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InterRidge News

InterRidge Update

During the last six months, significant progress has been made in both the Quantification of Fluxes and Southwest Indian Ridge (SWIR) Projects. In addition, the international ridge crest biologist community within InterRidge has been actively organising a number of important initiatives. Looking into the future, InterRidge is moving progressively towards a co-ordinating role for its integrated Phase 2 projects. In tandem with the development of Phase 2, InterRidge structure is evolving to become more project-based. *InterRidge News* will reflect this structure with the initiation of feature columns dedicated to reporting each project's progress.

This issue of *InterRidge News* contains the first call for piggyback and host projects as the InterRidge Office offers its services as a 'broker' matching investigators with smaller scale experiments with those who have funded ship time available (see page 44). The provisional InterRidge calendar of upcoming events reflects the program's continuing interaction with a broad range of international organisations in working towards common aims and objectives.

InterRidge Office Transfer

With the end of the UK term as host country in 1997, the InterRidge Office will transfer to another of its Principal Member nations. Any of the Principal Member nations of InterRidge may bid to host the Office. The call for bids will be opened in January 1996 with a closing date of March. Received bids will be reviewed by the Steering Committee and a new host country chosen by the end of the Summer. For more information concerning the bidding procedure or transfer please contact the InterRidge Office.

Recent InterRidge Workshops

On August 28 & 29, an actual/virtual meeting of the SWIR Working Group was held at Woods Hole Oceanographic Institution to draft a Project Plan. The result is an integrated 3-5 year science plan involving six to eight legs of ship time aimed at multi-disciplinary investigation of the super-slow spreading SWIR. The SWIR Project Plan is currently undergoing a last round of revision and will soon be available on the World Wide Web and for hard copy distribution.

InterRidge Workshop, "Quantification of Fluxes at Mid-Ocean Ridges: Experiment Design" was held on 26 & 27 June 1995, at Cambridge, UK. Its principal objective was to design an experiment to quantify mass, energy and chemical fluxes occurring at mid-ocean ridges at the axial segment length scale and extending from the mantle up into the water column. Site selection as well as integration with other InterRidge projects were discussed. The workshop report will soon be available from the InterRidge Office.

The Biological Studies *Ad Hoc* Committee of InterRidge met April 24 & 25 at Rutgers University, USA, to discuss integration of biological studies in the three principal InterRidge themes, to draft an inter-

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national agreement for sample exchange and to maximise the effectiveness of biological sampling during 'geological' cruises. In addition to accomplishing these objectives, a number of other initiatives were recommended and are being undertaken by InterRidge. These include the Ridge Crest Biologist Directory on the WWW (see page 11), an on-line sample database, and compilation and publication of a Faunal Identification Manual.

InterRidge Structure

As the Phase 2 projects develop, InterRidge structure is changing from large working groups associated with the three principal program themes to smaller working groups formed around each project. The principal themes of InterRidge will remain in place and the projects will be grouped within them. There are currently 8 projects, each with a project leader who will act as rapporteur to the Steering Committee. The project working groups will be made up of investigators directly concerned with each of the projects.

InterRidge Phase 2 Structure

Theme/Working Group	Rapporteur to the Steering Committee
Global Studies	
SWIR	C. Langmuir
Arctic Ridges	R. Rihm
Global Digital Database	K. Tamaki
Meso-Scale Studies	
4-D Architecture	TBA
Quantification of Fluxes	K. Von Damm
Back-Arc Basins	K. Tamaki
Active Processes	
Event Detection and Response	J. Cann
Biology	L. Mullineaux

Upcoming Events

The results of the joint French-US FARA Program will be summarised, and future research objectives formulated, at an international symposium to be held in Iceland during the week of June 17 - 21, 1996 (see announcement on page 48). The meeting, sponsored by French and US science agencies to mark the end of the program, is being convened under the auspices of InterRidge.

A joint JOIDES-InterRidge-IAVCEI workshop entitled "The Oceanic Lithosphere & Scientific Drilling into the 21st Century" will be held at Woods Hole Oceanographic Institution. This workshop will plan an integrated program of ocean drilling to ground truth and extend current models for the production of laterally complex and heterogeneous ocean lithosphere (see announcement on page 43).

Heather Sloan
InterRidge Co-Ordinator

Provisional Calendar

Mid-Ocean Ridges: Dynamics and Processes of the Creation of Crust
Royal Society London, 6 & 7 March 1996

Goldschmidt Conference
Heidelberg, Germany, 31 March - 4 April 1996

Eurpoean Geophysical Society: Mid-Ocean Ridge Processes
The Hague, The Netherlands, 6-10 May 1996

JOIDES/InterRidge/IAVCEI Conference: Ocean Lithosphere & Scientific Drilling into the 21st Century
Woods Hole, MA, USA; 26-28 May 1996

InterRidge/FARA Symposium
Iceland, 19-22 June 1996 (provisional)

XXV General Assembly of the European Seismological Commission: Mid-Ocean Ridge Processes Session
Reykjavik, Iceland, 9-14 September 1996

InterRidge Steering Committee Meeting
17 &18 September, 1996

Geology and Geophysics of the Indian Ocean
Goa, India, 21-24 October 1996

SCOR General Meeting
Southampton, UK, October 1996

International Symposium on Hydrothermal Vent Biology
Madeira, Portugal, Spring 1997

InterRidge Home Page

http://www.dur.ac.uk/~dgℓØzz1/

The InterRidge Home Page has undergone rapid development over the past few months. This home page is maintained by the InterRidge Office as a service to the international ridge crest researcher community. If you as a user have any suggestions or ideas for its improvement or expansion, we encourage you to please contact us. Here is a summary of what it has to offer.

- **InterRidge**
  Information concerning the InterRidge science plan, structure, membership and office.

- **Events and Announcements**
  A calendar of upcoming InterRidge and related events and workshops.

- **InterRidge Member Nations**
  A list of member nations with links to national ridge program home pages.

- **InterRidge Researcher Directories**
  The InterRidge Researcher Directory and the Ridge Crest Biologist Directory. Enter your name now by filling in the form on page 49 of this issue.

- **InterRidge Phase 2 Projects**

  - **The SWIR Project** (under development)
    The InterRidge Southwest Indian Ridge Project Plan, updates and progress reports.

  - **The InterRidge Global Digital Database** (under development)
    This InterRidge Phase 2 Project is currently under development. For the time being a link is provided to the RIDGE Multibeam Bathymetry Synthesis.

  - **The InterRidge Back-arc Basin Databases**
    InterRidge is currently compiling a Back-arc Basin Database Index, a Back-arc Basin Geochemical Database, and a Back-arc Basin Geophysical Database.

  - **International Research Platforms and Cruise Schedules**
    A summary of World Ridge Cruise Schedules, Platform Specifications and Schedules (mirrored from the Oceanic site at the University of Delaware), and a link to Oceanic.

  - **Some Event Detection and Response Resources**

- **Other Information Servers**

InterRidge Phase 2 Projects

SWIR Project

InterRidge Project on the Southwest Indian Ridge

The following summarizes in outline form some of the essential elements of the program plan for InterRidge investigation of the Southwest Indian Ridge. The full text of the program plan is available via the InterRidge home page (http://www.dur.ac.uk/~dgℓØzz1/).

Overall Justification for an InterRidge Project on the Southwest Indian Ridge

The Southwest Indian Ridge (SWIR) has been chosen as a focus for an InterRidge Project that combines major objectives of the Global Studies Program and the Mescoscale Program. At a global scale, the SWIR is one of the relatively little investigated sections of the global system of ridges; it serves as the bridge between the Atlantic and Indian Ocean ridge systems, and basalts recovered from the SWIR have some of the most extreme isotopic compositions of any ridge anywhere. At the mesoscale, the SWIR is the longest representative of the super-slow spreading end member, and is ideal for study because it has an essentially constant, super-slow spreading rate along its entire length, exhibits two contrasting types of ridge morphology, and has interactions with at least two hot spots. Thus, it provides the tectonic setting for comprehensive surveys that will provide the data set necessary to compare super-slow with slow, medium and fast-spreading ridges.

While the SWIR has intrinsic scientific interest, it poses logistical difficulties because of the high southern latitudes and the geographic location distant from the northern hemisphere. The logistical difficulties, and the fact that optimal tools for exploration reside in different nations, raise the possibility of more rapid scientific advance through a collaborative approach co-ordinated through InterRidge.

Scientific Problems to be Investigated

A) How do the various aspects of crustal accretion respond as the spreading rate becomes very slow? Do models based on faster spreading rates adequately describe phenomena at super-slow ridges? The following aspects should be considered:
   i) Crustal structure and geophysics
   ii) Crustal composition
   iii) Hydrothermal activity
   iv) Biology

B) What are the effects of variation in magmatic budget at constant spreading rate? How do such effects vary as a function of spreading rate?

C) What are the characteristics and scale of the geographical boundaries for crustal composition, and biogeographic provinces between the Atlantic and Indian Oceans?

General Strategy and Objectives

The general objectives that should be accomplished by the program are:

- To provide the long wavelength perspective in terms of bathymetry, geophysics and crustal composition.
- To provide the critical data set for a super-slow ridge that can be compared to faster spreading ridges. This data set should include for multiple segments, for the range of axial depth and segmentation style, multi-beam bathymetry, gravity and magnetics, seismic experiments that provide crustal structure information, closely spaced rock sampling, and an assessment of the hydrothermal budget. Critical regions will need to be investigated off-axis to an age of ten million years.
- To locate specific hydrothermal sites, preferably in regions with different styles of segmentation, and to sample hydrothermal fluids and the associated biological community.

The overall tectonic setting of the SWIR can be divided into regions with large transform offsets and those with relatively few offsets, and regions influenced by hot spots and those distant from hot spots. In order to investigate this range of tectonic characteristics, three different regions, representative of the range in magmatic budget and segmentation style, should be selected for intensive study on the segment scale. The ultimate aim is to investigate and understand the range in styles of crustal accretion at super-slow spreading rates and to identify, observe and sample hydrothermal sites and associated life.

Because deep-towed instruments and submersibles cannot operate effectively at high southern latitudes, accomplishment of the hydrothermal and biological objectives requires an emphasis on the northeastern portion of the SWIR. The desirability of having the geophysical, geochemical, hydrothermal and biological studies on the same segments suggests the entire program should emphasize the northeastern SWIR. It is possible to accomplish the scientific objectives in this region because it encompasses the entire range of axial depth and segmentation styles.

Specific Project Design

The following series of legs is envisaged as a minimum program to accomplish the scientific objectives.

A) One leg of multi-beam bathymetry and underway geophysics to supplement existing data and to provide the regional bathymetric and geophysical framework.
B) One or two legs of petrological sampling.
C) Two legs of a deep-towed instrument package that would provide side-scan and hydrothermal sniffing.
D) A seismic experiment to complement existing studies which would enable a comparison of crustal structure in the three regions.
E) An ROV leg with the aim of locating and photographing two active hydrothermal sites preferably in two of the three regions.
F) A submersible leg to dive on the two hydrothermal sites to sample water, sulfides and animals.

Two additional legs would be needed to investigate the southwestern portion of the ridge, for regional bathymetry, geophysics and sampling. These legs will be necessary to answer questions about the SWIR as a gateway between the Indian and Atlantic Oceans, and for comparison of geological, geophysical and petrological characteristics of the two ends of the ridge.

Program Coordination

No single nation has all the tools necessary to accomplish this scientific program. A co-ordinated approach whereby data and technologies of different nations are used in sequence, and possibly with shared sea-going platforms, will lead to the optimal scientific return.

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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. 44
InterRidge News, 1995, 4, 1, pp. 72
InterRidge News, 1995, 4, 2, pp. 52

Meeting and Workshop Reports:

InterRidge Program Plan, pp. 26, 1994.
InterRidge Program Plan Addendum 1993, pp. 9, 1994.
InterRidge Program Plan Addendum 1994, pp.15, 1995
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, 1994.
InterRidge Global Working Group Report 1994: Indian Ocean Planning Meeting Report, 1994.
InterRidge Meso-Scale Workshop Report: 4-D Architecture of the Oceanic Lithosphere, pp. 15, May 1995.
InterRidge Global Working Group Report: Arctic Ridges: Relults and Planning, in prep.
InterRidge Active Processes Working Groups Workshop Report: Event Detection and Response & A ridge Crest Observatory, in prep.

These publications are available from the InterRidge Office upon request.

Biological Studies at the Ridge Crest

Temporal Variations of Deep-sea Hydrothermal Communities at 13°N / EPR

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Since 1981, numerous detailed studies have been conducted on the hydrothermal area between 12°38'N and 12°54'N and between 103°50'W and 104°01'W on the East Pacific Rise where the opening rate is 12 cm/year. To date, more than 170 dives, conducted in this area during a 12 year period, provide an exceptionally detailed view of the distribution and temporal evolution of the vent activity, the mineral deposits and the associated communities. The following diving cruises were devoted fully or partially to the study of vent biology in the so-called "13°N/EPR vent area": BIOCYATHERM[1] (1982, RV *Noroit/Cyana*, 5 dives), BIOCYARISE[1] (1984, RV *Le Nadir/Cyana*, 13 dives), HYDRONAUT[2] (1987, RV *T. Thompson & Le Nadir/Nautile*, 30 dives), MMVT[3] (1990, RV *Atlantis 2/Alvin*, 3 dives), HERO'91[1] (1991, RV *Vickers & Le Nadir/Nautile*, 27 dives), HERO'92[4] (1992, RV *Vickers & Atlantis 2/Alvin*, 21 dives), VOYAGE 131, LEG 25[4] (1994, RV *Atlantis 2/Alvin*, 5 dives). The survey of the temporal variations is not yet complete and new dives are planned in early 1996[5], using RV *Le Nadir/Nautile*. The temporal study is mainly based on precise mapping, discrete observation and sampling but not based on long term recording devices (except current meters and thermistors).

At the time of the BIOCYATHERM cruise in March 1982, the only two hydrothermal fields in the East Pacific which had been explored and described were the Galapagos spreading center (GSC) and the 21°N field on the East Pacific Ridge. The French geology team then explored the segment called 13°N located on the ridge between the Orozco fault to the north and the Clipperton fault to the south. The section studied lay between two overlapping spreading centers (OSC) at 12°37'N and 12°54'N. The axial field has a dome structure gashed by an axial valley from 300 to 500 m in width and 30 to 50 m in depth. Mean depth of the valley floor is 2630 m. Sites are distributed in clusters separated by highly fissured inactive zones. The hydrothermal sites are divided into four ensembles located around the edges of collapsed lava lakes or close by. From south to north, fields centered around ELSA can be seen at 12°48.13'N, those around GENESIS at 12°48.53'N, those around POGONORD at 12°49'N and lastly those around CHAINETTE at 12°50.30'N (Fig. 1). Hydrothermal areas, as at 21°N, include both various types of high-temperature edifices (smokers or diffusers) and warm (20°C) fluid vents as on the Galapagos Spreading Center. During 12 years of observations along this segment, 31 active sites were located and described. No major volcanic or tectonic event such as the volcanic eruption at 9°N/EPR or Coaxial segment on Juan de Fuca Ridge were directly or indirectly observed. However, considerable variations of emission conditions were observed within these hydrothermal fields, except on the POGONORD/JULIE sites.

Upon first analysis, 13°N segment fauna is not fundamentally different from that of the active zones of the East Pacific ridge under the same abiotic conditions. In communities developing on warm vents, two vestimentiferan species (*Riftia pachiptila* or *Tevnia jerichonana*) predominate, along with their accompanying species (*Paralvinella spp.*, patelliform gastropods, etc.) and their predators (*Cyanagraea predator* and *Thermarces cerberus*). The main difference between 13°N/EPR communities and those found at the 21°N and Galapagos sites is the reduced size of the bivalve populations: mytilids (*Bathymodiolus thermophilus*) at 13°N/EPR never form large mussel beds as they do in the Galapagos, but are fixed to *Riftia* tubes by their byssus; *Calyptogena magnifica* was observed in only two cases: as dead, almost completely dissolved shells north of POGONORD in 1982, and as a few young individuals on the GENESIS site in 1992. Absence of large bivalve populations is above all related to instability of hydrothermal conditions in the zone, as we shall see further on. Obviously, our perception of the taxonomical diversity of communities depends on the sampling effort made and techniques employed. If we limit ourselves to the most studied sites in the East Pacific, the 13°N/EPR site

[1] D. Desbruyères, Chief Scientist.
[2] A.-M. Alayse, Chief Scientist.
[3] R.A. Lutz and R.C. Vrijenhoek, co-Chief Scientists.
[4] J.J. Childress, Chief Scientist.
[5] F. Gaill, Chief Scientist.

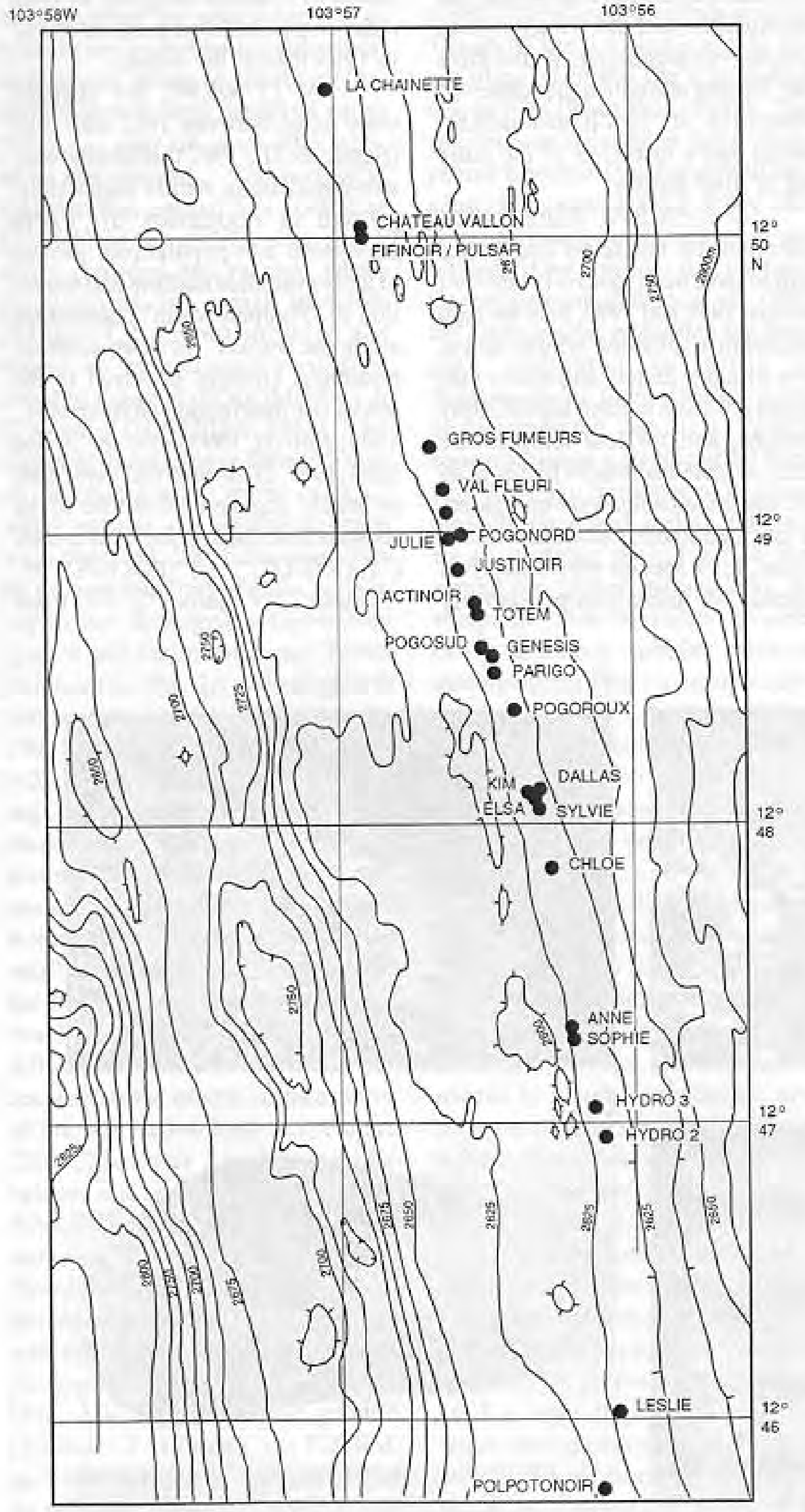

Figure 1. Sites of long-term temporal variability observations on the 13°N segment on the EPR.

showed itself to be more diversified than the Galapagos one: with 89 species described there, compared to 70 for the latter. However, diversity is approximately the same at EPR/21°N (85 species). Higher diversity in these two sites (13 and 21°N) was related to the co-existence of low temperature and high temperature events. However great biogeographical species differences were observed at the three sites. Only 40 species were common to both 13°N and GSC (47%) and 50 species with 21°N/EPR (59%). As for genera, relationships were very similar: out of 72 genera present at 13°N/EPR, 38 were present in the Galapagos (53%) while 45 were present at 21°N/EPR (63%). Hence the impression of uniformity of hydrothermal fauna in the tropical East Pacific is an error of perception due to the similarity of larger species making up the biomass (vestimentiferans, alvinellids and bivalves) which is not confirmed when small-sized species there are also taken into account. The specific faunal similarity is low (13%) with the Guaymas basin, certainly due to differences in edaphic conditions. It was even lower (5%) with the Northeast Pacific ridges because of biogeographical isolation due to the break in the ridge by the America plate and perhaps to climatic conditions (limiting by circulation of larva dispersal). The genera relation was about 25% in both cases.

Starting with the earliest cruises (CYAMEX, 1978) onward, observations of inactive edifices and shell graveyards showed that hydrothermal phenomena were discontinuous in time as well in space. The temporal discontinuity is a major structuring factor for communities since the result of emission cessation is the destruction of the associated populations. The fact that these emissions cease would imply that they can also appear! Therefore, we are certainly dealing with a cyclical activity with probable consequences for population successions. We felt it was necessary to determine the time constants for these communities, as well as their biological characteristics. Over the period from 1982 to 1994, we observed the evolution of hydrothermal communities on the 13°N segment of the East Pacific rise. In fact, only discrete observations could be made during diving cruises due to various technical hitches preventing "continuous" observation.

Observations over the last 12 years made during repeated visits to some East Pacific hydrothermal areas have demonstrated that important changes have taken place in the organism communities which flourish very near to fluid inputs. These modifications affect animal community composition, and can be contemporaneous to hydrothermal emission variations in intensity and location, or not. In the Galapagos zone (Hessler et al., 1988; Hessler and Desbruyères, 1991), visited in 1979, 1985, 1988 and 1990, no notable modification was measured by observers in emission conditions for fluid emitted through a low temperature vent network. Over the same time span, the most obvious variation in faunal composition was the decline of the giant worm *Riftia pachyptila* and the advantageous increase of the Mytilidae population *Bathymodiolus thermophilus* and the *Vesicomyidae Calyptogena magnifica*. At the same time, Hessler and colleagues observed penetration of "non-hydrothermal" species and a recession of the outer ring of filter feeders.

At 21°N/EPR (Lutz, 1991), hydrothermal emission conditions seem to have been relatively constant between 1982 and 1990, both for high temperature edifices whose spires grew by a few meters and whose output did not seem to have significantly changed, and for low temperature vents. When locations of live or dead *Vesicomyidae* banks were compared, we saw high stability of emission conditions, for a species whose survival depends on microbiotope stability (Fisher et al., 1988) even though bivalve graveyards would indicate displacement of activity. The vestimentiferan population decimated by research sampling in 1982 redeveloped and was more extensive in 1990 than at the outset.

At 13°N/EPR, few changes were noted between 1982 and 1984 (Fustec et al., 1987), affecting only sub-populations within some sites: growth or regression of *Riftia pachyptila* sub-populations, growth of active sulphide edifices and migration of "Pompeii worm" populations along the smoker. In sharp contrast, numerous changes occurred in the active site distribution (Alayse et al., 1988; Jollivet, 1993) over the period 1984-1987. Hydrothermal vents died or greatly degenerated in four of the six sites described on previous cruises ("PARIGO", "POGOSUD", "Actinoir", "Pogoroux"). On these

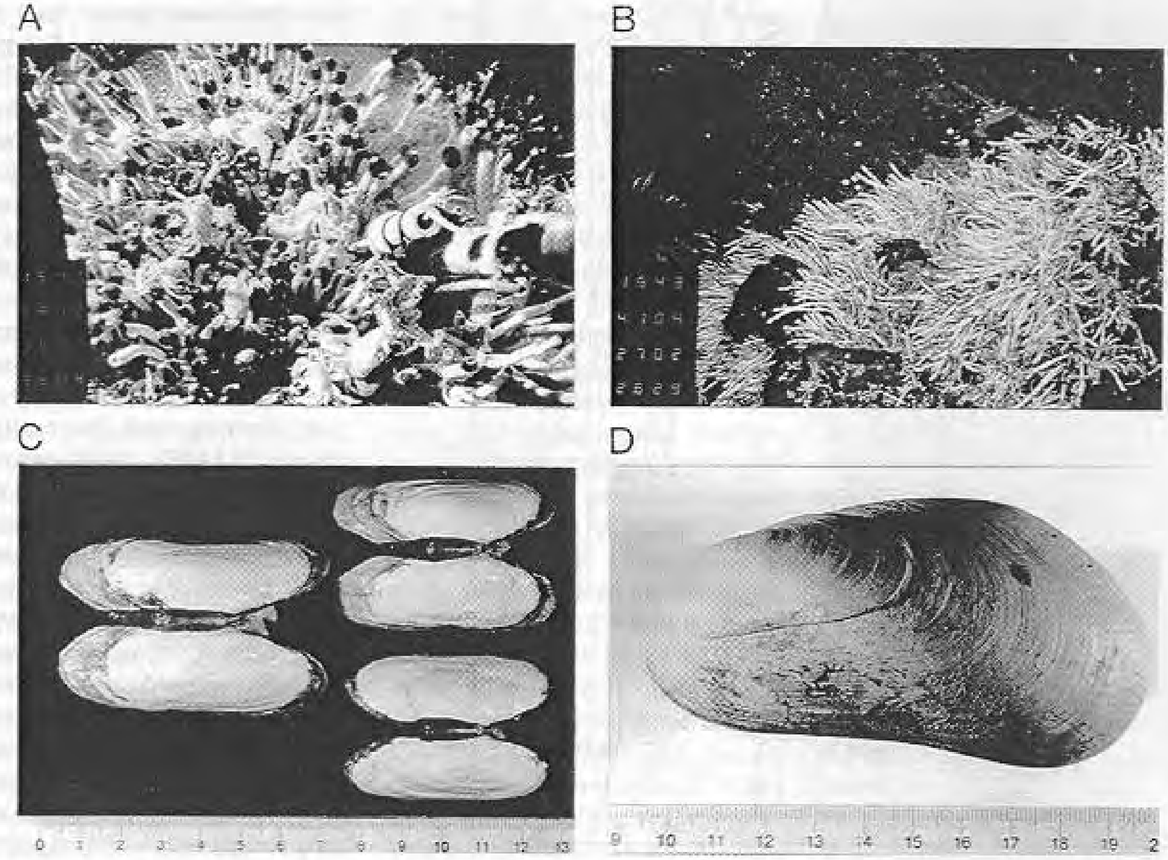

Figure 2. (A) "GENESIS" site in 1987, after reactivation. The fauna was made up of large numbers of crabs belonging to *Bythograea thermidron* and of vestimentiferans belonging to *Tevnia jerichonana* whose growth rate is particularly high. (B) At the same period, hydrothermal vents died or greatly degenerated in four of the six sites described on previous cruises. On these sites (here "PARIGO"), we saw rapid breakdown of *Riftia pachyptila*. (C) Shells of *Calyptogena magnifica* collected at GENESIS in 1991. (D) Shells of *Bathymodiolus thermophilus* with a large growth line indicating a major stress tentitavely attributed to the interuption of venting.

sites, we saw rapid breakdown of *Riftia pachyptila* (Fig. 2B) and a concentration of scavenger species (*Turidae, Galathea*, etc.). Mytilids (*Bathymodiolus thermophilus*) were able to subsist for several years even without any hydrothermal emissions: individuals living in inactive ("extinct") zones were sampled up to 1992, i.e., over six years after emissions had stopped. The inverse of this situation existed in a zone near (25 to 50 m) two of these sites, previously recorded and marked where populations of small mytilids (45mm< l < 65mm) survived and where no temperature anomalies could be detected (POGOMORT 1 & 2, renamed GENESIS in 1987). This zone was found to be reactivated: over an extensive area, warm (<23°C) water outputs and whitish deposits were observed. The fauna was made up of large numbers of crabs belonging to the *Bythograea thermidron* species and vestimentiferans *Tevnia jerichonana* (Fig. 2A) whose growth rate is particularly rapid (Roux et al., 1989) and juvenile *Riftia pachyptila* (<25cm). A site further on, containing mineralized polymetallic sulphides ("TOTEM") dated to be over seventy-five years old (Lalou, personal communication), located near Actinoir became active again and had small edifices (<2 m in height). Only the POGONORD site remained active throughout this period. In 1990, diffuse emission from GENESIS was concentrated at several surface points of the site; active high temperature (280°C) smokers 1 to 5 m high developed and were colonized by large Alvinellidae communities (*Alvinella pompejana, A. caudata* and *Paralvinella grasslei*). The *Tevnia jerichonana* population collapsed and was replaced by some dense *Riftia pachyptila* populations. Mytilids (Fig. 2D) resumed rapid growth (100mm < l <120mm). At TOTEM, an 8 m high black smoker developed on sulphide deposits and was covered by a very dense *Alvinellidae* population. In 1991 and 1992, these characteristics had not fundamentally changed: stabilization of emission conditions was observed. *Calyptogena magnifica*, which had only been observed as partially dissolved shells near POGONORD, resettled, and several individuals, measuring from 12.3 to 14.6 cm at their widest point, were sampled (Fig. 2C). According to estimates made in the Galapagos by Fisher et al. (1988), this size corresponds to about 7 years of age, i.e., colonization taking place as of the site's revitalization in 1985 (Roux et al., 1989). This species was thought to have disappeared from the zone for several decades. It recolonized the active sites when emission conditions were stabilized. If we consider that the habitat requirements (Fisher et al., 1988) for *Calyptogena magnifica* are stringent compared to those of *Bathymodiolus thermophilus*, it can be hypothesized that the 13°N/EPR zone underwent a stable period about fifty years ago (presence of dead and partially dissolved shells), followed by an unstable period which prevented the former species from developing. This instability favoured faster-growing species such as vestimentiferans or mixotrophic species such as *Bathymodiolus thermophilus*. This was followed by a return to emission condition stability up to recent times, during which recolonization of this species (*C.m.*) was observed.

To summarize, our study of 13°N/EPR indicated that periods of emission stability exist, interspersed with highly unstable periods when some sites move. Moreover, on the same site we saw a succession of phases in which intermediate temperature emission was diffused over a large area, then became concentrated at a few points with construction of sulphide edifices.

A rather comparable situation was observed in the Northeast Pacific by various authors. In the southern part of Juan de Fuca ridge, Stakes and Moore (1991) reported from 1984 to 1988 a large drop in hydrothermal fauna corresponding to a "readjustment" of hydrothermal emissions. Variability comparable to that of the Genesis site at 13°N was observed on the Endeavour site (Stakes and Moore, 1991, Delaney et al., 1992).

Thus a decade of observations on different hydrothermal zones in the East Pacific highlights:

(1) lack of evolution synchronism between hydrothermal sites on the same ridge or same active section.

(2) major structuring effect of emission instability on communities of organisms, affecting population succession dynamics.

(3) shifts of active zones in some sections by a few tens of meters, while high spatial-temporal stability was observed on other sections.

(4) some "extinct" zones can be reactivated after a few years.

Emission instability and its consequences on communities has often been attributed to tectonics (Hessler and Desbruyères, 1991; Jollivet, 1993) and/or volcanism (Haymon et al., 1991). More locally, fluid precipitation at the sub-surface (Hessler et al., 1988), or even the effect of sampling (Tunnicliffe and Juniper, 1990), have been suggested as causes for intra-site variations. However the more or less catastrophic nature of this sort of mechanism does not support the apparently systematical character (notably for the East Pacific Ridge) of population and fluid emission instability within hydrothermally active zones. Instability of convection through a porous system can be mentioned (Watremez and Kervevan, 1990) as a tentative explanation factor. Therefore, hydrothermal communities are linked to an aperiodic resource (although sometimes affected by a semi-diurnal signal, (Chevaldonné et al., 1991; Schultz et al., 1992) which is unpredictable (chaotic dynamics) in the medium term even when outside events are absent). On a local level (called "site") the instability of geothermal conditions on time scales around those of some species life span (about 10 years) does not allow communities of organisms to evolve to a stable state (or climax). To remain in this unstable environment, the hardiest species of the environment must colonize newly active zones and thus transform the environment. The ecological niches become diversified and colonizing species are progressively replaced by specialized species.

The most unstable periods should favour:

- species with an "r" type population strategy: rapid growth, many descendants, precocious sexual maturation, high reproduction level during life span.

- Mobile species, compared to fixed ones, and mixotrophic species that can use both geothermal carbon and the detrital carbon from photosynthesis.

Acknowledgements

This short communication of my own is a first attempt at a synthesis on 13°N/EPR evolution which will be published by several scientists including the Chief Scientists of *Nautile* and *Alvin* cruises and several ecologists. I am greatly indebted to Anne-Marie Alayse, James J. Childress, Richard A. Lutz, Robert C. Vriejenhoek, Horst Felbeck, Didier Jollivet and Alan Fustec for their contributions to this work, to Pierre Watremez for comments and discussions, and Heather Sloan and Ruth Williams who kindly helped me to edit this paper.

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Sensory Adaptations of Vent Organisms: Progress Report of Team Limulus

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We have completed structural and ultra-structural analyses of the eyes of six species of hydrothermal vent shrimp from the Mid-Atlantic Ridge collected in 1993. Two preliminary abstracts have been published[1,2].

Two *Rimicaris* species (*R. exoculata* and *?Rimicaris* (Snake Pit)) have winged dorsal eyes with massive amounts of photosensitive rhabdom backed by a white diffusing matrix. Three *Chorocaris* species (*C. chacei, ?Chorocaris* (Lucky Strike), and *?Chorocaris* (Broken Spur)) have enlarged frontal eyes with massive amounts of rhabdom backed by a white diffusing matrix. The cellular relationships between the retinas of these five shrimp and surface shrimp such as *Palaemonetes* are clear. *Alvinocaris markensis* seems to have followed the same general path of adaptations as the others; however, it has gone blind. The photoreceptors and some other cell types present in *Palaemonetes* are largely missing from the *A. markensis* retina. Perhaps *A. markensis* is an older species with more time to evolve.

The archival paper describing the retinal anatomy of *Rimicaris exoculata* will appear in the next issue of Visual Neuroscience[3]. Archival papers describing the retinal anatomy of the other five species are in the final stages of preparation. Progress on the anatomy and physiology of chemosensory capabilities of *Rimicaris* species will be reported in the October issue of Biological Bulletin[4].

Current work includes the production of an atlas of the brains of *Rimicaris exoculata* (completed) and *Chorocaris chacei* (in progress) and the immunocytochemical and biochemical survey of the brain of *R. exoculata* for neurotransmitters and neuropeptides. So far we have successfully mapped serotonin-like and histamine-like immunoreactivities in the *R. exoculata* brain.

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This Directory is intended to heighten the profile of biological studies within InterRidge and to facilitate collaboration amongst ridge crest biologists. Each listing contains the full contact information and a summary of recent and current work. It can be reached via the InterRidge Home Page at

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If you would like to listed in the directory, please send us your correct postal address, telephone, fax, e-mail address and a paragraph summarising your research. You may use the form on page 49 of this issue by ticking the Biologist Directory box and enclosing a research summary. All entries on the Ridge Crest Biologist Directory will also be entered on the InterRidge Researcher Electronic Directory.

International Co-Operative Research

Indian Ocean Column

The Sonne Field - First Massive Sulfides in the Indian Ocean

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On cruise SO 92 (HYDROTRUNC) RV *Sonne* scientists collected the first massive sulfides on the Indian Ocean floor, approximately 270 km north of the Rodriguez Triple Junction (RTJ). The polymetallic deposit is situated close to the rift axis of the medium-spreading Central Indian Ridge (CIR). The site is hydrothermally inactive; biological activity is not apparent on the black smoker topped mound nor are anomalous geochemical signatures evident in the water column above the former vent site. Chimney structures are being physically degraded and show various stages of weathering; hydrothermal precipitates are about to be buried by sediment. Specific elements, such as gold and copper, are enriched by late-stage, low-temperature maturation processes. Here we report on the geological setting, mineral zonation, different ore types and stages of formation of the "Sonne Field".

Geological setting

The Sonne Field is situated at the midpoint of the fifth CIR segment north of the RTJ, at 23°23.56'S, 69°14.53'E (central coordinates; Fig. 1). The metal deposit is located at 2845 m depth on the eastern flank, close to the top of a 300 m high and 4 km wide neovolcanic intra-rift ridge, transsecting the well defined rift valley for 20 km along strike. The immediate rift axis is marked by fresh, hyaline basaltic N-MORB, free of sediment cover. Fissures and fractures are as much as 5 m wide, and roughly NE oriented. At about the position of the deposit the neovolcanic zone is marked by up to 200 m of left-lateral displacement (Fig. 1).

Hydrothermal site

The massive sulfide mineralisation covers an area of at least 250 x 400 m of a small plateau on the neovolcanic ridge (Fig. 2). The site is not active any more, in fact it is in a stage of disintegration. Neither temperature nor Mn and CH_4 anomalies exist in the water column. The lack of hydrothermal fauna, even of clam shell relicts, at the former vent site is explained by the relatively long duration of seawater dissolution effects. Sediment thickness generally measures 2-3 m; assuming a sedimentation rate of 0.6 cm/ka (Walter et al., 1986), emanation of fluids and chimney growth must have ceased several thousand years ago.

The mineralized area (Fig. 2) forms a hydrothermal mound. The central portion, 100 to 150 m wide, is topped by chimney stumps, 1 m in diameter and up to 1.5 m high. The smoker remnants are sediment-dusted and have brown patches or porous spots. Superficial oxidation has transformed Cu-rich sulfide minerals into black-coloured secondary Cu assemblages. This innermost zone is surrounded by an aureole with numerous, almost completely eroded smoker relicts forming subcircular cavernous collapse-like structures up to 0.5 m in diameter with 0.3 m high outer walls. The relatively fast disintegration of the massive sulfide smokers is due to an originally high content of anhydrite, which is unstable under ambient cold seawater conditions; many of the studied sulfide fragments contain relict anhydrite in pore spaces; gypsum is less often observed in the samples. In the outer zone (Fig. 2) Fe-oxihydroxides form semi-consolidated m-thick mud layers, which probably represent early-stage, low-temperature mineral precipitates. Manganese crusts observed and sampled from the periphery of the mineralized site are low-temperature distal precipitates.

Massive sulfide mineralogy and chemistry

Three varieties of sulfide mineralizations, sampled by a TV-grab device, are recognized:

(A) Green-grey coloured pyrite-marcasite precipitates frequently display a layered structure. Euhedral to subhedral pyrite crystals are intimately intergrown with younger marcasite. Locally marcasite replaces pyrite. Minor sulfides include sphalerite and chalcopyrite, locally hosted by pyrite. Relicts of anhydrite pore filling. Secondary, high-reflecting sulfosalt minerals are occasionally observed. The latest mineral phases are amorphous silica filling pore spaces and Fe-hydroxide (probably goethite) in microfractures.

(B) Black-grey chalcopyrite ore is comprised of minerals formed during the main-stage high-temperature phase, and to a lesser extent during a later stage, lower-temperature phase of hydrothermal activity. Massive chalcopyrite is the main-stage mineral hosting older euhedral to subhedral pyrite. In surficial portions samples are covered with an up to 5 mm thick layer of later-stage sulfur-rich Cu sulfides (bornite, digenite, ± covellite), formed by replacement of chalcopyrite during waning hydrothermal activity. Locally, sample surfaces are partly corroded to a microporous framework; the pore spaces are coated with bornite and digenite. Cm-sized patches or vugs on the surface are filled with late-stage euhedral mm-sized pyrite, intergrown with barite ± gypsum, and partly covered with amorphous silica. This pyrite is probably also a product of late-stage chalcopyrite replacement.

(C) Sphalerite-bearing jasper and jasper breccia forms the substrate and contiguous parts of the chimneys in the hydrothermal mound set-up. The jasper is either massive, or brecciated with small-scale soft-sediment deformation structures, and represents the older, pre-chimney mineralization. Jasper, containing disseminated sulfides, varies from rust coloured to dark red. In thin section, massive layers of jasper have cellular or rounded structures, in which partially recrystallized Fe-hydroxide may reflect a colloidal origin. Subhedral sphalerite is the principal sulfide, often displaying Fe-rich cores (sphalerite I), and hosting

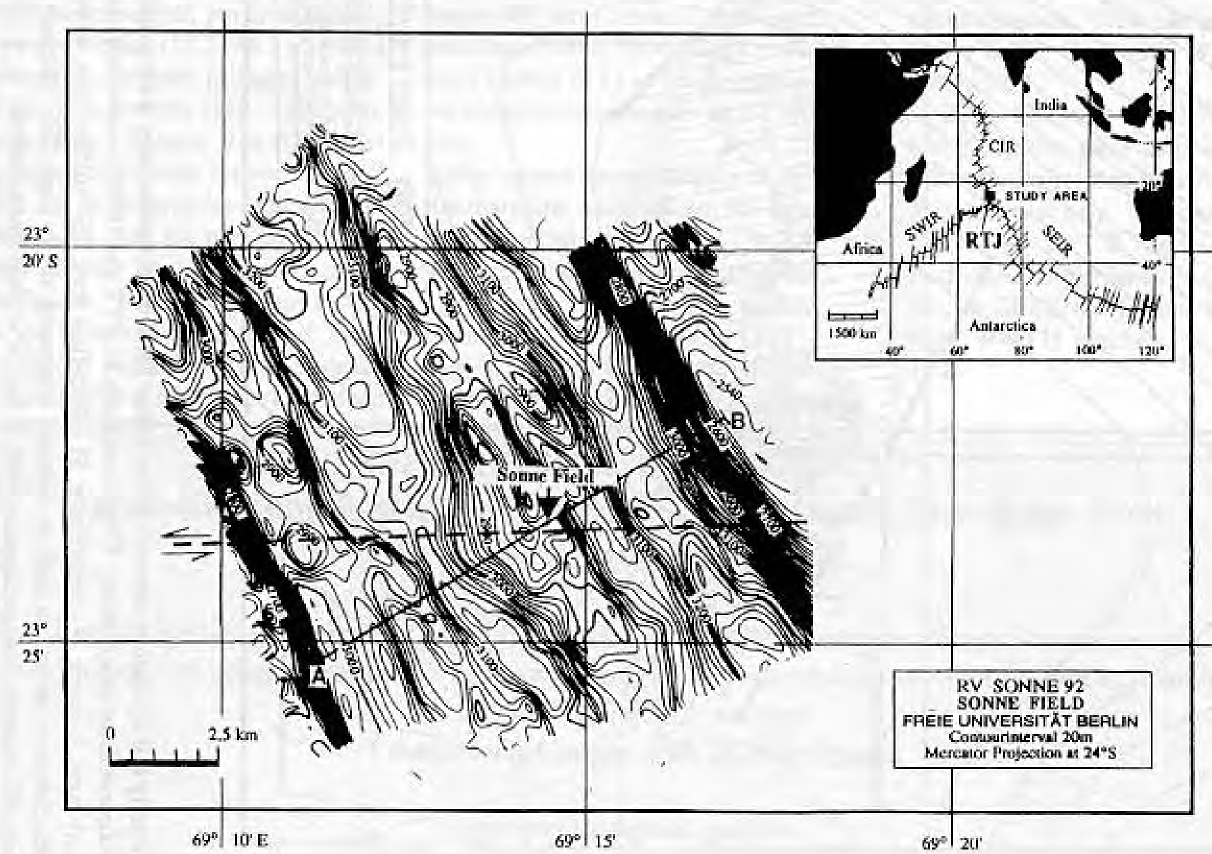

Figure 1: Main map: Bathymetric map of the Central Indian Ridge rift valley (5th segment) with position of the Sonne Field. The left-lateral transcurrent fault trends oblique to the rift valley strike. Inset: Location of the study area on the Central Indian Ridge north of the Rodriguez Triple Junction.

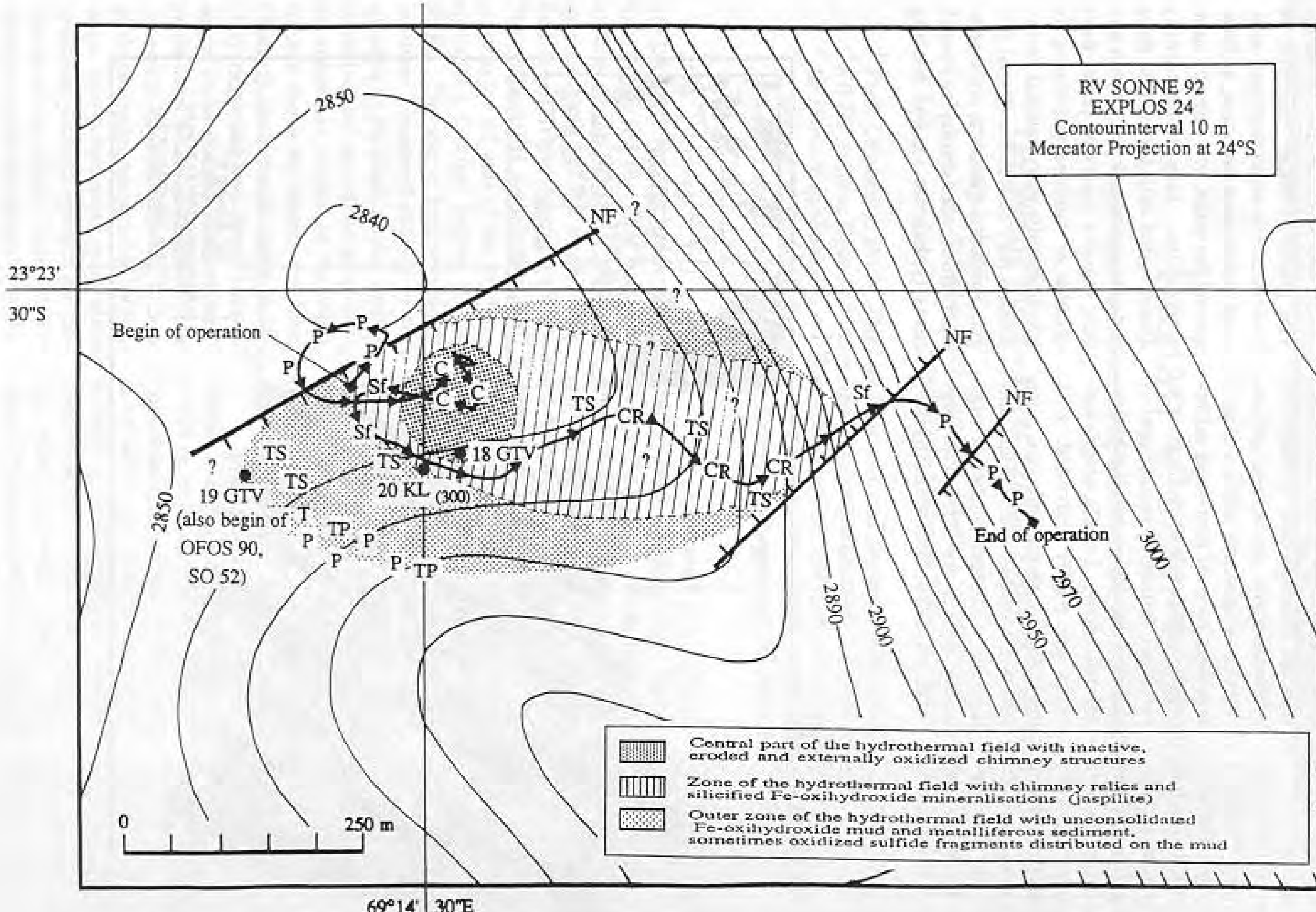

Figure 2: Detailed bathymetry (10 m contour interval) of the Sonne Field hydrothermal site, with zonation of mineral assemblages and tectonic elements. Track of EXPLOS 24 with start and end of ocean floor observation. TV-grab stations 18 GTV and 19 GTV recovered massive sulfides and oxidic/silicic hydrothermal precipitates, respectively; 20 KL sediment gravity core. Legend: P - pillow lava; Sf - sheet flow lava; TS - sulfide talus, weathered sulfide debris; TP - pillow talus, m-sized fragments of basaltic lava; C - inactive, eroded chimneys up to 3 m high, or chimney stumps up to 1 m high; CR - chimney relicts, ring-shaped relicts of sulfide chimneys up to 30 cm high and up to 50 cm in diameter; NF - normal fault escarpment with 2-3 m of vertical displacement.

minute silica inclusions. Fe-poor sphalerite (II) hosts small pyrite and chalcopynte grains; in places chalcopyrite disease is evident. Minor chalcopyrite, pyrite and marcasite are present as individual grains. Barite crystals and latest-stage amorphous silica coating barite as well as sulfide grains are late-stage gangue minerals.

The following mineralization history is envisaged: low temperature Fe-hydroxide mud (a), was impregnated at higher temperature by silica-rich solutions, silicifying the mud (b: jasper); tectonic fragmentation and upwelling of hydrothermal solutions of increasing temperature led to the precipitation of sphalerite I (c) and sphalerite II (d1), more or less coeval with the crystallization of chalcopyrite (d2) and pyrite (d3). Marcasite (e), barite (f) and amorphous silica (g) were precipitated when hydrothermal activity ceased. Among the three sulfide types, the Fe-sulfide dominated pyrite-marcasite ore assemblage (19.2 - 48.7 wt. % Fe) shows the highest primary, lattice-hosted Au contents (530 - 4400 ppb), averaging 1.94 ppm. The significant positive correlation between Au and Pb, Ag, Sb in the pyrite-marcasite ore indicates that Au precipitated together with late and mature stage sulfosalts. Such associations reflect a low temperature transport of these metals as aqueous sulfur complexes (Hannington et al., 1986). Late-stage secondary euhedral pyrite cubes tend to concentrate Au; in particular the smaller crystals are enriched, with a maximum content of 5.1 ppm. The mean Ag-content of pyrite-marcasite type ore (40 ppm) is identical to that of chalcopyrite-type sulfides; sphalerite-dominated jasper-rich samples average 29 ppm Ag.

Chalcopyrite type ore with 7.4 - 33.3 wt. % Cu and 20.3 - 42.7 wt. % Fe is marked by relatively high contents of Se (mean 514 ppm) and Mo (mean 256 ppm), both likely hosted in primary Cu-phases. Cu concentrations of the Sonne Field are among the highest compared to other submarine massive sulfide deposits (Rona & Scott, 1993). In particular, maturation and transformation to secondary Cu-sulfides accounts for a significant enrichment of this element.

The mound-building sphalerite-jasper mineralization with Zn contents of 6.8 - 31.1 wt. % and accordingly high Cd concentrations (mean 989 ppm) contains significant amounts of barite; Ba reaches a maximum content of 13 wt. %, Sr fixed to barite reaches abundances up to 2100 ppm.

Sulfur isotope determinations on pyrite-marcasite and chalcopyrite-type pyrite samples yield ratios of 1.9 - 3.7 ‰, values typical for basalt-hosted mid-oceanic ridge massive sulfide occurrences. $\delta^{34}S$ of barites (16.5 - 20.1 ‰) closely compare to isotope ratios of submarine hydrothermal sulfates (Ohmoto et al., 1983). Values somewhat lighter than modern seawater sulfate imply a moderate (max. 20 %) admixture of magmatic (0‰) sulfur.

Acknowledgements

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The InterRidge Office is currently accepting submittal of articles for the next issue of *InterRidge News* to be published in May 1996.

InterRidge News is intended for rapid publication of preliminary results and cruise reports which do not appear in other publications. Ridge crest researchers are encouraged to submit their findings as short articles:

1-4 manuscript 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.

Submission:

- Prefered submission method/format is by e-mail to intridge@durham.ac.uk as an attached RTF file. Originals or good quality reproductions of figures may be sent by post or ftp.
- Reference style should conform to references appearing in this issue.

Articles must arrive in the InterRidge Office no later than 25 March 1996.

Marine Geology And Geophysics Cruises To The Southeast Indian Ridge, 1995-1996

Contributed by Dave Christie, Oregon State University

The Southeast Indian Ridge between 88°E and 118°E Westward Legs 9 and 10, RV *Melville*

PIs Leg 9: James R. Cochran (Lamont-Doherty Earth Oservatory) and Jean-Christophe Sempéré (University of Washington)

PIs Leg 10: David M. Christie (Oregon State University) and John J. Mahoney (University of Hawaii)

The first leg started from Fremantle (Australia) on December 10, 1994 and returned to Fremantle on January 23, 1995. This leg was devoted to a geophysical survey between 91°E and 118°E. The second leg, which departed Fremantle on January 29 and arrived in Hobart on March 13, 1995, extended the geophysical coverage from 91°E to 88°E and focused on geochemical sampling of the ridge axis using conventional dredges and wax cores. Brief reports were published in *EOS* of March 14, 1995 and in *RIDGE Events* in June 1995.

In all, a 2500-km long section of the ridge axis was surveyed including 4 detailed study "boxes" which extend for a total of 1100 km along the axis and include 8 second-order ridge segments. Within each box, SeaBeam 2000 bathymetry, magnetics and gravity lines extended to approx. 10 Ma seafloor age on either side of the axis. A total of 80 dredges and 20 wax cores were recovered for a maximum along-axis sample spacing of 30 km, with at least one sample from every second order segment. In key areas, more closely spaced samples were acquired.

Between 89°E and 118°E significant variations occur in both axial topography and segmentation characteristics at essentially uniform spreading rate, as the Southeast Indian Ridge (SEIR) passes from a region of high mantle temperature in the vicinity of the Kerguelen/Amsterdam hotspots to a region of low mantle temperature in the vicinity of the Australian-Antarctic Discordance (AAD). The average depth of the SEIR axis increases by ~1500 m from ~ 2500 meters in the west, to >4000 meters in the east and there is a general evolution in ridge morphology from a shallow axial high in the west to a deep rift valley in the east. Between 100°E and 110°E, several first order (transform-bounded) segments display remarkable within-segment transitions in axial morphology, from axial high in the west to rift valley in the east. Mantle Bouguer anomalies generally show little along-axis variation within segments except within ~10 km of ridge offsets.

Finally, ridge propagation appears to have been the dominant mechanism in the recent evolution of the plate boundary configuration.

Major element compositions of more than 140 glass groups from 80 dredges and 20 wax cores display a surprising lack of variability for such a large geographic area. MgO values cover a "normal" mid-ocean ridge basalt (MORB) range from approx. 5.2-9.8 wt.%. No andesitic or other siliceous glasses were recovered, but more enriched compositions ($K_2O/TiO_2>0.15$) occur in several areas. The greatest concentrations appear to be associated with an anomalously shallow first order segment near 108°E. When these are excluded, the variability of most other elements, at a given MgO value, is rather small (<0.5 for TiO_2 and Na_2O, <1.0 for FeO, CaO and Al_2O_3). As mean axial depth increases from ~2600 meters, close to the Kerguelen and Amsterdam-St Paul hotspots to ~4700 meters approaching the cold mantle region of the AAD, mean Na8.0 increases from ~2.5 to ~3.3 consistent with the global trend of Klein and Langmuir (1987).

A very preliminary appraisal of the major element data suggests that, on a segment-by-segment scale, there may be a shift in the style and degree of variability of lava compositions. Basalts from axial ridges in the western part of the study area tend to be both more fractionated and more variable in MgO than those from axial valleys farther east, although some of the highest MgO values are for axial ridge lavas, and some axial valley lavas are quite highly fractionated. In almost every case, when individual segments, bounded by second or third order discontinuities, are considered, the variability of other elements at constant MgO is very small, suggesting that zero-age lavas from a given segment are typically derived from a common parent. This low variability contrasts with published data from the AAD and the Mid-Atlantic Ridge that appear to show a great diversity in inferred parental magmas for axial valley lavas. It may in part reflect the enhanced ability to sample precisely at the axis that is provided by the use of SeaBeam 2000 in conjunction with the new dynamic positioning capability of RV *Melville*, implying that chemical diversity develops as the range of ages sampled increases, even in a short time. If this is so, then many of the sampled enriched MORB were also erupted on-axis and not in a broader neovolcanic zone as at 9°N on the East Pacific Rise.

BOOMERANG 5 RV *Melville*
January 16-February 19, 1996
Near 130°E at the eastern boundary of the Australian Antarctic Discordance (AAD)

PIs: Jean-Christophe Sempéré and W. Wilcock (University of Washington), David M. Christie (Oregon State University) and Douglas G. Pyle (San Diego State University).

This cruise focuses on the off-axis configuration, out to about 10 Ma, of the Indian-Pacific isotopic boundary, presently located within segment B5, near the eastern end of the AAD. A grid of dredge sites on 0-10 Ma seafloor is designed to locate the Indian-Pacific mantle isotopic boundary and to determine whether it has undergone long-term migration or maintained its current position within the eastern AAD. Detailed magnetic and gravity data will be collected in the 0-5 Ma region to facilitate ocean crustal modelling and constrain crustal thickness variations, which are critical to an understanding of the origin of the AAD and its boundaries. The modelling will seek to extend off-axis, crustal thickness information obtained during the December 1994, near-axis seismic refraction experiment, carried out by J. Orcutt, J. Phipps-Morgan, M. Tolstoy, D. Blackman and others. Like the sampling program, these studies will seek to understand and define the recent configuration of the isotopic and transform boundaries.

SeaBeam 2000 bathymetric data will be used for seafloor morphology/tectonics studies, in particular to determine whether the "chaotic" seafloor terrain of Zone B4, immediately west of the isotopic boundary, is spatially related to the isotopic boundary.

Based on these results, final sites for a proposed Ocean Drilling Program leg will be selected. Single channel seismic reflection data will be collected on older seafloor out to 30 Ma or more, primarily as an aid to site selection.

BOOMERANG 6, RV *Melville*
February 23-April 16, 1996
77°E to 88°E, Near the Amsterdam/St. Paul Hotspot

PIs: Kevin T. M. Johnson (Bishop Museum), Daniel S. Scheirer and Donald W. Forsyth (Brown University) and David W. Graham (Oregon State University)

SeaBeam 2000 bathymetry and reflectivity, gravity and magnetics data will be collected along the SEIR from approximately 88°E, linking with data collected in 1995, to approx. 77°E, northwest of the Amsterdam and St. Paul hotspot.

This section of the ridge is closest to the large Kerguelen Plateau and hotspot, which may have played an important role in the development of globally distinctive Indian Ocean mantle. This portion of the ridge also appears to have two types of transitions from median-valley to no-median-valley topography: one controlled by crustal thickness variations and the other by changes in spreading rate.

Nearly complete SeaBeam 2000 bathymetry and side-scan coverage will be obtained, in addition to high resolution gravity and magnetics, from the axis out to crust of age 1 Ma on either side of the axis. Rock or glass samples will be collected approximately every 10 km along-axis for a total of 40-50 dredges and a similar number of wax cores.

The principal problems to be addressed by this study include: plume-ridge interaction, mantle contamination by plumes, mantle melting, fracture zone damming of along-axis flow, transition from axial valley to no axial valley, along-axis variations in mantle Bouguer anomalies, and relationships between seafloor roughness, segmentation style and spreading rate.

An Examination of Genetic Conformity Between Co-existing Basalt, Gabbro and Residual Peridotites from 15°20'N Fracture Zone, Central Atlantic: Evidence from Isotope Composition of Sr, Nd and Pb

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Introduction

A simplified geodynamic model of the oceanic lithosphere accretion suggests that a vertical stratigraphy, consisting of an assemblage of basalts, sheeted dykes, isotropic and layered cumulates and residual mantle peridotites, forms along the ridge axis. The basic point of this model is genetic conformity between co-existing erupted basalts, gabbros and residual mantle peridotites. At the same time, there are no systematic studies of basalts, layered mafic-ultramafic rocks, and residual peridotites, obtained at single sites along the ridge axis, with the exception of the well known data of Roden et al. (1984). This is due to the fact that locations along a ridge axis, where assemblages of co-existing basalt, gabbro and residual peridotite are found, are not numerous. In addition, most geochemical and petrological data for abyssal peridotites, and many of those for gabbros, have not been studied with co-existing basalt suites. Therefore, there is a gap in the understanding of the inter-relation between different members of mantle derived magmatic complexes and residual peridotites of mid-ocean ridges. This study is intended to fill this gap, at least for the intersection of the Mid-Atlantic Ridge (MAR) and the 15°20' Fracture Zone (FZ) - a large offset FZ in the Atlantic Ocean which has been investigated in detail. This region of the MAR corresponds to a large geochemical anomaly manifested in mafic and ultramafic rocks (Bougault et al., 1988; Casey et al., 1994). Samples selected for this study were obtained during the expedition of R/V *Atalante* (IFREMER, Brest, France) in 1992 by dives of submersible *Nautile* on the western slope of the rift in the eastern Ridge-Transform Intersection (RTI; Site F03, 15°04'N, 44°57'W) and on the eastern slope of the rift to the north of the western RTI (Site F12, 15°37'N, 46°32'W; Fig. 1).

Description Of Rocks

Site F12, Western RTI

Basalts (Sample F12-11) are characterised by aphyric Pl-Cpx rock with a micro-ophitic texture. The rocks are weakly altered: pyroxene has been partly replaced by chlorite. With a $(La/Sm)_{cn}$ value of 1.30, they correspond to volcanics intermediate between T-type (0.85-1.27) and E-type (1.28-2.29) Mid-Ocean Ridge Basalt (MORB) (characteristic values given after Wilson, 1989). The major element chemical analysis of this sample confirms this assumption (data on petrochemistry and mineral chemistry of all rocks studied will be published).

Sampled gabbro (Sample F12-05) consists of plagioclase, clinopyroxene, orthopyroxene, biotite and secondary amphibole and chlorite. The rock has a gneissic texture which is common in sheared gabbro from RTI zones along the MAR. Earlier phlogopite-bearing gabbros were described by Cannat et al. (1992) at 15°37'N, 16 miles north of the western RTI. Gabbro from Site F12 with a $(La/Sm)_{cn}$ value of 1.90 corresponds to basalts associated with it.

Hyperbasites (Sample F12-04) are typified by massive serpentinites with characteristic pseudomorph-

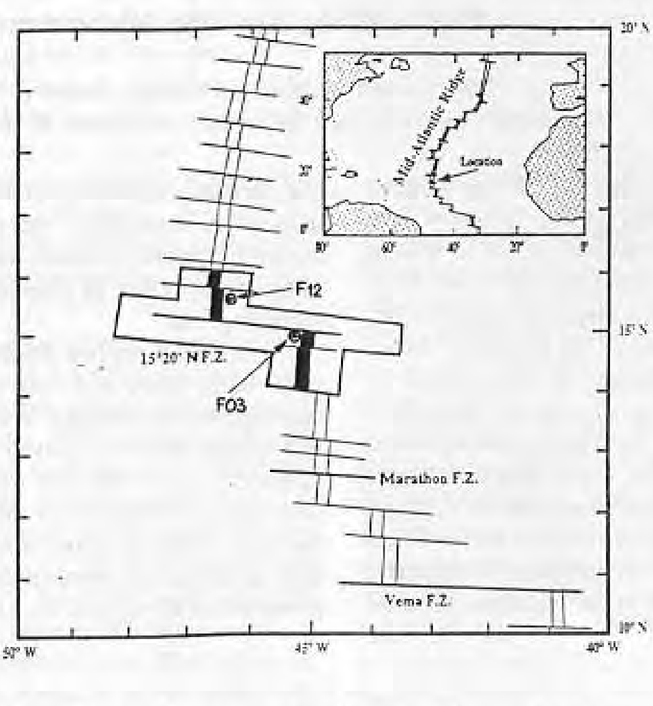

Figure 1. Locations where co-existing basalts, gabbro and residual peridotites were obtained.

plate texture determined by the predominantly plate shapes of serpentine and small xenomorphic grains of spinel from the rock matrix. Thin prismatic segregations of brown spinel are equally distributed in the rock matrix. It is remarkable that small brown phlogopite scales are associated with spinel segregations in these rocks. The mineral composition of peridotites from Site F12 leads us to suggest that the primary rocks were characterised by phlogopite bearing dunites subjected to high stress by subsolidus conditions. Essential enrichment of LREE in Sample F12-04 has been detected: $(La/Sm)_{cn} = 2.96$. The value of this parameter for peridotites from Site F12 differs noticeably from that for mafic rocks associated with them. Even taking into consideration the possible LREE mobility, during low temperature recrystallization of these peridotites, the enrichment level of Sample F12-04 is so high that the above mentioned explanation for this phenomenon is only one possibility. Thus, it is possible that enrichment of LREE is a geochemical peculiarity inherited from primary mantle derived rocks.

Site F03, Eastern RTI

Basalts (Sample F03-02) from this site are almost fresh containing plagioclase, clinopyroxene and olivine and characterized by subdoleritic texture. Distribution of LREE in these rocks ($(La/Sm)_{cn}=1.40$) is similar to that of E type MORB.

The gabbros here (Sample F03-04a) are coarse-grained rocks. They consist of plagioclase and clinopyroxene partly replaced by actinolite. There was no textural evidence of strain in these rocks. Gabbro from Site F03 corresponds to normal tholeiitic gabbro by its petrochemical peculiarities.

Ultramafic rocks from Site F03, sampled at the eastern wall of the rise, were almost totally composed of residual peridotites and located at the western slope of the rift valley. The largest outcrop of peridotites among those known at mid-oceanic ridges was discovered here (Silantyev et al., 1991). Sample F03-04b is typical serpentinite characterized by a protogranular texture. The rock is cut by many thin chlorite - actinolite veins. Relics of primary reddish-brown spinel and plagioclase (about 5%), replaced by chlorite and serpentine pseudomorphic plates after orthopyroxene and olivine, have also been recognized in Sample F03-04b. Peridotites from Site F03 belong to the plagioclase-spinel bearing harzburgites judging by their mineralogic features. Peridotites represented by Sample F03-04b have $(La/Sm)_{cn} = 1.59$, close to that for basalts from the same site.

Isotopic compositions of strontium, neodymium, and lead in associated basalts, gabbros and residual peridotites

The isotopic compositions of Sr, Nd, U and Pb in peridotites were determined using a multichannel mass-spectrometer "Finnigan-MAT 261", at the Institute of Precambrian Geology and Geochronology, which allows simultaneous registration of ion currents of different isotopes. The isotopic compositions of Sr, Rb, Nd and Pb in the samples studied are shown in Table 1.

The data obtained allow us to make a few preliminary inferences that are important for identification

Table 1. Concentrations and isotopic compositions of Sr, Rb, Nd, U and Pb in rocks studied

Sample	F12-11	F12-05	F12-04	F03-02	F03-04a	F03-04b
Rock type	Basalt	Gabbro	Peridotite	Basalt	Gabbro	Peridotite
Sm ppm	4.942	2.755	0.906	2.313	0.502	0.182
Nd ppm	16.26	8.635	4.176	8.393	1.349	0.628
Rb ppm	53.47	4.007	1.125	15.41	1.198	1.165
Sr ppm	159.6	116.9	33.89	169.6	48.44	12.37
$^{147}Sm/^{144}Nd$	0.18439	0.19351	0.13152	0.16715	0.22573	0.17540
$^{143}Nd/^{144}Nd \pm 2\sigma$	0.513144 ±8	0.513214 ±18	0.512142 ±16	0.513001 ±9	0.513238 ±21	0.513084 ±28
$^{87}Rb/^{86}Sr$	0.96876	0.09908	0.09601	0.26282	0.07151	0.27236
$^{87}Sr/^{86}Sr \pm 2\sigma$	0.703498 ±13	0.703002 ±19	0.708744 ±17	0.703396 ±12	0.703547 ±11	0.704735 ±19
$^{206}Pb/^{204}Pb$ resid.	18.485	18.449	18.757	19.187	18.876	18.982
$^{207}Pb/^{204}Pb$ resid.	15.523	15.530	15.671	15.582	15.630	15.647
$^{208}Pb/^{204}Pb$ resid.	38.080	38.112	38.832	38.949	38.764	38.899
Pb ppm whole rock	1.598	0.3693	7.675	0.4869	0.0687*	0.7018
U ppm whole rock	0.2558	0.1744	0.4494	0.1997	0.0119*	0.5318

Remarks: All the samples were subjected to acid attack (resid. corresponds to sample after this procedure). Isotopic compositions and concentrations of Sr, Rb, Sm and Nd were determined in whole rock. Error of determinations is about 5%.

* in residue.

of possible genetic relationships between associated basalts, gabbros and residual peridotites. The ultramafic rocks represented by Sample F03-04b, as seen in Fig. 2, are closer to mantle peridotites complementary with tholeiitic MORBs, judging by their isotopic characteristics. An insignificant shift toward ^{87}Sr enrichment, observed in this rock, may reflect preservation of secondary phase, which has kept its strontium isotopic composition, in spite of acid attack. Variations of Sr and Nd isotopic compositions, observed in co-existing basalts, gabbros and peridotites from Site F03, show that all of these rocks belong to a single magmatic assemblage perhaps derived from a single magmatic source. Another characteristic of the isotopic composition relationships of Sr and Nd has been established in rocks from Site F12. It is impossible to explain the observed variations in ^{87}Sr/^{86}Sr and ^{143}Nd/^{144}Nd values in these basalts, gabbros and peridotites assuming that they originated from a single mantle source. Extremely unusual isotopic compositions of Sr and Nd are characteristic of sample F12-04. This sample has a very low value for ^{143}Nd/^{144}Nd (Table 1, Figure 2) due to strong ^{87}Sr enrichment. Influence of marine sediments on Nd isotopic composition is not the explanation, because features of brecciation and admixing of alien substances have not been observed in the rocks studied. The high value of the strontium isotope ratio obtained for this sample can be explained by the same reason as well as the analogous shift of this ratio from the mantle array established for Samples F03-04b. However, the isotopic composition of Nd is a reliable indicator of genetic type for mantle derived rocks and usually not dependent on secondary low-temperature recrystallization of primary rocks (Faure, 1986). Another remarkable geochemical peculiarity of Sample F12-04 is a high concentration of Sm and particularly of Nd (Table 1). This phenomenon reflects a primary biotite presence in the peridotites. Therefore, it seems important to compare the concentrations of Sm and Nd observed in Sample F12-04 with values from well studied mantle xenoliths of metasomatized mantle ultramafic rocks containing biotite and amphibole, as well those from different kinds of unmetasomatized mantle peridotites. The results of this comparison confirm that two types of mantle derived peridotites are present at the MAR segment examined. The first type corresponds to the normal residual MAR-peridotites related to the MORB suite (Sample F03-04b). The second one represents peridotites that are close to compositional fields of metasomatized mantle peridotite bearing biotite and amphibole (Fig. 3). In the case of Site F12 these residual peridotites do not genetically conform with basalts co-existing with them, that belong to the MORB suite.

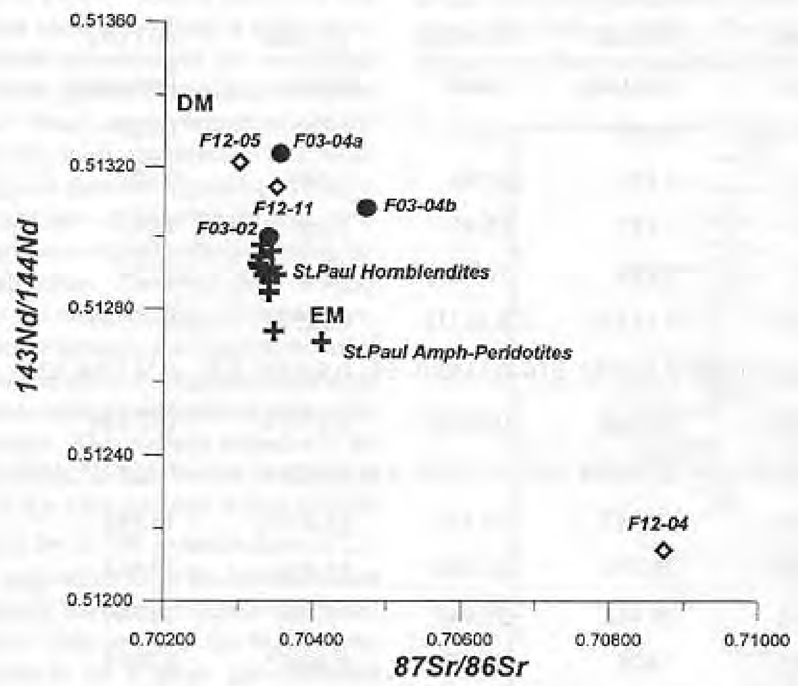

Figure 2. Variations of Sr and Nd isotopic compositions in basalts (F12-11, F03-02), gabbros (F12-05, F03-04a), and residual peridotites (F12-04, F03-04b) from 15°20' FZ. DM-depleted mantle, EM-enriched mantle, Crosses-peridotites and hornblendites from St.Paul's Rocks taken from Roden et al., (1984).

Data on lead isotopic composition in studied mafic and ultramafic rocks from Sites F12 and F03, presented in Table 1, confirm our interpretation of the genetic relationships between basalts, gabbros and residual peridotites discussed above. All of these rocks from the triple assemblage of Site F03 have similar values of ^{206}Pb/^{204}Pb, ^{207}Pb/^{204}Pb and especially ^{208}Pb/^{204}Pb, and demonstrate clear genetic conformity. On the other hand, gabbros and basalts from Site F12 essentially differ from the peridotites associated with them in all of these parameters. Another notable peculiarity of peridotite represented by sample F12-04 is a very low ratio of U/Pb. This sample has an unusually high concentration of lead (about 8ppm). The most reasonable explanation of these phenomena implies an ancient age for mantle derived peridotites from site F12. This suggestion is supported by the fact that samples taken from rocks close to ancient mantle peridotites at St.Paul's Rocks can be distinguished by their lead isotopic composition as well as by the other geochemical parameters discussed above.

Conclusion

This study of isotopic compositions of Sr, Nd and Pb, in basalts, gabbros and residual peridotites coexisting at the eastern and western RTI of 15°20' FZ, shows that two different kinds of geological sequences are present in the segment of the MAR examined. The first one consists of genetically related basalts, gabbro and peridotites derived from a single mantle source and conforms to a canonic model of oceanic crust accretion in ridge crest zones. The

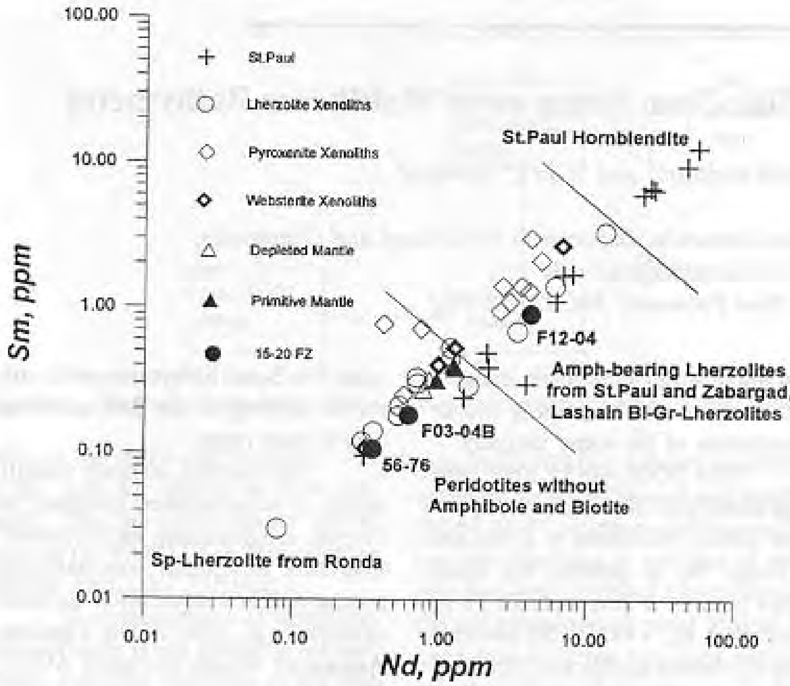

Figure 3. Variations of Sr and Nd contents in different kinds of mantle derived peridotites. Sample 56-76 was dredged at the western slope of the rift valley to the north of the western RTI. Data taken from Kramers et al. (1977), Obata (1980), Frey (1980), Roden et al. (1984) and Bonatti et al. (1986) are also shown.

second one does not conform to such a model and includes basalts and gabbros which do not have genetic relationships with co-existing residual peridotites. These peridotites may correspond to metasomatized ancient mantle substrata not related to zero age basalts from the axial zone of the MAR. Peridotites from Site F12 were exposed, as mentioned above, at the eastern slope of the rift valley; on the other hand, geochemically normal peridotites were dredged from the opposite slope of the rift valley at almost the same latitude from site 16ABP-56 (16th cruise of R/V *Akademik Boris Petrov*). Thus, serious reasons appear for our assumption of the existence of shortwavelength geochemical and isotope heterogeneity at the MAR segment examined.

Acknowledgements

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Methods and Techniques

Texture Mapping TOBI Side-Scan Sonar on to Multibeam Bathymetry

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Near-bottom TOBI side-scan sonar data collected in the last 5 years or so have provided high-resolution images of the seafloor, and have been used to obtain a better understanding of the geologic processes that act to produce seafloor topography such as faulting, volcanism and mass wasting. It has become clear in the analyses of the side-scan imagery, however, that fine-scale bathymetry data are critical to interpreting them. This problem has been addressed, and in the near future the TOBI side-scan system will also supply detailed co-registered bathymetry.

In this article we focus on the existing TOBI side-scan sonar data, and show how the analysis of the TOBI data is aided by combining them with previously collected low resolution multibeam bathymetry data (e.g. Sea Beam). In particular, we describe a method of texture mapping TOBI side-scan sonar on to colored bathymetric surfaces to aid in the visualization of the blended data sets. Advances in graphics hardware and software have now made it possible for workers using only desktop computers to do this. Texture mapping is a powerful tool used to add visual detail to surfaces in computer graphics. It consists of a series of spatial transformations: a texture plane (e.g., TOBI image) is transformed on to a 3-D surface (e.g., multibeam bathymetry) and then projected on to a 2-D output surface (e.g., computer screen or plotted figure; e.g., Wolberg, 1988). Despite the large differences in resolution between the side-scan sonar data and the multibeam bathymetry, and the problems associated with the fact that the two data sets are not co-registered, we have found that combining the two into a single composite image is extremely useful in guiding the interpretation of the sonar imagery.

The TOBI 30/32 kHz side-scan sonar provides high-quality images whose resolution is a function of range, but in general, the image pixel size is a few meters (e.g., Murton et al., 1992). By contrast, each depth returned by a surface ship-mounted multibeam echosounder represents a patch of seafloor 100-200 m in diameter. To produce a composite image of these two data sets we identify the swath of multibeam bathymetry that corresponds to a swath of TOBI side-scan imagery using estimated latitudes and longitudes of the TOBI vehicle. The two data matrices are then resampled to the same physical size (as described below) to ease the process of texture mapping. Each scanline of TOBI side-scan sonar data in its original form contains 8000 pixels of information, 4000 to port and 4000 to starboard. The original data file contains a ping approximately every 4 seconds. We resample each scanline to 200 pixels of information (1/40 the original size), and along track we retain every fifth data point. Even after downsizing the TOBI data, however, the size of the matrix of echo amplitudes is still several times larger than the corresponding size of the matrix of bathymetric depths. To adjust for this difference, the bathymetry data are interpolated and resampled to the same number of points as the TOBI data. If there is a mismatch in the two data sets due to navigational errors, adjustments are made by shifting the TOBI data either along the track or across the track. Sections of TOBI data up to 15 km along track have been mapped on to Sea Beam bathymetry with only minor shifting of the data sets relative to each other.

The texture mapped visualization is accomplished utilizing the "visual programming environment" available in several commercially available 3-D visualization software systems (e.g., IBM's Data Explorer, Advanced Visual System's AVS5). The systems provide easy to use visualization environments that do not require extensive 3- D graphics expertise or traditional programming skills. The visually co-registered gridded bathymetry and TOBI side-scan sonar images are read by the "visual program" (Fig. 1). The gridded bathymetry data are used in two ways. First to create a 3-D surface, and second to generate a 2-D color image associated with the 3-D surface. The 2-D colorized surface representation of the bathymetry is combined with the TOBI image to produce a composite image that is texture mapped on to the 3-D bathymetric surface to produce the final graphic display. The combination of the TOBI image and the colorized surface enhances the information available from the TOBI image alone.

Figs. 2-4 present examples of TOBI imagery texture mapped on to Sea Beam bathymetry using AVS (Figs. 2 and 3) and Data Explorer (Fig. 4). The images are of volcanic features on the median valley floor of the Mid-Atlantic Ridge (MAR) between the Kane and Atlantis transforms (24°-30°N). The TOBI data were collected on RRS *Charles Darwin* Leg 65 (Cann et al., 1992; Smith et al., 1995) within a pre-existing Sea Beam bathymetric survey (Purdy et al., 1990). Figure captions give de-

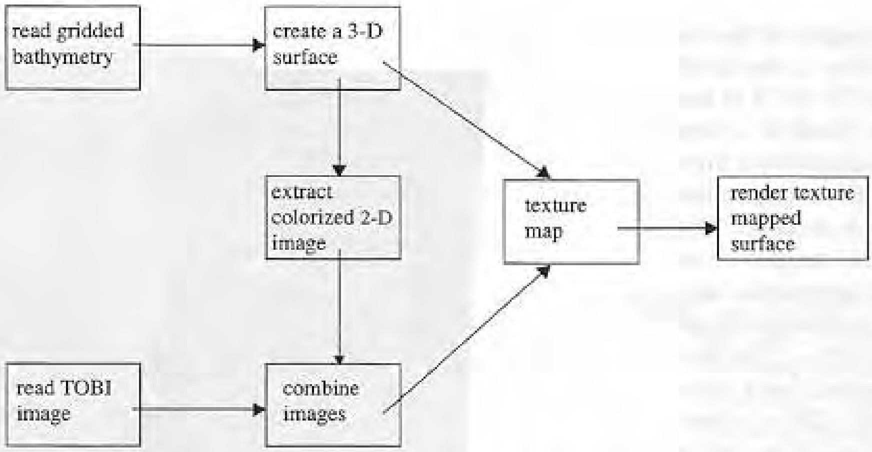

Figure 1. Diagram of the steps in the method of texture mapping TOBI side-scan sonar images on to bathymetry data.

tails on the individual features. All of the plots are shown in black and white. The full color images can be seen on the World Wide Web: <http:/ /humm.whoi.edu/TOBI3D>.

If commercial 3-D visualization software is not available for use, freely available software exists that can also be used to combine the two data sets. Khoros provides capabilities similar to both AVS and Data Explorer (see World Wide Web page <http://www.khoros.unm.edu>). In addition, Figure 5 shows an example of merging TOBI data and multibeam bathymetry data using Generic Mapping Tools (GMT), a freely available software package (Wessel and Smith, 1995). GMT produces similar results but the technique is not that of texture mapping. Instead a less sophisticated technique of pixel lookup is used that requires two data sets of identical physical dimension. In this case using the program "grdview", artificial illumination of the contoured, colored 3-D surface is based on the values of the TOBI echo amplitudes.

There are many benefits that result from constructing plots such as those displayed in Figs. 2-5, a few of which are listed here.

(1) Gaining an understanding of the subjectivity that goes into the interpretation of side-scan images. As an example, it is common to relate linear regions of high backscatter in the TOBI side-scan images to scarps identified in the multibeam bathymetry data that correspond approximately in location. We found that in several places the highest backscatter might instead be located at the foot of a scarp or in a flanking deep, and may correspond to debris piles or landslide zones. To avoid biasing our interpretations, we tried

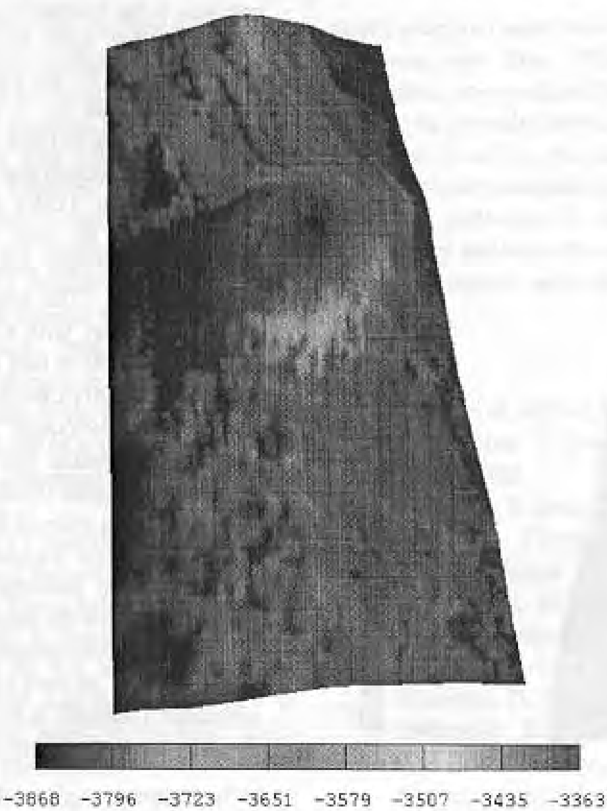

Figure 2. TOBI side-scan imagery of the tallest seamount identified by Smith and Cann (1992) located near 28° 50'N at the MAR. The swath is ~ 3km wide, and illumination is from the right. Bright is a reflection and dark is a shadow. The TOBI data are mapped on to the colored bathymetric surface using Advanced Visual System's AVS5. The seamount is ~350 m in relief with a basal diameter of ~ 2200 m and summit diameter of ~ 600 m. Numerous faults cut its flanks, and hummocks cover parts of the flanks and summit. A shallow graben is observed at the summit. The hummocky or lumpy texture observed in the TOBI data is below the resolution of the Sea Beam bathymetry. In addition, the faults are not defined in the bathymetry data.

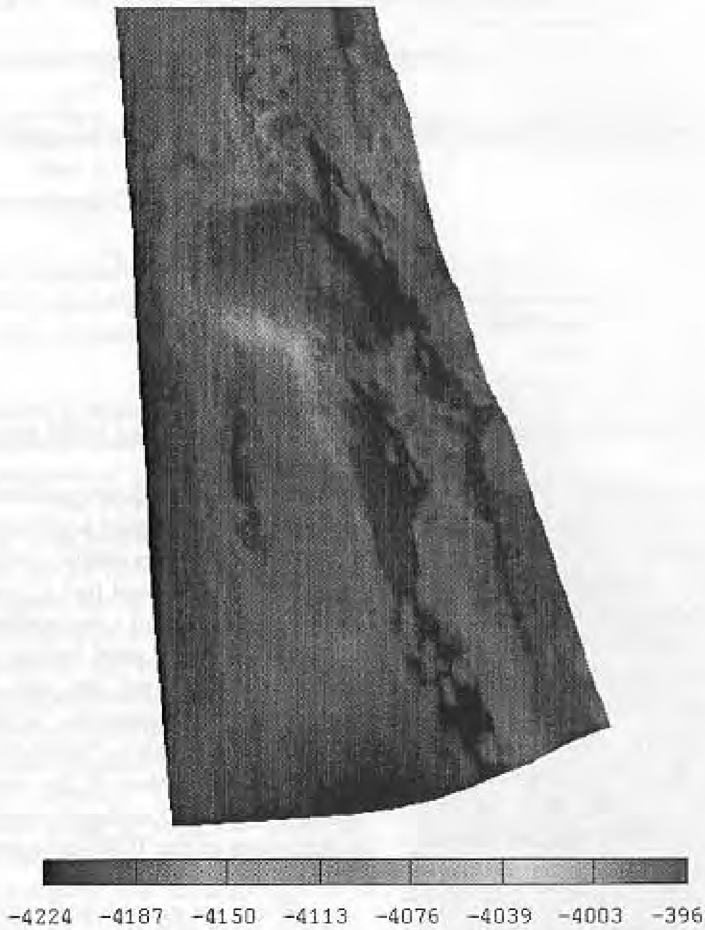

Figure 3. TOBI imagery of the inner valley floor of the MAR located near 25 30' N at the MAR. The swath is ~ 3km wide, and illumination is from the left. Bright is a reflection and dark is a shadow. The TOBI data are mapped on to the colored bathymetric surface using Advanced Visual System's AVS5. The flat-topped seamount has a summit height of ~120 m, a basal diameter of ~1350 m, and a summit diameter of ~625 m. Small ridges extend to the north and south of this feature, and it is possible that the seamount was built when an original fissure eruption collapsed to a single feeder. The top is faulted and a down dropped block has formed on its western side. A smooth textured patch occurs between two of the ridges to the south. As in all the figures the hummocky or lumpy texture observed in the TOBI data is below the resolution of the Sea Beam bathymetry.

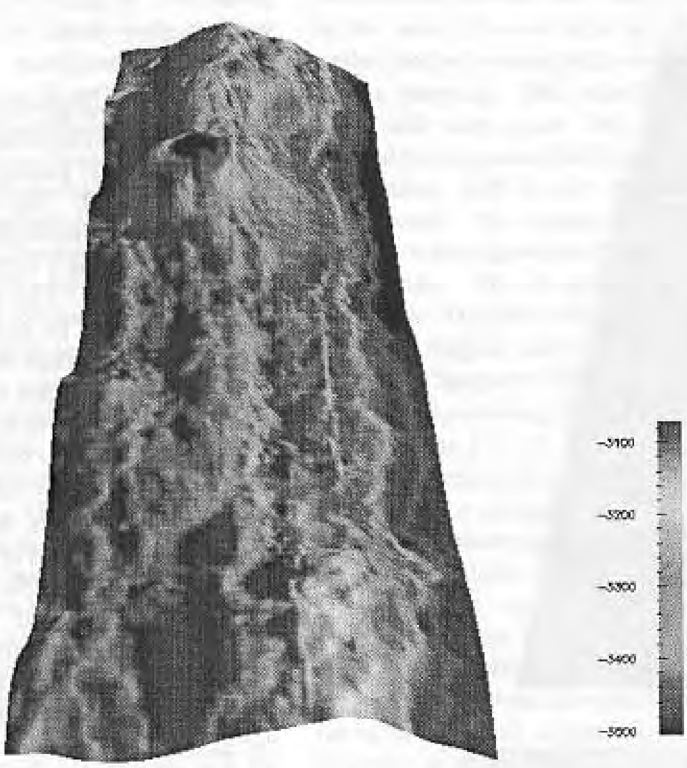

Figure 4. TOBI imagery of the axial volcanic ridge located near 29° N at the MAR and a cratered seamount that forms part of the ridge. The swath is ~ 3 km wide, and illumination is from the right. Bright is a reflection and dark is a shadow. The TOBI data are mapped on to the colored bathymetric surface using IBM's Data Explorer. The seamount is ~220 m in relief with a basal diameter of ~1500 m and a summit diameter of ~600 m, most of which is taken up by the crater. The summit is cut by faults and fissures, and down-dropped blocks are observed on each side of the crater. Not only is the hummocky or lumpy texture observed in the TOBI data below the resolution of the Sea Beam bathymetry, but the large crater observed at the seamount's summit is also not defined in the bathymetry data.

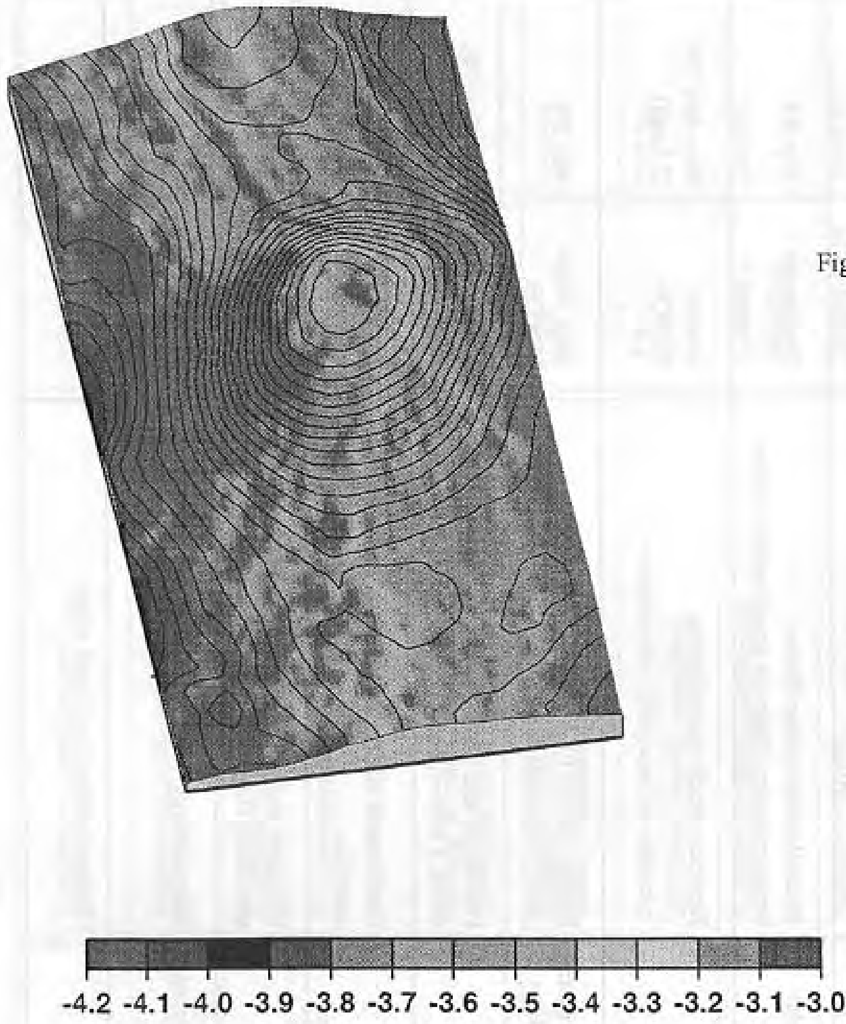

Figure 5. This image was generated using GMT (Wessel and Smith, 1995) and is of the same seamount as shown in Figure 2. See Figure 2 for a description of the seamount. The colored bathymetric data have been contoured at 20-m intervals. The bathymetry has been artificially shaded using the intensities of the TOBI side-scan sonar data.

to minimize any shifting of the data sets relative to each other.

(2) Understanding the contribution of regional slopes to the illumination and resulting shadow length of features. In order to interpret features correctly it is essential to know the regional topography as well as the location of the TOBI vehicle with respect to the topography. For example, features look significantly different in the side-scan sonar images if they are illuminated along the dip of a slope as compared to being illuminated normal to the slope face.

(3) Constraining the shape and sizes of features. The hummocky or lumpy topography observed in the TOBI data in Figures 2-5 is not defined by the Sea Beam bathymetry, but we can use the bathymetry to place upper limits on the relief of individual hummocks.

The simple methods of visualization described here have significantly aided our analyses of the TOBI side-scan sonar data. With the high-resolution, co-registered bathymetry soon to be provided by the TOBI instrument, it will be very easy to use the techniques available in commercial 3-D software to merge the bathymetry and side-scan sonar data, providing critical new views of the seafloor.

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World Ridge Cruise Schedule 1995-6*

Country	PI	Institution	Name/Location	Research Objectives	Ship	Date
Canada/ USA	Juniper/ Fisher	Univ. du Québec Penn State Univ.	**BioROPOS 95:** Endeavour Segment, Juan de Fuca Ridge	Biology, hydrothermal vents	John Tulley/ ROPOS	July '95
Canada	Edwards/ Scott	Univ. of Toronto	**GeoCanRidge IV:** Southern Explorer Ridge	rock and bacteria sampling, electromagnetic exp. to survey hi-T vent field	John Tulley/ ROPOS	July '95
Canada	Thomson	IOS	Endeavour & Coaxial Segments Juan de Fuca Ridge	Hydrothermal plume fluxes biogeochemical links w/ upper water column	Endeavour	July '95
Canada/ Germany	not available	Canadian univ. and gov., NOAA, German institutes	**SonneROPOS 96**: Juan de Fuca Ridge	Remote vehicle investigation	Sonne/ ROPOS	May-July '96 (2 Legs)
Canada	not available	Canadian univ.	**BioROPOS 96**: Endeavour Segment Middle Valley,Juan de Fuca Ridge	Return visit to biological observatory, survey of massive sulfide	John Tully/ ROPOS	July '96
France	Bideau/ Hekinian	IFREMER	**OCEANAUT:** Central North Atlantic	Petrologic and geochemical variations along a slow-spreading ridge	Nadir/ Nautile	Aug-Sept '95
France	Tapponnier/ Huchon	IPG Paris ENS	**TADJOURADEN 1:** Gulf of Tadjoura	Continental rifting, initiation of seafloor accretion	Atalante	Aug-Sept '95
France	Patriat	IPG Paris	**GALLIENI**: Southwest Indian Ridge	Structure and evolution of an ultra-slow spreading ridge	Atalante	Oct '95
France	Prieur	Univ. de Brest	**MICROSMOKE 95:** N. Atlantic, 23°22'N, 45°57'W - Snakepit	Microbiology, hydrothermal vents	Nadir/ Nautile	Nov-Dec '95
France	Deplus	IPG Paris	**SAMUDRA**: Northeast Indian Ocean	Oblique subduction, fossil ridge	Atalante	Nov-Dec '95

*Archives of the 'World Ridge Cruise Schedule' as published in *InterRidge News* from 1992 onwards will soon be accessible on the World Wide Web via the InterRidge Home Page (http://www.dur.ac.uk/~dg/Ø zz1/).

France	Géli	IFREMER	**PACANTARTIC**: Antarctic-Pacific Ridge	Geophysics, geochemistry	Atalante	Jan/Feb '96
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	**HYFIFLUX:** North Fiji Basin	Hydrothermalism, biology, fluxes	Sonne	Jan '95
Germany	Halbach	FU Berlin	**HYDROCK I:** SonneField South Central Indian Ridge	Genesis of massive sulfides and formation of ultramafic rocks	Meteor	Nov '95
India	not available	National Inst. of Oceano./DOD	Central Indian Ridge, 15°-20°S	Mapping regional tectonic fabric, evolution of seamounts	TBA	1995/6
India	not available	National Inst. of Oceanography	Central Indian Ridge	Tectonic & petrologic implications of FZs on crustal generation	TBA	1995/6
India	not available	Geological Survey of India	Carlsberg Ridge	Mapping magnetic anomalies	Samudra Manthan	Jan '96
Japan	Taira/ Ishii	ORI/ Univ. of Tokyo	**KT-95-9:** Mariana Trough	Magnetics survey	Tansei-maru	June '95
Japan	Fujimoto	JAMSTEC/ ORI	**Y95-04**: Mariana Arc, Mariana Trough	Tectonics of the Mariana Arc	Yokosuka	Sept '95
Japan	Urabe	JAMSTEC/ Geological Survey of Japan	**Y95-05 Manus Basin Diving Experiment:** Manus Basin	15 dives, geochemistry, geophysics	Yokosuka/ Shinkai 6500	Oct/Nov '95
Japan	Kinoshita	Geological Survey of Japan	**Ridge-Flux S-EPR:** Southern East Pacific Rise, 13°-18°S	Morphological survey	Gyre/ TAMU[2]	Oct-Dec '95

Country	PI	Institution	Name/Location	Research Objectives	Ship	Date
Spain	Canals	University of Barcelona	**GEBRATERM**: Bransfield Basin Antarctica	Monitoring hydrothermal activity using long-term moored thermisters	Hesperides	1994/5
Spain	Dañobeitia	Inst. de Ciencias de la Tierra, CSIC	**PASO-94:** Easter Island Ridge and Society Islands	Geophysics	not available	1994/5
Spain	Dañobeitia/ Córdoba	Inst. de Ciencias de la Tierra, CSIC	**CORTES-96**: Gulf of California Middle Americas Trench	Tectonic evolution of Mexican Cont Margin and Gulf of California	not available	1996/7
Spain	Dañobeitia	Inst. de Ciencias de la Tierra, CSIC	Galapagos Swell	Geophysical reconnaissance along a segment of the Galapogos Swell	not available	1996/7
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
United Kingdom	Murton/ German/ Dixon/ Herring	IOSDL/ PML	**FLUXES I:** MAR 29°N Broken Spur hydrotherm. site	Integrated fluxes experiment	Charles Darwin/ BRIDGET/ SHRIMP	Aug/Sept '95
United Kingdom	Searle/ Mitchell/ Cowie	Universities of Durham and Edinburgh	Mid-Atlantic Ridge, 29°N axial segment	Side-scan sonar, 3-D magnetics, swath bathymetry	Charles Darwin/ TOBI	April '96
United Kingdom	Sinha/ Peirce	Cambridge/ Durham	Valu Fa Ridge, Lau Basin Southwest Pacific	Geophysics: electromagnetics, wide angle seismics using OBSs	Ewing	Nov-Dec '95
USA (RIDGE)	Spiess	Scripps Inst. of Oceanography	Juan de Fuca Ridge	Seafloor strain measurements	not available	94/95/96
USA (MG&G/ RIDGE)	Christie/ Cochran et al.	Oregon State Univ./LDEO	Southeast Indian Ridge, 90° to 120°E	Geochemistry and geophysics: SeaBeam, gravity, magnetics, dredging	Melville	Dec '94-Mar '95 (2 legs)
USA	Sempere	University of Washington	Pacific-Antarctic Ridge Australian-Antarctic Discordance	SeaBeam, dredging, airgun	Melville	Jan-Feb '95

USA	Karson	Duke University	Mid-Atlantic Ridge	Geology, 15 dives	Atlantis II/ Alvin	Jan-Feb '95
USA	Von Herzen/ Becker/ Schultz	WHOI/ Univ. of Miami/ Cambridge	Mid-Atlantic Ridge	Hydrothermal venting, biology 11 dives	Atlantis II/ Alvin	Feb-Mar '95
USA	Johnson	University of Washington	Southeast Indian Ridge	SeaBeam, dredging, magnetics, gravity	Melville	Feb-Apr '95
USA	Mullineaux	WHOI	East Pacific Rise, 10° N	Hydrothermal vent biology, 10 dives	Atlantis II/ Alvin	Mar-Apr '95
USA	Mutter	LDEO	East Pacific Rise, 15°-17° N	Geophysics	Ewing	May '95
USA (RIDGE)	Delaney	University of Washington	Juan de Fuca Ridge	Hydrothermal systems	Atlantis II Alvin	May-June '95
USA	Embley/ Tivey	PMEL/ WHOI	Juan de Fuca Ridge	Hydrothermal vent survey, 12 dives	Atlantis II/ Alvin	June-July '95
USA	Fisher	TAMU/ODP	Gorda & Juan de Fuca Ridge	Coring	Ewing	June-July '95
USA (MG&G)	Tivey/ Becker	WHOI/ Univ. of Miami	Juan de Fuca Ridge	Magnetic polarity boundary, 12 dives	Atlantis II/ Alvin	July '95
USA (MG&G)	Mottl	University of Hawaii	Juan de Fuca Ridge	Off-axis hydrothermal venting, 16 dives	Atlantis II/ Alvin	Aug '95
USA (RIDGE)	Johnson/ Delaney	University of Washington	Juan de Fuca Ridge	Coaxial eruption response and time dependent changes in young crust, 22 dives	Atlantis II/ Alvin	Aug-Sept '95 (2 legs)
USA	Macdonald	Univ. of Calif. Santa Barbara	South Pacific	SeaBeam survey	Melville	Sept-Oct '95
USA	Haymon	Univ. of Calif. Santa Barbara	East Pacific Rise, 17°-18° N	AMS-120 mapping, sampling	Melville/ ARGO II	Oct-Nov '95
USA (MG&G)	Batiza	University of Hawaii	East Pacific Rise, 13°N	Hyaloclastites, 9 dives	Atlantis II/ Alvin	Oct-Nov '95

Country	PI	Institution	Name/Location	Research Objectives	Ship	Date
USA (RIDGE)	Forsyth/ Chave et al.	Brown University/ WHOI	**MELT**: East Pacific Rise	Electromagnetic and seismic experiment	Melville	Oct-Nov '95
USA (MG&G)	Lonsdale/ Hawkins/ Castillo	Scripps Inst. of Oceanography	Pacific-Antarctic Ridge	Off-axis to origin, Seabeam, dredging	Meville	Nov-Dec '95
USA	Lutz/ Lilly/ Cary	Rutgers Univ. Washington/ Oregon State Univ.	East Pacific Rise, 9°-10° N, 13° N	Hydrothermal vent biology, 19 dives	Atlantis II/ Alvin	Nov-Dec '95
USA	Mullineaux/ Walden	WHOI	East Pacific Rise, 9°-10° N	Hydrothermal vent biology, 19 dives Alvin	Atlantis II/	Dec '95
USA	Cande	Scripps Inst. of Oceanography	South Tasman Sea	Geophysics	Ewing	Jan-Feb '96
USA (RIDGE)	Grindlay/ Madsen et al.	Univ. Porto Rico/ Univ. of Delaware	Southwest Indian Ridge, 15°E to 35°E	Geophysics	Melville	Feb '96
USA	Chave/ Van Dover/ Ravizza/ Cary	WHOI/ Harvard Univ./ Oregon State University	East Pacific Rise, 9°-10° N, 13° N	Hydrothermal vent biology 14 dives	Atlantis II/ Alvin	Apr-May '96
USA	Karson	Duke University	Hess Deep	Geology, 20 dives	Atlantis II/ Alvin	May-June '96
USA	Tucholke	WHOI	Mid-Atlantic Ridge	Mapping	Ewing	July-Aug '96
USA/ UK	Klinkhammer	Oregon State University	Mid-Atlantic Ridge	Hydrothermal venting, 16 dives	Atlantis II/ Alvin	Aug-Sept '96
USA (RIDGE)	Detrick	WHOI	Mid-Atlantic Ridge, 34°-37° N	Seismic experiment	Ewing	Oct-Nov '96

InterRidge Workshop Summaries

Quantification of Fluxes at Mid-Ocean Ridges: Experiment Design

InterRidge Meso-scale Workshop held on 26-27 June 1995, Cambridge UK

Contributed by Harry Elderfield

Quantification of mass, energy and chemical fluxes occurring at mid-ocean ridges has been identified as an important component of Phase 2 of InterRidge for the next few years. The first Workshop dedicated to discussion of the types of fluxes that should be measured was held in Durham in 1993 in conjunction with a Symposium and Workshop on "Segmentation and Fluxes at Mid-Ocean Ridges". Three types of fluxes were identified extending from the mantle up into the water column (magmatic fluxes, chemical fluxes associated with rock-seawater interactions, and hydrothermal fluxes) and the concept of a "box" experiment was defined in which a segment of a mid-ocean ridge would be selected within which all fluxes would be quantified and their inter-relationships examined. This meeting was then followed up by a RIDGE/VENTS Workshop in September 1994 that tried to assess the status of knowledge of hydrothermal fluxes and their potential global impact. Issues important to the design of a segment-scale flux experiment that arose from that meeting included: the magnitude of flank fluxes, the relative importance of focused and diffuse flow at the ridge axis, event plumes, vertical transport into upper oceanic levels, and models of vent productivity.

The logical next step was to get to grips with experimental design and to this end a two-day Inter-Ridge Workshop, convened by Harry Elderfield (University Cambridge), Susan Humphris (Woods Hole Oceanographic Institution), Gary Klinkhammer (Oregon State University), Adam Schultz (University Cambridge) and Heather Sloan (Inter-Ridge Office), was held in The Earth Sciences Department, University of Cambridge in June 1995 and attended by about 30 delegates from the UK, USA and Japan. The purpose of the Cambridge Fluxes Workshop was to design an experiment at the segment scale that would quantify magmatic, hydrothermal, chemical and biological fluxes.

The Workshop discussed the concept of a box experiment and then went on to discuss what fluxes need to be measured. It considered fluxes of heat and chemicals, the physics and chemistry of plumes, and biological interactions. It discussed what tools are available and what new tools are needed. Of new tools, travel time- and scintillation-tomography was emphasised. Next, there was consideration of what criteria define the site (or sites) and where is the best place to do the experiment. Emphasis was placed on the Atlantic hydrothermal sites: TAG, Snakepit, Broken Spur, Lucky Strike, Menez Gwen, and Rainbow. A proposed timetable was outlined for the period 1995-1999. The Meeting report will be available shortly which, it is hoped, will provide a framework for a co-ordinated field programme involving the different national programmes.

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Biological Studies at the Mid-Ocean Ridge Crest

InterRidge Biological Studies Ad Hoc Committee Workshop

24-25 April, 1995
Rutgers University in New Brunswick; New Jersey, USA

Convenors: Daniel Desbruyères and Richard Lutz

The Biological *Ad Hoc* Committee held its first workshop at Rutgers University on 24 & 25 April 1995. The 25 participants included the members of the *Ad Hoc* Committee and various members of the ridge crest biologist community.

The objectives of the workshop were:

- To develop an implementation Plan for integration of biological studies into the 3 principal InterRidge themes
- To draft a formal international agreement to be endorsed by InterRidge to provide for exchange of data and samples
- To develop approaches and methods to maximise the effectiveness of biological sampling and observations during "geological" cruises.

It is the opinion of the Biological *Ad Hoc* Committee that biological studies do not fall easily within the framework of InterRidge. The scales on which the three principal themes operate are not those used by biologists. This may be the reason for the very limited participation of biologists in InterRidge workshops. However, Active Processes is the most natural theme for biological studies to fit into.

A Basic Framework for Biological Studies at the Ridge Crest

1 Origin and Evolution of Vent Taxa

- Paleo-tectonics
- Paleo-oceanography (need input from geosciences)
- Evolution
- Genetics
- Biogeography

2 Community Structure and Species Persistence (Community Dynamics)

- Cold seep deposits
- Temporal variation
- Monitoring (observatories link)
- Ridge fauna
- Dispersal and reproduction
- Lifecycle
- Symbionts transmission
- Adaptation to extreme conditions

Hydrothermal vents are an unstable environment. Biological communities must persist within a segment and then disperse in lifecycles which help them to survive. Cold seep deposits are not being studied at present but may be the most important aspect of hydrothermal venting in terms of volume and their associated biological communities.

3 Biogeochemical Interaction

- Biological modification of vent fluid chemistry
- Biomineralisation
- Subsurface circulation system plumbing

These are fundamental processes occurring at hydrothermal vents, yet there is currently little or no work going on in these areas.

4 Biological Production

- Chemosynthetic production
- Symbiosis
- Ultrathermophily (limits of life)
- Exploration of OM from vents to ridge
- Cold biological production (psychlophilic chemosynthetic production)

All of this is currently under discussion over the Internet and an implementation plan is being formulated which will eventually be ready for discussion at the Steering Committee level.

Recommmendations and Actions of the Biological Studies *Ad Hoc* Committee

International Sample Exchange Agreement and 'Bio-box'

The bio-box is an American concept. It is a box containing all the supplies and information necessary for non-biologist to effectively and correctly sample and preserve hydrothermal vent biota. Optimally, all vessels carrying a bio-box would be in communication with a biologist.

The International Sample Exchange Agreement pertains to preserved and frozen samples. Its aim is to avoid duplication of sampling which is costly not only in monetary terms but also in terms of environmental impact. The Biological *Ad Hoc* Committee will request ratification of the Agreement which will have been endorsed by all the member nations of InterRidge. The Agreement excludes commercial use of any exchanged sample. Each nation will have a curatory clearing house kept by a national corresponding curator whose responsibility it will be to:

- keep a record of all samples collected by PI from his or her country;
- respond to sample requests;
- keep a record of all exchanged samples; and
- curate bio-box samples.

Limitations of the Agreement will include:

- non-commercial use of samples;
- investigators must supply reports on work carried out;
- the life of the study must be agreed upon before exchange;
- citation must be agreed upon before exchange; and
- samples may never be redistributed by the requester.

Ridge Crest Biologist Directory

This directory is currently under development on the WWW.

Data Exchange - BioOcean-H

BioOcean-H is currently used as a format for data exchange in France for deep sea research data but not for hydrothermal vent fauna. This database is being extended as a project of the Biological *Ad Hoc* Committee to include vent fauna so that data may be exchanged on the WWW.

International Vent Biology Symposium

An international symposium is being planned by M. Biscuito (Portugal) and C. Cary (US) to be held in Madeira in the Spring of 1997. The proceedings will be published in a volume edited by D. Dixon (UK).

Species Identification Manual

A manual is currently being compiled which will be distributed to all cruises working at the ridge crest so that biological samples that arrive on deck can be identified and described by geologists in a way which can be understood by biologists. Contributions of manual pages will be made by numerous individuals within the community.

Demarcation of Sanctuaries and Definition of Collection Area

Areas of particular interest, areas where instruments are deployed and areas where monitoring is on-going will be designated and the community will be informed and requested to respect them. An effort will be made to co-ordinate sampling.

International Listing of Sea-going Capabilities

A listing has been compiled by the InterRidge Office and is accessible via the WWW. Work will continue on the listing to expand and update it.

News from Ridge Research and Related Programmes

BRIDGE

1995 has been a significant year for BRIDGE. In May we had our mid-term review and the final report from the Review Group is now being presented to the Natural Environment Research Council (NERC). Over the summer the administrative changes mentioned in the last issue of InterRidge News were put into place. After a very successful term as Science Co-ordinator Dr Cherry Walker has now moved on to new pastures with all our appreciation and thanks. In accordance with the new policy of the NERC, the role of Programme Manager, formerly a post held at NERC HQ, has devolved to the programme itself. The new Programme Manager is Dr Keith Harrison who is based at the BRIDGE Office in Leeds. The Programme Manager will now be the first port of call for all matters relating to BRIDGE.

BRIDGE has recently distributed a call for research proposals. Due to the lead-in time for funding proposals, the current funding round under BRIDGE will be the last. Two Announcements of Opportunity have been distributed: one for Research Grants, seatime and Research Fellowships to undertake work at one of the five BRIDGE geographic areas (the Kane-Atlantis area of the Mid-Atlantic Ridge (24°-30°N); the Mid-Atlantic Ridge between the Azores Triple Junction and the Rainbow Hydrothermal Site (39°-36°N); the Reykjanes Ridge southwest of Iceland: the Lau/N.Fiji Basin complex in the southwest Pacific; and the East Scotia Sea back-arc basin of the south Atlantic); the other inviting applications from researchers wishing to have access to manned submersible capabilities.

It is hoped that this second, Special, Announcement will attract interest from applicants whose research proposal would not itself justify a full manned submersible cruise, but would benefit from access to submersible facilities. The BRIDGE Programme will charter a block of submersible time which will be allocated to a number of researchers based on the quality of their proposals. The closing date for both Announcements is 1st December 1995. For further details contact Keith Harrison at the address below.

In April BRIDGE, together with the Marine Studies Group of the Geological Society of London and the Challenger Society for Marine Science, convened a meeting on "Tectonic, Magmatic, Hydrothermal & Biological Segmentation at Mid-Ocean Ridges" in London. The papers from this meeting will be published as a symposium volume in the near future. BRIDGE also held its 6th Workshop in July at the British Geological Survey. This workshop, entitled "Microbiology of Vent Ecosystems (MOVE)" was convened to assess and promote the role of UK research in this important field. A BRIDGE Workshop Report is currently in preparation.

In August and September Cruise CD95 (FLUXES 1) sailed to Broken Spur at 29°10'N on the Mid-Atlantic Ridge (Segment 17) to carry out an investigation of the energy, chemical and biological fluxes from this hydrothermal vent field. A preliminary report of the findings will be published in BRIDGE Newsletter No. 9 which is currently in preparation.

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CanRidge

Three cruises involving Canadian research vessels took place in the northeast Pacific in the summer of 1995.

1. BioROPOS 95 (K. Juniper, chief scientist; C. Fisher, co-chief scientist)

This collaborative cruise in July 1995 involved principal investigators from the Université du Québec à Montreal (K. Juniper), the University of Victoria (V. Tunnicliffe) and four US institutions - Penn State University (C. Fisher), Texas A&M University (I.R. MacDonald), NOAA/PMEL (G. Massoth) and the Chicago Field Museum (J. Voight). The primary objective of the cruise was to continue work at the previously established biological observatory in the Main vent field of Endeavour Segment of the Juan de Fuca Ridge. As in 1994, the group sailed on the C.S.S. *John P. Tulley* with the ROPOS remote controlled vehicle.

Two significant additions to ROPOS instrumentation greatly improved seafloor data gathering. Gary Massoth mounted his SUAVE flow-injection chemical scanner system on the vehicle and the nearly flawless performance of the ROPOS/SUAVE marriage resulted in the real-time acquisition of nearly 100 scan points in diverse vent habitats, providing data on dissolved H_2S, Fe, Mn and temperature. A second major improvement to the ROPOS system was the addition of a 3-CCD colour camera with a surface-controlled zoom lens as the primary imaging tool. Imagery is now transmitted as an RGB signal through the fibre optic link to the surface vessel and recorded in either Y/C or BetaCam-SP formats. The Y/C format is used for continuous logging of all dives, while on-line editing permits selective recording of close-up imagery in the higher quality (=more costly) BetaCam-SP format.

Work focused first on documentation of two similar low-flow tube worm sites, where time lapse cameras and recording thermistors had been deployed in 1994. The sites were imaged, and stained worms and thermistor tips were scanned with the SUAVE. Following this documentation, the deployed instruments were recovered by ROPOS. Initial examination indicated that all cameras and thermistors recorded data and results are presently being analyzed. Stained tube worms were collected from the two sites for analyses of growth increment in relation to condition indices (total tissue, gonad and trophosome). Four sites in the same area were selected for redeployment of the tube worm growth experiments by C. Fisher. The sites are representative of low (x2) , medium and high rates of diffuse flow and included one of the 1994 low diffuse flow locations. The tube worm stainer and the SUAVE scanner were both mounted on the ROPOS vehicle so that individual groups of worms could be scanned and stained in a single two-step operation. All four experiments were successfully deployed.

Another focus of the observatory effort was a sulfide structure known as S&M. Documentation of the temporal dynamics of this structure dates back to *Alvin* and *Jason* visits in 1991. Video swaths for mosaic reconstruction of S&M were completed and over 50 points between the base and the summit of the structure were scanned with the SUAVE for a study of organism distribution and community composition in relation to environmental variables (J. Sarrazin, PhD project). Two major changes from 1994 in hydrothermal and biological activity on S&M were noted. A nearly extinct area at the northern foot of the structure had reactivated and was colonized by bacterial mats and a limpet/alvinellid assemblage. No tube worms were visible. The site, called Palm Springs, was scanned, imaged and a HOBO recording thermistor was deployed. At the summit of S&M, a dramatic bloom of tube worms (Ridgeia) had occurred since 1994. Focused high temperature flows at this location appear to have been transformed into high volume diffuse flow that extended over the entire top of the structure.

2. Endeavour Plume Study 1995

An on-going collaboration between the Institute of Ocean Sciences (R. Thomson), the University of Hawaii (J. Cowen) and NOAA/PMEL (W. Lavelle) continued in 1995 with studies of water properties (Fe, Mn, He), microbiology and micro-zooplankton ecology in the neutrally-buoyant plume originating in the Main vent field at Endeavour Segment, Juan de Fuca Ridge. Sediment traps deployed on and off-axis in 1994 were recovered in May 1995. The moorings included both up and down looking traps. Two sediment trap moorings were redeployed in July 1995 on a cruise on the C.F.A. *Endeavour* (R. Thomson, chief scientist).

The July 1995 cruise also included bioacoustic studies using a combined ADCP and remotely controlled trawl net payload for surveys of previously documented zooplankton populations associated with the hydrothermal plume. In addition to the chemical and microbiological measurements, the plume was surveyed using a WISP fine particle sampler and a camera/video system that imaged particles in suspension for quantitative analysis.

This cruise marked the end of scientific research in the northeast Pacific with the vessel C.F.A. *Endeavour* which has been re-assigned to the Atlantic coast by the Canadian Navy. The *Endeavour* has been used for hydrothermal vent research on the Juan de Fuca since the early 1980's. Mooring recovery in 1996 will probably involve the C.S.S. *John P. Tulley*.

3. GeoCanRidge IV

The fourth in this series of Canadian contributions to the InterRidge effort, was a 10-day marine geological and geophysical cruise with the ROPOS remotely operated vehicle onboard CSS *John P. Tully* led by Nigel Edwards and Steve Scott from the University of Toronto. This brief return to Explorer Ridge was intended to complete work cut short by bad weather in 1994 to map, sample rocks and bacteria and, by means of an electromagnetic experiment, determine the 3-D geometry of a very large field of high temperature hydrothermal vents. The prime site was on the east side of the spreading axis where surface and submersible trips since the 1980's led by Verena Tunnicliffe (University of Victoria), Dick Chase (University of British Columbia) and Steve Scott had found active hydrothermalism, including the 250 m diameter "Magic Mountain" polymetallic sulfide deposit. Another site named AGOR 171 on the west side of the axis, known only from its intense hydrothermal plume and a few seconds of video, was a secondary target.

To cut a long and disappointing story short, bad weather intervened again in what is supposed to be the "good weather window". Half of the dive time was lost and this was followed by an accidental cutting of the coaxial tether connecting ROPOS to its cage. ROPOS is not an AUV but, being positively buoyant, eventually popped back to surface to the relief of all! The repair took only a few hours. One dive, cut short when hydraulic gauges were accidentally damaged, returned good bacterial and rock samples. Although marred by navigation problems (which are being fixed!), the electromagnetic experiment was moderately successful. ROPOS deployed the receiver on a hydrothermal mound without difficulty and transmitted signals from several different locations. These data are being processed to determine the thickness of the sulfide deposit.

Plans for 1996

SonneROPOS 96

A major cruise involving deployment of the ROPOS remote vehicle on the German vessel RV *Sonne* will occur in the northeast Pacific in the summer of 1996. The cruise is a collaborative effort involving Canadian university and government scientists, NOAA and a large contingent of German investigators. This will be the first deployment of ROPOS on the RV *Sonne*. Present plans are for a two-leg effort from May 24 through to July 8, although a subsequent 3rd leg is being considered.

BioROPOS 96

a return visit to the biological observatory at Endeavour Segment using ROPOS and the *John P.Tulley* is planned to follow the ROPOS/*Sonne* cruise. The cruise would recover and re-deploy experiments, as described above. Logistics permitting the cruise will also include a visit to the nearby Middle Valley hydrothermal area, site of an upcoming ODP drilling leg. Submersible work at Middle Valley, a sedimented hydrothermal site, will involve intensive mapping and instrumentation of a small area adjacent to a re-entry hole with the intent of documenting the effects of predicted drilling-related perturbations of vent field hydrology. A survey of sulfide deposits at Middle Valley will also be conducted as a complement to drilling activities.

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InterRidge Japan

Based on the agreement at the InterRidge workshop on biological studies held in April 1995, InterRidge plans to start an international biological sample exchange program. In response to the action of InterRidge Office, Dr. Jun Hashimoto (JAMSTEC, Fax 81-468-66-5541) will serve as a national corresponding curator from Japan.

In late 1994, Dr. K. Tamaki and others carried out a SeaBeam mapping survey across the Pacific-Antarctic Ridge aboard RV *Hakuho-maru*. Deep-towed and surface survey of magnetic anomalies was carried out across the spreading axis of the Mariana Trough near latitude 18°N during the RV *Tansei-maru* cruise KT-95-9 in June 1995. A proton magnetometer was deep-towed across both the central part of an axial segment and near the segment boundary. Deep-tow three-component magnetic measurement combined with the attitude measurement was partly successful along the central line. A second-generation shipboard three-component magnetometer (STCM MK2) equippped with an optical laser gyrocompass developed by Dr. N. Isezaki and others, demonstrated its high-resolution performance during the surface survey. Dr. H. Fujimoto and others carried out a geophysical survey over the southernmost part of the Mariana Trough in September 1995 during a submersible diving cruise using the submersible Shinkai 6500 and the mother ship *Yokosuka*.

As a contibution of InterRidge/Japan, Drs. K. Fujioka, K. Tamaki, and H. Shimamura convened a special session on researches of mid-ocean ridges during 1995 Japan Earth and Planetary Science Joint Spring Meeting held in Tokyo in March. Thirty oral presentations and 21 posters were contributed. A JAMSTEC symposium on deep-sea researches focused on submersible diving researches will be held in Tokyo on 19-20 December 1995.

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DeRidge

The first issue of the DeRidge Newsletter appeared in September of this year. This newest of national ridge program newsletters is published in English with the intent of reaching the widest possible readership. The focus of the first issue is on four of the six themes of the DeRidge Program: North Atlantic, East Pacific Rise, Back-Arc Basins, and the Indian Ocean. The two remaining themes, Technical Development and the Red Sea will be presented in the next issue.

On September 11 & 12, GEOMAR in Kiel was host to the annual InterRidge Steering Committee Meeting. Following the meeting DeRidge researchers and members of the InterRidge Steering Committee presented and heard talks about recent and current work as well as the history and structure of the two closely tied organisations at the InterRidge-DeRidge Science Day organised by the DeRidge Co-Ordinator, Roland Rihm.

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Dorsales

(Excerpts from La Lettre Dorsales, translated by H. Sloan)

Discussion is taking place concerning the organisation of a general meeting of the French ridge crest researcher community in the Spring of 1996. The objectives of this meeting will be to take stock of the development, scientific and otherwise, within Dorsales since the last general meeting held in 1993 and to plan future scientific and technical development.

Funds have been put aside by the Comité Dorsales for publication of a synthesis of French bathymetric data from the Atlantic. The synthesis will be published both in map form and numerically (perhaps on CD Rom).

The BIOCEAN-H Project, currently underway in France, consists of extending an existing abyssal biota database to include hydrothermal organisms. This project is also being pursued on an international level under the auspices of InterRidge.

The "Biology 95 Workshop: Adaptations linked with hydrothermal environmental constraints" organised by the Dorsales Program will be held at the Observatoire Océanologique de Banyuls-sur-Mer on 13-15 December 1995. The co-convenors will be Aline Fiala-Médioni and Françoise Gaill. The objectives of this workshop will be:

- to examine the present knowledge of specific constraints and fundamental adaptation mechanisms which permit the colonisation of and survival in the hydrothermal vent environment.
- to define research priorities for the 1996-1997 time frame
- to discuss prospective cruises and their relation to the defined priorities.

In addition to these projects, several ridge crest and related cruises are planned for 1995 and 1996: Océanaut, Gallieni, Microsmoke, Pacantarctic, Galinaute, Tadjouraden and Samudra. See the 'World Cruise Schedule' for further details.

La Lettre Dorsales - Table of Contents

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Due to its largely unsampled and unchartered status, the Mid-Ocean Ridge (MOR) in the Indian Ocean is presently drawing much attention. The three segments of the Indian Ridge system, Southeast, Central and Southwest Ridge systems (SEIR, CIR, SWIR) meet at an inverted Y junction (Ridge-Ridge-Ridge type triple junction) near 25°S, 70°E known as Indian Ocean Triple Junction (IOTJ). The sparse data coverage shows that the Indian Ocean Ridge System (IORS) is highly segmented due to variable rates of spreading; for example - SEIR is spreading at 58 mm/yr near IOTJ and 76 mm/yr near the Australian-Antarctic Discordant zone (AAD); CIR is spreading at 54 mm/yr near IOTJ and 30 mm/yr north of the equator; whereas spreading across SWIR has been slow (13-18 mm/yr throughout its length).

Many striking phenomena at the ridge crest made IORS unique. For example, a localised negative Bouguer gravity anomaly along SEIR and CIR suggests focused accretion in these two segments. High seismic activity with earthquake swarms occur at IOTJ. Slightly older basalts from SWIR have similar compositions to fresh glasses in CIR and SEIR. Volcanism appears to have occurred in two stages in the Indian Ocean - a sheet lava flow stage followed by a volcanic cone stage. A strikingly uniform spreading rate of 16 mm/yr is registered along SWIR which has not changed since 20 Ma (RRS *Discovery* result April-May 1994). Crustal thickness at the survey site is 4.4 km - much less than that of normal oceanic crust (7 km).

However, there are unresolved questions concerning: thermal cooling effect on the degree of mantle melting at RTI; episodicity of melt migration and structural variation at RTI; ridge segmentation and along-axis variation in ridge petrology; interaction between magmatism and faulting at the ridge crest; impact of hydrothermal flux on deep-ocean circulation and oceanic sediment; and understanding of the physical chemistry of iron in the ocean.

Indian researchers have made 5 cruises so far to the Indian Ridge - three on board RV *Sagar Kanya* and one each on the FS *Sonne* & RV *Samudra Manthan*. These cruises were mainly of a reconnaissance nature.

However, the inventory of rock and water samples from all the world oceanic ridges shows that a clear gap exists along a substantial length of the CIR. Therefore, the IORS has been identified by both InterRidge and RIDGE Initiative as an area to focus on during 1995-96.

India is presently carrying out two major programmes, one each in the Central Indian and Carlsberg Ridges. The CIR research would be carried out by the National Institute of Oceanography, Goa in two phases. The first phase on CIR is funded by the Department of Ocean Development, New Delhi, which envisages it documenting the regional tectonic fabric of the slow spreading CIR with special reference to growth and evolution of near-axis seamounts. The area to be surveyed is between latitudes 15°S to 20°S. The sponsor for the second project is not yet finalised. However this project would focus on tectonic and petrological implications of fracture zones on crustal generation, and hydrothermal activities. Four major intersections of FZs with CIR (RTIs; i.e., at the Vitiyz FZ, Vema FZ, Argo FZ and Marie Celeste FZ) have been chosen for study during this project.

These studies are expected to provide a substantial amount of fundamental and new information about the ridge system. Firstly, tectonics related to ridge offsets. Secondly, the interaction of the wide deformation zone in Central Indian Ocean Basin with CIR between 0-4°S would provide a unique site for studying incipient processes of triple junction formation and evolution. Thirdly, CIR seems to be a good site for studying the interaction between mantle plume and spreading centres (manuscript in preparation). Fourthly, to understand the effect of mantle temperature variation on IORS processes. Geochemical and radiochemical studies of rock samples indicate such signatures. CIR rocks are found to be less alkaline, less basic, less depleted in LILE, and contain a higher ratio of $^{87}Sr/^{86}Sr$ than those of the East Pacific Rise and Mid-Atlantic Ridge. Documentation and causes of such differences need to be thoroughly investigated.

The geological Survey of India in Calcutta has been working on the geodynamics of the Carlsberg Ridge. During cruise # 101 of RV *Samudra Manthan*, Fe-Mn encrusted chunks of mid-ocean ridge basalt were recovered from a depth of 3020 m in the median valley region. Two types of magnetic anomalies have been noted. The first type is of high frequency, short wavelength associated with the axial part of the ridge, while the second type of magnetic anomaly is of low frequency, larger wavelength. One more cruise of R/V *Samudra Manthan* will work in January 1996 on and around the Carlsberg Ridge.

India's InterRidge National Correspondent:
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RIDGE

In June 1995 the Fourth RIDGE Theoretical Institute Short Course "Faulting and Magmatism at Mid-Ocean Ridges" was held at the Granlibakken Conference Center in Lake Tahoe, California. The topic was one of great interest to a large portion of the RIDGE community and about 150 people attended. The convenors, W. Roger Buck, Paul Delaney and Jeffrey A. Karson divided the meeting into three themes: general theories and observations of faults and magmatic structures, constraints from ridges on faulting and magmatism, and models of mid-ocean ridge processes. The meeting succeeded in bringing together a community of scientists and students who work on these problems both on the continents and in the oceans. An AGU monograph containing papers related to this Theoretical Institute is in the planning stage.

In September, AGU Monograph 91 "Seafloor Hydrothermal Systems: Physical, Chemical, Biological and Geological Interactions", edited by S.E. Humphris, R.A. Zierenberg, L.S. Mullineaux and R.E. Thomson, which is a result of the Third RIDGE Theoretical Institute, was published, and can be purchased directly from AGU. Additional information is available from the RIDGE Office, or AGU.

Also in September, the RIDGE Office moved from Woods Hole Oceanographic Institution to the University of New Hampshire with the rotation of the chair of the RIDGE Steering Committee from Bob Detrick to Karen Von Damm. Chris Keeley will be joining the Office in November as co-ordinator, and Laureen Caddick is already on board as the secretary for the office. You can reach us at:

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It is likely to be January before our new World Wide Web home page is operational.

If you have not visited it yet, you may want to look at the RIDGE Multibeam Synthesis Project Web Site, which has been set-up by Bill Ryan at Lamont-Doherty Earth Observatory. The data set presently includes results from the Mid-Atlantic Ridge, the East Pacific Rise and the Juan de Fuca Ridge. The address is: http://imager.ldeo.columbia.edu.

There have been quite a few RIDGE-related cruises this year, with much of the effort this past summer focusing on the Juan de Fuca Ridge. This fall marks the start of the field program for the Mantle MELT experiment and the first cruise will sail in early October to begin the deployment of ocean bottom seismometers on the southern East Pacific Rise.

Spain

After about two years of negotiation with our national authorities for Spain to join InterRidge as a Principal Member Nation, it was decided in September 1994 to prepare a "Memorandum for the Incorporation of Spain to InterRidge". This Memorandum was supported by 7 research groups[1], and was sent to the Spanish National Agency for Science and Technology, CICYT, which finally decided to support InterRidge in 1995.

Research projects

Spanish researchers have participated in several research projects directly related to InterRidge interests, either in the framework of Spanish research projects or associated with projects run by foreign institutions, namely IFREMER, WHOI and GEOMAR. Their work concerns the Antarctic Seas, the Mid-Atlantic Ridge, the West Pacific back-arc basins and the East Pacific region.

List of National Funded Projects and future plans:

Funded

- Geological and geophysical study of the Scotia Arc: the South Scotia Ridge. 1992. *PI:* J.Acosta and M. Canals. *Main objective:* Geological structure of the transformant South Scotia Ridge and presumed pull-apart basins.
- Geological evolution of the Bransfield Basin and the South Scotia Ridge (GEBRA 93). 1993. *PI:* M. Canals.

Objective: very initial stages of seafloor spreading in a back-arc environment, and relations with the South Scotia transform plate boundary.

- Detection of potential submarine hydrothermal sources in the Bransfield Basin (Antarctica): GEBRATERM Project, *Period:* 1994-95. *PI:* M. Canals. *Objective*: monitoring of hydrothermal activity by long-term moored thermistor arrays.
- Geophysical study at the South Pacific: Easter Island Ridge (Hot-line) and Society Islands (Hot-spot) PASO-94 Project, *Period*: 1994-95. *PI*: J.J. Dañobeitia.
- Tectonic evolution of the western continental margin of Mexico: The Middle American Trench and the Gulf of California. CORTES-96 Project, *Period*: 1996-97. *PI*: J.J. Dañobeitia and D. Córdoba.
- Geophysical reconnaissance along a segment of the Galapagos Swell, *Period*: 1996-97; *PI*: JJ Dañobeitia.

Planned

- Geological evolution of the Pacific margin of Western Antarctica: Sea-floor spreading and Plate Tectonics. *Period*: 1996-97. *PI*: M. Canals. *Objective*: relationships between the Drake-Aluk subducted ridge, the South Shetland Trench, transform zones and the juvenile Bransfield Ridge.
- A deep seismic reflection and refraction investigation of the origin of the Galapagos Swell. *Period:* 1997-98. *PI:* R.S. Detrick and J.J. Dañobeitia. It is planned to use the RV *Hesperides*.

Research Platforms

RV *Hesperides*, which was launched in 1991, is the main Spanish platform for InterRidge related studies. It is a 2710 MT ship, 83 m long, 14 m wide, with accommodation for 27 scientists. The hull has been strengthened for navigation in icy water and can break through ice up to 40 cm thick. It is operated by the Spanish Navy, and its base is the port of Cartagena, Spain.

Its scientific equipment includes the EM-12S and EM-1000 SIMRAD swath bathymetry systems, Bentech Subsea Bottom Parametric Source (BPS), Geometrics magnetometer G-876, gravity-meter Bell Aerospace-Textron BGM-3, multichannel and single channel seismic reflection equipment, an RDI-VM150 ADCP current-meter, CTD with rosette, plankton multisample nets Bioness and LHPR, wet and dry laboratories, and analytical equipment for geochemical and biological purposes. It has three cranes, one on the back deck. The navigation system is GPS.

Up to now, RV *Hesperides* has carried out 26 oceanographic cruises in Antarctic waters, the Atlantic and the Pacific oceans, and the Mediterranean Sea. Various research groups involved in Spanish InterRidge related activities have also had experience in deploying and mooring of instruments (thermistors, particle traps, current-meters, OBSs), and others have participated in submersible activities.

The Spanish Ridge Research Community

The Spanish InterRidge scientific community numbers less than 25 active scientists and technicians, most of them in the field of Geology and Geophysics. There are about a dozen staff members, and a similar number of junior scientists plus technicians, who, in most cases, have been totally or partly trained in foreign institutions. A few PhD Thesis have been presented recently, and some new ones will be presented in the next few months.

The Spanish Scientific Structure and InterRidge

The "Comisión Interministerial de Ciencia y Tecnologia" (CICYT) is the Spanish National Agency responsible for the endorsement of Spain to InterRidge, and also manages shiptime attribution of the RV *Hesperides*. CICYT has nominated two Spanish representatives to the Steering Committee, Dr. M. Canals (University of Barcelona) and Dr. J.J. Dañobeitia (Instituto de Ciencias de la Tierra, CSIC, Barcelona).

[1] Research Groups initially supporting the "Memorandum for the Incorporation of Spain to InterRidge":

Geology and Geophysics

1. Universitat de Barcelona / Dept. Geologia Dinàmica, Geofisica i P., GR Geociències Marines / Dr. M. Canals
2. Institute Español de Oceanografia / Unidad de Geologia Marina / Madrid / J. Acosta
3. Instituto de Ciencias de la Tierra "Jaime Aimera" / Consejo Superior de Investigaciones Cientificas / Barcelona / Dr. J.J. Dañobeitia
4. Instituto de Ciencias del Mar / Consejo Superior de Investigaciones Científicas / Barcelona / Dr. B. Alonso

Geochemistry

5. Instituto de Investigación y Desarrollo / Consejo Superior de Investigaciones Científicas / Barcelona / Dr. J.Grimalt Benthos
6. Institute Español de Oceanografia / Laboratorio de Fuengirola / Fuengirola (Málaga) / Dr. A. Ramos
7. Universitat de Barcelona / Dept. Zoologia - Invertebrats / Dr. M. Ballesteros

JOIDES - Ocean Drilling Program News

New Director at ODP-TAMU

Dr. P Jeff Fox has been appointed as the new Director of ODP-TAMU, College Station. He took up his new position with effect from 1 June 1995 after a very successful period in the Graduate School of Oceanography of the University of Rhode Island. Jeff has a long history of involvement with ocean drilling, and was on the steering committee for COSOD II, and more recently a member of the ODP East Pacific Rise Detailed Planning Group (DPG), the ODP Deep Crustal Drilling DPG, and until he moved to ODP-TAMU, he was the URI member of the JOIDES Planning Committee.

Port call news - Napoli, Italy

The *JOIDES Resolution* was in Napoli, Italy, between ODP Leg 160 dedicated to the eastern Mediterranean, and Leg 161, dedicated to the western Mediterranean, May 3-6, 1995. This was the first port call in Italy since the beginning of Deep Sea Drilling and not only the scientific community but also military and civil authorities were pleased to have the opportunity to visit the ship, and see her equipment and laboratories.

ODP - InterRidge - IAVCEI Workshop The Ocean Lithosphere & Scientific Drilling into the 21st Centruy

A joint funded symposium and workshop will be held on 26-28 May 1996, at Woods Hole Oceanographic Institution. Its purpose is to plan an integrated program of scientific ocean drilling to evaluate and extend current models for the formation of a laterally complex and heterogeneous ocean lithosphere. For further information see the announcement on page 43 of this issue or contact the InterRidge Office, intridge@durham.ac.uk

JOIDES Resolution Cruise Schedule 1995-96

Leg	Destination	Cruise Dates	Port of Origin	Days	Transit	On Site
163	S E Greenland VRM	7 September - 28 October '95	Reykjavik, 3-6 September '95	51	9	42
164	Gas Hydrates	1 November- 19 December '95	Halifax, 28-31 October '95	48	6	42
165	Caribbean Ocean History *	24 December '95 - 18 February '96	Miami, 19-23 December '95	56	11	45
166	Bahamas Transect*	23 February - 11 April '96	San Juan, 18-22 February '96	48	8	40
167	California Margin	21 April - 16 June '96	Panama, 11-13 April '96 Acapulco 20 April '96	56	11	45
168	E. Juan de Fuca Hydrothermal	21 June - 16 August '96	San Fransisco, 16-20 June '96	56	4	52
168S	Saanich Inlet**	17-18 August '96	Victoria, 16 August '96	2	-	2
169	Sedimented Ridges II	23 August - 18 October '96	Victoria, 18-22 August '96	56	6	50
170	Costa Rica Accretionary Wedge	23 October - 18 December '96	San Diego, 18-22 October '96	56	11	45

Although five day port calls are generally scheduled, the ship sails when ready.

* These legs may be switched if further study shows that currents in the Santaren Channel are more favourable for the Bahamas project on Leg 165.

** Subject to environmental and safety reviews.

Announcements and Notices

ODP - InterRidge - IAVCEI Workshop

The Ocean Lithosphere & Scientific Drilling into the 21st Century

26-28 May, 1996
Woods Hole Oceanographic Institution
Woods Hole Massachusetts, USA

Convenors:

H.J.B. Dick (USA)
C. Mével (France)

Steering Committee

M. Cannat (France)
M.F. Coffin (United States)
J.R. Delaney (United States)
R.S. Detrick (United States)
R.A. Duncan (United States)
K.M. Gillis (Canada)
P.M. Herzig (Germany)
E. Kikawa (Japan)
J.A. Karson (United States)
J.L. Karsten (United States)
C.J. MacLeod (Great Britain)
J.H. Natland (United States)
P. Pezard (France)
R. Searle (Great Britain)
D. Stakes (United States)
K. Tamaki (Japan)

This symposium and workshop is jointly sponsored by the JOIDES Planning Committee of the Ocean Drilling Program, the InterRidge Steering Committee for an internationally coordinated study of ocean ridges, and the Commission on Large-Volume Basaltic Provinces of the International Association of Volcanology and Chemistry of the Earth's Interior. Its purpose is to plan an integrated program of scientific ocean drilling to evaluate and extend current models for the formation of a laterally complex and heterogeneous ocean lithosphere. A program which must include drilling in crust formed at fast and slow ridges, near and far from mantle hot spots, and at large oceanic igneous provinces (LIPs) formed outside the framework of the global ridge system.

In 1998 the Ocean Drilling Program begins Phase III of scientific drilling in the oceans, concluding the current program at the end of 2002. A new phase (IV) of ocean drilling, however, is being planned for beyond 2003. It will likely involve multiple platforms and riser drilling, bringing the ability to drill in-situ through the entire ocean crust.

The symposium will review the current state of knowledge of the ocean lithosphere, summarize the capabilities of present drilling technology and review new technologies planned for Phase IV. Some contributed talks, and a poster session on the composition and structure of the ocean lithosphere, are solicited from participants. The workshop will seek to establish community goals and priorities for ocean lithosphere drilling for 1998 to 2003, and begin the formal planning and proposal process for multi-leg deep drilling during Phase IV.

Deadline for applications 1 Feb. 1996. Late applicants will be accepted on a space available basis only.

For Information or to Apply Contact:

Ocean Lithosphere & Scientific Drilling Conference, InterRidge Office, Dept. of Geological Sci., Univ. of Durham, South Road, Durham, DH1 3LE, UK, email: intridge@durham.ac.uk.

For funding, participants must separately contact their national RIDGE or ODP program, or other national source. US participants should contact Dr. Henry Dick, C/O Ms. May Reed, McLean Laboratory, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, email: mreed@whoi.edu.

InterRidge

LIPs

The XXV General Assembly of the European Seismological Commission

9-14 September 1996
Reykjavik, Iceland

In addition to the standard Subcommission open symposia, several sessions of special interest to the mid-ocean ridge research community are planned. These include:

- Seismology and Faulting at Ridges
- The Iceland Hot Spot
- Crust/Mantle Structure and Processes
- Seismology, Deformation and Structure of Volcanoes

There will also be field trips to the plate boundary in the south of Iceland.

For further informaiton write to:
LOC XXV General Assembly ESC
Att: Mr. Bardi Thorkelsson
The Icelandic Meteorological Office, Bustadavegur 9, 150 Reykjavik, Iceland
Fax; +354-552-8121; e-mail: esc96@vedur.is

ANNOUNCEMENT AND CALL FOR PAPERS

1996 European Geophysical Society General Assembly Marine Geophysics Session SE21 02 :

Mid-Ocean Ridge Processes

Den Haag, The Netherlands, 6-10 May 1996
Convener: D.F. Naar
Co-Conveners: J. Francheteau, H. Sloan

This symposium will cover the tectonic aspects of Mid-Ocean Ridge Processes, including kinematic, dynamic, and structural processes. Abstracts dealing with observation or theory ranging from large-scale studies such as analysis of altimetry data to small-scale studies such as submersible studies are desired. Marine geophysical surveys and other intermediate scale studies are also desired that are relevant to the tectonic aspect of mid-ocean ridge processes at slow, medium, and fast spreading environments. Abstracts should be submitted to the convener.

Deadline for Abstract Submission: **15 December, 1995.**
First Deadline for Pre-registration (low rate): **31 December, 1995**.

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EUROPEAN RESEARCH CONFERENCES

1996 Programme of European Research Conferences

The Programme of European Research Conferences is run by the European Science Foundation, in association with several learned societies, and with funding from the Human Capital and Mobility Programme of the European Union. Each Conference consists of a series of meetings, held typically every other year. There are neither written contributions nor proceedings. Unconventional ideas and new approaches, not yet fully explored, are encouraged.

This announcement includes only a selection of events. The full 1996 Programme, comprised of about 45 conferences, will be released in October 1995.

Mathematics

- **Mathematical Methods in Industrial Problems: Mathematical and Numerical Models for the Simulation of Turbulent and Reactive Flows**, A. Quarteroni (Milano) - Mt Ste Odile (near Strasbourg), France, 16 - 21 February
- **Algebra and Discrete Mathematics: Group Theory: Finite to Infinite**, L. Babai (Budapest) - Castelvecchio Pascoli, Italy, 13 - 18 July

Physics

- **Solid/Fluid Interfaces: Wetting and Capillarity**, A.M. Cazabat (Paris) - Aghia Pelaghia, Crete, Greece, 22 - 27 March
- **Fundamental Aspects of Surface Science: Semiconductor Surfaces**, C. Sebenne (Paris) - Blankenberge, Belgium, 8 - 13 June
- **Advanced Quantum Field Theory: Integrability, Conformal Invariance, Topolgical Field Theory and Applications**, V. Rittenberg (Bonn) - La Londe les Maures, France, 31 August - 5 September

Materials

- **Physical Metallurgy: Interfacial Engineering in Materials**, E.D. Hondros (London) - Castelvecchio Pascoli, Italy, 9 - 14 October

Chemistry

- **Metal Clusters in Chemistry**, A. Simon (Stuttgart) - Mt Ste Odile (near Strasbourg), France, 2 - 7 May

Life Sciences

- **Self-Nonself Discrimination: Molecular Basis of Autoaggression**, B. Arnold (Heidelberg) - place and dates open
- **Bioseparation**, C.R. Lowe (Cambridge) - place and dates open
- **Neural Mechanisms of Learning and Memory: Modulation of the Trace**, W.H. Gispen (Utrecht) - San Feliu de Guixols, Spain, 16 - 21 April

Co-sponsored by the European Science Foundation and the Euroconferences Activity of the European Union

MID-ATLANTIC RIDGE SYMPOSIUM

JUNE 19-22, 1996
Reykjavik, Iceland

InterRidge announces a symposium on the Mid-Atlantic Ridge, with emphasis on the region between 15°N and 40°N. The meeting will take place in Iceland to provide the opportunity for investigators to present and discuss their recent results both in scientific sessions and in the context of field trips to active volcanic zones.

The last five years have seen an extensive research effort on the mid-oceanic ridge in the central North Atlantic under the France-US FARA project and including various investigations by the Ocean Drilling Program, the British BRIDGE program, the European Marflux project, and by Russian, Japanese and Portuguese scientists. The symposium will provide a forum where the results of this diverse and extensive work can be compared and synthesized, and where future research objectives can be formulated. The meeting, sponsored by French and US science agencies to mark the end of the FARA project, is being convened under the auspices of InterRidge and hosted by The Nordic Volcanological Institute at the University of Iceland. It is supported as a Ewing symposium by Lamont-Doherty Earth Observatory and papers will be published in a Ewing Symposium volume.

The symposium will include a field trip to the Reykjanes Peninsula during the meeting and an extended field trip will be held prior to the meeting.

MEETING PARTICIPATION

Further information concerning the meeting will be sent to all people on the symposium mailing list. To add your name to the list, send your name and full address before November 30, and preferably by e-mail, to:

The InterRidge Office,
Department of Geological Sciences, University of Durham,
South Road, Durham DH1 3LE, UK
Tel: 44 191 374 2532; Fax: 44 191 374 2510; E-mail: intridge@durham.ac.uk
(For E-mail responses, please state FARA-IR Symposium as Subject)

For logistical reasons, participation in the meeting is likely to be limited to about 100 people. However, a call for provisional titles of proposed contributions, along with further details of meeting organisation, will be sent to all people on the November mailing list.

For further information about, or suggestions for, the meeting contact the InterRidge Office or either of the convenors:

David Needham (needham@ifremer.fr) or
Charles Langmuir (langmuir@ldeo.columbia.edu).

This announcement can be accessed via the InterRidge home page
(http://www.dur.ac.uk/~dgl0zz1/).

InterRidge Researcher Electronic Directory/Maillist

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 contains a listing of each researcher's field of interest and expertise as well as their full coordinates. The Directory is accessible on the World Wide Web via the InterRidge Home Page (http://www.dur.ac.uk/~dglØzz1/) making it possible to carry out effective searches quickly and easily. If you would like to be listed in the directory please complete this form and send it to the InterRidge Office.

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), ☐ The Ridge Crest Biologist Directory. ☐ This is a change of address notice.

Name ______________________________

Department/Institute ______________________________

Address ______________________________

____

City ______________ **State/County** ______________

Post Code ______________ **Country** ______________

Tel.: ______________ (country code, area code, number) **Fax.:** ______________ (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?

☐ Biochemistry
☐ Biogeography
☐ Biology
☐ Crustal structure
☐ Ecology
☐ Electromagnetism
☐ Engineering/Instrumentation
☐ Event detection and response
☐ Genetics
☐ Geochemistry
☐ Gravity
☐ Hydrology
☐ Hydrothermal vents/plumes
☐ Magnetism
☐ Microbiology
☐ Modelling
☐ Petrology
☐ Plate kinematics
☐ Rheology
☐ Seafloor Morphology
☐ Sedimentology
☐ Seismology
☐ Structural geology
☐ Tectonics
☐ Volcanology

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