

# INTERRIDGE NEWS



Promoting international cooperation in ridge-crest studies

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**IFM-GEOMAR**  
Leibniz Institute for Marine Sciences  
at the University of Kiel

**2004**

**The NEXT DECADE of IR begins  
with the IR Office move to  
Germany!**

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INTERRIDGE NEWS



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[www.interridge.org](http://www.interridge.org)

**LAYOUT**

Katja Freitag, Kiel, Germany

**INFORMATION FOR CONTRIBUTORS**

Please send all items for publication via email to the InterRidge Office ([coordinator@interridge.org](mailto:coordinator@interridge.org)) Text should be in Microsoft Word format. Figures should preferably be sent in eps format for optimal printing, although other formats are accepted.

**DEADLINE FOR INTERRIDGE NEWS**

**VOL. 14 CONTRIBUTIONS**  
**31 AUGUST 2005**

**Errata**  
**IR News Vol. 12.2, Fall 2003**

Please note, the authors of the article "Taking the temperature of the Lucky Strike area" formed the 'LuckyFlux Science Party'. This has been amended in the electronic version of IR News.

## LETTER FROM THE CHAIR

### Do we really need InterRidge?

When asked by a funding agency, this question caused my stomach to lurch. What tangible benefit, I asked myself, does InterRidge really offer? The more I have been faced with this question, the more I have become convinced that not only do we as researchers need InterRidge, but so do a lot of other people. This realisation prompted my interest in the InterRidge Chair and motivates me to expand the scope of InterRidge over the next three years from the excellent position left by the Japan office. I would like to explain why I think InterRidge is worth my time and yours.

We all know that InterRidge is seriously underfunded but let's be positive and first take stock of its assets. InterRidge has a large, international community of members (active and passive) around the world and a great reputation. Someone who is definitely in a position to judge wrote me recently: "I have always been impressed with the accomplishments of the program, particularly as an independent activity amongst a world of projects that sit under various international organizations." Wow. So how do we make more out of that?

In order to ensure its long-term sustainability, InterRidge must expand the range of people it reaches, as well as the communities of people it serves. As scientists, we need InterRidge to cover what we can't accomplish at a national level; InterRidge has become pretty good at this. The Theoretical Institutes, for example, attract world experts to discuss long-term research plans. The InterRidge Working Groups, when populated with enthusiastic and committed members, are international powerhouses driving research progress. As office coordinator, Katja Freitag will focus on motivating and keeping the interest in this part of InterRidge's work alive. One of our new office initiatives is to renew the commitment

of current Working Group members and actively recruit new members. Scientifically, it seems, InterRidge is on the right track.

However, when we look at how InterRidge interacts with people outside the ridge community, we are certainly making less of a splash. Yet the potential to stimulate non-scientist audiences to care about ridge research is tremendous. The origin of life on Earth, the possibility of mining ridge deposits, and real-world applications of newly discovered ridge inhabitants are just a few in a laundry list of reasons why the lay person ought to care about the ridge. Educationally, a spreading axis is a natural laboratory for many aspects of chemistry, biology, geology and physics. Populated with strange creatures, extreme pressures and temperatures, and active volcanoes, what more could a science teacher want to engage students in the process of discovery? InterRidge has the network to reach teachers worldwide. One of its prime future goals is to reach out and provide services and materials for school teachers. The alternative is to lose a great part of our societal relevance, in the long-term fatal for InterRidge.

Extending our reach into the public arena will take two things: expertise and extra funding. Acquiring both of these were and are major goals as I assume the Chairmanship. The expertise we have now got on board is in the person of Kristen Kusek, a science writer. We are working on the funding. Kristen will initially work in an advisory capacity to the InterRidge Office, helping to gather teaching materials that already exist, and brainstorm new ways of reaching the international community in cost-effective, educationally sound ways. She and Katja will then come to you, the InterRidge scientists, for help in transforming the the ideas into tangible realities for all of us. Please help them in their efforts; it is to our collective benefit and perhaps even survival as an organization.

**COLIN DEVEY**

PLEASE VISIT OUR WEBSITE AT  
**[www.interridge.org](http://www.interridge.org)**

**MEET THE TEAM!!**

**Kristen M. Kusek**, currently based in St. Petersburg, Florida, holds dual master’s degrees in marine science and journalism / mass communications from the University of South Florida. Kristen’s passion lies in bridging the gap between scientific and nonscientific audiences, and she has worked as a science writer and education outreach specialist for about six years. Kristen approaches her work knowing that terrific learning opportunities lurk in the heart of a good story, and the mid-ocean ridge is chock full of good stories. She recently wrapped up her tenure as education outreach director for the IMAX film “Volcanoes of the Deep Sea.” Her favorite memory from this project: a dive on Alvin to the 9° North hydrothermal vent site!

**Katja Freitag**, born and raised in South Africa, earned a geology degree at the Technical University Clausthal, Germany. She then moved to the USA and completed a PhD in geology at the Colorado School of Mines. She loves deformed massive sulfides and spent 3 summers in Alaska mapping an orebody of the highly deformed Greens Creek massive sulfide deposit. After completing her studies, she worked at the Cripple Creek gold mine, Colorado, as a contractor, and then moved to South Africa where she spent the last 3 years working for Rio Tinto’s

Palabora underground copper mine. Her experience ranged from operating a drill rig on shift, running a seismic system, being geotechnical superintendent, and doing process improvement work to optimize production. She moved to Germany in March and looks forward to the adventure of running the IR Office!



**Kristen M. Kusek**

**Colin W. Devey**

**Katja Freitag**

**COORDINATOR UPDATE**

Although changes seem to take a long time before they actually happen, looking back on these first six months of mine as coordinator, the InterRidge office has established and developed rapidly. The move from Tokyo via Bremen to Kiel was made so much easier due to the email help I received (and still call on!!) from Agnieszka, the exchange of ideas for projects such as the InterRidge flier that I had with Kristen Kusek and the steering committee, the help I got from the student helpers Swen Meyer who has great creative ideas, and Tom Kwasnitschka who is becoming a Filemaker Pro pro, and so many other InterRidge members who brought me up to speed quickly. But I think the reason I, and thus the office, settled in so quickly was because you, the InterRidge community, made me feel so welcome from the start. Thanks and I hope to work with many more of you in the near future.

Geology at the University of Toronto and Director of its Scotiabank Marine Geology Research Laboratory.

China became an associate member of InterRidge at the start of 2004. The Chinese representative and national correspondent is John Chen. John is professor at the Department of Geophysics at Peking University’s School of Earth and Space Sciences.

Germany nominated a second steering committee member, Nicole Dubilier. Nicole is a marine microbiologist at the Max Planck Institute of Marine Microbiology in Bremen.

Recently the UK also nominated a new steering committee member, Tim Henstock. Tim is a geophysicist at the Southampton Oceanography Center and will replace Damon Teagle.

**Steering Committee News**

There have been some changes to the membership of the steering committee in 2004.

Steve Scott has replaced Kim Juniper as national correspondent and Canadian representative on the steering committee. Steve is Chair of the Department of

**InterRidge Working Group News**

Seven InterRidge working groups started off the New Decade of InterRidge. Two of the new InterRidge working groups now have chairs and the membership of these groups are being established. Furthermore, an eighth working group was formed when the steering committee accepted Nadine le Bris’ proposal for a new InterRidge

working group at their meeting in May. This latest addition to the InterRidge working groups is called "Biogeochemical interactions at deep-sea vents".

### InterRidge Meetings

In January 2004, the Biology working group got together in Bremen, Germany, to identify near-term actions to advance Next Decade ridge-crest biology/ecosystem objectives and discuss a code of conduct for research at hydrothermal vents that is being developed by the working group.

The second meeting that InterRidge was involved in took place in Korea in May 2004. This was the Ridge 2000-InterRidge Joint Theoretical Institute on Interactions among Physical, Chemical, Biological and Geological Processes in Back-Arc Spreading Systems. Thanks to the scientific organizing committee, the Ridge 2000 office and Sang-Mook Lee and his team of students, this was very successful in getting together back-arc basin scientists who then came up with a plan of action for research in the future.

To find out more about InterRidge meetings in 2005 see the Upcoming Events section in this Newsletter.

### InterRidge Office Projects

There will be some changes in the way the InterRidge Office worked in the past. One of these is that IR News will be issued once a year starting this year. This allows more time to keep the website updated. Articles will however be accessible online as soon as they have been accepted, this way the information will be readily available to the interested community much faster than before.

The office has been busy with numerous projects. These include:

**InterRidge Logo:** at the 2004 steering committee meeting, the members decided that a new InterRidge logo would symbolize a positive start to the next decade of InterRidge. With professional help and input from the committee, a new logo was found and we hope you like it too!

**InterRidge website:** I have been working on restructuring the website. The main reason for this is to make navigation easier and therefore lead interested people faster to what they are looking for. With Kristen Kusek at the front, we are also planning on exciting education and outreach links and activities from the InterRidge website. We will work on redesigning the home page next year.

**InterRidge flier:** InterRidge has a new flier introduced on page 52 of this IR News volume! This describes InterRidge and will be handed out at meetings and conferences to awaken the interest in our program. Should you require some fliers for your work, please contact your national correspondent.

KATJA FREITAG




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## THE CURRENT INTERRIDGE WORKING GROUPS AND THEIR CHAIRS

**Hotspot-Ridge Interactions** – Jian Lin (jlin@whoi.edu) and Jérôme Dyment (jdy@ipgp.jussieu.fr)

**Back-arc Spreading System/Back-arc Basins** – Sang-Mook Lee (smlee@snu.ac.kr)

**Mid-ocean Ridge Ecosystems** – Françoise Gaill (Francoise.Gaill@snv.jussieu.fr)

**Monitoring and Observatories** – Javier Escartin (escartin@ipgp.jussieu.fr)

and Ricardo Santos (ricardo@notes.horta.uac.pt)

**Deep earth sampling** – Benoit Ildefonse (benoit@dstu.univ-montp2.fr)

**Ultraslow spreading ridges** – Jon Snow (jesnow@geobar.mpch-mainz.mpg.de)

**Biogeochemical interactions at deep-sea vents** – Nadine le Bris (Nadine.Le.Bris@ifremer.fr)

**Global exploration** - still looking

If you are interested in being a part of a working group, please contact the InterRidge office coordinator@interridge.org or the working group chairs directly.

## The Logatchev hydrothermal field – revisited: preliminary results of the R/V METEOR Cruise HYDROMAR I (M60/3)

T. Kuhn<sup>1</sup>, B. Alexander<sup>2</sup>, N. Augustin<sup>3</sup>, D. Birgel<sup>4</sup>, C. Borowski<sup>5</sup>, L.M. de Carvalho<sup>6</sup>, G. Engemann<sup>7</sup>, S. Ertl<sup>8</sup>, L. Franz<sup>9</sup>, C. Grech<sup>10</sup>, P.M. Herzig<sup>1</sup>, R. Hekinian<sup>11</sup>, J.F. Imhoff<sup>1</sup>, T. Jellinek<sup>12</sup>, S. Klar<sup>13</sup>, A. Koschinsky<sup>2</sup>, J. Kuever<sup>14</sup>, F. Kulescha<sup>1</sup>, K. Lackschewitz<sup>3</sup>, S. Petersen<sup>9</sup>, V. Ratmeyer<sup>13</sup>, J. Renken<sup>13</sup>, G. Ruhland<sup>13</sup>, J. Scholten<sup>11</sup>, K. Schreiber<sup>9</sup>, R. Seifert<sup>8</sup>, J. Süling<sup>1</sup>, M. Türkay<sup>12</sup>, U. Westernströer<sup>11</sup>, F. Zielinski<sup>5</sup>

### 1. Introduction

The HYDROMAR I cruise, which is the first in a series of cruises to take place over the next 6 years, was carried out by the German R/V METEOR from January 14 to February 13, 2004. The main scientific aim of the cruise was to investigate the interrelationship of geological, geochemical, and biological processes in the active, ultramafic-hosted Logatchev hydrothermal field at 14°45'N on the Mid-Atlantic Ridge (MAR). The main tool for seafloor investigations and sampling was the deep-sea ROV Quest provided by the University of Bremen.

There were two main approaches during the cruise: (i) to map the seafloor at different scales (bathymetry, visual observations using a TV-sled and ROV Quest) and (ii) to obtain geological, fluid, and biological samples using the ROV Quest and a TV-grab. For detailed mapping and site relocations we used a combination of acoustic (the Posidonia system) and Doppler Velocity Log (DVL) navigation for Quest and only acoustic navigation for the TV-sled. This combination enabled us to navigate the ROV Quest within a one meter-scale accuracy on the seafloor and made a detailed mapping of seafloor structures possible.

The MAR between the 15°20'N fracture zone and about 14°35'N has a “blocky” and irregular morpho-structural setting characterized by abundant faulting and outcrops of serpentinized ultramafic rocks. The common occurrence of serpentinized peridotite on both flanks of the rift valley indicates a high ratio of tectonic to magmatic extension (Escartin and Cannat, 1999; Fujiwara et al., 2003). The Logatchev hydrothermal field at 14°45'N is situated in this tectonically controlled area. South of about 14°35'N these characteristics change to more regular, axis-parallel ridges as are typical for more robust magmatic extension.

### 2. Preliminary results of the HYDROMAR I cruise

#### 2.1. Regional Geology

Extensive bathymetric and video mapping during the M60/3 cruise revealed three factors which appear to control the location of the Logatchev hydrothermal field:

- (1) cross-cutting faults, (2) young basaltic volcanism, and
- (3) slump structures.

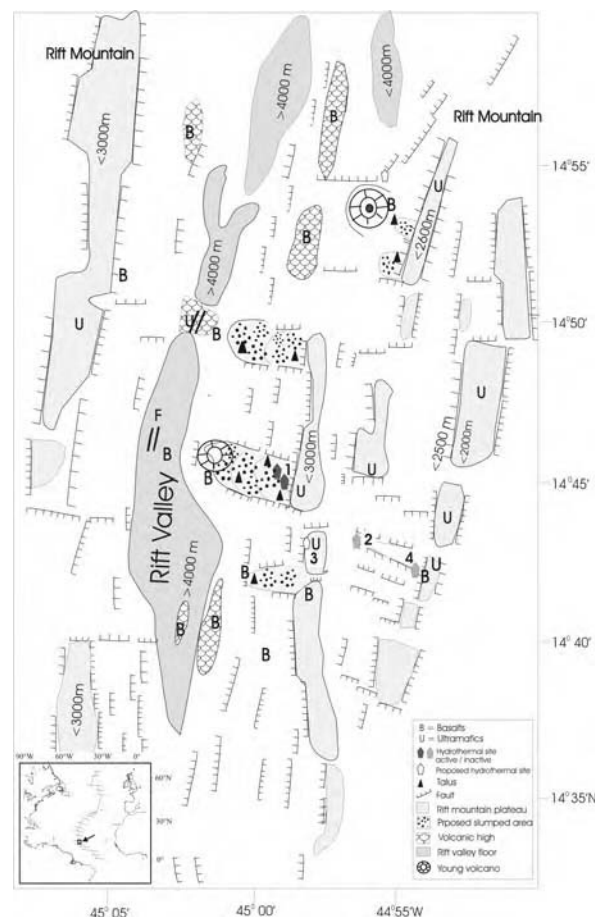


Figure 1

Sketched structural interpretation drawn after multichannel (Hydrosweep) bathymetry data of the MAR segment near 14°45'N – 45°00'W obtained during the HYDROMAR I cruise. Note the cross-cutting faults and the fault-related occurrence of hydrothermal fields. 1, 2, 3, and 4 are separate hydrothermal fields (Logatchev 1-4). Inset: location of the working area at the MAR.

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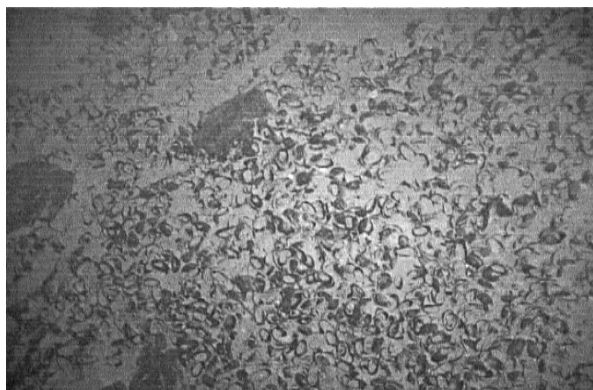


Figure 2  
The inactive Logatchev-4 hydrothermal field discovered during HYDROMAR I at 14°42.38'N / 44°54.50'W in 2000 m water depth. The field extends over a strike length of about 90 m and was detected during a TV-sled track about 50 m below the top of a WNW-ESE striking ridge (see Figure 1). There were no associated temperature or methane anomalies in the near-bottom water.

(1): N-S and WNW-ESE striking faults dismember the eastern valley wall into an irregular, blocky morphology (Figure 1). At least 3 hydrothermal fields occur at the intersection of a large WNW-ESE structure with N-S faults: the known Logatchev-1 and -2 hydrothermal deposits (Cherkashev et al., 2000; Lein et al., 2003) as well as a new, but inactive hydrothermal field (Logatchev-4 at 14°42.38'N / 44°54.50'W; Figure 2) which was discovered during M60/3 (Figure 1). (2): Relatively fresh basaltic lava flows were discovered in the rift valley just west of the Logatchev fields. Moreover, a young off-axis volcano was mapped at the intersection of the rift valley with the eastern valley wall at 14°45.3'N and 45°02'W (Figure 1). (3): The presence of several "step like" terraces bounded by WNW-ESE oriented transverse faults is believed to represent slumped structures as defined from the concentric ovally shaped contour lines observed from bathymetry and from ocean floor observations (Figure 1). These slumps are probably the result of major tectonic events that must have taken place during the uplift of the rift valley walls.

Our investigations show that hydrothermal circulation may have taken place throughout talus material and has altered peridotite debris. Indeed, sulfide-bearing, serpentinized ultramafic fragments underneath the hydrothermal chimneys and their surroundings were collected during several ROV and TV-grab stations. The formation of hydrothermal deposits on top of serpentinized peridotite is believed to result from the circulation of hot fluid through the fissured and faulted terrain associated with avalanche debris forming a porous medium. The heat is probably supplied from magmatic pools associated with basaltic melts localized underneath the adjacent rift valley and/or off-axis volcanic structures (Figure 1). Heat could also be provided by localized intrusion of melts (probably focussed along faults) into the peridotite. The presence of gabbroic and dolerite

fragments imbedded in the serpentinized ultramafics suggests late intrusion of magma post dating the emplacement of the serpentinized ultramafics.

To date, a situation similar to that of the Logatchev area has only been found at 14°54'N / 44°55'W (Figure 1), where a hydrothermal field was described from previous ocean floor observations (Eberhardt et al., 1988). Although we could not locate this hydrothermal field during the HYDROMAR I cruise, the similarity of the local geological setting to that of the Logatchev area indicates that this region has hydrothermal potential.

## 2.2. The Logatchev-1 hydrothermal field

The Logatchev-1 hydrothermal field is situated on a plateau right below a 350 m high cliff and at a water depth of 3060 m to 2900 m. Mapping and sampling with ROV Quest and the TV-grab revealed that the field is larger than previously described (Gebruk et al., 2000). It extends at least 800 m in a NW-SE and 400 m in a SW-NE direction (Figure 3). During a TV-sled track, hydrothermal precipitates were detected up to about 600 m SW of the main mound. Two main areas of high-temperature (high-T) hydrothermal activity make up the central part of the field: an area of at least three "smoking craters" (ANNA-LOUISE, IRINA and SITE "B") and the large mound of IRINA II with black smoker chimneys at its top as well as the newly discovered QUEST smoking crater (Figure 3). The smoking craters consist of a rampart-like rim that is 1-2 m high and a 2-3 m deep central depression. ANNA-LOUISE seems to be the largest crater observed having a diameter of about 10 m, whereas IRINA and "B" have distinctly smaller craters. Black smoke was intensely venting at all three sites. Strong bottom absent in these environments, and first inspections of the video material revealed that conspicuous hydrothermal fauna was largely restricted to alvinocarid shrimps occurring in moderate numbers, a few crabs (*Segonzacia*), unidentified actinians, the hydrozoan *Candelabrum* and several species of fish (Figure 4A). Abundant microbial mats were seen at locations where the black smoke emanating from the sea floor was in regular contact with the surfaces.

IRINA II consists of a mound with steep slopes rising about 15 m above the surrounding seafloor. The round to elongate structure has a basal diameter of about 60 m. Four vertical chimneys a couple of meters high mark the top of the mound. The chimneys are densely overgrown with mussels (*Bathymodiolus* cf. *puteoserpentis*). Shrimps (*Rimicaris exoculata*) gather in large numbers over low-T fluid vents along the sides of the chimneys. The chimneys are surrounded by densely populated mussel beds and also by dead chimneys and mussel shells further down the slope. The Marker ANYA was found on the NW base of the IRINA II slope surrounded by diffuse fluid venting with loosely aggregated mussels, a *Thyasira*-species living in the sediment and dense clusters of dead vesicomid shells. Living vesicomid specimens were not encountered. However, we doubt that this site is identical to the ANYA's

Garden locality described in the literature, because its position and distance from IRINA II does not correspond to the published data (Gebruk et al., 2000). ROV and TV-grab samples revealed that the populations of mussels, crabs and shrimps contained animals of all body sizes, which indicates continuous recruitment of these species rather than recruitment in discrete events, which would produce similar size cohorts.

QUEST is a newly discovered high-T, black smoke venting site situated about 130 m WNW (circa in 330° direction) of the active chimneys of IRINA II (Figure 3). The formation of a depression, small chimneys and smoking pipes emanating black smoke make the QUEST site comparable to the smoking craters on the main mound (Figure 4B). However, QUEST does not show the typical circular crater rim and therefore may represent a younger structure, possibly an early state of a developing smoking crater. While the faunal composition grossly corresponded to that found at the smoking craters on the main mound, QUEST additionally harboured scattered clusters of mussels.

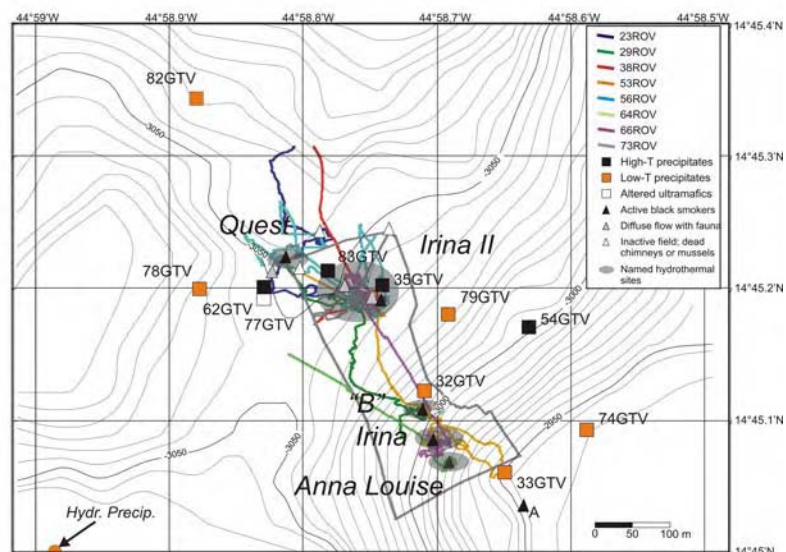
Dead mussel beds and inactive sulfide structures were mapped about 50 m to the north of the QUEST site, approximately 80 m north of IRINA II, and about 80 m WSW of ANNA-LOUISE. A temperature anomaly of 0.12°C was detected in bottom water during a TV-sled operation close to sampling station 82GTV. The samples recovered from this station contained low-temperature (low-T) hydrothermal precipitates (Fe-Mn oxides) similar to the ones generally found in the surroundings of the high-T areas of Logatchev-1 (Figure 3).

Hydrothermal fluids were sampled with a special fluid sampling system mounted on the ROV Quest. All fluid samples (both high and low-T) display similar patterns of their chemical composition. Therefore, the presence of a single fluid type is concluded. The emanating high-T fluids (sampled at black smokers) are strongly reducing and have a salinity close to or slightly less than seawater. Iron is the dominant dissolved and particulate bound metal. Measured hydrothermal fluids (all data are measured values are not yet extrapolated to hydrothermal endmembers!) have maximum dissolved Fe concentration of 60 mg/l, followed Mn (2.3 mg/l), Cu (0.1 mg/l), and Zn (0.1 mg/l). The maximum sulfide concentration

was 1.7 mg/l. The maximum measured concentrations of the gases  $^{222}\text{Rn}$ ,  $\text{H}_2$  and  $\text{CH}_4$  in the vent fluids are up to 22 dpm/l, 1.8 mmol  $\text{L}^{-1}$  and 0.28 mmol  $\text{L}^{-1}$ , resp. The resulting  $\text{H}_2/\text{CH}_4$  ratio of about 6.4 is in accordance with data reported by Charlou et al. (2002) for hydrothermal fluids of the Rainbow field that is also hosted in ultramafic rocks at the MAR. These authors give Mg-based calculated endmember concentrations of 2.5 mmol  $\text{L}^{-1}$  (methane) and 16 mmol  $\text{L}^{-1}$  (hydrogen). In view of the exact match of the  $\text{H}_2/\text{CH}_4$  ratios, one might assume our ROV samples comprise about 10% of the endmember fluid. The high methane and hydrogen concentrations and the low sulfide content (mainly below 1 mg/l) suggest a strong influence of serpentinization during fluid formation. This finding is supported by high Fe/Mn (ca. 25) and Fe/Cu ratios (> 100). The intense black smoke and first analyses of particles filtered from the black smoke support the high metal excess of the fluids. Sulfide may be almost completely removed from the fluids by precipitation of metal sulfides. Therefore, methane and hydrogen but also precipitated metal sulfides are considered to be the major energy sources for the development of life in the Logatchev field.

Host rocks of the Logatchev field sampled by TV-grab and ROV were mainly serpentinized peridotites while basalts and gabbros (sometimes in magmatic contact with peridotite) occurred subordinately. Remarkable were samples of coarse grained websterites, orthopyroxenites and Opx-rich, pegmatoid norites, which were interpreted as magmatic cumulates from the crust/mantle transition zone. A large variety of hydrothermal precipitates were recovered including massive chalcopyrite chimneys, massive pyrite crusts, silicified breccias, abundant secondary Cu-sulfides, red jaspers, abundant Fe-Mn-oxhydroxides as well as atacamite and Mn-oxides. Three TV-grabs recovered silicified crusts that may act as a caprock allowing for conductive cooling of the hydrothermal fluid (Figure 4C). Sulfides are enriched immediately underneath this caprock and usually contain more pyrite-rich sections at the top followed by more Cu-

Figure 3  
Logatchev-1 hydrothermal field with ROV tracks and TV-grab stations carried out during M60/3. QUEST is a newly discovered site venting high-temperature black smoke. Site "A" was not observed during M60/3 but described in literature (Gebruk et al., 2000). Hydrothermal precipitates (but no current hydrothermal activity) were also observed during station 89OFOS about 500 m to the SW of the Logatchev-1 field.





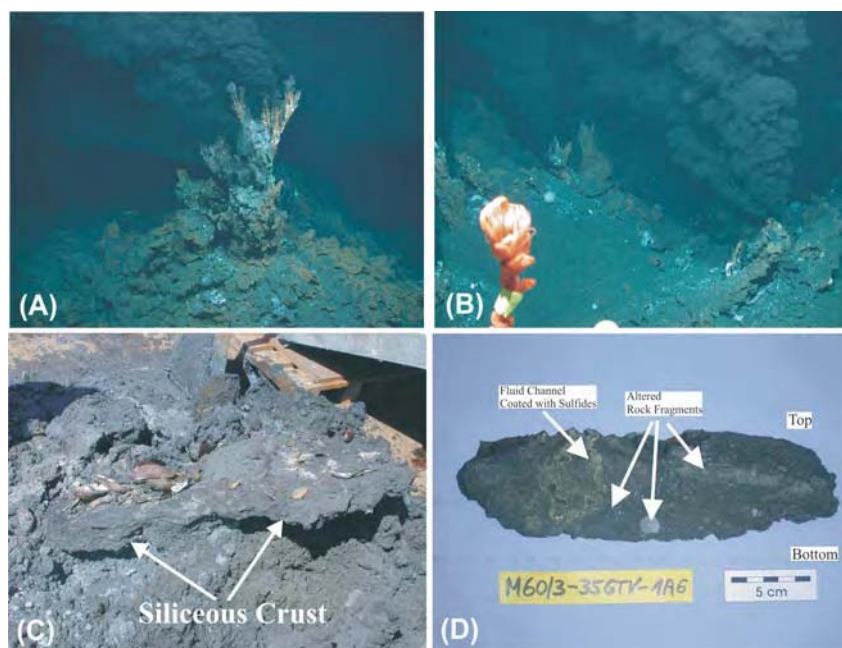


Figure 4

(A): Black smoker at rim of smoking crater site "Anna Louise". Note the very scarce fauna, which is in marked contrast to black smoker chimneys like IRINA II. (cf. Gebrück et al., 2000). (B): QUEST site venting black smoke. The characteristics of QUEST are very similar to other smoking craters. (C): Siliceous crust forming a caprock over massive sulfides, altered sediment and wallrock. Typical hydrothermal fauna on sediments above the crust. Maximum temperatures measured below the crust were 106°C. (D): Detail of siliceous crust of Figure 4C showing altered wallrock fragments and a fluid channel consisting of Cu-rich sulfides.

rich sulfides underneath. Single fluid channels coated with sulfides break through the caprock (Figure 4D) and may form black smoke emanation sites as they appear in the smoking craters. The base of the grabs often contained large amounts of grey to green-grey indurated mud possibly related to the alteration of host rock material. This suggests that the massive sulfides along the flanks of the deposit might only be a thin veneer directly at or below the seafloor. The amount of sulfide talus, the state of oxidation and the widespread abundance of atacamite suggest an old hydrothermal system. While oxidising environments prevailed, local reducing conditions resulted in the formation of secondary Cu-sulfides, mainly chalcocite, minor bornite and digenite along with small amounts of native copper.

### 3. Outlook

The HYDROMAR I cruise M60/3 was the first of a series of cruises to the Logatchev field within the German DeRidge program. The cruises will mainly aim at repeated and long-term measurements of hydrothermal fluids and vent biology. The investigations of hydrothermal precipitates, hydrothermally altered rocks and ultramafics focus on the genetic relationship between the hydrothermal system and their ultramafic host rocks. Shallow rock drilling using a 15-m core drill device will be used to develop a 3-D model of the near-subsurface structures of the Logatchev-1 field.

### Acknowledgements

We are grateful to captain M. Kull, the officers and the crew of the R/V METEOR as well the ROV crew for their excellent performance and co-operation which was essential for the success of the cruise. We are also thankful to G. Cherkashov for providing Russian data and maps prior to the HYDROMAR cruise and chief scientist A. Shagin of R/V Professor Logatchev for providing side-scan data of the Logatchev field during our meeting at sea. The

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### References

- Charlou, J.L., J.P. Donval, Y. Fouquet, P. Jean-Baptiste, and N. Holm, Geochemistry of high  $H_2$  and  $CH_4$  vent fluids issuing from ultramafic rocks at the rainbow hydrothermal field (36°14'N, MAR), *Chem. Geol.*, 191, 345-359, 2002.
- Cherkashev, G.A., A.M. Ashadze, and A.V. Gebruk, New fields with manifestations of hydrothermal activity in the Logatchev area (14°N, Mid-Atlantic Ridge), *InterRidge News*, 9 (2), 26-27, 2000.
- Eberhardt, G.L., P.A. Rona, and J. Honnorez, Geologic Controls of Hydrothermal Activity in the Mid-Atlantic Ridge Rift Valley: Tectonics and Volcanism, *Mar. Geophys. Res.*, 10, 233-259, 1988.
- Escartin, J., and M. Cannat, Ultramafic exposures and the gravity signature of the lithosphere near the Fifteen-Twenty Fracture Zone (Mid-Atlantic Ridge, 14°-16.5°N), *Earth Planet. Sci. Lett.*, 171 (3), 411-424, 1999.
- Fujiwara, T., J. Lin, T. Matsumoto, P.B. Kelemen, B.E. Tucholke, and J.F. Casey, Crustal Evolution of the Mid-Atlantic Ridge near the Fifteen-Twenty Fracture Zone in the last 5 Ma, *G3*, 4 (3), doi:10.1029/2002GC000364, 2003.
- Gebruk, A.V., P. Chevaldonné, T. Shank, R.A. Lutz, and R.C. Vrijenhoek, Deep-sea hydrothermal vent communities of the Logatchev area (14°45'N, Mid-Atlantic Ridge): diverse biotopes and high biomass, *J. Mar. Biol. Assoc. U. K.*, 80, 383-393, 2000.
- Lein, A.Y., G.A. Cherkashev, A.A. Ul'yanov, N.V. Ul'yanov, T.V. Stepanova, A.M. Sagalevich, Y.A. Bogdanov, E.G. Gurchich, and M.P. Torokhov, Mineralogy and Geochemistry of Sulfide Ores from the Logatchev-2 and Rainbow Fields: Similar and Distinctive Features, *Geochem. Intern.*, 41 (3), 271-294, 2003.

## A new hydrothermal field at 16°38.4'N, 46° 28.5'W on the Mid-Atlantic Ridge

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A new inactive hydrothermal field with massive sulfide deposits has been discovered at 16° 38.4'N, 46° 28.5'W on the Mid-Atlantic Ridge. In 2002, during cruise 19 of R/V Professor Logatchev, hydrothermal signals were recorded from bottom waters and sediments in this area. The site was revisited during the 24th cruise of R/V Professor Logatchev in February 2004 when samples of massive sulfides were recovered and video records of the deposits made. In all, four dredges and three TV-grabs with sulfides were deployed.

The new hydrothermal field is located at a depth of 3700-3750 m, 600 m above the inner floor on the eastern slope of the rift valley (Figure 1). Structurally, the new field is located at the intersection of a deep along-axis marginal fault and a transverse sub-latitudinal

Six sulfide mounds and several sites of metalliferous sediments were sampled and/or recorded by video profiling within the hydrothermal field. The largest mounds are located in the southern part of the field. In the NNE part of the field, the deposits are overlain by metalliferous sediments. The southern and western boundaries of the field have not yet been delineated. The largest ore body, 500 x 225 m, consists of small blocky talus and relics of sulfide chimneys covered by iron oxyhydroxides. The chimneys are 1-5 m high. The remaining ore bodies have similar structures. The sediments consist of a metalliferous component with varying amounts of biogenic carbonate. The main indicators of hydrothermal activity in the sediment are barite and iron oxyhydroxides. Their abundance increases downcore reaching more than 70% of the heavy mineral fraction.

Ore-bearing (metalliferous) sediments form 50 to 150 m thick bands which cover the northern and northeastern flanks of the ore bodies. The thickest layer of ore-bearing sediment containing sulfide debris was found at a depth of 1.0-1.4 m within a sediment core. This appears to mark the period of most intense hydrothermal activity. No typical hydrothermal fauna were observed and no anomalies were detected in the near-bottom waters during this study. This confirms that the period of hydrothermal activity which generated the sulfide deposits has already ended.

More than 1,100 kg of massive sulfides and stockwork mineralization were sampled at 7 sites. In all samples, iron sulfides are the principal minerals present. Pyrite, in association with lesser amounts of

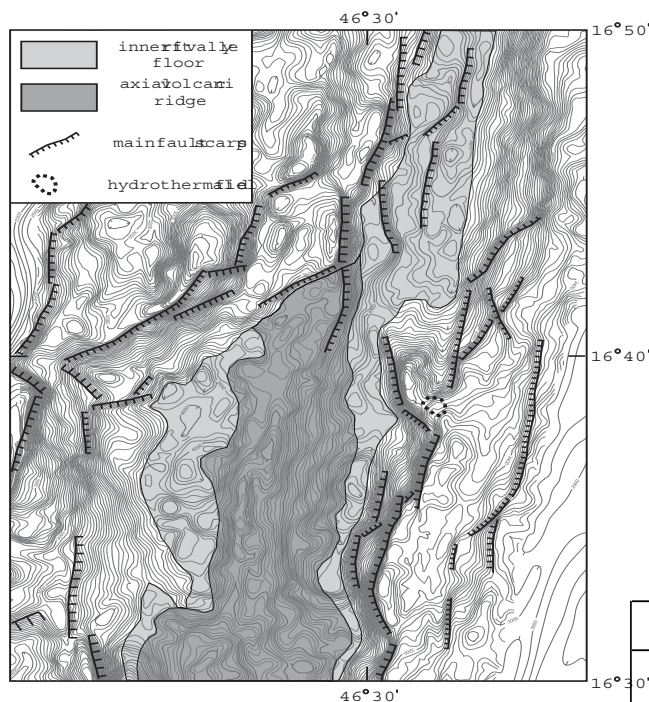


Figure 1  
Bathymetric map with morphostructural elements and location of the new hydrothermal field at the Mid-Atlantic Ridge. The contour interval is 25 m.

dislocation. Basalts form the host rocks within the hydrothermal field. Gabbro-peridotites were dredged from the terrace of the western rift valley slope opposite the hydrothermal field. The steep cliff and terrace on the eastern slope above the hydrothermal site are probably also mainly made up of ultramafic rocks.

Sample description	Cu	Zn	Fe	S	Au	Ag
Fe-sulfides	0,18	0,35	44,13	45,26	0,94	15,00
	0,15	0,21	45,29	49,01	1,29	10,20
	0,07	0,17	45,39	46,96	0,37	4,90
Cu-Fe sulfides	25,00	0,26	24,13	28,64	6,25	122,00
	31,30	0,24	32,77	32,01	0,43	27,30
	19,12	0,07	31,82	37,60	1,88	68,10
Zn-Fe sulfides	0,30	2,08	42,09	46,93	2,92	31,50
	0,06	1,25	44,62	48,82	1,79	14,90
	0,07	0,45	44,97	48,19	4,84	14,80
Metalliferous sediments	1,68	0,17	37,33	2,10	0,28	4,30
	0,26	0,49	33,75	2,14	0,38	6,10

Table 1.  
Chemical composition of samples recovered from the new hydrothermal field (Cu, Zn, Fe, S in %; Au, Ag in ppm).

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chalcopyrite, occurs in both massive sulfides and stockwork mineralization. Of particular interest is the chalcopyrite-siliceous stockwork where silicified basalts are intruded by a network of chalcopyrite veinlets. These zones can be fairly thick and enriched in base metals. Sphalerite which typically occurs in chimneys, was very rare in the dredged samples. Preliminary compositional data of sulfides and metalliferous sediments are listed in Table 1.

A preliminary estimate of the ore resources of the field is about  $4.7 \times 10^6$  t. However, further studies may lead to higher estimates if the ore bodies buried under the metalliferous sediments in the NNE part of the field are taken into account and the western and southern boundaries of the field are extended.

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### **Deep-tow sonar survey of the Mariana spreading axis : initial results of the KR03-12 cruise**

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#### **1. Introduction**

The Mariana Basin has been opening for the past 6 Ma (Hussong and Uyeda, 1982) behind the Mariana subduction zone, where the Pacific Plate subducts beneath the Philippine Sea Plate. Spreading processes are driven by strong extensional forces due to the combined effects of the sea-anchor force of the subducted Pacific Plate beneath the Mariana Arc and the rapid northwestward movement of the Philippine Sea Plate. The basin extends from 12°N to 23°N and is characterized by a crescent shape. Crustal thickness varies from 4 to 7 km in its central part, with a velocity structure typical of slow-spreading ridges (e.g., LaTraille and Hussong, 1980; Sinton and Hussong, 1983). Magmas in the central part of the basin are back-arc basin basalts (BABB). They are similar to normal mid-ocean ridge basalts, but with a "subduction component" that travels with fluids extracted from the subducted slab or sediments (Newman et al., 2000; Stern et al., in press).

In the central part of the Mariana Basin the full spreading rate ranges from 3 to 5 cm/y (Bibee et al., 1980; Hussong and Uyeda, 1982; Seama and Fujiwara, 1993; Deschamps and Fujiwara, 2003). The spreading axis is composed of several spreading segments, each 20 to 50 km in length. Segment morphology varies from wide, deep valleys, with or without a median axial volcanic ridge (AVR), to narrower, shallower and hourglass-shaped valleys. Segments with an hourglass-shaped morphology are interpreted as being more magmatically robust (Fox et al., 1991; Sempere et al., 1993). Within a single spreading segment, axial depth varies by 1-2 km between the shallow axial high at the segment center and the deeper segment ends. Each segment longer than 20 km displays along-axis variations in crustal thickness and/or upper mantle density, as demonstrated by low residual gravity anomalies at segment mid-points (Kitada et al.,

2002). This is evidence that magma emplacement is focused at segment midpoints (e.g., Lin et al., 1990).

The spreading ridge is characterized by highly asymmetric spreading processes, the half-spreading rate being two to three times larger on the western side of the ridge than on the eastern side. This asymmetry is as strong at the centers of segments as at their ends, and does not systematically correlate with an asymmetric shape of the rift valley: segment ends typically have a half-graben shape and at segment centers, a symmetric to slightly asymmetric graben shape characterizes the valley despite the presence of a highly asymmetric central magnetic anomaly (Deschamps and Fujiwara, 2003).

#### **2. Scientific purpose of the KR03-12 cruise (MICRO-MAR project)**

The MICRO-MAR (MICRObathymetry on the MARIana spreading ridge) project consisted of a survey of the central Mariana Basin's ridge system. We conducted a deep-tow sidescan sonar survey of the ridge in order to document small-scale spreading axis morphology. The goal was to understand the interrelationship between seafloor faulting and volcanism, and its variation depending on the spreading rate, the thermal state of the underlying mantle and the spreading asymmetry. The cruise surveyed the axial valley floor along two distinct spreading segments, each characterized by different spreading rates, degrees of asymmetric spreading and magmatic robustness. The KR03-12 cruise began in Yokosuka (Japan) on October 22, and ended at Guam (U.S.) on November 14, 2003.

#### **3. Cruise instrumentation**

In order to get surface bathymetric and side-scan sonar data with higher resolution than existing surface data, we performed low speed (5 to 5.6 knot) surface surveys

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over areas where we collected deep-tow sonar data. A SEABEAM 2112 system was used. Acquisition, post processing, and display softwares are Sea View, Caribes (IFREMER) and GMT, respectively.

The “Wadatsumi” (SYSTEM100D) deep-tow sidescan sonar from ORI (Ocean Research Institute, Univ. of Tokyo) operates at a frequency of 100 kHz, and collects a ~1 km wide swath, 500 m on each side of the vehicle, at a tow altitude of ~300 m. There are 2048 pixels across the swath, each pixel containing a water depth and an echo intensity measurement. Image pixel size is 50 x 100 cm on average. The system produced phase-bathymetry data with a resolution of ~2-5 m only on the starboard side of the sonar due to technical problems. Sub-bottom profiles using 4-6 kHz chirp profiler attached to the towfish were also collected. All measurements are corrected for actual towfish altitude using an internally mounted, six-component, motion sensing unit. The entire system consists of towfish, depressor, tow winch, surface electronics processing system (SEP), logging computer and printers. During this cruise, we used 10 km-long optical cable for towing. The position of the towfish was determined by the SSBL (Super Short Base Line) system and corrected taking into account the wire length.

**4. Preliminary results**

The Wadatsumi was towed within the inner floor of the axial valley of two spreading segments of the Mariana

Ridge, that are characterized by differing spreading rates and magmatic robustness.

**4.1. “Tectonic” segment A**

Segment “A” is located at ~18°N. Its median valley floor consists of a wide (10-15 km) graben bordered by rectilinear walls. The valley floor shoals and slightly narrows towards the segment midpoint, and contains a well-developed, almost linear AVR (1-4 km wide, up to several 100’s of m high). The spreading occurs at ~32 mm/yr full rate (Deschamps and Fujiwara, 2003). We collected data along 4 ~22 km-long lines over the AVR, at the segment midpoint and towards its southward extension, resulting in a surveyed region ~4 km wide.

The dominant constructional texture of the AVR is a highly reflective, hummocky volcanic terrain with no sediment. It consists of a conglomeration of almost circular mounds. Mound diameters range from a few tens of meters to about 400 m. They have rounded summits and no summit craters except for the few largest ones (~400 m diameter). TOBI data from the Mid-Atlantic Ridge between 24°N and 30°N (e.g., Smith et al., 1995; Lawson et al., 1996; Briais et al., 2000) show AVRs with similar characteristics. According to other studies combining deep-tow backscatter and camera data, each hummock probably represents one pillow flow (e.g., Lawson et al., 1996). Sometimes, the hummocks have a strong linear arrangement such that a row of connected mounds form

constructional linear ridges. These ridges are up to ~1 km long and 150 to 250 m wide. Some of them trend 015°W parallel to the general trend of the rift valley. Rarely, ridges trend N-S and there are often fissures on the summit of such ridges. The fissures parallel the trend of the ridges, i.e., 015°W or N-S. Toward the segment midpoint, a few smoother lava flows are observed. They seem to have pits that may be related to small areas of lava collapse.

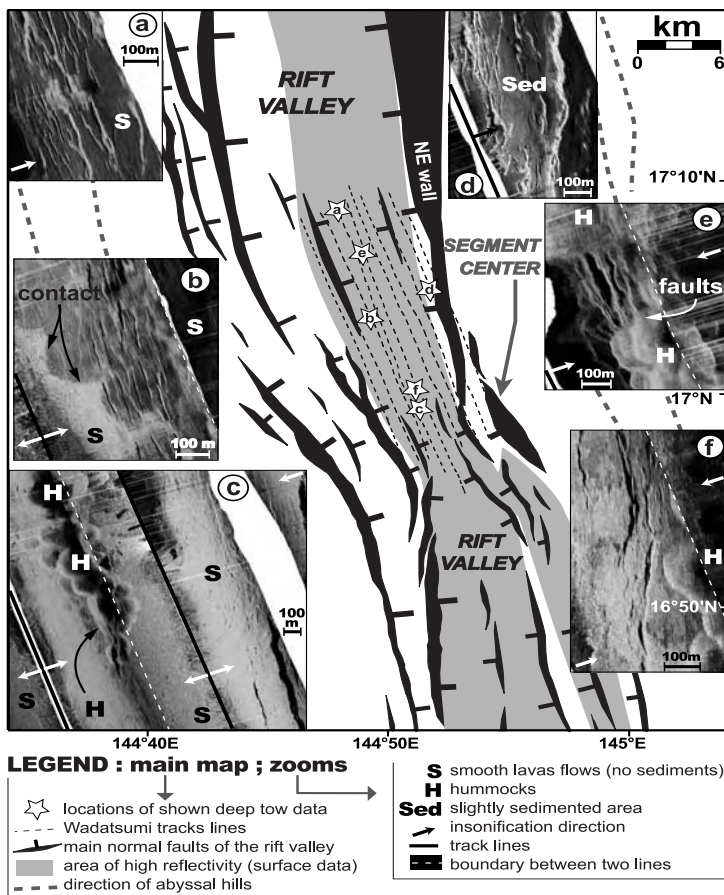


Plate 1

Main frame : simplified structural map of segment B. The large normal fault scarps observed from surface bathymetric data are indicated. Gray area: zone of highest reflectivity of the seafloor on surface backscatter data: it thus represents the most volcanically active area of the valley. Stars: location of deep-tow data examples. Dotted lines: Wadatsumi track lines.

Small frames: Wadatsumi backscatter data over 6 areas. Areas of highest reflectivity: white. (a) set of 015°W-striking fissures; (b) fissured terrain partially buried below recent (in white) smooth flows; (c) contact between smooth flows and a hummocky ridge; (d) N-S fissures and normal faults; (e) 020°W faults partly covered by hummocks. These hummocks are often cut themselves by N-S fissures and faults (not shown here); (f) N-S set of fissures and faults.

In general, there are many more fissures and faults on both flanks of the AVR than on its summit. Two sets of fissure orientations are observed. One trends  $015^{\circ}\text{W}$  and can be found everywhere, but mainly on both flanks of the AVR. The other set trends N-S, that is oblique with respect to the trend of the rift valley and to the AVR. These N-S tectonic structures seem to be present only on the summit of the AVR. However the small number of faults prevents a reliable determination of the spatial distribution of such sets.

#### 4.2. "Magmatic" segment B

Segment B is located at  $\sim 17^{\circ}\text{N}$  (Plate 1). It is characterized by a dome-shaped morphology. The median valley floor is hourglass-shaped, narrowing and shoaling to  $< 3400$  m depth at the magmatic center (at  $\sim 17^{\circ}\text{N}$ ), and widening and deepening to  $> 4700$  m at its end. The valley is  $\sim 10$  to  $13$  km wide, and does not contain an AVR. This segment exhibits enhanced magma supply compared to segment A and is hence likely to be characterized by a higher thermal regime. Spreading occurs at a faster rate ( $\sim 40$  mm/yr, full-rate) than along segment A, and its asymmetry is also stronger. We collected 10 deep-tow side-scan sonar data lines, each  $\sim 12$  km long, and located over the center of segment B and its northward extension, resulting in a survey area over  $\sim 10$  km wide across the ridge axis.

The dominant constructional texture at the center of the segment is a smooth and highly reflective terrain, with little to no sediment (Plate 1). The terrain also displayed irregularly scattered, small ( $< 10$  m diameter) mounds. These highly reflective and smooth areas probably correspond to recent lava flows that extruded at a relatively high rate. Toward the segment end, hummocky terrain becomes dominant, and consists of a conglomeration of almost circular mounds. Mound diameters range from a few tens of meters to about  $\sim 350$  m. The mounds have rounded summits and no summit craters. The boundary between hummocks and smooth flows has a V-shape, with the "V" being enlarged toward the end of the segment where hummocks dominate.

The rift valley is characterized by an array of fissures and normal faults that affect both hummocky and smooth flow terrains. Numerous grabens from few meters to a few tens of meters wide are also observed. They may be dike-induced grabens. The density of faults or fissures is high, with a cross-strike spacing of often less than  $\sim 30$  m. The exception is a small area located at segment midpoint that is covered by smooth flows and does not display a large amount of fissures and faults. Two distinct trends of faults are defined. One fault set is roughly parallel to the global valley trend ( $025^{\circ}\text{W}$  at segment center and  $010^{\circ}\text{W}$  toward segments ends). The second fault set trends N-S, oblique to the direction of the valley. Frequently, in the inner valley floor,  $025$ - $020^{\circ}\text{W}$  trending faults that parallel the axial valley are covered by hummocks, and these hummocks themselves are cut by N-S trending faults. N-S trending fissures and faults are

found in the innermost part of the valley and along its northeastern wall ("NE wall" on Plate 1). This "NE wall" appears, from surface data, to be composed of several connected N-S fault scarps.

In general, faults in the innermost part of the valley seem to be less complex and therefore less evolved than faults located close to valley walls. At this latter location, the fault zone contains a complex array of anastomosing and linking fault traces. Faults are generally longer and are defined by an irregular trace in plan view.

#### 5. Summary

Segment A is characterized by a wide and deep rift valley, while segment B is much shallower with an hourglass shape, the latter being interpreted as more magmatically robust (Deschamps and Fujiwara, 2003). Yet the innermost part (i.e., the AVR) of segment A appears to be less faulted than segment B. This may indicate that AVR in segment A is in a period of volcanic construction, and that segment B is presently more magmatically-starved and in a period of tectonic dismemberment. However, the median floor of segment A outside the AVR could not be surveyed, thus we could not observe the density of faulting at that location.

The overall fault and fissure pattern (i.e., the presence of two sets of faults at both segments A and B) might be the result of oblique extension, i.e., spreading non-perpendicular to the ridge trend. The N-S trend of the innermost faults and fissures at both segment A and B could indicate a  $090^{\circ} \pm 15^{\circ}$  direction for the minimal stresses along the Mariana ridge axis.

#### Acknowledgments

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#### References

- Bibee, L.D., G.G. Shor Jr., and R.S. Lu, Inter-arc spreading in the Mariana Trough. *Mar. Geol.*, 35, 183-197, 1980.
- Deschamps A. and T. Fujiwara, Asymmetric accretion along the slow-spreading Mariana Ridge. *Geochemistry, Geophysics, Geosystems (G<sup>3</sup>)* 4, 10, 8622, doi:10.1029/2003GC000537, 2003.
- Fox, P.J., N.R. Grindlay, and K.C. Macdonald, The Mid-Atlantic Ridge ( $31^{\circ}\text{S}$ - $34^{\circ}30'\text{S}$ ): Temporal and spatial variations of accretionary processes. *Marine Geophysical Research*, 13, 1-20, 1991.
- Hussong, D.M., and S. Uyeda, Tectonic processes and the history of the Mariana Arc, A synthesis of the results of Deep Sea Drilling leg 60. Initial Reports of the Deep

Sea Drilling Project: U.S. Government Printing Office, Washington D.C., edited by D.M. Hussong, et al., pp. 909-929, 1982.

Kitada, K., N. Seama, Y. Nogi, T. Matsuno, H. Iwamoto, T. Goto, N. Wakabayashi, K. Nakase, K. Okino, T. Fujiwara, W. Soh, Y. Hasegawa, K. Mitsuzawa, T. Yamazaki, and K. Suyehiro, Gravity Anomaly of Mariana Trough (abstract), NSF-IFREE MARGINS Workshop on the Izu-Bonin-Mariana Subduction System, Honolulu, Hawaii, September 8-12, 2002.

LaTraille, S.L. and D.M. Hussong, Crustal structure across the Mariana Island Arc. The Tectonic and Geologic Evolution of Southeast Asian Seas and Islands, edited by D.E. Hayes, Geophysical Monograph, American Geophysical Union, Washington DC, 23, 209-221, 1980.

Lawson, K., R.C. Searle, J.A. Pearce, P. Browning, and P. Kempton, Detailed volcanic geology of the MARNOK area, Mid-Atlantic Ridge north of Kane transform. in MacLeod, C.J., P.A. Tyler, and C.L. Walker (eds), Tectonic, Magmatic, Hydrothermal and Biological Segmentation of Mid-Ocean Ridges. Geological Society Special Publication, 118, 61-102, 1996.

Lin, J., G.M. Purdy, H. Schouten, J.C. Sempere, and C. Zervas, Evidence from gravity data for focused magmatic accretion along the Mid-Atlantic Ridge. *Nature*, 344, 627-632, 1990.

Newman S., E. Stolper, and R. Stern, H<sub>2</sub>O and CO<sub>2</sub> in magmas from the Mariana arc and back arc systems.

*Geochemistry, Geophysics, Geosystems*, 1, 1999GC000027, 2000.

Seama, N. and T. Fujiwara, Geomagnetic anomalies in the Mariana Trough 18°N. Preliminary report of the Hakuho-Maru Cruise KH92-1, edited by J. Segawa, Ocean Research Institute, University of Tokyo, 70-71, 1993.

Sempere, J.C., J. Lin, H.S. Brown, H. Schouten, and G.M. Purdy, Segmentation and morphotectonic variations along a slow-spreading center: the Mid-Atlantic Ridge (24°00'N-30°40'N). *Marine Geophysical Researches*, 15, 153-200, 1993.

Sinton, J.B. and D.M. Hussong, Crustal structure of a Short Length Transform Fault in the Central Mariana Trough. The Tectonic and Geologic Evolution of Southeast Asian Seas and Islands, Part 2, edited by D.E. Hayes, Geophysical Monograph, American Geophysical Union, Washington DC, 27, 236-254, 1983.

Smith, D.K., J.R. Cann, M.E. Dougherty, J. Lin, S. Spencer, C. MacLeod, J. Keeton, E. McAllister, B. Brooks, R. Pascoe, and W. Robertson, Mid-Atlantic Ridge volcanism from deep-towed side-scan sonar images, 25 degrees - 29 degrees N. *Journal of Volcanology and Geothermal Research*, 67 (4), 233-262, 1995.

Stern, R.J., M.J. Fouch, and S.L. Klemperer, An Overview of the Izu-Bonin-Mariana Subduction Factory. The subduction factory, edited by J. Eiler and M. Hirschmann, AGU special volume, in press.

### **Acoustic monitoring of the Mid-Atlantic Ridge north of the Azores: preliminary results of the SIRENA experiment**

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#### **1. Introduction**

Since 1996, autonomous hydrophone arrays have been deployed in several oceanic basins to monitor earthquake activity along plate boundaries (Dziak and Fox, 1999, Dziak et al., 2000, Fox et al., 2001, Smith et al., 2003). The NOAA's Pacific Marine Environmental Laboratory in Newport, Oregon, developed these instruments as a mobile version of the U.S. Navy's classified military technology SOSUS (SOund SURveillance System real-time multiple-hydrophone instruments) used in the North Pacific. Autonomous hydrophones are deployed in the SOFAR (SOund Fixing And Ranging) channel on a modified oceanographic mooring. The temperature- and pressure-related variations of the sound velocity in seawater result in the presence of a minimum-velocity channel in which acoustic waves are "trapped". This effect allows them to travel efficiently over very long distances (up to several

thousand kilometers) with very low signal attenuation.

Seismic waves from earthquakes or volcanic tremor when crossing the rough seafloor-ocean interface, generate hydroacoustic phases called T-phases (T stands for "Tertiary", because these waves travel more slowly in water than seismic waves do within the solid Earth and are the third main phase to arrive on land seismometers). Due to their efficient propagation in the SOFAR channel, T-phases recorded on autonomous hydrophones allow low-magnitude seismic events to be detected that are not otherwise recorded by land-based seismic stations. Such a lowering of the magnitude threshold is of particular interest for monitoring mid-ocean ridge seismicity, as the vast majority of earthquakes occurring along axis of oceanic ridges are small-magnitude events.

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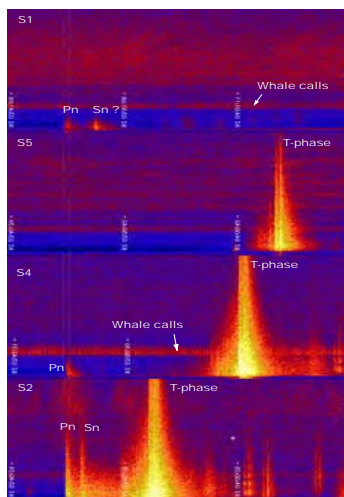


Figure 1 Spectrograms of the four hydrophones illustrating Pn and (Sn) arrivals from an event located in the Oceanographer Fracture Zone. Time is along the X-axis. For each channel, frequencies range from 0 to 124 Hz from bottom to top. S1 registers Pn and Sn seismic phases, however due to the Azores plateau blocking the SOFAR channel it is not able to record T-phase signals from the same event.

Here we present preliminary results on the analysis of seismicity at the axis of the northern Mid-Atlantic Ridge (MAR), as recorded by the SIRENA hydrophone array deployed for sixteen months between Iceland and the Azores.

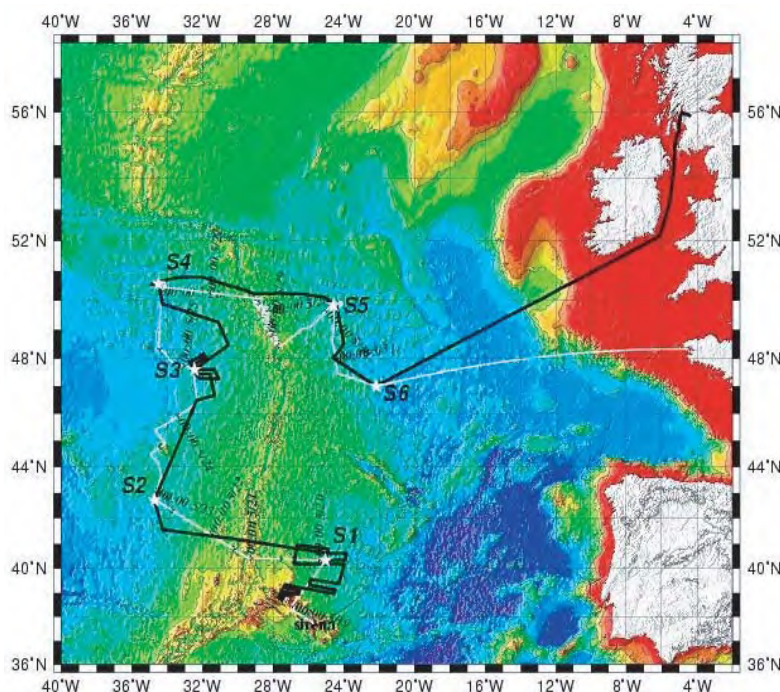
**2. The scientific objectives**

The main objective of the SIRENA array deployment is the long-term monitoring of earthquake activity occurring at the Mid-Atlantic Ridge (MAR) axis. Understanding the spatio-temporal distribution of earthquakes along the MAR in context of the interactions between this slow-spreading ridge and the Azores plume will help achieve the following objectives:

**2.1. Main objective: to understand better active processes at the axis of mid-ocean ridges**

Slow-spreading ridges are characterized by the partitioning of magmatic and tectonic episodes in space and time (e.g. Dauteuil & Brun, 1996, Thibaud et al., 1998; Thibaud et al., 1999). However, the relative division of these two processes and the width of the active tectonic deformation zone remains largely unknown and awaits direct observation of ridge seismicity at segment scales, as well as understanding associations between the spatial distribution of seismicity and the main topographic features observed along the ridge. Such associations will be made possible with the help of Digital Elevation Models (DEMs) recently obtained over the MAR axis.

Figure 2 Ship tracklines during the SIRENA1 (black) and SIRENA2/D274 (white) cruises. Indexed stars indicate the positions of the SIRENA hydrophone mooring sites.



In particular, TRIATNORD (Goslin et al, 1999) and SIRENA1 cruises enabled a detailed multi-beam swath mapping of the Mid-Atlantic Ridge axis. Together with previous surveys, these data provide complete bathymetry coverage from 40°20'N to 51°55'N (with the exception of the section between 46°N and 48°20'N where only a few single-beam and multi-beam tracks crossed the MAR).

**2.2. Tomography of the crust and upper mantle under the MAR's axis in a ridge/hot-spot interaction context**

Acoustically converted seismic phases recorded by the hydrophones can be used to get some information on the seismic velocity structure of the crust and upper mantle under the MAR's axial domain. Lower crust, upper mantle P<sub>n</sub> arrivals generated by large ridge earthquakes are frequently recorded by one or two hydrophones. P<sub>n</sub> arrives earlier than the T phase as the seismic wave velocity is much higher along the Moho than acoustic propagation speeds in seawater (Figure 1). However, because of rapid attenuation of the P<sub>n</sub> waves when traveling through the crust, only instruments close (< 2000 km) to the epicenter will record them. The P<sub>n</sub> arrivals can be used to derive an average sub-Moho velocity between the epicenter and the instruments where they were recorded (Dziak et al., in press).

Global tomography models (e.g. Ritsema et al., 1999; Mégnin and Romanwicz, 2000) derived from the inversion of teleseismic data represent the only direct information on the distribution of seismic velocities (and hence of densities and temperatures) in the upper mantle. Unfortunately global models do not provide a sufficient horizontal resolution for the upper mantle (normally resolution is less than 1000 km for depths shallower than 150 km and they are not reliable at all in the shallowest 50 km).

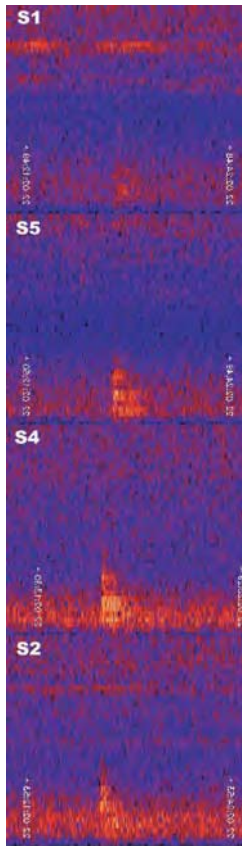


Figure 3  
Hydrophone spectrograms displaying P phase arrivals from a large magnitude earthquake ( $M = 7.6$ ) with epicenter at the Middle America Trench ( $104^{\circ}06'W$ ,  $18^{\circ}46'12''N$ ). Frequency range 0–10 Hz.

Hydrophone data can be used to improve regional-scale tomographic models because the inversion of travel time anomalies of seismic waves generated by ridge-crest earthquakes recorded at land stations does not allow for well-constrained epicenter locations. Therefore precisely located epicenters should improve both the reliability of the inversion and estimates of the upper mantle velocity structure. Such a “high”-resolution model would represent a major advancement of the understanding of ridge-hotspot interaction processes active in the upper mantle.

Unfortunately, only a few ridge earthquakes release sufficient energy to be recorded by several distant stations (typically only those with  $m_b > 5.0$ ). Long-term deployment of hydrophone arrays can aid in both reducing location error of ridge earthquakes as well as providing sufficient time to allow for a significant number of large magnitude ridge events to occur.

### 2.3. Observations on the time-variability of along-axis seismicity of the MAR

These observations both south and north of the Azores and comparisons with the seismicity of the Azores Archipelago may provide a framework to assess the seismic hazard of the inhabited Azores Archipelago.

### 2.4. Detection of sounds produced by whales

Hydrophone data will also be analyzed to detect sounds produced by whales in order to evaluate the distribution and migratory pattern of various major and endangered cetacean species. This piggyback experiment on SIRENA is conducted by PMEL in collaboration with the University of the Azores as part of the environmental monitoring program of marine mammals in the world's oceans.

## 3. The SIRENA experiment

The SIRENA Project was set up in 2000, as a cooperative agreement between UMR6538/CNRS (Brest, France; PI J. Goslin), the “Géosciences Marines Lab” from IPG Paris, the PMEL/NOAA (Pacific Marine Environmental Lab, Newport, OR, USA), the CGUL (Lisbon University Geophysical Center) and the CIMA (Marine and

Environmental Research Center, University of Algarve – Portugal).

Two cruises have already occurred within the framework of this project (Figure 2):

- SIRENA1-2002 cruise aboard the R/V Le Suroit, started in Ponta Delgada (Açores) on 16 May and docked in Brest on 4 June 2002. Six hydrophones were successfully deployed on both flanks of the Mid-Atlantic Ridge between the Kurtchatov Fracture Zone immediately north of the Azores Plateau and a major discontinuity south of the Charlie Gibbs Fracture Zone (between  $40^{\circ}20'N$  and  $50^{\circ}35'N$ ) (see report at <http://www.sdt.univ-brest.fr/~goslin/SIRENA/REPT>).

- The hydrophone array was recovered during the SIRENA2/D274 cruise, undertaken on RRS Discovery, which started in Govan, Scotland on 12 September and ended in Ponta Delgada on 1 October 2003) (Figure 2).

Throughout the deployment duration of the hydrophone array, a seismological land station was operated on the northern coast of Graciosa Island (Azores). Data recorded by this station were analyzed to look for converted T-phases (crustal phases that are converted from hydroacoustic T-phases, where the SOFAR channel meets the island slope). The results obtained from the recovered hydrophone data (see below) suggest a strong time-variability of seismicity. Team members are therefore presently focusing their efforts in their respective countries to try to secure ship-time to re-deploy the array in 2005 for a one-to a maximum of a two-year period to lengthen the series of observations.

Prior to the deployment of the SIRENA array, another autonomous hydrophone array was deployed in February 1999 south of the Azores by NOAA/PMEL, Woods Hole Oceanographic Institution and Lamont Doherty Earth Observatory between latitudes  $17^{\circ}N$  and  $35^{\circ}N$  (Smith et al, 2003, Dziak et al, 2004). This array will be kept in operation until 2006 through US-NSF funding. Unfortunately, while hydrophones are capable of recording acoustic signals originating from thousands of miles away, the presence of the shallow and extensive Azores Plateau disrupts the SOFAR channel and acts as a natural barrier to sound propagation. This reduces the number of earthquakes the “NSF array” is able to detect along the MAR axis north of the Azores. The SIRENA array is also similarly affected by the Azores Plateau, however a surprisingly large number of earthquakes from the MAR south of Azores were detected on SIRENA. Location of these events will be greatly aided by the simultaneous interpretation of data from both networks. Such an interpretation is presently in progress. Thus, the two networks complement one another, which was the main rationale for deployment of the SIRENA array. Together they enable optimized earthquake monitoring of the entire Northern Mid-Atlantic Ridge axis from  $16^{\circ}N$  to  $50^{\circ}N$ . Lastly, in addition to the T-phase arrivals, the Sirena hydrophone array has also observed seismic



phases, generated by distant earthquakes, which have traveled through the lower mantle and core (Figure 3).

#### 4. SIRENA2 / D274 Cruise Results

##### 4.1. Autonomous hydrophone and along-track data

Of the six hydrophones deployed in May 2002 (Figure 2), five were recovered during SIRENA2/D274. Due to the probable failure of the acoustic release, and despite nearly two days of efforts, we were not able to recover S3. Hydrophones S1, S2, S4 and S5 recorded data during the entire time they were deployed (respectively 1015, 1003, 988 and 976 data files about ~21-MB each: as the moorings were recovered in reverse order from the deployment order, S1 was deployed first, recovered last, and therefore recorded a longer time series). S6 stopped recording data on the 12<sup>th</sup> day after its deployment. Fortunately, the four operational hydrophones occupied the four corner sites of the array and preliminary data analysis indicated they provided accurate locations of earthquakes that occurred within the array. For all the hydrophones deployed, the data resolution was 12-bit and the sampling rate was 250Hz with 110Hz cut-off frequency.

In addition to the hydrophone acoustic data, towed magnetic and shipboard gravity data were continuously recorded along the ship's tracks during both SIRENA1 & 2. Multi-beam bathymetry and seafloor imagery were also recorded during SIRENA1 and single-beam bathymetry during SIRENA2. The very rough weather throughout SIRENA1 precluded the optimization of transit lines between sites to acquire valuable along-track data. A multi-beam survey of the ridge axis between latitudes 48°20'N and 50°05'N could however be completed.

More accommodating wind and sea conditions during SIRENA2/D274 enabled full use of the transit lines between mooring sites for geophysical surveys. These lines were planned to bridge gaps in marine magnetic and gravimetric North Atlantic compilations, namely where anomalies C6 and C13 had poorly constrained geometries on either flank of the MAR. In addition to transit lines between sites, three specific magnetic surveys were conducted: (1) two long E-W lines (Figure 2) were run overnight in the vicinity of site S3, between attempts to recover the S3 hydrophone; (2) two days were devoted to performing a magnetic survey along the eastern flank of the Mid-Atlantic ridge north and south of site S1; finally (3) a survey was completed to the west and to the southeast of Terceira Island in the Azores Archipelago. West of the Island lies the Serreta ridge, where a submarine eruption took place in 1999 (Luis et al., 1999).

##### 4.2. Preliminary results from a first analysis of the SIRENA II hydro-acoustic data

Analysis of hydrophone acoustic data began in Brest in early November 2003. We present here some preliminary results from this first analysis, during which we concentrated on acoustic data recorded within periods in which events were detected along the northern MAR

by global seismic networks and listed in the USGS-NEIC earthquake data catalog. Such an approach allowed for a first-order estimate of the performance of the hydrophone network and provided new results on the seismic activity of the Reykjanes Ridge. The hydrophone array succeeded in detecting - and precisely locating - about thirty times more MAR events than the global seismological networks over the same time period. This confirms that the hydrophone magnitude threshold is much lower than that of the global networks.

The distribution of earthquakes along the MAR was not even in space and time during the 16-month deployment period.

1. It seems that the Mid-Atlantic Ridge north of the Bight Fracture Zone (i.e. the Reykjanes Ridge) was the most active section of the MAR during the SIRENA observation period. Five seismic swarms were registered along the axis of the Reykjanes Ridge, lasting from one to a maximum of five days. A total of 917 events were localized during these five swarms. The largest swarm had 304 events, only 16 of which were detected by global seismic networks. As the Reykjanes Ridge swarms occur well outside the hydrophone array, epicenter locations are strongly dependant on the network geometry. As a result of this, latitude uncertainties are quite large, while longitudes are well constrained. However, due to the large number of events, statistics could be used to further constrain locations with respect to the major ridge features (segments and inter-segment discontinuities) (Goslin et al., 2004). It should be noted that the five swarms observed during the sixteen-month observation period account for nearly half of the total number (11) of swarms (seismic episodes lasting five hours or more) which have been observed on the Reykjanes Ridge by the global networks since 1990. The time distribution of the seismicity along this ridge therefore appears very irregular.

2. In contrast to the Reykjanes Ridge, the MAR section between Kurtchatov F.Z. and Charlie Gibbs F. Z. seems to be less active (Sirena Team., 2004). Only a limited number of short duration swarms (normally less than a day) were detected along the MAR axis between these two latitudes during the period of observation. However, some of these swarms had a large number of individual events, e.g., 66 small-magnitude earthquakes were detected and localized near 48°N, 27°W, while the global networks only observed a single event (with a magnitude  $m_b = 4.6$ ). As these earthquakes are located within the hydrophone network, their location error is less than a few kilometers in latitude and longitude.

The SIRENA network did a surprisingly good job of detecting a significant number of earthquakes that occurred on the MAR south of the Azores. As was the case for the Reykjanes Ridge epicenters, the location of these events is biased because they occurred outside the network. However, we discovered that many of these events were recorded by only three hydrophones (S2, S4 and S5), had large location errors and plotted in an

abnormal off-axis region around 33°W, 44°N. In order to overcome this artifact, the SIRENA network data are now being processed together with the "NSF array" deployed south of the Azores (Sirena Team, 2004). The common period of operation of both networks is from May 2002 (deployment of the SIRENA network) to April 2003 (last servicing of the South Azores network). This processing should improve the location of the events which occurred between latitudes 35°N and 41°N (between the two networks) in particular for the Lucky Strike segment of the MAR.

Finally, the SIRENA array detected and located earthquakes from as far south as the Sierra Leone Fracture Zone (around 7°N) and as far north as the Reykjanes Ridge (62°N). Thus, as was hoped when deploying the SIRENA array, it succeeded (with the NSF array) in providing a comprehensive monitoring capability of the MAR, covering more than 50 degrees in latitude.

#### 5. Web sites related to the SIRENA experiment

The SIRENA1 & SIRENA2/D274 preliminary cruise reports and two web sites aimed at a general public can be accessed via links from the SIRENA web home page: <http://www-sdt.univ-brest.fr/~goslin/SIRENA/>

#### Acknowledgments

The scientific parties on board R/V Le Suroit and RRS Discovery for the SIRENA1 and SIRENA2/D274 cruises wish to thank the ships' masters Gilles Ferrand and Robin Plumley, the officers and crews of both ships for conducting all cruise operations with great seamanship, efficiency and permanent availability. These thanks are extended to the GENAVIR and UKORS technical teams for their permanent help and good humor.

Funding from various sources made the SIRENA experiment possible: after the experiment had received scientific approval by the "Géosciences Marines" Committee, the French Ministry of Research funded ship time for the two cruises. Salaries and travel costs were provided by the universities and institutions to the nationals of the three countries involved. In Portugal, these were provided by the STAMINA Project (contract # 3/3.1/CEG/2619/95). The cost of developing and building the SIRENA hydrophones, deployment costs, as well as the freight costs to and from Newport were provided by the NOAA Ocean Exploration program. The south Azores hydrophone experiment is supported by the U.S. National Science Foundation (OCE-0137164, OCE-0226444).

One of the authors (NL) visited Brest in autumn 2003 for a two-month visit. Support for this visit came through a fellowship from the French-Portuguese Cooperation Program in Oceanology (contract # 2003/4). Another author (RD) also visited Brest for a month as an invited Professor of the Université de Bretagne Occidentale.

#### References

Dauteuil, O. and J.-P. Brun, Deformation partitioning in a slow-spreading ridge undergoing oblique extension (Mohs Ridge, Norwegian Sea). *Tectonics*, 15, 870, 884,

1996.

Dziak, R.P. and C.G. Fox, Long-term seismicity and ground deformation at Axial Volcano, Juan de Fuca Ridge. *Geophys. Res. Lett.*, 26(24), 3641-3644, 1999.

Dziak, R.P., C.G. Fox, R.W. Embley, J.L. Nabelek, J. Braunmiller, and R.A. Koski, Recent tectonic of the Blanco Ridge, Eastern Blanco Transform Fault Zone. *Mar. Geophys. Res.*, 21(5), 423-450, 2000.

Dziak, R.P., J. Goslin, D. Smith, N. Lourenco, H. Matsumoto, C.G. Fox, J. Luis, M. Tolstoy, and D. Bohnenstiehl, Long-term monitoring of Mid-Atlantic Ridge Earthquake activity using autonomous Hydrophone arrays. Workshop on "Seismo-acoustic Applications in Marine Geology and Geophysics". Woods Hole OI, 24-26 March, 2004.

Dziak, R.P., D.R. Bohnenstiehl, H. Matsumoto, C.G. Fox, D.K. Smith, M. Tolstoy, J. Haxel, and M. Fowler, P- and T-wave detection thresholds,  $P_n$  velocity estimate, and detection of lower mantle and core P-waves on Ocean Sound-Channel Hydrophones at the Mid-Atlantic Ridge. *Bull Seism Soc. Am.* (in press).

Goslin, J. and the TRIATNORD Scientific Party, Extent of Azores plume influence on the Mid-Atlantic Ridge north of the hotspot. *Geology*, 27, 991-994, 1999.

Goslin, J., N. Lourenço, R.P. Dziak, D. Bohnenstiehl, J. Haxel, Long-term seismicity of the Reykjanes Ridge (North Atlantic) recorded by a regional hydrophone array. EGU Meeting, Nice 26-30 April 2004.

Luis J. F., N. Lourenço, J. M. Miranda, J. L. Gaspar and G. Queiroz, A Submarine Eruption west of Terceira Island (Azores Archipelago). *InterRidge News*. Vol 8: N°1: 13-14, 1999.

Mégnin, C. and B. Romanowicz, The three-dimensional shear velocity structure of the mantle from the inversion of body, surface and higher-mode waveforms. *Geophys. J. Int.*, 143, 709-728, 2000.

Ritsema, J., H.J. van Heijst, and J.H. Woodhouse, Complex shear wave velocity structure imaged beneath Africa and Iceland. *Science*, 286, 1925-1928, 1999.

The SIRENA team: J. Goslin, J. Perrot, J.-Y. Royer, C. Martin, C. Fox, R.P. Dziak, H. Matsumoto, M. Fowler, J. Haxel, J. Luis, N. Lourenço, and S. Bazin, Interactions between the MAR and the Azores hotspot as imaged by seismicity distributions using autonomous hydrophone arrays. Workshop on "Seismo-acoustic Applications in Marine Geology and Geophysics". Woods Hole OI, 24-26 March, 2004.

Smith, D.K., J. Escartin, M. Cannat, M. Tolstoy, C.G. Fox, D. R. Bohnenstiehl, S. Bazin, Spatial and temporal distribution of seismicity along the northern Mid-Atlantic Ridge (15-35°N), *J. Geophys. Res.*, 108, 2167, 10.1029/2002JB001964, 2003.

Thibaud, R., P. Gente, and M. Maia, A systematic analysis of the Mid-Atlantic Ridge morphology and gravity between 15°N and 40°N : constraints on the thermal structure. *J. Geophys. R.*, 103, 24223-24243, 1998.

Thibaud, R., O. Dauteuil, and P. Gente, Faulting pattern along slow-spreading ridge segments : a consequence of along-axis variation in lithospheric morphology. *Tectonophysics*, 312, 157-174, 1999.

## **Updates on Philippine geology: Evidence from crust-mantle sequences, collision zones and accretionary environments**

G.P. Yumul, Jr.<sup>2</sup>, C.B. Dimalanta<sup>1</sup>, B.D. Payot<sup>1</sup>, L.O. Suerte<sup>1</sup>

### **1. Fieldwork done with ophiolite basements**

The complex evolution of the Philippine island arc system is documented by the occurrence of ophiolites and dismembered oceanic lithospheres as basement complexes all over the archipelago. At present, twenty-eight ophiolite and ophiolitic complexes have been identified and the number is expected to increase with the recent boom of interest in these oceanic crust-mantle sequences. Though the origin of ophiolites is usually linked to a single marginal or several oceanic basins, the origin of most crust-mantle sequences in the Philippines remains to be proven. The comprehensive study of these units will not only provide clues to the processes that brought about its formation but will also provide common features for the possible correlation of these crust-mantle units.

The mapping of NE Leyte-Southern Samar and Southern Leyte in Central Philippines revealed the presence of the Tacloban Ophiolite Complex (TOC) and the Malitbog Ophiolite Complex (MOC) in the northern and southern portions of the Leyte island, respectively (Dimalanta et al., 2003). As defined by the Penrose Conference (1972), the TOC and MOC are complete ophiolite suites consisting of the following units from top to bottom: residual and layered ultramafic rocks, layered and isotropic cumulate rocks, dike/sill complex and pillow lavas. Both ophiolites are unconformably overlain by pelagic sediments, volcanic and sedimentary sequences dated Late Miocene to Pleistocene for the TOC and Late Cretaceous to Pleistocene for the MOC. Field, petrographic and geochemical data from rock samples of the TOC and MOC suggest that these basement complexes were generated in a subduction-related marginal basin. Moreover, field evidence suggests that these units were generated in an intermediate to a fast spreading center. Sensitive High Resolution Ion Microprobe (SHRIMP) U-Pb isotopic dating of a gabbro sample yielded two possible magmatic ages for the TOC,  $145.1 \pm 3.2$  Ma and  $124 \pm 3.3$  Ma (Early Cretaceous) which is older than the previously reported whole rock K-Ar derived Eocene age. The work of Florendo (1987) gave the MOC a probable Late Cretaceous age based on foraminifera found in the overlying pelagic sediments. The presence of these two ophiolites suggest that the evolution of Leyte island involved several stages: first, the generation, emplacement and uplift of the crust-mantle sequences, followed by the deposition of sedimentary units and reefal limestones on top of the sequences and the subsequent arc magmatism. Correlation with other Cretaceous ophiolites in Central Philippines, which include those in Cebu, Southeast Bohol

and Samar, reveals the possible extent of the proto-Philippine Sea Plate remnants now exposed onland.

Bounded by numerous subduction systems, the Philippine island arc system is also characterized by major collision zones. The continent-oceanic collision along the western edge of the archipelago is typified by lithologies and structures exposed in Palawan, Minodoro, Panay and Zamboanga. However, the extent of this collision in the islands of Tablas, Romblon and Sibuyan, also known as the Romblon Island Group (RIG), is still subject to investigation. The work of Faure and others (1989) suggests that the RIG may still be part of the collision zone. To address this issue, recent mapping of the RIG was done last April 2003. This led to the identification of a crust-mantle sequence exposed in the San Andres area going to Calatrava. Harzburgite, wherlithite, diabase and pyroxenite comprise this ophiolitic unit. Best exposures of the layered complex (pyroxenite) and gabbro are observed in Calatan. Basaltic and andesitic lava flows were also encountered in the eastern part of Tablas and as isolated outcrops along the western side of Sibuyan Island. The volcanic rocks exposed in the latter are believed to be associated with the diorites. Clastic sedimentary and carbonate rocks are present in the eastern, central and southwestern areas of Tablas island. Exposures of schist were seen in the southern portion of Tablas and along the eastern side of Sibuyan. Preliminary field data suggests that the RIG may still be part of the perceived collision zone along the western margin of the Philippines.

Further fieldwork and structural mapping was conducted in Dingalan, Baler, Aurora province in western Luzon last May 2003. This was in collaboration with Dr. Shigeyuki Suzuki of Okayama University in Japan. The Cretaceous to Lower Paleogene sandstone deposits in Dingalan are believed to be turbiditic sequences developed in a deep sea environment and are characterized by abundant plagioclase (16-37%) and basic to intermediate volcanic clasts (43-63%), relatively few quartz grains (1-5%) and common clinopyroxene grains (1-7%). The Dingalan sandstones are believed to have been deposited from both basaltic and dacitic volcanic provenance. As part of this collaboration with the Okayama University, a provenance study is being conducted on the Middle to Late Miocene Klondyke Formation and Late Oligocene to Early Miocene Zigzag Formation of the Baguio Mineral District. Initial petrographic studies revealed that the greenish sandstones of the Late Oligocene to Early

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Miocene Zigzag Formation are primarily composed of plagioclase, quartz, biotite with granodioritic and dioritic lithic fragments. Preliminary geochemical data gave low to moderate values for  $\text{SiO}_2$  (42-47%) and high  $\text{FeO}+\text{MgO}$  contents (5-18%). The study of the sedimentary suites in Dingalan and Baguio areas provide constraints on the accretion history of the Philippine island arc system. From the preliminary data on the Dingalan sandstones, a primary oceanic island arc setting is inferred for the Philippine Mobile Belt during the Cretaceous through Lower Paleogene. Erosion of granodioritic bodies during the Miocene provided the components for the Baguio sandstones. This event suggests that the PMB later developed to become an island arc (Suzuki et al., 2004).

#### References

Anonymous, Penrose field conference on ophiolites. *Geotimes* 17, 24-25, 1972.

Dimalanta, C.B., G.P. Yumul, Jr., and L.O. Suerte, *Geochemistry of the oceanic basement complex of Leyte island: Role of the ephemeral marginal basins in the evolution of Central Philippines Terminal Report*. National Research Council of the Philippines, 101 pp., 2003.

Faure, M., Y. Machadier, and C. Rangin, Pre-Eocene synmetamorphic structure in the Mindoro-Romblon-Palawan area, west Philippines, and implications for the history of Southeast Asia. *Tectonics* 8, 963-979, 1989.

Florendo, F.F., The tectonic framework and the Cretaceous to Cenozoic evolution of the East-Central Philippines. Master's Thesis, University of Tulsa, Oklahoma, USA, 103 pp., 1987.

Suzuki, S., G.P. Yumul, Jr., T.A. Tam, and M.J.J. Rahman, Two different types of sandstones from the Philippine archipelago: Implications to its early stage accretion. Abstract submitted to the IGC 2004, 2004.

### **Tectonic structures of the Atlantic ocean and their connection with magmatism and ore formation – summary of successfully completed studies of the Russian Academy of Sciences.**

Yu.M. Pushcharovsky<sup>1</sup>

Several research programs relating to the tectonics, magmatism and ore formation of the ocean bottom were completed in 2003 at the Geological Institute of the Russian Academy of Sciences. Investigations as well as a final monograph on the lithospheric's tectonic delamination in the Atlantic and Indian oceans were accomplished. The main conclusion is that the lithosphere in both oceans is deformed on a huge scale and in all main structural-morphologic areas: mid-ocean ridges, abyssal basins, volcano-tectonic rises, and in the transitional zone between ocean and continent. Typical deformation, resulting in

thrusts, tectonic naps and detachment faults, bring about tectonic delamination of the Earth's crust and upper mantle (Figure 1). This study presents a new understanding of the rigidity and tectonic stagnancy of the oceanic lithosphere. A comparison to tectonic delamination of the lithosphere in paleoceanic basins (ophiolite complexes) is made (Raznitsin, 2003; 2004).

Bathymetric, structural and geochemical investigations of the Mid-Atlantic ridge segment in the Sierra Leone fracture zone area (Central Atlantic) were accomplished. Ore-

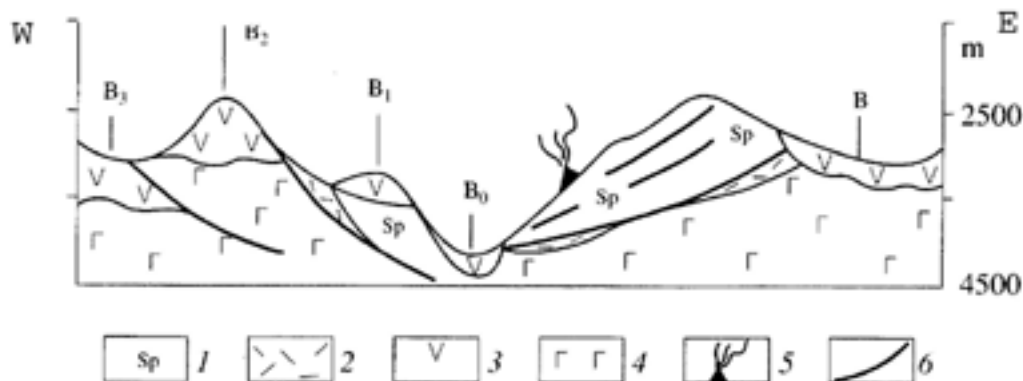


Figure 1

Geological profile across MAR rift valley

1 - serpentinitized ultramafics and serpentinites; 2 - gabbro affected by dynamic polythermal metamorphism; 3 - basalt; 4 - gabbro; 5 - methane plume above the Logachev hydrothermal field; 6 - thrust faults and deep-seated detachments. B-B<sub>3</sub> basalts of different age.

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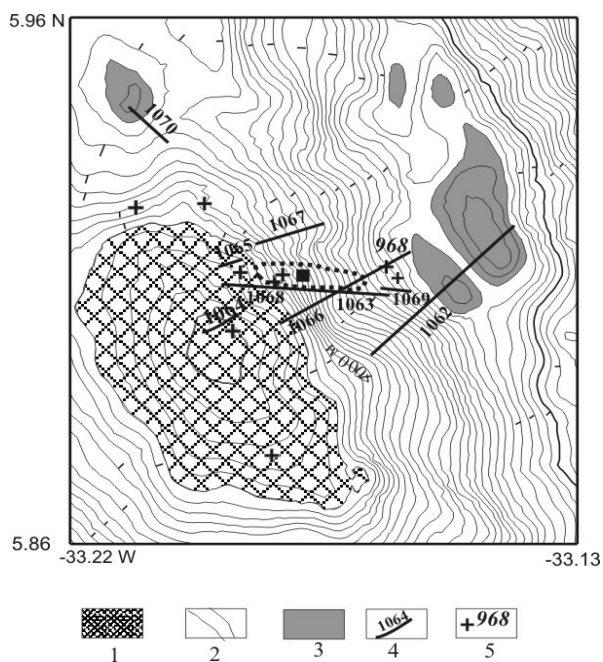


Figure 2  
Markov deep  
1 - bottom of the deep; 2 – bathymetric lines of the slope; 3- rises on the east flank; 4 – position of the dredge station I1032 with massive sulfides; 5 – area of the most probable position of high temperature hydrothermal fluids.

bearing rift basins (Figure 2) and the thermohaline structure of the water column were described. Thermohaline parameters can be used to prospect for ocean hydrothermal systems (Skolotnev, Peyve, Bortnikov et al., 2003; Demidova, Skolotnev et al., 2003).

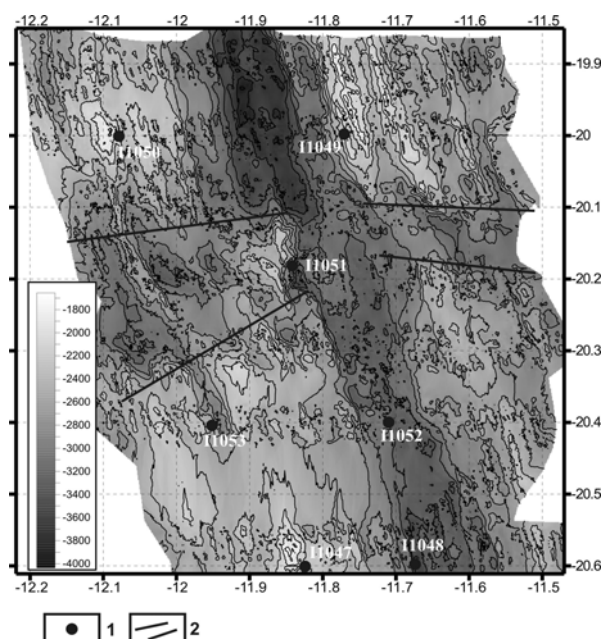


Figure 3  
Bathymetric map of the north part of the Martin Vaz polygon. 1 - position of the dredge stations and their numbers; 2 – transverse zone of depressed relief. At the left – scale of depth in meters.

Data on the structure of the Mid-Atlantic ridge segment near the Martin Vas fracture zone (South Atlantic) were summarized (Figure 3). The influence of the Cameron “hot line” on tectonic-magmatic processes in the rift zone was revealed here (Skolotnev, Peyve et al., 2003). Analysis of the composition and distribution of Fe-Mn deposits of both fracture zone segments made it possible to make several fundamental conclusions about conditions of their origin, connection with hydrothermal fluids and with tectonic and magmatic regimes (Bazilevskaja and Skolotnev 2003a, 2003b).

An expedition to the Atlantic ocean on R/V “Akademik Sergey Vavilov” was carried out in 2003. Data on the geological structure of the Rio Grande rise (South Atlantic) was collected (Figure 4). A tectonic–geodynamic model for the formation of the Atlantic ocean deep basin was

Track of 17 expedition on R/V “Akademik Sergey Vavilov”

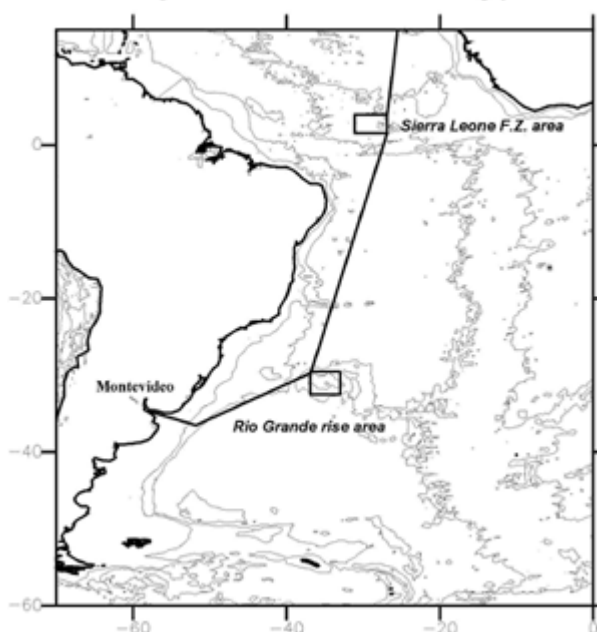


Figure 4  
Track of the 17-th expedition on R/V “Akademik Sergey Vavilov”.

developed. A combination of tectonic subsidence of the ocean bottom that is induced by the crust extension due to continent separation and spreading process are the underlying thoughts behind the model (Pushcharovsky 2003a). Different fracture zones with complicated structures that cross the Atlantic were described and classified. Geodynamic conditions of their formation were interpreted (Pushcharovsky 2003b).

Investigations of the instability of the spreading process in the Atlantic ocean were achieved (Pushcharovsky 2003c). Furthermore, hypotheses were developed to explain the formation of giant Proterozoic manganese deposits. These suggest that the deposits may have

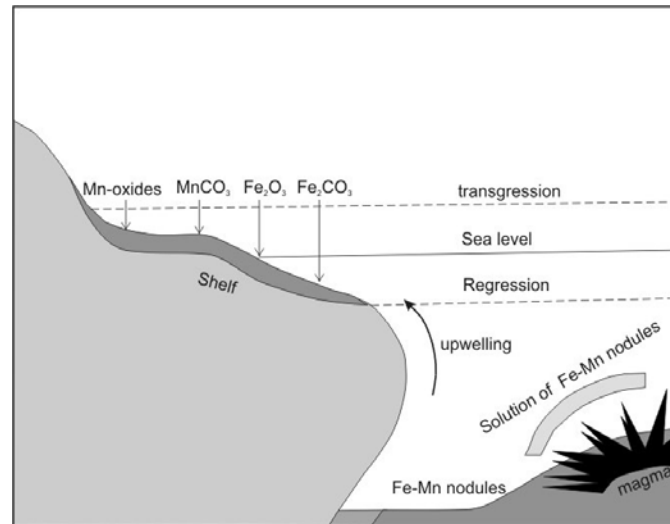


Figure 5  
Schematic illustration of events which could have taken place 2 Ga years ago at the Early Proterozoic supercontinental margin. Magmatic activation caused by the asteroid downfall thousands of km from the continental margin is in the right low corner. Arrows show output of metals dissolved under the deep waters upwelling during the ocean transgression. Lines show the sequence of ore deposition in a shelf zone, which were exposed during the ocean regression.

formed when an asteroid fell into the ocean (Figure 5) (Bazilevskaja, 2003).

The distribution of neotectonic structures in a new area of the Equatorial Atlantic was described. This contributes to the understanding of the structural development of these oceanic areas during the neotectonic phase of the Earth's evolution (Skolotnev, Tsukanov et al., 2003).

#### References

- Bazilevskaya E.S., Manganese phenomenon of the Earth. *Priroda*, N 5, pp. 35–42, 2003.
- Bazilevskaya E.S. and S.G. Skolotnev 1, Composition of Fe-Mn sediments in the Sierra Leone fault area (near-Equatorial Atlantic). *Geology of ore deposits*, v. 45, No. 3, pp. 225–231, 2003. Translated from *Geologia rudnykh mestorozhdenii*, v. 45, No. 3, pp. 253–260, 2003.
- Bazilevskaya E.S. and S.G. Skolotnev 2, Ferromanganese sediments in the Martin Vas Fracture Zone Area (20° S Mid-Atlantic Ridge). *Doklady Earth Sciences*, v. 390, No. 4, pp. 520–523, 2003. Translated from *Doklady Akademii Nauk*, v. 390, No. 4, pp. 507–510, 2003.
- Demidova T.A., S.G. Skolotnev, N.S. Bortnikov, and N.N. Turko, Ore-bearing rift depressions in the Sierra Leone Fracture Zone (Equatorial Atlantic): implications for thermohaline water structure, geology, and ore genesis. *Doklady Earth Sciences*, v. 393, No. 8, pp. 1067–1071, 2003. Translated from *Doklady Akademii Nauk*, v. 392, No. 5, pp. 660–665, 2003.
- Pushcharovsky Yu.M., Formation of deep-water basins in the Atlantic. *Doklady Earth Sciences*, v. 389A, No. 3, pp. 358–361, 2003. Translated from *Doklady Akademii Nauk*, v. 389, No. 6, pp. 790–794, 2003a.
- Pushcharovsky Yu.M., Complex fracture zones in the Atlantic ocean. *Ceotectonics*, v. 37, No. 6, pp. 448–456, 2003. Translated from *Geotektonika*, No. 6, pp. 18–27, 2003b.
- Pushcharovsky Yu.M., Geodynamic variations in ocean-floor spreading with reference to the Atlantic ocean. *Ceotectonics*, v. 37, No. 4, pp. 261–270, 2003. Translated from *Geotektonika*, No. 4, pp. 3–13, 2003c.
- Raznitsin Yu.N., The tectonic layering of the young oceans lithosphere and palaeoceanic basins. In press.
- Raznitsin Yu.N., The role of tectonic delamination of lithosphere for formation of hydrothermal fields and methane plumes related to the ultramafic rocks in the Atlantic Ocean. *Ceotectonics*, v. 37, No. 6, pp. 435–447, 2003. Translated from *Geotektonika*, No. 6, pp. 3–17, 2003.
- Skolotnev S.G., A.A. Peyve, N.S. Bortnikov, et al. 1, Geology of ore-hosting rift deeps near the Sierra Leone Fracture Zone, Equatorial Atlantic. *Doklady Earth Sciences*, v. 391, No. 5, pp. 679–684, 2003. Translated from *Doklady Akademii Nauk*, v. 391, No. 2, pp. 232–238, 2003.
- Skolotnev S.G., A.A. Peyve, N.S. Bortnikov, et al. 2, New data on the structure of the Mid-Atlantic Ridge Crest near the Martin Vas Fracture Zone (20°–21° S) in the South Atlantic. *Doklady Earth Sciences*, v. 391A, No. 6, pp. 779–784, 2003. Translated from *Doklady Akademii Nauk*, v. 391, No. 3, pp. 361–367, 2003.
- Skolotnev S.G., N. V. Tsukanov, N.N. Turko, and A.A. Peyve, New data on the neotectonic activity in the Mid-Atlantic Ridge Crest (5°–6° N). In press.

### **Multibeam sonar survey of the central Azores volcanic islands**

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In September-October 2003, we surveyed the central Azores islands (Figure 1) with a portable Reson Seabat 8160 multibeam echo-sounder installed on the University of the Azores R/V *Arquipélago*. The cruise was a unique collaboration between marine geophysicists from Cardiff University, and marine biologists and geologists from the University of the Azores. Besides revealing the volcanic and tectonic structure of parts of the Azores spreading plate boundary, the data will aid the assessment of spawning grounds for pelagic fish, which form an important resource for the local economy, and will inform local authorities of geological hazards to coastal populations.

The Azores islands are often visited by scientists as they provide convenient and pleasant ports for research vessels working in the central Atlantic but they have been less a focus for marine geophysics themselves. Along with the 1999 Italian-UK AZZORRE99 TOBI deep-tow sidescan sonar survey around the central islands (Ligi et al 1999), forthcoming multibeam sonar surveying by the Portuguese STAMINA group around Terceira (N Lourenço, pers. comm.) and rock dredging from FSPoseidon (CW Devey, K Haase pers. comm.), this project represents a renewed interest in the Azores.

#### **The Azores as an ultra-slow spreading plate boundary**

There has been much recent interest in the volcanic and tectonic structure of ultra-slow spreading ridges such as the Southwest Indian Ridge and Gakkel Ridge in the Arctic, because the extreme spreading rate may potentially shed light on melting processes in the underlying mantle and delivery of melt through the lithosphere to form the oceanic crust (Mapping and Sampling the Arctic Ridges: A Project Plan, InterRidge, pp. 25, Dec. 1998). Spreading at ~3 mm/yr (Searle, 1980), the Azores region is an ultra-slow

spreading plate boundary, much slower than the Gakkel Ridge (6-15 mm/yr; deMetts *et al.*, 1990). Volcanism is distributed sporadically across the plate boundary, creating the individual islands and interspersed submarine edifices, a result of a broad underlying melting anomaly (Bonatti, 1990). The volcanic centres illustrated by the topography (Figure 2) show that volcanism is localized in a way that is comparable to that of Gakkel Ridge (Edwards *et al.*, 2001).

#### **The Azores as a 'natural laboratory' of mid-ocean ridge processes**

The islands and their adjacent submarine ridges reveal volcanism and tectonic features over a range of water depths and with different tectonic-volcanic configurations, which have the potential to shed light on a variety of mid-ocean ridge processes. For example, the elongated morphology of the islands of São Jorge and Pico-Faial and of their adjacent submarine ridges suggest that they are tectonically controlled. São Jorge and eastern Pico, in particular, are bisected by linear arrays of volcanic cones - studying their geometrical relationships to faults may aid understanding of how volcanism is affected by tectonics. Furthermore, the submarine ridges transcend a variety of water depths and ambient pressures. By studying the distribution of different surface morphologies of cones in these ridges over a range of water depths, it may be possible to infer if ambient pressure affects the style of volcanic extrusion. The geochemistry of rock samples dredged from Poseidon will help to reveal effects of varied lava chemistry on extrusion style, as well as spatial heterogeneity of the underlying melt source.

#### **The Azores as a 'natural laboratory' of volcanic ocean island processes**

The Hawaiian, Canary and several other volcanic ocean islands have been imaged with multibeam sonars over the past decade (we use the term 'ocean island' to distinguish these from arc islands). However, those data were collected with deep-water sonars fitted to large vessels that were unable to work in the coastal zone. The small vessel *Arquipélago* was able to work in very shallow water (10 m) where the unique dynamic beam focusing of the Reson Seabat 8160 sonar allowed us to image fine-scale features. As the system also functioned well in 1000 m, we were able to collect data over the whole profile of the islands, to address both deep and shallow processes during the same survey.

Many issues concerning submarine volcanic growth and

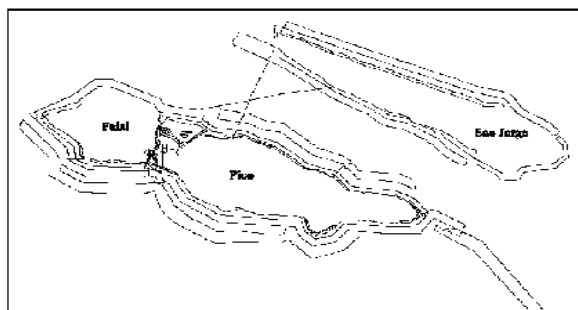


Figure 1  
Survey tracks around the coasts of Faial, Pico and São Jorge. The system was used to map from depths as shallow as 10 m down to below 1000 m.

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modification of volcanic islands remain unresolved, and much of the existing work has been carried out on Hawai'i, which is not representative of most oceanic volcanism. The submarine parts of volcanic islands are usually much larger than their parts above sea level but it is still unclear to what extent the submarine parts grow from direct volcanic extrusion or from material originating from above sea-level (debris from coastal lava-sea water interactions and erosion or from lava tubes transcending the surf zone (Moore *et al.*, 1973)). The new data should help address these aspects. Furthermore, the coastal zones of the Azores contain abundant submarine terraces. Correlating them with the global sea-level curve and interpreting them along with cliff and shelf geometry and rock dating at Kiel University, will help unravel the history of tectonic vertical motions, volcanic growth and coastal erosion.

Multibeam sonars have revealed some spectacular landslides around the Hawaiian, Canary and other volcanic islands (Moore *et al.*, 1989; Watts and Masson, 1995). Such giant landslides are infrequent, however, probably occurring on average only every 10,000 years globally. The Azores are remarkable in that they show relatively little evidence for such large-scale landslides (Mitchell, 2003). Small landslides around lava deltas and the upper submarine slopes of the islands, though individually less hazardous, probably represent a more frequent threat to local populations. Submarine landslides could explain some of the several historical tsunamis in the Azores. The new data collected reveal a remarkable array of submarine slope failures, which will assist local hazard assessment and also help in developing a more complete understanding of seismic and other causes of slope failure around such islands.

#### Habitat mapping for sublittoral biological communities

Due to increasing anthropogenic activities affecting the

ocean bed, the demand for comprehensive environmental appraisals of benthic habitats and associated biological communities (biotopes) is growing in the Azores. The scarce knowledge on the variety and distribution of marine biotopes has complicated well-informed decision making on issues of conservation and management of shallow and deep water areas and biological resources.

From the point of view of ecology, these new data will aid the description, classification and mapping of sublittoral habitats/biotopes at one of the areas of the coastal Azores most relevant for conservation: the Faial-Pico channel. This information will not only assist the refinement of the management measures proposed for this area but will also be helpful for the planning of other marine activities and Special Areas of Conservation (SACs – Natura 2000 network), the prioritisation of new potential sites for nature conservation and the establishment of baseline conditions for monitoring studies.

For further information please contact Neil at [neil@ocean.cf.ac.uk](mailto:neil@ocean.cf.ac.uk) (geological aspects), Eduardo at [eduardo@notes.horta.uac.pt](mailto:eduardo@notes.horta.uac.pt) (biological aspects) or João Carlos at [nunes@notes.uac.pt](mailto:nunes@notes.uac.pt) (Azores geological hazards aspects). (Websites <http://www.ocean.cf.ac.uk/people/neil/>, <http://www.horta.uac.pt/> and <http://www.uac.pt/~jcnunes/>.)

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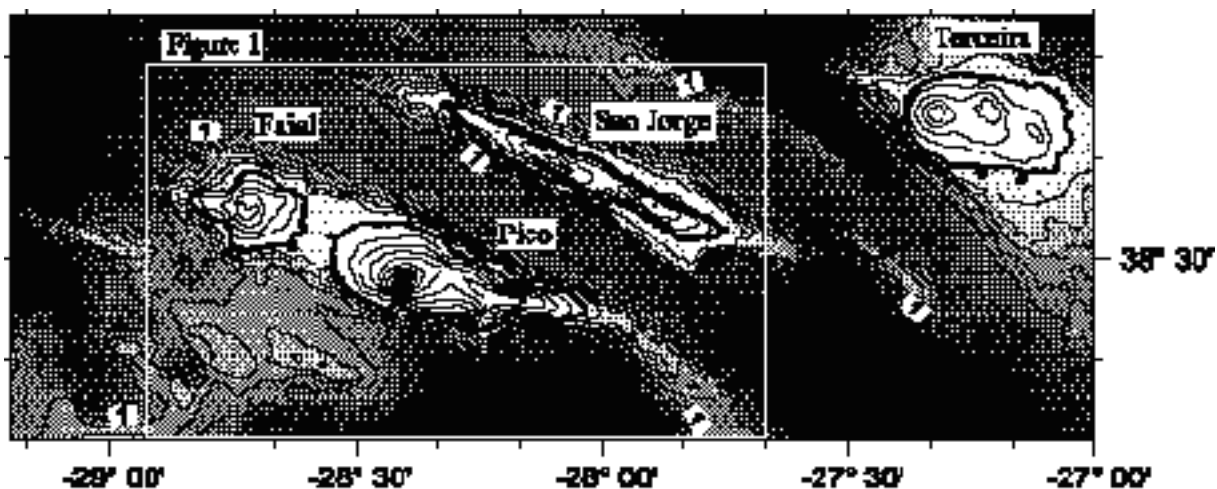


Figure 2. Topography of the central Azores islands (contours every 200 m with bold contours annotated every 1 km). The structure forming Faial-Pico and the island of São Jorge are elongated volcanic ridges, and further volcanic ridges exist among the islands. An eruption on the ridge immediately west of Terceira in particular was the subject of a previous article by Freire Luis *et al.* (InterRidge News, 8(1), 13-14, 1999).



with thanks from Russell Dodd of GSE Rentals Ltd with the equipment installation, the Portuguese Hydrographic Institute for installation of a tide gauge, the crew of the *R/V Arquipélago* and Bernie Coakley for advice on the installation design.

#### References

Bonatti, E., Not so hot "hot spots" in the oceanic mantle, *Science*, 250, 107-111, 1990.

DeMets, C., R.G. Gordon, D.F. Argus, and S. Stein, Current plate motions, *Geophysical Journal Int.*, 101, 425-478, 1990.

Edwards, M., *et al.*, Evidence of recent volcanic activity on the ultraslow-spreading Gakkel ridge, *Nature* 409, 808-812, 2001.

Ligi, M., N.C. Mitchell, M. Marani, F. Gamberi, D. Penitenti, G. Carrara, M. Rovere, R. Portaro, G. Centorami, G. Bortoluzzi, C. Jacobs, I. Rouse, C. Flewellen, S. Whittle, P. Terrinha, J. Freire Luis, and N. Lourenco, Giant volcanic

ridges amongst the Azores islands, *EOS Trans. AGU*, 80, Fall Meet. Suppl., F913, 1999.

Mitchell, NC, Susceptibility of Mid-Ocean Ridge Volcanic Islands and Seamounts to Large-Scale Landsliding, *J. Geophys. Res.*, 2003 (DOI: 10.1029/2002JB001997).

Moore, J.G., R.L. Philips, R.W. Grigg, D.W. Peterson, and D.A. Swanson, Flow of lava into the sea, 1969-1971, Kilauea volcano, Hawaii, *Geol. Soc. Am. Bull.*, 84, 537-546, 1973.

Moore, J.G., D.A. Clague, R.T. Holcomb, P.W. Lipman, W.R. Normark, and M.E. Torresan, Prodigious submarine landslides on the Hawaiian Ridge, *J. Geophys. Res.*, 94, 17465-17484, 1989.

Searle, R.C., Tectonic pattern of the Azores spreading centre and triple junction, *Earth and Planetary Science Letters*, 51, 415-434, 1980.

Watts, A.B., and D.G. Masson, A giant landslide on the north flank of Tenerife, Canary Islands, *J. Geophys. Res.*, 100, 24499-24507, 1995.

### **The BIOSPEEDO cruise: a new survey of hydrothermal vents along the South East Pacific Rise from 7°24'S to 21°33'S**

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Since their discovery during the Geocyarise 1984 cruise (Renard *et al.* 1985), hydrothermal vents of the Southern East Pacific Rise (SEPR) have been revisited several times over a great spatial range (Scheirer *et al.* 1993, Auzende *et al.* 1994, Fujioka *et al.* 1995, Halanych *et al.* 1999). The cruises offered a unique opportunity to study animal communities associated with ultrafast spreading ridges governed by either effusive volcanism (dome-shaped ridge) or tectonism (graben-shaped ridge). Heat convection in the deeper layers of the ocean crust has a strong effect on the evolution of nascent vent emissions and thus the level of extinction/recolonizations in the associated populations and communities. The first descriptions of hydrothermal vent assemblages along the SEPR indicated the occurrence of a fauna identical to that previously found along the North East Pacific Rise (NEPR) such as *Alvinella pompejana*, *Riftia pachyptila* or *Bathymodiolus thermophilus* (Renard *et al.* 1985, Geistdoerfer *et al.* 1995, Van Dover 2002). However, the fauna was more continuously distributed (smaller average inter-site distance, especially between 17°24S and 18°36S: Chevaldonné *et al.* 1997). The fauna was also spatially organized as a succession of small patches

dominated either by vestimentiferan tubeworms, bivalves or stalked cirripedes, each of them resembling assemblages typical of 13°N/9°50N/EPR, 21°N/EPR and the Western Pacific back-arc basins, respectively. Such observations allowed us to speculate about the possibility that this ridge portion could represent a transition zone between the NEPR vent fauna and those of the mid-Atlantic Ridge or the Western Pacific back-arc basins where species might attain their range limits. Preliminary phylogeographic studies partly addressed these questions and showed gene flow breaks and potential cryptic speciation among well-described taxa either across the equator or at the boundary of the Easter Microplate region (*i.e.* between 21°33S and 32°S: Hurtado *et al.* 2002, 2004, Guinot and Hurtado, 2003, Won *et al.* 2003). However, a fine-tuned latitudinal survey of the SEPR fauna combining systematics, population genetics and ecology over a large set of biological samples was still necessary to better understand the biogeographical and geological processes that control the vent fauna distribution, and especially long-term migration/hybridization *versus* selective processes in relation to vent instability.

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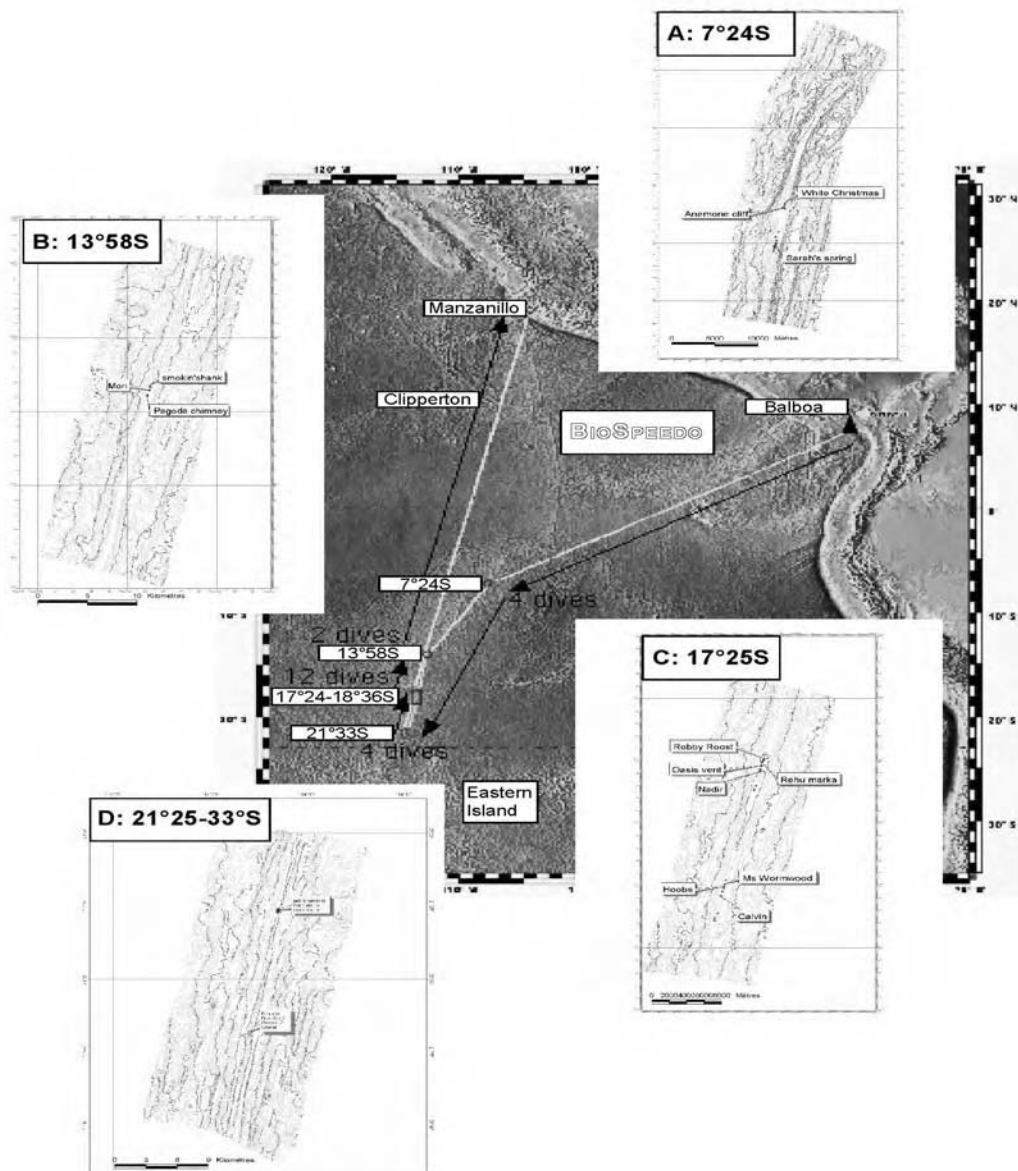


Figure 1  
Biospedo cruise's route along the South EPR with fine-scale EM12 resolution maps of the main hydrothermal vent sectors surveyed with the French RV L'Atalante. A: 7°24S bathymetric map, B: 14°S bathymetric map, C: 17°25-34S bathymetric map and, D: 21°25-33S bathymetric map. Black arrows represent the cruise's route.

The BIOSPEEDO cruise was held on a unique 45-day leg along the South East Pacific Rise on board of the oceanographic research vessel L'Atalante with the manned submersible Nautilie. The cruise left from Balboa (Panama) on the 31<sup>st</sup> of March and ended in Manzanillo (Mexico) on 13<sup>th</sup> of May 2004. An integrated survey of hydrothermal vent assemblages was conducted between 7°24S and 21°33S/EPR (Figure 1) by combining expertise from different research fields: (1) biodiversity and assemblage ecology, (2) population dynamics and genetics, (3) biology of symbiotic vent species and (4) adaptive biology to environmental stresses. The main objectives of the cruise were to gain access to the latitudinal distribution (i.e. 14 degrees span of latitude: c.a. 1600 km) of the main components of the vent communities (microbes, protists, parasites, small

macrofauna and the key symbiont-bearing species) and especially to determine (1) the level of gene exchanges between fragmented populations, (2) the role of transform faults as a barrier to dispersal and (3) the importance of vent dynamics on the composition of assemblages and the population structuring. In addition, we also performed *in situ* ecological analyses of the vent assemblages with special focus on the biogeochemistry of venting, a better characterization of tubeworm symbioses and lastly, *in vivo* experiments on the adaptive physiology of vent organisms.

The approach was based on an integrated effort from ecologists (4), systematicists (3), population geneticists (5), microbiologists (4), physiologists (7) and chemists (2).

Studies were devoted to:

- (1) spatial and temporal variations of end-member fluid composition among hydrothermal vent chimneys at both local and SEPR scales.
- (2) a micro-spatial scale geochemical description of hydrothermal vent chimneys in order to determine the role of the biogeochemical processes in structuring alvinellid assemblages.
- (3) a fine-tuned description of diffuse venting assemblages according to both environmental conditions and the temporal state of a site.
- (4) latitudinal evolution of assemblages over the SEPR and its biogeographical consequences; this includes a comparative phylogeography approach across a set of vent species (mollusks and annelids) to better understand long-term colonization processes.
- (5) biodiversity and phylogeography of retroviruses, viruses, Methanogene and Thermococcales archaea, protozoa and parasites using molecular methods
- (6) impact of transform faults on dispersal and its consequences in terms of cryptic speciation.
- (7) role of site turn-over on extinction/recolonizations in the vent populations by comparing contrasting hydrothermal discharge regimes (dome-like ridge associated with volcanism vs graben-like rift associated with tectonism).
- (8) effects of selective processes in shaping population structures at local scales
- (9) characterization of organismal life-history traits, with an emphasis on larvae in order to better understand reproduction and settlement dynamics of a few key species.
- (10) relationships between life-history traits/settlement dynamics and the level of genetic diversity to infer the relative role played by these factors and the environment on barriers to gene flow.
- (11) sampling to gain a better understanding of symbiosis functioning in *Riftia pachyptila* using a combined transcriptomics/proteomics approach (subtractive DNA libraries across different tissues).
- (12) sampling to enable a complete sequencing of *Alvinella pompejana*'s transcriptome (Genoscope project).
- (13) physiological and biochemical responses of vent polychaetes to thermal and oxidative stresses using pressurized aquaria.

During this cruise, eight distinct hydrothermal vent fields were visited. Among these, 23 previously described vent sites were successfully revisited following indications obtained from literature and the R/V Atlantis-DSC Alvin cruise report of dives 3319-3342 on the SEPR. These were kindly provided by chief scientists R. C. Vrijenhoek and J. Lupton. 6 Additional vent sites were discovered (see Table 1 for the positions of the 20 vent sites that were successfully sampled or marked). The cruise's route along the SEPR, the dive schedule and fine-scale EM12 bathymetric maps of the main vent sectors are presented in Figure 1.

*In situ* observations of the vent sites may indicate an increase of vent discharge throughout the 1600 km-long portion of the ridge since the last 1998 cruise. This suggests a fairly recent focusing of vent emissions, however this needs to be confirmed by the fluid chemistry. Indeed, we found a lot of previously diffuse vent sites now extinct coupled with the raise of new black smoker

Table 1. Position and depth of the vent sites already sampled and/or marked (BS) during the BIOSPEEDO cruise. Bold and italicized fonts correspond to vent sites discovered during the cruise. Dive number per site is followed by the dive identifier inside brackets.

Vent site	Coordinates	BS marker	Depth (m)	Dives
White Christmas	7°21.620S-107°47.080W		2735	1 (PL1571)
Sarah'Spring	7°25.240S-107°47.660W	BS2	2752	3 (PL1572-74)
<b><i>Last Hope</i></b>	<b><i>7°25.452S-107°47.700W</i></b>	<b><i>BS1</i></b>	<b><i>2735</i></b>	<b><i>1 (PL1574)</i></b>
Pagoda's chimneys #2,3,4	13°58.900S-112°28.850W	BS16, BS17 & BS18	2632	1 (PL1591-92)
Smokin'Shank	13°58.300S-112°28.740W		2635	1 (PL1591)
<b><i>Lucky Eric</i></b>	<b><i>13°59.060S-112°28.945W</i></b>		<b><i>2623</i></b>	<b><i>1 (PL1592)</i></b>
Oasis	17°25.385S-113°12.280W	BS6, BS9	2585	7 (PL1579,82-84, 86, 89-90)
Rehu Marka (#24)	17°24.960S-113°12.125W	BS10, BS11, BS13	2589	7 (PL1579, 82-84, 86, 89-90)
Hobbs	17°35.202S-113°14.755W		2593	2 (PL1587-88)
Suzie	17°35.471S-113°14.822W	BS14	2594	2 (PL1587-88)
Miss Wormwood	17°34.905S-113°14.670W	BS15	2595	1 (PL1587)
<b><i>Fromveur (#22)</i></b>	<b><i>18°25.930S-113°23.320W</i></b>	<b><i>BS7</i></b>	<b><i>2636</i></b>	<b><i>2 (PL1580-81)</i></b>
<b><i>Cathedral</i></b>	<b><i>18°24.878S-113°23.035W</i></b>	<b><i>BS8</i></b>	<b><i>2642</i></b>	<b><i>1 (PL1580)</i></b>
Sojourn	18°25.330S-113°22.940W		2654	1 (PL1580)
Animal Farm	18°36.520S-113°23.995W	BS12	2585	1 (PL1585)
<b><i>Unnamed new site</i></b>	<b><i>21°24.675S-114°16.265W</i></b>	<b><i>BS4</i></b>	<b><i>2808</i></b>	<b><i>1 (PL1576)</i></b>
Bordreaux	21°25.295S-114°16.465W	BS5	2832	1 (PL1576)
Krasnov	21°33.600S-114°17.965W	BS3	2838	3 (PL1575, 77-78)
Gromit	21°33.625S-114°17.805W		2840	3 (PL1575, 77-78)
Brandon	21°33.735S-114°17.950W		2845	2 (PL1575, 78)

Table 2. List of biological and geological samples collected during the BIOSPEEDO 2004 cruise. S: titanium syringe, N: Niskin bottle, X: at least one sample collected, Number of individuals collected (preserved in ethanol or frozen) = \*: 1-10 ind. ; \*\*: 11-100 ind. ; \*\*\*: >100 ind.

Vent field	7°25S	14°S	17°25S	17°34S	18°25S	18°36S	21°25S	21°33S
Fluid sample	3S	4S	5S	2S	2S	0	4S	4S
Water sample	2N	0	12S+4N	4S	4S	0	0	2N
Plankton tow	0	0	2	0	0	0	0	1
Nasse	2	1	5	1	0	0	0	2
Sulfide/rocks	X	X	X	X	X	0	X	X
Microbial sample	13	8	26	7	5	0	3	7
Alchemist measurements	0	X	X	X	X	0	0	0
Alvinellid chimney	X	X	X	X	X	0	X	X
Mussel bed	X	X	X	X	0	X	0	X
Sampled key species								
Polychaeta								
<i>A. pompejana</i>	***	**	***	***	***	0	***	***
<i>Paralvinella</i> spp.	*	0	**	**	*	0	*	**
<i>R. pachyptila</i>	0	0	*	**	0	0	0	0
<i>T. jerichonana</i>	0	0	**	*	0	0	0	*
<i>B. symmytilida</i>	**	**	**	**	0	**	0	**
<i>H. bergi</i>	*	*	**	*	*	0	**	*
Bivalvia								
<i>B. thermophilus</i>	**	**	***	***	0	***	0	***
<i>C. magnifica</i>	0	0	**	0	0	0	0	0
Gastropoda								
<i>E. auzendei</i>	0	0	0	0	0	**	*	**
<i>L. elevatus</i>	**	***	***	***	0	**	0	***
<i>E. vitrea</i>	**	**	***	**	0	***	0	**
Crustacea								
<i>Neolepas</i> aff. <i>rapanui</i>	0	0	**	0	0	0	0	**
<i>Chorocaris</i> sp.	0	0	0	0	0	0	0	**
<i>Bythograea</i> spp.#	*	0	**	*	*	0	*	**
<i>C. praedator</i>	0	**	*	*	0	0	0	0
Vent fishes###	0	0	*	*	0	0	0	*

#: mixing of *B. thermydron*, *B. laubieri*, *B. vrijenhoeki* and *B. microps* from 17°34S to 21°33S,  
 ##: Bythidiidae and Synaphobranchidae

edifices in their close proximity, especially at 7°24S and 17°25S. At the 23 previously described vent sites explored from 1994 till 1999 (mk or # in the following text), all the hydrothermal vent edifices were still active black smokers. However, most of the fauna at the diffusely venting areas have become extinct or moribund (e.g. White Christmas/Sarah'Spring/Robbie'Roost/Animal Farm/Pagoda) and only one diffuse venting site with a vestimentiferan cluster was discovered. An extended period of time was thus dedicated to explore the rift valley and allowed us to discover 6 additional vent sites (e.g. Last Hope at 7°24S or Lucky Eric at 14°S) and the deployment of 18 new BS markers (Table 1).

Despite the lack of several key vent species (i.e. vestimentiferan tubeworms, *Paralvinella grasslei* or *Hesiolyra bergi*), the Nautilid dives allowed us to collect numerous biological samples from at least one alvinellid-colonized vent chimney and one mussel bed per vent field together with fluids, pore-water and microbial samples (Table 2).

#### Brief description of the explored vent fields

At 7°24S, we were able to find both the sites White Christmas (mk 42) and Sarah'Spring (mk US Biomarker)

but there was a noticeable lack of venting. Empty tubes of vestimentiferans were found at White Christmas. They have totally disappeared from Sarah'Spring where anemones and a few deep-sea vent mussels were still alive. However, a new site called Last Hope (BS1) characterized by a set of alvinellid-colonized black smokers was discovered a few hundred meters south of Sarah'Spring within a larger area of extinct chimneys suggesting the occurrence of an ancient vent field that was highly active.

At 13°58S, Pagoda's chimneys #1-#4 (BS16-18) and the Smokin'Shank vent site were also found successfully but were nearly devoid of fauna. Black smokers were all very active and surrounded by scarce empty bivalve shells. A second dive further south of Pagoda (#4, BS16) allowed us to find two additional vent sites composed of alvinellid-colonized black smokers at 13°59.210S-112°28.958W followed by a bed of large mussels (Lucky Eric vent site).

At 17°25S, we found all the previously discovered vent chimneys (Stanley, Chimney US#1, Northern chimney #24, S-vent, Nadir #4). All of these are still active black smokers that are covered with *Alvinella* spp. However, apart from the occurrence of large patches of

mussels, clams and stalked cirripedes both at the Oasis vent site (Figure 2) and in the southern part (BS13) of the Rehu Marka vent chimneys (Northern chimney #24), no other diffuse venting areas were detected (Robbie' Roost #2 vent site was totally extinct). Moreover, vestimentiferan tubeworms were rare, small and located within small collapsed holes in the lava lake (Figure 3).

At 17°34S, we successively visited the dense mussel bed at the Calvin vent site, and the alvinellid-covered chimneys of the Hobbs and MissWormwood vent sites which seemed unchanged compared to previous observations made in 1998. Particularly, they displayed few *R. pachyptila* tubeworms at their base. The vent sites were aligned along the ridge axis within a narrow graben.

At 18°25S, the active part of the ridge was narrow and highly tectonized. Very large, extinct chimneys were abundant (every few tens of meters) and well-aligned at the base of a small crest. Apart from numerous inactive sulfide chimneys, three groups of active black smokers were localized without any diffusion and vent fauna at their base. A single colony of *Alvinella* spp. was found near the Fromveur site at the location of the Japanese marker #22 (BS7). Another new vent site (Cathedral) was discovered between the Fromveur and Sojourn vent sites and is characterized by an assemblage of crabs, serpulid worms and anemones at the base of active but not otherwise colonized black smokers (BS8).

At 18°36S, the northern part of the lava lake where the site Animal Farm is located, appears to have been the place of recent active venting as extinct vent chimneys and numerous clam/mussel cemeteries were found. No sign of hydrothermal activity was detected, with the exception of a bed of surviving deep-sea mussels associated with numerous *Eosipho auzendei* gastropods, crabs and anemones (BS12).

At 21°25S, we found very large active chimneys (more than 20-meters high) covered with *Alvinella* worms at the location of the Bordeaux (BS5) and Natacha&Boris



Figure 2  
Mussel/clam bed at the Oasis vent site surrounded by dense *Neolepas aff rapanui* cirripedes (copyright IFREMER).

vent sites. However, no other marker was found to confirm the submersible position. Furthermore, another new venting site (BS4) with small black smoker pipes and a few *Alvinella* colonists was discovered at 21°25.237S-114°16.456W near the Jasmine vent site.

At 21°33S, our dives located all the active vent sites discovered during the American 1998 SEPR Expedition (i.e. Krasnov, Gromit, Feathers and Brandon #BL). The area was very active, with numerous black smokers. Two types of chimney were found; the first type was made of thin sulfide pipes that merged at their base and was dominated by *Chorocaris* shrimp swarms (Brandon's chimney, BL), the second type consisted of massive black smokers covered with alvinellid tubes (Krasnov's chimney, BS3). A very large mussel bed was also found at Gromit (21°33.669S-114°17.904W) where mussels, crabs, hagfishes and *Eosipho auzendei* gastropods surrounded small diffusors.

#### Geodiversity at hydrothermal vents

The sampling of hydrothermal vent chimneys over the whole 1600-km range of the SEPR portion led to a large collection of sulfide rocks (mostly chimney tops) from the eight hydrothermal vent fields. Microbial samples were collected from these rocks and preserved or cultivated on board. Moreover, 24 fluid samples whose temperature ranged from 51° to 370°C were also collected from these chimneys using titane syringes. Preliminary results showed that the fluids exhibit a very wide range of temperatures, chemical and gas compositions. Gas-enriched fluids with low chlorinities and depleted in dissolved metals contrasted relatively to gas-depleted fluids with high chlorinities and enriched in dissolved metals. This confirms that phase separation processes controlled by volcanic and tectonic activities are very active on this ultra-fast spreading ridge from 7°24S to 21°33S, as previously described along the 17°-19°S ridge section (Charlou et al. 1996).

#### Biodiversity and biogeography of metazoa at hydrothermal vents

The sampling of hydrothermal vent communities over the same spatial range led to the upcoming description of several new species within annelids, and especially alvinellid, polynoid, sphaerodorid and archinomid polychaetes, the discovery of undescribed lineages of parasitic monogeneous and digeneous trematodes associated with at least three new undescribed species of deep-sea fishes, and to an undescribed lineage of turbellariid parasites associated with bythograeid crabs. In addition, external parasites such as the nemertean *Carcinonemertes* sp. and the worm *Bathybdella sawyeri* (Hirudinea) were found on the crab *Cyanagraea praedator* and the clam *Calyptogena magnifica*, respectively. Comparisons between the different faunal assemblages also showed a progressive mixing of the classical EPR vent fauna with metazoan species closely related to the western Pacific back-arc basin species such as the gastropod *Eosipho auzendei*, the cirripede



Figure 3. Residual population of vestimentiferan tubeworms (*Riftia pachyptila*) within crevices and collapsed lava lake holes surrounded by mussels and stalked cirripedes (copyright IFREMER).

*Neolepas* aff. *rapanui* and *Eochionelasmus paquensis* and the polychaete *Thermiphione* aff. *fijiensis*. This was particularly clear within the 21°33S vent field where there is a mixing of hydrothermal vent chimneys inhabited by either *Alvinella* colonies (Krasnov/Gromit sites) or *Chorocaris* sp. swarms (Brandon/Feathers sites) similar to those found along the mid-Atlantic Ridge, the Indian Ridge and the western Pacific back-arc basins (Van Dover et al. 2001). Moreover, 35 cultures containing mixed populations of protists were successfully conducted at 15°C and brought back alive to Roscoff, where they are currently being purified by serial dilutions. So far, 14 pure cultures have been isolated and these are being maintained within the RCC (Roscoff Culture Collection, <http://www.sb-roscoff.fr/Phyto/RCC/index.php>). New species of protists may be found and morphologically/molecularly described among these novel isolates.

#### Microbial diversity and phylogeography

During the cruise, 43 and 58 bacterial-specific enrichments were processed from sulfide rocks and *Alvinella* tubes from nearly all the hydrothermal vent fields to assess both the diversity and biogeography of Methanogene and Thermococcales archaea, respectively. Specific viral enrichments were also performed from the same substrata. A collaborative project with geologists was established to correlate the composition of archeal/bacterial assemblages with rock mineralogy. Other microbes such as *Bacillus*, *Thermus* or thermopiezophilic species were conditioned on board under anaerobic conditions but at one atm. Moreover, bacterial assemblages associated with *Alvinella* tubes were sampled specifically on Alchemist-scanned areas at the Hobbs vent site (17°34S) to better understand the microbial distribution at micro scales. In addition, the diversity of retrovirus (i.e. transposable elements of eukaryote genomes) was assessed both from vent annelid and decapod crustaceans that were collected between 7°24S and 21°33S.

#### Reproductive strategies, larval dispersal & population genetics

A massive hierarchical sampling of *Alvinella pompejana*, *Bathymodiolus thermophilus*, *Branchiopolynoe symmytilida* and *Lepetodrilus elevatus* over the eight vent fields allowed us to perform sex-specific demographic and genetic analyses at various spatial scales in order to fully understand both reproductive and recruitment processes in the SEPR vent sites. This was performed in connection with larval sampling above three distinct mussel beds using a plankton net (63 mm mesh size) specifically designed for the submersible Nautile. The use of intronic/microsatellite DNA markers on adults, juveniles and larvae together with sex determination and biometry will provide useful information to determine long-term migration, hybridization and potential cryptic speciation. Reproduction and larval development (PICCEL) of *A. pompejana* were also carried out in order to complete previous studies made at 13°N/EPR in 1999 and 2002.

#### Biogeochemical processes and microhabitat characterization

The relationships between total sulfide and total Fe<sup>II</sup> concentrations, temperature and pH in the habitats of vent animals were studied from *in situ* measurements with the submersible chemical analyser 'ALCHIMIST'. Four distinct vent chimneys for which the conditions and the alvinellid coverage were strikingly different, were selected. A second series of measurements was conducted on an extended clams/mussels bed of the Oasis vent site at 17°25S. This ecological survey on diffuse venting assemblages also included video-mosaicking, time-series measurements of temperature (autonomous temperature probe tripods), *in situ* sulfide analysis with the ALCHIMIST measurements over a spatial grid and faunal samplings performed along a metal-link chain lying on several faunal units (mussels, clams/mussels, cirripedes).

#### Transcriptomics of vent annelids

Because genome sequencing projects have been funded for both *Alvinella pompejana* and *Riftia pachyptila* within GENOSCOPE and the European Network of Excellence « Marine Genomics » for a French Consortium, specific *in vivo* experiments were performed on board in order to provide enough material for the construction of tissue-specific cDNA libraries, chromosomal counts, genome size calculation and cell-lineage cultures. The high number of samples which were processed will enable us to come up with a nearly complete sequencing (full length cDNAs) of the annelid transcriptomes.

#### Adaptive responses of vent organisms to thermal, oxidative and metallic stresses

During the cruise, a great number of clams and mussels were collected to study the metallothionein response of bivalves according to various *in situ* vent conditions. In addition, the study will also correlate metallothionein concentrations with variations of the intracellular metallic elements and radionuclides of several tissues from the animals.

Because both *Paralvinella grasslei* and *Hesiolyra bergi* were very rare, the response to oxidative stress was only studied on *Alvinella pompejana*, *Alvinella caudata* and *Tevnia jerichonana* at different oxic conditions using three new pressurized chamber devices (DESEARE) equipped with the gas-condition controller SYRENE. For the same reason, a few thermal-stress *in vivo* experiments were conducted on *H. bergi*, the crab *Cyanagraea praedator* and the gastropod *Eosipho auzendei*. Additional simulated vent conditions were tested within the pressurized chamber devices (IPOCAMP) to improve survival of *A. pompejana* after its collection (B. Shillito). Megalopae of *C. praedator* were also kept alive at 4°C and 1 atm during the complete duration of the cruise and then in Roscoff for 3 months. These were not able to metamorphose.

### Conclusion

Despite the occurrence of numerous vent extinctions at previously described SEPR vent localities and the restricted amount of time dedicated to each vent field, most of the BIOSPEEDO cruise's objectives were reached. *In situ* observations and the extensive sampling of vent fauna ranging from 7°24S to 21°33S will be the basis for future promising ecological and molecular analyses over all the faunal compartments of the vent assemblages. This will allow us to test various biogeographical and ecological hypotheses and, as an ultimate goal, to extend our knowledge of population functioning within a single vent sector (i.e. 13°N/EPR: HOPE99) to broader spatial scales.

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### References

Auzende, J.-M., V. Ballu, R. Batiza, D. Bideau, M.-H. Cormier, Y. Fouquet, P. Geistdoerfer, Y. Lagabriele, J. Sinton, and P. Spadea, *Activité magmatique, tectonique et hydrothermale actuelle sur la dorsale Est Pacifique entre 17° et 19°S (campagne NAUDUR)*. *C. R. Acad. Sci. Paris*, 319, 811-818, 1994.

Charlou, J.-L., Y. Fouquet, J.-P. Donval, J.-M. Auzende, P. Jean-Baptiste, M. Stievenard, and S. Michel, *Mineral and gas chemistry of hydrothermal fluids on an ultrafast spreading ridge: East Pacific Rise, 17° to 19°S (Naudur cruise, 1993) – phase separation processes controlled by volcanic and tectonic activity*. *J. Geophys. Res.*, 101(B7), 15899-15919, 1996.

Chevaldonné, P., D. Jollivet, A. Vangriesheim, and D. Desbruyères, *Hydrothermal-vent alvinellid polychaete dispersal in the eastern Pacific. I. Influence of vent-site*

*distribution pattern, bottom currents and biological features*. *Limnol. Oceanogr.*, 42(1), 67-80, 1997.

Fujioka, K., G. Massoth, C. de Ronde, A. Tanaka-Nakano, J. Gendron, M. Kinoshita, A. Nishizawa, O. Okano, G. Paradis, K. Roe, M. Shinohara, K. Shitashima, U. Tsunogai, and N. Ytow, *MODE'94: Active hydrothermal systems of a super-fast spreading ridge, Southern East Pacific Rise (13°58S to 18°26S)*. *InterRidge News*, 4(1), 7-10, 1995.

Geistdoerfer, P., J.-M. Auzende, V. Ballu, R. Batiza, D. Bideau, M.-H. Cormier, Y. Fouquet, Y. Lagabriele, J. Sinton, and P. Spadea, *Hydrothermalisme et communautés animales associées sur la dorsale du Pacifique Est entre 17° et 19°S (campagne NAUDUR)*. *C. R. Acad. Sci. Paris*, 320, 47-54, 1995.

Guinot, D., and L.A. Hurtado, *Two new species of hydrothermal vent crabs of the genus Bythograea from the southern East Pacific Rise and from the Galapagos Rift (Crustacea: Decapoda Brachyura Bythograeidae)*. *C. R. Acad. Sci. Paris, biologie*, 326, 423-439, 2003.

Halanych, K.M., M. Tieger, G.D. O'Mullan, R.A. Lutz, and R.C. Vrijenhoek, *Brief description of biological communities at 7°S on the East Pacific Rise*. *InterRidge News*, 8(2), 23-26, 1999.

Hurtado, L.A., R.A. Lutz, and R.C. Vrijenhoek, *Distinct patterns of genetic differentiation among annelids of eastern Pacific hydrothermal vents*. *Mol. Ecol.*, 13, 2603-2615, 2004.

Hurtado, L.A., M. Mateos, R.A. Lutz, and R.C. Vrijenhoek, *Molecular evidence for multiple species of Oasisia (Annelida: Siboglinidae) at eastern Pacific hydrothermal vents*. *Cah. Biol. Mar.*, 34, 377-380, 2002.

Renard, V., R. Hékinian, J. Francheteau, R.D. Ballard, and H. Bäcker, *Submersible observations at the axis of the ultra-spreading East Pacific Rise (17°30' to 21°40'S)*. *Earth Planet. Sci. Lett.*, 75, 339-353, 1985.

Scheirer, D.S., K.C. MacDonald, D.W. Forsyth, and the Scientific Party, *Widespread volcanic and tectonic activity on the Southern East Pacific Rise and its flank*. *Ridge Newsletter*, 4(1-2), 8-10, 1993.

Van Dover, C.L., *Community structure of mussel beds at deep-sea hydrothermal vents*. *Mar. Ecol. Prog. Ser.*, 230, 137-158, 2002.

Van Dover, C.L., S.E. Humphris, D. Fornari, C.M. Cavanaugh, R. Collier, S.K. Goffredi, J. Hashimoto, M. Lilley, A.L. Reysenbach, T.M. Shank, K.L. Von Damm, A. Banta, R.M. Gallant, D. Gotz, D. Green, J. Hall, T.L. Harmer, L.A. Hurtado, Z.P. McKiness, E. Olson, I.L. Pan, M. Turnipseed, Y. Won, C.R. Young III, and R.C. Vrijenhoek, *Biogeography and ecological setting of Indian Ocean hydrothermal vents*. *Science*, 294, 818-823, 2001.

Won, Y., C.R. Young, R.A. Lutz, and R.C. Vrijenhoek, *Dispersal barriers and isolation among deep-sea mussel populations (Mytilidae: Bathymodiulus) from eastern Pacific hydrothermal vents*. *Mol. Ecol.*, 12, 169-184, 2003.

## Russian biological studies using *Mir* submersibles at North Atlantic and East Pacific hydrothermal sites

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The 49<sup>th</sup> cruise of R/V *Akademik Mstislav Keldysh* with 2 manned submersibles *Mir* started on 31<sup>st</sup> May 2003 from Kaliningrad, Russia, and ended here on 3<sup>rd</sup> December 2003. The cruise was undertaken to study geological and biological processes at the Charlie Gibbs Fracture Zone, to investigate the wreck site of the HMS „Titanic“, and to study hydrothermal vent fields along the Mid-Atlantic Ridge (MAR), East Pacific Rise (EPR) and in the Gulf of California. In this paper we focus on the biological studies at the hydrothermal vent fields Menez Gwen, Lost City, Snake Pit, 9°N, 21°N (EPR) and in the Guaymas Basin.

Overall attention was focused on the entire hydrothermal ecosystems: benthic, benthopelagic, and planktonic components were examined with equal priority. The biological team consisted of Sergey Galkin (head of the biological group, benthos distribution, mapping and landscape approach to the vent communities), Georgy Vinogradov (water column and near-bottom ecology, amphipod biology), Darya Zasko (radiolarian studies), Vladimir Gagarin (primary production, deck works and Vladimir Dyakonov (computation biologist). Andrey Gebruk (benthos distribution and ecology) and Elena Krylova (bivalve biology) participated in biological work at the Charlie Gibbs Fracture Zone (CGFZ) within the framework of the MAR-ECO project (Bergstad, 2002).

### Water column studies

The principal goal of plankton studies was the investigation of the pelagic communities' structure in the water column and in the near-bottom layer above the hydrothermal fields. Special attention was paid to the possible exposure of chemosynthetically derived organics in pelagic food chains. Four dives were devoted to a plankton research program at the Charlie Gibbs Fracture Zone (CGFZ), at Menez Gwen (MAR), 9°N East Pacific Rise (EPR) and Guaymas vent sites. During these dives, large planktonic animals (0.5 cm and more) were visually studied using a standard 3m<sup>2</sup> frame (see details of the method in Vereshchaka & Vinogradov, 1999). In addition to the visual observations, a vertically hauled BR <sup>113</sup>/<sub>140</sub> plankton net (opening area 1 m<sup>2</sup>, mesh size 500 mkm) was used. Above all vent fields, the near-bottom layer was sampled, whereby the net position was controlled with a pinger ("Benthos"). The sampled layers corresponded to the different water masses recorded by previous vertical probing with a CTD "Rozette". Here we discuss only the principal results from these studies.

During the dive at the *Charlie Gibbs Fracture Zone*, macroplankton was counted in the water depth layer from 170 to 4361 m (bottom depth). The most important result of the dive was the discovery of a well-pronounced near-bottom maximum of appendicularian "houses" (Figure 1). Similar patterns were previously reported from many hydrothermal sites (Vereshchaka et al., 2002). Our observations confirm that a near-bottom concentration of appendicularians is typical also for non-vent regions.

In the region of the *Menez Gwen* vent site no near-bottom maximum of appendicularian "houses" was recorded. A more pronounced maximum was observed adjacent to the upper layer of Mediterranean water masses, which were well marked by the salinity curve. This maximum was mainly composed of gelatinous animals (including voluminous appendicularian "houses"). The only group demonstrating a maximum near the bottom were pelagic shrimps. However, we found similar increases of shrimps

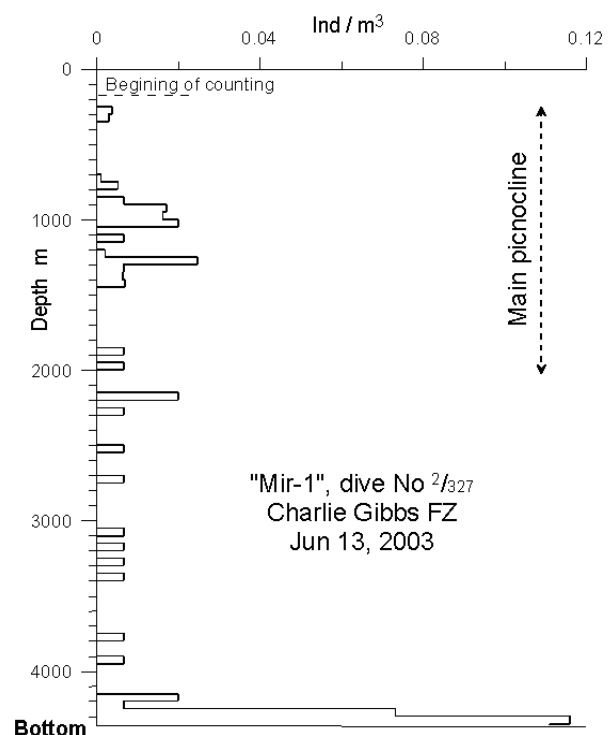


Figure. 1  
Distribution of appendicularian "houses" in the whole water column above Charlie Gibbs Fracture Zone.

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far from the bottom at depths of 800m-1000m in other regions.

In the zone adjacent to active hydrothermal vents, chaetognaths and fishes (cyclothones, mictophids and deep-sea hatchetfishes) as well as small red pelagic shrimps were observed. Euphasiid and hyperiid amphipods (*Platyscelus ovoides*?) that swarmed near the submersible lighting appliances were recorded. Gelatinous animals (siphonophores, ctenophores) were rare in the near-bottom layer. Near the bottom, large eel-like fishes of the family Siphonobranchidae were common. Sometimes we observed these fishes feeding on dead fishes and mytilids.

Net samples above the *Lost City* vent area (30°07'N) revealed the presence of south-boreal species *Calanus helgolandicus* (16,7 mg/m<sup>2</sup> in the whole water column; maximum concentration 0,047 mg/m<sup>3</sup> in the layer 400-600 m). In this 400-600m layer *C. helgolandicus* occurred mainly as adult (mature) males. Formerly this species was recorded only north of 35°N (Fleminger, Hulsemann, 1977). The presence of *C. helgolandicus* in the *Lost City* area was first observed in 2002 (Vereschaka et al., 2002) and is therefore probably not rare here.

Water column studies in the area of 9°N (EPR) showed plankton distribution patterns similar to the Atlantic sites. A near-bottom maximum of gelatinous animals was well pronounced. Suspension-feeding appendicularians may be attracted by the suspended organic matter concentrated in hydrothermal plumes. But the concentration of "marine snow" (lifeless detritus particles) in the same layer suggests this phenomenon might be conditioned by sharp hydrological gradients along the plume boundaries (Figure 2).

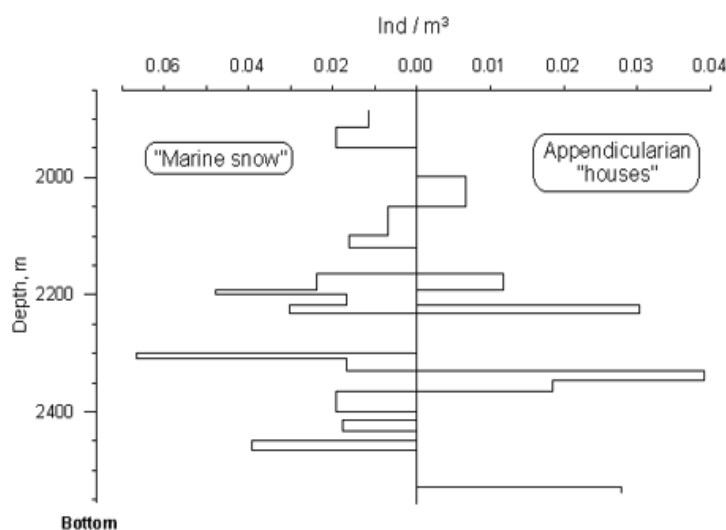


Figure 2  
Distribution of "marine snow" and appendicularian "houses" in the near-bottom layer above 9°N vent area (Mir-2 dive # 18/356, Station 4623, Sep.5. 2003).

Water column studies in the *Guaymas Basin* (Gulf of California) included submersible dives and net samples. Macroplankton distribution patterns here were different from those in the open ocean. The total biomass in the water column was extremely high (2,5gC<sub>org</sub>/m<sup>2</sup> compared to 1,3g C<sub>org</sub>/m<sup>2</sup> at 9°N). This site is characterised by a high abundance of appendicularians, presumably a result of the high concentration of organic detritus in the entire water column. The maximum accumulation of appendicularians was observed in the layer 220-240 m (up to 1,4 - 2,3 individuals/m<sup>3</sup>). A second, less prominent maximum corresponded to depths of 1000-1500 m. Different appendicularian species contribute to the plankton maxima at different depths. Notable characteristics of Guaymas plankton communities was the abundance of small, pinkish-red, active and mobile pelagic polychaetes, which were not observed at other sites. Benthopelagic holothurians (15-20 cm long) were regularly observed near the bottom. Gelatinous animals showed maximum distributions in the layer of the main pycnocline. No near-bottom maximum of gelatinous animals was recorded. Large red medusas were regularly observed near the bottom. Pelagic shrimps increased in the lower part of the water column but they avoided the muddiest near-bottom layer. We suggest that suspended organic detritus concentrated in deep layers beneath the highly productive surface waters may attract carnivorous pelagic shrimps. Chaetognaths are the second group that contribute to the deep-sea plankton community in the Gulf of California. No direct influence of chemosynthetically derived organic matter on plankton abundance and composition was recorded.

#### Benthic studies

##### Mid-Atlantic Ridge

Six areas (Snake Pit, TAG, Broken Spur, *Lost City*, Lucky Strike, and Rainbow) were explored using *Mir* submersibles during the 47<sup>th</sup> cruise of *Akademik Mstislav Keldysh* in 2002 (Vereshchaka et al., 2002). Therefore during this expedition special attention was focused on the *Menez Gwen* hydrothermal area not visited previously by Russian submersibles.

*Menez Gwen* (37°50'N MAR, depth 840-875 m) is the shallowest known Atlantic vent area inhabited by specific hydrothermal macrofauna (Fouquet et al., 1994; Desbruyères et al., 2000; 2001). A total of 29 biological samples were recovered during 9 dives. Direct observations as well as videotape recordings using a high-resolution system and photography were made.

More than 30 species of bottom animals were recovered. Several active sites were investigated on the southeast slope of a small

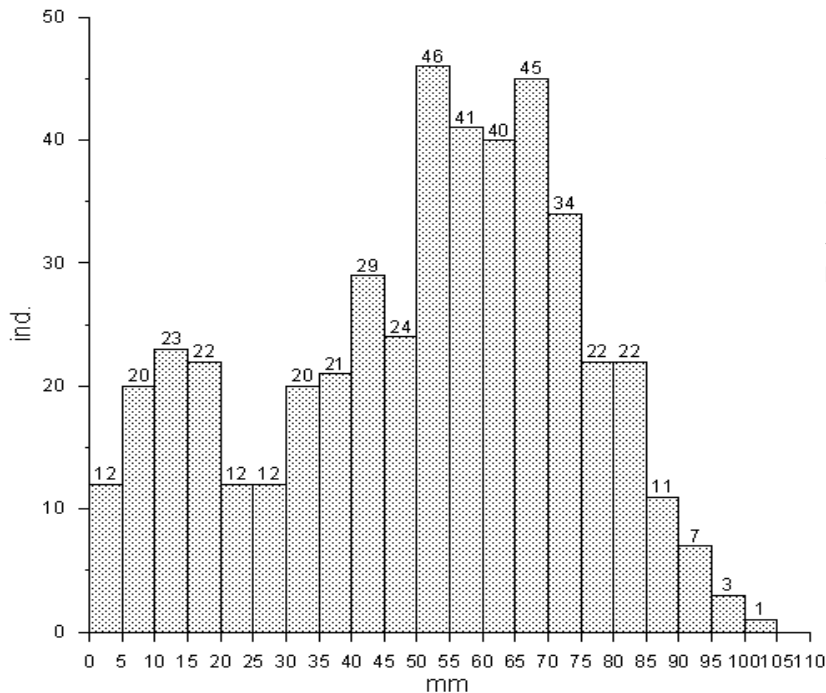


Figure 3  
Size structure of *Bathymodiolus azoricus* population in southern part of Menez Gwen hydrothermal field (Mir-2 dive # 9/347, Station 4582, Jul. 29. 2003). Vertical axis, number of individuals; horizontal axis is the length of the shells (mm).

volcano at water depths ranging from 845 to 875 m. One site along an escarpment of the slope, between 850 and 865 m depth, was studied in detail. At this site, hydrothermal precipitates cover an area of about 70 m in diameter. Hydrothermal deposits, from which a 10-50°C fluid diffused, occupy the center of the site. A few small anhydrite chimneys (up to 60 cm high) emitted fluids with temperatures of 180°C. The site is bordered by a field of pillow lava and by crumbled rocks. The periphery of this vent field was occupied by a small, dense accumulation of sessile suspension feeders. Several species of corals (*Lophelia prolifera*, *Madrepora oculata*, *Caryophyllia sarsiae*) dominate the background community. Gorgonian and soft corals and sponges are also abundant locally. In some places, dead *Lophelia* and *Madrepora* cover an area of up to 1-2 m in diameter. Numerous small animals inhabit these "reefs": eunicid polychaetes, serpulids, mud and galatheid crabs, picnogonids, cidarid urchins, barnacles (*Bathylasma hirsutum*), bryozoans and others. At least 10 species (mainly polychaetes, ophiurids, and gastropods) regularly associated with corals were recorded. Some rocks around the field as well as hard hydrothermal deposits were densely populated by large hydroids (*Eudendrium* spp., *Grammaria abietina*). Numerous bathial fishes such as *Gaidropsarus*, *Neocyttus helgae* and others, were observed around the site.

Mytilids *Bathymodiolus azoricus* dominate the vent community in the hydrothermally active zone. Significant mussel colonies were attached to hard deposits adjacent to vents, sometimes in the "shimmering water" zone. The mytilid populations found in the southern study area (F12 marker) consisted mainly of large individuals: 79% of collected mussels were 30-85 mm long (mode 50-75 mm: 45%). But one younger cohort (mode 5-20 mm)

was also present and represented ca. 14% of the population (Figure 3) (compare: Comtet, Desbruyères, 1998). In contrast, two most representative samples from the northern site (PP33 marker) showed a predominance of young mussels: small individuals ( $L < 2$  cm) represented 85% of the population (Figure 4: 73% - left histogram; 85% - right histogram). An extremely low invasion of mussels by commensal scale-worms was observed. There were no commensal worms in the mussels from the southern site. Only one specimen of scale-worm *Branchiopolynoe seepensis* was recovered from the northern site (in all, more than 1300 mussel individuals were examined). This observation agrees with data by Desbruyères et al. (2001).

Extensive bacterial mats covered some of the mussel populations. Numerous patelliform gastropods were present on the mussels' shells, *Protolyra valvatoides* and *Lepetodrilus atlanticus* were most abundant (up to ten individuals/m<sup>2</sup>). *Laeviphytus* sp., *Lurifax vitrens*, *Shinkailepas briandi*, *Xilodiscula analoga* and Trochid gastropods occurred in relatively small numbers. Many small animals inhabited the mussel beds: amphipods (*Eusiridae*), isopods, ostracods, eunicid polychaetes, rare Nemertina, cancellariid and opisthobranch gastropods. Many geronid crabs *Chaceon affinis* came to feed on the mussels.

The main peculiarities of the Menez Gwen vent community were relatively small numbers of indigenous "hydrothermal" species and a significant occurrence of non-vent species in the vent environment.

Some animals previously reported as "patchy" or "common" (see Desbruyères et al., 2001; 2002), were rare or not recorded during our dives. Only a single individual of *Mirocaris fortunata* was observed during

the dives. Neither *Chorocaris chacei* nor *Segonzacia mesatlantica* were recorded. Only one commensal scale-worm was recovered (see above). All these observations (including some patterns of *Bathymodiolus* population size structures) present evidence of instability in time and space. We propose that the Menez Gwen hydrothermal community does not represent a fully independent, stable vent ecosystem. This region may represent a non-reproductive part of a population for some vent-endemic species (e.g. bresilioid shrimps, bythograeid crabs, commensal scale worms). We suggest there may be a periodical genetic connection between the Menez Gwen vent community and the rich and thriving Lucky Strike vent community. Lucky Strike is one of the largest known active fields in the modern ocean, while Menez Gwen is one of the smallest fields. Menez Gwen and Lucky Strike are separated by only 49 nautical miles and demonstrate the most significant similarity between faunas (see Desbruyères et al., 2000). All "obligate hydrothermal" species recorded at Menez Gwen are also known at Lucky Strike.

Lost City, the most recently discovered MAR vent area, shows unusual geological and biological settings. Specialized biological observations were undertaken here in 2002 (47<sup>th</sup> cruise of *Akademik Mstislav Keldysh*) (see: Vereschaka et al., 2002). During our expedition (2003) more than 25 species were recovered. Most of them represent non-vent (background) taxa. However, some specific hydrothermal species such as polychaetes *Archinome rosacea* (Archinomidae) were collected. Many specimens were prepared for future laboratory analyses.

The Snake Pit hydrothermal area was visited by a Russian expedition in 2002 (op.cit.). During our cruise (2003), additional material was collected, particularly for mussel - commensal relationship studies (Britaev, Krylova in prep.). Several specimens of actinostolid actinians *Maractis rimicarivora* (Fautin and Barber, 1999) were sampled at the periphery of vent fields. Based on previous collections at TAG and other vent sites, we propose that this species, not *Parasicionis ingolfi* (see Desbruyères, Segonzak, Handbook of deep-sea hydrothermal vent fauna, 1997, p.30) represent a dominant peripheral species at many Atlantic vent areas (N.Sanamyan – pers. comm.).

#### **Eastern Pacific**

EPR, 9°N. Five active hydrothermal sites extending along a 1-km long section of the floor of the axial summit caldera (ASC) between 9°50,50'N and 9°51,00'N were explored. The venting fluids in this area ranged from high temperature (more than 200°C) fluids emanating from the orifices associated with sulfide deposits to clouds of diffuse flow issuing from fissures, cracks and deep pits in collapsed lavas.

At least 50 species of bottom animals were recorded. Numerous non-vent suspension feeders inhabited the floor and walls of the caldera. Nematocarinid shrimps,

octopods, galatheids *Munidopsis subsquamosa* and bythograeid crabs were abundant at the periphery of venting sites. Serpulid polychaets *Laminatubus alvinae* and *Protis hydrothermica* (up to 180-220 individuals/m<sup>2</sup>) inhabited the nearest periphery of vents. The fields of active venting were occupied by dense populations of mussels *Bathymodiolus thermophilus*. Numerous patelliform gastropods (*Lepetodrilus ovalis*, *L.elevatus*, *L.cristatus*, a.o) were present on the mussels' shells. Trochidae *Bathymaegarites* sp. was also abundant. Large *Phymorhynchus* were observed regularly sometimes in groups of 3-10 individuals. Sea anemones (*Cyanathea hydrothermala*) were common, and usually found in small clusters. Bythograeids were widespread within the active zone. Visual observations suggested that galatheids prefer the periphery of a field. Bresilioid shrimps (*Alvinocaris*) were regularly observed but not abundant. Vesicomysids *Calyptogena magnifica* were not abundant and usually associated with bare basalts at the periphery of mussel beds. Lava pillows between *Bathymodiolus* beds were extensively populated by pedunculate cirripeds *Neolepas zeviniae*. Zoarcid fishes *Thermarces andersoni* and large pantopoda *Colossendeis colossea* were common. Vestimentiferan tubeworms *Riftia pachyptila* were found clustered near the most intense diffuse flow (in "shimmering water"). *Bathymodiolus* beds covered most vestimentiferan tubes. Above *Riftia* populations, dense clusters of pardaliscid amphipods *Halice hesmonestes* were regularly observed. Small vestimentiferan *Oasisia alvinae* were observed attached to *Riftia* tubes and to basalt. Of note is that no living *Tevnia jerichonana* (known as early inhabitants of newly formed hydrothermal vents) were recorded during our dives.

The most "thermophilic" vent assemblages associated with active sulfide chimneys adjacent to black and white smokers were dominated by "pompeji worms" *Alvinella pompejana* (Alvinellidae). Extensive bacterial mats covered alvinellid populations. In addition *Alvinella caudata*, some Nereids and Polynoids (*Lepidonotopodium fimbriatum*) were recorded in this zone (Figure 5).

The EPR 9°N vent area is known as a region of high tectonic and volcanic activity. The April 1991 discovery of newly formed hydrothermal vents in areas of recent volcanic eruptions between 9°45N and 9°52N provided an unique opportunity to follow temporal changes in biological community structure following the "birth" of numerous hydrothermal vents. Photo and videographic documentation of mega faunal colonization was taken from March 1992 till November 1995 (Shank et al., 1998). Time series analyses revealed the principal sequence of events in the successional changes in vent communities: development of bacterial mats, increase of mobile vent fauna abundance, settlement of the vestimentiferan tube worm *Tevnia jerichonana* in areas where diffuse flow is most intense. Dense thickets of the vestimentiferan *Riftia pachyptila* dominated vent openings previously inhabited by *Tevnia jerichonana* characterize

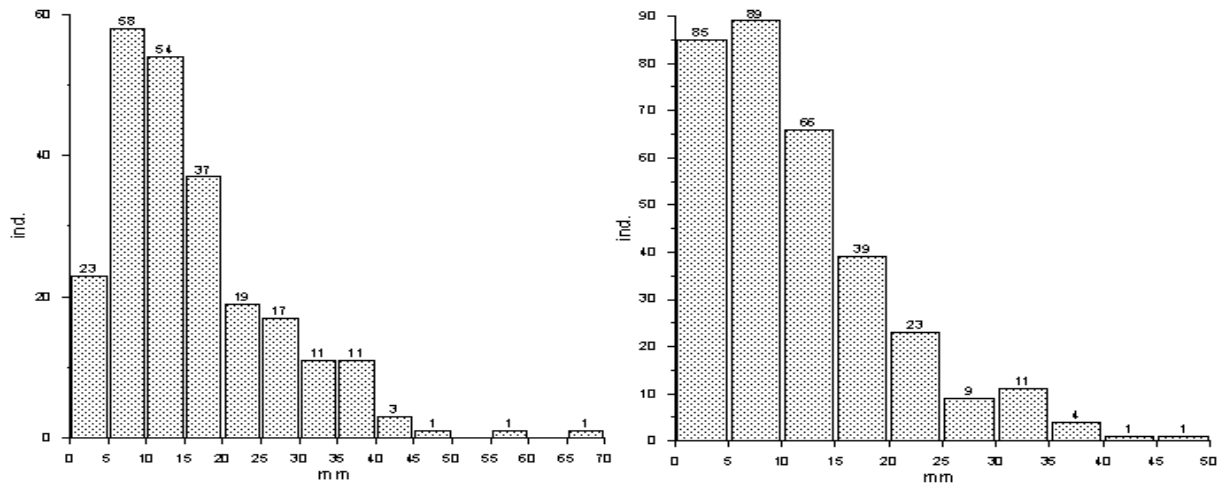


Figure 4  
Size structure of *Bathymodiolus azoricus* population in the northern part of Menez Gwen hydrothermal field (left, Mir-1 dive #11/336, Station 4593, Aug.08.2003; right, Mir-2 dive # 12/350, Station 4594, Aug, 02.08.2003).

the next stage. Three years after the volcanic activity, maximum hydrogen sulfide levels declined and mussels (*Bathymodiolus thermophilus*) were observed on basaltic substrates. Four years after the eruptions, mussels had colonized the *Riftia pachyptila* tubes (Shank et al., 1988).

Based on our observations, we suggest that no direct traces of the 1991 eruption could be observed. All investigated communities are in their mature stages. Based on the size of bivalvia shells, the age of most oases is at least 10-12 years. Mytilid bivalves have fully replaced vestimentiferans as the dominant mega-fauna. No *Tevnia* were observed in the study area, *Oasisia* were rare and seemed to be more tolerant to lower hydrogen sulfide levels compared to *Riftia*. In general, the communities are characterized by high numbers of species in the faunal assemblages and well pronounced spatial zonation.

The *EPR 21°N* vent area was discovered in February 1978 and subsequently explored by many expeditions. During our cruise, detailed investigations were provided on the vent site named Clam Field – one of the biggest and most active sites within the “21°N” area (coordinates of explored site: 21°49,57’N, 109°06,20’W, depth around 2620 m).

During four dives, approximately 25 species were recovered. Mapping of the main hydrothermally active areas and faunal assemblages was done using photo and video documentation.

This active site comprises a field of young pillow lava laterally bordered by crumbled rocks. Low temperature diffuse flow issues from fissures, cracks and deep pits in the collapsed lava. High temperature black and white smokers are associated with 7 hydrothermal chimney structures that are concentrated in the central and northern parts of the field. The periphery of the vent field is occupied by dense settlements of serpulids *Laminatubus*

*alvinae* and *Protis hydrothermica*. Pedunculate cirripeds are less abundant compared to 9°N. Low temperature diffuse flows are inhabited by numerous colonies of *Caliptogena magnifica*. Vestimentiferan *Riftia pachyptila* occupy the places where shimmering water is visible. However the most extensive vestimentiferan colonies are associated with diffuse flows on the walls of sulfide chimneys. The population on the main chimney (12 m high) numbered several thousands living individuals. The clusters of *Riftia* provide the habitat for many small animals. We observed the feeding behavior of Bythograeid crabs biting off parts of vestimentiferan’s plumes. Most of the high-temperature biotope (up to 40°C) is occupied by alvinellid polychaetes. In contrast to 9°N, at 21°N *Alvinella caudata* prevailed in number of individuals over *A. pompejana*.

Consequently, in the investigated community four faunal zones could be established: (1) Periphery – no temperature anomalies, dense populations of serpulids and barnacles, relatively high abundance of galatheid crabs; (2) Low temperature diffuse venting marked by *Caliptogena* populations; (3) “Simmering water” zone dominated by Vestimentiferans, Bythograeid crabs are the dominant indigenous predator; (4) High temperature zone occupied by alvinellid polychaetes. Similar distributions of faunal assemblages are characteristic for other Eastern Pacific communities in their mature stage. The main difference of 21°N compared to 9°N is the absence of *Bathymodiolus thermophilus* known as one of the dominating groups in EPR vent assemblages south of 13°N. This phenomenon is currently unexplained.

#### Guaymas Basin

Hydrothermal evidence in the Guaymas Basin was previously explored by Russian expeditions in 1986 and 1990 (12 and 22 cruises of *Akademik Keldysh*). During this 2003 expedition, we studied the composition and micro-distribution of vent assemblages in the Southern

Trough (depth around 2050m). Approximately 35 species of vent organisms were collected.

The vent community in the study area was dominated by vestimentiferan *Riftia pachyptila* mainly associated with small sulfide mounds or with vertical walls of high sulfide chimney structures. We anticipate that *Riftia* in the Guaymas basin could represent a different morphological form (subspecies?) compared to EPR populations (Galkin, Malakhov in prep.).

Extremely complicated configurations of hydrothermal chimney structures result in a very high diversity of microhabitats. On the surface of sulfide chimneys most vent animals are associated with temperatures ranging from 5°C to 35-40°C. Many animals we observed inhabited vestimentiferan clusters (most abundant were polynoid polychaets, patelliform gastropods, and bythograeid crabs). On surfaces covered by bacterial mats away from vestimentiferan clusters, numerous alvinellid polychaetes *Paralvinella bactericola* were visible. Populations of small pink sea anemones were regularly observed in „simmering water“. Large orange anemones *Phelliactis pabista* attached to bivalvia shells were common at the base of chimneys.

Near the base of high chimneys, a concentration of carnivores and scavengers (Galatheids, Lithodids a.o.) was often observed. In contrast, Bythograeids were most

abundant on clusters of *Riftia*. At the base of one chimney, an extremely dense population of hexactinellid sponges was observed.

Thick bacterial mats usually covered the soft sediment away from sulfide structures. In this low-temperature biotope, polychaets *Ophriotrocha* were abundant. The dominant megafaunal animals found on soft sediment were three new species of *Arcovesica* (*Vesicomysidae*) (Krylova, Starobogatov – in prep.). These bivalves formed clusters up to several m<sup>2</sup> (several hundred individuals) *Nuculanid* and *Thyasirid* bivalves and *Calyptogena pacifica* were common in the areas of cold diffuse seepage away from high temperature vents.

In the Guaymas Basin no pronounced concentrations of background suspension feeders and carnivores were found around the vent sites. Such concentrations were observed at most investigated mid-ocean ridge vent fields. We suggest this phenomenon could be partially explained by the lack of hard substrata in the Guaymas Basin. It is also possible that because of the extremely high photosynthetic productivity in the Gulf of California (>500mg Corg/m<sup>2</sup>/day), hydrothermal convection does not have a conspicuous effect on non-vent animal distributions.

In all research areas representative material was collected for laboratory investigations of the ecology of

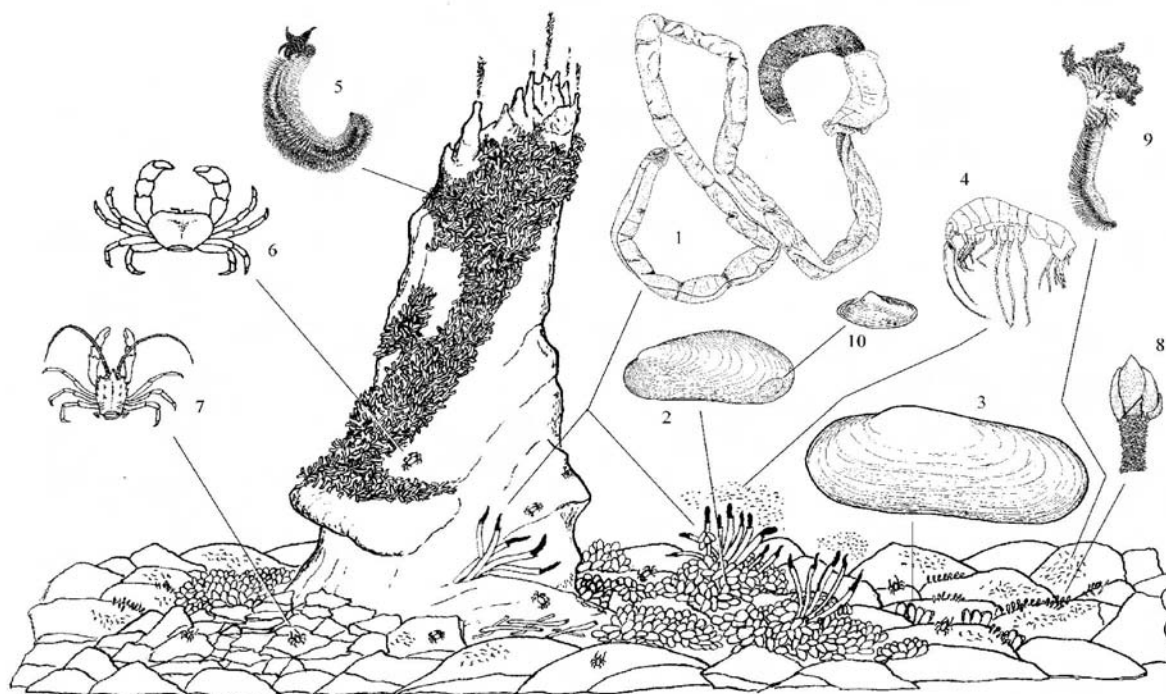


Figure 5  
Distribution of the fauna at the vent field 9°N EPR on the site named „BV“ (9°50,97'N; 104°17,59'W; depth 2517m). The hydrothermal building is about 5 m high, diameter near the base about 2 m. View from the NE.  
Reconstruction made based on direct observations, photo and video documentation (Mir-2 dive #22/360, Station 4642, Sep.16.2003). Main fauna: 1 – *Riftia pachyptila*; 2 – *Bathymodiolus thermophilus*; 3 – *Calyptogena magnifica*; 4 – *Halice hesmonectes*; 5 – *Alvinella pompejana*; 6 – *Bythograea thermidron*; 7 – *Munidopsis subsquamosa*; 8 – *Neolepas zeviniae*; 9 – *Laminatubus alvinae*; 10 – *Lepetodrilus aff. elevatus*.

hydrothermal communities. Collections of tissues for isotope analyses, samples preserved for the SEM and molecular analyses represent all dominant species, both adult and juvenile stages, thus creating an opportunity for further studies of the adaptive morphology and trophic ecology including special features of symbiosis between shrimp and mussel species and bacteria. Genetic collections of various animals and their ontogenetic stages collected from various micro-habitats of visited vent fields will enable us to analyse colonisation processes and recruitment along the Mid-Atlantic and Eastern Pacific vents.

#### Acknowledgements

We would like to thank Captain Yuri Gorbach of the R/V *Akademik Mstislav Keldysh* and his crew for their essential collaboration in the cruise. We also acknowledge the MIR pilots and team for their constant support. Special thanks to Dr. Anatoly Sagalevich for his competence and kindness. We thank also James Childress and Dijanna Figueroa for their valuable help in the work at sea. Many thanks to Drs. N.Sanamyran, E.Turpaeva, L.Moskalev and E.Krylova for identification of vent animals. We express our sincere thanks to Dr. Katharina Georgeleit who's careful review and corrections greatly improved this article.

#### References

Bergstad O.A. MAR-ECO – "Patterns and processes of the ecosystems on the Northern Mid-Atlantic"; an international project under the Census of Marine Life programme. *InterRidge News*, 11(1): 12-14, 2002.

Comtet T., D. Desbruyères, Population structure and recruitment in mytilid bivalves from the Lucky Strike and Menez Gwen hydrothermal vent fields (37°17'N and 37°50'N on the Mid-Atlantic Ridge). *Mar.Ecol.Progr.Ser.*, 163:165-177, 1998.

Desbruyères D., A. Almeida, M. Biscoito, T. Comtet, A. Khripunoff, N. Le Bris, P.M. Sarradin, M. Segonzac, A review of the distribution of hydrothermal vent

communities along the Northern Mid-Atlantic Ridge: dispersal vs. environmental controls. *Hydrobiologia*, 440 (1-3): 201-216, 2000.

Desbruyères D., Biscoito M., Caprais J.-C., Colaco A., Comtet T., Crassous P., Fouquet Y., Khripunoff A., Le Bris N., Olu K., Riso R., Sarradin P.-M., Segonzac M., Vangriesheim A.. Variations in deep-sea hydrothermal vent communities on the Mid-Atlantic Ridge near the Azores plateau. *Deep-Sea Res.* 1. 48:1325-1346, 2001.

Fleminger A., K. Hulsemann, Geographical range and taxonomic divergence in North Atlantic *Calanus* (*C. helgolandicus*, *C. finmarchicus* and *C. glacialis*). *Marine Biology*, 40 {3}: 233-248, 1977.

Fouquet J.L., J.-L. Charlou, I. Costa, J.P. Donval, J. Radford-Knoery, H. Pelle, H. Ondreas, N. Lourenco, M. Segonzac, M.R. Tivey, A detailed study of the Lucky Strike hydrothermal site and discovery of a new hydrothermal site: Menez Gwen; preliminary results of the DIVA 1 Cruise (5–29 May, 1994). *InterRidge News*, 3(2): 14–17, 1994.

Shank T., D. Fornari, K. Von Damm, M. Lilley, R. Haymon, R. Lutz, Temporal and spatial patterns of biological community development at nascent deep-sea hydrothermal vents (9°50'N, East Pacific Rise). *Deep-Sea Research*, II. 45: 465-515, 1998.

Vereshchaka A.L., S.V. Galkin, A.V. Gebruk, E.M. Krylova, G.M. Vinogradov, C. Borowski and the "Mir" submersibles team. Russian biological studies at six North Atlantic hydrothermal sites in 2002. *InterRidge News*, 11(2): 23-28, 2002.

Vereshchaka A.L., G.M. Vinogradov, Visual observations of the vertical distribution of plankton throughout the water column above Broken Spur vent field, Mid-Atlantic Ridge. *Deep-Sea Research I.* 46 (9): 1615-1632, 1999.

**The New PetDB: BETA VERSION 2.1 RELEASED**

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PetDB, the Petrological Database of the Ocean Floor, is pleased to announce the release of its beta version 2.1 featuring a revised and updated database and a new user interface. The beta site is accessible at <http://beta.petdb.ciesin.columbia.edu/index.jsp> or through a link from the current PetDB web site (<http://petdb.ideo.columbia.edu/petdb>).

Since 1999, PetDB has provided to the scientific community easy and fast on-line access to a global, comprehensive compilation of all published geochemical analyses of rocks, volcanic glasses, mineral phases, and melt inclusions for sub-oceanic igneous and metamorphic rocks generated at mid-ocean ridges including rocks from fracture zones, back-arc basins, young, near-axis seamounts, and old oceanic crust. An interactive, dynamic web interface has allowed users to explore in depth both data and extensive metadata, and to use a wide range of selection criteria to retrieve, view, and download customized subsets of the data. A distinctive feature of PetDB has been the unique sample identifier that was generated for each sample in the database to allow linking and integration of all data for a sample that were acquired in different

labs and published in different references. PetDB's user community has steadily grown to more than 2000 unique users per month, many of which are students and educators working with the data set in courses and seminars.

**A New System Architecture**

Over the past 18 months, PetDB has undergone a complete change of its operational architecture. The database has been migrated from a Windows-based system (Windows NT, MS Access) to a substantially more stable and safer UNIX/ORACLE environment at the Center for International Earth Science Information Networks (CIESIN) at Columbia University. This move entailed a considerable revision of the database schema to improve data quality control mechanisms, which in turn required the development of

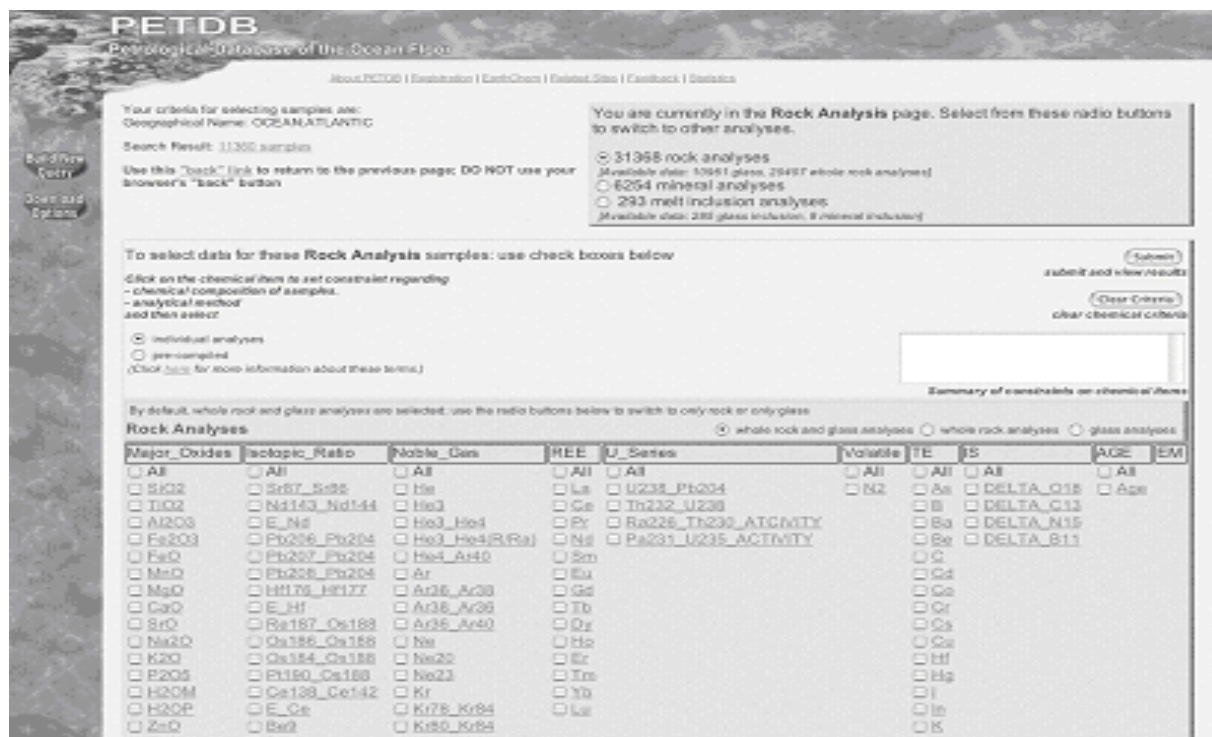


Figure 1 Look & Feel of the new PetDB user interface as exemplified by the data selection page.

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new data loading procedures. While addition of new data has been delayed because of the change in operational architecture, the new procedures are now being successfully applied to update PetDB's content with data from recent publications. Over the next few months, several consecutive updates will occur. Lists of newly added references will be posted on the web site.

#### A New User Interface

The release of the beta version 2.1 marks the completion of the first development phase of a new and largely improved interface based on JSP technology. Features of the new interface include: (1) *Stream-lined query procedures* (e.g. less clicks, continuous view of selected criteria, pop-up windows for setting criteria), (2) *improved performance*, (3) *no size limits for individual queries*, (4) *the option to save queries during a session*, (5) *the option to query by data availability* (For example: "Select all samples for which isotope ratios are available"), (6) *the option to click on individual values in the final data table to view method and reference information*.

Starting in May 2004, we will enter a second development phase during which we will implement additional changes to further expand the functionality of the user interface. These will include: (1) *User registration*. This will allow users to create customized workspaces with queries saved between sessions, and it will allow the database providers to have more continuous and better contact with the user community. (2) *Map interfaces*. Maps will be available both for sample selection, and for visualization of query results. Maps will be interactive, i.e. clicking on a sample point will bring up windows with complete sample information. (3) *Queries by database versions*. Any new data entered into the database is 'time-stamped'. Users will be able to query for data 'by version' retrieving only those data that were added to the database after a specific date. (4) *Processed content*. Segment position and average chemical compositions by segment will be provided for zero age samples, high quality data compilations and regional and global average compositions will be available for downloading.

***The release of the beta site is part of an ongoing development process that will be guided by input from our user community. We invite your comments, and suggestions for further improvements. Please, send your remarks to [lehnert@ldeo.columbia.edu](mailto:lehnert@ldeo.columbia.edu). Reports of technical problems should be mailed to [petdb@ciesin.columbia.edu](mailto:petdb@ciesin.columbia.edu).***

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## NATIONAL NEWS

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### CHINA



InterRidge-China was organized and established late 2003. China became an Associate Member of InterRidge in 2004. This report highlights significant progress in InterRidge-related research activities in China.

#### **The 2003 InterRidge Workshop in Beijing, China**

On 27-29 October 2003, an InterRidge workshop on "Opportunities and contributions of Asian countries to the InterRidge Next Decade Initiative" was held on the campus of Peking University in Beijing, which attracted over 70 scientists and students including 18 from the international community. The meeting was co-chaired by John Chen of Peking University (China) and Jian Lin of the Woods Hole Oceanographic Institution (USA) with Kensaku Tamaki and Agnieszka Adamczewska (Japan), Sang-Mook Lee (Korea), and Catherine Mevel (France) as members of the Organizing Committee. Many of the InterRidge Steering Committee members attended and contributed greatly to this successful workshop. Details of this meeting are described at both <http://www.interridge.org/> (under "meetings" -> "InterRidge workshops and meetings; past and future") and [http://ir-china.geophy.pku.edu.cn/english/int\\_china/2003bj/index.htm](http://ir-china.geophy.pku.edu.cn/english/int_china/2003bj/index.htm). InterRidge-China hosted this meeting, which was the first major InterRidge

workshop held in Asia.

#### **InterRidge-China Steering Committee**

The Steering Committee of InterRidge-China consists of 15 scientists from various universities and institutions in China and is chaired by Prof. Y. John Chen of Peking University, where the InterRidge-China Office is located. The InterRidge-China web page can be found at <http://ir-china.geophy.pku.edu.cn/index.htm>, where the Chinese version is more completed, while the English version is still under construction. Please contact either John Chen at [johnyc@pku.edu.cn](mailto:johnyc@pku.edu.cn) or Ms. Jian Zhu at [johnycZJ@geophy.pku.edu.cn](mailto:johnycZJ@geophy.pku.edu.cn). Ms. Zhu is a Ph.D. student in John Chen's research group and is responsible for the construction and maintenance of this web site.

#### **Introducing InterRidge sciences to the Chinese research community**

Both the English and Chinese versions of the InterRidge Next Decade Plan are now available at the InterRidge-China web site. Ms. Leonna Tian, a graduate student at the Ocean University of China, and Dr. Jian Lin of WHOI, USA have translated the full English text of the "InterRidge Next Decade Science Plan" into the Chinese language.

The primary goal is to significantly increase the visibility of InterRidge in the Chinese research community and Chinese government funding agencies. An abbreviated version of this translation article was also published in the Chinese journal "Marine Geology Letters", vol. 20, pages 10-15, 2004. This article has already started to have a positive impact as funding agencies and researchers use it for long-term research planning. STCOM of InterRidge-China thank both Ms. Leonna Tian and Dr. Jian Lin for their effort of introducing the InterRidge Next Decade Plan to the Chinese scientific community.

#### **A joint China-international research cruise to the East Pacific Rise**

A joint China-international research cruise is scheduled for Dec. 2004-Jan. 2005 to conduct mid-ocean ridge geo-bioscience research on the East Pacific Rise. The cruise will be conducted on R/V DaYanYiHao (Ocean #1). Dr. Shiqin Guo of COMRA (China Ocean Mineral Research & Development Association) and Dr. Jian Lin of WHOI, USA will co-lead this expedition, together with several members of the InterRidge-China STCOM including John Chen. This cruise will collect samples from hydrothermal vents at the EPR 13°N and is funded by COMRA. The cruise will also conduct a detailed deep-towed survey of the ridge-crest geological features and hydrothermal water column anomalies of the EPR 1°N-3°S ridge crest. This is a region previously little investigated and we are all excited about this first joint China-international ridge cruise.

This is hopefully to be the first of several international cruises that China will sponsor in the coming years in collaboration with the InterRidge community. It shows that real progress is being made in deep sea-going research in China.

#### **Events in 2004**

In China there are at least three events related to the InterRidge research in the summer of 2004.

- Short Course on Geo-microbiology, Shanghai, 13-19 June 2004, sponsored by the IODP-China (<http://www.iodp-china.org/chs/news/c/news0017.htm>). This seven-day short course hosted lectures covering various subjects of geo-microbiology from four US scientists, Dr. Kenneth H. Nealson from USC, Dr. Steven L. D'Hondt from U. of Rhode Island, and Drs. David Betsch and Hong Yang from Bryan College.

- Summer Theoretical Institute (STI) on "International Advanced Research in Marine Geo-Biosciences" in Qingdao, 19-21 June 2004. This STI was jointly organized by the Ocean University of China and IPACES (International Professionals for Advancement of Chinese Earth Sciences), together with three oceanographic research institutions in Qingdao and InterRidge-China. Prof. Yang Zuosheng of the Ocean University of China, Dr. Jian Lin of WHOI, USA, and Dr. Paul Liu of North Carolina State University, USA, organized this STI, which is designed to provide a broad review of major international progress in marine geo-biosciences for graduate students, post-docs, and young researchers.

- "XiangShan Special Topics Meeting" on Hydrothermal Systems and Bio-community at Deep Sea Settings is jointly organized by Nanjing University and the Chinese Academy of Sciences and was held in Nanjing, 29 June – 1 July 2004. This meeting was co-chaired by Prof. Pinxian Wang of Tongji University (Co-Chair of the IODP-China STCOM), Prof. Shaoyong Jiang of Nanjing University (Member of InterRidge-China STCOM), and Prof. Ying Chen of Zhejiang University. This high level XiangShan national scientific forum attracts many active scientists working on the related topics from China.

Dr. Y. John Chen



## FRANCE



After the completion of *Programme Dorsales* at the end of 2001, it took year 2002 - when the new programs in Earth and environmental sciences were defined - and year 2003 - with the difficult implementation of these programs in a context of budget cuts - to reorganize in a quite different way the ridge activities in France.

#### **MOMAR**

The major initiative is the designation of the MOMAR area south of the Azores as a natural laboratory, in order to prepare for the installation of a multidisciplinary observatory. A French MOMAR committee is currently being nominated to coordinate the efforts in this area. A meeting with the interested community was held in Paris in November 2003 to define a strategy for 2005 and 2006. Several cruises are at different stages of preparation. Cruise SISMOMAR (P.I. W. Crawford), devoted to seismic investigations of the Lucky Strike area, is already pre-scheduled for 2005. Cruise GRAVILUCK (P.I. V. Ballu),

interested in gravity and geodetic measurements in the Lucky Strike area, has been well evaluated and may be scheduled in 2005. Cruise MOMARMAP (P.I. J. Escartin), focused on micro-bathymetry and detailed imagery of the Lucky Strike area, will be submitted again for 2006. Cruise MOMARETO will test new biological equipment developed under EU funded project EXOCET/D ("Extreme ecosystem studies in the deep ocean: technological developments", P.I. P.M. Sarradin) on the MOMAR sites, most likely in 2006. Finally, the French-Japanese cruise EXOMAR (P.I. Anne Godefroy), scheduled in 2005, will, among other targets take microbiological samples on the Lucky Strike and Rainbow sites. Beyond this ambitious cruise schedule, French researchers are involved in the EU-funded Marie Curie network MOMARNET (P.I. M. Cannat), which will offer 12 Ph.D. scholarships and 3 post-doctoral fellowships in 14 European laboratories, starting in fall 2004.

**Bureau InterRidge France**

Although MOMAR has become a major ridge target in France, French ridge scientists are also actively involved in other topics and areas. With the recent reorganization, French ridge activities are currently funded by a variety of disciplinary and interdisciplinary programs, which may result in a gradual fading of the multidisciplinary ridge community built by *Programme Dorsales*, as well as a lack of national and international visibility. To maintain the community spirit, keep national and international communication channels open, and ensure the French participation to InterRidge, a Bureau InterRidge France is currently being constituted. This light structure, made of 4 or 5 CNRS and IFREMER scientists involved in InterRidge, will be the InterRidge correspondent in France. It will pass relevant information between InterRidge and the various interested French programs, and will improve international visibility of the French ridge community by offering a clear interlocutor to InterRidge and, through InterRidge, to the foreign Ridge Programs. It will inform French researchers involved in ridge studies via an electronic mailing list and an annual newsletter, and support initiatives at the national level (workshop, meeting sessions...) in order to maintain and develop a multidisciplinary ridge community.

**Cruises**

Cruise SWIR 61-65 (P.I. M. Cannat), a bathymetric and geophysical off-axis survey of the Southwest Indian Ridge between 61 and 65°E, was successfully carried out by R/V Marion Dufresne in October 2003. Cruise PARISUB (P.I. P. Gente), a deep sea investigation of the East Pacific Rise segment at 16°N, scheduled for spring 2004 with R/V L'Atalante and submersible Nautile, was unfortunately cancelled by IFREMER for financial reasons. Cruise

BIOSEEDO (P.I. Didier Jollivet), a biological investigation on the East Pacific Rise at 17°S, is still scheduled on R/V L'Atalante and submersible Nautile for spring 2004. Cruise PACANTARCTIC II (P.I. L. Dosso and H. Ondreas), devoted to the exploration and rock sampling of the Pacific-Antarctic Ridge between 35 and 55°S, is planned for December 2004-January 2005. Other cruises are planned in the framework of the MOMAR project (see above). Projects intend to revisit the East Pacific Rise at 13°N in 2006-2007 to study bio-geochemical interactions and population stress.

**Scientific fleet and equipment**

A new research vessel, "Pourquoi Pas?", is now being built in Saint-Nazaire for IFREMER and the French Hydrographic Office. This ~100 m-long vessel will carry both deep sea submersible Nautile and ROV Victor, will offer spacious laboratories and accommodation for 40 scientists, and will have excellent bathymetric and geophysical survey capabilities. The new ship is due in mid-2005 for tests and operations.

An underway measurement unit including various sensors (optical cameras, multibeam echosounder, side scan sonar, sub-bottom profiler, magnetometer, CTD, ADCP, chemical analyzers...) is currently being designed and will soon be available for operations with ROV Victor. This unit will add to the already excellent site exploration and sampling capabilities of ROV Victor. Furthermore, a „coastal“ AUVs (to be used down to 3000 m) has been acquired by IFREMER, and its scientific instrumentation is progressively developed/purchased with the participation of CNRS. For practical reasons, the equipment should be transferable between ROV and AUV.

JÉRÔME DYMENT

**GERMANY**

The beginning of 2004 saw some important events for DeRidge. The first cruise in the series planned for the six-year program took place between 15<sup>th</sup> January and 15<sup>th</sup> February. Under the leadership of Thomas Kuhn (Kiel), the cruise Meteor 60/3 visited the Logatchev hydrothermal field. Details of this cruise are reported by the ship-board party in this issue of InterRidge News. The DeRidge community will be having its first annual meeting on 2-3 June 2004 in Schloss Etelsen near Bremen. This two-day meeting will be used to discuss the results of the first cruise, to coordinate future work in the Logatchev area, and to assess the applications of new technologies, especially AUV, to the DeRidge initiative.

Early 2004 also saw the move of the InterRidge Office from Tokyo to Bremen, further raising the profile of ridge research within Germany. Running the office in Germany will be two very competent women: Katja Freitag, a South

African with German parents who has joined us from the Palabora mine in South Africa and Kristen Kusek, a marine science and journalism major with extensive experience of marine education outreach. Together we hope to bring ridge activity to a wider audience than has perhaps been targetted up to present and in so doing strengthen the foundation of InterRidge around the world.

And finally – having moved the office to Bremen it will be leaving again, as the whole group is moving to the Leibniz Institute for Marine Research in Kiel where Colin Devey takes up the position of Professor for "Dynamics of the ocean floor" as of 1 May 2004. The enthusiasm with which the Director of the Leibniz Institute, Prof. Peter Herzig, has welcomed InterRidge to Kiel bodes well for the near future of InterRidge! We look forward to seeing you in the Office in Kiel very shortly.

COLIN DEVEY



## KOREA



The success of Ridge 2000-InterRidge Joint Theoretical Institute on backarc spreading system in Jeju Island earlier this year has sparked new interest among Korean scientists and policy makers for seafloor hydrothermal vent studies. We are anticipating launch of new programs on the horizon. One of such programs is the New Daeyang Program, a successor to earlier Daeyang Program that ran from 2000-2003, led by Korea Ocean Research and Development Institute (KORDI). As in the earlier program, the New Daeyang Program will start as an in-house project with funding from KORDI. A group of scientists from various disciplines have started a 10-year plan for this new program. A report is to be produced by early 2005 in time with the program, which may start as early as mid-2005. The more likely target for the start of the program is beginning of 2006. In addition to a healthy increase in the size of the budget and length of the ship

time, several new changes will be adopted. There will be a closer link between KORDI and universities in Korea, especially with Seoul National University, than before. A substantial part of the resources will be devoted to acquiring and building of instruments. At the moment Korea does not have a strong infrastructure for making near-bottom search, observations and sampling at the level of precision that is necessary for hydrothermal vent studies. Three areas are being considered for intensive studies: the Ayu Trough in the southern Philippine Sea, Bismarck Sea in Papua New Guinea, and the East Pacific Rise. One of these sites will be chosen for 3-5 year investigation in the first phase. A 1500-ton vessel, R/V Onnuri, will be used in the first phase, but a new 6000-ton research vessel will come on the line in 2008. Like the previous Daeyang Program, we expect that the new program to foster various international collaborations.

SANG-MOOK LEE



## PHILIPPINES



Philippine research undertaken by the University of the Philippines-National Institute of Geological Sciences, Department of Science and Technology (DOST) - Central Office, DOST - Philippine Council for Industry and Energy Research and Development, DOST regional offices and Mines and Geosciences Bureau regional offices is focused on a comprehensive study of ophiolites and dismembered oceanic lithospheres which form basement complexes all over the Philippine archipelago. The goal of this research is to understand the origin and formation of these ophiolites and crust-mantle sequences and thereby help in the understanding of present-day ocean ridge and subduction magmatism. This involves extensive fieldwork. The following areas were mapped in 2003:

1. Central Philippines: NE Leyte-Southern Samar and Southern Leyte - revealed the presence of the Tacloban Ophiolite Complex (TOC) and the Malitbog Ophiolite Complex (MOC) in the northern and southern portions of the Leyte island, respectively (Dimalanta et al., 2003).

2. Western edge of the Philippine archipelago: mapping of the Romblon Island Group (RIG) made up of Tablas, Romblon and Sibuyan islands was done this April 2004. This led to the identification of a crust-mantle sequence, clastic sedimentary and carbonate rocks, and schist. Preliminary field data suggests that the RIG may still be part of the perceived collision zone along the western margin of the Philippines.

3. Fieldwork and structural mapping was conducted in Dingalan, Baler, Aurora Province and the Baguio Mineral District in Luzon last May 2003. The sedimentary suites encountered in both areas are interpreted as turbiditic sequences which may provide clues to the accretion history of the Philippine island arc system. This study is being done in collaboration with Japanese (e.g. Okayama University, Kanazawa University), French (e.g. Universite Bretagne de Occidentale, Universite Paul Sabatier) and Chinese (e.g. University of Hong Kong) universities.

GRACIANO YUMUL



## RUSSIA



Russian researchers from national scientific, applied industrial and educational centers working in geochemistry, petrology, biology, and geophysics continued their mid-ocean ridge work in 2003-2004. Russia's current ridge research is carried out primarily by the following organizations:

**Vernadsky Institute of the Russian Academy of Sciences, Moscow:**

1. Global correlation of mid-ocean ridge basalt chemistry and petrology as well as geophysical and bathymetric parameters of ridge crest zones, and distribution of hydrothermal events along ridge axis strike.

2. Geochemistry and petrology of mid-ocean ridge basalt and residual peridotites and their relationship to magmatism in rift valleys.
3. Metamorphism of the oceanic crust and its relationship to hydrothermal circulation and the geodynamic style of accretion of the oceanic lithosphere.
4. Magmatism of mid-ocean ridges with different spreading velocity: petrology, geochemistry, geodynamics.
5. Mantle metasomatism below the mid-ocean ridges and its relationships to magmatism.
6. Conditions of formation of mantle magmas and their sources in different geodynamic settings.
7. Within-plate magmatism in the central part of De Long Archipelago as a response to Gakkel Ridge propagation onto the Laptev Sea passive margin.
8. Tectonics and magmatism of the Southern Ocean.

**Institute of Geology, Mineralogy, and Ore Deposits of the Russian Academy of Sciences, Moscow:**

Ore deposits related to active hydrothermal systems at mid-ocean ridges.

**Geological Institute of the Russian Academy of Sciences, Moscow:**

Tectonics, magmatism and ore-formation at the mid-Atlantic ridge.

**Shirshov Institute of the Russian Academy of Sciences, Moscow:**

1. Hydrothermal processes at mid-ocean ridges and related ore formation.
2. Cold methane seeps and their role in the oceanic carbon cycle.
3. Matter influx from deep within the earth into the ocean and its importance for the natural environment and climate.

**Moscow State University:**

Comparative study of geological and geophysical data from different segments of the mid-ocean ridges with special emphasis on their compositional and geophysical segmentation.

**VNIIOceangeologya (Institute of the Ocean Geology – Russian Academy of Sciences and Ministry of Natural Resources of Russian Federation), St. Petersburg:**

1. Hydrothermalism and ore-formation related to the main structures of the ocean basins.
2. Geology of the spreading centers of the Arctic Basin.

**Polar Marine Geosurvey Expedition (Ministry of Natural Resources of Russian Federation), St. Petersburg:**

Search and study of hydrothermal fields along mid-ocean ridges as well as investigation of ore-forming processes related to the main structures of the ocean basins.

**United Institute of Geology, Geophysics and Mineralogy of the Russian Academy of Sciences, Siberian Branch, Novosibirsk:**

1. Petrological and geochemical features of magmatism in the central and south Atlantic.
2. Numeric modeling of mantle plume geodynamic parameters.

**Institute of Earth Magnetism and Wave Propagation of the Russian Academy of Sciences, Moscow-St.Petersburg:**

Correlation of magnetic fields parameters with bathymetric and tectonic features of mid-ocean ridges.

The most complete Russian data base with necessary information about Russian R/V cruises in the Atlantic Ocean (at least during last two decades) is contained in the electronic atlas of digital maps. This can be found on the Geological Institute of Russian Academy of Sciences' website: <http://geo.tv-sign.ru/tectonic/marine>. This database includes information on sampling distribution (1820 data records), earthquake epicenters, heat flow, DSDP/ODP sites etc.

The Electronic Globe is being prepared in the Vernadsky State Geological Museum of the Russian Academy of Sciences. This Globe will make available information on the geophysical and geochemical construction of the oceanic crust and mantle.

Two "MIR" submersibles with a diving range of ~ 6000m are fixed onboard R/V "Akademik Mstislav Keldysh" (Shirshov Institute of Oceanology of Russian Academy of Sciences). These are limited to the use of scientific tourism and passing investigations of active hydrothermal fields. Only a few Russian research vessels currently operate for purely scientific purposes. They are all equipped with the necessary devices for geophysical surveying and hydro-cast operations as well as for dredging and sediment core sampling. The most successful Russian scientific cruises of the last three years were undertaken at the axial zone of the mid-Atlantic ridge between 12°-17°N using the R/V "Professor Logachev" (Ship owner - Polar Marine Geosurvey). Two new hydrothermal fields were discovered during the 22nd and 24th cruises of "Professor Logachev" in 2002-2004. The first one was named the Ashadze Hydrothermal Field (2002-2003) and is located at 12°58'N, the second one was found in 2004 and is located at 16°38'N.

The bilateral meeting dedicated to the 30th Anniversary of French-Russian Cooperation in investigations of the mid-Atlantic ridge was held in Brest, IFREMER (France) on April 5-7, 2004. This meeting was accompanied by the stop of the R/V "Professor Logachev" in Brest Harbour as she ended the 24th cruise to the central Atlantic. During the meeting in Brest, Russian and French scientists had the opportunity for productive discussions regarding perspective collaboration from 2004-2006 within the frame work of the Russian-French Project "The Mid-Atlantic Ridge Geodynamics and the Ore Formation Processes".

SERGEI SILANTYEV



## USA



As we write this update, the Ridge 2000 office is in the final stages of launching a new website targeted at a general public audience and featuring R2K explorations to the Lau Basin. The Lau Basin has been dubbed “the perfect geological experiment” and as a new Integrated Studies Site (ISS) for R2K, it offers a perfect opportunity to engage the public in the science we love.

The Lau Basin was one of several back-arc systems featured during the R2K–InterRidge Joint Theoretical Institute. For those unable to attend the Institute, the American Geophysical Union will publish a geophysical monograph in 2005 based on the short-course presentations. The monograph’s working title is “Interactions in Back-Arc Spreading Systems—Geological, Biological, Chemical, and Physical.”

Led by Fernando Martinez, U Hawaii, the first R2K cruise to the East Lau Spreading Center (ELSC) ISS in the Lau Basin took place in May. Charles Langmuir is leading the second R2K cruise in September. Three other cruises originally scheduled for late 2004 have been rescheduled for spring 2005. Data from the cruises will be used to select a focal area for the smallest-scale interdisciplinary studies of the Lau Basin ISS (the “bull’s eye”) and provide a wealth of new information on this relatively unexplored spreading center. As part of outreach, R2K provided support to Tongan and Fijian scientists to attend the Theoretical Institute in Korea and to work in the US with R2K investigators.

Six cruises to the East Pacific Rise ISS (8°–11°N) occurred between 31 October 2003 and 30 April 2004. Four cruises focused on biology, microbiology, ecology, and fluid chemistry, and two focused on the area’s geophysical underpinnings. Two more cruises in the 2004 field season will occur in November and December. For cruise reports from Janet Voight (Field Museum) and Karen Von Damm (U New Hampshire), check the R2K website for the latest edition of the *Ridge 2000 Events* newsletter. In addition to formal research, the April cruise (Rich Lutz et al.) hosted the R2K SEAS pilot program. SEAS is an acronym for “Student Experiments At Sea,” and five middle and high school student experiments were selected in a competition and conducted successfully on the EPR cruise. Work is underway to continue the program for a second year. For details, check out the SEAS Web site: [www.ridge2000.org/SEAS/](http://www.ridge2000.org/SEAS/).

The 2004 field season at the Endeavour ISS on the Juan de Fuca Ridge began in May. Representing a diversity of funding sources, the seven cruises through September have studied relations between subsurface microbes, diffuse flow, petrology, seismology, chemistry, and heat and fluid flux. The first cruise hosted the “Dive and Discover” web outreach program (<http://www.divediscover.who.edu/>), and a follow-on cruise in

June hosted the REVEL program (<http://www.ocean.washington.edu/outreach/revel/>), which took several K-12 teachers to sea. Of note, Suzanne Carbotte, Bob Detrick, and others have found evidence of a crustal magma chamber feeding the five hydrothermal vents fields on the Endeavour segment, a finding that challenges the prevailing hypothesis of a magma-starved system. Although imaging the deep crust and mantle was not included in the original ISS Implementation Plan for this site, the importance of these types of studies was recognized at the community workshop in Boulder last November.

For more information on the three Integrated Studies Sites and on Time Critical Studies, check the R2K website: [www.ridge2000.org](http://www.ridge2000.org) and the most recent issue of *Ridge 2000 Events*.

In March, R2K convened a workshop to determine if there is a single area of the Mid-Atlantic Ridge suitable for R2K integrated, interdisciplinary studies across a wide range of disciplines. A second goal of this workshop was to begin formulating a strategy to bring together resources required to launch a large interdisciplinary research program on the MAR. Participants from the US, UK, France, Portugal, and Germany heard updates from a variety of national and international research programs as well as reviews of past and current research activities at seven potential areas. Following two plenary sessions and breakout discussions by discipline, the group came to consensus on a single area ranging from 35° N to 37.5° N on the MAR. This area was chosen with full recognition that it has significant overlap with the area recognized by InterRidge and several EU countries as their preferred site for long-term interdisciplinary studies of the MAR (the MOMAR area). There was consensus that working in the same area will be an advantage, because the scope of the questions the community wants to address will require the assets of more than one, or even a few countries.

At its April meeting, the R2K Steering Committee approved various levels of support for several exciting workshops over the next few years. R2K will work with InterRidge to organize a workshop in April 2005 for advancing plans for MOMAR and to support the 3<sup>rd</sup> International Hydrothermal Vent and Cold Seep Biology Meeting in San Diego in September 2005. The Committee also agreed to help support a joint R2K–IODP workshop, a joint R2K–Polar Programs workshop on studies of polar ridge systems, and a field school in Cyprus in 2005. Finally, a letter of intent for the next Ridge 2000 Theoretical Institute, which would focus on using modeling to advance our understanding of the linkages “from mantle to microbe” on mid-ocean ridges, was favorably received and a more detailed proposal was requested.

CHUCK FISHER

**Back-arc Spreading System/Back-arc Basins Working Group**

Interactions among Physical, Chemical, Biological, and Geological Processes in Backarc Spreading Systems  
 Ridge 2000 - InterRidge Joint Theoretical Institute  
 May 24 - 28, 2004, Jeju Island, Korea

In May 2004 a joint Ridge2000 – InterRidge Theoretical Institute took place on Jeju Island, Korea. The focus was on back-arc spreading centers, and especially on the interactions, linkages, and feedbacks within the dynamic system by which material and energy are transferred “from mantle to microbe....,” from Earth’s interior to the seafloor and ocean, from the geosphere to the biosphere.

It was the first TI to focus on spreading systems in back-arc rather than mid-ocean ridge settings, and it was also the first to be held in the Asia-Western Pacific region. The Theoretical Institute comprised a 2-day short course where invited speakers presented an overview of current knowledge on back-arc basins and participants supplemented talks with numerous poster presentations. The standard for the talks and posters was high, and the InterRidge outstanding student award of US\$ 700 was presented to Sharmishtha Dattagupta for her excellent poster entitled “The possibility of syntrophy between hydrocarbon seep tubeworms and sub-surface sulfate-reducing bacteria”. Student participants also had the chance to ask the researchers present any questions they had on back-arc basins in the form of a student panel discussion.

The short course was followed by a 1-day field trip on the hydromagmatic volcanoes around Jeju Island lead by Young Kwan Sohn from the department of Earth and Environmental Sciences at the Gyeongsang National

University. The TI ended with a 2-day workshop. The workshop was used to discuss and formulate future research directions in back-arc basin research and focused initially on two overarching questions

- What can we learn from individual back-arc spreading systems about global-scale geological, biological, and oceanographic processes and systems?
- What can we learn from back-arc regions about the processes of plate formation, and especially about interconnections and interactions among the solid earth, magma and hydrothermal fluids, organisms and ecosystems and the oceans?

The TI was also the perfect occasion to reestablish the membership of the InterRidge back-arc spreading system/ back-arc basin working group chaired by Sang-Mook Lee. The team going into the next next decade of InterRidge will consist of  
 Sang-Mook Lee (chair)  
 Fernando Martinez  
 Anna-Louise Raysenbach  
 Wiebke Siebzis  
 Steve Scott  
 Ivan Savov  
 Carol Chin



Panel of judges (left to right) K. Tamaki, A. Reysenbach, C. Devey, T. Urabe, C. Langmuir



Colin Devey (InterRidge Chair) presents Sharmishtha Dattagupta with the InterRidge outstanding student award



The student panel discussion



Korean student helpers and dignitaries



Korean dignitaries

Thanks to the conveners Sang-Mook Lee and David Christie, student helpers from Seoul National University, the Ridge2000 office, as well as numerous generous sponsors, the TI was a huge success, with 86 participants

from 9 countries (Japan, Korea, USA, France, Germany, Tonga, UK, Fiji, Canada).

KATJA FREITAG AND SANG-MOOK LEE

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### Monitoring and Observatories Working Group

With the InterRidge Office transfer, we anticipate that the Monitoring and Observatories Working Group (MOWG) will change shortly its composition, and a new mandate will be put in place. Originally, this MOWG was set up to help build up and coordinate efforts on seafloor observatories, with special emphasis on the MOMAR project. Several MOMAR-related projects are underway and supported by the European Union and individual countries, partly facilitated by past Workshops sponsored by InterRidge. In addition, a Ridge 2000 workshop selected the Mid-Atlantic Ridge between 35°N and 37.5°N (encompassing the MOMAR area) as a slow-spreading ridge Integrated Study Site.

Now that MOMAR has a life of its own, we expect InterRidge to play an active role in coordinating and favoring international efforts both within MOMAR, and among NEPTUNE, MOMAR, Integrated Study Sites, and other seafloor observatory efforts. An international MOMAR Implementation Meeting and Workshop will be held in early Spring 2005 to coordinate efforts between the EU, Ridge 2000 community, and other partners. Announcements will be made through InterRidge, Ridge

2000 and the MOMAR websites (<http://www.momar.org>).

The European Union has signed the EXOCET/D project (PI : P. M. Sarradin, IFREMER), with a funding level of >2 M. Euros, and the MOMARNET (PI : Mathilde Cannat, CNRS/IPGP) research network (>2.5 MEUR). The first project will develop technology development for deep seafloor observations, including an instrument test cruise at the MOMAR area. The second project will finance a network of scientists, including PhD and Postdoc appointments, to establish a pluridisciplinary approach to the study of the MOMAR area (details of these projects available through <http://www.momar.org>).

In addition, several cruises funded by national programs are planned in the MOMAR area for 2005 and 2006. MOMAR is also one of the sites within the ESONET initiative (<http://www.abdn.ac.uk/ecosystem/esonet>) to establish a European network of cabled seafloor observatories ; we expect that a proposal will be put forward in the near future to finance the required infrastructure.

JAVIER ESCARTÍN AND RICARDO SANTOS (CHAIRS)

InterRidge seeks submission of a **logo to be used in the MOMAR project**. If you have any design, ideas or suggestions, you may submit it to [logo@momar.org](mailto:logo@momar.org) - for more information, see [www.momar.org](http://www.momar.org)

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### Mid-ocean Ridge Ecosystems Working Group

The mid-ocean ridge ecosystems working group met in Bremen, Germany in January 2004. An update of this working group can be found on the InterRidge website where their working group meeting report (February 2004) is available from the InterRidge Downloads page.

If you are interested in finding out more about the InterRidge working groups and their activities, please take a look at our website.

[www.interridge.org](http://www.interridge.org)



Also, if you would like to submit a proposal for a new InterRidge working group, please contact the InterRidge coordinator

[coordinator@interridge.org](mailto:coordinator@interridge.org)





## A new InterRidge Working Group : 'Biogeochemical interactions at deep-sea vents'

A new Working Group on 'Biogeochemical Interactions at deep-sea vents' has been created at the initiative of the InterRidge programme. This interdisciplinary group comprises experts in chemistry, geochemistry, biogeochemistry, and microbial ecology addressing questions of biogeochemical interactions in different MOR and BAB environments.

The past decade has raised major issues concerning the interactions between biotic and abiotic compartments of deep-sea hydrothermal environments and the role they play in the microbial turnover of C, S, N, Fe, fluxes from the geosphere to hydrosphere, the formation of biominerals, the functioning of vent ecosystems and life in extreme environments, the deep-biosphere, and the origin of life.

Recent multidisciplinary studies have provided some new insights to these issues. Results of some of these studies will be presented here. They point out the variability and complexity of geobiological systems at vents in space and time and highlight the need for interactions

across the fields of chemistry, geochemistry, biogeochemistry, and microbial ecology of hydrothermal environments. Limitation for advances in these fields include the availability of seafloor observation/ experimentation time, and of underwater instrumentation allowing quantitative, in situ measurements of chemical and biological fluxes, as well as physical and chemical sensing and sampling along small scale gradients and repeated observation of study sites.

The aim of this new Working Group is to strengthen the scientific exchange among chemists, geochemists, biogeochemists and microbial ecologists to favor collaboration in field studies including intercomparison of methods and planning of integrated experiments. The Biogeochemistry working group will also foster development of underwater instrumentation for in situ biogeochemical measurements and microscale sampling, and promote exchange and collaboration with students and scientists of neighboring disciplines, particularly with vent biologists, ecologists and geologists.

N. LE BRIS AND WORKING GROUP MEMBERS

### Working Group member list

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## WORLD RIDGE CRUISE SCHEDULE 2004/2005

Country	P.I.	Cruise ID/Location	Research Objectives	Ship	Dates (Ports)
Australia	A. Crawford, L. Danyushevsky	Intersection Hunter Ridge with main north-south spreading centre at the southern end of the North Fiji Basin	'Hot subduction' theme- focus on multibeam mapping (9 days) and dredge sampling (9 days) of the intersection of the Hunter Ridge (a largely submerged intra-oceanic arc extending between Fiji and southern Vanuatu, which was active probably for only 3-4 m.y. until ~4 Ma) with the main north-south spreading centre at the southern end of the North Fiji Basin.	R/V Southern Surveyor	1-25 October 2004
USA	C. Langmuir (Harvard)	Lau Basin		R/V Kilo Moana, ABE	8 Sept - 15 Oct 2004, Suva, Fiji
Germany	T.J. Reston	METEOR M62/4Mid-Atlantic Ridge at 7°S	Determine variation in the structure of the crust and upper mantle within and between spreading segments, structure beneath a well-developed corrugated surface, using wide-angle seismic profiles, high resolution seismic reflection studies, microseismicity and tomographic studies using a grid of ocean bottom instruments to determine local 3-D crustal structure and fault activity.	R/V Meteor	29 Sept - 6 Nov 2004 Mindelo-Abidjan
Japan	JAMSTEC	Lau Basin and Kermadec Ridge	Geological and biological investigations using Shinkai 6500 (3-manned Submersible)	R/V Yokosuka	Sept - Nov 2004
USA	M. Tivey (WHOI)	Lau Basin		R/V Roger Revelle, Jason II	20 Oct-22 Nov 2004 Suva, Fiji - Nuku'alofa, Tonga
Japan	JAMSTEC	NW-North Pacific Ocean	Biological investigations and physical oceanographic studies	R/V Mirai	Oct - Nov 2004
Germany	C. Devey, K. S Lackschewitz	METEOR 62/5 MAR 4-11 °S	Investigations using side-scan sonar, ROV, MARP, CTD/yoYo	R/V Meteor	9 Nov - 30 Dec 2004 Recife - Ascension - Walvis Bay
USA	J. Childress (UCSB)	Lau Basin		R/V Roger Revelle Jason II	26 Nov - 16 Dec 2004 Nuku'alofa, Tonga - Suva, Fiji

WORLD RIDGE CRUISE SCHEDULE 2004/2005 (CONT.)






Country	P.I.	Cruise ID/Location	Research Objectives	Ship	Dates (Ports)
Japan	JAMSTEC	West Philippine Basin	Geophysical and geological studies	R/V Kairei	Nov - Dec 2004
USA	R. Vrijenhoek	Lau Basin		R/V Roger Revelle Jason II	20 Dec 2004 - 4 Jan 2005 Suva, Fiji
Japan	JAMSTEC	Suruga Bay and Nankai Trough	Technology and engineering	R/V Yokosuka	Nov 2004 - Feb 2005
France, USA, Marocco	H. Ondréas, L. Dosso	PACANTARCTIC II	PACANTARCTIC II cruise is a geophysical and geochemical study of the Pacific-Antarctic Ridge between 41 and 52°S (south of Juan Fernandez microplate to the north of the Vacquier F.Z)It will allow complete bathymetric and rock sampling of the Pacific ridge system to check 1) the evidence of two sub-pacific mantle domains south and north of the Easter microplate 2) the relationship between geochemical and morphological variations described along the ridge and the thermal structure of the underlying mantle 3) the presence of intraplate volcanic structures, consequence of kinematic changes and to describe an incipient microplate on each side of Menard F.Z.	R/V l'Atalante	17 Dec 2004 - 30 Jan 2005 Talcahuano (Chile- - Guyaquil (Equador)
Japan	JAMSTEC	Western tropical Pacific Ocean	Geophysical and geological studies	R/V Kairei	Jan 2005
Russia		MAR Rift Valley at 13°N	Marine Geological Expedition	R/V "Professor Logachev" owned by Polar	Jan - May 2005
Japan	JAMSTEC	Northwest-North Pacific Ocean	Biological and physical oceanographic studies	R/V Mirai	Feb - March 2004
Germany	K. Haase	METEOR M64/1 Mid-Atlantic Ridge at 4° - 11° S	Investigations using ROV, TV-grab and dredging	R/V Meteor	2 April - 3 May 2005 Abidjan - Fortaleza
Germany	H. Villinger	METEOR M64/2 Mid-Atlantic Ridge at 15°N	Investigations using ROV, TV-grab, CTD, as well as taking compliance measurements	R/V Meteor	6 May - 6 June 2005

If you are planning a ridge- or back-arc basin related cruise, please send the InterRidge office (coordinator@interridge.org) these details so that the InterRidge cruise schedule and cruise database (www.interridge.org) are kept updated.

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**CALENDAR OF SPREADING CENTER-RELATED EVENTS 2004/2005**


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- 1-7 Sept 2004      **34<sup>th</sup> Annual Conference of the Underwater Mining Institute:  
Marine Minerals - the European Dimension**  
*London, UK*
- 27-30 Sept 2004      **2004 SCOR General Meeting**  
*Venice, Italy*
- 27-29 Sept 2004      **Neptune Canada, Ocean Observing Systems Workshop**  
*Victoria BC, Canada*
- 13-17 Dec 2004      **AGU 2004 Fall Meeting**  
*San Francisco, California, USA*
- 
-  19-21 Jan 2005      **IR Workshop: Tectonic & oceanic processes along the  
Indian Ocean Ridge System**  
*Goa, India*
-  European Spring 2005 **Field School and Field Trip to the Troodos Ophiolite**  
*Cyprus*
-  April 2005      **International MOMAR implementation Workshop**  
*Portugal*
- 23-27 May 2005      **2005 AGU Joint Assembly**  
*New Orleans, Louisiana USA*
- 6-8 June 2005      **Russia Ridge workshop: Hydrothermal clusters along MOR's**  
*St. Petersburg, Russia*
- 20-23 June 2005      **International Conference: Fluxes and Structures in Fluids**  
*Moscow, Russia*
-  European Summer 2005 **InterRidge Steering Committee Meeting**  
*Kiel, Germany*
- 21-25 August 2005      **40th European Marine Biology Symposium (EMBS)**  
*Vienna, Austria*
-  26-30 Sept 2005      **3<sup>rd</sup> International Symposium on Hydrothermal Vent and Seep Biology**  
*La Jolla, Scripps, California, USA*
- 
- 20-24 Feb 2006      **Ocean Sciences Meeting**  
*Honolulu, Hawaii, USA*

More details on the following and new meetings can be found by clicking the



icon on [www.interridge.org](http://www.interridge.org)



The initiative of Council of Scientific & Industrial Research (CSIR), through National Institute of Oceanography and National Geophysical Research Institute and the Department of Ocean Development (DOD), Govt. of India, resulted in the formulation of a Network program to investigate the Mid-Ocean Ridge systems and the backarc basin in the Indian Ocean. The interdisciplinary exploration program aims to understand the tectonic and oceanic processes occurring at these dynamic plate boundaries.



## INTERRIDGE WORKSHOP: TECTONIC & OCEANIC PROCESSES ALONG THE INDIAN OCEAN RIDGE SYSTEM

### Workshop Objectives

The workshop will focus on the geological, geophysical, physical, chemical and biological processes at the Indian Ocean spreading centers and provide forum for exchange of ideas and results. One of the major goals of the workshop is to develop a new international collaborative phase of exploration using latest tools & techniques for better understanding of the ridge processes and hydrothermal vent system in the Indian Ocean.

### Themes for the Workshop

- Tectonics & Ridge Segmentation
- Evolution of the Andaman Back Arc Basin
- Hydrothermal Vent Processes
- Ridge biology
- Mantle Dynamics
- Plume dynamics and deep-sea circulation
- Biogeochemistry of bottom waters
- Emerging technologies in Ridge Research

### Dates to remember

Registration : 15 October, 2004  
Accommodation : 31 October, 2004  
Abstract submission : 15 November, 2004

### Registration fees

Foreign participant US\$ 150	Foreign research scholars/ student US\$ 50
Indian Participant Rs 1500	Indian Research scholars/ student Rs 500
Corporate participants (Foreign) US\$ 250	Corporate participants (Indian) Rs 2500

### Accommodation

Cidade De Goa Hotel ([www.cidadedegoa.com](http://www.cidadedegoa.com)).  
Contact Mr. Ajay Nayak ([ajay@cidadedegoa.com](mailto:ajay@cidadedegoa.com)) by 31 October to ensure availability

*Please register and submit abstracts directly through the InterRidge Office ([coordinator@interridge.org](mailto:coordinator@interridge.org)) or online through the Ridge 2000 website ([www.Ridge2000.org](http://www.Ridge2000.org))*

### Workshop Conveners

Abhay Mudholkar, Goa, India - [abhay@darya.nio.org](mailto:abhay@darya.nio.org)  
R.K. Drolia, Hyderabad, India - [kumardrolia@yahoo.co.in](mailto:kumardrolia@yahoo.co.in)  
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**Ridge 2000 PROGRAM**

First Announcement  
**Field School ~ Spring 2005 ~ Field Trip**  
**Troodos Ophiolite, Cyprus**

Professor Joe Cann, University of Leeds expert on ophiolite complexes and the construction of ocean crust at mid-ocean ridges, and a team of specialists will run both a field school and a field trip to the Troodos ophiolite complex in May 2005.

Readily accessible by road, Troodos is remarkable as a major ophiolite that has remained virtually undeformed and unaltered since its formation at a spreading center above a subduction zone 90 million years ago. Highlights include superb volcanics, sheeted dykes, black smoker deposits, the root zones of hydrothermal systems, deeper plutonic and mantle rocks, and an exposed transform fault.

Scientists from all disciplines (geosciences and biosciences) are welcome. Students and postdocs are encouraged to attend the field school, while the field trip will be aimed at more experienced scientists.

Emails will announce details and registration information when posed on the Ridge 2000 and InterRidge websites. Visit the websites to sign up for mailings.

[www.Ridge2000.org](http://www.Ridge2000.org)

[www.interridge.org](http://www.interridge.org)

**Ridge 2000 PROGRAM**

First Announcement  
**International MOMAR Implementation Workshop**  
**Portugal, Spring 2005**

InterRidge and Ridge 2000 will convene an International MOMAR Implementation Workshop, to take place next Spring 2005 in Portugal. The goal of the Workshop will be to establish an implementation plan for studies in the MOMAR area, coordination of different national and international efforts, and to set a common data, management and conduct policy.

Further announcements will be distributed and posted by the InterRidge, Ridge 2000 and MOMAR sites.

Background MOMAR information and data is available at:

<http://www.momar.org>

**First Announcement****Russian-RIDGE Workshop****held by the Russian Branch of InterRidge****6-8 June 2005****VNIIOkeangeologia, St. Petersburg**

A Workshop is being held to discuss the results of interdisciplinary studies of Mid-Oceanic Ridges obtained for the period of 2003-2004 and to coordinate further investigations.

**Subject of the Workshop: An Hydrothermal Cluster at MAR axis between 12° - 17°N: Unique native phenomenon or common feature of the hydrothermal systems of Mid-Ocean Ridge's ?**

Last decade investigations carried out from aboard the Russian Research Vessels have shown that a few large hydrothermal fields forming distinctive hydrothermal garlands exist along the MAR axial zone between 12°58' - 16°38'N. Therefore the main goal of the next Russia-RIDGE Workshop will be discussions on petrology, geochemistry, geophysics and geodynamic factors that are responsible for the formation of such clusters of hydrothermal fields located at axial zones of the Mid-Ocean Ridges.

**Abstract title should be submitted before December 1, 2004.**

**Abstract should be submitted before March 15, 2005.**

**Addresses for more details and abstracts submission:**

VNIIOkeangeologia, St.Petersburg: **Dr. Georgy Cherkashov** e-mail: [cherkashov@vniio.ru](mailto:cherkashov@vniio.ru)

Vernadsky Institution, Moscow: **Dr. Sergei Silantsev** e-mail: [silantsev@geokhi.ru](mailto:silantsev@geokhi.ru)

**40th EUROPEAN MARINE BIOLOGY SYMPOSIUM****Vienna, 21-25 August 2005**

Organizers: Marine Biology Section of the Institute of Ecology and Conservation Biology (IECB), University of Vienna and ProMare: Association for the promotion of marine biology in Austria.

**Themes**

- 1. Remote and inaccessible marine habitats: From sea caves, oceanic island, wave beaten shores and sea ice to deep sea hot vents.**
- 2. Advances in underwater observation and experimentation: From SCUBA to submersibles, ROVs and subsea observatories.**

Dear colleagues and friends:

the choice of topic is in recognition of the contributions of Rupert Riedl, eminent marine scientist, who will celebrate his 80th birthday in 2005. We hope that many of you will find time to join us in celebrating this date.

Please visit our site at [www.promare.at/embs40](http://www.promare.at/embs40)



## Ridge 2000 PROGRAM



# Announcement Third International Symposium on Hydrothermal Vent and Seep Biology

19-23 September, 2005

Scripps Institution of Oceanography, La Jolla, California

The current plan (to be approved and/or altered by a scientific advisory committee) is for contributed sessions (oral and posters) centering around the following topics:

- Ecology, microdistribution, temporal evolution
- Physiology - adaptation
- Biogeography, evolution, genetics and taxonomy
- Exploration and new frontiers
- Fossil vents and seeps
- Biogeochemical interactions, environmental patterns
- Microbiology: symbionts and free-living bacteria  
thermophiles, sub-seafloor life,  
anaerobic methane oxidation

Suggestions are welcome and papers on all aspects of the biology of hydrothermal vents and seeps will be considered. Contact the organizers at [ventseep@ucsd.edu](mailto:ventseep@ucsd.edu).

In addition, we anticipate holding round table discussions to address topical issues. Possible topics include:

- Applications of vent research
- Imaging and acoustics
- Chemical sensors
- Insights from molecular technologies
- Micro-array technology
- Automated and in situ sampling

We will create a webpage for this symposium with a specific address. However, you will be able to access the site through a link on the Ridge 2000 and InterRidge websites.

We hope to see you there,  
Horst Felbeck, Lisa Levin, Doug Bartlett

[www.Ridge2000.org](http://www.Ridge2000.org)

[www.interridge.org](http://www.interridge.org)





### Job announcement

#### Faculty position in GEOBIOLOGY at COAS, Oregon State University, USA

The College of Oceanic and Atmospheric Sciences (COAS) at Oregon State University announces a **new tenure-track Assistant, Associate or Full Professor faculty position in Geobiology**. We seek a colleague with interest and expertise in microbial interaction with geological materials in the marine environment. The successful candidate should have broad interests and contribute to multidisciplinary research in the area of microbiological mediation of geological processes or to molecular biological studies of microbes involved in subsurface geochemical processes. The appointee will be expected to develop and maintain a vigorous, externally funded research program, to interact with faculty colleagues, to advise and mentor graduate students, and to participate in the COAS teaching program and subsurface biosphere Integrated Graduate Education and Research Traineeship (IGERT) program.

Essential qualifications include a Ph.D. in microbiology, biogeochemistry, or related field.

**Complete position announcement and application instructions** may be found at:

<http://oregonstate.edu/admin/hr/jobs/academic/005-552.html> or

<http://www.coas.oregonstate.edu>.

Applications must be received by **1 November 2004**. Questions about the position may be directed to Dr. Martin Fisk, by telephone (541-737-5208) or by e-mail ([mfisk@coas.oregonstate.edu](mailto:mfisk@coas.oregonstate.edu)) and to Dr. Barry Sherr by telephone (541-737- 4369) or by email ([sherrb@coas.oregonstate.edu](mailto:sherrb@coas.oregonstate.edu)).

### Announcement

#### Opening of the exocetd/d European project web site



#### EXtreme ecosystem studies in the deep OCEan: Technological Developments : EXOCET/D

A research project supported by the European Commission under the Sixth Framework Programme: Integrating and Strengthening the European Research Area, Priority thematic area : GLOBAL CHANGE AND ECOSYSTEMS, FP6-GOCE-CT-2003-505342

The general objective of EXOCET/D is to develop, implement and test specific instruments aimed at exploring, describing, quantifying and monitoring biodiversity in deep-sea fragmented habitats as well as at identifying links between community structure and environmental dynamics. Onboard experimental devices will complement the approach, enabling experiments on species physiology. The EXOCET/D working fields include: video and acoustic imagery, in situ analysis of physico-chemical factors, quantitative sampling of macro- and micro-organisms, in vivo experiments, integration of multidisciplinary data, implementation on European deep-submersibles and a final phase of technical and scientific validation.

<http://www.ifremer.fr/exocetd>



Courtesy of Richard A. Lutz, Rutgers University (modified)



Kristen Kusak, Cathi Dorey, Sulpis Freitag

**CONTACT US:**  
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<http://www.interridge.org>



Courtesy of NASA (modified)



**WELCOME TO INTERRIDGE**  
 AN INTERNATIONAL PROGRAM DEDICATED  
 TO EXPLORING VOLCANIC SPREADING CENTERS AT  
 THE BOTTOM OF THE OCEAN,  
 ONE OF EARTH'S LAST TRUE FRONTIERS.



Courtesy of Eric Arns, Rutgers University

<http://www.interridge.org>




**INTRODUCING THE NEW INTERRIDGE FLIER**

If you interested in obtaining fliers for work you are doing, please contact either your national correspondent or the InterRidge office ([coordinator@interridge.org](mailto:coordinator@interridge.org))

### THE EVOLUTION OF INTERRIDGE


The event that sparked the birth of InterRidge occurred when two countries using the same resource- and labor-intensive tools to visit the same place on the ocean floor realized that it made more sense to share resources than have to find ways to independently fund their own. It was 1992. More than a decade later, InterRidge remains anchored by the principle of collaboration. It is an international organization that pools the resources of its member countries to drive oceanic ridge research forward in a way that is cost-effective, cooperative and proven to be successful.




Courtesy of Richard A. Lutz, Rutgers University

The first ten years of InterRidge produced a coordinated, international ridge community of member countries that had previously been working alone, and left a string of success stories in its wake. Two examples are the first-ever mapping and sampling of one of the slowest spreading and remote centers known to date – the Gakkel Ridge in the Arctic Ocean, and the exploration and study of the South-West Indian Ridge. Embarking on its second decade plan, InterRidge is currently 2700 researchers and 27 countries strong. The doors are wide open for more to join. The plan for the next decade (2004-2013) is three-fold:

- Establish a long-term, real-time presence on the ocean ridges
- Support oceanic ridge science in large-scale international research programs
- Raise public awareness of the oceanic ridge environment through education outreach initiatives



Courtesy of Sven Petersen, IFM-GEOMAR




Courtesy of G. Fournier, TU Freiberg


### WHAT DOES INTERRIDGE DO?

InterRIDGE exists to:

- Promote interdisciplinary, international studies of the ocean's spreading centers
- Coordinate scientific exchange (information, technology, facilities) between national research groups
- Provide a unified voice for ocean ridge researchers worldwide
- Encourage the protection and management of the oceanic ridge environment
- Promote communication between nonscientists, scientists, educators and policy-makers
- Spearhead education outreach efforts to raise awareness of the oceanic ridge environment



Courtesy of IFMUR



Courtesy of Richard A. Lutz, Rutgers University


*"Ridge science is entering its fascinating era, as long-term, real-time and continuous monitoring of the deep-oceans becomes technologically and financially feasible. [InterRidge] represents a milestone toward Earth establishing a presence in an environment that covers 70% of the surface of our world."*

### WORKING GROUPS

The InterRidge working groups – the teams that meet regularly in manageable groups and reflect current research priorities – include the following:


- Ultralow spreading ridges
- Ridge-hotspot interaction
- Back-arc spreading systems
- Mid-oceanic ridge ecosystems
- Monitoring and observatories
- Deep earth sampling
- Global exploration
- Biogeochemical interactions of deep-sea vents

### INTERDISCIPLINARY, TEAM-BASED APPROACH



InterRidge reaches its research and outreach objectives in a number of ways by:

- Hosting specialized scientific workshops
- Publishing scientific implementation plans in the form of workshop reports
- Developing, managing and hosting the InterRidge website and databases
- Coordinating collaboration and information exchange between members and partners
- Publishing the InterRidge newsletter
- Acting as an exchange base for information on international ridge cruises
- Promoting responsible ridge science, management, and exploration



Courtesy of Richard A. Lutz, Rutgers University



# NOTES

**[www.interridge.org](http://www.interridge.org)**

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