vol. 5, no. 2 *Fall/Winter 1996*

InterRidge News

InterRidge Update

The InterRidge Office has sustained a high level of activity during 1996 organising the ODP-InterRidge-IAVCEI Workshop in North Falmouth, MA and the FARA-InterRidge Mid-Atlantic Ridge Symposium in Reykjavík. The InterRidge Office edited abstract volumes for both meetings. Both meetings were well attended and productive (see below). Their success was largely due to the many contributions made by participants as formal oral presentations and posters and to discussions. We'd like to take this opportunity to thank the participants of both meetings for their involvement and for the positive feedback received. In addition, the InterRidge Office continued overseeing ongoing work on various InterRidge Projects and managed to produced the Spring/Summer issue of *InterRidge News* on schedule.

InterRidge Office Transfer

The 1997-1999 term of InterRidge will be hosted by France. Mathilde Cannat of CNRS/University of Paris 6 has been named as the next InterRidge Chair. The Office will be transfered to Paris in January 1997.

Membership

InterRidge Membership has remained constant since the beginning of 1996 with 6 Principal Members (France, Germany, Japan, Spain, the United Kingdom, the United States), 2 Associate Members (Norway, Portugal) and 11 Corresponding Members (Australia, Canada, Denmark, Iceland, India, Italy, Korea, Mexico, Russia, Sweden, Switzerland). Australia has announced its intention to upgrade to Associate Membership in 1997.

InterRidge and SCOR

The decision to apply for formal SCOR Affiliation was taken at the 1996 InterRidge Steering Committee Meeting. InterRidge has been involved in discussions of SCOR affiliation over the past year and played an active part in the initiation of SCOR Working Group 99 "Linked Mass and Energy Fluxes at Ridge Crests". Since its formal recognition by SCOR, InterRidge has closely followed the progress of WG 99, and several InterRidge representatives participated in the September 1996 SCOR WG 99 Symposium at the Southampton Oceanographic Centre, UK.

InterRidge Projects

4-D Architecture of the Oceanic Lithosphere

A meeting of the 4-D Architecture of the Oceanic Lithosphere Project working group (L. Parson, Southampton, Chair) was held in parallel with the ODP-IR-IAVCEI Workshop in North Falmouth. Since

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Dr. Ruth Williams, Assistant Editor
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ocean drilling will play an important role in the 4-D Architecture Project, it was deemed particularly relevant to schedule the working group meeting so that the results could be presented to the more general ODP-IR-IAVCEI community in attendance. During the meeting, the working group carried out an assessment of progress towards the goals identified at the Boston 1994 4-D Architecture Workshop.

Biological Studies at the Ridge Crest

Work on the Hydrothermal Vent Fauna Identification Manual, overseen by D. Desbruyères of IFREMER, is reaching completion. A 1997 publication date is anticipated for the color volume containing descriptions and photographs of over 100 species. The manual will be published in a loose leaf binder format to facilitate updating.

ODP-InterRidge-IAVCEI Workshop

The Oceanic Lithosphere & Scientific Drilling into the 21st Century Workshop set out to define a unified drilling programme for mid-ocean ridges (MORs) and large igneous provinces (LIPs) in the next century. Five working groups drew up programmes for LIPs, Fast (hot) MORs, Slow (cold) MORs, Active Processes and Observatories, and Back-arc Spreading Centers. The Workshop is recommending a number of new ODP Working Groups to participate in ODP's proposal panel structure, and InterRidge was charged with nominating members for several of these (in some cases working with other interested programmes such as MARGINS). A report of the meeting will be published by InterRidge.

InterRidge Steering Committee Meeting 1996

Portugal hosted the 1996 meeting of the InterRidge Steering Committee in Estoril near Lisbon on September 25 & 26. A number of Steering Committee Members, having reached the end of their 4 year terms, will be rotating off the Committee at the end of this year.

WWW InterRidge Home Page

InterRidge continues to maintain an up to date calendar of events, workshops and meetings. Since the addition of our electronic subscription form, increasing numbers of ridge crest researchers have been included in the InterRidge Electronic Directory.

Heather Sloan
InterRidge Co-Ordinator

The InterRidge Office is Moving!

As of 1 January 1997,
please direct all correspondence to:

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4 Place Jussieu
75252 Paris Cedex 05, France

Take this opportunity before the InterRidge Office leaves Durham to inform us of any change of address or other contact information by filling in the form on page 5.
Forms should be mailed to the Durham Office no later than 1 December 1996.

A Letter from the Co-Ordinator

Dear Colleagues,

As some of you already know, I will be leaving the post of InterRidge Co-Ordinator as this newsletter is published, to accept a position at the American Museum of Natural History. I would like to thank you all for your good will and contributions over the last three years. I encourage you to continue your support as the InterRidge Office moves to Paris. I'm sure the new Co-Ordinator will find you all as helpful as I have.

It has been a pleasure and a privilege to work with the members of the Steering Committee past and present, and with the members of the international ridge crest research community. I intend to continue to participate in the activities of InterRidge and look forward to meeting more of the people behind the e-mail and to continuing contact with the many people I have had the pleasure to meet.

All the best,

Heather Sloan
InterRidge Co-Ordinator

P.S. Don't panic. Ruth has the Office under control.

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
InterRidge News, 1996, 5, 1, pp. 52
InterRidge News, 1996, 5, 2, pp. 68

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 Program Plan Addendum 1995, pp.15, 1996.
InterRidge Program Plan Addendum 1996, in prep.
InterRidge Meeting Report, Brest, France, 1990.
InterRidge Meeting Report, York, UK, 1992.
InterRidge Meso-Scale Working Group Meeting Report, Cambridge, UK, 1992.
InterRidge Steering Committee Meeting Report, Seattle, USA, 1993.
InterRidge Meso-Scale Project Symposium and Workshops Reports, 1994:
Segmentation and Fluxes at Mid-Ocean Ridges: A Symposium and Workshops &
Back-Arc Basin Studies: A Workshop, pp. 67, June 1994.
InterRidge Global Working Group Report 1993:
Investigation of the Global System of Mid-Ocean Ridges, pp. 40, July 1994.
InterRidge Steering Committee Meeting Report, Tokyo, Japan, 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 Steering Committee Meeting Report, Kiel, Germany, 1995.
InterRidge Meso-Scale Workshop Report: Quantification of Fluxes at Mid-Ocean Ridges: Design/Planning for the Segment Scale Box Experiment, pp. 20, March 1996.
InterRidge Global Working Group Workshop Report: Arctic Ridges: Results and Planning, in prep.
InterRidge Active Processes Working Group Workshop Report: Event Detection and Response & A ridge Crest Observatory, in prep.
InterRidge Biological Ad Hoc Committee Workshop Report: Biological Studies at the Mid-Ocean Ridge Crest, pp. 21, August 1996.
InterRidge SWIR Project Plan, in prep.
InterRidge Steering Committee Meeting Report, Estoril, Portugal, 1996, in prep.

These publications are available from the InterRidge Office upon request.

Calendar

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

Magnetisation of Oceanic Crust
Orcas Island, San Juan Islands, WA, USA, 21-24 October 1996

Exploration and Exploition of Non-living Deep-sea Marine Resources
Royal Society, Burlington House, London, UK 29 & 30 October 1996

Europa Ocean: An International Conference
San Juan Capistrano Research Institute, CA, USA, 12-14 November 1996

American Geophysical Union Fall Meeting
San Francisco, CA, USA, 15-19 December 1996

Joint Mineralogical Society Winter Meeting & Volcanic Studies Group Research in Progress Meeting
Cambridge, UK, 6-9 January 1997

European Union of Geosciences: EGU 9
Strasbourg, France, 23-27 March 1997

International Symposium: Plumes, Plates and Mineralization (PPM'97)
Pretoria, South Africa, 14-18 April 1997

European Geophysical Society: XXII General Assembly
Vienna, Austria, 21-25 April 1997

Neves Corvo Field Conference
Lisbon, Portugal, 11-14 May 1997

Modern Ocean Floor Processes and the Geological Record
Geological Society of London, Burlington House, Piccadilly, London, 14-15 May 1997

American Geophysical Union Spring Meeting
Baltimore, MD, USA, 27-30 May 1997

American Malacological Union: Deep-Sea Mollusca
Santa Barbara, CA, USA, 22-27 June 1997

MAST 3 Advanced Study Course: "Benthic Communities Fueled by Chemosynthesis"
Paris, France 1-19 September 1997

InterRidge Steering Committee Meeting
Barcelona, Spain, 18 & 19 September 1997 (Provisional)

Eighth Deep Sea Biology Symposium
Monterey, CA, USA, 22-27 September 1997

International Symposium on Hydrothermal Vent Biology
Madeira, Portugal, 20-24 October 1997

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/~dgl0zz1/) 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.: ____________________ **Fax.:** ____________________
country code area code number country code area code number

e-mail: ____________________

Name of your national ridge research program: ____________________

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

☐ Active Processes ☐ Meso-Scale Studies ☐ Global Studies

What are your fields of interest/expertise?

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

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cut

InterRidge Phase 2 Projects

SWIR Project

Southwest Indian Ridge 15°E-35°E: A Geophysical Investigation of an Ultra-Slow Spreading Mid-Ocean Ridge System

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From 10 February to 28 March, 1996, as part of a RIDGE-funded program, we conducted a marine geophysical investigation of the very slowly opening (16 mm/yr full rate) Southwest Indian Ridge (SWIR) between longitudes 15°E and 35°E (Figure 1). Prior to this survey the only direct sampling of this ~1500 km-long portion of the SWIR consisted of a few sounding profiles and rock samples from a dozen localities. During the *R/V Knorr*'s longest cruise ever, 10,833 nautical miles, we collected SeaBeam 2112 multibeam bathymetric and backscatter data, and sea surface magnetic and gravity data over two sections of the SWIR with markedly different tectonic settings. Between 15°E and 25°E the SWIR is relatively straight without significant offsets, whereas between 25°E and 35°E the SWIR is offset more than 1100 km by several closely spaced transform faults. We obtained nearly complete bathymetric and backscatter coverage of the ridge axis and flanking terrain out to magnetic anomaly 3A (5.8 Ma) in both areas.

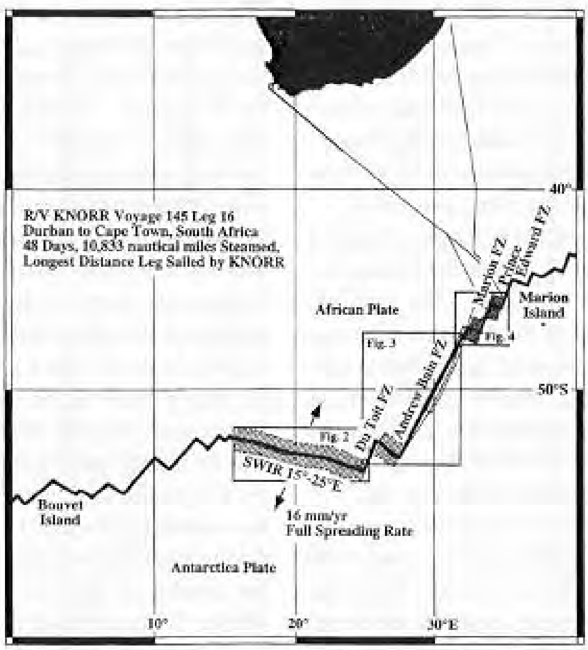

Figure 1. Regional setting of SWIR and survey area. Plate boundary shown by thick line. Ship's trackline shown by thin line. Boxed areas show locations of Figures 2-4.

This remarkable data set will allow us to define the morphologic and geophysical characteristics of an ultra-slow spreading center and examine how these characteristics vary spatially between ridge segments opening at the same rate but in different tectonic settings (i.e. no major offsets vs. a transform dominated tectonic environment). We will also be examining the frequency and systematics of ridge axis segmentation at these ultra-slow spreading rates and determining the kinematics of the plate boundary over the past 5 Ma.

An additional objective of this project is to provide a high-resolution bathymetric map of the region to the general oceanographic community. The bathymetry can be used as a detailed base map for guiding future studies in this region (e.g. systematic dredging, seismic refraction/ reflection, deep-towed instrument studies), a tectonic framework for the petrologic data that has been collected along this portion of the SWIR (Fisher et al., 1987; Dick, 1989; le Roex et al., 1989; Mahoney et al., 1992), and a means to ground-truth and calibrate remote sensing observations (e.g. altimeter and earthquake seismology).

In this article we present some first-order morphologic observations of the SWIR between 15°E and 35°E. Analysis of the geophysical data, in conjunction with the bathymetry and backscatter data, is ongoing and initial results will be presented at the 1996 American Geophysical Union Fall Meeting.

Section I: SWIR 15°E-25°E

This region encompasses a very linear, nontransform offset portion of the ridge that is far from any hotspot influence (Figure 1). The closest hotspot (Bouvet) is over 820 km to the west; and the distance to the Marion hotspot is over 1100 km to the northeast. This section of the SWIR is thus presumably free of the thermal and geochemical effects known to be associated with hotspots, and can be considered to have "normal" mid-ocean ridge properties.

An extreme range of depths was measured within the region between 15°E and 25°E. The shallowest (<140 m at the Anna de Koningh Seamount, located at the inside corner high) and deepest (>6000 m, at the adjacent intersection deep) depths were observed where the spreading center intersects with the Du Toit transform fault (Figure 2). This change in depth of more than 5800 m over a distance of only 15 km represents the most extreme relief observed along the entire global mid-oceanic ridge system.

The SWIR between 15°E and 25°E is characterized by a highly variable rift valley morphology (Figure 2). The maximum depth of the rift valley floor varies from 3300 m to 4800 m; the flanking rift mountains shallow to depths ranging from 1000 m to 2700 m. Rift valley outer wall widths are as great as 77 km, and as narrow as 18 km; rift valley floor widths range from 2 km to 19 km. This portion of the SWIR has a wider (~5-10 km) rift valley, and greater overall relief (~100-300 m) between the rift mountains and the valley floor, than a comparable length of the northern Mid-Atlantic Ridge (MAR) between 24°N and 30°45'N (Sempéré et al., 1990). A large number of conical-shaped features, interpreted to be axial volcanoes, are observed on the floor of the rift valley. These volcanoes have diameters ranging from <1 km to 5 km and rise 100 m to 400 m above the surrounding rift valley floor.

The overall strike of the rift valley between 15E° and 25°E changes abruptly in three areas, and these locations appear to mark major zones of transition in the morphologic character of the rift valley and flanking terrain. From the Du Toit transform fault westward to 22°20'E, the rift valley strikes N70°W, nearly perpendicular to the regional direction of spreading. In this region, the along-axis continuity of both tectonic and magmatic features is striking (Figure 2). Within the rift valley, linear ridges, defining individual accretionary segments, extend to over 50 km in length. On the flanking terrain, fault scarps and volcanic ridges can be traced as continuous features over distances of several ten's of kilometers, some approaching up to 100 km in length. These remarkably continuous features have not been observed at other slow spreading centers (e.g. the MAR). Asymmetric ridges observed on the rift flanks in this area, that are bounded on one side by a steep inward-facing (toward the ridge axis) scarp, and on the other by an outward-facing (away from the ridge axis) relatively low relief slope, are similar to the bow-form, scroll-shaped features observed at the intermediate spreading Juan de Fuca Ridge (Kappel and Ryan, 1986).

Near 22°20'E the strike of the rift valley changes to N80°W. This change in strike corresponds with the end of the remarkably continuous ridge parallel features and, towards the west, the beginning of what can be characterized as high relief, discontinuous and blocky flanking terrain (Figure 2). Accretionary segments in this area are of shorter length and less well-defined. Average depths to the floor of the rift valley are greatest in this area. The margins of the rift valley are defined by a series of scarps trending N70°W and N60°E, forming a zigzag pattern of indentures and re-entrants along the rift valley walls. Off-axis, the terrain pattern consists of a seemingly chaotic arrangement of alternating irregular-shaped highs and lows, the length and width dimensions of which are similar to the rift valley basins in the area.

Near 20°E the rift valley changes strike back to N70°W, and to the west the morphology again assumes the remarkable linearity observed between the Du Toit Fracture Zone and 22°20'E (Figure 2). It is along this portion of the ridge that there is evidence for a rapid (25 mm/yr) eastward migration of a point source of magmatism. A distinct V-shaped pattern of off-axis highs is visible about the rift valley. Three large volcanoes on the south flank of the rift valley are aligned along a N85°E trend, and on the north flank four less well-defined volcanic highs trend S60°E. These trends intersect the rift valley at a local shallow point near 20°20'E. From 17°E to the westernmost extent of the survey area the ridge axis trend reverts back to N80°W and the asymmetric axial basins and blocky off-axis terrain are once again observed.

Second-order ridge segmentation of the SWIR between 15° and 25°E is poorly defined. The plate boundary is characterized by a series of relatively narrow (2-15 km), linear ridges with intervening circular- to elongate-shaped basins that lie within the axial rift valley. The basins, interpreted to be nontransform offsets, are 300-800 m deeper than the ridges, and show no evidence of narrowly focused zones of strike-slip faulting. None of the ridge offsets are greater than 10 km. A plot of minimum depth along the rift valley shows that this portion of the SWIR can be divided into sixteen segments ranging in length from 15 to 70 km (average length 40 km, s=±15.8 km; Figure 2). A more detailed study of the nature of ridge segmentation of this portion of the SWIR is currently being undertaken through an analysis of gravity and magnetic anomalies, bathymetric and backscatter data and previously dredged rock samples.

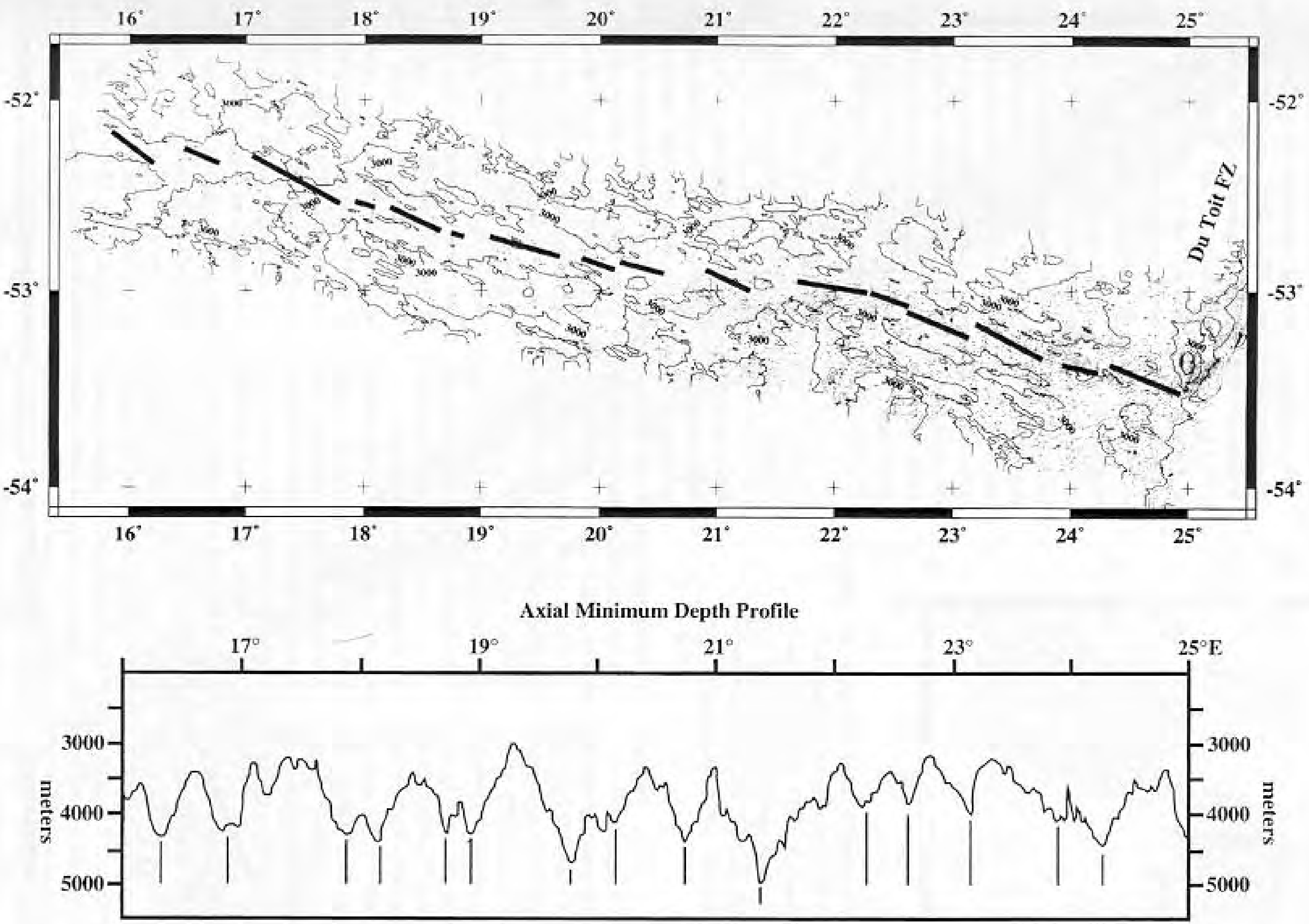

Figure 2. Bathymetry and axial minimum depth profile of the SWIR between 15°E and 25°E. Bathymetric contour interval is 300 m. Dark contour lines at 1500 m intervals. Bold lines on bathymetric map show second-order ridge segments. Thin lines on axial minimum depth profile show second-order ridge segment boundaries.

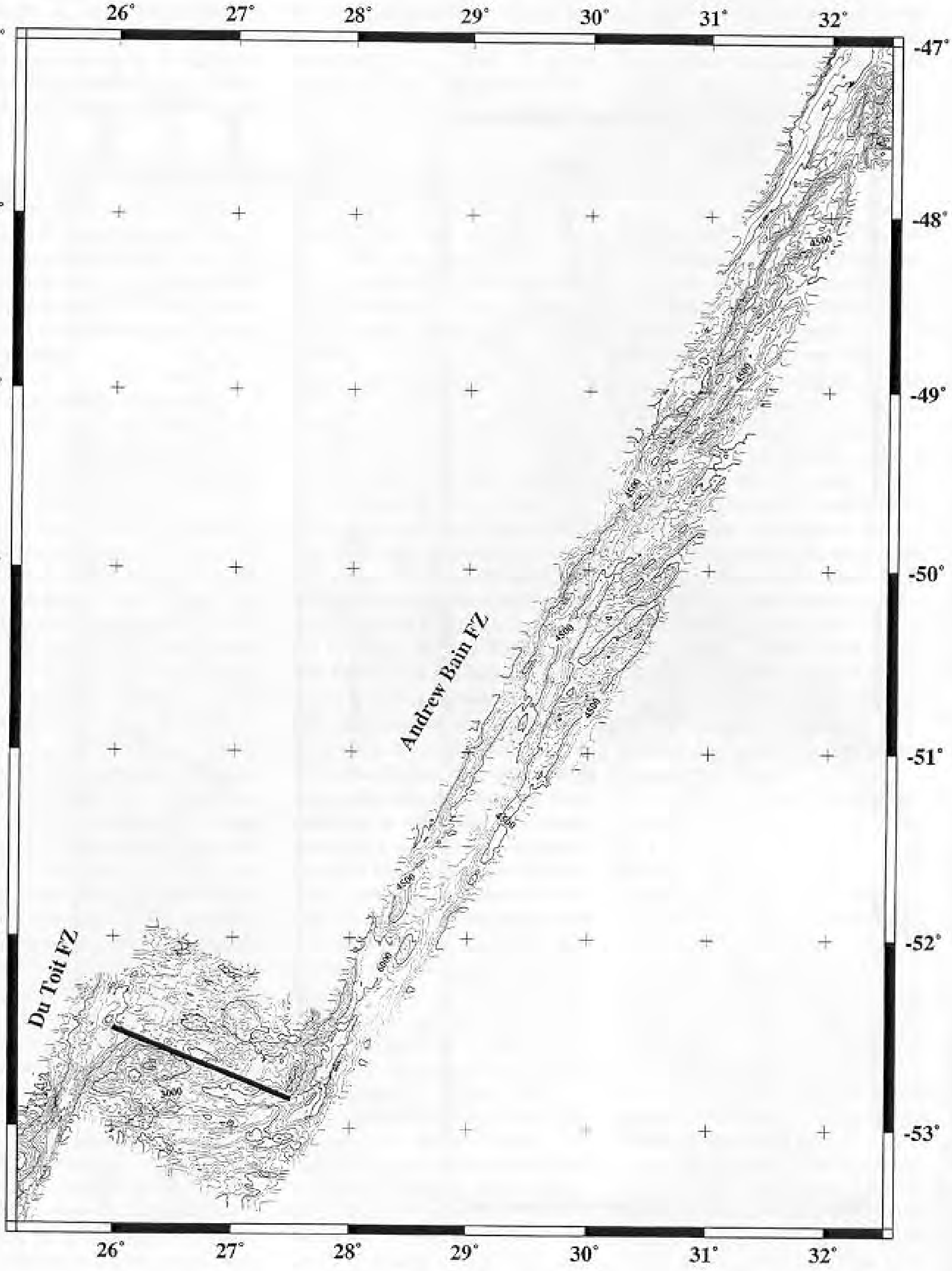

Figure 3. Bathymetry of SWIR between 25°E and 32.5°E. Bathymetric contour interval is 300 m. Dark contour lines at 1500 m intervals. Bold line shows location of plate boundary for ridge segment between the Du Toit and Andrew Bain FZs.

Section II: SWIR 25°E-35°E

This section of the SWIR is dominated by several fracture zones, the Du Toit, Andrew Bain, Marion and Prince Edward (Figure 1). Several short ridge segments are offset in a north-south sense along the transform portions of these fracture zones. All of the transform offsets are right-lateral. The major fracture zone in this region is the Andrew Bain. The transform portion of the Andrew Bain Fracture Zone (FZ) offsets the SWIR by ~750 km, second in offset length only to the Romanche transform fault in the central Atlantic. The Andrew Bain FZ, however, has the widest (~120 km) transform valley measured along the Mid-Ocean Ridge system. The smaller transform portions of the Du Toit, Marion, and Prince Edward FZs offset the SWIR by 150 km, 130 km and 160 km, respectively.

The ridge segment between the Du Toit and Andrew Bain FZs is ~120 km long (Figure 3). Seafloor depths in this area range from >6600 m at the nodal basin associated with the southern Andrew Bain ridge-transform intersection (RTI) to <1000 m at the inside-corner high associated with the northern Du Toit RTI. Along this segment the exact location of the plate boundary is somewhat ambiguous. Placement of the boundary is mainly based on interpretation of the central anomaly magnetic data. From the Du Toit RTI the ridge axis shallows to depths of <3500 m, and is located at the base of a steep escarpment that defines the northern flank of the inside corner high of the Du Toit RTI. Off-axis terrain shows alternating ridge-parallel highs and lows on the northern flank and on the southern flank a substantial inside corner high. The ridge axis maintains relatively shallow depths of 3500 m and can be traced along the base of the escarpment to about 27°E where it reaches a local depth maxima of >4000 m. From this point eastward the ridge axis morphology is defined by a broad asymmetric high with a steep south facing flank and a gently sloping north-facing flank. Axial depths decrease to less than 3250 m at the summit of this feature. Axial depths then increase to 3500-3750 m on the eastern side of the axial high. The plate boundary can be traced along the southern base of the inside-corner high associated with the Andrew Bain RTI and then appears to curve slightly northward before plunging to depths in excess of 6250 m in the Andrew Bain transform valley. The inside-corner high at the Andrew Bain RTI is not as pronounced as the one associated with the southern Du Toit RTI, however, its overall morphology is very similar. The off-axis terrain in the southeast quadrant of this area is dominated by huge (up to 130 km-long, 16 km-wide) curved asymmetric ridges, with gentle inward facing slopes and steep outward facing slopes. The seafloor morphology off-axis in the northeastern quadrant displays both ridge-parallel and ridge-perpendicular trends.

Our SeaBeam coverage of the Andrew Bain FZ extends over six degrees of latitude, 47°S-53°S (~670 km), and five degrees longitude, 27°30'E-32°30'E (~125 km; Figure 3). The overall trend of the transform valley is N27°E. Depths within this area range from 6700 m to 2500 m. The most intriguing features of the Andrew Bain FZ are the series of at least 20 narrow (~10 km-wide) elongate highs within the transform valley that display a range of orientations from roughly transform parallel to 25°-30° oblique to the trend of the transform valley (Figure 3). Lack of magnetic signal associated with these intratransform highs suggests they are not intratransform accretionary segments, rather the result of deformation due to shearing stress along the transform plate boundary.

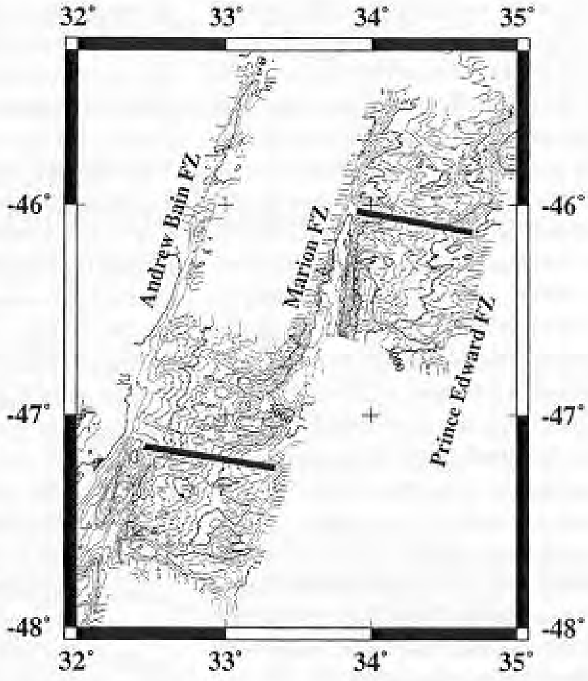

Figure 4. Bathymetry of SWIR between 32°E and 35°E. Bathymetric contour interval is 300 m. Dark contour lines at 1500 m intervals. Bold line shows location of plate boundary for ridge segments between the Andrew Bain and Marion, and Marion and Prince Edward FZs, respectively.

The ridge segment between the transform portions of the Andrew Bain and Marion FZs is ~75 km in length (Figure 4). Axial depths shallow to 2500 m at the center of the segment producing an overall along-axis relief on the order of 2000 m. The segment is dominated by a volcanic center located approximately 40 km from the northern Andrew Bain RTI. This volcanic center appears to have influenced crustal accretion along this portion of the segment for at least the past five million years as shown by a series of flanking elongate highs along flow lines to the north and south. The morphology of the eastern part of the segment is characterized by long asymmetric ridges that curve inward toward the transform portion of the Marion FZ. These ridges appear to be fault bounded, and are separated by intervening deep basins.

The ridge segment between the Marion and Prince Edward FZs is of comparable length (~75 km) to the segment between the Andrew Bain and Marion FZs. The ridge axis morphology is dominated by a central axial volcano that fills the rift valley and rises to depths of 2250 m (Figure 4). Similarly to the segment to the south, this volcanic center also appears to have been active during the past several million years. A very pronounced transverse ridge is observed that parallels the Marion FZ to the south. This feature shallows to 800 m and is very asymmetric in overall form. The western slope has a steep scarp (>3500 m of relief) that defines the eastern valley wall of the transform portion of the Marion FZ. The morphology of the northwestern and eastern portions of this ridge segment are defined by a series of long curvilinear ridges and intervening basins. As the Prince Edward FZ is approached the ridges taper, lose definition and curve inward toward the transform portion of the FZ.

Conclusions

The high-resolution bathymetric data show that this ultra-slow spreading ridge is characterized by a number of unique elements that are markedly different from features observed at the well-studied slowly spreading MAR. We have found significant differences between both segmentation length and magnitude of the inside corner highs at the SWIR and those observed on the MAR. These differences are sufficiently large to suggest that the MAR does not spread at a slow enough rate to be considered typical of a slow-spreading ridge. The extremely slow-spreading rate and the long straight section of the SWIR between 15°E and 25°E make this an extremely attractive area to examine in detail the principle features of a typical slow-spreading ridge. The early results suggest that novel tectonic and magmatic processes are occurring along the SWIR that will need to be incorporated into a model of crustal accretion along the global ridge system.

Acknowledgements

The success of the cruise KN145L16, which was conducted under hostile and trying weather conditions, was due in large part to the dedication, perseverance and good humor of Captain A.D. Colburn, officers and crew of the *R/V Knorr*. This cruise represented the initial scientific use of the SeaBeam 2112 system installed on the *R/V Knorr*; the system performed exceptionally well given the rough sea conditions. Peter Lemmond and Michael Thatcher of WHOI provided outstanding technical support; Shef Corey of SeaBeam Instruments, Inc. assisted in monitoring the operation of the 2112 system. We are grateful for their help. This study was supported by NSF Grants OCE-9314324 (JAM) and OCE-9528885 (NRG).

References

Dick, H.J.B., Abyssal peridotites, very slow spreading ridge and oceanic magmatism, in Saunders, A.D. and Norry, M.J. (eds.), Magmatism in the Ocean Basins, Geological Society Special Publications No. 42, 71-105, 1989.

Fisher, R.L., H.J.B. Dick, J.H. Natland and P.S. Meyer, Mafic/ultramafic suites of the slowly spreading Southwest Indian Ridge: PROTEA exploration of the Antarctic plate boundary, 24°E-47°E, Ophiolitii, 2, 147-178, 1987.

Kappel, E.S. and W.B.F. Ryan, Volcanic episodicity and a non-steady state rift valley along northeast Pacific spreading centers: Evidence from SeaMARC I, J. Geophys. Res., 91, 13925-13940, 1986.

le Roex, A.P., H.J.B. Dick and R.L. Fisher, Petrology and geochemistry of MORB from 25°E to 46°E along the Southwest Indian Ridge: Evidence of contrasting styles of mantle enrichment, J. of Petrol., 30, 947-986, 1989.

Mahoney, J., A.P. le Roex, Z. Peng, R.L. Fisher and J.H. Natland, Southwestern limits of Indian Ocean Ridge mantle and the origin of low $^{206}Pb/^{204}Pb$ mid-ocean ridge basalts: Isotope systematics of the Central Southwest Indian Ridge (17°-50°E), J. Geophys. Res., 97, 19771-19790, 1992.

Sempéré, J.-C., G.M. Purdy and H. Schouten, The segmentation of the Mid-Atlantic Ridge between 24°N and 30°40'N, Nature, 344, 427-431, 1990.

Quantification of Fluxes Project

MARFLUX/ATJ
Mid-Atlantic Ridge: Hydrothermal Fluxes at the Azores Triple Junction

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MARFLUX/ATJ, Mid-Atlantic Ridge : hydrothermal Fluxes at the Azores Triple Junction, is a European project to study hydrothermal fluxes at the Mid-Atlantic Ridge (MAR) near the Azores Triple Junction (ATJ). It was the first project dealing with the study of the ridge system funded by the European Community (EC). The project, attached to the EC's MAST 2 (MArine Sciences and Technology) programme, started in December 1993 and ends formally in November 1996.

EC funding

EC funding can include salaries, equipment, consumables and travels but the MAST2 programme did not include ship time. Eligibility for EC funding requires a partnership between different laboratories from different countries of the European Community. In the case of MARFLUX/ATJ the principal laboratories were in France, the UK, Portugal and Ireland. Several European scientists responded to a call for a manifestation of interest by the EC in 1991. A proposal was written and accepted in 1992. After negotiation, a formal contract was signed in Nov. 1993 between the partners of the project and the EC. The contract, a document of 75 pages, defines the rules and agreements between the EC and the partners. The various tasks and the "deliverables" are formally identified. In addition, a consortium agreement between the partners is required by the EC. The contract requires that the project is monitored closely under the responsibility of the co-ordinator of the project and of a steering committee. Six monthly progress-reports and annual scientific and financial reports have to be submitted to the EC.

Funds are provided annually, conditional upon acceptance of the annual reports. Ship time was funded according to the procedure of the country where a ship time proposal (independent of the EC proposal) was submitted.

The objectives of MARFLUX/ATJ

The principal objectives of MARFLUX/ATJ were:

- to group and compile all existing data in the area of the ATJ.
- to document occurrences of physical and chemical anomalies in the water column.
- to map hydrothermal plumes and determine magmatic and tectonic settings of potential hydrothermal sites.
- to provide the scientific community with natural laboratories for future experiments.

The project has been based around two surface-ship cruises, HEAT and ESCAPE. The HEAT cruise (C. German PI), conducted in Aug.-Sept. 1994, was designed to investigate hydrothermal activity along the MAR between 35°45'N and 38°40'N in relation to the bathymetry and morphology of the axis. ESCAPE (M. Miranda PI) was conducted in Oct. 1995 and investigated hydrothermal activity at the MAR axis from 38°40'N to 40°N, and within the island archipelago of the Azores.

The project built on early re-

Note 1:

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A formal co-operation was established with G. Klinkhammer[13] and C. Langmuir[14].
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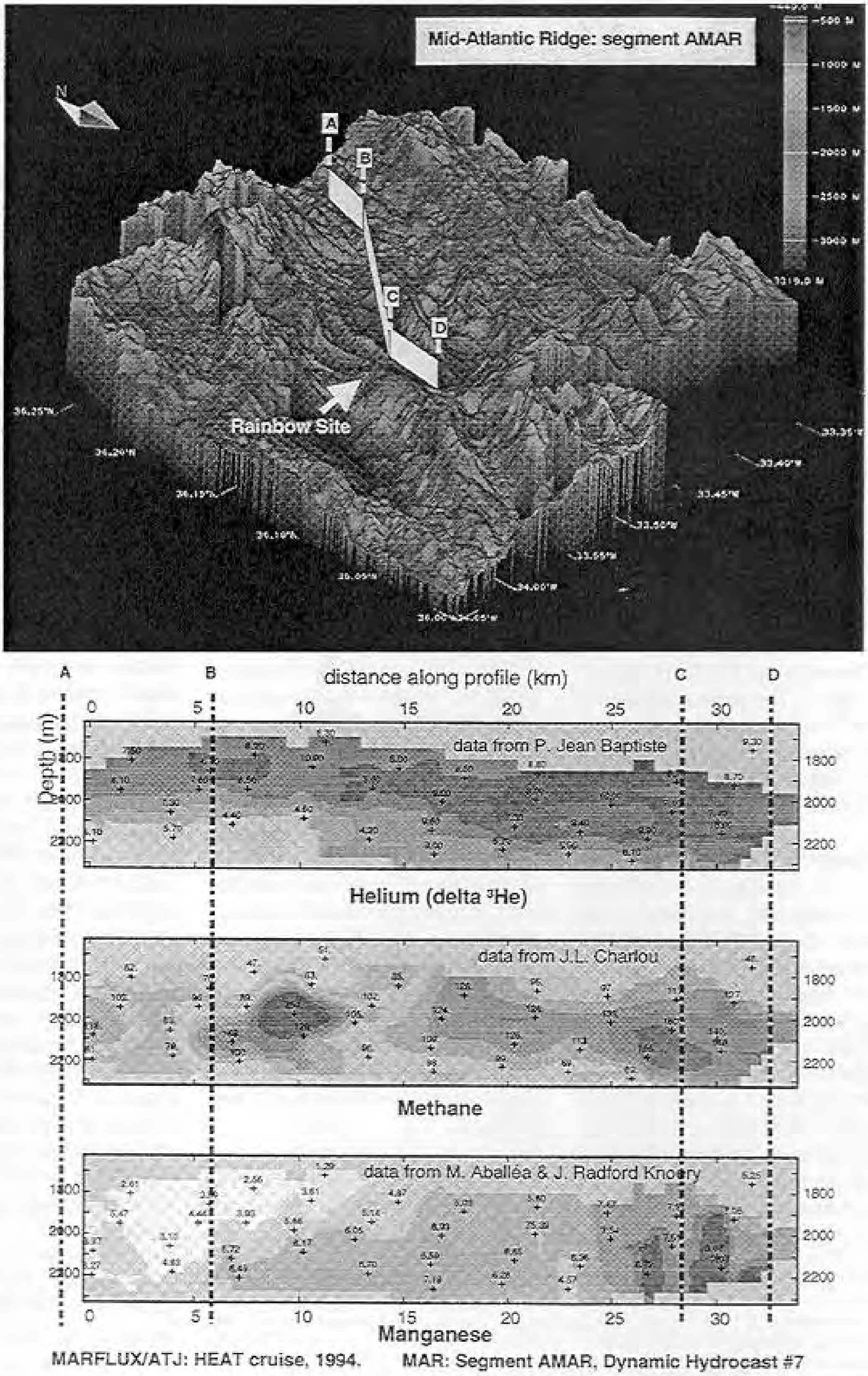

Figure 1. Hydrothermal plumes along the AMAR segment of the MAR, southwest of the Azores. Vertical cross section of Δ^3He, CH_4 and Mn (total disolved manganese (Aballéa et al., 1995)) along ABCD. Between 1700 m and 2300 m depths, chemical signals are detected everywhere along the segment, with values at least 10 times the seawater background. The three chemical tracers have different chemical properties and consequently do not display identical plume cross sections. All chemical tracers focus on a potential hydrothermal site, the Rainbow site at 27 km near 36°15'N where the transmissometer on TOBI detected a strong signal during the HEAT cruise (German et al., 1996). Note that the Rainbow site is a complex offset. It is an example of the diverse geological settings where hydrothermal discharge takes place along the MAR.

sults of FARA (French American Ridge Atlantic project) and has continued in co-operation with that programme. MARFLUX/ATJ relied in particular upon the swath bathymetric data and related geophysical data collected during the SIGMA cruise (1991) of the FARA programme (Needham and SIGMA Scientific Team, 1991; Detrick et al., 1995; Needham, 1996), and on aeromagnetic data collected by the University of Lisbon (Freire Luis et al., 1994; Freire Luis and Miranda, 1996). The project also relied upon data concerning hydrothermal signals detected in the water column (Charlou et al., 1993) and on rock sampling (Langmuir et al., 1996; Dosso et al., 1996) between 33°N and 40°N conducted during the FAZAR cruise (1992, C. Langmuir P.I.). There has been close co-operation between the MARFLUX/ATJ partners and North American colleagues during the FARA programme, SIGMA and FAZAR (above), Alvin dives on Lucky Strike hydrothermal site (1993, C. Langmuir P.I.), Nautile dives on Lucky Strike and Menez Guen hydrothermal sites (Diva 1, 1994, Y. Fouquet P.I. and Diva 2, 1994, D. Desbruyères P.I.) and during the cruises of MARFLUX/ATJ.

The objectives of HEAT were to characterise the variation in tectonism and volcanism and their relationship to the second-order segmentation of the MAR, 36°-38°40'N (Parson et al., 1995), to locate and quantify the extent of hydrothermal activity along this section of the neovolcanic ridge axis (Bougault et al., 1996; German, 1996), and to investigate the geological and geophysical controls on the nature of hydrothermal venting in different morphotectonic settings (German et al., 1996).

Initially, 150 nautical miles of an along-axis side-scan sonar survey were completed using the SOC deep towed instrument, TOBI, 36°-38°N. Areas covered included the Menez Guen and Lucky Strike vent sites (38°N, 37°N), the FAMOUS and AMAR segments (36°-37°N) and the ATJ overlapper at 38°30'N. Simultaneously, a transmissometer on TOBI recorded the presence of particle-rich hydrothermal plumes.

Subsequent sampling included 7 dynamic hydrocast (Note 2) deployments (overlapper, southern Lucky Strike, FAMOUS and AMAR), yielding more than 250 seawater samples for shore-based CH_4, Mn and ^3He analyses. These dynamic hydrocast deployments provided an along-axis vertical cross-section of hydrothermal plumes for CH_4, Mn and ^3He along a cumulative distance of 108 nautical miles. In addition, a total of 22 vertical ZAPS/CTD profiles were carried out for plume sampling and correlation with TOBI plume data. This information was used to direct collection of 20 large-volume plume-particle samples, by *in situ* filtration, for shore based geochemical/microbiological analysis.

The principal objective of ESCAPE was to detect hydrothermal activity from 38°40'N (the expected location of the Triple Junction) to 40°20'N (south of Kurchatov F.Z.) and within the Azores domain, Hirondelle Basin (west of San Miguel), West Terceira Basin, West Graciosa Basin and west of Faial. Seventeen successful vertical CTD-rosettes were conducted yielding 170 seawater samples for Mn, CH_4 and ^3He analyses.

Principal results

TOBI transmissometer data identified the presence of particle rich hydrothermal plumes in all of the south AMAR, AMAR Minor, southern and central AMAR, southern FAMOUS, north FAMOUS and southern Lucky Strike segments, providing a minimum estimate of perhaps one vent site per 20 miles along axis. Thirty vertical hydrocasts and seven dynamic hydrocasts, along AMAR, FAMOUS, southern Lucky Strike, south ATJ, (covering a cumulative distance of 108 nautical miles along the ridge axis) recorded hydrothermal anomalies along each segment between AMAR (36°N) to south of Kurchatov F.Z. (40°N). There was one exception, along the ridge segment located in the area of the triple junction itself between 38°40'N and 39°30'N, where no CH_4 or Mn signal was detected. Hydrothermal plume signals were found to be very strong along southern FAMOUS and AMAR.

The two hydrothermal sites already known in the area of interest, namely Lucky Strike (Langmuir et al., in press) and Menez Guen (Fouquet et al., 1995), are located on the central topographic highs of segments which are characterised by an intense magmatic production. Many hydrothermal plume signals, either detected through the transmissometer on TOBI or by dynamic hydrocasts, were found along rift valley walls (southern FAMOUS), in transform faults (south of Lucky Strike), at a segment end (south of FAMOUS) or associated with complex off-sets like that on AMAR (Fig. 1; Bougault et al., 1996; German et al., submitted; German et al., 1996). The plume maxima, several hundred meters above the inner valley floor, are not related to typical neovolcanic ridges but are associated with tectonics as suggested by the bathymetric and side-scan sonar data (Needham and SIGMA Scientific Team, 1991; Blondel et al., 1996). From previous studies of hydrothermal signals in the water column along the MAR (Charlou et al., 1996) and from the results of the MARFLUX/ATJ project briefly described above, it appears that hydrothermal activity along the MAR is as common as that along the EPR but develops in more much more diverse geological settings. Evidence for hydrothermal activity in areas where ultramafics are exposed, at the inner corner of an intersection with

Note 2

A dynamic hydrocast is composed of four modules attached at different depths to a cable towed behind the ship. Each module contains 10 "proportional" bottles and an electronic controller to monitor the operation (recording depth, bottle filling). A proportional bottle consists of a cylinder and a piston. The proportional bottle is filled up by a pump / propeller system. According to this principle, each sample of seawater is collected "proportionally" along the distance covered by the bottle and represents an "average" sample over this distance. When a bottle is filled up, the system goes on to fill the next one. As a result, one obtains a sample array (four lines parallel to the bottom, 10 samples per line) along a vertical cross-section of the plume.

a fracture zone as well as on the walls of the rift valley well away from fracture zones, was described in the area of 15°N on the MAR (Bougault et al., 1993; Charlou and Donval, 1993). The recent discovery of a hydrothermal site developing on the wall of the rift valley at 14°45'N on the MAR, a site where ultramafic rocks are exposed (Krasnov et al., 1995), is an illustration of the large differences in hydrothermal activity existing between the MAR and the EPR. The major result of MARFLUX/ATJ is to confirm and describe the various geological settings where hydrothermal activity takes place.

In addition to the principal objective of the project, to detect and locate hydrothermal activity in the area of the ATJ and to tie the sites to seafloor (side-scan) images, MARFLUX/ATJ was funded for the study of several aspects of hydrothermal exchanges, and complementary studies were undertaken in the course of the project. The distribution of hydrogen sulfide, a short life hydrothermal tracer in sea water, was studied around the Lucky Strike and Menez Guen hydrothermal sites (Radford Knoery et al., 1996). The explosive versus effusive character of eruption phases were studied as a function of depth on the 38°20'N and Menez Guen segments (Ondréas et al., 1996). Hydrothermal deposits formed in different geological settings of the MAR (i.e. different depths; Fouquet et al., 1996), slab formation at Lucky Strike, alteration of sulfides and comparison with ancient fossil deposits (Barriga, 1996; Costa et al., 1995) have been studied. Significant current velocities have been recorded at Lucky Strike. Using dynamic hydrocast ^{3}He data and current velocity measured on the bottom, ^{3}He flux at the segment scale has been compared to the ^{3}He flux at the scale of the North Atlantic (Jean Baptiste et al., 1996). Larvae collected in sediment traps deployed over a period of one year at Lucky Strike enabled study and dicussion of the recruitment periodicity of bivalves (Comtet et al., 1996). Differences in the fish fauna at Lucky Strike (1700 m) and Menez Guen (800 m) have been described (Saldanha and Biscoito, 1996). The chemistry of large-volume plume-particle samples, obtained by *in situ* filtration, is being studied along with detection and description of their microbial community structure (O'Brien et al., 1996).

Based on the results obtained during the FARA and MARFLUX/ATJ projects in the area of the Azores, further studies will be conducted in 1997-98 under the AMORES project funded by the MAST 3 EC. Its aims are:

• to discover new expressions of Ocean/Lithosphere exchanges from the different signals recorded in the water column corresponding to different geological settings of the MAR

• to study volcanic and/or tectonic controls on hydrothermal discharges, in particular related to transform faults and complex offsets

• to study the influence of the Azores Hot Spot (gradient in depth and in chemical properties of the ocean crust) on physico-chemical properties of hydrothermal exchanges from Menez Guen at 38°N to AMAR at 36°N

• to study the behavior of chemical and biological species both around hydrothermal sites and in plumes

• to study the various aspects of hydrothermal biological communities

• to establish natural laboratories to study the time variation of hydrothermal sites.

References

Aballéa, M., J. Radford-Knoery, H. Bougault, J.Y. Landuré, H. Pellé, P. Appriou, M. Laur and C.R. German, Preliminary results from the MARFLUX/ATJ program. Characterisation of hydrothermal plumes using manganese samples collected with dynamical hydrocasts, EUG Strasbourg, Terra Abstracts, 7, 205, 1995.

Barriga, F.J.A.S., Seafloor mineral deposits: The ancient examples, Journal of Conference Abstracts, 1, 754-755, 1996.

Blondel, P., L.M. Parson, B.J. Murton and C.R. German, Hydrothermalism and surface geology along the Mid-Atlantic Ridge: Acoustic classification of TOBI side-scan imagery from 27°N-30°N and 36°N-38°N, Journal of Conference Abstracts, 1, 759-758, 1996.

Bougault, H., J.-L. Charlou, Y. Fouquet, H.D. Needham, N. Vaslet, P. Appriou, P. Jean-Baptiste, P.A. Rona, L. Dmitriev and S. Silantiev, Fast and slow spreading ridges: structure and hydrothermal activity, ultramafic topographic highs, and CH_4 output, Journal of Geophysical Research, 98, 9643-9651, 1993.

Bougault, H., J. Radford Knoery, J.-L. Charlou, H.D. Needham, P. Appriou, M. Aballéa, P. Jean Baptiste, C.R. German, M. Miranda and C.H. Langmuir, MARFLUX/ATJ. Hydrothermal activity along the Mid-Atlantic Ridge axis, in the area of the Azores Triple Junction. Mn, CH_4, He plumes from dynamic hydrocasts, Journal of Conference Abstracts, 1, 761-762, 1996.

Charlou, J.-L., H. Bougault, J.-P. Donval, H. Pellé, C. Langmuir and F.S. Team, Seawater CH_4 concentration over the Mid-Atlantic Ridge from the Hayes F.Z. to the Azores Triple Junction, Eos Trans., AGU, 74, 380, 1993.

Charlou, J.-L., H. Bougault, Y. Fouquet, J.-P. Donval, E. Douville, J. Radford Knoery, M. Aballéa, H.D. Needham, P. Jean-Baptiste, P.A. Rona, C.H. Langmuir and C.R. German, Methane degassing, hydrothermal activity and serpentinization between the Fifteen-Twenty Fracture Zone area and the Azores Triple Junction area (Mid-Atlantic Ridge), Journal of Conference Abstracts, 1, 771-772, 1996.

Charlou, J.-L. and J.-P. Donval, Hydrothermal methane venting from 12°N to 26°N along the Mid-Atlantic Ridge, Journal of Geophysical Research, 98, 9625-9642, 1993.

Comtet, T., D. Desbruyères, A. Khripounoff and A., Vangriesheim, Mussel population structure and recruitment on two hydrothermal areas on the Mid-Atlantic Ridge: Lucky Strike (37°17'N, 1700 m) and Menez Guen (37°50'N, 850 m), Journal of Conference Abstracts, 1, 777-778, 1996.

Costa, I., F.J.A.S. Barriga and Y. Fouquet, Alteration processes associated with active hydrothermal sites: The Lucky Strike and Menez Guen examples (37°20'N and 37°50'N, Mid-Atlantic Ridge), Memorias n°4, Universidade do Porto - Faculdade de Ciencias, Museu e Laboratorio de Geologico, 979-983, 1995.

Detrick, R.S., H.D. Needham and V. Renard, Gravity anomalies and crustal thickness variations along the Mid-Atlantic Ridge between 33°N and 40°N, Journal of Geophysical Research, 100 (B3), 3767-3787, 1995.

Dosso, L., O. Bonnier, C. Bollinger, H. Bougault, J. Etoubleau and C.H. Langmuir, Geochemical structure of the Mid-Atlantic Ridge between 10° and 41°N, Journal of Conference Abstracts, 1, 784, 1996.

Fouquet, Y., P. Murphy, M.K. Tivey, K. Henry, F. Barriga, I. Costa, P. Cambon, H. Bougault, C. Langmuir, D. Prieur, P. Rona, S. Krasnov and I. Poroshina, Comparison of sulfide mineralization related to slow spreading ridges with high magmatic budget (Lucky Strike and Menez Guen) and low magmatic budget (15°N Area), Journal of Conference Abstracts, 1, 789-790, 1996.

Fouquet, Y., H. Ondréas, J.-L. Charlou, J.-P. Donval, J. Radford-Knoery, I. Costa, N. Lourenço and M.K. Tivey, Atlantic lava lakes and hot vents, Nature, 377, 201, 1995.

Freire Luis, J., J.M. Miranda, A. Galdeano, P. Patriat, J.C. Rossignol and L.A. Mendès Victor, The Azores Triple Junction evolution since 10 Ma from an aeromagnetic survey of the Mid-Atlantic Ridge, Earth and Planetary Science Letters, 125, 439-459, 1994.

Freire Luis, J. and J.M.A. Miranda, Elastic thickness of the lithosphere at the Azores Plateau deduced from gravity data, Journal of Conference Abstracts, 1, 818-819, 1996.

German, C.R., Hydrothermal activity along the Mid-Atlantic Ridge: Tectonic vs. volcanic controls ?, Journal of Conference Abstracts, 1, 794, 1996.

German, C.R., G.P. Klinkhammer and M.D. Rudnicki, The Rainbow hydrothermal plume, 36°15'N, Mid-Atlantic Ridge, Geophysical Research Letters, submitted.

German, C.R., L.M. Parson and HEAT Scientific Team, Hydrothermal exploration near the Azores Triple Junction: tectonic control of venting at slow-spreading ridges?, Earth and Planetary Science Letters, 138, 93-104, 1996.

Jean-Baptiste, P., J.C. Dutay, A. Dapoigny, P. Allard, H. Bougault, J.-L. Charlou, Y. Fouquet, J. Radford Knoery, A. Vangriesheim, H.D. Needham and P. Rona, Hydrothermal Activity on the Mid-Atlantic Ridge from 15°N to 65°N: Helium isotope distribution and constraints on hydrothermal fluxes, Journal of Conference Abstracts, 1, 803, 1996.

Krasnov, S.G., G.A. Cherkashev, T.V. Stepanova, B.N. Batuyev, A.G. Krotov, B.V. Malin, M.N. Maslov, V.F. Markov, I.M. Poroshina, M.S. Samovarov, A.M. Ashadze, L.I. Lazareva and I.K. Yermolayev, Detailed geological studies of hydrothermal fields in the North Atlantic, in Hydrothermal Vents and Processes, edited by L.M. Parson, C.L. Walker and D.R. Dixon, pp. 43-64, The Geological Society, London, 1995.

Langmuir, C., S. Humphris, D. Fornari, C. Van Dover, K. Von Damm, M.K. Tivey, D. Colodner, J.-L. Charlou, D. Desonie, C. Wilson, Y. Fouquet, G. Klinkhammer and H. Bougault, Description and significance of hydrothermal vents near a mantle hot spot: The Lucky Strike vent field at 37°N on the Mid-Atlantic Ridge, Earth and Planetary Science Letters, in press.

Langmuir, C.H., J. Reynolds, H. Bougault, T. Plank, L. Dosso, D. Desonie, E. Gier and Y. Niu, A petrological traverse along the Mid-Atlantic Ridge across the Azores hot spot, Journal of Conference Abstracts, 1, 813-814, 1996.

Needham, H.D., Some features of the North America - Africa plate boundary, Journal of Conference Abstracts, 1, 834-835, 1996.

Needham, H.D. and SIGMA Scientific Team, The crest of the Mid-Atlantic Ridge between 40° and 15°N: Very broad swath mapping with the EM 12 echo sounding system, EOS Trans., AGU ,72, 470, 1991.

O'Brien, D., D. Eardley, M. Carton and J. Patching, Bacteriology of hydrothermal plumes from the Mid-Atlantic Ridge, Journal of Conference Abstracts, 1, 838, 1996.

Ondréas, H., Y. Fouquet, I. Costa, N. Lourenço, M. Tivey and G. Auffret, Volcanic and morphological features at the Mid-Atlantic Ridge axis south of the Azores (37° - 39°N): A study at the submersible scale, Journal of Conference Abstracts, 1, 839-840, 1996.

Parson, L.M., D.W. Coller, C.R. German, H.D. Needham and H.S. Party, Inter-relationship between volcanism and tectonism at the MAR, 38-36°N, EUG Strasbourg, Terra Abstracts, 7, 148, 1995.

Radford Knoery, J., J.-L. Charlou, M. Aballéa, J.-P. Donval and Y. Fouquet, Near seafloor distribution of hydrothermal tracers (sulfide, methane, manganese) in Lucky Strike and Menez Gwen segments, Journal of Conference Abstracts, 1, 808, 1996.

Saldanha, L. and M. Biscoito, On the fish fauna from the Lucky Strike and Menez Gwen hydrothermal vent fields (Mid-Atlantic Ridge), Journal of Conference Abstracts, 1, 853, 1996.

Arctic Mapping

Arctic Geophysical Data Acquisition from US Navy Submarines

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Since 1993 the US Navy has made a Sturgeon-class nuclear powered attack-submarine available for annual unclassified science cruises to the Arctic Ocean. These cruises have collected water samples and CTD casts from surface stations as well as collecting underway oceanographic and geophysical data across the entire deep Arctic Ocean. Approximately 30,000 km (approximately 20,000 km more should be collected during the cruise of the *USS Pogy*, which is presently underway) of underway gravity anomaly and narrow beam bottom sounder data have substantially expanded the unclassified database for the Arctic Ocean. Three more cruises in 1997, 1998 and 1999 will complete the planned SCICEX program.

It has been widely recognized that the stability, silence, range and independence from surface conditions render a Sturgeon-class submarine a nearly ideal platform for geophysical measurements. Floating pack ice, which covers most of the Arctic Ocean, restricts or prohibits access to much of the basin. The submarine's independence from surface ice is a particular advantage in the Arctic permitting the first ever systematic bathymetric surveys in the basin.

While the "silent service" has traditionally abhorred active sonar, the Navy has responded to the enthusiasm of the scientific community for additional data from the once-in-a-lifetime opportunity of unrestricted access to the deep Arctic Ocean. Additional instrumentation for future cruises requires funds for study, acquisition, testing and implementation. NSF's Office of Polar Programs supported an initial engineering study last year and has agreed to fund the fabrication and testing of a SeaMARC™-type Side-scan Swath Bathymetric Sonar and a Data Acquisition and Quality Control System. In support of NSF's commitment, a private organization, the Palisades Geophysical Institute, is funding acquisition of a chirp, swept-frequency sub-bottom profiler. The transducers for these sonars will be mounted in a instrument "pod" attached to the keel of the submarine. This equipment should be ready for the next SCICEX cruise, which is scheduled to get underway in late July or early August of 1997

If all goes according to plan, the SCICEX program will collect co-registered backscatter, bathymetry, chirp sub-bottom profiler and gravity anomaly data during the remaining unclassified Arctic cruises. If previous cruises are an indication of what we can expect in the future, the next three cruises in this program will collect approximately 60,000 km of additional underway data and approximately 1,000,000 km^2 of swath imagery by the end of the 1999 trip.

Four organizations are collaborating to make these plans a reality. Lamont-Doherty Earth Observatory (LDEO) is acting as lead institution, managing acquisition, integration and testing of the instruments and computer data logging system. Alliant Techsystems of Mukilteo, Washington has been contracted to fabricate the Arctic-optimized SeaMARC™-type side-looking sonar. The Hawai'i Mapping Research Group (HMRG) will adapt their software for the MR-1 towed side-looking sonar for the submarine application. The Arctic Submarine Lab (ASL) of San Diego, California is developing a design for the transducer "pod" that will be mounted on the submarine keel and preparing the engineering documentation required by the Navy for this installation. Once completed, LDEO will act as caretaker for the instrumentation, maintaining, repairing and improving it as necessary or desirable. ASL will be responsible for the annual installation and demobilization of the instruments. LDEO and HMRG will operate the system and archive and reduce the data to a consistent standard over the three year life of the program in support of PIs funded under the SCICEX program and for the community at large.

Questions about this instrumentation, known collectively as SCAMP (Seafloor Characterization and Mapping Package), can be directed to Bernard Coakley at LDEO (bjc@ldeo.columbia.edu or +1 (914) 365-8552). Questions about the SCICEX program and future cruises can be directed to either Odile de la Beaujardiere at the Office of Polar Programs at NSF (odelab@nsf.gov or +1 (703) 306-1033) or Mike Van Woert at the Office of Naval Research (+1 (703) 696-4720).

Biological Studies at the Ridge Crest

Colonization of Hydrothermal Vents near 9°50'N, East Pacific Rise: A Cruise Report from Block Party 1, 2 & 3

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The ridge crest of the East Pacific Rise (EPR) near 9°50'N, 104°W is a region of recent (1991) volcanic activity and vigorous hydrothermal venting, and is therefore of great interest to biologists studying colonization and temporal change in vent faunal communities. An international group of scientists (Table 1) has been studying these and other processes at a group of vents near 9°50'N on a series of three NSF-funded cruises conducted on the *R/V Atlantis II* in November 1994, April 1995, and December 1995. The cruises were dubbed Block Party 1, 2 and 3 by participants because a primary activity during each was use of the submersible Alvin to place hundreds of basalt blocks (each 10 cm on a side) as colonization surfaces in the vent communities. The scientific objectives of these cruises included a wide variety of topics including physiology, larval ecology, reproduction, population ecology, symbioses, molecular biology and population genetic structure of vent species, but we will restrict our discussion here to colonization studies.

Scientific Motivation

Hydrothermal vent environments are patchy and ephemeral on relatively short time scales (years to decades), so the suite of largely endemic species living there must be able to colonize new vent habitats effectively. Recent field observations at 9°N EPR have indicated that colonization can occur relatively quickly, on time scales of months to a year. These and previous studies suggest that species may colonize in a predictable sequence over time, and in distinct faunal zones. We are interested in the ecological mechanisms and interactions that result in observed colonization sequences and faunal zonation in vent communities. We know that intense gradients in physiological stresses and chemosynthetic nutrient sources occur in vent communities as a result of spatial variation in the intensity of hydrothermal fluid flux. These gradients play a role in dictating distribution of some vent species, and temporal variation in hydrothermal effluent is likely to effect changes in the community structure over time. We also know that, in the near vicinity of vents, population densities of benthic invertebrates are frequently very high, implying a potential for competition, and that densities of consumers such as gastropod grazers, crabs and deep-sea fishes are also high in some systems, implying a potential for biological disturbance to contribute to community organization. The objectives of our studies at

Nation	Institution
USA	
	Woods Hole Oceanographic Institution
	Pennsylvania State University
	University of North Carolina
	San Francisco State University
	University of Delaware
	Harbor Branch Oceanographic Institute
	Agouron Institute
	Rutgers University
	Scripps Institution of Oceanography
	Savannah State College
France	
	Université Pierre et Marie Curie
	CNRS
	IFREMER/Centre de Brest
	Station Biologique, Roscoff
Canada	
	Université du Québec à Montréal

Table 1. List of nations and institutions participating in Block Party cruises 1, 2 & 3 (presented in order of number of individual participants). The cruises and the diffuse-flow colonization studies were funded by NSF; other studies were funded by a variety of sources.

9°N EPR are to evaluate the relative roles of physico-chemical influences and biological interactions during the colonization of vent communities.

Approach

To describe the sequence of colonization and community within a diffuse-flow vent system at EPR, we introduced basalt settlement blocks into each of four zones: the tubeworm zone (characterized by temperature anomalies of 5°-25°C, high H_2S concentrations and typically inhabited by vestimentiferan worms); the bivalve zone (1°-5°C, moderate H_2S, inhabited by vent mussels and clams); the suspension-feeder zone (<2°C, undetectable H_2S, inhabited by serpulid polychaetes, barnacles and anemones); and the peripheral faunal zone (no temperature or H_2S anomalies, inhabited by non-vent species), and followed subsequent colonization and community development. Zones were characterized on three occasions over 13 months (Nov. 1994 and Apr. and Dec. 1995) by semi-quantitative analysis of video surveys, recording free space, areal coverage by dominant space occupiers, and consumer/predator (crabs and fishes) abundances. Plankton pumping was employed to evaluate patterns of larval abundance with zone over time. Internally-recording temperature probes (Hobos) were installed at each zone to serve as a proxy for measuring the intensity of fluid venting over time and space at the study sites. This study regime was replicated at each of three vent sites at 9°50' N (Biovent, East Wall and Worm Hole; Fig. 1). Aanderaa current meter deployments provided records of flow fields during each cruise and for a 4-month inter-cruise period at our study area.

We exposed settlement blocks on three different dates (0, 5, and 13 months) in a design that involved recovery of subsets of blocks from each deployment on two subsequent recovery dates. The overlapping exposure times allow tests of whether recruitment onto blocks during community succession is altered in any way (e.g., facilitated or impeded) by prior occupation of those blocks by earlier colonists. This experimental test of one major type of biological interaction was conducted in each of

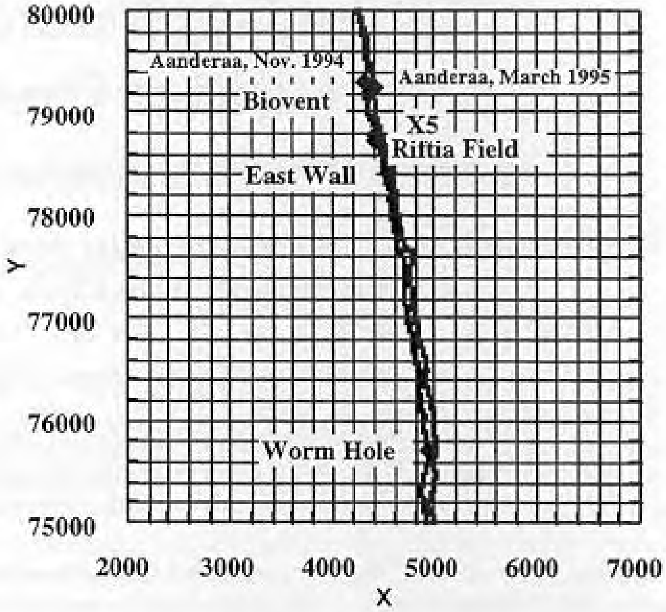

Figure 1. Location of study sites in the axial summit valley of the East Pacific Rise. Axes are plotted in meters east-west (X) and north-south (Y). For reference, the position of Biovent is 9°50.96'N, 104°17.62'W. Locations of the Aanderaa current meter moorings are shown for 1994 and 1995 deployments.

the four zones around the EPR vents. To evaluate the role of predation and biological disturbance in the development of spatial and temporal patterns at the vent, we also designed and deployed settlement blocks inside cages. The cages were 20-cm cubes constructed with 7 mm plastic mesh; blocks were suspended in the center of the cage with plastic cable ties. As a test of the artifacts of introducing cage mesh material, we designed a second caging experiment that contrasted colonization of uncaged blocks, caged blocks, and blocks contained inside partial cages (cages with one side missing). Finally, to test for any effects of elevating blocks 2-6 cm above the seafloor, as required when deployed inside cages, a final caging experiment compared colonization on uncaged blocks, caged blocks, and on uncaged blocks suspended at 2-6 cm from PVC frames like those used as structural skeletons inside all cages and partial cages.

To evaluate the role of physiological adaptation during community development at vents, we developed and applied molecular assays for the presence of symbionts among new recruits of vestimentiferans and bivalves on all recovered settlement blocks. We also characterized the maximum temperature in the microenvironment surrounding each individual block as a proxy for the physiological stress (from exposure to high temperature, H_2S or toxic metals) or nutritional benefit (reduced chemicals for microbial production) at each block position. These latter measurements were essential because microhabitat variation was high within zones and appeared to have a strong influence on colonization of even very closely-spaced blocks.

Most of the colonization experiments were conducted in diffuse vent flows with moderate (< 25°) temperature anomalies, because the faunas inhabiting high-temperature environments are difficult to manipulate. These technical challenges, however, did not daunt our French colleague F. Gaill, who engineered a colonization study of alvinellid polychaetes in high temperature flows at the X5 vent (Fig. 1). The alvinellid experiment was recovered in February 1996 as part of the HOT 96 program.

Many of these experiments are ongoing, and a set of basalt blocks remains at the study sites for a future, as yet unscheduled, recovery cruise. We ask that anyone working in the vicinity of these sites contact us so that we can provide exact locations and details about our on-going studies.

Initial Colonization and Faunal Zonation

The processing and analysis of colonization of roughly 400 basalt blocks is a time-consuming task, so only preliminary results can be presented at this time. Nevertheless, several intriguing patterns have emerged from our initial findings. Blocks from all deployment intervals (5-, 8- and 13-mo) were colonized by large numbers of vent species, including 12 gastropods, the vent mussel *Bathymodiolus thermophilus*, 3 vestimentiferans (*Riftia pachyptila*, *Tevnia jerichonana* and *Oasisia alvinae*), 13 polychaetes, and a variety of crustaceans and less abundant taxa. Most of the species were identified using standard morphological techniques, but many of the vestimentiferan worms were too small to distinguish by eye, so a polymerase chain reaction (PCR) technique with restriction fragment length polymorphism (RFLP) analysis was developed to distinguish among the three species of vestimentiferans.

As expected, the vestimentiferan, bivalve and suspension-feeding species successfully colonized blocks in the zones that they occupied as adults. Other species also showed strong zonation; for instance, gastropod species were particularly choosy, with each species settling into only one, or at most two, of the four faunal zones (these results were unanticipated because species distributions of the adults had not yet been described).

Another unexpected result was that many species, including vestimentiferans, mussels and serpulids, displayed broad settlement ranges, indicating that larvae were capable of colonizing zones where the adults could not persist. This observation suggests that either the physiological tolerances and/or nutritional requirements of the organisms change as they mature, or that interactions among species (competition, predation) prevent species from maturing in zones outside those occupied by the adults. The results of our caging experiments and overlapping deployments should allow us to resolve these two possibilities.

One puzzling observation was that larval settlement on blocks located in dense mussel beds was very sparse, even by the mussel larvae themselves. In shallow environments, dense mussel beds have been shown to remove substantial numbers of particles, including larvae, from the overlying water column. It is possible that dense beds of vent mussels may effectively prevent subsequent larval settlement; this is an intriguing topic for future investigation.

Initial analyses of colonization by the three vestimentiferan species suggest that *Tevnia* tended to recruit more rapidly than *Riftia* during the 5-month block exposure. On blocks colonized by large numbers of tubeworms, all the individuals large enough for identification by morphology were *Tevnia*; and only the smallest individuals among those identified by molecular techniques were *Riftia*. This pattern emerged even on blocks positioned directly in a clump of adult *Riftia*. We speculate that initial colonization by *Tevnia* may facilitate subsequent colonization by *Riftia*. Individuals of *Oasisia* were also identified, but no time-dependent pattern has yet emerged.

In summary, we have strong preliminary evidence from our manipulative experiments that biological interactions, in addition to physiological tolerances and requirements, influence the sequence of colonization and the faunal zonation in hydrothermal vent communities. Our ongoing analyses of overlapping deployment intervals and caging experiments will help explain how these processes interact to determine species distributions and temporal change in vent communities.

Ridge Crest Biologist Directory on the World Wide Web

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

http://www.dur.ac.uk/~dgl0zz1/

If you would like to be 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.

HOT 96 NEWS

F. Gaill[1], H. Felbeck[2], D. Desbruyères[2], F. Lallier[1], A. Toulmond[1], A.-M. Alayse[2], P. Briand[2], J.-P. Brulport[2], J.C. Caprais, P. Chevaldonné[11], J. Y. Coail, R. Cosson[5], P. Crassous[2], J. Delachambre[4], C. Durif, L. Echardour, G. Hervé[1], S. Hourdez[1], D. Jollivet[8], J. Kerdoncuff[2], A. Kripounoff[2], J.P. Lechaire, A. Pruski[3], J. Ravaux, P.M. Sarradin[2], B. Shillito[1], J.Y. Toullec[6], C. Arndt[7], C. Fisher[10], R. Lutz[11] and J. Childress[12]

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A team of French and American biologists has just returned from a joint expedition at 9°50'N and 13°N on the EPR. The expedition, HOT 96, was the latest of a long list of collaborative French/American cruises by hydrothermal vent biologists (Note 1). Five of the participating scientists (J. Childress, H. Felbeck, C. Fisher, F. Gaill and R. Lutz) were at sea together during the first Oasis expedition to 21°N on the EPR in 1982, and D. Desbruyères was the chief scientist of a French cruise with Cyana at 13°N.

HOT 96, was led by F. Gaill (CNRS INSU Roscoff UPMC) within the joint research group URM 7 associating IFREMER, CNRS and the University of Paris 6, on board the *N/O Nadir*, mother-ship to the submersible, Nautile. Also present on site was the US *R/V Wecoma*, with Chief scientist H. Felbeck of Scripps Institute of Oceanography. A total of 26 French and 20 US scientists participated in at least one of the two legs of the expedition and several French and American scientists were exchanged between the two research vessels according to their scientific interests. One dive during this cruise was funded by the European Community and attributed to the young scientist C. Arndt of the Institut für Ostseeforschung in Warnemünde, Germany.

The 31 dives were divided between two venting areas of the EPR. Vent sites of the 13°N area have been intensively studied by French scientists since 1982, including 10 French-American biological expeditions (Note 1). The other dive area was in the vicinity of 9°50'N, at which 100 Alvin dives have been performed since the recent volcanic eruptive event of 1991. Numerous French-American collaborative studies have been initiated during the course of 10 American cruises (Note 2) to the 9°50'N region. French scientists have participated in most of the biological cruises devoted to this area and, during HOT 96, several instruments deployed from the submersible Alvin over the last year were retrieved with the Nautile.

Analysis performed on the *N/O Nadir*

Various *in situ* experiments and measurements of the main chemical and physical vent parameters were conducted by the French team in order to study the organism/environment interactions at different sites.

Water sampling was performed on several selected sites, Totem Parigo and Genesis (13°N), and East Wall and Tube Worm Pillar (9°N), and allowed new 150 ml sampling bottles to be successfully tested. These bottles are based on vacuum depression and were deployed by the Nautile. Analyses were done by P.M. Sarradin and J.C. Caprais to characterize accurately the chemical environment around the vent organisms in order to correlate both the organism and the chemical species distributions. The chemical species studied were pH, sulfide, methane, carbon dioxide, oxygen, nutrients, copper and lead, sulfur compounds and magnesium as tracer. Preliminary results obtained on board show methane traces among the 9°N vent sites and high CO_2 and H_2S concentrations which differ between areas colonised by *Riftia* and *Alvinella*. Animals from selected sites were also collected in order to define a specific biological signature which includes carbon fixation (A.-M. Alayse) and metallic concentrations (R. Cosson)

Hydrothermal vent particles were also sampled at the Totem site (13°N) to study direct sedimentation around chimneys. The settling particles were collected using time series sediment traps on which current meters were fixed. Two traps were deployed by the Nautile at 1 m and 2.5 m from the chimney base. The aim of these studies, conducted by A. Kripounoff, was to measure how the particle flux exported by hydrothermal springs vary at a micro-scale. The third trap was used as a pelagic reference and moored out of the vent region.

Totem was also an excellent site to analyze various ecological aspects of the fauna associated with smokers, especially *Alvinella* worms, and will be used as a population reference in the near future. This work includes population dynamics and genetics studied by P. Chevaldonné and D. Jollivet. Populations of additional smokers (e.g. Elsa and Parigo) were

Notes

1. Oasis in 1982, Guaymas in 1985, Galapagos in 1985, Hydronaut 1987, Galapagos in 1988, Magical Mystery Tour 1990, HERO 91, HERO 92, 9°N in December 1993 and HOT 96.

2. April 1991, November 1991, March 1992, December 1993, March 1994, October 1994, November 1994, February 1995, November 1995 and December 1995 and 2 French expeditions (October 1991 and February 1996).

also sampled for further ecological and genetic analyses in order to study how populations have evolved since 1991 (i.e. the populations that have already been analyzed in 1987 and 1990). This study includes a fine tuned analysis among cohorts already settled. Moreover, mRNA extractions were also performed on board in order to identify genes coding for enzymes sensitive to environmental parameters (e.g. temperature) and to assess adaptive mutations.

A major thrust of the French ecological experiments was the deployment of SAMO, an *in situ* instrument designed to monitor temporal variation of an array of biologically important parameters and equipped with a time-lapse video system. SAMO uses an array of four thermistors which are positioned in the field of view of the video camera which can be aimed and focused by those on board the Nautile. In addition to the temperature measurements, SAMO also yielded data collected by a transismometer, CTD and current-meter. All these data, including digitized video images, were acoustically transmitted to the surface and monitored from the *N/O Nadir* in real time. SAMO was deployed at both the Genesis site (13°N) and the site known as Riftia Field (9°N) and devoted to the ongoing recruitment studies of L. Mullineaux (WHOI), C. Peterson (Univ. N. Carolina) and C. Fisher. Results from SAMO will be a welcome addition to their studies.

Protective surfaces (tubes and body wall) were collected from various vestimentiferan and annelid species by B. Shillito, J.P. Lechaire, C. Durif and J. Ravaux from the F. Gaill team and J. Delachambre (University of Dijon CNRS) for further studies on the properties, molecular structure and phylogeny of collagen and chitin protein complexes. The molecular characteristics and behavior of such biopolymers are specific to the vent species and may be used as environmental markers. Additional *in vitro* experiments were done on the *R/V Wecoma* to analyze various aspects of the tube secretion process including growth rate, polymerization and enzymatic activities. Other tissues were also sampled from a set of various bivalves and crustaceans by A. Pruski from A. Fiala's group (Banyuls, University of Paris 6) and J.Y Toullec (ENS, Univ. Paris 6) for complementary studies related to their ecophysiological adaptations and molecular evolution.

During a recent Alvin expedition in December of 1995, F. Gaill and C. Fisher (Pennsylvania State Univ.) initiated *in situ* tube-worm growth experiments using a staining device, and alvinellid recruitment experiments using titanium and basalt settlement surfaces. Both experiments were collected during HOT 96 and additional short-term experiments on tube-growth and recruitment were conducted by the two scientists during the cruise. Some of these are still underway at 13°N and 9°N vent areas. Similarly, another type of recruitment experiment, "SMAC", was deployed for D. Desbruyères (IFREMER) at 9°50'N during a November 1995 Alvin cruise conducted by R. Lutz (Rutgers Univ.), recovered during HOT '96 and supplemented by 3 additional short-term similar experiments during the cruise.

R. Lutz used a Nautile dive to describe the ecological state of most of the vent fauna aggregations situated along the 1.3-km long stretch of the axial summit caldera known as "Biotransect" (9°49.6'-9°50.3'N), a region which has been intensively studied since 1992 in an attempt to investigate temporal changes in both vent conditions and community structures. Two separate 3-chip video cameras (recording on SVHS and Beta SP PAL formats), combined with a lighting system customized by the Nautile group, were used to provide excellent video coverage of the Biotransect, at altitudes varying from 4 to 6 m, which will be compared to a similar coverage obtained in November 1995. Observations made during the course of the transect run suggest that the amount of iron oxides may have substantially increased since November 1995 in the vicinity of a site recognized as "Bio-9" inside the "Hole-to-Hell" region, associated with a steadily increasing mortality of vestimentiferan tube worms at this site.

Studies on the *R/V Wecoma*

J. Childress and his group (Univ. of California, Santa Barbara) were on board the *R/V Wecoma*. They had an array of pressure aquarium systems capable of simulating *in situ* vent conditions for the maintenance of, and experiments on, living vent animals. Their studies focused on estimating processes and rates of important metabolite uptake by *Riftia*. Measurements, under a high pressure respirometer system, demonstrated rapid rates of net inorganic carbon uptake by *Riftia* and *Tevnia* and the effects of temperature, oxygen concentration, sulfide concentration, pH, and PCO_2 on these rates. Experiments were also conducted using pressure aquaria to determine the relationships between external conditions and internal pools of metabolites using inhibitors to elucidate the uptake processes involved. Collaborative studies were carried out with French scientists on: tube accretion in *Riftia* by F. Gaill and B. Shillito; crab population biology by D. Desbruyères; and *Riftia* physiology by A. Toulmond and F. Lallier.

H. Felbeck's group concentrated on molecular and metabolic studies of vent fauna using their pressure aquarium systems, *in situ* experiments and on board laboratory experiments. Excretion of succinate by endosymbionts was investigated and new studies on the immunological reactions between symbionts and hosts were initiated. The recently discovered potential for nitrate respiration and nitrate concentration mechanisms by *Riftia pachyptila* was further investigated. *In vitro* egg fertilizations were also performed to study larval development in *Riftia* both on board (pressure chambers) and on the seabed (*in situ* experiments). Collaborative efforts overseen by the German researcher C. Arndt were focused on the elucidation of a switch in metabolic pathways towards anaerobic metabolism in vent organisms. Initial results indicate that *Riftia pachyptila* can survive extended periods of anoxia and can overcome these conditions by producing extremely high concentrations of succinate in all its body tissues. In addition, a collaborative work has started on carboxylating enzymes with the French researcher A.-M. Alayse (IFREMER).

A. Toulmond and F. Lallier (Univ. of Paris VI and CNRS at Roscoff, France) were on board the *R/V Wecoma*, collecting blood from various vestimentiferan and annelid species for further studies on the physiological properties, molecular structure and phylogeny of the giant extracellular hemoglobins. *Riftia* tissues were also sampled and fixed in various conditions for immunological studies on the so-called "band 3 proteins", constituents of the chloride-bicarbonate transport system in the vertebrate red blood cell. Previous observations have shown that these proteins were present in various parts of *Riftia*'s body. Experiments were done on board, using a Ussing chamber, to tentatively measure bicarbonate fluxes through the body wall. These studies are part of a collaboration between J. Childress's and A. Toulmond-F. Lallier's teams. Another member of the group, S. Hourdez, was on the *N/O Nadir* to sample blood and tissue from Alvinellids and Branchipolynoids worms in order to continue ongoing work on their elaborate coelomic-vascular oxygen transfer systems.

G. Hervé (CNRS and Univ. of Paris 6) also invited on board the *R/V Wecoma*, pursued his group's studies on the localisation and properties of enzymes of the pyrimidine nucleotides pathway in *Riftia* and its related symbionts. Previous studies on samples collected by F. Gaill had shown that aspartate transcarbamylase (ATCase) was only found in the trophosome. Preparations of symbionts and vestimentiferan gonads were made during the cruise in order to precisely locate the cellular origin of such a restricted activity. If this enzyme is indeed located inside the symbiont, its high specific activity would suggest that the symbiont is growing actively. Carbamylphosphate synthetase (CPSase), the enzyme which provides carbamylphosphate to ATCase, was not found in the trophosome but in the vestimentum and the plume and raises the problem of a carbamylphosphate source in the trophosome. This problem has been reinvestigated by tests of CPSase activity performed immediately after sample collection. Numerous samples were prepared for further enzyme assays of both the "*de novo* pathway" and the "salvage pathway". The lack of ATCase in *Riftia* itself suggests that CPSase is only operating in adult, non-growing individuals. To test this hypothesis samples of young *Riftia* (15 cm) were also prepared.

The future of French-American co-operation

The cruise was very successful for all members of the scientific party involved and was a model for international collaboration. A variety of very sensitive experiments were conducted and are still underway at these sites and utmost care needs to be taken by all the scientists involved to respect the ongoing work of others. In these days of dwindling resources, truly collaborative expeditions like this are an excellent way for the participating countries to get the most out of the limited funds available for submersible expeditions.

Since the April 1991 eruption, the region of the EPR crest between 9°49'N and 9°51'N has been extensively studied by French and American scientists from a wide variety of disciplines and considerable equipment and experiments are currently deployed on the bottom in this region. On-going geological and chemical studies are being conducted by D. Fornari and T. Gregg of Woods Hole Oceanographic Institution, R. Haymon of the University of California at Santa Barbara, K. Von Damm of the University of New Hampshire and M. Lilley of the University of Washington. On-going time-series imaging studies of temporal changes in biological community structure within the area of the Biotransect are being conducted by R. Lutz and T. Shank of Rutgers University. Numerous ecological experiments have been deployed on the bottom (or are being conducted periodically at certain sites) in the region as part of the ongoing studies of the following scientists: L. Mullineaux, C. Fisher, C. Peterson, F. Gaill, D. Desbruyères, C Cary of the University of Delaware, as well as others.

To date, all the above scientists have respected these long-term experiments and/or observations and it is requested that all individuals having an interest in working in this intensively studied region respect them. Questions concerning the nature or the location of these ongoing studies should therefore be addressed to some or all of the listed persons in order not to disturb or destroy these studies.

Report on ROPOS Submersible Operations on the *R/V Thomas G. Thompson* Cruise: 12-27 August 1996

K. Juniper[1], C. Fisher[2] and J. Delaney[3] (Co-chief scientists)

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Participating PIs: K. Juniper (UQAM), C.Fisher (PSU), V. Tunnicliffe (UVic), I. MacDonald (TAMU), J. Voight (Chicago Field Museum), J. Delaney (UW)

Other Participating Institutions: Freiberg University (Germany), University of British Columbia (Canada), University of Toronto (Canada), The Discovery Channel (Canada).

The REVEL-ROPOS Cruise on the *R/V Thomas G. Thompson* was tremendously successful from both operational and scientific points of view. A novel feature of the cruise was a combined research and instructional mission where 9 high school/ college teachers from Washington State (8) and British Columbia (1) participated in scientific activities and attended a series of on-board lectures by members of the scientific party.

The *R/V Thomas G. Thompson* proved to be a very stable platform for ROPOS deployment and no diving was postponed as a result of sea conditions, despite typical northeast Pacific summer weather. The new navigational hardware performed extremely well and the vehicle and cage were navigated with an accuracy of 1-6 meters, depending on local topography. A total of 18 dives were conducted at depths of 2200-2250 m during 12 days on site at Endeavour and CoAxial Segments of the Juan de Fuca Ridge. This translates into 4.7 hours of bottom time per dive or 7.1 hours bottom time per day on site. Transit to and from the seafloor, pre-dive and post-dive checks, and maintenance and change-over of ROPOS sampling tools and scientist-supplied equipment consumed the remaining time.

Dives varied in length from 1.5 to 13.5 hours on bottom, depending on mission requirements. When successive dives required no equipment changes, turn-around between dives was as little as two hours. An average daily time budget, based on 1.5 dives per 24 hour day, is given in the table below:

Activity	Time allocation (hours)
1. Pre-/post-dive checks	2
2. Launch/recovery, Ascent/descent	5
3. Bottom time	7
4. Equipment changeovers	6
5. Routine maintenance	4

ROPOS Operational Highlights

1) Deployment/recovery of a time lapse video system. The 430 lb (in air) camera and attached array of recording thermistors were deployed on a flange on the side of an active sulfide structure (Salut) for 4 days. After setting the camera at the back of the flange looking down, ROPOS detached the thermistor array and placed it on the flange surface in view of the camera. Recovery was accomplished by attaching a Benthos float that carried the package to the surface.

2) Deployment/recovery of a J-hook temperature/conductivity probe in a flange pool. This deployment followed the time lapse video deployment and was done at the same flange. The recovery dive first sent the camera to the surface, then released the J-hook by removing a pull pin.

3) Deployment of a 1 year time lapse still camera system. This camera was set up in front of an experimentally cleared dense cluster of tube worms, along with a 3-D scale and recording thermistor (HOBO). It will be recovered in 1997.

4) Tube worm staining. ROPOS placed a stainer dome over 14 groups of tube worms and held it in place for 4-6 minute staining operations in conjunction with tube worm growth experiments.

5) Thermistor array deployments. Three deployments of thermistor arrays, which consisted of 4 pairs of thermistors each, with each thermistor pair positioned to record temperature at gill and ground level among stained tube worms. One array was deployed and recovered after three days and then re-deployed along with a second array for recovery in 1997.

6) Recovery of sulfide samples. 7 sulfide samples were recovered, including active smoker chimneys, flanges and inactive sulfides.

7) Smoker fluid sampling. A high temperature fluid sample was collected during a dive on the Mothra hydrothermal field, using a titanium "major" sampler paired with a gas-tight sampler. During a second attempt to sample fluids at CoAxial Segment the sampler failed to trigger.

8) Biological Sampling. This year ROPOS clearly demonstrated the capability of ROVs to obtain high quality biological collections suitable for a variety of investigations. More than 20 biological samples were collected by manipulator "grabs" or by suction.

a) Using its large new, temperature-insulated collection box with hydraulic lid, even moderate sized tube worms were routinely transported to the surface in excellent physiological condition, and freshly collected animals were used on board for experiments requiring live material, or frozen for laboratory-based physiological analyses.

b) Using its "PAC-Man" grab sampler (an optional configuration), 4 discrete samples were taken for analy-

discrete samples were taken for analysis of biomass and community composition.
c) Using the ROPOS suction sampler with the carrousel array of 8 x 2 liter sampling jars, 6 discrete samples of small or fragile animals were collected. Several hundred pynogonids (sea spiders) were collected using this tool.
d) ROPOS pilots developed a technique for excising legs from large spider crabs for stable isotope analysis. Five crabs were chased down, then a hind leg was grasped with the function manipulator and humanely removed with a quick wrist rotation. The released crab then continued with the rest of its day.
9) Deployment of fish traps - 7 baited minnow traps were deployed during a single dive at the Clam Bed vent site and recovered on another dive 5 days later. One trap was lost during recovery.
10) A temperature probe was used on several dives for measurements in both diffuse and high temperature flows.

Scientific Highlights

The primary objective of the dive operations was continued support of time series biological observations at Endeavour Segment. Completion of all planned experimental deployments, sampling and imaging work during the course of the cruise made this the third and most successful year of the Biological Observatory
1) The S&M chimney complex was imaged on separate dives using lighting optimized first for the black and white SIT camera and then for the 3-CCD colour camera. Photographic coverage using both mono and stereo still cameras was also completed. This completes a fourth year of time series observations of the interaction of biological and geological changes on the chimney complex.
2) Four previously identified faunal communities on the S&M structure were sampled in the most quantitative way possible using the PAC-Man grab, and the sampled surface was measured using a pair of parallel lasers visible in the video cameras. These samples will be used to "ground truth" information derived from imaging studies of the succession of biological communities on sulfide structures.
3) Tube worms stained blue in 1995 were relocated and the new growth was stained red. This will enable growth to be followed over two successive years. Two additional aggregations of tube worms were chosen for initiation of growth studies and 4-5 clumps of worms were stained in each aggregation.
4) Recording thermistor arrays were deployed such that venting conditions in three different stained aggregations will be monitored over the next year.
5) Several community collections were made and subsampled for C and N stable isotope determination which will be used for analysis of food webs in those microhabitats. The 5 spider crab legs sampled *in situ* will be part of the same study.
6) The routine collection of living vestimentiferans in the new temperature-insulated bio-box provided material for a suite of onboard experiments with trophosome tissue. Scientists indicate that the viability of the tissue was the highest that they had seen in material from any submersible collection.
7) Baited traps proved to be a very efficient means of collecting the otherwise elusive pink vent fish. The 116 hour deployment of 7 cat food-baited minnow traps yielded over 20 individuals of this small zoarcid species, 15 of which survived the recovery process. In addition to the fishes, many large amphipods, probably *Pardalisca endeavouri* - previously known only from a single specimen - were recovered in the traps along with smaller amphipods and pynogonids.
8) Discovery of the Mothra vent field. This new vent field, located slightly more than 2 km south of the Main Endeavour vent field was first detected with CTD work and then located, mapped and sampled by ROPOS during a single dive.
9) Fall of Godzilla. The 45-50 m high sulfide structure first observed in 1991 in the High Rise vent field at Endeavour Segment was found to have toppled over. Sulfide and tube worm debris at the base suggested a recent collapse. A 20 meter high "stump" was sprouting several anhydrite spires.
10) Extinction of Coaxial venting. A visit to the Huge Diffuse Vent site at Coaxial Segment revealed a dying tube worm colony with very little detectable venting. This appears to complete a cycle initiated by a dyke injection event in June 1993 that produced venting. Faunal colonization of new vents was first observed in 1994.
11) HTML text/image dive log. A system was developed for real-time logging during dives in World Wide Web-compatible hypertext format (html). Observations were linked, where appropriate, to frames of video captured from the live feed from the bottom and to post-dive notes drafted by the PIs regarding the division and disposition of sampling. By the end of the cruise, we has amassed over 80 megabytes of fully web-compatible text and imagery. While at sea, selected sections of these web pages were uploaded via satellite to the U. Washington WWW site. The full set of dive logs was recorded on CD-ROM and provided to the PIs before they left the vessel. The complete cruise log, minus the dive logs, can be viewed at the following URL:

http://www.ocean.washington.edu/exploraquarium/revel/

An example of one complete html dive log from the cruise is on-line at a second URL:

http://gergu3.tamu.edu/irm/ropos96/hys354.htm

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4-D Architecture of the Oceanic Lithosphere

On- and Off-axis Submersible Investigations on an Highly Magmatic Segment of the Mid-Atlantic Ridge (21°40'N): the TAMMAR Cruise

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The TAMMAR cruise (May 1996) of *R/V Nadir* and submersible Nautile explored a 75 km long highly magmatic ridge segment located on the Mid-Atlantic Ridge (MAR), south of the MARK area, between 21°25'N and 22°N (Fig 1). This area had already been mapped by a multi-beam bathymetric system (SIMRAD EM 12) during the 1991 FARA-SEADMA I cruise of *R/V L'Atalante* (Gente et al., 1991, 1995). Twenty one Nautile dives were made and 227 samples collected during the TAMMAR cruise. Nineteen dives were devoted to the study of the segment located between 21°25'N and 22°N, hereafter named the TAMMAR segment (Fig. 2). These dives have provided three cross-sections of the inner floor and of the walls of the axial valley at 21°45'N, 21°40'N and 21°30'N, located respectively at the center, halfway between the center and the tip, and at the southern tip of the segment. Each cross-section reaches 1 Ma crust. The 21°40'N cross-section has been extended off-axis on abyssal hills to magnetic anomaly 2. Four dives were run parallel to the axis on the inner floor of the axial valley.

One dive (Dive 01) explored the summit of the "Puy des Folles" mound located at 20°30'N (Fig. 3), where hydrothermal sediments had been cored during the GEOFAR cruise (G.A. Auffret, unpublished data). Three large inactive hydrothermal vents were observed during this dive. The last dive (Dive 21) was devoted to the exploration of the southern wall of a high located at the northern boundary of the TAMMAR segment, at 22°18'N (Fig. 4), where peridotites had been dredged during the 1993 FARA-SEADMA II cruise of *R/V Le Noroît* (Cannat et al., 1995). This dive has shown a long section in peridotites and their contact with diabase.

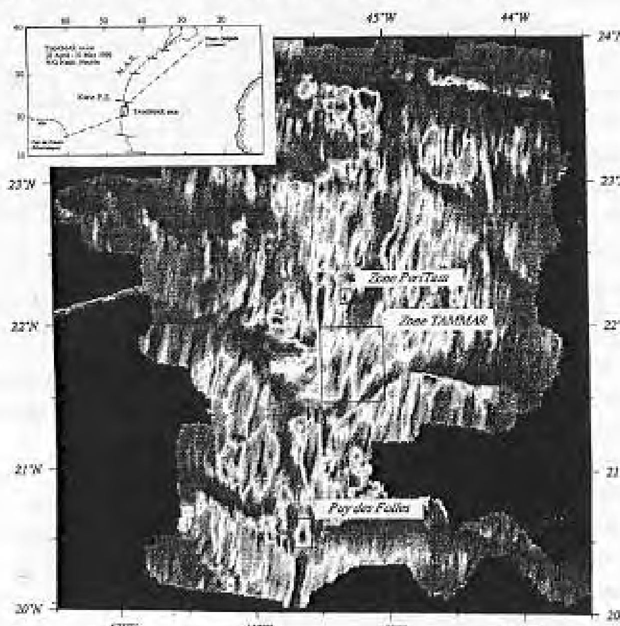

Figure 1 Location map of the working area during the TAMMAR cruise (*R/V Nadir*, submersible Nautile) in the North Atlantic Ocean. The TAMMAR segment is located on the Mid-Atlantic Ridge, south of the MARK area, between 21°25'N and 22°N. This area had been already mapped by a multi-beam bathymetric system (SIMRAD EM 12) during the 1991 FARA-SEADMA I cruise of *R/V L'Atalante* (Gente et al., 1991, 1995).

Geophysical experiments on

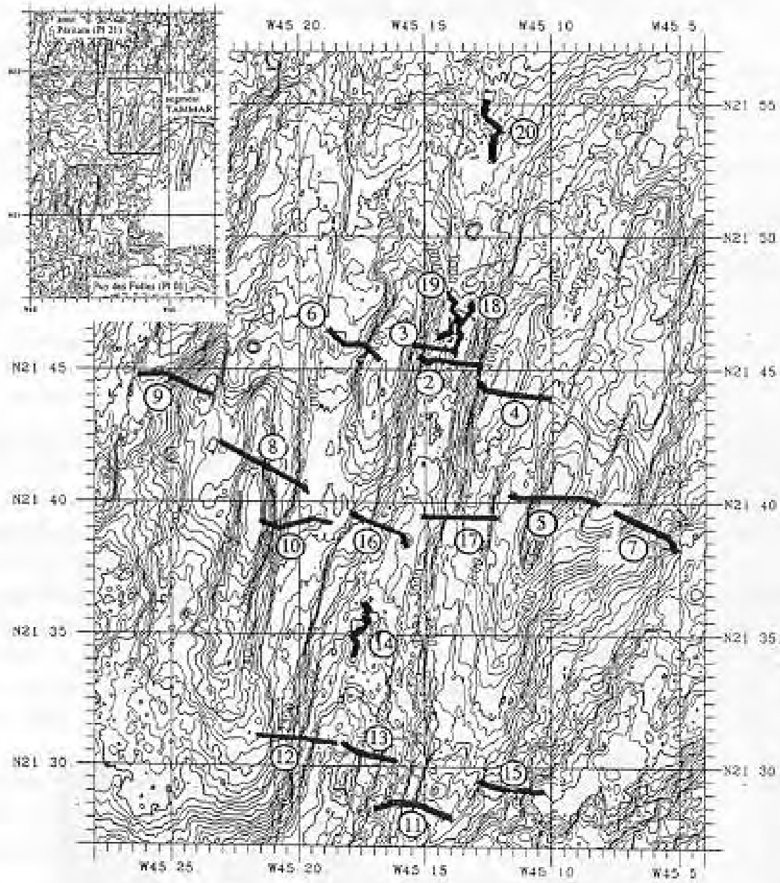

Figure 2 Bathymetric map of the TAMMAR segment and location of the dives.

the TAMMAR cruise included thirty one on-bottom gravity measurements made with a Worden gravimeter (Fig. 5); a continuous acquisition of the three components of the magnetic field along the submersible tracks, made possible by the successful installation on Nautile of the deep-tow three-components magnetometer developed by the Ocean Research Institute of the University of Tokyo; and a detailed sea-surface magnetic survey carried out during the night for a total of 2130 km of parallel, closely spaced magnetic profiles.

The 75-km-long TAMMAR segment is bounded to the north by a zero-offset second order discontinuity, marked by oblique structures on the ridge flanks (Fig. 1). These oblique structures correspond to several prominent, aligned ridge-parallel bathymetric lows and highs, with relief of 600-1000 m, located symmetrically about the ridge axis (Gente et al., 1994, 1995). Peridotites have been dredged on these structures (Cannat et al., 1995). Changes in directions of the discontinuity traces show that the segment boundary has alternatively migrated to the north and to the south during the last 5 Ma.

The southern segment boundary corresponds to a 40 km long offset, associated with a small and recently developed transform fault. This transform fault is bounded by V-shaped structures which reflect the southern propagation of the TAMMAR segment during the last 3 Ma. The V-shaped structures connect the recent transform domain to a fossil fracture zone which displays a similar offset. The offset has remained constant during the southern propagation of the segment (Gente et al., 1994, 1995).

The TAMMAR segment is characterized by a large bulge, 50 km in diameter. This topographic feature correlates with a -40 mgals mantle Bouguer anomaly, one of the largest observed along the MAR (Maia and Gente, in press). At the ridge axis, this bulge is cut by a small graben, 5 km wide and 500 m deep. Abyssal hills on both side of this graben are 4-5 km wide, 20 km long and 200 to 900 m high. They present a typical asymmetric shape, with a smooth outward-facing slope and a steep inward-facing slope. The shallowest point of the segment occurs at 1860 m depth.

In a detailed study of the bathymetry, Durand et al. (1995) suggest variations in the volcanic and tectonic expression along the segment: volcanism and tectonism are focused at the center and sparse at the tip of the segment.

The objectives of the TAMMAR cruise were to study the variations in style, surface expression and amplitude of the tectonic and volcanic activities between the center and the tip of the segment, the extent and the timing of these activities along the segment and on the ridge flanks, the symmetry of the structures located on the ridge flanks, the relationships between magmatism, faulting, alteration and magnetic anomaly; to constrain thickness variations of the basaltic layer by using gravity and magnetic measurements on abyssal hills; to determine petrological and geochemical variations of the lavas between the center and the tip of the segment, and at different stages of the segment propagation (Fig. 6).

Preliminary results of the TAMMAR cruise

Center of the segment

At 21°47'N, the shallowest on-axis area of the TAMMAR segment, the inner floor of the axial valley is 2 km wide and about 3000 m deep and the walls of the rift valley are 600 m high. The walls correspond to the inward-facing

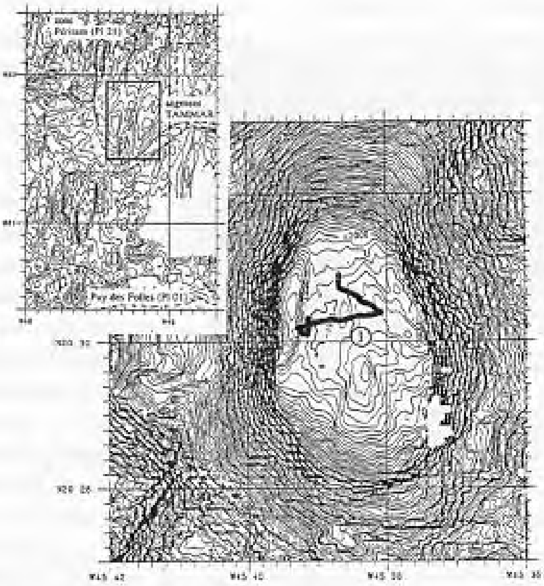

Figure 3 Bathymetric map of the "Puy des Folles" mound and the location of Dive 01 at its summit.

slopes of 20 km long, 5 km wide asymmetrical highs trending N010°E-N015°E. The size and characteristics of these highs are similar to those of the abyssal hills along the MAR, although they are shallower and located close to the axis. Six dives have been accomplished in this area. Four were designed to study the inner floor and the walls of the rift valley, and two to explored the outward-facing slopes of the adjacent highs.

Two types of volcanism have been identified on the inner floor. Isolated volcanoes 500 m to 1000 m in diameter, which can be coalescent, consist mainly of pillow lavas and lava tubes on the steeper slopes. The summit of these volcanoes is often cut by a series of NS to N015°E fissures. Flat areas of the inner floor are covered by lobate lavas or lava lakes with pillars. These lava lakes, never deeper than 6-7 m, are shallower than those which have been observed on the East Pacific Rise. The flat areas represent a larger part of the inner floor surface than the isolated volcanoes, in contradiction to the suggestion of Smith and Cann (1992) regarding the volcanic construction of the MAR. The thickness of sediments and the contact between fluid lavas in the flat areas and pillow lavas on the volcanoes show that the volcanoes were emplaced before the more fluid lavas. The fresh fluid lavas are divided into three parallel zones, 500 m wide, separated by small ridges made of older pillow lavas. If these zones are not simultaneously active, the width of the neovolcanic zone would therefore be about 500 m; however, it is likely that the neovolcanic zone moves about within a 2 km wide band on the inner floor. Many flat areas are also present on the inner floor of the axial valley north of this area. At 21°54'N, Dive 20 found numerous fresh lava lakes. In contrast, the southern part of the central area is mainly made of pillow lavas, observed during Dives 02 and 03 and on sea-bottom videos and photos acquired by the French deep tow Scampi during the FARA-SEADMA II cruise (C. Mével and M. Cannat, unpublished data). The volcanoes correspond to the more recent volcanic eruptions in this area. Around these volcanoes, the inner floor is highly tectonized in small horsts and grabens.

The walls of the axial valley display a series of lava flows (mainly pillow and massive lavas) cut by numerous sub-vertical small faults which separate small steps. The fault throws vary from a few meters to 250 m. The western wall seems more active than the eastern wall, as suggested by the presence of fresh unsedimented talus and fissures at the foot of the faults. So, although the morphology of the axial valley is symmetrical at this location, the tectonic activity appears not to be synchronous on both walls.

The outward-facing slopes of the highs bounding the axial valley consist mainly of pillow lava flows

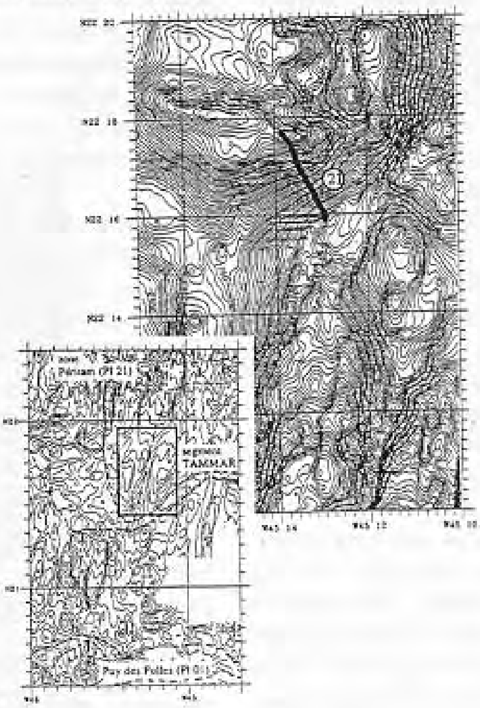

Figure 4 Bathymetric map of the Peritam zone mound located in the northern discontinuity of the TAMMAR segment, and the location of Dive 21.

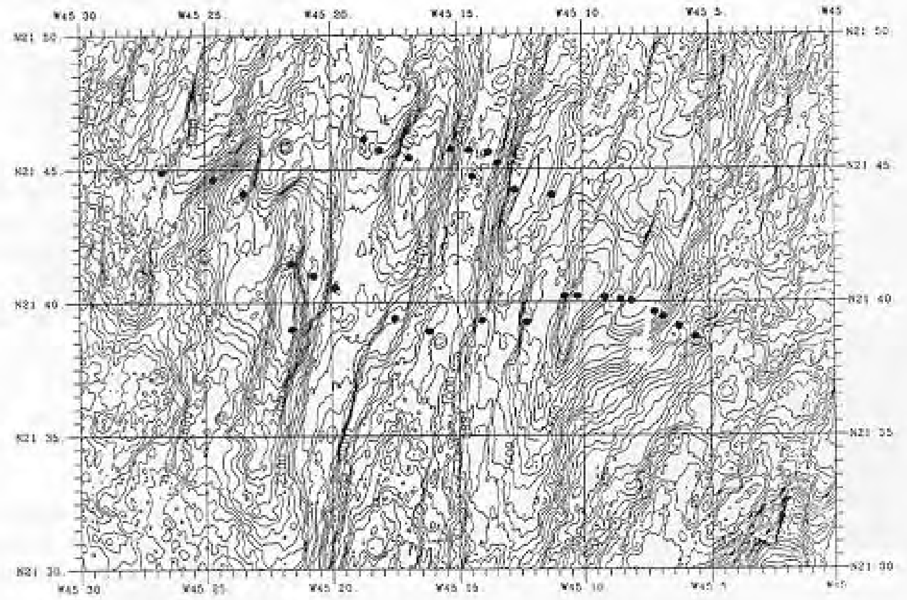

Figure 5 Location of the thirty one on-bottom gravity measurements made with a Worden gravimeter during the TAMMAR cruise in the TAMMAR segment.

(Dives 04 and 06). Accumulation of fresh debris on sedimentary surfaces, related to small normal faults and debris slides, suggests moderate recent tectonic activity on the western slope of the western high (Dive 06). Flat areas are completely sedimented with the occasional outcropping top of a pillow mound.

Off-axis area

Similar characteristics are observed in off-axis relief: inward-facing slopes correspond to a series of steps limited by subvertical normal faults, and outward-facing slopes consist mainly of pillow lava flows (Dives 04, 05, 07, 08, 09, 10). These features are totally inactive beyond 10 km off the axis on the western flank and 5 km on the eastern flank. These observations suggest that the formation of abyssal hills takes place within 10 km of the ridge axis, following a two stage process: 1) an important magmatic event generates a dome structure, which is presently observed on the outward-facing slopes, and 2) a tectonic event cuts across this dome and creates the normal faults observed on the inward-facing slopes. The result is half-dome structures which are later moved away to the ridge flanks. The pillow lava dome, which is cut by an axial graben, is similar to the Lucky Strike dome located on the MAR axis at 37°20'N. During formation of the axial graben, the inner floor is highly tectonized and some fluid lava may be extruded, as it is observed in the present axial valley.

The southern tip of the segment

In the southern part of the segment, the inner floor of the axial valley is 4-5 km wide and 3500 m deep on average. The eastern wall of the axial valley is made of six steps, 600 to 1100 m wide and 150 to 250 m high, giving a total relief of 800 m. The western wall presents a more continuous slope for a total relief of 1000 m.

Three dives have provided a complete cross-section of the axial valley at 21°30'N. Two isolated volcanoes on the inner floor, 1600 m in diameter, have been explored. They consist only of pillow lava flows, and do not exhibit evidence of recent volcanic activity. The freshest basalts are in the deepest part of the inner floor, located between these two volcanoes (Dive 13). The volcanic activity seems less recent in this area than it does at the center of the segment. This outward-facing slope is mainly constituted of pillow flows. It presents numerous small inward-facing normal faults and some outward-facing normal faults and debris slides, presently inactive.

The transition zone

This zone is located halfway between the center and the southern tip of the segment. In this area, the

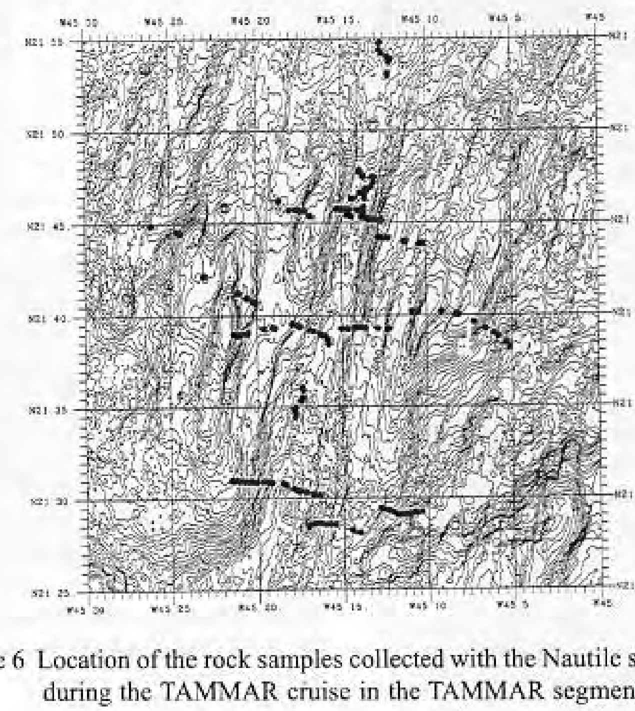

Figure 6 Location of the rock samples collected with the Nautile submersible during the TAMMAR cruise in the TAMMAR segment.

crests of the axial valley reach the shallowest depths of the TAMMAR segment, 1900 m on the eastern flank and 1700 m on the western flank. The width of the inner floor increases from north to south. The walls of the axial valley are made of a series of steps, some kilometers wide and as high as 600 m. This area corresponds to a relay zone between the focused tectonic structures of the segment center and the sparse tectonic structures at the tip of the segment.

Five dives were devoted to the domain located at 21°40'N. The freshest lava is located at the deepest part of the inner floor, as in the other parts of the segment. Tectonic activity continues to a distance of at least 10 km off-axis to the west and 5 km to the east. This activity is observed everywhere in the inner floor but is limited to the major scarps outside. The terraces between these scarps are sedimented and completely inactive, except in a few places where recent fissures are observed.

Conclusions

The TAMMAR cruise has demonstrated the existence of important variations in style, surface expression and amplitude of the tectonic and volcanic activities between the center and the tip of the segment, and has reinforced the model of magmato-tectonic cycles to construct the abyssal hills. At the center of the segment, the major tectonic activity is focused at two major scarps located at least 10 km away from the axis, the terraces being completely inactive outside the inner floor. No synchronism of the tectonic activity exists between the eastern and western walls, only the western wall presently being active. The volcanism is concentrated in a 2 km wide band on the inner floor and is mainly represented by fluid lava (lava lakes and lobate flows). At the tip of the segment, tectonism is active on many scarps on both walls, and the volcanism is represented only by isolated pillow lava volcanoes.

The inward-facing slopes of the abyssal hills are made of a series of steps bounded by sub-vertical normal faults. The outward-facing slopes are mainly pillow lava volcanic constructions without major tectonic features. Each abyssal hill corresponds to a half-dome structure and results from a major 100,000-300,000 year long magmatic event followed by a tectonic period. During the formation of the axial graben, a small uplift of the hills may have taken place.

Acknowledgements

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References

Cannat, M., C. Mével, M. Maia, C. Deplus, C. Durand, P. Gente, P. Agrinier, A. Belarouchi, G. Dubuisson, E. Humler and J. Reynolds, Thin crust, ultramafic exposures, and rugged faulting patterns at Mid-Atlantic Ridge (22°N - 24°N), Geology, 23, 49-52, 1995.

Durand, C., P. Gente and O. Dauteuil, Caractéristiques mosphologiques des segments axiaux le long de la dorsale Médio-Atlantique, Comptes rendus de l'Académie des Sciences de Paris, 320411-320418, 1995.

Gente, P. and 13 others, Geometry of the past and present-day segmentation of the Mid-Atlantic Ridge south of Kane Fracture Zone (prelimary results of SEADMA I cruise), EOS Trans., AGU, 72, 477, 1991.

Gente, P. and 13 others, Structures obliques sur les flancs de la Dorsale Médio-Atlantique: traces fossiles de la propagation le long de l'axe de segments d'accrétion, Compte Rendu de l'Academie des Sciences de Paris, 318, 1239-1246, 1994.

Gente, P., R.A. Pockalny, C. Durand, C. Deplus, M. Maia, G. Ceuleneer, C. Mével, M. Cannat and C. Laverne, Characteristics and evolution of the segmentation of the Mid-Atlantic Ridge between 20°N and 24°N during the last 10 million years, Earth Planet. Sci. Lett., 129, 55-71, 1995.

Maia, M. and P. Gente, Three-dimensional gravity and bathymetry analysis of the Mid-Atlantic Ridge between 20° and 24°N: Flow geometry and temporal evolution of the segmentation, J. Geophys. Res., in press.

Smith, D.K. and J.R. Cann, The role of seamount volcanism in crustal construction at the Mid-Atlantic Ridge (24°-30°N), J. Geophys. Res., 97, 1645-1658, 1992.

International Co-Operative Research

Geophysical Investigation of Ridge-Hot Spot Interaction at the Galápagos Spreading Center

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Introduction

The Cocos-Nazca Spreading Center (also known as Galápagos Spreading Center or GSC) is located north of the Galápagos Archipelago and extends approximately E-W from the East Pacific Rise (EPR) to the South American Trench. The GSC is an intermediate spreading ridge, with full rates varying from ~45 mm/yr up to ~66 mm/yr from East to West (Wilson and Hey, 1995). Due to its proximity to the Galápagos hot spot (Morgan, 1973), this area is a unique natural laboratory in which to study hot spot-ridge interactions and the role of variations in magma supply and spreading rate on ridge morphology.

The along-axis peak in bathymetry occurs at the point on the ridge closest to the hot spot and coincides with a peak in rare-earth elements in ridge basalts, indicative of an enriched mantle source typical of hot spots (Verma and Schilling, 1982). This correlation between bathymetry and geochemistry has been interpreted as the feeding of the Galápagos plume into the ridge axis and lateral spreading of the plume material along the ridge axis (Morgan, 1978; Schilling et al., 1982; Verma et al., 1983; Schilling, 1985). This model for the Galápagos system has become the conceptual paradigm for plume-ridge systems and predicts significant variations in magma supply, crustal thickness, basalt geochemistry and mantle density structure along the spreading center away from the hot spot. A recent study by Ito and Lin (1995) shows that the gravity anomaly along the spreading center results from a relatively broad thermal anomaly extending more than 600 km from the Galápagos hot spot, comparable in wavelength to the observed geochemical anomaly. This mantle thermal anomaly leads to excess melting which results in excess magma production.

Spreading rate and magma supply have been widely recognized as two variables that strongly affect the nature of crustal accretion processes at oceanic spreading centers. The shape of the axial topography (rift valley or axial high) depends critically on the strength of the axial lithosphere (Chen and Morgan, 1990), which is controlled by both temperature and composition. At slow spreading rates, the morphology of the ridge axis is a rift valley, while at fast spreading rates, the ridge exhibits an axial high. At intermediate spreading rates, the thermal structure of the ridge axis is more sensitive to small changes in magma supply. Recent models of ridge-axis morphology (e.g. Phipps Morgan and Chen, 1993a and b) hypothesise that, at a fixed spreading rate, the ridge axis thermal structure is controlled by the balance between magma supply and hydrothermal cooling. An increased magma supply at a given spreading rate will produce a thicker and hotter crust and weaker axial lithosphere, resulting in an axial high topography. The thermal structure of the GSC, as an intermediate spreading ridge, is expected to be sensitive to changes in magma supply due to the interaction of the ridge with the Galápagos hot spot.

The main objective of this study is to examine the morphological expression of the Cocos-Nazca spreading center using recent multibeam bathymetry, gravity and magnetics measurements acquired during the GALAPAGOS'96 experiment (Dañobeitia et al., 1996). These data will allow us to test models of hot spot-ridge interactions and to quantify the effect of variations in magma supply on axial morphology and crustal accretion processes at intermediate spreading rates. In particular, we wish to determine how axial morphology varies along the ridge axis with increasing distance from the Galápagos hot spot, as well as constrain the magnitude of the crustal thickness variations associated with the Galápagos swell and the changes in axial morphology observed along the GSC. Our investigation is mainly centered along a 1000 km long section of the GSC lying between the 95.5°W propagator and 85°W Fracture Zone.

The experiment

During spring 1996, the Spanish oceanographic vessel *B/O Hespérides* collected more than 2400 km of multibeam bathymetry, backscatter, gravity and magnetics data along the axis of the GSC from 85°W to 97°W (Figure 1). The lack of reliable bathymetry data in part of the study area led us to use satellite gravity data in order to determine the precise location and trend of the GSC. These data proved to be quite reli-

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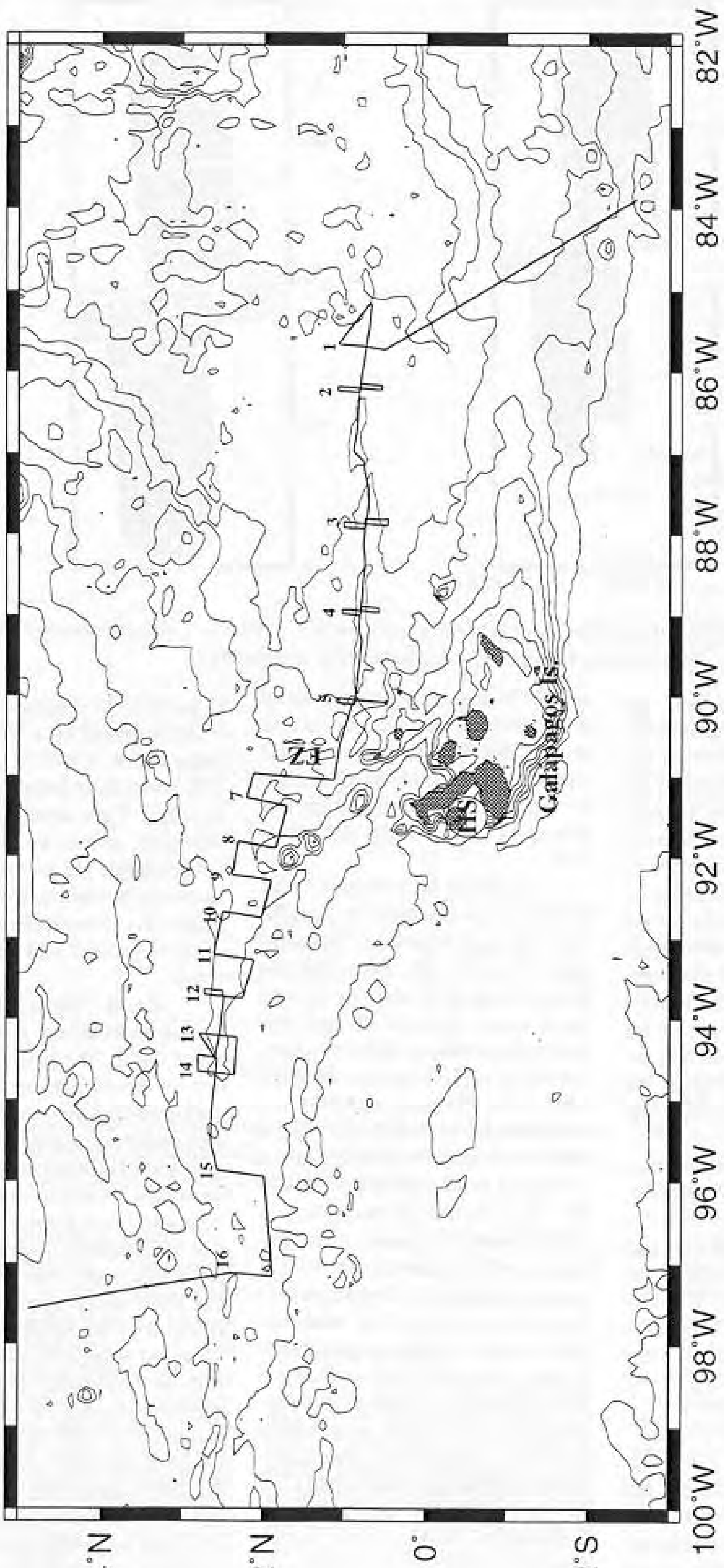

Figure 1. Bathymetry map of the surveyed area. Thin solid lines are contours every 500 m. Bold solid line is the ship track. Numbers indicate the across-axis profiles. HS denotes the present location of the Galápagos hot spot and FZ denotes the 91° W Fracture Zone.

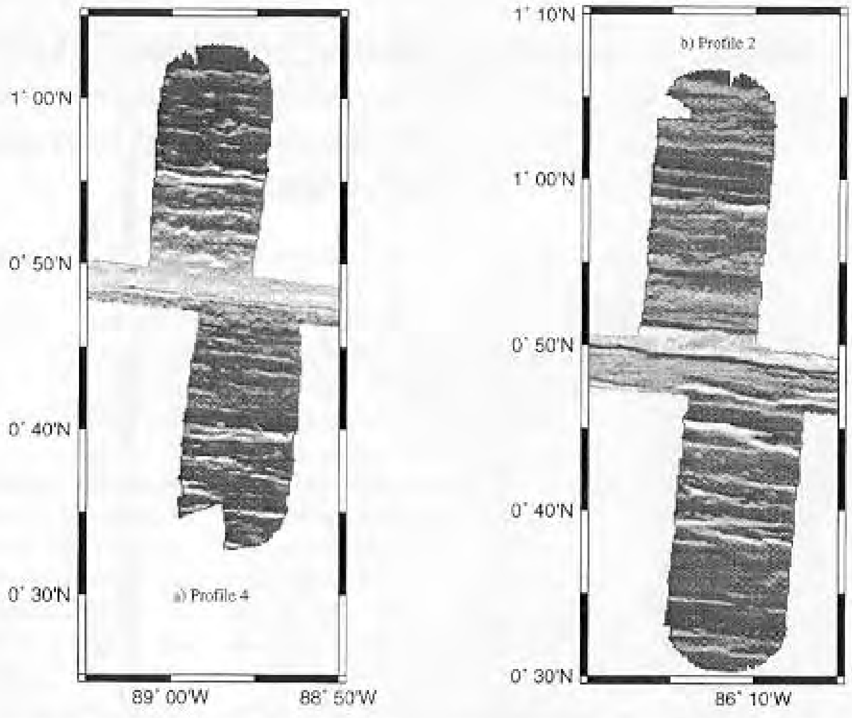

Figure 2. Shaded relief of two selected box surveys of the eastern section. a) Profile 4, which shows an EPR-like axial high. b) Profile 2, showing an example of transitional axial morphology.

able in locating the ridge axis. In addition to the along-axis profile, we performed a few box surveys orthogonal to the mean trend of the ridge at the eastern section, in order to obtain cross-sections of the axial morphology and gravity measurements so as to properly define the location and azimuth variation of the ridge (Figure 2a and b). We adopted a slightly different survey plan west of the 91°W FZ due to multibeam malfunction halfway through the leg (see Figure 1). In spite of this, we were able to map the westernmost 250 km of this section of the ridge into the 95.5°W propagator.

Gravity and magnetics data were collected along all the profiles. The magnetics together with the multibeam backscatter data were particularly useful in determining the location of the ridge axis. The distinct backscatter images from fresh young flows to old sediment flows provide accurate mapping of the neovolcanic zone.

First results

The results from the GALAPAGOS'96 survey document systematic changes in axial morphology along the intermediate spreading (48-66 mm/yr) GSC between 85°W and 97°W, that are primarily related to variations in crustal thickness and/or axial thermal structure associated with the presence of the Galápagos hot spot (rather than changes in spreading rate or ridge segmentation).

Between 88.5°W and 93°W, the GSC is associated with an EPR-like axial high (Figure 2a). The axial high is typically 400-500 m high and 20 km broad at its base. At increasing distance from the hot spot this axial high develops a distinctive summit rift up to 30-50 m deep and about 1 km wide. The axial high broadens and deepens, eventually forming a transitional axial morphology that is neither an axial high nor a rift valley. This transitional morphology is quite variable along-axis. It is typically a wide region, up to 6-7 km across, consisting of short, linear ridges bounding flat, low relief terrain or a broad, fault-bounded graben elevated above the surrounding sea floor (Figure 2b). Small axial volcanoes up to 200 m high occur within this zone. West of 94°W, this transitional morphology evolves into a 2-3 km wide, 200-400 m deep valley bounded by flanking highs which gradually deepens and broadens toward the 95.5°W propagator. West of the 95.5° W propagator, the GSC is characterized by a MAR-like rift valley that is 250-1000 m deep and 7-10 km wide at the base of the valley walls. Thus, along this one plate boundary, and at nearly constant spreading rate (15 mm/yr maximum variation), we see the entire range of ridge axis morphology observed along the global Mid-Ocean Ridge system.

Figure 3 displays the changes in axial morphology along the surveyed GSC. The simplest explanation for these changes in axial morphology is that they are related to an increased magma supply as the thermal anomaly associated with the Galápagos hot spot is entrained by the ridge and flows along the spreading axis for distances of several hundred kilometres away from the hot spot. The observations described are consistent with the hypothesis that the increased magma supply associated with the Galápagos hot spot is primarily responsible for the systematic variations in axial morphology observed along more than 1000 km of the GSC. Gravity data collected during the survey will be used to constrain the magnitude of the changes in crustal thickness with increasing distance from the hot spot, and the

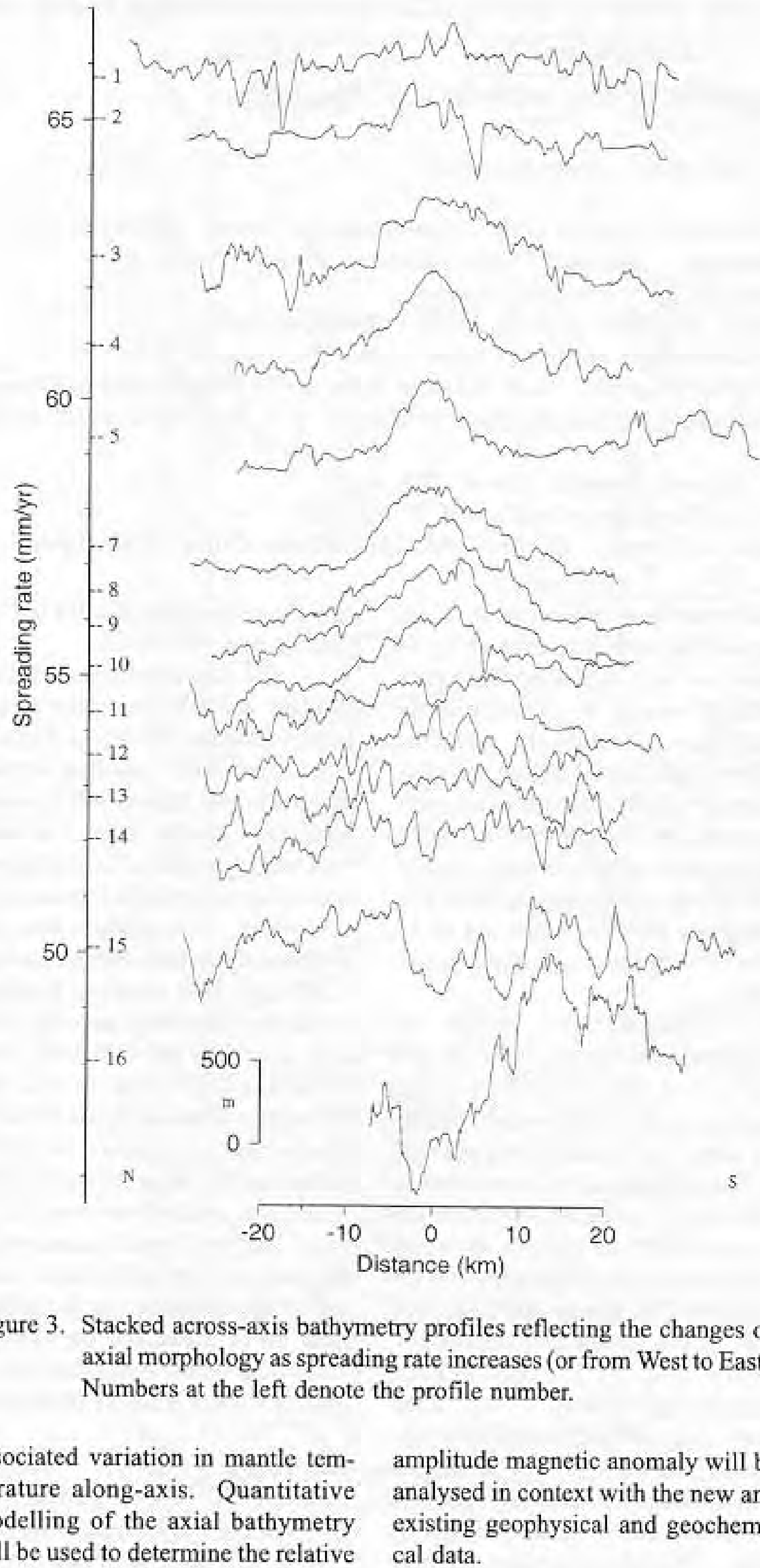

Figure 3. Stacked across-axis bathymetry profiles reflecting the changes on axial morphology as spreading rate increases (or from West to East). Numbers at the left denote the profile number.

associated variation in mantle temperature along-axis. Quantitative modelling of the axial bathymetry will be used to determine the relative importance of factors such as crustal thickness and axial thermal structure in controlling axial morphology. Processing and interpretation of the magnetics and backscatter data will be used to constrain emplacement processes within each of these morphological regimes for comparison with well-studied areas on fast- and slow-spreading ridges. In addition, along-axis variation of the axial high amplitude magnetic anomaly will be analysed in context with the new and existing geophysical and geochemical data.

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References

Chen, Y. and W. J. Morgan, Rift valley/no rift valley transition at mid-ocean ridges, J. Geophys. Res., 95, 17571-17581, 1990.

Dañobeitia et al., The GALAPAGOS-96 Cruise Report, 60 pp., 1996.

Ito, G. and J. Lin, Mantle temperature anomalies along the present and paleoaxes of the Galápagos spreading center as inferred from gravity analyses, J. Geophys. Res., 100, 3733-3745, 1995.

Morgan, W.J., Plate motions and deep mantle convection, Geol. Soc. Am. Bull., 132, 7-22, 1973.

Morgan, W.J., Rodríguez, Darwin, Amsterdam,... A second type of hotspot island, J. Geophys. Res., 83, 5355-5360, 1978.

Phipps Morgan, J. and Y.J. Chen, The genesis of oceanic crustal magma injection, hydrothermal circulation, and crustal flow, J. Geophys. Res., 98, 6283-6298, 1993a.

Phipps Morgan, J. and Y.J. Chen, Dependence of ridge-axis morphology on magma supply and spreading rate, Nature, 364, 706-708, 1993b.

Schilling, J.-G., Mantle heterogeneities and dynamics, Nature, 314, 62-67, 1985.

Schilling, J.-G., R.H. Kingsley and J.D. Devine, Galápagos hot spot-spreading center system, 1, Spatial petrological and geochemical variations (85°W-101°W), J. Geophys. Res., 87, 5593-5610, 1982.

Verma, S.P. and J.-G. Schilling, Galápagos hot spot-spreading center system, 2, $^{87}Sr/^{86}Sr$ and large ion lithophile element variations (85°W-101°W), J. Geophys. Res., 87, 10838-10856, 1982.

Verma, S.P., J.-G. Schilling and D.G. Waggoner, Neodymium isotopic evidence for Galápagos hotspot-spreading center evolution, Nature, 306, 654-657, 1983.

Wilson, D.S. and R. Hey, History of rift propagation and magnetization intensity for the Cocos-Nazca spreading center, J. Geophys. Res., 100, 10041-10056, 1995.

A geophysical and geochemical study of the Pacific-Antarctic Ridge south of Udintsev FZ: The Pacantarctic cruise with *R/V L'Atalante*

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The Pacantarctic cruise took place aboard the *R/V l'Atalante* between 6 January and 20 February 1996. This cruise was dedicated to the geochemical and geophysical study of the Pacific-Antarctic Ridge (PAR), north of 65°35'S, 170°W and south of Udintsev Fracture Zone. Except for the swath bathymetry data collected with *R/V Maurice Ewing* in 1992 along a 60 km wide corridor centered on Pitman FZ (Cande et al, 1992; Cande et al, 1995), no multibeam data were available from this remote ridge segment. During the return transit, we spent about 60 hours on the reconnaissance and study of the Hollister Ridge, an oblique structure located on the western flank of the PAR, between Udintsev FZ and the Eltanin fault system (Natland et al., 1995). The weather conditions allowed us to work without interruption during the 21 days that we spent in the study area. In total, we covered a 960 mile section of the ridge axis and successful collected 26 rock samples.

The PAR south of Udintsev FZ can be divided into three domains of different morphological signatures: the southern area, between 65°30'S, 174°40'W and 64°40'S, 172°W, has an axial valley-type morphology; the northern area, to the north-east of 63°10'S, 157°20'W, has an axial dome-type morphology. In between, there is a transitional area of unstable morphology. The morphological transition from rift valley to axial dome is progressive over a 800 kilometer long ridge section, as the spreading rate increases from 54 mm/y in the south-west of the transitional area up to 64 mm/y in the north-east. Besides the spreading rate, which acts as a first order parameter governing the axial morphology, other parameters appear to shape the axial relief locally. Analysis of our geochemical data will hopefully provide indications of the role of variations in mantle temperature.

Near 63°30'S, 167°W, we mapped a propagating rift, which was initiated at about Anomaly 2A, that appears clearly on the satellite gravity map. The present dying segment of the propagating rift system has an axial valley, while the propagator has an axial high. In addition, the negative bathymetric gradient towards the tip of the "V" appears to be less than that at the Galápagos propagator. North of 62°S, 155°W, the axial morphology is more robust. Magnetic data and bathymetric data collected near 62°30'S, 154°W suggest that the ridge axis probably migrated westward shortly after anomaly 3A time. This ridge migration and linkage process helps explain the fact that the traces of old fracture zones visible on the satellite gravity map appear to be interrupted after about this time (Sahabi et al., 1996). It also suggests that the morphological reorganisation along the axis of the PAR during the last few Ma may have consisted of a series of ridge migrations and linkages alternating with phases of ridge propagation like the one we observe near 167°W.

Our data also indicate that the Hollister Ridge is not a chain of well defined, circular volcanoes. Instead, it is a quasi-linear structure, extending over 240 miles, 3000 meters high, and 13 miles wide at its base. This edifice seems to have a flat top that widens progressively towards the north-west. Five dredges from the Hollister Ridge were carried out over a 200 mile long distance, from the south-east extremity near the PAR axis, up to 52°33'S, 142°30'W. Near 53°40'S, 140°39.30'W, in less than 165 meters water depth, we collected phenocrists and calcareous shells, indicating that the top of the Hollister Ridge was probably subareal in the past. The Nb/Zr ratios measured on the samples from the Hollister Ridge are clearly different, on the whole, than those measured on samples from the PAR south of Udintsev FZ. Further work is presently in progress.

References

Cande, S.C., C.A. Raymond, W.F. Haxby, W.B.F. Ryan, S. Tebbens, S. O'Hara, D. Mueller, D. O'Brien and M. Wilkinson, Preliminary results of a hydrosweep swath bathymetry, magnetics and gravity survey of a Pacific-Antarctic ridge F.Z. I. Plate kinematics, EOS Trans. AGU, 73 (16), 295-296, 1992.

Cande, S. C., C. Raymond, J. Stock and W.F. Haxby, New constraints on Cenozoic Pacific-

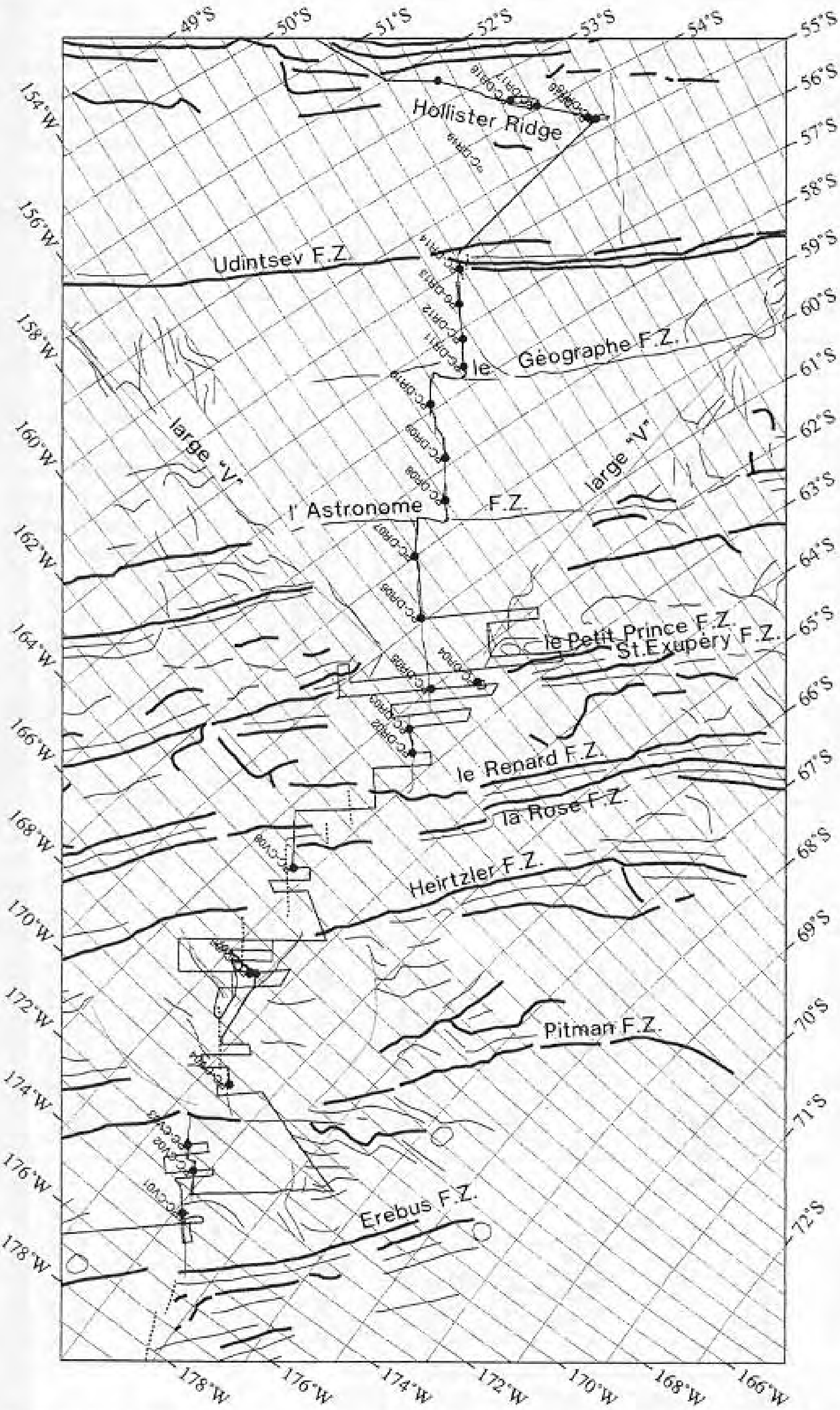

Figure 1. Navigation of *R/V L'Atalante*. The ship's tracks are superposed on the structures digitized by Sahabi et al. (1996) after the satellite gravity map of Sandwell and Smith (1992). Dots indicate sample locations. The names Erebus, Pitman, and Heirzler FZ are after Cande et al., (1995). Between Heirtzler and Udintsev FZ, the names of the fracture zones have been taken from the novel "Le Petit Prince", by Antoine de Saint-Exupéry (Saint-Exupéry was a French writer and an aviator who promoted at the same time worldwide exploration and poetry; he died as a hero during WW II). These names have been proposed to the International Hydrographic Bureau for consideration by the GEBCO sub-committee on Geographical Names and Nomenclature of Ocean Bottom Features.

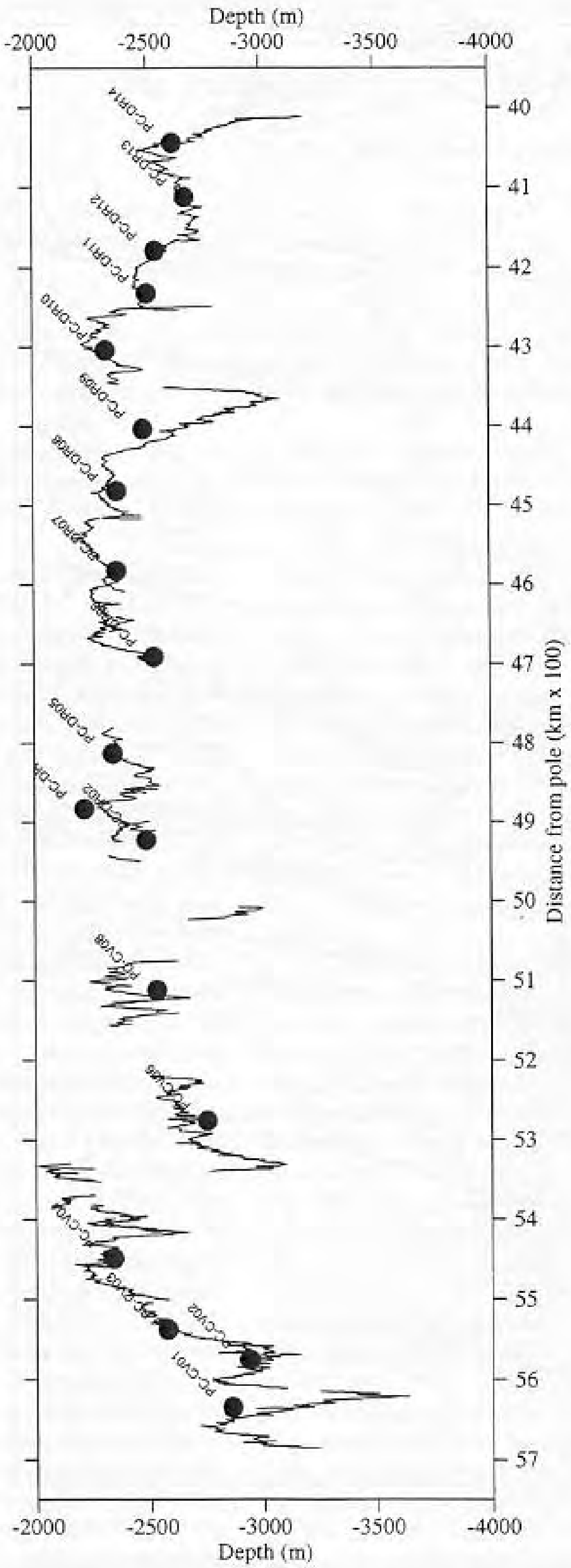

Figure 2. Axial depth profile and sample locations along the PAR between the Udintsev FZ (on the right) and 65°S, 170°W (on the left). Depths are plotted vs. distance (in km x 100) from the northern Euler pole of rotation related to the Pacific and Antarctic plate motion.

ence, 270, 947-953, 1995.

Natland, J.H., P.R. Castillo, Y. Niu, S.H. Bloomer and P. Lonsdale, Dredging exploration of fast-spreading ridges in the far southern Pacific Ocean: A preliminary report, Ridge Events, 6 (1), pages 1, 2, 26, 27, 1995.

Sahabi, M., L. Géli, J.L. Olivet, L. Gild-Capar, G. Roult, H. Ondréas, P. Beuzart and D. Aslanian, Morphological reorganization within the Pacific-Antarctic Discordance, Earth and Planet. Sci. Lett., 137, 157-196, 1996.

Sandwell, D.T. and Smith, W.H.F., Global marine gravity from ERS-1, Geosat and Seasat reveals new tectonic fabric, EOS Trans., AGU, 73, 133, 1992.

World Ridge Cruise Schedule 1995-7*

Country	PI	Institution	Name/Location	Research Objectives	Ship	Date
Australia/ Canada	Binns/ Scott	CSIRO Australia/ Univ. of Toronto	**PACMANUS-III**: Eastern Manus Basin, Yuam Ridge Hydrothermal Field	Hydrothermal field study: CTD-transmissometer, dredge, corer, video	Franklin FR09/96	Nov-Dec '96
Australia/ Canada	Binns/Davis/ Scott	CSIRO Australia/ Univ. of Sydney/ Univ. of Toronto	**PACMANUS IV**: Eastern Manus Basin, Bismark Sea, Papua New Guinea	Core drilling to 100m at PACMANUS hydrothermal field with PROD seafloor drill.	Franklin FR09/97	Oct-Nov '97
Canada/ USA	Thomson/ Cowen/ Lavelle	Inst. Ocean Sci./ Univ. of Hawaii/ PMEL/NOAA	**ER96**: Juan de Fuca Ridge: Endeavour Segment, CoAxial Ridge, Cascadia Basin	Recovery of two strings of current meters, conventional and inverted sed. traps, bio-acoustic net tows, camera, video, CTD, water chemistry.	J.P. Tully	June '96
Canada/ USA	Juniper/ Fisher/	Univ. du Québec/ Penn State Univ./ U. Washington	**BioROPOS 96**: Juan de Fuca Ridge: Endeavour Segment, Middle Valley	Return visit to biological observatory, survey of massive sulfide	Thompson/ ROPOS	Aug '96
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
France	Géli	IFREMER	**PACANTARTIC**: Antarctic-Pacific Ridge	Geophysics, geochemistry	Atalante	Jan/Feb '96
France/ USA	Gaill	IFREMER/ Univ. Oregon	**HOT 96**: 9°N and 13°N, East Pacific Rise	Hydrothermal activity and thermaphilic organisms, biology	Nadir/Nautile Wecoma	Feb-Mar '96

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

Country	PI	Institution	Name/Location	Research Objectives	Ship	Date
France	Gente	Univ. Bretagne Occidentale	**TAMMAR**: 22°N, Mid-Atlantic Ridge	Submersible study of mid-ocean ridge segmentation	Nadir/Nautile	Apr-May '96
France	Sibuet	IFREMER	**SARRidge**: 33°-39°N, Mid-Atlantic Ridge	Mapping	Nadir/SAR	Oct '96
France	Maia	Univ. Bretagne Occidentale	**FOUNDATION HOTLINE**: Foundation Seamounts, Pacific-Antarctic Ridge	Geophysics, mapping	Atalante	Nov-Dec '96
France	Munschy/ Peznard	EOPG/IMT	**Mai-Mai**: Cocos-Nasca Ridge	Accretionary process and segmentation interaction with hotspot	Atalante	Feb '97
France	Mével	Univ. Paris 6	**EDUL**: Southwest Indian Ridge	Dredge sampling of an ultra-slow spreading ridge	Marion Dusfrene	Apr '97
France	Fouquet	Univ. Bretagne Occidentale	**FLORES**: Azores, Mid-Atlantic Ridge		Atalante/ Nautile	June-July '97
France	Desbruyères/ Alayse	IFREMER	**MARVEL**: Azores Sea, Mid-Atlantic Ridge	Study of deep-sea hydrothermal vent communities; influence of depth, chemical, physical and biological factors	Atalante/ Nautile	June-July '97
Germany	Devey	University of Kiel	**Poseiden**: Kolbeinsey Ridge, 68.5° - 70°N, Eggvin Bank, S. Mohn Ridge	Bathymetry, rock sampling, geochemistry. Small-scale variation in MORB composition relation between geochemically defined mantle domains and ridge offsets.	Poseidon	July-Aug '96 rescheduled
Germany	Halbach	FU Berlin	**HYDROCK I**: SonneField, South Central Indian Ridge	Genesis of massive sulfides and formation of ultramafic rocks	Meteor	Nov '95
Germany	von Huene	GEOMAR Kiel	**ORWELL**: Northeast Pacific	Exploration of the lithosphere: a geophysical experiment	Sonne	Apr-May '96
Germany/ Canada	Herzig/ Suess/ Embley	TU Freiberg/ GEOMAR Kiel/ Univ. Victoria/GSC NOAA	**HYDROTRACE (SO-109)**: Juan de Fuca Ridge: Cascadia Margin, Axial Seamount	Remote vehicle investigation. Tracer distribution and chemical fluxes at hot vents and cold seeps. Biology.	Sonne/ ROPOS	May-July '96 (3 Legs)

Germany	Villinger	UHB	**HYDROCELL**: Northeast Pacific	Hydrothermal circulation in the oceanic crust	Sonne	Aug-Sept '96
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	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
Japan	Fujikura	JAMSTEC	**Y96-13 Mariana Cruise**: Mariana Trough	Biology, geochemistry and geophysics of the Mariana Back-Arc Basin	Yokosuka/ Shinkai 6500	Nov-Dec '96
Japan	Hashimoto/ Ohta	JAMSTEC/ ORI-Univ. of Tokyo	**BIOACCESS**: Manus Basin 2 Legs	Submersible study of hydrothemal vent community distribution, biological and geological characterisation.	Natsushima/ Shinkai 2000/ ROV Dolphin	Oct-Nov '96 Nov '96
Korea	Suk/ Lee	Korea Ocean Resh. & Dev. Inst.	East Sea: 37°-37.5°N and 131°-132°E	Geophysical survey SeaBeam 2000, SBP, gravity	Onnuri	Mar '96
Korea	Suk/ Kim	Korea Ocean Resh. & Dev. Inst.	East Sea: 37°-38°N and 130.5°-131.5°E	Geophysical survey SeaBeam 2000, mag., grav., multi-channel seismics.	Onnuri	Sept '96
Korea	Han	Korea Ocean Resh. & Dev. Inst.	**BASAPES-96**: East Sea: Ulleung Basin 37°-38°N and 130°-132°E	Basin structure and past changes in the East Sea. SeaBeam 2000, mag., grav., multi-channel seismics, sed. sampling	Onnuri	Sept-Oct '96 (3rd year)
Mexico/ USA	Knox	Scripps Inst. of Oceanography	Middle Americas Trench	Origin and evolution of the Cocos Plate. Multi-beam bathymetry.	R. Revelle	July '96

Country	PI	Institution	Name/Location	Research Objectives	Ship	Date
Russia	Krasnov	Polar Mar. Geo.Exp. Sevmorgeologiya/ VNIIOkeangeol.	**Logatchev - 12**: Mid-Atlantic Ridge, TAG Hydrothermal Field, 24.5°N, 15.8°N	Geological mapping, quantative evaluation of massive sulfide deposits, prospecting for new deposits.	Prof. Logatchev	Fall '96 110 days
Russia	Batuev/ Chercashov	Polar Mar. Geo.Exp. Sevmorgeologiya/ VNIIOkeangeol.	**Logatchev - 13**: Mid-Atlantic Ridge, 24°N- 26°N	Investigation of relic and active hydrothermal vents. Electric field profiling, CTD, dredging, coring, TV grab, submersible.	Prof. Logatchev	Apr, May, June '97
Spain	Canals	University of Barcelona	**GEBRA-2**: Bransfield Basin Antarctica: Western Antarctica, Pacific Trinity Peninsula, South Scotia Sea	Continuing investigation of the Bransfield Basin Swath bathymetry, seismic reflection, gravity magnetics, bottom parametric source	Hesperides	Dec '96- Feb '97
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	Galápagos Swell	Geophysical reconnaissance along a segment of the Galápagos Swell	not available	1996/7
United Kingdom	Murton/Dixon/ German/ Herring	IOSDL/ PML	**FLUXES I**: MAR, 29°N Broken Spur hydrotherm. site	Integrated fluxes experiment	Ch. Darwin/ BRIDGET/ SHRIMP	Aug/Sept '95
United Kingdom	Sinha/ Peirce	Univ. of Cambridge/ Univ. of Durham	Lau Basin: Valu Fa Ridge	Geophysics: Electromagnetics, wide angle seismics using OBSs	Ewing	Nov-Dec '95
United Kingdom	Searle/ Mitchell/ Cowie	Universities of Durham and Edinburgh	**CD99**: Mid-Atlantic Ridge, 29°N axial segment	Quantification of total strain in a single spreading segment. Deep-towed side-scan and multi-beam sonar, 3-component magnetics.	Charles Darwin/ TOBI	Mar-Apr '96
United Kingdom	Cann/ Blackman	Univ. of Leeds	**CD100**: Mid-Atlantic Ridge, Segment south of Atlantis FZ	Determine strain from strain indicators near ridge-transform intersection. Test low-angle serpentinite landslide zone vs. fault scarp model. New TOBI inst. package, dredge.	Charles Darwin/ TOBI	Apr-May '96

United Kingdom	Murton/ Palmer	Southampton Oceano. Cen./ Univ. Bristol	**FLUXES II CD102**: MAR, 26°N and 29°N	Hydrothermal sediment processes at TAG and recovery of FLUXES I instruments	Charles Darwin/ BRIDGET	Sept '96
United Kingdom/ Greece	Varnavas/ Dando	U. of Patras U. of Wales - Bangor	Milos, Hellenic Arc	Recovery and re-deployment of video and flux landers, current meters and sed. traps, sampling of: vent fluid bacteria, fauna and sediment.	Vasilos G	Sept '96
United Kingdom	Larter	BAS	**JR18 SLICE-Sandwich Lithospheric and Crustal Exp.**: South Sandwich arc and East Scotia Sea	Crustal structure and geodynamics of the South Sandwich Arc and back arc. Multi channel seismic reflection, wide angle OBS and land stations, geodetic mapping, sampling on land and at sea - dredge, coring.	James Clark	Jan-Mar '97
United Kingdom/ USA	Kent/Harding/ Orcutt/Singh/ White	WHOI/ U. of Cambridge/ BIRPS	East Pacific Rise, 9°03'N	3-D seismic reflection imaging, 3-D wide angle/ocean bottom seismometer survey of the axial magma chamber(s) beneath OSC	Ewing	Apr/May '97 provisional
United Kingdom	German	Southampton Oceano. Cen.	**FLAME** Fluxes at AMAR Exp.: Rainbow, Lucky Strike, Famous, 36°-37°N, Mid-Atlantic Ridge	Study of hydrothermal discharge at 3 sites phys. oceano., plume geochem., marine biology	Discovery	May-June '97 provisional
USA (RIDGE)	Spiess	Scripps Inst. of Oceanography	Juan de Fuca Ridge	Seafloor strain measurements	not available	94/95/96
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
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

Country	PI	Institution	Name/Location	Research Objectives	Ship	Date
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	Atlantis II/ Alvin	Dec '95
USA	Cande	Scripps Inst. of Oceanography	South Tasman Sea	Geophysics	Ewing	Jan-Feb '96
USA (RIDGE)	Grindlay/ Madsen et al.	Univ. Puerto Rico/ Univ. of Delaware	Southwest Indian Ridge, 15°E to 35°E	Geophysics	Melville	Feb '96
USA	Taylor	SOEST, Univ. of Hawaii	**MW9603**: Lau Basin: 17°-18.6°S, 174.3°-178°W Central Lau Spreading Center ETZ - Peggy Ridge	HMR1 & MGG Survey of back-arc basin rifting and spreading.	Moana Wave	Feb-Mar '96
USA	Johnson/ Scheirer/ Graham/ Forsyth	Bishop Museum/ Brown Univ./ Oregon State U.	**Boomerang - Leg 6**: SEIR 77°-90°E, St. Paul/Amsterdam Hotspot	SeaBeam, dredging, wax coring, gravity, magnetics.	Melville	Feb-Apr '96
USA	Chave/Stein/ Van Dover/Cary/ Cavanaugh/ Ravizza	WHOI/ Univ. Alaska/ Univ. Delaware/ Harvard Univ.	**AII/Alvin**: East Pacific Rise, 9°-10°N, 13°N	Hydrothermal vent biology. 14 dives, light measurements, biological and water sampling	Atlantis II/ Alvin	Apr '96
USA	Michael/ Hanan	Univ. of Tulsa/ San Diego State U.	**SMARTS**: Southern Mid-Atlantic Ridge, Temporal variation Study: 32.5°-33.5°S, axis to 7 Ma.	Determine temporal variation of mantle composition and extent of melting.	Knorr	Apr-May '96
USA	Cannon	PMEL/NOAA	**Kodiak-Seattle Transit**: Juan de Fuca Ridge: Cleft Segment	Current meter mooring recovery	Discoverer	May '96

USA	Karson	Duke University	Hess Deep	Geology, 20 dives	Atlantis II/ Alvin	May-June '96
USA	Chave/ Dorman	WHOI/ Scripps	**MELT II**: East Pacific Rise at 17°S	Deploy magnetotelluric array of 60 instruments	T. Thompson	May-June '96
USA	Baker/Cannon/ Freely/Lupton/ Massoth	PMEL/NOAA	**VENTS 1996 Leg 1**: Juan de Fuca	Plume survey and water sampling for hydro-thermal activity; mooring deployment and recovery	Discoverer	June '96
USA	Fornari/ Humphris/ Langmuir/ Van Dover	WHOI/ LDEO	**Lucky Strike-Jason/ARGO II-120 kHz Sonar**: Mid-Atlantic Ridge, 37°18'N	Mapping and sampling of the Lucky Strike Hydrothermal Field.	Knorr	June-Aug '96
USA	Tucholke/ Kleinrock/ Lin	WHOI/ Vanderbilt Univ.	**Eastern Mid-Atlantic Ridge Flank Survey**: 26°N	Mapping of 400 x 200 km box centered near 26°N. Segment history, spreading asymmetry, episodicity	Ewing	July-Aug '96
USA	Klinkhammer	Oregon State University	Mid-Atlantic Ridge	Hydrothermal venting, 16 dives	Atlantis II/ Alvin	Aug-Sept '96
USA	Speiss/ Hildebrand/ Chadwell/ Zumberge	Scripps Inst. of Oceanography	**GEO 3**: Juan de Fuca Ridge: Cleft Segment, 48°10'N, 127°10'W	Seafloor geodesy, revisit precision benchmark transponders & absolute gravity reference points, testing installation of fiber optic strain meter. Seafloor strain measurements, plate motion.	New Horizon	Sept '96
USA	Rona/ Jackson	Rutgers Univ./ U. of Washington	Northern Clef Segments, Juan de Fuca Ridge	Acoustic imaging of hydrothermal plumes and diffuse flow.	Laney Chouest/ Sea Cliff	Sept '96
USA	Macdonald/ Scheirer/ Cormier	UCSB/ Brown Univ./ LDEO	**Sojourn-1**: Southern East Pacific Rise Flanks, 16°-20°S. (MELT area and south)	SeaBeam 2000 mapping gravity, magnetics	Melville	Sept-Oct '96
USA	Haymon/ Macdonald	UCSB	East Pacific Rise: Axis 17°-18°S	JASON/ARGO II, AMS 120, hydrothermal/ tectonic studies	Melville	Oct-Nov '96
USA (RIDGE)	Detrick	WHOI	Mid-Atlantic Ridge, 34°-37° N	Seismic experiment	Ewing	Oct-Nov '96

InterRidge Workshop Summaries

Report on the FARA-InterRidge Mid-Atlantic Ridge Symposium

Reykjavik, Iceland, June 19-22, 1996

C.H. Langmuir and H.D Needham

A symposium focused on the Mid-Atlantic Ridge (MAR) between 15° - 40°N was held recently in Iceland to mark the completion of the FARA (French American Ridge Atlantic) project, and to review results obtained by FARA and other national and international projects in this region. Eighty scientists from eight nations presented their recent research. The symposium incorporated some forty oral presentations and thirty posters and was planned primarily around sessions covering different portions of the ridge rather than by theme, hence emphasizing the interdisciplinary nature of the research that has taken place. Generous time was allowed for discussion. A concluding session, preceded by introductory talks, was devoted to a brief review of current knowledge and to new perspectives.

Several field trips provided opportunities for ridge scientists to familiarize themselves with the sub-aerial expression of the MAR and for further interaction with the geologists of Iceland.

Background

The FARA project was conceived and carried out under the US-France Co-operative Program in Oceanography. Principal objectives, outlined in a project plan published in late 1989, concerned the along-strike variability of the properties of the ridge in the axial zone and the associated distribution and character of hydrothermal systems. The first field programs took place in 1991, and the last of the sea-going operations are being completed in 1996. During the same five-year period the BRIDGE program of the United Kingdom concentrated six expeditions on the region between 24° and 30°N. Russia continued to focus on the 15° N area, the European Community co-ordinated a project near the Azores, the US Office of Naval Research (ONR) supported an off-axis study near 25°N, and the Ocean Drilling Program undertook a series of surface ship and submersible studies in the TAG area near 26°N preceding and following a 2-month drilling leg in 1995.

New Data

Results reported at the symposium complement those which have already been presented in scientific meetings or published, and offered an overview of observations made during the past 5 years. There is now virtually complete multibeam bathymetric coverage of 90% of the ridge axis in the 15°- 40° N region, with a few maps extending out to crustal ages of 10 Ma or more (30 Ma in the case of the ONR survey). Most of the recent surveys included underway geophysical, as well as bathymetric, data acquisition. Surface ship and deep-tow acoustic imaging has been achieved for significant portions of the ridge axis. *In situ* geophysical data were collected during micro-earthquake and seismic experiments near 29°N and 35°N. A submersible expedition was dedicated to seafloor gravity measurements in the 23°N area. There is new geochemical data from more than 250 surface ship sampling stations, particularly between 33°N and the Azores and in the 21°- 23°N area south of the Kane Fracture Zone. New fine scale volcanological and tectonic observations and precise sampling have been carried out by submersible in several regions. Several surface ship cruises were designed for detecting hydrothermal signatures in the water column. The number of known hydrothermal sites (two at the outset of the recent work) has been quadrupled. The biology and geology of four of the new sites (at 14°45'N, 29°N, 37°20'N and 37°50'N) have now been studied from submersibles. The inactive site on the axial volcano at 20°30'N has been investigated. Hydrothermal plumes have been identified near 36°N and 36°40'N. In addition, past hydrothermal activity between 33°-40°N has been investigated through studies of sediments.

Some Result Highlights

The new information has enabled a number of existing models of crustal accretion and associated hydrothermalism within the study area to be tested and modified, has led to the introduction of some new ideas to account for the data and has, in some cases, underlined the conflicting nature of different hypotheses.

- The recently discovered hydrothermal sites which have been visited, and which include both black and white smokers, show variations in both fluid and solid deposits as a function of water depth, volcanic and tectonic setting and source rocks.
- The ecosystems at the newly discovered hydrothermal sites show limited species diversity.
- Striking aspects of basement morphology include segmentation provinces a few hundreds of kms in length

combined with great diversity in the characteristics of individual segments.

- High density rock sampling has allowed a far better description of the effects of mantle heterogeneity in giving rise to the diversity of crustal compositions and has opened new perspectives for deciphering relationships between composition and temperature of mantle sources.
- The surface and deep-towed side-scan sonar (and magnetics) results coupled with the multi-beam bathymetric data have enabled fine-scale investigation of tectonic and volcanic features at the segment scale with implications for the distribution of magma within the crust.

Future Directions

The results of the FARA Project make it possible to formulate much more precise questions now than was possible five years ago, and provide an improved basis for deciding on future approaches to some of the unresolved problems.

Future hydrothermal surveys will need to locate the sources of and characterize the hydrothermal signals that have to various degrees been detected along most of the ridge axis. Highly focused studies will be necessary to understand the properties of the hydrothermal sites, their geodynamic controls, and their variation through time. Many questions and models relate to the number, locations and styles of hydrothermal venting within segments, and further progress in this area will require much more detailed data on the segment scale.

Many first order biological questions revolve around the number and distribution of hydrothermal sites. There is also the broad question of the apparent lack of species diversity, which is not yet understood. Is this low diversity a general Atlantic characteristic, and if so, why? How stable are the populations through time, and what are the environmental controls on the contrasting shrimp and mussel-dominated communities? Other important questions for the future are: How do organisms colonize and survive in the different sites? How do they adapt to toxic conditions? How much methane is necessary to meet the energy requirements? Do thermophilic methane oxidizers exist? The question also still remains concerning the existence of a deep crustal biosphere in the Atlantic.

The issues of segment morphology, segment-offset relationships, crustal structure, asthenospheric flow, volcanism and tectonic deformation emerge increasingly as part of the same issue. Hence we are likely to make rapid progress by focusing studies of all these aspects of crustal creation in a small number of regions. Considerably more seismic data, for example, is needed to help to determine crustal thickness and internal structure, but what is the petrological and geological meaning of seismically determined crustal thickness? This requires combining diverse seismic, geological and sampling investigations. Is there active upwelling anywhere? On what scale does it occur, and how does it relate (or not relate) to segmentation? To what extent is magmatic activity within a segment controlled by vertical vs. horizontal melt movement, and how do variations in basalt chemistry at the surface map into the crust and mantle below? These questions are all related to one another and require more detailed underway mapping, near seafloor and *in situ* geophysical and other experiments, very high resolution sampling and direct field observations - all on the same segments or segment pairs.

There is a clear need for a better geological understanding of the MAR: Iceland is a reminder of the dearth of geological information. For example, how does the geology of the MAR change from the Kane transform to the Azores hot spot? How does it vary with magmatic budget ? Are segments a single species which changes through time, or are there distinct sets of segments each of which has its own restricted range of evolution? Research into these issues can draw on larger scale observations such as those coming from the detailed bathymetry and from whole mantle tomography and satellite altimetry, but concentrated studies on selected areas are also now essential and timely. Understanding how magmatic and amagmatic extension are distributed, how basaltic dykes, gabbros and serpentinite bodies are emplaced, appear now as urgent issues. Another is the testing of the low angle (detachment) fault model, still neither well confirmed nor refuted, which was developed for the inside corner area of the segment immediately south of the Kane Fracture Zone. Does this model apply elsewhere as well? And how does such a model evolve temporally?

While regional work at different wavelengths needs to continue, particularly off-axis, many of the most pressing questions now require more focused studies. The results of the last five years provide an adequate framework for the present plate boundary in the central north Atlantic within which multi-disciplinary efforts on a small number of selected segments and some offset zones can take place. This new work will need to be coupled closely with a drilling program and possibly in due course with long-term monitoring of active processes.

Symposium Abstracts

Extended abstracts of the meeting were published in the Journal of Conference Abstracts : J. Conf. Abstr.1, (1996), 749-888. The abstracts can be accessed at the following address over the World Wide Web:

http://www.campublic.co.uk/science/J.Conf.Abs./

AGU Volume

Following the Iceland Symposium, a volume of results from the 15°-40°N area of the mid-Atlantic Ridge will be published in the Maurice Ewing series through AGU. Submission of papers will take place in the fall of 1996, with publication planned in 1997.

News from Ridge Research and Related Programmes

BRIDGE

THE BRITISH MID-OCEAN RIDGE INITIATIVE

Although BRIDGE has now completed its funding allocation, BRIDGE projects will be running until 1999 and the programme can be said to have moved from its foundation stage to full maturity. With this move, the emphasis has changed from a concentration on funding policy to a focus on publicising the benefits of the programme as the results begin to accumulate.

As part of this publicity drive, September saw the BRIDGE meeting, 'Abyssal Inferno: seafloor volcanoes, hot vents and exotic life at the mid-ocean ridges' at the British Association's Annual Festival of Science in Birmingham. The British Association for the Advancement of Science has been organising annual science meetings since the 1830s. The famous debate on Darwinism between Bishop Wilberforce and Thomas Henry Huxley took place at a BA meeting in Oxford in 1860. While not claiming equivalent historical status for the BRIDGE day at this year's public festival, we certainly caught the imagination of the media with TV, radio and national newspaper coverage.

It is not possible to convey the full range of BRIDGE science in seven talks but we had tried to cover the broad range of topics. The press conference was booked for 15 minutes but lasted 50. Interviews have been broadcast on Channel 4 television; BBC Radio 4; the BBC World Service (several times); and there have been articles in the national press. Media interest continues. If the purpose of the meeting was once again to raise public awareness of BRIDGE science, we have had a resounding success. The programme for the BRIDGE meeting can be found in BRIDGE Newsletter No. 10, page 36 or on the British Association's Festival of Science web site at:

http://www.bbc.co.uk/tw/ba96/thu22.htm.

Abstracts of most talks can also be obtained from this location. Reports on the talks given by Martin Sinha and David Dixon are on the web at

http://www.bbc.co.uk/tw/ba96/rthu58.htm and **.../rthu70.htm** respectively.

In the week commencing 16th September 1996, Southampton Oceanography Centre (SOC) hosted the General Meeting of the Scientific Committee on Oceanic Research (SCOR). As part of the meeting, two days of presentations on mid-ocean ridge research were organised for members of the SCOR committees and working groups, and for other interested delegates. Over the past three years, InterRidge has taken an active part in initiating SCOR WG 99 on 'Linked Mass and Energy Fluxes at Ridge Crests' and has closely followed its progress since. On Wednesday 18th, Martin Sinha of Cambridge University and Chair of SCOR Working Group 99, organised a meeting on the WG 99 theme, and on Thursday 19th Lindsay Parson of SOC arranged a day focusing on BRIDGE research results. Over the two days there were 14 talks, several video presentations and 17 supporting posters.

Programmes:

Wednesday 18th September 1996

SCOR WG 99 Symposium: Linked Mass and Energy Fluxes at Ridge Crests

* David Needham (IFREMER) Background: the global ridge system
* Martin Sinha (Cambridge University) Crustal accretion and lithospheric construction

* Charlie Langmuir (Lamont Doherty Earth Observatory) Melt generation and mantle flow
* Henri Bougault (IFREMER) Hydrothermal processes: Exchange, concentration and dispersal
* Kim Juniper (University of Quebec) Biological productivity associated with hydrothermalism
* Nils Holm (University of Stockholm) Abiotic organic synthesis in hydrothermal systems
* Hiromi Fujimoto (Ocean Research Institute, Tokyo) (Video presentation)

Thursday 19th September 1996

BRIDGE Research Results: An Overview

* Christine Peirce (Durham University), M. Sinha, S. Constable, D. Navin, L. McGregor, A. White, G. Heinson & M. Inglis, Geophysical evidence for a magma chamber beneath the slow-spreading Reykjanes Ridge, N. Atlantic.
* Rex Taylor (SOC), Petrogenesis of extrusives at the Reykjanes Ridge section of the MAR.
* Chris German (SOC), Controls on high temperature hydrothermal activity: latest BRIDGE collaborative research south of the Azores.
* Ian Rouse (SOC), BRIDGE technology: the present and the future.
* Adam Schultz (Cambridge University), Diffuse flow, crypto-plumes, water-rock interactions, solid earth deformations & the oceanic lithosphere from 0-65 Ma: new research directions arising from BRIDGE-supported studies of axial hydrothermal circulation.
* Gerald Ernst (Bristol University), Chris German, Martin Palmer, John Davis & Steve Sparks, Sedimentation from hydrothermal plumes in cross-currents.
* Peter Herring (SOC), Vent shrimp dispersal from the Broken Spur site.
* David Dixon & Linda Dixon (Plymouth Marine Laboratory), Blind vent shrimp has eyes after all.

It is anticipated that abstracts from the meetings will be produced as a Southampton Oceanography Centre Report in the foreseeable future (details from Lindsay Parson, e-mail: lmp@soc.soton.ac.uk).

Since the last BRIDGE update the report of the 1995 meeting 'Tectonic, Magmatic, Hydrothermal and Biological Segmentation at Mid-Ocean Ridges' has been published. The volume of the same name, edited by C.J. MacLeod, P. Tyler and C.L. Walker is Special Publication No. 118 of the Geological Society (ISBN: 1-897799-72-1) and retails at £65 or US$108. Details from: Geological Society Publishing House, Unit 7, Brassmill Enterprise Centre, Brassmill Lane, Bath BA1 3JN, UK (fax +44 1225 442836) or, in the US, American Association of Petroleum Geologists, Tulsa, Oklahoma (fax +1 918 560 2652).

Like its sister volume 'Hydrothermal vents and Processes' (Special Publication No. 87), the above work was the result of a joint meeting sponsored by BRIDGE; the Marine Studies Group of the Geological Society; and the Challenger Society for Marine Science. On 14th - 15th May 1997, we will be co-sponsoring another joint meeting at the Geological Society entitled 'Modern Ocean Floor Processes and the Geological Record'. There will be four sessions: 1. Crustal accretion at modern and ancient mid-ocean ridge systems; 2. Alteration of the oceanic crust and evaluation of hydrothermal fluids; 3. Refining our understanding of ore formation; and 4. Gene flow and site colonisation: evidence from modern systems and the geological record. Offers of papers and posters are currently being invited and should be sent to the BRIDGE Office by 4th December 1996. It is anticipated that this meeting will result in another Geological Society Special Publication. Further details of the meeting are available in BRIDGE Newsletter No. 11 and will be circulated by e-mail (see announcement on page 64).

The BRIDGE Annual Science Progress Meeting will be held this year at Southampton Oceanography Centre on 6th - 7th January 1997. Offers of papers for this meeting are also being accepted. As with last year there will be a forum to discuss the future of British deep ocean ridge-related research following the absence of a ridge-relevant proposal in the recent bids for new thematic programmes submitted to the Natural Environment Research Council.

Bridge Cruise

In May 1997 BRIDGE will be funding the shiptime on a cruise to conduct EU research under the aegis of the MAST III study AMORES. The cruise of the *RRS Discovery* (D228, 21st May 1997-28th June 1997, Vigo-Vigo) is to study the fluxes from the RAINBOW hydrothermal vent field near the Azores Triple Junction and is entitled

'FLAME: the Fluxes at AMAR Experiment'. The PI is Chris German of SOC, and Peter Herring, also of SOC, will be deploying fine-meshed mid-water nets as part of his BRIDGE-funded biological studies of shrimp larvae and larval dispersal from vent sites.

For any information about BRIDGE please contact:

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The British Mid-Ocean Ridge Initiative is a thematic programme of the Natural Environment Research Council. Background information on BRIDGE can be found at the web site maintained by the BRIDGE-supported research unit at Southampton Oceanography Centre:

http://www.soc.soton.ac.uk/CHD/bridge/

DeRidge

The next DeRidge Workshop will be held on 17 - 18 October 1996 at GEOMAR, Kiel. The workshop is being held in order to come to decisions about the continuation of the DeRidge Program. Topics slated for discussion include:

- Regional focus
- Compilation of existing data (e.g. swath bathymetry)
- Interdisciplinary research strategies
- Technical development

The first item will be discussed in relation to recent research and projects. Expression of interest were received from perspective participants concerning the following regions: EPR, EXCO II, Juan de Fuca, Easter Microplate, Foundation Seamount Chain, Hess Deep, Chile Ridge, Back Arc Basins, North Fiji, Lau Basin, Rodriguez Triple Junction, Red Sea, MAR, TAG, Kolbeinsey, Reykjanes, Arctic.

For further information about DeRidge contact:

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InRidge

To date, Indian researchers have made 9 cruises to the Indian Ocean Ridge system (IORS). Ridge segmentation and its influence on the petrology of the IORS were examined during these expeditions. Reconnaissance studies of about 4200 km of the IORS, from the Owen FZ in the northwest to the Indian Ocean Triple Junction (IOTJ), were made and the results have been compiled in recent publications (Mukhopadyay and Iyer, 1993; Banerjee and Iyer, 1992). Samples from three tectonic environments along the length of the IORS were collected. Some correlations between degree of offset and petrology are found. The fairly dominant plagioclases + olivine + pyroxene assemblage in IORS rocks indicates solidification from moderately fractionated melt which has experienced a long cooling time. Occurrence of polybaric fractionation seems to be apparent, as evidenced by accumulation of Ca-rich (calcite) plagioclase. These data may indicate that polybaric fractionation could have been accomplished in two stages - the first occurring at 15-25 km depth and the second at <5 km depth below the seafloor. Mixing of the high and low pressure magma probably explains the mineral assemblages.

Radio-isotope studies of the rocks show no big surprises. However, 'Reunion-like' signatures in a few samples located at 20°05'S and low Pb (lead) values in ancient near-axis seamount samples are interesting. Hotspot signatures at the ridge-transform intersection (RTI) may suggest that the concept of magma flow along the ridge channel requires further testing.

Many questions remain unresolved, for example: thermal cooling effects on the degrees of mantle melting at RTIs; episodicity of melt generation and migration and structural variation at RTIs; and impact of hydrothermal flux on deep ocean circulation.

All the above findings have been the results of loosely organised ridge research conducted by Indian researchers. However these positive results and the potential of ridge research has led to the formation and launch of the "InRidge" Programme (India's Ridge Programme or Inside the Ridge?). This programme has been launched at the National Institute of Oceanography (NIO) in Goa, India. Under the InRidge Programme, two major projects have been identified. The first involves exploration of the Carlsberg Ridge. The Geological Survey of India (GSI) and NIO are expected to be jointly involved in this project. A couple of cruises have already been carried out on various segments of the Carlsberg Ridge, the details of which will be published in due course. The second project involves the Central Indian Ridge (CIR) south of the equator to the triple junction. The first cruise to the CIR (after InRidge's' formation) will be made in July-August 1997.

Encouraged by recent findings from reconnaissance surveys, another programme has been initiated to explore the back-arc prism in the Andaman Sea. A national committee has been established to formulate, implement and monitor the Andaman Programme. They will probably launch their first expedition in early 1997.

For further information concerning the InRidge Programme, please contact:

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RIDGE

In late February of this year, the SOSUS array in the NE Pacific detected an event on the northern Gorda Ridge, and NOAA was able to quickly deploy the research vessel *MacArthur* to the region with Ed Baker (NOAA/PMEL) as chief scientist. Their tow-yos revealed a megaplume in the water column.

The *R/V Wecoma*, with support from NSF, sailed in early April to document possible changes that had occurred on the seafloor as well as to conduct further studies of the water column megaplume. Jim Cowen (U. Hawaii) and Bob Embley (NOAA/PMEL) were co-chief scientists on this cruise. Camera tows at the event site revealed a recent eruption. Preliminary results of this cruise are available on the World Wide Web at:

http://www.pmel.noaa.gov/vents/eruption.html

and in the July 1996 RIDGE Events Newsletter.

A special session will be held at the AGU Fall Meeting to discuss the results of the event detection and response cruises: U05 "Northern Gorda Ridge Intrusive/Eruptive Event: Remote Detection and Directed Rapid Response"; Convenors: J. Cowen & C. Fox.

The second of the MELT cruises sailed in May 1996, to recover OBSs and deploy instruments for the electromagnetic portion of the experiment. Preliminary results suggest the OBS deployment successfully acquired the required data. Information related to MELT is available on the World Wide Web at:

http://www-mpl.ucsd.edu/obs/reports/tn061/index.html

and in the July 1996 RIDGE Events Newsletter.

A Special Session related to the MELT Experiment will be held at the AGU Fall Meeting: T09 "The Super-Fast Spreading Segment of the East Pacific Rise"; Convenors: T. Hilde, D. Forsyth, K. Kisimoto (see announcement on page 54).

Workshop reports and framework and guideline documents for the RIDGE Seafloor Observatory on the Juan de Fuca Ridge and LARVE have been issued during the last year. These are available either electronically from the RIDGE Web Site or in hard copy from the RIDGE Office. Both projects remain in the proposal submission stage.

RIDGE is a co-sponsor of the upcoming "Magnetization of the Oceanic Crust Workshop" (along with NSF and JOI-USSAC), convened by Paul Johnson (U. Washington) and Dennis Kent (L-DEO). The workshop is scheduled for October 21-24, 1996 in Orcas Island, Washington. Updates related to the Workshop are available on the World Wide Web at:

http://www.ocean.washington.edu/conference/conference.htm

RIDGE will host the annual 'RIDGE Smoker' at the AGU Fall Meeting in San Francisco this December. All members of the ridge community are invited to attend to meet their colleagues. Please look for updates related to the Smoker, as well as all other RIDGE-related updates, on the RIDGE website under the Announcements category. If you have any information that would be of interest to the RIDGE community, that you wish posted on the RIDGE website, please include it in an email message to the RIDGE Office at: ridge@unh.edu.

The Report from the Southern East Pacific Rise Workshop held in January 1996 is now available from the RIDGE Office and on the World Wide Web at:

http://ridge.unh.edu/sepr/report.html

You can contact the RIDGE Office at:

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Announcements and Notices

Position Available: InterRidge Coordinator

InterRidge is a non-governmental, international and interdisciplinary initiative concerned with all aspects of mid-ocean ridge research (biology to geophysics). It is designed to encourage international scientific and logistical coordination, with particular focus on scientific problems that cannot be addressed efficiently by nations acting alone or in limited partnerships. Its activities range from dissemination of information on existing, single-institution experiments to initiation of fully multi-national projects.

InterRidge has an international Steering Committee and a published Science Plan. It has 6 Principal Members (France, Germany, Japan, Spain, the UK and the USA), 2 Associate Members (Norway and Portugal), and 11 Corresponding Members (Australia, Canada, Denmark, Iceland, India, Italy, Korea, Mexico, Russia, Sweden and Switzerland).

The InterRidge Office acts as an information centre and clearing house for ridge-related matters. It convenes symposia and workshops and publishes the reports of these meetings as well as a semi-annual newsletter. The newsletter is distributed free to members of the ridge crest research community and contains: reports on recent ridge crest cruises, updates on international co-operative research projects, news from national and international research programmes, various announcements and notices pertaining to ridge crest research and an up to date schedule of ridge crest cruises. The InterRidge Office also maintains a World Wide Web Home Page with updated informations and announcements, a directory of international research platforms, updated cruise schedules, links to other programs, and an international directory of ridge crest researchers.

InterRidge is presently chaired by Professor Roger Searle of the University of Durham, England and the InterRidge Office in Durham is run by Dr. Heather Sloan (Coordinator), with the help of Dr. Ruth Williams (part time assistant). From 1st January 1997, Dr. Mathilde Cannat (CNRS-Université de Paris VI) will take over as Chair of InterRidge, and the InterRidge Office will move to Paris, for a period of three years. It is intended to appoint a new InterRidge Coordinator to be based in Paris and provide general assistance to the Chair.

The post is expected to last for three years, but continuation beyond the first year will be dependent on continued international financial support for InterRidge. A contract will be offered by the University of Paris VI to the successful applicant, initially for one year but renewable annually to a maximum of three years, subject to finance and satisfactory performance. The starting salary will be about 27K$/yr with full health benefits.

Duties

- Assist the InterRidge Chair in coordination and administration of the InterRidge office (which will have independent secretarial support).
- Write, edit and produce InterRidge programme documentation, including meeting reports, science plans and proposals.
- Edit and produce the semi-annual newsletter.
- Write and edit other items, e.g. news or information articles for scientific journals.
- Respond to requests for information.
- Maintain the InterRidge WWW Home Page.
- Interact with national funding agency personnel and researchers at universities and research institutes in InterRidge countries and elsewhere.
- Coordinate and provide on-site support for several meetings per year in various locations. Specific tasks may include developing agendas and participant lists; overseeing arrangements for meeting logistics, travel arrangements, and reimbursements; taking minutes at meetings; handling follow-up documentation and meeting products.
- Other administrative duties include budget management, and supervision of assistant.
- Some travel is required to meetings in other InterRidge countries.

This will be a full-time coordinating position. It will have the advantage of introducing the holder to a very wide range of active researchers world-wide. The job does not carry a component of scientific research. The Office will be hosted on the Jussieu campus, with a large number of active ridge-scientists. The prospective Chair's laboratory specializes in slow spreading ridge geophysics and geology, and in the petrology and geochemistry of MOR basalts, peridotites and gabbros.

continued on following page...

Qualifications

The applicant should have the ability to interact effectively with a wide range of scientists, administrators and support staff. A Ph.D. or substantial research experience in some aspect of mid-ocean ridge science is highly desirable. Fluent English, excellent writing and editing ability, and computer literacy (Word processing, use of electronic mail) are essential. Some experience in the management of a WWW home page is desirable. Experience in budget administration and proposal writing would be useful.

Please send a CV, statement of interest and the names of 2 referees as soon as possible to:

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AMERICAN GEOPHYSICAL UNION FALL MEETING SPECIAL SESSIONS:

T09 The Super-Fast Spreading Segment of the East Pacific Rise

The super-fast spreading segment of the East Pacific Rise (S-EPR), between Garrett Fracture Zone and the Easter Microplate, has been extensively investigated in recent years by many institutions from several countries. These studies have included multi-channel seismic, submersible, swath mapping, sampling, heatflow and other observations.

The MELT (Mantle Electromagnetic and Tomography) experiment and the US- Japan FAST (Flux and Spreading Tectonics) expedition are the most recent examples of studies that have successfully obtained array OBS and seafloor EM data (MELT) and high resolution swath images, detailed bathymetry, 3-component magnetics and gravity data (FAST). We are calling for scientists involved in MELT, FAST and other S-EPR studies in recent years to join together in sharing their observations and interpretations.

Convenors:

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T11 High-Resolution, Near-bottom Characterization of the Oceanic Crust

Our understanding of the structure and development of the oceanic lithosphere has been influenced by the instruments used to survey it. The resolution of surface measurements is limited by zones of various sonars and the diminished amplitude of potential field anomalies. Modern, high-resolution data obtained from near-bottom techniques are capable of resolving the shallow structure of the oceanic crust in far greater detail than traditional surface geophysical methods, thereby contributing to our understanding of the dynamics of seafloor processes and facilitating direct comparison with ophiolites. This session will focus on high resolution methods being used to examine the seafloor from close range. Appropriate topics include: near-source magnetic and gravity surveys conducted from submersibles, bottom surveys and deep-tow surveys.

Convenors:

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FIRST ANNOUNCEMENT

1st INTERNATIONAL SYMPOSIUM ON DEEP-SEA HYDROTHERMAL VENT BIOLOGY

Funchal, Madeira, Portugal; 20-24 October, 1997

Following a recommendation by the InterRidge Biological Studies *Ad Hoc* Committee, an International Symposium on deep-sea hydrothermal vents biology is being organized under the auspices of InterRidge. Biologists involved in research on deep-sea hydrothermal vents as well as those involved in cold-seep studies are invited to take part.

Oral communications (15 min.) or posters on the following topics are welcome:

Biogeography/Evolution/Genetics/Taxonomy
Ecology/Micro-distribution/Temporal Evolution
Microbiology/Ultra-thermophiles/Bacterial symbiosis
Physiology/Adaptation
Biological cycles/Larval dispersal/Plankton
Cold Seeps

Official language: English

Scientific Committee Chair: Prof. Robert Hessler
Organisational Committee:
Manuel Biscoito - Museu Municipal do Funchal (História Natural), Portugal. biscoito@tethys.uma.pt
Craig Cary - College of Marine Studies, University of Delaware, USA. caryc@strauss.udel.edu
David Dixon - Plymouth Marine Laboratories, UK. d.dixon@pml.ac.uk
Heather Sloan - American Museum of Natural History, USA. sloan@amnh.org

Interested scientists are kindly requested to contact the InterRidge Office by e-mail before 1 December 1996:
intridge@durham.ac.uk

Provisional Program

Sunday, 20
18:00 - 19:00 - Registration
19:00 - 22:00 - Reception

Monday, 21
09:15 - 10:00 - Official Inauguration
10:30 - 12:30 - Morning session
12:30 - 14:15 - Lunch break
14:15 - 15:00 - Invited speaker
15:00 - 17:30 - Afternoon session
17:30 - 18:00 - Coffee break
18:00 - 19:00 - Workshop and poster session

Tuesday, 22
09:15 - 10:00 - Invited speaker
10:30 - 12:30 - Morning session
12:30 - 14:15 - Lunch break
14:15 - 15:00 - Invited speaker
15:00 - 17:30 - Afternoon session
17:30 - 18:00 - Coffee break
18:00 - 19:00 - Workshop and poster session

Wednesday, 23
09:15 - 10:00 - Invited speaker
10:30 - 12:30 - Morning session
12:30 - 14:15 - Lunch break
14:15 - 15:00 - Invited speaker
15:00 - 17:30 - Afternoon session
17:30 - 18:00 - Coffee break
18:00 - 19:00 - Workshop and poster session

Thursday, 24
09:00 - 18:00 - Excursion (optional)

Friday, 25
10:00 - 13:00 - AMORES/BIOLOGY
- Post-cruise meeting

Call for Piggy-Back/Host Proposals

The InterRidge Office proposes to act as a broker, matching projects which may be 'piggy-backed' with funded and scheduled cruises that have available time and space.

Proposals of both piggy-back projects and ship time will be published in InterRidge News and on the InterRidge World Wide Web Home Page (http://www.dur.ac.uk/~dglØzz1/). Proposal submission should include:

- for ship time proposed:
  - objectives and dates of the planned cruise
  - ports of call, location of study
  - equipment to be employed/deployed
  - space (deck, lab, accommodation) and time available
- for piggy-back project proposed:
  - objectives and time required
  - shipboard equipment/facilities required
  - what equipment will be brought on board
  - space required
  - preferred location(s)

Submissions and enquiries should be directed, preferably by e-mail, to:
InterRidge Office, Dept. of Geological Sciences,
University of Durham, South Road, Durham, DH1 3LE, UK
tel: 44-191-374-2532; fax: 44-191-347-2510; e-mail: intridge@durham.ac.uk

INTERNATIONAL SYMPOSIUM: PLUMES, PLATES AND MINERALIZATION [PPM'97]

University of Pretoria, South Africa
14 to 18 April 1997

Guest speakers:

Prof Lew Ashwal: anorogenic magmatism
Dr Mark Barley, Western Australia: plumes and mineralization
Dr Ian Campbell, Canberra:Yilgarn
Dr Millard Coffin, Texas: large igneous provinces
Dr Richard Ernst, Ottawa: plate reconstruction
Prof Stephen Haggerty, Massachusetts: superplumes
Dr Nazario Pavoni, Zurich: bipolar mantle convection
Dr Neil Phillips, New Zealand: fluid migration in Wits basin
Prof Alan Smith, Cambridge UK: computer-aided plate reconstruction
Dr Bryan Storey, Cambridge UK: Phanerizoic plumes
Dr Robert White, Cambridge UK: plumes and continental breakup
Prof Maartin de Wit, Cape Town: Archaean supercontinents
Prof Maartin de Wit, Cape Town: Archaean superplumes

Excursions:

Pre- and post-symposium excursions to (planned)
Witwatersrand geology and Bushveld Complex

Workshops:

Exploration models with focus on Africa (planned)
Seismic profiles through Kaapvaal Craton
Seismic imaging of the Witwatersrand
Computer-aided plate reconstruction
Geoscience teaching in Africa

For more information please contact: Sybrand de Waal, Chairman Organizing Committee
Tel: +27 (12) 4202454; Fax: +27 (12) 433430; E-mail: ppm97@scientia.up.ac.za

Institut National des Sciences de l'Univers du CNRS - France
Institut Supérieur d'Etudes et de Recherches Scientifiques et Techniques - Djibouti
University of Addis Ababa - Ethiopia

SYMPOSIUM: FLOOD BASALTS, RIFTING AND PALEOCLIMATES IN THE ETHIOPIAN RIFT AND THE AFAR DEPRESSION

ADDIS ABABA, ETHIOPIA, 3-16 FEBRUARY 1997

Preliminary Registration

We are pleased to announce the Symposium entitled: "Flood basalt, Rifting and Paleoclimates in the Ethiopian Rift and the Afar Depression" which will be held in Addis Ababa on 3 - 16 of February 1997.

The main objective of this Symposium is to gather together scientists working on volcanism, tectonics and paleoclimates in the whole Afar region or in comparable environments. In addition, 3 field trips will be organised:

Field trip 1: Trapps as the main objective (North Ethiopia: Lima-limo section) from Monday 3 to Friday 7 of February.
Field trip 2: Paleoclimates as the main objective (Ethiopian lakes: Abyata, Salla and Langano) from Wednesday 5 to Friday 7.
Field trip 3: Quaternary tectonics as the main objective (Republic of Djibouti: Lake Asal area) from Wednesday 12 to Friday 16.

Scientific sessions will be held in Addis Ababa from Saturday 8 to Monday 10 of February.

Tuesday 11: Rest in Addis Ababa.

Head of Scientific Committee:
V. Courtillot (IPGP - France), T. Solomon (University of Addis Ababa), and
A. Abdallah (ISERST - Republic of Djibouti)

Provisional Agenda:

October 1st: first circular
November 30th: deadline for receipt of abstracts and registration for both meeting and field trips.

Those wishing to attend the Symposium should, please, send as soon as possible a tentative title of their presentation and an indication of their wish to participate in the field trip(s). All expressions of interest should, if possible, be made by e-mail.

Contact Address:
Sofia NADIR
3 rue Michel-Ange
BP 287
75766 Paris Cedex 16, France
Tel: +33 (01) 44 96 43 72
Fax: +33 (01) 44 96 49 65
e-mail: sofia.nadir@cnrs-dir.fr

All further information will be on the World Wide Web in October 1996 at:
http://www.insu.cnrs-dir.fr/

EUROPA OCEAN: AN INTERNATIONAL CONFERENCE

SAN JUAN CAPISTRANO RESEARCH INSTITUTE, CA, USA 12th - 14th NOVEMBER 1996

This NASA and NSF sponsored conference will explore ideas related to Europa's possible ocean, submarine volcanism and biological activity.

Europa is one of the four large Galilean satellites of Jupiter. Data and theory have suggested (though not proven) that Europa has an ocean of liquid water beneath its icy crust. Europa undergoes tidal heating similar to that driving the spectacular volcanism on the Jovian moon Io, and this heating may have been sufficient to melt the ice and maintain an ocean.

Among the topics the conference will address are geologic and geophysical evidence concerning an ocean, and what its physical state might be.

If an ocean exists on Europa, the question of whether it could support life immediately arises. The first detailed examination of Europa by the Voyager spacecraft (in 1979) coincided very closely with the first detailed investigation by oceanographers of volcano-hydrothermal sites on the Earth's seafloor. That work has shown that in the presence of liquid water, volcanoes can sustain life without energy from the sun. Submarine volcanism is also a possibility on Europa. A major purpose of the conference, then, will be to examine critically the arguments for and against submarine volcanism on Europa, and the likelihood that such activity could support biological activity there as well. A related and controversial topic is the issue of whether life could have originated at submarine volcanic systems, on Earth and on planets in general. The conference will bring together the planetary science, oceanography and exobiology communities to explore these topics.

The conference, jointly supported by NASA's Solar System Exploration Division (Exobiology Program Office) and NSF's Ocean Sciences Program, will also deal with ongoing and future robotic exploration of Europa. The Galileo spacecraft is now in orbit around Jupiter, and will make multiple flyby examinations of Europa during its mission. Follow-on missions could be flown to Europa that would address the existence of an ocean in detail, and that would explore the ocean if it were found to be present. The conference will address the measurement techniques that could be used on such missions, and their implications for future solar system exploration.

SCIENTIFIC PROGRAM

Scientific presentations are invited (abstracts due September 18, 1996) on topics of the conference outlined above. Abstracts are limited to two pages. The Program Committee will use the abstracts to prepare a program of oral presentations consisting of both invited talks and contributed papers. Other presentations can be poster talks or exhibits.

Abstracts will be printed in a booklet to be provided in the registration packet at the conference. These short papers may be expanded later for inclusion in a book or special journal issue.

The last session of the conference will be a panel discussion and debate on Thursday morning. This will provide a forum to summarize Europa Ocean studies to date, and what future research and directions should be.

PRE-REGISTRATION

The registration fee will be $160 for all participants who pre- register by September 18, 1996, and $190 afterward.

continued on following page...

LOCAL INFORMATION

San Juan Capistrano is a lovely community located midway between Los Angeles and San Diego, four miles inland from the Pacific Ocean (with beaches and local marina at Dana Point). The weather should be warm and sunny, with temperatures in the 60's, and a slight chance of rain in November. The meeting site (San Juan Institute) is within easy walking distance of two motels, a tourist shopping district, many restaurants, Amtrak station, and the famous mission (to which "the swallows return").

TRANSPORTATION

Several travel options are available including flying into Orange County John Wayne Airport (15 miles north of San Juan Capistrano), driving by rental car from John Wayne, Los Angeles, or San Diego Airports, or riding the Los Angeles-San Diego Amtrak train which makes numerous stops per day at San Juan Capistrano. Detailed information will be provided in a second announcement to follow.

PROGRAM COMMITTEE

Convenors and Steering Group:
- John Delaney, Marine Geologist, U. Washington
- Steve Squyres, Planetary Geoscientist, Cornell U.
- Torrence Johnson, Planetary Scientist, JPL
- Dennis Matson (Program Chairman), Planetary scientist, JPL
- Doug Nash (Local Organizer), Planetary Geologist, San Juan Institute

Advisory Members:
- John Baross, Marine Microbiologist, U. Washington
- Francois Raulin, Exobiologist, CNRS & U. Paris
- Gerda Horneck, Exobiologist, German Aerospace Res. Est. Linderhohe
- Chris McKay, Exobiologist, NASA Ames Res. Center
- Daniel Prieur, Oceanographer, CNRS
- Gene Shoemaker, Planetary Geologist, USGS Flagstaff & Lowell Observ.
- Rick Thomson, Physical Oceanographer, Inst. Ocean Sci., BC

IMPORTANT DATES

Expression-of-interest response due .... As soon as possible!
Second Mailing, call for abstracts .... July 22, 1996
Abstract Deadline .... Sept. 18, 1996
Pre-Registration deadline .... Sept. 18, 1996
Third (final) mailing.................................... Oct. 21, 1996

For general logistic information and future mailings, contact as soon as possible:

Doug Nash (Local Organizer)
San Juan Institute
31872 Camino Capistrano
San Juan Capistrano, CA 92675
E-mail: nash@sji.org
Phone: +1 (714) 240-2010
FAX: +1 (714) 240-0482

For Program information, contact:

Dennis Matson (Program Chair):
Ph: +1 818-354-2253 Fax: +1 818-393-4495
e-mail: dmatson@jpl.nasa.gov

ANNOUNCEMENT OF A CONFERENCE ON
THE MAGNETIZATION OF THE OCEAN CRUST

ORCAS ISLAND, WA, USA
21st - 24th OCTOBER 1996

REGISTRATION DEADLINE 1st AUGUST 1996

A Conference on the Magnetization of Oceanic Crust will be held from October 21st to October 24th, 1996, on Orcas Island, in Washington State. The purpose of this conference will be to define the new directions that magnetic studies of ocean crust will need to take in the future. There are unresolved first-order problems remaining in the field of marine magnetics, including the fundamental origin of linear magnetic anomalies and the relative importance of geomagnetic and crustal processes that control their amplitude and coherence. A better understanding of crustal magnetization should ultimately lead to new insights into past geomagnetic field behavior and to higher resolution for examining ridge crest accretionary processes, as well as improving the traditional role of the discipline in determining the tectonic history of the ocean basins.

It is our belief that a large-scale, fully-integrated program of research is required in order to resolve these long-standing scientific problems in the field of marine magnetics. For example, results from marine magnetic surveys can be integrated with land-based paleomagnetic studies to characterize field behavior over the same time interval. Recent surveys utilizing 3-component magnetometers or multiple-level near-bottom surveys demonstrate the possibility of better characterizing crustal magnetization at a variety of scales and resolutions. When accompanied by complementary petrological, geochemical and geophysical data regarding crustal fluid flux and the thermal/chemical environment, such comprehensive magnetic surveys could unravel the full time-dependent nature of magnetization in the oceanic crust.

The primary goal of the Conference will be to develop a consensus on what are the major high priority problems in marine magnetics, and to define the best approach to their solution. Almost any effective strategy for solving these first-order scientific problems will require the direct involvement of the larger (ODP, RIDGE, InterRidge) scientific community. The final output of the Conference, therefore, will be a widely-distributed report that identifies the primary direction for our sub-discipline for the near future. In order to recognize present fiscal realities, this report should include a plan that is both adequate in detail such that it can be incorporated within individual research proposals, and with sufficient flexibility that allows it to be integrated into the field requirements of other marine disciplines.

This Conference will be supported in part by RIDGE, USSAC and NSF/MG&G, who will provide partial travel support to participants from the USA. Non-US-based participants are encouraged to apply to their appropriate funding agencies.

During the Conference, an evening session will be spent examining and discussing posters in an informal setting. This Poster Session will be an ideal format for the presentation of newly acquired data, recently developed models and the discussion of new analytical techniques. If you wish to present a poster during the Conference, please indicate your title on the Application Form.

Registration Fee: Each participant will be required to submit a US$50 registration fee by the August 1st deadline in order to reserve their accommodation at the conference resort. This registration fee is necessary, even if you are applying for financial support for the conference. Financial support will be awarded on the basis of the arrival time of completed applications, including the registration fee, prior to 1st August 1996. Accommodations are either single occupancy ($99.53 per night) or double occupancy ($107.60 per night, divided by 2). Please indicate which you would prefer, and if double occupancy, if you have a preferred roommate. Because of limited lodging and funding, on-site accommodation will be limited to approximately 60 people.

A description of the goals of this Conference has been published in EOS, RIDGE, BRIDGE and ODP newsletters, and an expanded version is available on-line at:
http://ocean.washington.edu/conference/conference.htm

continued on following page...

If you have any questions about this conference, please contact either of the convenors:
Paul Johnson, johnson@ocean.washington.edu, +1 206 524 7083;
Dennis Kent, dvk@lamont.columbia.edu, +1 914 365 8544;
or a member of the Steering Committee:
Maurice Tivey, mtivey@whoi.edu; Jeff Gee, jsgee@popmail.ucsd.edu;
Roger Larson, rlar@gsosun1.gso.uri.edu; Bob Embley, embley@new.pmel.noaa.gov.

The WWW-page above provides a description of the conference site and travel arrangements, and also allows you to register for the conference on-line.

JOINT MINERALOGICAL SOCIETY WINTER MEETING & VOLCANIC STUDIES GROUP RESEARCH IN PROGRESS MEETING

UNIVERSITY OF CAMBRIDGE, UK
6th - 9th JANUARY 1997
DEADLINE FOR REGISTRATION AND ABSTRACTS 1st NOVEMBER 1996

"vsg-minsoc '97"

The joint Mineralogical Society Winter meeting and Volcanic Studies Group research in progress meeting will be held at the Department of Earth Sciences, Cambridge, England from January 6 to 9, 1997.

We invite contributions for any of a number of general or thematic sessions, including: research in progress; pyroclastic deposits and their emplacement mechanisms; continental and intraplate magmatism; and isotope geology of the crust and mantle.

It is also hoped that there will be a "Montserrat Update", and we would particularly encourage the submission of materials suitable for poster or audio-visual presentation for this.

The Mineralogical Society Winter Meeting theme is "equilibrium and kinetic behaviour of minerals", and the annual Hallimond Lecture of the Society will be given by Prof. B.J. Wood, University of Bristol, on January 8, 1997.

Sponsorship means that we have been able to keep the registration and abstract fee down to 60 pounds sterling (approx. 90 USD), and less for students and members of either the Geological Society or the Mineralogical Society. This fee includes admission for the four days of the meeting, lunches, refreshment at the poster sessions, a wine reception and the conference dinner.

Further details are available from the convenors (Richard England, Sally Gibson, David Pyle and Simon Redfern) by email (vsg-minsoc@esc.cam.ac.uk), fax (+44 1223 360779), or through the meeting homepage (http://www.esc.cam.ac.uk/vsg.html).

The deadline for registration and abstract submission is November 1st, 1996. Abstracts that are accepted will be published in the Journal of Conference Abstracts.

David Pyle, Department of Earth Sciences, Downing Street, Cambridge, CB2 3EQ, UK.

SEG NEVES CORVO FIELD CONFERENCE 1997

LISBON, PORTUGAL
11th -14th MAY 1997

The Neves Corvo mine, the Iberian Pyrite Belt, massive sulphide deposits and seafloor hydrothermal exploration in one great meeting.

GENERAL INFORMATION

The University of Lisbon will host the Neves Corvo Field Conference, to be held at the Rectory of the University, in Lisbon, Portugal, on 11th - 14th May, 1997.

The Neves Corvo Field Conference is the first ever international, off-shore North American conference to be sponsored by the Society of Economic Geologists (SEG). It will be co-sponsored by the Institution of Mining and Metallurgy (IMM), Society for Geology Applied to Mineral Deposits (SGA), Departamento de Geologia da Faculdade de Ciências da Universidade de Lisboa (GEOFCUL), Instituto Geológico e Mineiro (IGM), Instituto de Ciência Aplicada e Tecnologia (ICAT) and Sociedade Mineira de Neves Corvo (SOMINCOR). The University of Huelva will organise field trips in Spain.

The Conference will be organised around visits to the Neves Corvo mine and other points of interest in the Iberian Pyrite Belt, both in Portugal and Spain, and will consist of a three day thematic meeting, designed to bring together those interested in most aspects of massive sulphide geology and genesis, and present-day oceanic equivalents.

The Program will include one specific session on the Iberian Pyrite Belt and another ascribed to the presentation of the results of the GEOMMINCOR scientific contract.

Given that Neves Corvo and the Iberian Pyrite Belt continue to generate great interest in the ore geology community, it is expected that this Field Conference will attract a high enrolment, of both European and non-European ore geologists. It will be an excellent opportunity for the discussion of the newest developments in the understanding of this fascinating type of sulphide ores and, simultaneously, to establish the connection between the modern submarine hydrothermal processes and their fossil counterparts, on-land VMS deposits.

CALL FOR PAPERS

The Organising Committee welcomes submission of abstracts of both oral and poster presentations on any of the topics related to massive sulphide geology and genesis, and present day submarine hydrothermal activity.

OFFICIAL LANGUAGE

The official language of the Conference is English. All the abstracts should be submitted in this language.

EXHIBITS

Technical equipment, mineralogical specimens and representative samples of the major Portuguese ore deposits, including the Neves Corvo and Panasqueira (Sn-W) mines, and also from submarine hydrothermal sites (e.g. Lucky Strike).

SYMPOSIA

The Program will include four Symposia as follows:
Present-day submarine hydrothermal systems - Chairman: Y. Fouquet;
Massive sulphide genetic models - Chairmen: R.W. Hutchinson and D. Richards;
Iberian Pyrite Belt ore geology - Chairmen: D. Carvalho and E. Pascual;
The geology of Neves Corvo mine - Chairmen: F.J.A.S. Barriga and P. Carvalho.

Invited Keynote Speakers:
W.S. Fyfe (London-Ontario), J. Franklin (Ottawa), Michael Russell (Glasgow), P.M. Herzig (Freiberg), A. Ribeiro (Lisbon)

continued on following page...

FIELD TRIPS

Three Field Trips in the Iberian Pyrite Belt will be offered as both pre- and post-meeting trips (8th - 10th and 15th - 17th May, respectively).

There will be a total of 240 places for the three field trips: A three day field trip which includes an underground visit to the Neves Corvo mine will be limited to 120 places (six groups of 20 people).

A second trip in Portugal will focus on the regional geology and will also include a mine visit (Aljustrel mine).

A third one will be held in Spain, and will include Rio Tinto and Aznallcóllar.

Field Trip Technical Committee: F.J.A.S. Barriga (GEOFCUL), A. Mateus (GEOFCUL)

Field Trip Leaders: J.T. Oliveira (IGM, Univ. Porto), V. Oliveira (IGM), P. Carvalho, A. Ferreira (SOMINCOR), J.B. Silva (GEOFCUL), J.C. Leitão (Pirites Alentejanas), R. Sáez, G. Ruiz de Almodóvar, M. Toscano and E. Pascual (University of Huelva)
The Field Trip in Spain is organised by the University of Huelva.

Additional field trips:

1. Geology of the Ossa-Morena Zone
2. Geology of the Algarve
3. Geology of the Lisbon region
   3a) North of River Tagus
   3b) South of River Tagus

SOCIAL PROGRAM

A variety of social events is being planned, including a welcoming reception and a closing dinner. A complete evening program of city tours and entertainment will be offered, possibly including handicraft exhibits and demonstrations. A special program will be available for accompanying participants. If there is sufficient interest, baby-sitting will be available.

ORGANISING COMMITTEE:

F.J.A.S. Barriga (GEOFCUL), R. W. Hutchinson (Colorado School of Mines, SEG), G. Snow (SEG), D. Richards (RTZ, IMM), P. Herzig (Freiberg, SGA), A. Ribeiro (GEOFCUL), D. Carvalho (IGM), P. Carvalho (SOMINCOR), A. Ferreira (SOMINCOR)

TECHNICAL SESSION COMMITTEE:

J. M. R. S. Relvas (GEOFCUL), M. A. Gonçalves (GEOFCUL), M. Gaspar (GEOFCUL)

INSTRUCTIONS FOR REGISTRATION

In order to receive the 2nd Circular you may either fill the Pre-Registration Form on theWorld Wide Web page (http://skull.cc.fc.ul.pt/geologia/Neves.Corvo/SegNetPage.html) or send your personal data by e-mail, post or fax to one of the following addresses:

European Address:
Fernando J. A. S. Barriga
GEOFCUL
Edificio C2, Piso 5, Campo Grande
1700 Lisboa, Portugal
Phone: +351-1-750-0066
Fax: +351-1-759-9380

North American Address:
Geoffrey Snow
Barranca Resources, c/o SEG Office,
5808 Rapp Street # 209,
Littleton, Colorado, 80120 USA
Phone +1 303-797-0332
Fax +1 303-797-0417

To pre-register, please send the following data to gbarriga@cc.fc.ul.pt:
Name, Title or Position,
Organisation, Address, Country
Telephone, Fax, E-mail address
My attendance at the Conference is: Very probable/Probable/Unlikely
I will bring an accompanying person
I intend to submit an abstract
I would like to participate in the Field Trips: Pre-Conference/Post-Conference

MODERN OCEAN FLOOR PROCESSES AND THE GEOLOGICAL RECORD

14-15 May 1997

Geological Society of London
Burlington House, Piccadilly, London

Over the last five years, the BRIDGE Programme and ODP have generated new models of crustal accretion, crustal alteration and fluid flow, metalliferous deposit formation and vent site colonisation. For example, we now understand the process of melt generation within the crust and the consequences over a range of tectonic settings. The drilling of the TAG mound and Middle Valley has given us insight into subsurface circulation within deposits and the importance of sea water entrainment in deposit accretion and brecciation, and combined plume and larval studies in the Atlantic have led to models of faunal dispersion over vast distances.

There is widespread evidence for all these processes in the geological record, and it is timely to combine the output of two international programmes studying modern sea floor processes, to reassess our understanding of on-land analogues.

This will be a two-day meeting sponsored by The Marine Studies Group of the Geological Society; The British Mid-Ocean Ridge Initiative (BRIDGE); and The Challenger Society for Marine Science. The meeting will bring together a wide community of marine scientists, with four sessions studying various aspects of the mid-ocean ridge systems. Each session will invite a keynote speaker from the 'ancient' side of the spectrum.

Provisional sessions

Session 1: Crustal accretion at modern and ancient mid-ocean ridge systems.
Session 2: Alteration of the oceanic crust and evaluation of hydrothermal fluxes.
Session 3: Refining our understanding of ore formation.
Session 4: Gene flow and site colonisation: evidence from modern systems and the geological record.

It is anticipated that this meeting will result in a Special Publication of the Geological Society, as did the previous joint meetings: 'Hydrothermal Vents and Processes' (Special Publication 87), and 'Tectonic, Magmatic, Hydrothermal and Biological Segmentation at Mid Ocean Ridges' (Special Publication 118).

Offers of papers and/or posters, accompanied by a short abstract (one page maximum), should be submitted to the convenor, Dr Keith Harrison, (preferably by e-mail, avoiding attachments) by Wednesday 4th December 1996 at the latest.

Dr Keith Harrison
BRIDGE Programme Manager
Department of Earth Sciences
University of Leeds
Leeds LS2 9JT
UK

Tel: +44 (or 0 if calling within UK) 113 233 5241 Fax: +44 (or 0 if calling within UK) 113 233 5259

e-mail: BRIDGE@earth.leeds.ac.uk

MAST 3 ADVANCED STUDY COURSE

"BENTHIC COMMUNITIES FUELLED BY CHEMOSYNTHESIS"

PARIS, FRANCE, 1 - 19 SEPTEMBER 1997

An "Advanced study course" (MAST 3) will be held in Paris from 1st to 19th September 1997. It will deal with "Benthic communities fuelled by chemosynthesis". It will be funded under the EC MAST 3 programme for undergraduate and graduate students.

If you know anyone who could be interested please contact:

Dr. Jean-Francois Pavillon,
Institut Oceanographique de Paris
E-mail address: 100670.615@compuserve.com.

The InterRidge Office is currently accepting submittal of articles for the next issue of *InterRidge News* to be published in Spring 1997.

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:

- Preferred submission method/format is by e-mail to the Paris Office as an attached RTF file. Originals or good quality reproductions of figures may be sent by post or ftp.
- Reference style **must** conform to references appearing in this issue.

Articles must arrive in the InterRidge Office no later than 15 March 1997..

RVS Planning, Safety & Operations Announces:

Available Shiptime

Aboard the *RRS Challenger*

RRS Challenger (54 Metres) is available for funded research projects for several months in 1997. The co-ordinating contact is the Research Vessel Services (RVS) Operations Office at the Southampton Oceanography Centre - for projects which already have funds available for chartering the vessel. For projects requiring NERC funding via peer review for 1998 - the contact is Dr Caroline Harper at NERC Scientific Services Swindon who will assist with apllication (NB: The 1997 applications have already closed). Please also note that both the *RRS Discovery* and the *RRS Charles Darwin* programmes for 1997 are already full.

RVS can advise and assist in organising use of *RRS Challenger* to make a cruise effective, and are prepared to quote for a range of scientific equipment and cruise objectives subject to the availability of equipment and technical support to run it.

For further details of the ship, equipment and cruise preparation please contact the following:-

RVS Operations Office: Tel: +44 1703 596800
Fax +44 1703 635130

Contacts: Chris Adams, Head of Planning, Safety & Operations
(email cmga@soc.soton.ac.uk)

Andy Louch - Logistics Planning Officer
(email arlo@soc.soton.ac.uk)

NERC NSS Marine Planning: Tel +44 1793 411662
Fax +44 1793 411610

Contact: Dr. Caroline Harper (email ceh@nss.nerc.ac.uk)

For any cruises to be undertaken within another country's EEZ, there is a requirement for 6 months notice for diplomatic clearance reasons. Whilst this might be a bureaucratic difficulty, it is a fact of marine research with which RVS have to comply. However, RVS can often find means of achieving clearances with the minimum of disruption to the scientific aims but do require early advice from potential customers.

Although *RRS Challenger* is the smallest of the NERC fleet, the ship can undertake a range of deep sea work within her normal operating parameters of 15 days between ports, or pre-placement to a more distant port which can be utilised as a base for research legs.

RVS would be pleased to consider a combination of scientific groups sharing projects and costs if this can create an effective research cruise.

National Administrative Representatives

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