaffected by plumes, making sulphide a potentially attractive tracer of hydrothermal plumes. However, vent fluids are typically diluted 106-fold in the overlying plume, and sulphide is rapidly removed (oxidized) from the water column. Therefore, analytical performance (detection limits, sample size, shipboard analyses) is central in using sulphide as an hydrothermal plume tracer. A new sulphide analysis method (detection limit 0.1nmol/L) was developed in the laboratory and tested onboard during the cruise (Radford-Knoery et al., 1994). A distribution map of sulphide at 2-5m above bottom at Lucky Strike (MAR at 37°20'N) was drawn. Sulphide anomalies (10-1000nmol/L) are observed in the vicinity of known venting sites, but not above the lava lake or near sedimented areas. Methane concentrations (up to 42nmol/L) from the same samples were always significantly above the background levels expected at this depth (0.4nmol/L) and showed more variability. Sulphide and methane data from the first exploration dive in the 37°50'N MAR segment allowed discovery, during the subsequent dive, of the Menez Gwen site. Again, a distribution map of near

bottom sulphide in the Menez Gwen segment was drawn. It shows two distinct sources of sulphide: the identified hydrothermal venting site, and an as yet unidentified site located near the contact surface between basalt and volcanic ejecta on the western graben wall.

The Menez Gwen site is near the top of the young volcano at the bottom of the graben. The volcano is composed entirely of extremely fresh pillows with no sediment cover. Compared to the Lucky Strike area, and more generally to the other sites on the MAR, the site is very young, but already very active. The first chimneys are just starting to grow on the fresh pillows. The site covers a 200m² area at a water depth of between 871m and 847m. The highest temperature measured (281°C) is close to the boiling point for this depth (305°C; Bischoff and Rosenbauer, 1985). Chimneys are typically less than 5m high and essentially composed of white anhydrite, formed by heating the seawater by hot, but clear, hydrothermal fluid. Around these white chimneys are small, relatively flat, mounds with hot water diffusing through all surfaces. These mounds are enriched in barite. At lower temperature, silicic slabs with some sulphides are formed. At one place white "smoke" with no deposits percolates slowly from a deep hole in the pillows. One major characteristic of the site is the scarcity of animals. This, together with the very fresh pillows, argue for the site being extremely young. However, the size of the mussels indicate that the site is probably at least a few years old. In 1993, a hydrocast from near the southern limit of the graben detected no methane anomaly.

38°20'N Segment

Only two dives were made on this segment at a water depth of between 930m and 510m. The morphology of the segment is very similar to the Menez Gwen segment. There is no rift valley and the central volcano is comparable in size (25km in diameter and 1200m high). The axial graben is 2km wide, 800m long and 500m deep. Water sampling with mini-rosette and CTD records show no evidence of hydrothermal activity

on the segment at this time. Methane values near the bottom are close to background levels. However, some very recent lava flows were observed at the northern end of the graben. The EM12 images reveal relatively fresh lavas present along the segment. During the dives we saw that most of the graben bottom is occupied by more or less tectonised volcanic ejecta very similar to the material observed at the top of the Menez Gwen segment. As at the Menez Gwen segment, there is a young volcano at the northern part of the graben. This volcano is composed of pillows, sometimes relatively brecciated. One characteristic of these pillows is their red color, indicating rapid oxidation of the hot lava. Past hydrothermal activity on this segment is expressed as silicification and iron oxidation in many of the volcanic ejecta samples are indicators of past hydrothermal activity on this segment. No other evidence of past or current hydrothermal activity was observed.

Hydrothermal Fluids

Twenty hydrothermal fluid samples were collected at the Lucky Strike (LS) site (1700m) and five on the new Menez Gwen (MG; 840m) site. At Lucky Strike, vents sampled in 1993 were revisited and new vents were also discovered with temperatures ranging from 170°C to 320°C and with pH 3.8-4.5. Menez Gwen vents exhibit temperatures between 265°C and 281°C with pH values between 4.2 and 4.8. Silica concentrations are different at the 2 sites (12-16mmol/kg at LS and 8-11mmol/kg at MG) but are consistent with control by quartz solubility. At Lucky Strike, major and minor elements are very similar to 1993 data (Colodner et al., 1993). Differences in major and minor elements are observed between the 2 sites. Menez Gwen chlorinities (360-380mM) are lower than Lucky Strike chlorinity levels (450-530mM). Similar differences are observed for other major elements. Na, K, and Ca levels are also lower in Menez Gwen hydrothermal fluids. Compared to other hydrothermal fields, all of the fluids collected at LS and MG have low sulphide concentrations (<2 mmol/kg). At the two

sites, all fluids are gas-enriched. Total gas volumes (520 to 957ml NTP/kg of fluid) are 3 to 5 times higher than those found in TAG black smokers. CH₄ (up to 2.2mmol/kg), H₂ (up to 0.7mmol/kg) and N₂ (up to 1.7mmol/kg) concentrations are high at the 2 sites compared to on the EPR, with CH₄ values 2 or 3 times higher at MG than at LS. All of the fluids have low concentrations of metallic elements. Chloride, hydrogen sulphide and metal depletion associated with gas enrichment in LS and MG fluids confirm the expectation that phase-separated effluents are delivered to the deep ocean in this area (Donval et al., 1994).

Conclusions

To conclude, we summarize the new findings of the DIVA1 cruise as follows:

- Discovery of the new Menez Gwen hydrothermal site.
- Use of a new strategy for exploration of vents with a submersible: CH₄ and H₂S measurement in near bottom seawater.
- Discovery of the first lava lake ever observed on a slow spreading ridge.
- Observation of the limit between effusive and explosive volcanism producing layered volcanic ejecta at water depths shallower than 900m.
- Complete cross-section of a volcano, including massive lava and volcanic ejecta.
- Detailed sampling (water and rocks) and geological mapping of the Lucky Strike site.
- Deployment of temperature probes for 18 days on the vents, showing a remarkable stability of temperature.
- Fluids sampled at Lucky Strike and Menez Gwen show low chlorinities, low H₂S content, low concentrations of metallic elements, and are gas enriched suggesting that phase-separated effluents are delivered to the deep ocean at these two sites.
- Hydrothermal precipitates cover a very large surface area (1km²), and correspond to several hydrothermal episodes. The size of the ac-

tive discharge zone contrasts with the well focused flow observed at black smokers sites in the Atlantic.

- Hydrothermal products are distinct in their mineralogy (enriched in barite) and morphology (hydrothermal slabs) when compared with other Atlantic hydrothermal deposits.
- Preliminary results will be presented at the AGU 1994 Fall meeting (oral and poster; Fouquet et al., 1994; Donval et al., 1994; Radford-Knoery et al., 1994).

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**New Information on the
Ecology of Deep-sea vent Communities in the Azores Triple Junction Area:
Preliminary Results of the Diva 2 Cruise
(May 31-July 4, 1994)**

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Following the Lucky Strike 1993 cruise and the DIVA 1 geological cruise (May 1994), 26 biological dives were completed with the submersible Nautilie in these two hydrothermally active areas: 1) the Lucky Strike Site located on Mid-Atlantic Ridge (MAR) between 37°17.25'N and 37°17.65'N at 1700m water depth (Langmuir et al., 1993; Fouquet et al., in press; Van Dover et al., in prep); and 2) the Menez Gwen Site located between 37°50.45'N and 37°50.56'N at 840-870m water depth (Fouquet et al., in press).

The principal objectives of the cruise were:

1. Description of the hydrothermal vent communities, i.e. faunal composition, population structure, microdistribution and environmental conditions.
2. Microbial studies: (a) isolation of thermophilic and ultrathermophilic bacteria and (b) structure of microbial communities associated with hydrothermal plumes.
3. Study of nitrogen, sulphur and carbon metabolic pathways in the symbiosis between mussels and chemoautotrophic bacteria.
4. Study of the transport of CO₂ and O₂ by blood pigments in shrimps and polynoid worms and mussel commensal.
5. Analysis of adaptation of collagen (Polynoids) and chitin (shrimps) to the vent environment.
6. Sample collection for genetics (phylogeny and population genetics).
7. P.O.M. fluxes from vents and from the surface were measured using sediment traps.

Lucky Strike

In the Lucky Strike area, several newly discovered sites located at the periphery of the central lava lake (cf. Fouquet et al., 1994 and this issue) were surveyed. All sites were dominated by beds of an undescribed mussel species distinct from all previously observed deep-sea mytilids (Craddock et al., in press). At this site, nearly all individuals were infested by one to three commensal polynoid worms belonging to *Branchyolynoe seepensis*. Mussels were distributed in patches of thousands of individuals, the smaller ones being located on the outer part of the beds and the largest were located in the middle (max. observed size 113 mm). Mean size of the mussels varies between patches according to their position within the site, the biggest individuals being located in the

warmest areas. All the frequency distributions are plurimodal and showing 3 to 6 modes. The population structures are different from site to site within an active zone and there is spatial segregation at any given site (Comtet, pers. comm.). Several mussel patches were covered by thick fibrous bacterial mats. Fifteen temperature time series (from one day to two week duration) were recorded using HOBO probes (cf. Fornari, 1994) at different places within mussel beds. As previously described from other vent areas (Chevaldonné et al., 1991), temperature varies rapidly with a maximum of 18°C; and several periodicities seem to be superimposed. Shrimps were living in small swarms on smoker walls or within the mussel beds. They belong to three species, two species of *Chorocaris* (Van Dover et al., in prep.) and one species related to the genus *Rimicaris* (Lallier, pers. comm.). Bythograeid crabs belonging to the genus *Segonzacia* were abundant within mussel clumps and on active sulphides. Several species of limpets and coiled gastropods were found on mytilid shells. An Ampharetid polychaete belonging to a new taxa of Samythingi, generically distinct from *Amphisamytha* (Desbruyères, pers. comm.) was ob-

served dwelling in tubes on shells and sulphides. Non-vent fishes were seen penetrating into the vent areas. The most commonly observed species belongs to the genus *Cataetyx*. A pink fish tentatively attributed to *Onogadus* was observed living in cracks within mussel beds. Several rat-tail fish, deep-sea sharks, and chimaeroids were observed at the periphery of the sites. Two squids belonging to *Mastigoteuthis* (Gonçalves, pers. comm.) were collected and video recorded around the vent area one in Lucky Strike and the other at Menez Gwen (Saldanha and Bischoff, pers. comm.). The specific diversity of the communities seems rather low as compared to EPR vent communities but of the same order as other MAR communities. Urchins (*Echinus* sp.; Sibuet, pers. comm.) observed at the border of several of the vents in 1993 (Van Dover et al., in prep.) were very rarely observed in 1994.

Menez Gwen

The Menez Gwen Site is situated near the top of a young volcano (Fouquet et al., this issue) and covers a 200m² area. Maximum venting temperature recorded was 281°C inside a smoker but diffuse venting (up to 25°C) occurred throughout the entire area. Sulphide mounds were covered with populations of mytilids. Mussel beds contained a mixed size range of individuals and the determination of the number of species, and whether or not they are the same mussels found at Lucky Strike, will require genetic studies. In contrast to Lucky Strike, the Menez Gwen population did not contain commensal Polynoid worms. Some clumps of mussel had numerous limpets on their shells. Bresiliid shrimps (*Chorocaris* sp.), serpulids, ophiuroids and crabs (including a geryon red crab belonging to *Chaceon affinis*) were also present. Abundant bathyal faunas were observed at the periphery of the site including pandalid shrimps (*Plesionika* sp.), fish (*Etmopterus pusillus*, *Lepidion schmidti*, *Epigonus telescopus*, *Synaphobranchus* sp., *Photostomias* sp., *Scorpaena* sp., *Malacocephalus laevis*, *Beryx*

splendens, *Neocyttus helgae* ...), squid (*Omastrephes pteropus*?) and living and dead black coral (*Anthipates* sp.; Bischoff and Saldanha, pers. comm.). One of the most exciting findings was that the mussels and shrimps from the Menez Gwen Site could be kept alive and in good condition in cooled seawater at atmospheric pressure for weeks. This introduces the possibility of easily carrying out physiological experiments.

Histological studies of the endosymbionts in mussel gill tissue demonstrate that the Lucky Strike mussels contain both sulphide-oxidizing and methylotrophic bacteria (Fiala Médioni, pers. comm.) as do mytilids from Snake Pit (Cavanaugh et al., 1992). Enzyme studies showed that the gills, but no other tissues of the mussels, contained methanol dehydrogenase (an enzyme found in methane-oxidizing bacteria), adenylylsulphate reductase and ATP sulphurylase enzymes usually found in sulphur oxidizing bacteria. Isolated gills remove both sulphide and methane from the water at an appreciable rate (Dando, pers. comm.). Several enzymes which are part of the nitrogen metabolic pathways were tested including enzymes involved in nitrogen assimilation or dissimilation. No sign of the presence of nitrogenase was observed when glutamine and glutamate synthetases were present (Felbeck, pers. comm.).

The faunal compositions of Lucky Strike and Menez Gwen vent communities differs markedly from those previously described at the Snake Pit and TAG areas (MAR). This variation may be due to isolation mechanisms such as water depth at Lucky Strike and Menez Gwen (800m) which is very much shallower than at the Snake Pit and TAG areas (3400m). Further extension of our exploration to the deeper FAMOUS area would lead us to a better understanding of the role of bathymetry as an isolating mechanism versus latitudinal gradients and isolation by transform faults and fracture zones.

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MODE '94

Diving and Surface Surveys of the Western Part of the Kane Transform Fault

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Introduction

In June and July 1994, we carried out a submersible dive program and surface ship survey of the western part of the Mid-Atlantic Ridge Kane transform fault area (WMARK) as part of a joint research program between the Japan Marine Science and Technology Center (JAMSTEC) and the Woods Hole Oceanographic Institution (WHOI). This cruise is the first of four cruises of the Mid-Ocean Ridges Diving Expedition (MODE '94) which will survey the Mid-Atlantic Ridge and the East Pacific Rise using a submersible "Shinkai 6500", and its mother ship, "Yokosuka". MODE '94 was planned as a contribution to InterRidge program from Japan in cooperation with US. The WMARK area was chosen for this research because this it is one of the best areas for the studies of deep crustal structure. In addition, it has been extensively studied from the surface and very little by submersible.

The cruise started from San Juan, Puerto Rico on 25 June 1994 and ended at Woods Hole on 24 July. The weather was good to excellent, permitting the successful execution of the fifteen scheduled dives during the one month cruise. The dive locations were planned based on Sea Beam swath bathymetry provided by WHOI and TOBI side-scan images of detailed seafloor topography kindly provided by a UK team. Along with a focused diving survey, we carried out a surface geophysical survey around the diving site at night and also on submersible maintenance days.

Objectives

Dives in the WMARK area were concentrated in two zones: Site 1 at the intersection of the neovolcanic zone and the Kane transform fault; and Site 2 in the active transform fault immediately to the east of the intersection. The surface geophysical survey was another important aspect of this cruise. The following is a brief summary of the objectives for this research.

The main objective of the dives at Site 1 was to observe and understand tectonics and volcanism in and around the ridge-transform intersection (RTI). We adopted two approaches to compare crustal composition and physical properties across the boundary between the active spreading center and the old crust to the south. The first is fundamental to any diving survey: visual observation and rock sampling. The second was seafloor gravity and magnetic measurements which were combined with a sea surface geophysical survey.

The dives at Site 2 had three objectives. The first was to determine the nature and crustal properties of the prominent median ridge observed in the multibeam bathymetry at the western end of the active transform fault. The second was to understand detailed tectonic processes at the active transform. The third was to place constraints on the composition of deep crustal rocks at the inside corner high to the northeast of the RTI. Submarine geophysical measurements were also important here.

Surface ship operations were planned to achieve the following ob-

jectives. The first was to provide the necessary background information on the regional geological, tectonic and geophysical setting of the dive sites. The second was to obtain shipboard gravity data along the Mid-Atlantic Ridge north of the Kane transform fault in order to define the variations in crustal density structure associated with ridge segments and a series of non-transform offsets. The third was to obtain off-axis narrow multi-beam bathymetry, gravity, and magnetic data coverage in order to define variations in crustal structure associated with the evolution of the MAR segmentation during the last 7-10 million years.

Preliminary Results of the Dive Survey

Eight dives were devoted to the survey of the RTI. Fresh pillow basalts were observed on the tip of the neovolcanic zone close to the Kane transform fault. A belt of fractured rocks in the neovolcanic zone shows that recent crustal deformations occurred across it. We also observed several clefts running parallel to the transform fault. Repeated landslides have occurred on the steep slopes near the RTI. The south wall of the RTI is composed of basaltic rocks in contrast to observations from inside corner highs in the eastern Kane transform fault. The submersible dove to the depth of 6025m at the center of the nodal deep to make a gravity measurement. The sediment was thinner than expected.

During four dives across the transform faults east of the RTI, we observed well-preserved fault scarps
continued on page 27

Shinkai-Yokosuka MODE '94 Leg 2 Cruise Summary: Studies of an Active Hydrothermal Mound at the TAG Area on the Mid-Atlantic Ridge

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Richard P. Von Herzen, Woods Hole Oceanographic Institution
and the Shipboard Scientific Party*

Introduction

A series of dive experiments designed to monitor active hydrothermal vents were successfully performed with the deep-sea submersible Shinkai 6500 at the TAG hydrothermal mound on the Mid-Atlantic Ridge. The 30 day cruise which started from Woods Hole on 29 July, 1994, and ended at San Juan, Puerto Rico on 27 August. It was planned as a co-operative research project between Woods Hole Oceanographic Institute (WHOI) and Japan Marine Science and Technology Center (JAMSETC), and was carried out during the second leg of the Yokosuka/Shinkai 6500 Mid-Ocean Ridge Diving Experiment, MODE '94. The TAG cruise also played an important role in determining pre-drilling parameters such as temperature, heat and chemical fluxes and their variability, in preparation for ODP Leg 158 in which several drill holes are planned at and near the TAG mound.

Objectives

The main objectives of this cruise were to evaluate the heat and material fluxes that emanate from the TAG mound through black smokers, white smokers and diffuse zones by the use of geophysical and geochemical instruments, before ODP drilling. To do so, long term monitoring of the thermal state under the TAG mound required development of special instrumentation. These systems were deployed by the Japanese submersible Shinkai 6500 around the central black smoker at the site called "Laputa".

During 15 dives by the Shinkai 6500, the following geophysical, geological and geochemical objectives were accomplished:

1. Deployment of three "Giant Kelp", vertical thermistor arrays which are ~50m in height and are

composed of 8 thermistors with a floatation device at the top. The Giant Kelp arrays were distributed approximately evenly over the edifice of the Laputa.

2. Deployment of Daibutu system, a data logger connected to a horizontal network of 8 heat flow probes on the TAG mound.
3. Geochemical analysis of the time series sampling of hydrothermal fluids using both ORI and Alvin type water sampler to collect fluid from the black smoker, white smoker, diffuse water and ambient water.
4. Sampling of sulphide blocks, crust and sand from various locations on the TAG mound and slope.
5. Measurement of heat flow and gravity on the mound and surrounding areas.
6. Observation of faults, cracks and fissures over the region between the TAG and the MIR site.
7. Deployment of a long term observation system, Manatee, which includes a CTDV, current meter, video and still cameras, and transmissometer, next to a black smoker site to observe currents and the temporal variation of temperature and biological community near the ocean floor.
8. Deployment of three OBSH to the west of the present spreading center axis and one OBSH just beside the Manatee system in order to detect both tectonic and volcanic seismicity during 7 days. This data will be used to try to determine the depth of the magma chamber beneath the TAG mound.
9. *In situ* chemical analysis of Si and H₂S were carried out and an Eh meter was deployed to evaluate oxidation and reduction along the ship's tracks.

Using data gathered in these measurements we intend to improve our understanding of the structure and

dynamics of the TAG hydrothermal mound.

Summary of the Results

During this cruise, 15 dives were successfully accomplished by the Shinkai 6500. The surface ship Yokosuka was also used to launch instruments and to make geophysical measurements. The following briefly summarize the results of this cruise.

Topography and geology:

The TAG site is located on the eastern flank of the rift valley of a segment of the Mid-Atlantic Ridge system. TAG is a nearly circular mound 150-200m in diameter whose maximum height is almost 70m. The TAG mound consists of two relatively flat terraces, the lower and upper terrace. The depth of the boundary between basal pillow lava and the sulphide mound differs around its periphery. This boundary occurs at greater depths at the northern edge, while pillow lava is exposed in the eastern and southern boundary almost at the same level as the upper terrace. The central black smoker site called "Laputa" stands ~15-20m above the upper terrace and has a diameter of 5-10m. The edges of the mound consist, for the most part, of sulphide talus overlying pillow lava and calcareous ooze. The lower part of the slope consists of huge blocks of sulphide, *in situ* outcrops of sulphide rock and crust make up the middle part. The upper part has small somma-like ridge 2-3 meters wide and 3 to 5 meters high. On the northeastern slope many huge slope failures, valleys and debris flow deposits were observed, suggesting recent and old slope failures that may have been triggered by nearby earthquakes.

The long term observation system called "Manatee" was deployed at the eastern pit for 16 days

and obtained 30 minutes of intermittent video and 800 still photos as well as current and nephelometry data.

Geophysics:

Three Giant Kelp thermistor arrays were deployed at ~5m intervals in a triangular pattern around the upper Laputa to monitor the black smoker for up to half a year. A high temperature probe was also deployed inside one of the black smoker vents near the Giant Kelp. A long-term heat flow monitoring system called "Daibutu" was deployed on the southern upper terrace. Three heat flow probes were set to the west, one to the southwest and one to the south of Laputa. The temperature fluctuation was notable during the first 10 days showing a probable variation with a 12 hour period. Heat flow measurements were carried out at 10 stations. One station east of the base of the Laputa recorded a value more than 100W/m², which is the highest value so far measured at the TAG mound.

Gravity measurements were performed at 12 stations across the TAG mound and surrounding seafloor in a north to south profile.

Gravity data indicate a significantly greater mean density beneath the sulphide mound compared to the surrounding basalt pillows.

Seismicity around the Mid-Atlantic Ridge will be deduced from the records of the OBSH deployed on the ridge axis. We have checked the first 12 hours of the records obtained at location HDJ3 and detected more than 20 events per hour. Most of these events are local microearthquakes with magnitudes less than 2 and events with S-P times of about 1 sec are dominant.

The records obtained by the OBSH installed on the TAG mound site are not retrievable onboard. We could only verify the number of files. The number of files is 1220 and each file includes continuous, 7 minute record.

Surface ship geophysical measurements, i.e. multi-beam bathymetry, gravity and magnetics, were carried out between the dive operations and during the maintenance days of the Shinkai 6500. Coverage extends over approximately 4000 miles on and off the ridge axis,

including the WMARK and TAG areas.

Geochemistry:

Several attempts were made to take end-member fluid samples from the black smoker site Laputa, but all failed owing to the poor visibility and strong current. We obtained fluid samples from white and black smokers at other sites to the east of Laputa and ambient seawater from the off-mound area. The pH and alkalinity of the white smoker fluid, were lower than that of any sample yet obtained. The black smoker fluids show an intermediate chemistry between real end-member and seawater. In situ measurements of Si and hydrogen sulphide content in the seawater were attempted twice on the TAG mound. Only the Si concentration measurement was successful. Several notably higher silica concentrations were detected during dive #216, and one large peak during dive #226 at the diffuse zone south of the Laputa. The data correlate well with temperature and Eh values measured simultaneously by Shinkai 6500.

**Shipboard Scientific Party
of Leg 2 of MODE '94 to the TAG Area**

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 - Dr. Richard P. VON HERZEN, WHOI, Assoc. Chief Scientist, Geophysicist
 - Dr. Toshitaka GAMO, ORI, Univ. of Tokyo, Geochemist
 - Dr. Hitoshi CHIBA, Dept. of Earth and Planet. Sci., Kyushu Univ., Geochemist
 - Dr. Harue MASUDA-NAKAYA, Dept. of Geosci., Osaka City Univ., Geochemist
 - Dr. Masataka KINOSHITA, School of Mar.Sci. & Tech., Tokai Univ., Geophysicist
 - Dr. Osamu MATSUBAYASHI, Geol. Surv. of Japan, Geophysicist
 - Dr. Azusa NISHIZAWA, Hydrogr. Dept. Jap., Maritime Safety Agency, Seismologist
 - Dr. Rob L. EVANS, WHOI, Geophysicist
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 - Ms. Henrietta N. EDMONDS, MIT, Geochemist
 - Mr. James G. KIRKLIN, WHOI, Marine Tech.
 - Ms. Misumi AOKI, Mar. Tech. Depart., Nippon Marine Enterprises Ltd. Marine Tech.
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A Biological Observatory at Endeavour Segment, Juan de Fuca Ridge

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A biological observatory was established in July 1994 in the Main Vent Field of Endeavour Segment, Juan de Fuca Ridge, as a result of a collaborative effort involving two Canadian and two American universities and the Geological Survey of Canada. Jointly funded by NSERC Canada and the West Coast NOAA National Undersea Research Center, the cruise used the Canadian deep water ROV ROPOS and support ship C.S.S. John P. Tulley to deploy instrumentation, stain tube worms for growth measurements, conduct high resolution temperature surveys of animal microhabitat, make complete collections of faunal assemblages at specific microhabitats and collect imagery for photo and video mosaics. Despite recurrent hardware prob-

lems with acoustic navigation, another result of the cruise was the georectification of a previously published map (Delaney et al., 1992) of the Endeavour Segment vent fields.

The long term goal for this observatory is to create a dynamic vent field model of carbon and energy flow that is coupled to changes in hydrothermal flux. Endeavour Segment vent fields, like most studied to date, comprise a heterogeneous patchwork of distinct vent habitats colonised by specific faunal assemblages. In order to study the full range of habitats, we have developed two complementary research strategies:

1) In each year of our observatory program, we are selecting one visually distinct faunal assemblage for

intensive study of productivity and ecological interactions, using year-long camera and thermistor array deployments. The evolution of these two sites will also be followed in subsequent years with continuing growth studies, biomass assessments and individual recording thermistors.

2) Determining biomass and productivity of biological communities on the large chimney complexes of the Endeavour Segment requires a different approach. Rather than focusing on a small area of a chimney that can be imaged by a single time-lapsed system, we have elected to study an entire chimney complex using mosaicking methods. Repeating imaging surveys and quantitative sampling over several years will permit documentation of chimney evo-



Figure 1. The AVCS time-lapse system in position at the S&M diffuse flow site. Submersible manipulator (at right) is deploying thermistor probes from quivers mounted on camera frame. Seamless mosaic (from ROPOS video) prepared by J. Sarrazin.

lution and faunal colonisation of chimney surfaces.

We are also developing a GIS database that will be used to quantify the surface occupied by different habitat types within the Main Vent Field. This tool will be the key to scaling up our growth and biomass measurements and developing a vent field model of carbon and energy flow through biological processes.

For the first year of the observatory we developed our *in situ* instrumentation at two low temperature diffuse flow sites inhabited by large vestimentiferans, and used a combined sampling and imaging approach to quantitatively map community distributions on a single sulphide chimney complex (S&M). One of the diffuse flow sites is located at the base of S&M, while the other is near another sulphide structure to the east (Peanut).

S&M chimney complex

The S&M site comprises an active sulphide edifice and adjacent diffuse venting in an area approximately 9m long and 4m wide, elongated north-south along the western edge of a fissure zone. The sulphide structure has a crudely elliptical base of sulphide rubble that forms the foundation for two sulphide chimney complexes known as the North Spire and the Southern Cluster, located at its north and south ends, respectively. The entire structure was imaged in 1991 using the Jason ROV and then temperature mapped using the Alvin submersible. Venting activity on the North Spire appears to have diminished significantly in the past 3 years, while chimneys of the Southern Cluster remain very active and have expanded both vertically and horizontally through sulphide accretion.

S&M diffuse flow vents

The diffuse venting area consists of numerous colonies of large vestimentifera and associated organisms, scattered over an area of 25m², along the north end of the mound. Their distribution is strongly controlled by north-south trending fracture patterns in the underlying pillow basalts.

Easter Island diffuse flow vents

The Easter Island vent area is located along the western margin of the Main Vent Field, approximately 20 m north of the Peanut sulphide structure. It is hosted by a small, low-walled fissure, or graben, that appears to be a relic sulphide chimney field. The north end of the graben floor is occupied by a vestimentifera colony 4 to 5 m long and 2 to 3 m wide, much of the colony is localised along fractures in the underlying pillow flows. Several smaller vestimentifera colonies are located to the east and southeast, along a line skirting the base of the Peanut-Bastille sulphide complex.

The diffuse flow sites are being monitored by time-lapse imaging systems coupled with thermistor arrays. Tube worm tubes at both sites were stained with vital chitin stain, and will be collected in 1995 for determination of annual growth. We are developing improved statistical methods for modelling and estimating growth parameters and ages from these kinds of annual growth data. Deployment of markers around the camera sites permitted reconstruction of each site as image mosaics from digitised video frames. The mosaics will ultimately serve in quantifying the biomass and spatial extent of these communities. At the S&M site, a Hi 8mm Autonomous Video Camera System (AVCS) is recording 1sec of video every hour for 300 days. The system deployed at Easter Island is a PhotoSea 35mm time-lapse camera package taking photographs every 30 hours, set for close-up imagery of stained vestimentifera. Each of the



Figure 2. Tube worm staining in progress. Once the staining dome is in place over tube worms, vital chitin stain is drawn from a reservoir mounted on ROPOS and recirculated within the dome for 2-4 minutes. There are presently 6 stained groups of tube worms at the observatory site. Image prepared by I. Urcuyo.

8 thermistors within the arrays is recording temperature every 10 minutes during the full deployment. Additionally, a HOBO recording thermistor is deployed among stained tube worms at each site.

Both still photos and video images are being used for mosaicking. Emphasis will be on linking changes in chimney growth and activity to the spatial distribution of the 3-5 visibly recognisable faunal assemblages that colonise the Endeavour sulphide structures. Initially, we will be comparing reconstructions of S&M based on the 1991 Jason imagery and the 1994 ROPOS images. We plan to re-image the structure again in 1995, 1996 and 1997. Individual chimney faces are presently being reconstructed at different levels of resolution, essentially flattening out local relief. From these mosaics and quantitative samples, we will develop first order estimates of organism abundance and biomass. We are also developing several approaches to 3-dimensional reconstruction of chimney complexes, including the draping of the mosaics onto simple 3-D geometric structures, guided by stereo photos and short-range acoustic ranging of the S&M structure.

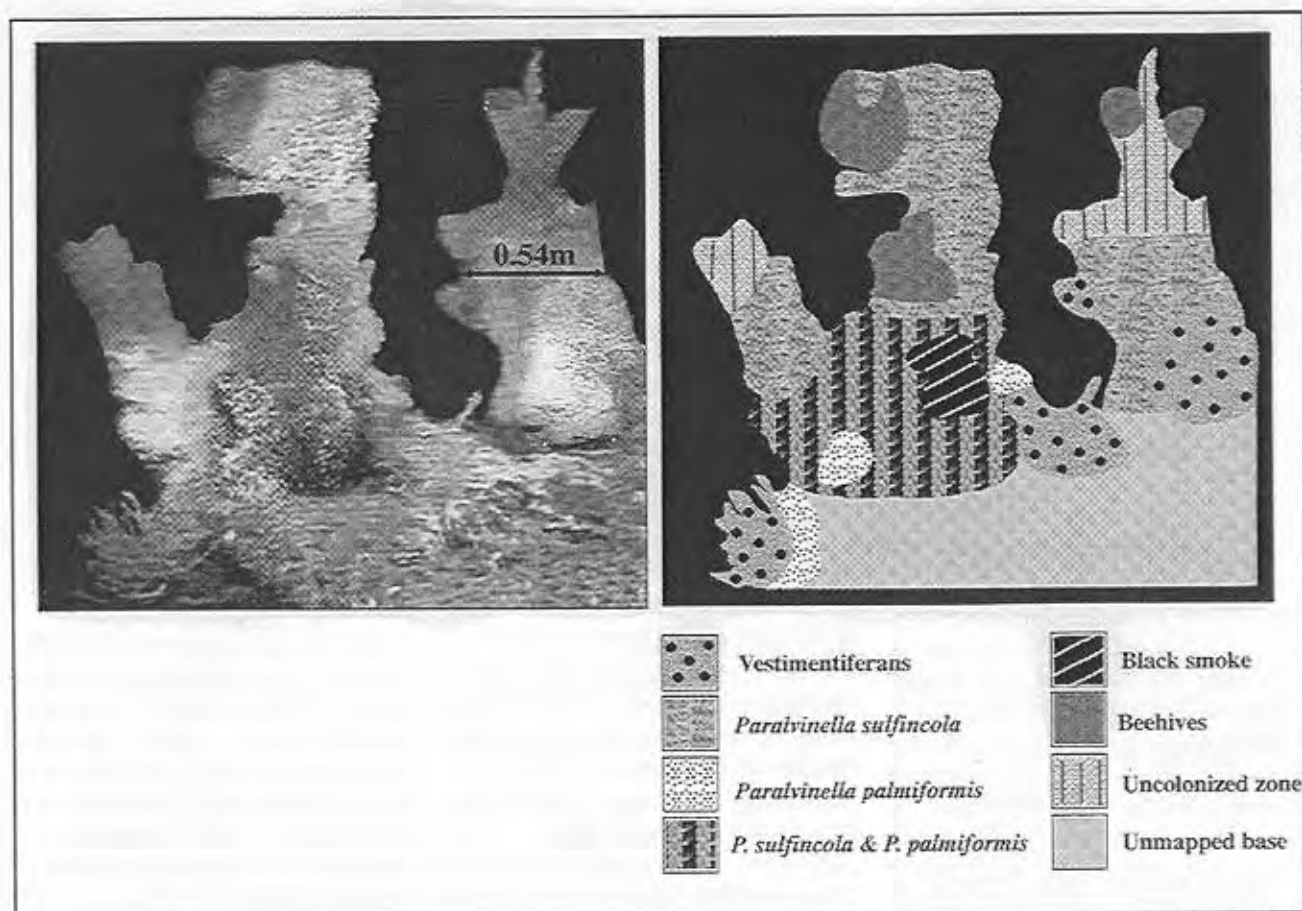


Figure 3. The Southern Cluster chimneys (S&M) in 1991. The image on the left is a mosaic reconstruction of the western face, from Jason video imagery. Right image illustrates preliminary analysis of faunal and substratum distribution, as determined from video imagery and ground truth sampling. Image prepared by J. Sarrazin.

The different faunal habitats within the vent field will be modelled as separate plug-flow reactor systems whose overall area will be determined from the GIS. Quantifying energy flow through these systems requires corroborating data on hydrothermal fluid and element flux, microbial metabolism, etc. Some of these data will be available through collaboration with other research programs in the Main Vent Field at Endeavour headed by J. R. Delaney (spatial and temporal variability in fluid chemistry), R. Thomson and J. Cowan (bio-

logical activity in hydrothermal plumes), A. Schultz (fluid flux) and the NOAA Vents program (plume studies). We are also interested in developing new collaborations, and are willing to assist other groups interested in participating in this observatory study on the Juan de Fuca Ridge. A synopsis of cruise activities, selected images, geo-rectified positions for the observatory sites, and eventually the vent field map, will be made available on the World Wide Web as a mosaic page. Mosaic is a mouse-driven interface to distrib-

ute databases available through the Internet (see Science, 12 August 1994). Contact Ian MacDonald on the Internet (ian@gergo.tamu.edu) for further information regarding the mosaic page.

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High Rates of Hydrothermal Activity at the West Rift of the Easter Microplate Deduce from Metalliferous Sediment Composition.

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Abstract

Sediments from two 3m box cores taken near the West Rift of the Easter Microplate at 23°50'S and 27°24'S have been shown to contain about 73% metalliferous component on a carbonate- and salt-free basis. The metalliferous content of these sediments is amongst the highest so far recorded on the East Pacific Rise (EPR) and its distribution with depth in the cores indicates that hydrothermal activity has lasted well over 100,000 years. These data suggest that the West Rift of the Eastern Microplate is highly prospective for submarine hydrothermal minerals. This is in accord with the high rate of seafloor spreading (15-16cm/yr) and the complex processes of plate extension and rotation in the region.

GEOMETEP Cruise 3 was conducted on a carbonate-free basis.

(Cruise SO-26 of the R.V. Sonne) took place between 17 December 1982 and 6 April 1983 and focused on an evaluation of hydrothermal activity in the East Pacific Rise between 14°20'N and 27°30'S. Massive sulphides were recovered at 18°30'S and 21°30'S during this cruise and received considerable attention but less attention was paid to the geochemistry of the associated sediments (Bäcker et al., 1985).

In this note, we report on the mineralogy and geochemistry of sediments from two cores taken at 23°50'S, 116°08'W, 3935m and 27°24'S, 113°32'W, 3059m in the vicinity of the West Rift of the Eastern Microplate.

Sediment from 23°50'S is a dark yellowish brown calcareous ooze. On leaching the sediment with acid, clinoptilite was observed. No other clay minerals were identified. The average composition of the sediment shows that it is dominantly calcareous ooze (50% CaCO₃) with appreciable iron (17.6% Fe₂O₃) and manganese (4.9% MnO) but low clay (3.0% SiO₂) contents.

Sediment from 27°24'S is dark brown to brown calcareous ooze. The average composition of the sediments shows higher carbonate (69% CaCO₃) and silicate (Si, Al, K, Cr) contents and lower contents of Fe, Mn, P, Cu, N, and Zn than at 23°50'S. These concentrations remain lower when the data are calcu-

lated on a carbonate-free basis. In order to assess the data, the average composition of these two cores were compared with those obtained by Walter and Stoffers (1985) for sediments from eight areas in the Galapagos Rift and EPR between 2°N and 42°S. Previously, Walter and Stoffers (1985) found that sediments from the southern section of EPR (10°-42°S) are dominated by Fe and Mn on a carbonate-free basis. Fe and Mn were shown to increase from north to south with maximum contents at 20°S and then to decrease slightly towards 42°S. Our data indicate that the maximum Fe and Mn contents in the sediments lie somewhere between 23°50'S and 27°24'S. However, the average (Fe+Mn)/Al ratio of the sediment is higher at 20°S (75) than at 23°50'S (50). Based on the proposed relationship between the (Fe + Mn)/Al ratio of rift sediments at the EPR and the spreading rate (Walter and Stoffers, 1985), this suggests that the spreading rate may be higher at 20°S than at 24°S, although the (Fe + Mn)/Al ratio is dependant on the distance of the sediment from the ridge crest as well as on other factors (such as the magmatic activity at the ridge crest). Cu and Zn showed a good correlation with Fe + Mn in the sediments indicating that these elements are bound to the hydrothermal component in the sediment. Leaching experiments demonstrated that Cu and Zn are associated mainly with the iron oxyhydroxide phase (and therefore susceptible to the HCl leach) whereas Co

and Ni are associated with the manganese oxide phase (and therefore more susceptible to the hydroxylamine hydrochloride leach). The high Fe₂O₃/Al₂O₃ ratio in the sediments from 23°50'S (29.4) and 27°24'S (8.3) reflects the high hydrothermal contributions at these southerly locations.

Using the method of Bischoff et al. (1979), the percentages of pelagic clay, hydrogenous metals, metalliferous sediment and biogenic silica in the sediments on a carbonate- and salt-free basis were computed. These data demonstrate the high contents of metalliferous material in these sediments (73% in each case). Walter and Stoffer (1985) have calculated slightly higher metalliferous contents in sediments from the EPR at 20°S and 42°S. The content of hydrogenous metals is higher (22%) in the core from 23°50'S whereas the content of pelagic clay is higher (19%) in the core from 27°24'S. In each case, biogenic silica was calculated to be absent.

The major findings of this study are the high rates of hydrothermal activity at 23°50'S and 27°24'S near the West Rift of the Easter Microplate within the sediment cores to depths of 2.7 and 1.9m respectively. Assuming a sedimentation rate of 15mm/10³ yrs at these two locations (Bäcker et al., 1985), the maximum ages for the sediments appear to be about

180,000 and 127,000 years respectively indicating long-term activity. In particular, the core at 23°50'S 116°07'W lies within the area of the West Rift of the Easter Microplate which is characterised by a rate of extension of about 15-16cm/yr coupled with the rotational motion and plate readjustments of the Easter Microplate. Our data suggest that this location is amongst the most hydrothermally active so far discovered on the crest of the EPR and is, therefore, highly prospective for hy-

drothermal minerals.

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continued from page 20

and extensive distribution of neotectonic clay. We have also found that the median ridge along the transform fault is formed by diapiric intrusions of deep crustal and mantle rocks. Two dives on the south wall of the fracture zone confirmed that the wall was composed of deep crustal rocks. A dive on the top part of the inside corner high, found calcareous sedimentary rocks as well as pillow basalts. We also sampled only basaltic rocks from the basement of the inside corner high at the scarps of the transform fault.

Continuous magnetic measurements were carried out during all dives with Alvin and ORI magnetometers. It was found that magnetic anomalies are weak along the active transform fault. The ORI magnetometer recorded pitch and roll angles every 1sec as well as the vector geomagnetic field. Combined with the heading of the submersible measured every 2sec we may get vector geomagnetic data. We also conducted gravity measurements at 20 station on the seafloor using a LaCoste & Romberg land gravimeter in the submersible. Preliminary results show that the average crustal density is higher along the transform fault than in the RTI.

Preliminary Results of the Surface Survey

We obtained multi-beam bathymetry, gravity, and magnetics data over the western Kane transform fault and the Mid-Atlantic Ridge flank immediately north of the Kane, in an area near 45°-47.5°W and 23.5°-25°N. We achieved nearly

100% bathymetric coverage of the study area at an average line spacing of 6.4km using a narrow multi-beam system HS10 installed on the Yokosuka. Sea surface gravity data were obtained using a LaCoste & Romberg gravimeter which yields r.m.s. cross-over errors of about 1mGal. Magnetic data were also obtained using a proton magnetometer and a shipboard 3-component magnetometer.

Seafloor topography and magnetic anomalies imply southward along-axis rift propagation of individual ridge segments over the past 7-8Ma. Evidence for rift propagation was most clearly observed in the second segment north of the Kane, which has a southward propagating velocity of about 1cm/yr, slightly slower than the half-rate of seafloor spreading. Although the computed magnetization is weak north of the Kane, the western ridge-transform intersection shows relatively high intensity, in agreement with the observed rift propagation. Mantle Bouguer gravity anomalies show weak, broad "bull's-eye" negative anomalies centered over several ridge segments north of the Kane, similar to those found elsewhere on the Mid-Atlantic Ridge between the Kane and Atlantis transform faults.

Acknowledgements

The side-scan sonar data in the WMARK area were obtained during a cruise of the R.R.S. Charles Darwin. Prof. Roger Searle, Chief scientist, generously permitted us to use the results for the planning of the dives.

The InterRidge Office is currently accepting submittal of articles for the next issue of InterRidge News to be published in April 1995.

Ridge crest researchers are encouraged to submit their findings as short articles (1-4 printed pages with up to 3 figures).

Appropriate topics include:

- preliminary results of ridge crest cruises, particularly involving multi-national co-operation
- technical or engineering developments capable of enhancing ridge crest investigations.

Articles must arrive in the InterRidge Office no later than 1 March 1995.

Vector Geomagnetic Field Measurements over Mid-Ocean Ridges with Shipboard Three-Component Magnetometers

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Introduction

In the last few years, the recently developed Shipboard Three-Component Magnetometers (STCM; Isezaki et al., 1981; Isezaki, 1986) have successfully provided vector geomagnetic field data in many study areas, particularly at mid-ocean ridges. Although geomagnetic total intensity anomalies are more accurately measured with a proton magnetometer towed behind a ship, vector geomagnetic anomalies obtained with a STCM give us a new insight into precise magnetic structures. It should also be noted that a STCM requires no extra ship time. STCM is particularly important for geophysical surveys of the mid-ocean ridges, because analyses of geomagnetic structure are crucial to tectonic studies, and because geomagnetic anomalies near spreading centers have large enough amplitudes for STCM measurements.

Principles of the vector field measurement

We measure not only vector geomagnetic data using three orthogonal fluxgate magnetometers mounted on the ship's deck but also ship's heading, and the roll and pitch angles with a gyrocompass and a vertical gyroscope.

The magnetic effects of the ship's magnetic susceptibility and the permanent magnetic moment on shipboard magnetic measurements are determined using the observed data obtained while the ship steers figure a "8" at several different places during the cruise. This process is essential to obtaining valid measurements. The data processing is rather complicated but the formulation is straightforward (Isezaki, 1986; Seama et al., 1993). Then, the geomagnetic field vector is calculated from the observed data. The residual

field of each component is calculated by subtracting the IGRF (IAGA Division I Working Group 8, 1991). Vector geomagnetic anomaly data obtained often contain noise which is principally caused by the following three reasons. The first results from an imperfection in the model equation; we have not modelled the VRM (viscous remnant magnetization) effect of the ship's magnetization. The second is the estimation error of the ship's magnetic effects. We used IGRF instead of the true geomagnetic field for the estimation. The third is the instrumentation itself. We need to have a very precise gyrocompass and gyroscope. Furthermore, synchronized data acquisition both of magnetic field and the ship's attitude are essential. In reality however, these corrections are not adequate. Thus, we must filter the residual field to remove this noise.

Advantages of the vector field measurements

Vector data of the geomagnetic field provide more detailed information, useful in understanding the magnetic structure of the oceanic crust, than total intensity geomagnetic data. There are two main advantages in using vector geomagnetic anomaly field data: (1) total intensity anomaly amplitudes are often much reduced depending on the orientation of the ambient geomagnetic field and magnetic lineations but neither of these has an effect on vector anomalies (Isezaki, 1986), and (2) vector geomagnetic anomaly field data provide the positions, strikes, and characteristics of magnetic boundaries, allowing changes in these boundaries to be identified along individual ship tracks (Blakely et al., 1973; Isezaki, 1986; Seama, 1992; Seama et al., 1993; Korenaga, submitted).

The first advantage permits

us to easily identify magnetic lineations even near the magnetic equator. Furthermore, vector geomagnetic field intensity variation directly shows a variation in the magnetized layer. A good example is the vector geomagnetic anomalies at the Mariana Trough back-arc spreading around 18°N, which is summarized below.

The second advantage permits tectonic interpretations to be well constrained, even in areas of widely spaced data coverage. The position of magnetic boundaries in such a case is then obtained from the magnetic field using ISDV (the intensity of the spatial differential vectors). The resolution of the ISDV method is closely related to the width of the magnetized block and water depth (Seama et al., 1993). Korenaga (submitted) calculated the resolution more quantitatively. Seama et al. (1993) described how to obtain the strike of magnetic boundaries (boundary vector) using the fact that the component of the magnetic field is zero in the direction parallel to the boundaries. Furthermore, 3-D magnetic structures are easily distinguished from 2-D structures using vector magnetic data, although there are three different methods (see Blakely et al., 1973; Isezaki, 1986; and Seama et al., 1993 for details). Korenaga (submitted) presented the parameter of 3-D index for the discrimination based on the method of Isezaki (1986). The results are summarized in magnetic boundary strike diagram (MBSD; Seama et al., 1993); these are maps that show the position, strike and character of the magnetic boundaries. MBSD provides valuable information for understanding the magnetic structure of the oceanic crust, such as geomagnetic lineations, pseudofaults, fracture zones, and the structure of the spreading center associated with the cen-

tral anomaly. Furthermore, the magnetization contrast at the magnetic boundary is also estimated using vector magnetic data and can be presented in MBSD to provide additional constraints on tectonic interpretations.

Studies of mid-ocean ridges using a STCM

The two advantages of the vector geomagnetic field measurements discussed in the previous section have gradually been recognized by the international research community and STCM systems have been used for surveys of spreading ridges onboard many ships. We installed a STCM system on the R/V Hakuohmaru of the Ocean Research Institute, University of Tokyo, and measured geomagnetic anomalies of the Juan de Fuca Ridge in 1988 (KH88-3 cruise; Seama et al., 1993), Mariana Trough (KH92-1), and the Rodriguez triple junction of the Indian Ridges (KH93-3). An interesting example of the results is vector geomagnetic anomalies in the Mariana Trough back-arc spreading center around 18°N (Seama and Fujiwara, 1993; Kong et al., 1992; Seama et al., unpublished manuscript). The anomalies evidently show the existence of magnetic anomaly lineations which suggest seafloor spreading of the Mariana Trough at least within the survey area. Furthermore, along-axis variations in vertical magnetic field intensity are observed; these can be explained as: 1) variation in the magnetized layer thickness, which is probably strongly dependent on different thermal gradient variations under the spreading axis (high thermal gradient beneath northern segment center, and low thermal gradient at segment edges); or 2) variations in the crustal magnetization intensity, which may result from hydrothermal alteration, mineralogical variations, or superposition of lava with opposing polarity.

Until 1992, vector geomagnetic field measurements had not been carried out onboard any non-Japanese research vessels. Since 1992, we have been participating in foreign research cruises to the mid-ocean ridges to measure the vector

field with a STCM. Travel costs have been supported by a science fund created by the Ministry of Education, Science, and Culture, which officially recognizes the InterRidge Initiative under a Monbusho International Scientific Research Program (P.I., H. Fujimoto). Beginning with a cruise aboard the R/V Maurice Ewing to the Mid-Atlantic Ridge (P.I., J.-C. Sempéré) in 1992, young Japanese scientists with a STCM have joined two cruises on the Mid-Atlantic Ridge and five cruises on the East Pacific Rise. Although some equipment problems were encountered, they have obtained good data from most cruises, and are now processing the results (e.g. Korenaga, submitted). We are now also developing deep-sea three-component magnetometers for focused submersible surveys of the seafloor. A preliminary system developed at Ocean Research Institute was installed on the submersible "Shinkai 6500" and successfully measured the seafloor geomagnetic field in the western part of the Kane transform fault in June and July of 1994 (see the report of the WMARK cruise this issue).

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World Ridge Cruise Schedule

Country	PI	Institution	Name/Location	Research Objectives	Ship	Dates
Canada	Juniper	Univ. of Québec	BIO-ROBE I: Endeavor Segment, Juan de Fuca Ridge	ROPOS ROV, establishment of a biological observatory	John Tully	June/July '94
Canada	Scott	Univ. of Toronto	BIO-ROBE II: Explorer Ridge, Juan de Fuca Ridge	Electromagnetic survey of the hydrothermal vent site with ROPOS	John Tully	July '94
Canada/ USA	Evans/Webb	Univ of Toronto/ SIO	Middle Valley Juan de Fuca Ridge	Electromagnetic mapping of shallow crustal structural variability	Meville	June '94
France (FARA)	Fouquet	IFREMER/ Brest	DIVA 1: 37°10'N MAR (Lucky Strike Segment)	Hydrothermal site submersible sampling: petro. hydrochem.	Nadir/Nautile	May '94
France (FARA)	Desbruyères	IFREMER/ Brest	DIVA 2: 37°10'N MAR (Lucky Strike Segment)	Hydrothermal site submersible sampling: biology hydrochem	Nadir/Nautile	June-Aug '94
France	de Lépinay/ Michaud	CNRS-Sophia Antipolis	NAUTIMATE: Middle Americas Trench - EPR triple junction	Submersible sampling: petro., hydrochem, photography	Nadir/Nautile	Jan/Feb '94
France	Lagabrielle/ Reullan	IFREMER/ Brest	NOFI: Northern Fijian Basin	Bathymetry (EM12), grav, dredging, magnetics, seismics, hydrology	Atalante	Sept '94
France	Bideau	IFREMER	OCEANAUT: Central North Atlantic	Petrologic and geochemical variations along a slow-spreading ridge	Nadir/Nautile	July '95
France	Taponnier	IPG Paris	TADJOURADEN 1: Gulf of Tadjoura	Continental rifting, initiation of seafloor accretion	Atalante	Aug '95
France	Patriat	IPG Paris	GALLIENI: Southwest Indian Ridge	Structure and evolution of an ultra-slow spreading ridge	Atalante	Sept '95

France	Prieur	Univ. de Brest	MICROSSMOKE 95: N. Atlantic 23°22'N, 45° 57'W	Microbiology, hydrothermal vents	Nadir/Nautile	Nov '95
France	Deplus	IPG Paris	SAMUDRA: Northeast Indian Ocean	Oblique subduction, fossil ridge	Atalante	Nov '95
France	Géli	IFREMER	PACANTARTIC: Antarctic-Pacific Ridge	Geophysics, geochemistry	Atalante	Jan '96
Germany/ Spain	Dchghani/ Dānobeitia	Univ Hamburg/ CSIC Barcelona	East Pacific Rise	Geophysics	Hesperides	Mar/Apr '94
Germany	Herzig	Berakademie Freiberg	Tabat-Feni Island Arc Manus Back-Arc Basin	Geophys., geochem., mapping, sampling	Sonne	Mar/Apr '94
Germany/ US	Herzig/ Humphries	Berakademie Freiberg/WHOI	ODP Leg 158: TAG Area Mid-Atlantic Ridge	Drilling a hydrothermal system	JOIDES Resolution	Oct./Nov '94
Germany	Devey	University of Kiel	Poseiden: Kolbeinsey Ridge 68.5° - 70°N	Bathymetry, rock sampling, geochemistry	Hesperides	1995 rescheduled
Germany	Stoffers	Univ. of Kiel	Red Sea	Hydrothermalism, sedimentation	Meteor	1995
Germany	Halbach/ Windoffer Giere	FU Berlin/ U. of Hamburg	North Fiji Basin	Hydrothermalism, biology	Sonne	1995
Japan MODE '94	Fujimoto/ Bryan	ORI/ JAMSTEC	WMARK: Western Kane FZ, MAR	15 dives, geophysics	Yokosuka/ Shinkai 6500	June/July 94
Japan MODE '94	Fujioka	JAMSTEC	TAG hydrothermal site, MAR	15 dives, geochemistry, geophysics	Yokosuka/ Shinkai 6500	July/Aug '94
Japan MODE '94	Urabe	Geological Survey of Japan	EPR-1: East Pacific Rise, 13°-18°S	15 dives, hydrothermal observations, geophysics, geochemistry	Yokosuka/ Shinkai 6500	Sept/Oct '94
Japan MODE '94	Fujioka	JAMSTEC	EPR-2: East Pacific Rise, 13°-18°S	15 dives, hydrothermal observations surveys geophysics, geochemistry	Yokosuka/ Shinkai 6500	Oct/Nov '94

Country	PI	Institution	Name/Location	Research Objectives	Ship	Date
United Kingdom	White	University of Cambridge	Southwest Indian Ridge	Geophysics	Discovery	Apr/May '94
United Kingdom	Searle	University of Durham	Reykjanes Ridge,	Geophysics	Charles Darwin	June/July '94
United Kingdom	German/Parson	IOSDL	HEAT: Mid-Atlantic Ridge: Azores	Hydrothermal exploration, geophysics	Charles Darwin	Aug/Sept '94
United Kingdom	German/Elderfield/Sinha	IOSDL/Cambridge	BRIDGET: Mid-Atlantic Ridge: Azores	Deep-towed detection and sampling of hydrothermal activity, trials	Charles Darwin	Sept '94
United Kingdom	Elderfield	University of Cambridge	Mid-Atlantic Ridge, Broken Spur 29°N	Geochemistry	Charles Darwin	Sept. '94
United Kingdom	Livermore/Mitchell/Larter	British Antarctic Survey/Univ. of Durham	East Scotia Sea, South American-Antarctic Ridge, Bouvet Triple Junction	Influence of subduction on ridge crest processes, tectonics of the Bouvet Triple Junction	James Clark Ross	Jan/Feb '95 2 legs
United Kingdom	Elderfield	University of Cambridge	BRAVEX/94: Mid-Atlantic Ridge Broken Spur and TAG	Geophysics, diving, geochemistry	Kheldysh	Aug/Sept '94
United Kingdom	Murton	IOSDL	MARFLUX: MAR 29°N Broken Spur hydrotherm. site	Integrated fluxes experiment	Charles Darwin	1995/96 provisional
United Kingdom	Searle	University of Durham	Mid-Atlantic Ridge: 29°N axial segment	Geophysics	Charles Darwin	1996/97 provisional
United Kingdom	Sinha/Peirce	Cambridge/Durham	Lau Basin	Geophysics	Ewing	Oct/Nov '95 provisional
USA (RIDGE)	Castillo/Langmuir	Scripps/LDEO	Pacific/Antarctic, East Pacific Rise	Swath mapping and dredging	Melville	Feb/Mar '94
USA (RIDGE)	Cannon/Joyce	NOAA/WHOI	Juan de Fuca Ridge	Hydrodynamic of water circulation at a hydrothermal vent site	Wecoma	1994

USA (RIDGE)	Von Damm/ Lilley	U New Hampshire U of Washington	East Pacific Rise 9°N	Temporal evolution of hydrothermal, volcanic and geological properties	Alvin	1994
USA (MG&G)	Kadko	University of Miami	North Clef, Juan de Fuca Ridge	Radioisotopes, temporal variability	Alvin	1994
USA (MG&G)	Batiza	University of Hawaii	East Pacific Rise 12°N	Hyaloclastites	Alvin	1995
USA (MG&G)	Mottl	University of Hawaii	Juan de Fuca Ridge	Off-axis Hydrothermal venting	Alvin	1995
USA (RIDGE)	Delaney	University of Washington	Juan de Fuca Ridge	Hydrothermal systems	Alvin	1995
USA (RIDGE)	Johnson/ Delaney	University of Washington	Juan de Fuca Ridge	CoAxial eruption response and time dependent changes in young crust	Alvin	1995
USA (MG&G)	Tivey	WHOI	Juan de Fuca Ridge	Magnetic Polarity boundary	Alvin	1995
USA (ODP)	Detrick	WHOI	Galapagos Ridge	Crustal structure at ODP hole 504B	Ewing	1994
USA (MG&G)	McClain/ Orcutt	UCSD	Clipperton Fracture Zone East Pacific Rise	information not available	Ewing	1994
USA (RIDGE)	Detrick	WHOI	Mid-Atlantic Ridge	Seismic experiment	Ewing	1996
USA (ODP)	Kleinrock	Vanderbilt Univ.	Mid-Atlantic Ridge	TAG - ARGO & AMS-120	Knorr	1994
USA (RIDGE)	Spieß	Scripps Inst. of Oceanography	Juan de Fuca Ridge	Seafloor strain measurements	Large	94/95/96
USA (MG&G)	Lonsdale/ Bloomer	Scripps Inst. of Oceanography	Eltanin transform East Pacific Rise	Mapping	Melville	1994

GEBCO Digital Atlas Update

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The last issue of InterRidge News (vol. 3, no. 1) contained an announcement of the recent publication of the General Bathymetric Chart of the Oceans (GEBCO) Digital Atlas on CD-ROM. The project is into its maintenance or updating phase, which includes identifying, selecting and feeding suitable material into the contour database via the GEBCO Bathymetric Editor (GBE) and the recently established global network of reviewers. In order that it can be maintained as the definitive version of global bathymetry, the GEBCO Digital Atlas (GDA) must contain up to date contours. These contours can only be obtained through the goodwill of the scientific and hydrographic communities. GEBCO is a non-profit making international project under the auspices of the Intergovernmental Oceanographic Commission, UNESCO and the International Hydrographic Organization, as such it relies on the authors of bathymetric charts making their products available once they have served their original intended purpose.

The GBE will examine possible contour updates with the help of the reviewers responsible for the geographical areas concerned. The editor will then arrange the transfer of the contours to the database, at this stage it will be helpful to interact with the contributing authors in order that the contours can be reconciled with the existing, abutting contours. In time, procedures will be developed to handle the variety of scales, projections and units of depth that are used on bathymetric maps. These problems will be greatly simplified by access to digital versions of the contours. GEBCO has limited resources to devote to digitizing but it may be undertaken in exceptional circumstances. It is important that the track compilations are included with the contours, they are the basis on which the accuracy of the contours will be judged by users of the GDA. Whenever possible, the contours will be presented at their original resolution. Future re-

continued on page 35

Country	PI	Institution	Name/Location	Research Objectives	Ship	Date
USA (MG&G)	Phipps Morgan Orcutt	Scripps Inst. of Oceanography	Australian-Antarctic Disconance	Crustal structure	Meville	1994
USA (MG&G)	Lonsdale	Scripps Inst. of Oceanography	Pacific-Antarctic Ridge	Off-axis to origin	Meville	1994/5
USA (MGG/RIDGE)	Christie/ Cochran et al.	Oregon State Univ/LDEO	Southeast Indian Ridge: 90° to 120°E	Geochemistry and geophysics	Melville	Dec 95 Mar 95
USA (RIDGE)	Grindlay/ Madsen et al.	Univ Porto Rico Univ of Delaware	Southwest Indian Ridge: 15°E to 35°E	Geophysics	Melville	1995
USA (RIDGE)	Chave	WHOI	MELT: East Pacific Rise	Electromagnet experiment	Melville	1995
USA (RIDGE)	Forsyth et al.	Brown University	MELT: East Pacific Rise	Seismic experiment	Melville	1995
USA (MG&G)	Coffin, Kerner Shor	UTIG	Macquerie Ridge	MR1 and seismics	Rig Seismic	1994

News from National Ridge Research Programmes

BRIDGE

The UK's BRIDGE programme has had a fruitful summer with four cruises, all to the Atlantic Ocean. Roger Searle (University of Durham) on CD87 returned from the Reykjanes Ridge with complete coverage of gravity, magnetics, SIMRAD swath bathymetry and side-scan sonar data from 57°N to 62°N - a map as large as the size of the UK - and we remain extremely impressed with the new SIMRAD multi-beam mapping system. Chris German (IOSDL) has been kept busy with the BRIDGE/MAST II-funded cruise, called HEAT (CD89), followed immediately by the sea trials of the first piece of new BRIDGE instrumentation, named BRIDGET, deployed on CD90 between the Azores and 36°N region. There are exciting discoveries from this work with indications that hydrothermal vents might be a lot more common place in the Atlantic than was previously thought. While all that was going on, and as this is being written, Harry Elderfield, Adam Schultz (University of Cambridge), Rachel Mills (University of Southampton) and others have been on a Russian/BRIDGE cruise on the R/V Akademik Mstislav Keldysh accomplishing 20 dives on the Broken Spur and TAG hydrothermal sites. All these cruises will be reported on in the next BRIDGE Newsletter (no. 7) currently in preparation and due out at the end of October.

In the future, scheduled cruises include the MARFLUX experiment to the Broken Spur segment by Bramley Murton (IOSDL) and a tectonic study by Roger Searle, Neil Mitchell (University of Durham), and Patience Cowie (University of Edinburgh), also to the Broken Spur segment. The latter will use the new high-resolution, co-registered swath bathymetry system that is under development for TOBI by IOSDL. This will not be until 1996/97. A little sooner is the BAS cruise to the East Scotia Sea led by Roy Livermore, who will be mapping the area as part of the BRIDGE programme. We hope this will lay the foundations for future work in this BRIDGE region.

Other BRIDGE projects in shore-based laboratories are progressing steadily with results filtering through from last years cruises. This includes new geochemical data from the PETROS sampling programme and further modelling of the seismological data from the Reykjanes Ridge. We are still awaiting confirmation as to whether the low-velocity zone at 57°N represents a crustal magma chamber. The two ALVIN dives on Broken Spur by Bramley Murton (IOSDL) and Cindy Van Dover (Duke University, USA) in June 1993 yielded ample biological and geological material which was disseminated within the BRIDGE community. In most cases, the results have reached the literature, or will be published in the Hydrothermal Vents & Processes Volume due out in March 1995.

Our fifth BRIDGE workshop was held in June at IOSDL on Sonar Processing in the UK, a report of which is available from the BRIDGE Science Co-ordinator. Planned workshops in the near future include a microbiology workshop to be held in early 1995, details of which can be found in the forthcoming issue of the BRIDGE Newsletter.

If any one would like more information about BRIDGE, please contact

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continued from page 34

leases of the GDA will contain proper references to the data used to compile the contour database and acknowledgements to the contributors.

As a further enhancement to aid the greatest possible access to high quality bathymetry, GEBCO intends to provide a gridded version of the GDA within the next few years. The resolution of the global grid will be at least 5' x 5', other

areas such as the mid-ocean ridges and the overflow pathways will have higher resolutions. Gridding tests are presently being carried out on the South Atlantic Ocean bathymetry which is the most recently compiled bathymetry represented in the GDA. This grid will eventually supersede the widely used DBDB5.

Areas of particular interest at the moment are the Arctic and Southern Oceans, the North Atlantic and Indian Oceans, the Caribbean Sea and

Gulf of Mexico, and the seas around Hawaii, New Zealand and Japan.

Contributions or suggestions of possible sources for maps are invited. Please contact: GEBCO Bathymetric Editor, Institute of Oceanographic Sciences Deacon Laboratory, Brook Road, Wormley, Godalming, Surrey, GU8 5UB, United Kingdom. Tel: 44-428-684141 ext. 251; Fax: 44-428-683066; Email: p.hunter@ios.ac.uk

CanRidge

CanRidge III Expedition: Southern Explorer Ridge CSS John P. Tully with the ROPOS Remotely Operated Vehicle 18-29 July, 1994

*Steve Scott, Chief Scientist
Nigel Edwards, Co-chief Scientist
University of Toronto*

Summary

CanRidge III was the third leg of an on-going Canadian investigation based at the University of Toronto and concerned with the geology, geophysics and biology of ocean ridges as a contribution to the international InterRidge program. CanRidge III deployed the Canadian ROPOS remotely operated vehicle (ROV) four times at southern Explorer Ridge (SER) in the Northeast Pacific Ocean where previous cruises since 1984 had discovered many, large and small, active and inactive, hydrothermal vents and metallic sulphide-sulphate-oxide deposits. Additionally, echo sounding survey work navigated by differential GPS was conducted at a hydrothermal site discovered during the CUROSS II expedition in 1987 along the spreading axis of West Valley at the far northern end of the Juan de Fuca Ridge. ROPOS operations at SER included mapping, sampling geological and biological materials, and conducting a transient electromagnetic (TEM) experiment for determining the thicknesses of different geological units from their electrical resistivities. Two ocean bottom magnetometers, dropped from the surface, recorded data for three days each using natural ionospheric radiation as a source. The cruise was successful despite having only 8.5 days on station of which 4.5 days were lost to bad weather and 1 day to mechanical-electrical problems with the ROV system. Some mapping, critical systematic sampling of geological materials and a second planned TEM experiment could not be completed because of the shortage of time.

The main part of the Magic Mountain hydrothermal deposit and the adjacent areas to the west and southwest were located, mapped and randomly sampled. Due to unrelated reasons, neither Benthos nor Oceano transponder systems were fully operational necessitating navigation by range and bearing on the cage using ROPOS sonar. The assumption, usually but not always correct, was made that the cage was directly below the stern of the ship which was located to within a few metres by differential GPS. Some transponder ranges displayed by the receiver were hand calculated to give accurate fixes. However, this was done infrequently as it was time consuming and necessitated shutting down the ROPOS systems for about 30 seconds while ranges were being measured. While this map will be suitable for some purposes, it needs to be checked and extended further afield using good transponder navigation for detailed and systematic studies of geology, geophysics and biology.

For the TEM experiment ROPOS placed an EM dipole receiver on the southwest edge of Magic Mountain. The transmitter was carried by ROPOS to locations in different directions and varying distances from the receiver. At each location the electrodes were contacted on or near the seafloor and a signal was transmitted along two orthogonal axes of the ROV. Lack of continuous computer-linked transponder navigation was a definite problem because positions must be known within a few metres for proper interpretation of the data. The experiment was conducted before the main sulphide deposit was located at Magic Mountain, but appears to have obtained good data in the low temperature hydrothermal southwest margin. The experiment should be repeated on the main sulphide mound as a means of determining its thickness.

ROPOS is a marvellous tool when it is working properly and has many advantages over a heavy occupied submersible, the most important being endurance. Altogether ROPOS achieved in 4 dives (one of which was aborted after 25 minutes of bottom time), 56 hours 59 minutes of total dive time, 42 hours 55 minutes of bottom time, took 37 geological samples, numerous and diverse biological samples, 375 still photos, recorded 42 hours of black and white wide-angle SIT video and 44 hours of colour close-range video. CanRidge III dives lasted for as long as almost 17 hours of bottom time and were terminated by choice. However, the system must be used more extensively if it is to become reliable, as commercial and paying scientific users will demand. Breakdowns are inevitable if a complex machine like ROPOS spends long idle periods of time in the Pat Bay hanger. At the very least, its obsolete telemetry system for which spares are no longer available must be replaced, the transponder navigation system must become absolutely reliable, and a heave compensator needs to be added to the cable termination on the cage to dampen the snap loads that are inevitable in the even normal good-weather sea states of 3-4 (15 knot wind, 1-2m seas with >7sec period) that are encountered in the offshore environment.

CSS John P. Tully ran flawlessly during the ROPOS and other operations. In most cases, the ship was able to hold station to within better than 25m for hours on end using only its main engine and bow thruster in all sea states encountered (dead calm to 3-4). This was accomplished thanks to differential GPS, an excellent computer graphics

navigation display and the dedication and skill of a very talented bridge crew. The deck crew launched and recovered a myriad of equipment, including the 6700 kg ROV and cage, once under difficult conditions, requiring great skill. CanRidge IV will return to SER with ROPOS and reliable transponder navigation to conduct the detailed geological mapping and sampling, TEM experiments on the main sulphide mass of Magic Mountain and biological sampling of a variety of well located sites that could not be done properly on CanRidge III for lack of time and good positioning. A minimum of three weeks of ship time is essential if cruise objectives are to be met in the face of anticipated down time for reasons of weather and normal mechanical repair and maintenance.

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DeRidge

Since the last update on German ridge research in the April issue of InterRidge News, some progress has been made in the DeRidge working groups. Following the success of RV SONNE cruise 92 (localization of a hydrothermal vent and sampling at Green Rock Hill, a serpentinite diapir, both near the Rodriguez Triple Junction), an Indian Ocean working group was established with Peter Halbach (Berlin) as co-ordinator.

The objective of the first stage of this project is to study the exchange between the crust and seawater (EXCO). It has been proposed that this be carried out with RV SONNE at the EPR between 130° and 160°S (Weigel et al., Hamburg/Kiel). The variation of geophysical and petrological parameters of the crust in correlation with hydrothermal circulation at the ridge axis will be examined as a function of crustal age at a fast- and a slow-spreading ridge. Sampling and seismic measurements will be carried out at the EPR in three boxes on 0-1 Ma, 4 Ma, and 10 Ma old crust. As the second part of the project, an equivalent survey is planned at the southern Reykjanes Ridge in subsequent years.

Interaction between ridge research and biology in Germany has recently been intensified. Some joint geology - biology cruises have been scheduled or are in preparation. Several German members of the InterRidge Biology *Ad Hoc* Committee have been named. These are K. Stetter (Regensburg), H. Fricke (Seewiesen) and O. Giere and R. Windoffer (Hamburg).

The DeRidge project "Synthesis of geoscientific data of the North Atlantic" (north of Charlie Gibbs FZ) has succeeded in locating numerous datasets of various disciplines and ranging in latitude from 53°N to 90°N. The areas where the best coverage exists, apart from the "tropical" parts of the Arctic (Iceland itself and Reykjanes Ridge), appear to be at the Kolbeinsey Ridge. Some of these datasets have shown remarkable results such as high resolution multi-channel seismic based identification of a small-scale magma chamber and an indication of hydrothermal venting at the southernmost part of Kolbeinsey Ridge (Neben, 1991). Petrology studies have shown one of the world's highest degrees of melting at Kolbeinsey Ridge and a large range of incompatible element ratios are interpreted to be the results of dynamic melting beneath the ridge (Devey et al., 1994). A fundamental geochemical boundary was identified between Kolbeinsey Ridge (MORB) and Iceland/Reykjanes Ridge (plume) at Tjörnes FZ and attributed to a southward regional direction of mantle flow (Mertz et al., 1991).

Much progress on the international data synthesis is expected to be made through the InterRidge Workshop: "Arctic Ridges: Results and Planning" to be held in Kiel (15-17 November 1994). The workshop has attracted much interest in Germany, and all major institutions that are actively pursuing research in the North Atlantic and Arctic regions have indicated their intention to participate, to present their data and results, and to contribute to future planning and activities in the area.

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Dorsales

The French "Dorsales" program was created in January 1994. It involves 4 institutions: Institut National des Sciences de l'Univers and Sciences de la Vie (CNRS-INSU & CNRS-SDV), IFREMER, Bureau de Recherches Géologiques et Minières (BRGM), and ORSTOM. The creation of Dorsales followed numerous meetings of the French InterRidge community in 1992 and 1993. The scope of this new program is presently limited to the financial support for specific ridge-related experiments, meetings and instrument development. Support for cruises and post-cruise work is still available only through existing proposal driven programs such as the CNRS-INSU "Géosciences Marines" program.

The Dorsales program Steering Committee will meet two or three times a year. Its mandate is to propose specific themes to be supported by the program, issue requests for proposals on these themes, review and fund these proposals through a classical external review process, co-ordinate the research and survey efforts of the community, and maintain a link with InterRidge. The Steering Committee will also oversee the production of a semi-annual newsletter, *La Lettre Dorsales*, which at present has a circulation of over 250 individuals.

For 1994, proposals have been or will be funded to apply satellite altimetry data to ridge segmentation studies by improving processing techniques and processing data over specific regions of the world ridge system, and to develop physical and chemical models of upper mantle dynamics beneath ridges. In addition, two funded workshops are being planned on the following biology-related topics: perspectives in evolutionary biogeography of hydrothermal fauna; and development of instrumentation for biological sampling under pressure. These workshops will take place in early 1995. Announcements will be made in *La Lettre Dorsale*, and in *InterRidge News*.

The program of French ridge crest cruises scheduled for 1994 and 1995 is listed on pages 30-34 of this issue.

The Dorsales Steering Committee:

Jean Francheteau (Chair)	Aline Fiala-Médioni	Rémi Louat
Jean Marie Auzende	Françoise Gaill	Marc Munsch
Henri Bougault	Jean Goslin	H.D. Needham
Mathilde Cannat	José Honnorez	Pierre Nihlig
Daniel Desbruyères	Eric Humler	Adolphe Nicolas

Australia

The Australian ridge crest research community is currently involved in a number of collaborative projects focusing on various petrologic and geochemical aspects of back-arc basin spreading and the mid-ocean ridge system. Listed below are some of the studies being pursued.

1. Petrological studies of basalts from the Australia-Antarctic Discordance (I. Sigurdsson and L. Danyushevsky, Univ. of Tasmania) and ODP Site 504B and 896 (A. McNeill and L. Danyushevsky, Univ. of Tasmania), focusing particularly on melt inclusions in phenocrysts.
2. Geochemical studies of Macquarie Island, an *in situ* ophiolite along the Pacific-Indian plate boundary south of New Zealand, which indicate that this oceanic crust was created from mixing between a MORB reservoir and the low-flux HIMU Balleny plume (A. Crawford, R. Varne, D. Kamenetsky, R. Lanyon, Univ. of Tasmania)
3. Petrological studies of plutonic rocks from the Hess Deep area drilled during ODP Leg 147 (T. Falloon, in collaboration with R. Pedersen, Univ. of Bergen, and J. Malpas, Memorial Univ.)
4. Experimental studies of MORB petrogenesis (T. Falloon, L. Danyushevsky) using the Univ. of Tasmania Department of Geology high-pressure experimental petrology laboratory.
5. On-going petrological-geochemical studies of back-arc basin basalts from the North Fiji Basin (R. Price, Latrobe Univ., A. Crawford and I. Sigurdsson, Univ. of Tasmania, and S. Eggins, Australia National Univ.), and Woodlark Basin (R. Binns, CSIRO, N Ryde).
6. Planned U-Th studies of MORB genesis by Ken Collerson and Yaoling Niu at Univ. of Queensland.

Dr A.J. Crawford, Australian InterRidge Correspondent

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RIDGE

In the last six months, the RIDGE Program has sponsored four workshops, two of which arose from discussion groups that formed during the 1993 RIDGE Theoretical Institute on "Physical, Chemical, Biological and Geological Interactions within Seafloor Hydrothermal Systems". In May, a workshop was convened by Lauren Mullineaux (Woods Hole Oceanographic Institution) and Donal Manahan (University of Southern California) to discuss "Dispersal, Gene Flow, and Larval Biology at Seep-Sea Hydrothermal Vents". The objectives of this meeting were to develop approaches for investigating dispersal and gene flow in vent environments, and to evaluate the potential role of these processes in generating and maintaining biogeographic patterns along mid-ocean ridges and across ocean basins. Twenty-five scientists from a number of different disciplines and with experience in studying both deep-sea and shallow water communities gathered at Fallen Leaf Lake, California, to define issues that could be addressed on tractable temporal (e.g. 5 years) and spatial (e.g. 10's-100's km) scales, and to develop novel collaborative approaches to address them. This resulted in the recommendation that a multi-year study of recruitment in vent communities be undertaken with an emphasis on the processes that affect larval dispersal and gene flow between vent sites. Specific experiments, target sites and target species were proposed and are discussed in detail in the workshop report which is available from the RIDGE Office.

In early September, RIDGE and the NOAA VENTS program co-sponsored a workshop on the "Global Impact of Submarine Hydrothermal Processes", which was organized by David Kadko (University of Miami), Jeff Alt (University of Michigan), Ed Baker (NOAA) and John Baross (University of Washington). Stimulated by preliminary discussions at the 1993 RTI, the purpose of this meeting was to assess the current state of knowledge of mass and energy fluxes associated with hydrothermal circulation at mid-ocean ridges and to determine ways to quantify their impact on global geochemical cycles. After an initial assessment of the magnitude of fluxes from both axial and flank systems (the latter being very poorly constrained), the possible impact of changes in the fluxes of selected elements on oceanic processes (e.g. productivity, sedimentation, etc.) was examined using simple box models. A report will be available from this workshop by December 1994.

One of the themes defined in the RIDGE Science Plan is that of understanding the inter-relations between different variables (e.g. spreading rate, magma supply, crustal thickness, etc.) in determining the nature of the crustal accretion process on the segment scale. In late September, a meeting was held in Boston to discuss the design and appropriate locations for future experiments and field programs aimed at expanding our knowledge of segment-scale crustal accretion processes. The convenors of this workshop were Jian Lin (WHOI), Jeff Karson (Duke University) and John Sinton (University of Hawaii). The RISES (Ridge Segment Structure and Dynamics) Workshop resulted in the definition of three main foci for the next phase of RIDGE segment-scale studies: (1) a co-ordinated geological and geophysical experiment to investigate the origin of gravity bull's eyes and their relation to axial morphology; (2) seismic, petrologic and drilling studies at selected sites on the EPR, and at Hess Deep, to examine the nature of the crustal magma plumbing system along a fast-spreading ridge; and (3) studies to determine temporal variation in magmatic/tectonic/hydrothermal interactions on the segment scale. A full report of this RISES workshop should be available by December, 1994.

RIDGE is continuing to explore mutually beneficial links with projects proposed for the Ocean Drilling Program. In July RIDGE co-sponsored a workshop (SCORE: Sedimented Ocean Ridge Experiments) with USSAC to discuss experiments that could be done in conjunction with the proposed sedimented-ridge drilling in the northeast Pacific. The primary objectives of this drilling are to investigate the formation of massive sulphide deposits and the structural and hydrologic controls on hydrothermal upflow zones at Middle Valley and Escanaba Trough. A number of experiments were discussed that would take advantage of drilling-induced disturbances in the hydrothermal field to begin to determine the subsurface controls on fluid flow and the physical, chemical and biological responses to changes in the hydrothermal systems. High priority objectives included resampling of the hydrothermal vents at both locations for time-series studies, instrumentation of vent sites to monitor changes in fluid flux and temperature before, during, and after drilling, a hole-to-hole hydrologic and induced seismicity experiment at Middle Valley, and high resolution side-scan mapping and definition of the distribution of organisms at the Escanaba vent field prior to drilling. The SCORE workshop report is available from the RIDGE Office.

For more information about RIDGE activities or workshop reports, please contact:
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Information may also be obtained via the Internet WWW using Mosaic at: <http://copper.who.edu/RIDGE>.

Announcements and Notices

R-RIDGE

(Russian RIDGE)

Workshop Announcement:

MID-OCEAN RIDGES: GEOLOGY, GEOPHYSICS AND ORE FORMATION

A three day workshop to be held in April/May, 1995.

St. Petersburg, Russia

The workshop is open to all Russian and foreign researchers interested in studies of spreading centers and processes of oceanic ore formation.

OBJECTIVES:

The aim of the workshop is to present and discuss the recent works of Russian and foreign scientists on the investigation of diverging plate boundaries and processes of oceanic hydrothermal ore formation. We would like to invite you, and your colleagues dealing with the geology and geophysics of the mid-ocean ridges to participate in this Workshop.

If you are interested in the workshop, please provide the following information:

- (1) Your name, Institution, Address, Phone, Fax, E-mail address.
- (2) Would you like to attend the Workshop in April-May 1995? The exact time of the workshop will be co-ordinated with the date of XI International School on Marine Geology (Gelendzhik). Participants are responsible for payment for registration (\$200), travel and accommodation.
- (3) If you are going to attend the workshop, please submit title(s) of your presentation(s).

Applications must be received by 1 September, 1994, and should be sent to the appropriate convenors (fax or e-mail are preferable).

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InterRidge Global Workshop Announcement: Arctic Ridges: Results and Planning

*Kiel, Germany
15-17 November, 1994*

Convenors: Roland Rihm and Mark Langseth

OBJECTIVES: The Arctic Oceans are an area in which strong interest has been expressed by members of the international ridge-crest research community. The ridges of the Arctic Ocean and Norwegian-Greenland Sea are one of the target areas of the InterRidge Global Working Group and present specific scientific and logistic challenges that differ from those of the other ocean basins. Development of strategies to meet these challenges and attain the objectives identified below require the combined capabilities of the international ridge-crest research community. In response to this challenge, Global Working Group announces the Arctic Ridges: Results and Planning Workshop with the following objectives:

- 1) To make known existing geological, geophysical and biological datasets from the Arctic to researchers interested in this region through a series of presentations which will also serve to identify major gaps in data coverage.
- 2) To correlate different data types in key regions as a first step in the compilation of a data synthesis which would lead to an integrated interpretation.
- 3) To define approaches and implementation plans as part of a co-ordinated international strategies to overcome logistical challenges and extend data coverage.

ATTENDANCE: To maintain an effective working group size, attendance will be limited to approximately 40 participants. Participation in the meeting implies agreement to contribute substantially to a meeting report.

TRAVEL FUNDING: The InterRidge budget does not include travel and accommodation funding for meeting participants. Travel funding should be requested from national ridge programs and funding agencies.

APPLICATION DEADLINE: 22 September, 1994

FOR FURTHER INFORMATION OR TO APPLY CONTACT:

Heather Sloan, InterRidge Co-Ordinator
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Position available:

Geophysicist, Marine Seismic Studies, IFREMER

Applications are invited for a research position in the Lithosphere Group of the Department of Marine Geosciences, Ifremer, Brest, France.

The successful candidate will be less than about thirty years old, will have at least one or two years experience and will devote his or her efforts to the processing of multichannel seismic reflection and marine seismic refraction data and to the improvement of data processing methods, with particular emphasis on oceanic crust and continental margin studies. The successful candidate will be in charge of the seismic data processing facilities of the Lithosphere Group and will be expected to participate in the development and conduct of new sea-going research programmes.

Inquiries and applications with the name of three referees should be addressed to J.-C. Sibuet, Chair, Search Committee, Department Géosciences Marines, Ifremer, B.P. 70, 29280 Plouzané, France.

Internet: jcsibuet@ifremer.fr Fax: (33) 98 22 45 49.

The closing date is 15 Nov, 1994



*InterRidge Active Processes
Working Group Announces the
Rescheduled Workshop:*

**Event Detection and Response
and
A Ridge-Crest Observatory**

*Paris, France
16-18 January, 1995*

Convenor: Joe Cann, Active Processes Working Group Chair

Active Processes combines two distinct, but related areas of activity: co-operation in the development of ridge-crest observatories and co-operation in mid-ocean ridge event detection and response. The two areas are closely linked through the need to respond to and investigate ridge-crest events in order to improve the siting and instrumentation of ridge-crest observatories. A first-class event detection and response system cannot be accomplished without international co-operation between countries close to mid-ocean ridges and those further away, and between countries able to contribute different instruments for use. It is intended that this workshop build upon previous workshops dealing with event detection and response, by broadening the geographic focus to include the Mid-Atlantic Ridge and back-arc basin systems, by considering the problem from the point of view of temporal variability rather than axial segmentation, and by stressing an international collaborative approach.

Prior to the workshop, a position paper covering a number of topic relevant to event detection and response and development and establishment of a ridge-crest observatory will be circulated to all participants. This position paper will serve to focus discussion and act as a foundation for a white paper to be produced in the course of the workshop.

OBJECTIVES:

- To discuss and design the techniques, instrumentation and methods relevant to the implementation of an event detection and response program and the development and deployment of a ridge-crest observatory.
- To produce a white paper discussing the relevant issues and detailing specific project implementation plans.

PARTICIPATION: In order to maintain an effective working group size, attendance will be limited to 50 people: 25 places will be reserved for invited participants and 25 for interested members of the ridge sciences community. Participation in this workshop implies agreement to contribute substantially to a workshop report. A registration fee of US\$20 will be asked of each participant. This fee will help to defray the cost of refreshments during the meeting and a small reception.

FUNDING: The InterRidge budget does not include travel and accommodation funding for meeting participants. Travel funding should be requested from national funding agencies.

APPLICATIONS: Those interested in participating in this workshop should notify the InterRidge Office no later than **September 30, 1994**. Further details will be made available after this date.

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continued on inside back cover