Jean-Luc CHARLOU

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InterRidge News

InterRidge Update

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

InterRidge Office Transfer

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

Membership

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

InterRidge and SCOR

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

InterRidge Projects

4-D Architecture of the Oceanic Lithosphere

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

Dr. Heather Sloan, Editor.
Dr. Ruth Williams, Assistant Editor
InterRidge News is published by the InterRidge Office,
Department of Geological Sciences, University of Durham, South Road,
Durham, DH1 3LE, United Kingdom;
tel: 44-191-374-2532, fax: 44-191-374-2510
e-mail: intridge@durham.ac.uk
http://www.dur.ac.uk/~ dgl0zz1/

Contents

Quantification of Fluxes Project

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

H. Bougault[1], C. German[2], M. Miranda[3] and the MARFLUX/ATJ Participants (note 1)

[1] *IFREMER/DRO/GM, BP 70, 29280 Plouzané, France*
[2] *Southampton Oceanography Centre, Empress Dock, Southampton, SO14 3ZH, UK*
[3] *Centro de Geofisica, Univ. of Lisboa, Rua da Escola Politecnica 58, 1200 Lisboa, Portugal*

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

EC funding

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

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

The objectives of MARFLUX/ATJ

The principal objectives of MARFLUX/ATJ were:

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

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

The project built on early re-

Note 1:
MARFLUX/ATJ participants: M. Aballéa[4], P. Appriou[4], F. Barriga[9], M. Biscoito[8], P. Blondel[6], J.-L. Charlou[1], A. Colaço[8], D. Coller[11], I. Costa[9], M. Critchley[11], L. Dosso[3], Y. Fouquet[1], P. Jean-Baptiste[5], A. Khripounoff[2], J. Freire Luis[7], N. Lourenço[7], E. Ludford[12], L. Mendès Victor[7], A. Marques[8], H.D. Needham[1], D. O'Brien[10], H. Ondréas[1], L. Parson[6], J. Patching[10], J. Radford Knoery[1], L. Saldanha[8]
[1] IFREMER/DRO/GM, BP 70, 29280 Plouzané, France
[2] IFREMER/DRO/EP, BP 70, 29280 Plouzané, France
[3] GDR GEDO, Ifremer, BP 70, 29270 Plouzané France
[4] Dpt. Chimie UBO, Av. Le Gorgeu, 29200 Brest, France
[5] Lab. Géochim. Isotopique, LMCE Bat. 709, 91191, GIF s/Yvette, France
[6] SOC, Empress Dock, Southampton, SO14 3ZH, UK
[7] Centro de Geofisica, Univ. of Lisboa, Rua da Escola Politecnica 58, 1200 Lisboa, Portugal
[8] IMAR, Lab Maritimo da Guia, Fac. Ciencias, Univ. Lisboa, Estrada do Guincho, 2750 Cascais, Portugal
[9] Dpt. Geologia, Fac Ciencias, Univ. Lisboa, Ed. C2 Piso 5 Campo Grande, 1700 Lisboa, Portugal
[10] University College Galway, Galway, Ireland
[11] ERA-MAPTEC Ltd, 5 South Leinster St., Dublin 2, Ireland
[12] Dpt of Geology, Univ. of Bristol, UK
A formal co-operation was established with G. Klinkhammer[13] and C. Langmuir[14].
[13] College of Ocean., OSU, Corvallis, OR 97331-5, USA
[14] LDEO, Columbia Univ., Palisades, NY 10964, USA

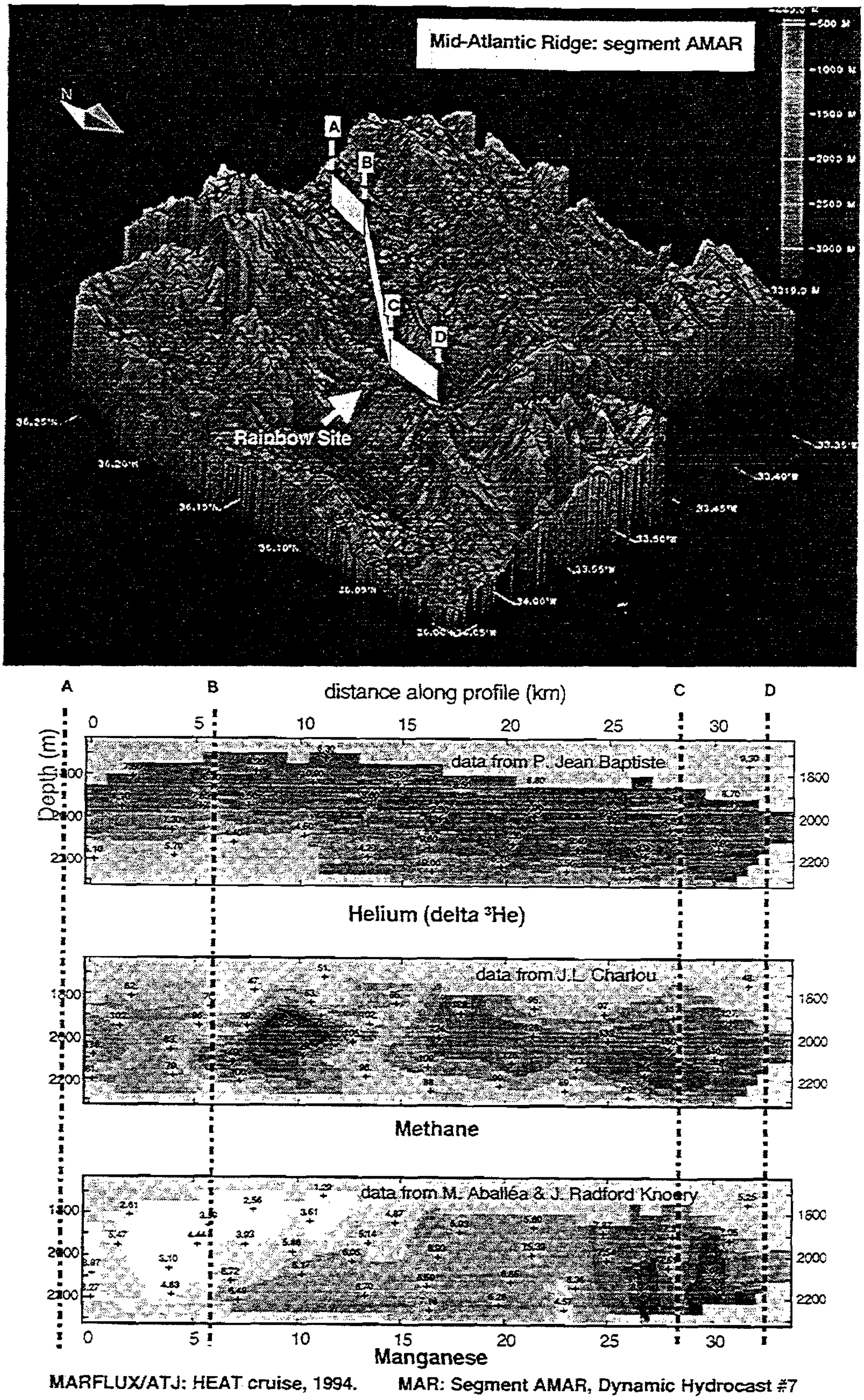

Figure 1. Hydrothermal plumes along the AMAR segment of the MAR, southwest of the Azores. Vertical cross section of Δ^3He, CH_4 and Mn (total disolved manganese (Aballéa et al., 1995)) along ABCD. Between 1700 m and 2300 m depths, chemical signals are detected everywhere along the segment, with values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

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

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

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

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

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

Principal results

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

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

Note 2

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

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

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

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

- to discover new expressions of Ocean/Lithosphere exchanges from the different signals recorded in the water column corresponding to different geological settings of the MAR
- to study volcanic and/or tectonic controls on hydrothermal discharges, in particular related to transform faults and complex offsets
- to study the influence of the Azores Hot Spot (gradient in depth and in chemical properties of the ocean crust) on physico-chemical properties of hydrothermal exchanges from Menez Guen at 38°N to AMAR at 36°N
- to study the behavior of chemical and biological species both around hydrothermal sites and in plumes
- to study the various aspects of hydrothermal biological communities
- to establish natural laboratories to study the time variation of hydrothermal sites.

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