InterRidge

Meeting Report

Ifremer
Brest, France
June 12-14, 1990

Convenors:
H.D. Needham, Ifremer, France
John R. Delaney, RIDGE Office, USA

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Acknowledgements

This report reflects the active interest of all participants. The efforts of the moderators of the plenary and working group sections and of the InterRidge correspondents (or their delegates) were particularly valuable. Encouraging support for the meeting came from many colleagues around the world.

Trileigh Stroh of the U.S. RIDGE Office coordinated the planning of the meeting and the preparation of the report. Diane Hunn (U.S. RIDGE Office) covered the secretarial tasks, in collaboration with Nicole Uchard (Marine Geosciences Departement, Ifremer), who also was largely responsible for the logistics in Brest.

The gathering was hosted by Ifremer.

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InterRIDGE Meeting
Ifremer, Brest, France
June 12-14, 1990

Convenors: H.D. Needham and J. Delaney

Agenda

June 12 — Tuesday afternoon and evening session

14h00 *Plenary session (Salon Rouge)*
- — Introductory remarks, aims of the meeting, agreement on agenda
- — Review of recent and anticipated national programs (Reports by correspondents)
  Moderator: L. Dmitriev

18h15 *Apéritif*

19h30 *Informal discussions*

June 13 — Wednesday morning session

09h00 *Plenary session (Salon Rouge)*
- — THEME 1: Spatial characterization of the ridge crest (mapping and sampling)
  - 1A) *Achieving global coverage of the spreading center network by the year 2000; problem areas*
    Moderators: C. Langmuir and M. Sinha
  - 1B) *Focusing on one or more significant portions of the rift system for thorough study of its physical, chemical and biological characteristics*
    Moderators: J. Francheteau and R. Detrick
- — THEME 2: Temporal characterization (active processes) of the ridge crest
  - 2A) *Using and complementing the international seismic network to identify important volcanic/tectonic events; exploring ways to develop a cooperative rapid-response capability*
    Moderators: E. Bergman and H. Schmincke
  - 2B) *Preparing for one or more permanent sea-floor observatories with real-time links to land*
    Moderators: J. Cann and F. Avedik

LUNCH

<u>June 13</u> — ***Wednesday afternoon session***

14h00 *Plenary session (Salon Rouge)*

Subgroup meetings to summarize main points of Themes 1 and 2:

- Rationale and long-range international goals
- Approach: how InterRidge cooperation could help to achieve objectives, including technological elements, logisitics, data management
- Possible research areas for most effective bilateral/multilateral
- Summary of recommendations
- Reports of subgroups
  - — Group 1: Global
  - — Group 2: Regional (intermediate and local scales)
  - — Group 3: Observatories, event detection and response
  - — Group 4: Biology

20h00 *InterRidge dinner*

<u>June 14</u> — ***Thursday morning session***

08h30 *Sub-groups draft write-ups of reports*

09h00 *Plenary session (Salon Rouge)*

— Organizational aspects of InterRidge

- *Relationships with other international programs*
- *Science planning structure including budgetary questions*
- *Near term efforts*
- *Next meeting*

Moderator: J. Fox

LUNCH

<u>June 14</u> — ***Thursday afternoon session***

14h00 *Plenary session (continued)*

16h00 *Meeting ends*

Participants

Jean-Marie Auzende	*Département Géosciences Marines, Ifremer/Brest*	*FRANCE*
Felix Avedik	*Département Géosciences Marines, Ifremer/Brest*	*FRANCE*
Georges Barbier	*Département Environnement Profond, Ifremer/Brest*	*FRANCE*
Eric Bergman	*U.S. Geological Survey, Golden, CO*	*USA*
Enrico Bonatti	*Lamont-Doherty Geological Observatory, Palisades, NY and Dipartimento di Scienze della Terra, Pisa*	*USA*
Henri Bougault	*Département Géosciences Marines, Ifremer/Brest*	*FRANCE*
Johnson R. Cann	*Department of Earth Sciences, University of Leeds*	*UK**
John R. Delaney	*School of Oceanography, University of Washington, Seattle*	*USA**
Robert Detrick, Jr.	*Graduate School of Oceanography, University of Rhode Island*	*USA*
João M. Alveirinho Dias	*Instituto Hidrográfico, Lisboa*	*PORTUGAL*
Leonid V. Dmitriev	*Vernadsky Institute of Geochemistry, Moscow*	*USSR**
Laure Dosso	*CNRS, Département Géosciences Marines, Ifremer/Brest*	*FRANCE*
Aline Fiala-Medioni	*Laboratoire de Banyuls-sur-Mer*	*FRANCE*
P. Jeff Fox	*Graduate School of Oceanography, University of Rhode Island*	*USA*
Jean Francheteau	*Institut de Physique du Globe, Paris*	*FRANCE*
Hiromi Fujimoto	*Ocean Research Institute, University of Tokyo*	*JAPAN**

**National Correspondents*

Karl Gronvold
Nordic Volcanological Institute — *ICELAND**

Roger Hékinian
Département Géosciences Marines, Ifremer/Brest — *FRANCE*

Jose Honnorez
Université Louis Pasteur, Strasbourg — *FRANCE*

Thierry Juteau
Universite de Bretagne Occidentale, Brest — *FRANCE*

Ellen Kappel
Joint Oceanographic Institutions, Inc., Washington, D.C. — *USA*

Michael Keen
Geological Survey of Canada, BIO, Dartmouth — *CANADA*

Kim Klitgord
U.S. Geological Survey, Woods Hole, MA — *USA**

Charles Langmuir
Lamont-Doherty Geological Observatory, Palisades, NY — *USA*

Catherine Mevel
Université de Pierre et Marie Curie, Paris — *FRANCE*

Bramley Murton
Institute of Oceanographic Sciences, Deacon Laboratory, Wormley — *UK*

John C. Mutter
Lamont-Doherty Geological Observatory, Palisades, NY — *USA*

David Needham
Départment Géosciences Marines, Ifremer/Brest — *FRANCE**

Hans-Ülrich Schmincke*
GEOMAR, Forschungszentrum für Marine Geowissenschaften, Kiel — *GERMANY*

Martin Sinha
Bullard Laboratories, University of Cambridge, Cambridge — *UK*

Christophe Sotin
Université de Paris-Sud, Orsay — *FRANCE*

Alan Southward
Marine Biological Association, Plymouth — *UK*

Eve Southward
Marine Biological Association, Plymouth — *UK*

Trileigh Stroh
RIDGE Office, School of Oceanography, University of Washington, Seattle — *USA*

*National Correspondents

Abstract

- A strong agreement was reached on the value of nations' working further together through an InterRidge-type initiative.

- Program components can be usefully examined under two principal headings:

  -- *Spatial characterization* (global and regional [intermediate to local] scales)
  -- *Temporal variability* (event detection and response; observatories)

- Biology must be integrated with the geosciences in the overall program.

- Organization of InterRidge should be formalized as the project matures. InterRidge will move forward during the coming year with a minimum organizational structure. A small international steering group was created to help advance near-term efforts to define and promote the project. Members of this group include J. Delaney (U.S.), J. Fox (U.S.), J. Francheteau (France), M. Keen (Canada), C. Langmuir (U.S.), D. Needham (France), and M. Sinha (U.K.). D. Needham and J. Delaney will serve as co-chairs.

- The steering group will formulate a short document to serve as a first draft of a science (project) plan outline for circulation and for discussion with agencies in the different countries.

  The plan should include:

  -- Scientific rationale, extent, and limits of project
  -- Principal program components
  -- Possible scenarios for implementation at international level (mechanisms, types and degrees of participation)
  -- Technological developments
  -- Technological and logistical collaboration
  -- Facilitation of data exchange and database construction
  -- Management
  -- Funding

- Decisions on formalization of the program must be made at the next meeting.

- National correspondents will interact with colleagues to assess potential interest and support of national scientific communities, institutions and agencies and to identify possible levels of activities relevant to scientific, technological, and geographical InterRidge goals.

- Venue for next meeting will be established in autumn 1990. Possibilities include the United Kingdom and Germany.

I. CONTEXT OF INTERRIDGE

(1) Rationale

The persistent reshaping of the earth, ultimately dependent on intra-planetary energy release, manifests itself principally along the lithospheric plate boundaries. Magmatic and tectonic processes at the crest of the mid-oceanic ridge control most of the first-order morphology of the ocean floors. Since the 1960's when recognition of the ocean floor magnetic polarity reversals and more generally the plate tectonic theory provided a coherent frame for understanding these processes, several scientific and technological developments have opened up new avenues of investigation of earth dynamics and have altered notions about priorities in oceanographic research for the coming decade.

The transfer of mass and energy associated with submarine volcano-hydrothermal systems along the ridge has now been shown to represent one of the planet's major exchange systems. It provides the elements necessary for sustenance and synthesis of aphotosynthetic fauna and may enter significantly into the earth's carbon cycle. Deep-diving submersibles have allowed direct observations and sampling of the results of this transfer process at the finest scales. Swath bathymetric systems have made it effectively possible to map, over large areas, the morphologic expression of second-order structures that provide critical information about tectonic patterns, and to design experiments to examine poorly understood correlations of physical and chemical parameters. Altimetric images of the sea surface have allowed broad-scale interpretation of ocean floor bathymetry, and have facilitated an important change of emphasis from regional to global perspectives of the mid-oceanic ridge.

At the same time, it has been more clearly recognized that neither solar driven changes in the earth's environment nor particular consequences of active mantle-crust-hydrosphere interactions (e.g., hydrothermal springs, associated fauna and sulfides, ridge crest contributions to global, chemical and heat budgets) can be fully understood in isolation. Outstanding inter-related problems at this time also involve the deep structure of the crust, absolute and relative age-dating of correlative magmatic and tectonic events, levels of stability of ridge crest segment distribution over a significant period of time, and mantle geochemical signals.

(2) Historical perspective

The recent evolution in the marine geosciences is reflected in ongoing national efforts in ridge-crest research and has led in particular to the U.S. RIDGE initiative, begun in 1987, whose underlying goal is "to understand the geophysical, geochemical and geological causes and consequences of energy transfer" along the global spreading-center network. A RIDGE Initial Science Plan, reposing on the conclusions of three workshops, community-wide, has been published. Five working groups met in 1989; reports of the working groups are available from the RIDGE Office. The first actions at sea under the Initiative are expected to take place in 1991.

A recommendation made at the initial workshop (sponsored by the U.S. National Academy of Sciences) that RIDGE activities be international in scope was followed up at an informal geosciences gathering organized by the U.S. RIDGE Office and held at the National Academy of Sciences in Washington, D.C. in July 1989. It was agreed there that the idea of an international initiative be pursued. **InterRidge** was adopted as the name for this effort. Suggestions were made for focusing initial activities on communication, coordination of surveys and efforts to foster international cooperation, and data exchange. InterRidge correspondents were nominated by the eight countries represented at the meeting. It was decided that the next meeting should be in Brest, France in the spring of 1990.

(3) Meeting in Brest, June 1990

The aim at the Brest meeting (12-14 June, 1990), attended by 35 scientists from 10 countries, was (a) to obtain a first overall view of national programs and (b) to test general notions of international cooperation against specific questions of appropriateness, feasibility and possible collaborative mechanisms. A new framework is required; existing models for multinational collaboration in oceanography (ODP, WOCE and others) are not simply transposable. Ridge studies involve many parameters, different disciplines, a great range of spatial and temporal scales and hence a variety of instruments and methodologies.

The Brest meeting was structured around two main operational approaches whose scientific rationales were developed by working groups under the U.S. RIDGE Initiative, namely (1) physical, chemical and biological spatial characterization of the ridge crest through mapping and sampling at the global and at the regional (intermediate to local) scales; and (2) monitoring of temporal variability of the operative, active processes associated with accretion (a) through event detection and response and (b) using observatories on the ocean floor. Numerical modelling was not considered as an independent item for discussion.

(4) Spatial characterization of the ridge crest

Some problems can be tackled only at the scale of the whole length of the ridge. A successful and efficient program of global mapping and sampling defined itself quite naturally as a task requiring some sort of centralized coordination of national actions. Targets for the end product could perhaps be defined in such a way that the effort could take on the characteristics of a multinational project driven by competitive scientific arguments and by a suitable blend of national goals and individual effort within a reasonably organized whole (see summary of working group conclusions, page 5).

Intermediate-scale geophysical mapping, and rock, sediment and water sampling, as well as associated fine-scale, local investigations (involving observations, sampling and measurements down to scales of centimeters) emerged as a less tractable theme for near-term, orchestrated multinational cooperation. The working group that discussed this subject at the meeting stressed the importance of defining long-term scientific strategies together, of encouraging specific national and bilateral (or multilateral) projects, of exchange of information and data and of sharing specialized instrumentation (see page 5).

(5) Temporal variations

Fine-scale observations of ridge crest sites made at intervals of only a few years have shown that rift environments can change very rapidly, even in areas where there is no reason to suspect abnormal instability of volcanic, tectonic, hydrothermal or biological activity. Ridge-crest processes have to be observed and measured in order to improve interpretations about how the ridge is evolving and to relate these processes to the rock and sediment record. We need, therefore, to study the ridge when it is most active as well as to quantify average flux rates over decades in order to make educated estimates about their significance.

The possibility of installing observatories to monitor the processes and measure the fluxes in selected areas over long periods of time has been discussed for many years. The concept has now matured to the point that pilot observatory experiments within about five years and one or two permanent stations within perhaps 10 years are now a feasible proposition. InterRidge can serve to coordinate the development of common elements for observatories, and facilitate the organization of a general program of observation within which individual projects would be the responsibility of autonomous teams unhampered by unnecessary bureaucracy (page 6-7). The Juan de Fuca Ridge is already targeted (U.S. and Canada); another North Atlantic site should be added.

Observing and recording what takes place during major, specifically volcanic, episodes along the ridge crest pose quite different challenges to those concerned with surveillance of more "steady state" or more transient, relatively low-energy phenomena. Not only must the events be detected and the information publicized rapidly, but a ship, armed with suitable instruments, must be deployed immediately. Several recommendations were made at the meeting, involving all the stages of the operation from event detection to response (reception of reports at an InterRidge office, alerting of national fleet coordinators and interested scientists). The development of a standardized rapid response instrument package (RRIP) was proposed.

(6) Biology and the geosciences

One of the most compelling insights generated by recent integrative studies of seafloor volcano-hydrothermal-biological systems is that "volcanoes in the presence of liquid water can sustain life." Exploration of the ramifications of this conclusion may constitute one of the major contributions of interdisciplinary ridge-crest research. Biological investigations of hydrothermal systems thus directly concern an understanding of the origin and evolution of life on earth. Other essential aims include the role of hydrothermal processes in the productivity of the deep sea and studies of new species, including those with potential biotechnological value for production of thermostable macromolecules and enzymes. Both highly specialized projects and an interdisciplinary approach are necessary.

At the Brest meeting the intermeshing of biological thematics and those of the different branches of the geosciences were discussed in terms of the general scheme adopted for discussing the geological objectives (page 7). It was stressed that biological objectives require investigation of a significant number of sites on a global scale. Integration with programs of selected fine-scale geological studies appears to pose no special problems, but joining a strategy of global mapping and sampling would require, for example, appropriate ship-controlled videosystems and the use of submersibles. Response capabilities for investigating new volcanic/hydrothermal sites would complement the goals of geologists, and observing the collapse of existing fields would be of special interest for biogeological research. Long-term observatories would best be combined with repeated submersible cruises in the same areas.

A general conclusion was that InterRidge could help to formalize new and existing collaborations and improve information and data exchange and that a central bureau would be necessary. Development of a comprehensive geological-geophysical database related to ridge studies, with ready access by all national participants, is essential.

(7) National programs and scope of InterRidge

Discussion of the principal themes outlined above against the background of national activities raised questions about the thematic and geographical limits of an international InterRidge initiative. These issues remain to be resolved. The initial U.S. program RIDGE concerns a zone along the ridge crest with almost all objectives at present lying within a corridor representing crust of 1-5 my age. Other national programs incorporate studies of older oceanic crust, including ophiolite suites onshore and back-arc basin systems.

Some countries with relatively small communities involved in oceanic crust studies may prefer a broader scope for InterRidge. Furthermore, the pressure for bathymetric and geophysical investigations of older, intra-plate, ridge-flank crust and sub-sediment sampling, for example, may increase before axial zone studies have run their course. Other countries have relatively focused thematic or geographical interests. Portugal, for example, is particularly interested in the Azores area; Japan, at present, emphasizes back-arc volcanism and spreading; Canada's main geographical target is the Juan de Fuca Ridge. The development of InterRidge will concern how, and to what extent, particular interests can be better pursued within an international context.

(8) Organization of InterRidge

What type of program InterRidge might be, how "passive" or "active," and how it might be organized will depend essentially on how long-range objectives specific to InterRidge are defined. Sentiments expressed at the meeting were that, on the one hand, InterRidge should be open to all interested countries regardless of the volume of their contributions and that, on the other hand, not all nations may want to, or could, participate equally in a major program. Many participants also stressed that some specific targets must be set in those areas in which international collaboration is necessary or would be particularly beneficial.

A three-frame progressive or in-parallel approach is one of several possibilities worth examining. In the first frame, some independent national and bilateral (or trilateral) programs could align themselves with the with broad, long-range InterRidge goals. This is essentially the notion of an international umbrella for facilitating ridge-crest research. In the second frame, InterRidge could act as an active promoter of, and would associate itself with (adopt), specific projects with formal bilateral or multilateral agreements. This would imply discussion and mutual constraints. InterRidge could, for example, promote the mobilization of ships of several nations around a particular theme, or in a particular part of the ocean, or both (notion of an InterRidge "geophysical" year). In the third frame, InterRidge would define and organize its own special projects targeting objectives that need a concerted effort.

It is evident that further progress for InterRidge will require not only some minimal organization but some minimal international funding. A suitable formula for the financial support of an InterRidge coordinating office is, for example, one of the questions that must be addressed soon. Meeting participants recommended that InterRidge should move now only from an ad hoc arrangement to an interim planning structure. A small international steering group was created to help to advance near-term efforts to define and promote the project. The steering group, working in collaboration with biologists and consulting with colleagues, will draw on the report of the Brest meeting to formulate a document to serve as a draft of a science (project) plan for discussion among scientists and with agencies at national levels. This document and comments on it will be examined at the next InterRidge meeting in about a year's time.

The success of InterRidge will depend ultimately on national positions and national efforts. InterRidge correspondents will need to broaden the base of consultation to assess potential levels of support for an InterRidge program (scientific, technological, budgetary). The U.S. already has an initial national program plan, as does the United Kingdom, which can both serve as national interfaces for InterRidge. Informal discussions about moving in this direction have started in Japan and France.

The location of the next InterRidge meeting will be determined in the autumn of 1990. Possible host countries include the United Kingdom and Germany.

II. PROGRAM COMPONENTS

(1) Spatial characterization: physical, chemical, and biological mapping and sampling of the ridge crest at global and regional scales.

1a. Global-scale studies

Program goals:

- Assess overall variability and systematics of global ridge-crest system to address problems of accretion at the scale of the planet and of ocean basins.
- Provide a planetary context for understanding more specific studies on larger (regional) scales.
- Generate a global ridge-crest map (bathymetry and morphology with geophysical control).
- Perform global-scale reconnaissance sampling of rocks, sediments, water to investigate hydrothermal, tectonic, petrologic and chemical evidence of processes dominating lithosphere formation.
- Develop an inventory of hydrothermal activity.
- Encourage direct involvement of biologists in a global data collecting strategy through development and use of improved video systems to:
  -- characterize first-order variation in biological colonies and processes;
  -- characterize environments in which life forms can be sustained.

Region of current interest:

- Pacific-Antarctic Ridge
- SW Indian Ridge
- Chile Rise

Possible InterRidge contributions:

- Centralized coordination of efforts in the planning stage.
- Sharing and exchange of ship time.
- Sharing and exchange of sampling and surveying equipment.
- Construction of digital data bases of underway geophysical data and geochemical data on rocks and waters.
- Calibration and standardization of analytic facilities to ensure comparable data of high quality.
- Independent funds to facilitate collaborative studies among scientists of different countries.

Near-term efforts:

- Create an ad hoc working group to define appropriate approaches to coordinated global-scale studies and to propose some ground rules for participation.

1b. Regional-scale studies (intermediate to local)

Program goals: Characterize roles of key variables that affect crustal accretion processes, through a wide range of interdisciplinary investigations focused particularly at the scale of a single spreading ridge segment (tens to a hundred or more kilometers). Constituent studies should include the following:

- Mapping and sampling to characterize the morphologic, structural, and compositional variability of the ridge
- Geophysical studies to constrain crustal and upper mantle structure
- Geochemical and geological observations to estimate hydrothermal fluxes at the segment scale
- Biological studies of vent populations, species replacement and genetic exchange

Regions of current interest:

- Central North Atlantic (15-40N)
- E.P.R. south of Garrett Fracture Zone
- Northern East Pacific Rise
- Juan de Fuca Ridge (focus of ODP drilling in InterRidge time frame)
- Reykjanes Ridge (current involvement of UK, FRG, Japan)

Possible InterRidge contributions:

- Strongly endorse national (e.g., U.S. RIDGE, U.K. BRIDGE) and multinational or bilateral (e.g., U.S./France FARA) programs aimed at investigating crustal accretion variables.

- Develop a long-term scientific strategy for mid-ocean ridge investigations.
- Establish an InterRidge Coordinating Office to collect and disseminate information about ridge-related activities to facilitate collaborative studies.
- Produce an International Data Exchange Catalogue, and establish standard formats and procedures for data exchange.
- Provide a means of facilitating the international use of specialized or unique equipment or instrumentation.
- Integrate biological applications into geological and water-column cruises.

Near-term efforts:

- Encourage development of a comprehensive database of multibeam bathymetry in the Atlantic.
- Compile a list of available specialized/unique equipment and instrumentation, and keep track of their scheduled use.
- Investigate establishment of an InterRidge office.

(2) <u>Temporal variability</u>: study of the operative, active processes associated with accretion.

<u>2a. Event detection and response</u>

Program goals:

- Characterize contribution of short-term energy releases to overall energy flux at mid-ocean ridges.
- Promote establishment and maintenance of an international event detection/ response network to allow observation and characterization of mid-ocean ridge events as they occur.

Regions of current interest:

- Mid-Atlantic Ridge from 20-70N
- Juan de Fuca and adjacent ridges in the Northeast Pacific

Possible InterRidge contributions:

- Detection:
  - -- Develop means of discriminating "events."
  - -- Encourage installation of digital local seismic networks in appropriate sites.
  - -- Investigate the possibility of access to information from acoustic network signals; if appropriate access can be arranged, then conduct research on acoustic recognition and discrimination of events.
  - -- Establish a facility dedicated to receiving reports of events and alerting appropriate scientists to activate a response.
- Response:
  - -- Alert potential responders to detected events.
  - -- Aerial response: explore possibilities of military assistance for rapid deployment of sonobuoys and bathythermographs.
  - -- Marine response: take advantage of ships of opportunity to transport and use appropriate response equipment.
  - -- Create Rapid Response Instrumentation Packages (RRIP's): collect and maintain equipment at appropriate locations (Europe, Iceland, Azores, U.S. West Coast) to transport aboard ships when required for response. RRIP's could, for example, contain hydrocast gear, sonobuoys, BT's, CTD's, dredge, magnetometer, chemical gear, etc. Identify and train scientists willing to participate in event response.
- Post-event monitoring: develop plans and provide strong encouragement for extended post-event monitoring of active segments. The collapse of a vent field with a thriving biological community would represent a particularly valuable opportunity for biological studies.

Near-term efforts:

- Investigate potential help from international ship coordination group (International Ship Operations Managers [ISOM]; meeting in early October 1990).
- Establish working group to consider desirable contents of RRIP and to guide InterRidge coordination efforts in event detection and response

<u>2b. Sea-floor observatories</u>

Program goals:

- Understand decadal-scale (and longer) temporal variability and covariability of geophysical, geochemical, and geobi-

ological processes operating at mid-ocean ridges.
- Foster establishment of seafloor observatories on mid-ocean ridges, placed in accessible sites to allow easy servicing.
- Set international standards for modular observatory construction, including power supply, information exchange, and standard base stations to which sensor/experimental/observation modules could be attached.

Regions of current interest:
- North Atlantic
- Juan de Fuca Ridge

Possible InterRidge contributions:
- Promote coordination of an international group of scientific teams, each responsible for one observational or experimental nodule, in a similar way to that used for space stations.
- Establish a small InterRidge office to coordinate international observational programs.

Near-term actions:
- Explore actual and potential technological efforts at national levels
- Consult with Ocean Drilling Program.

(3) Biology

Program goals:
- Understand origin and evolution of life.
- Characterize interdependence between volcanic and biological systems.
- Understand processes in ecosystems based on chemoautotrophy (composition of ecosystems, biogeography and evolution of species; functional aspects of ecosystems and species adaptations to environmental conditions).
- Investigate possible applications of species living in hydrothermal ecosystems (new species and organic compounds of possible industrial interest).
- Address long-term evolution of hydrothermal vent ecosystems and influence of variations in ecological conditions.
- Characterize fluxes associated with hydrothermal ecosystems and their importance at the oceanic scale.

Regions of current interest:
- East Pacific Rise, including related ridges, such as the Juan de Fuca Ridge
- North Atlantic
- Western Pacific

Possible InterRidge contributions:
- Biology and geology cruises should be coordinated, where appropriate, particularly before collection of geochemical data.
- Data exchange should be fostered by InterRidge and should include explored sites, planned cruises, types and archive locations of collected samples, and research teams involved.
- A protocol should be established for handling, preservation, and storage of biological materials.
- At least one biologist should participate where possible in any cruise including seabed geological sampling in hydrothermal areas (e.g., submersible cruises).

Near term actions:
- Explore and refine ways in which objectives can be integrated with geosciences aims from a thematic and operational point of view.

III. LIMITS OF INTER-RIDGE; NATIONAL CONTRIBUTIONS

- The U.S. RIDGE plan concerning the ridge crest sensu stricto (0-5 my) is recognized as forming the basis for InterRidge discussions.
- InterRidge, however, is not committed to follow the U.S. RIDGE plan, and must define its own initial scientific plan.
- Long range InterRidge objectives could be more or less restrictive than those of RIDGE (with different emphases, for example on on-ridge-crest and off-ridge-crest work).
- Critical considerations include:
  - -- Interests of different nations vary considerably, from geographically concentrated studies to wider-ranging reconnaissance in all oceans;
  - -- Volumes of effective possible contributions to sea-going investigations and technological efforts are significantly different.

IV. PROGRAM DESIGN

- Some science concerning accretion, global fluxes and biological research probably cannot be accomplished without considerable international collaboration.
- Two main end-member views concerning the possible strength of an InterRidge program are, with variations:
  - -- that InterRidge needs to achieve and/or coordinate specific projects in order to progress, and ultimately to justify its formal existence as a program;
  - -- that InterRidge is primarily an opportunity to facilitate international communication about on-going national and international efforts and to improve handling of, and access to, data.

V. PARTICIPATION AND MANAGEMENT

- Objectives retained for InterRidge and the way InterRidge is organized will be mutually interactive.
- The idea was expressed that no country should be excluded, but concern exists about how a country could benefit from InterRidge and how this would be equated with its contributions (including financial contributions) and levels of participation. The initial program plan will have to address this aspect of project organization.
- There was general support for the establishment of a small, central InterRidge office as necessary prerequisite for efficient communications and coordination, and discussion about how this would be funded, and how equally by various participating countries. Solutions remain to be defined.
- There was agreement that management structures should not evolve faster than an approved program. Only an interim steering group should be created now.

VI. RELATIONSHIPS WITH OTHER INTERNATIONAL PROGRAMS

- At present, InterRidge should maintain its own identity while pursuing links where appropriate; e.g., ODP, JGOFS, ILP (U.S. RIDGE already has such contacts).
- Approval of the InterRidge interest in cooperation was expressed by the Chair of ILP Working Group #4 (J. Mutter). The next ILP meeting in FRG will be a useful forum for InterRidge promotion and discussion. Mutter will act as InterRidge/ILP correspondent.

VII. NEXT STEPS

- Pending further preparation of the InterRidge program, necessary interim coordination will be assured by the interim steering group and by national correspondents.
- The steering group will prepare a draft of a science (program) plan in informal consultation with national correspondents and with other colleagues.
- National correspondents will act with colleagues in their countries in order to improve assessment of interest and potential support of national scientific communities and of institutions and agencies concerned. (At present, only the U.S. [RIDGE] and the U.K. [BRIDGE] have coordinated programs that can serve as appropriate national interfaces with an InterRidge initiative.)
- National correspondents will give consideration to the practical question of financial support for an InterRidge office. (For the present, the chairs of the interim steering group will coordinate correspondence and the U.S. RIDGE office will act as an interim InterRidge bureau.)
- The next InterRidge meeting will be held in Summer/Fall of 1991. The U.K. and Germany are possible venues.

VIII. WORKING GROUP REPORTS

1. SPATIAL CHARACTERIZATION: GLOBAL-SCALE STUDIES

2. SPATIAL CHARACTERIZATION: MID-OCEAN RIDGES AT REGIONAL (INTERMEDIATE TO LOCAL) SCALES

3. TEMPORAL VARIABILITY:

(A) EVENT DETECTION AND RESPONSE
(B) MID-OCEANIC RIDGE OBSERVATORIES

4. BIOLOGY IN INTERRIDGE

1. SPATIAL CHARACTERIZATION: GLOBAL-SCALE STUDIES

(Prepared by C. Langmuir and M. Sinha from contributions of the Working Group)

Working Group:
Laure Dosso
Jeff Fox
Ellen Kappel
Kim Klitgord
Charles Langmuir
John Mutter
David Needham
Martin Sinha

Rationale and objectives

Study of ocean ridges must be considered on a variety of scales. One important scale of variability is the global scale. Making observations on this scale requires a level of effort that any individual country cannot sustain on its own. At the same time, such observations provide the global context in which all more specific studies on a smaller scale can be better understood. The global perspective provides a framework for each country's particular interests. InterRidge could provide the necessary international coordination for achieving the global scale observations.

The purpose of the global program is a spatial characterization of mid-ocean ridges necessary for investigating mantle heterogeneity; the geologic, hydrothermal, geodynamic, petrologic and biologic processes that dominate lithospheric generation; and the environment in which life forms can be sustained. The purpose of the program is to investigate problems and processes, and not simply to make a map. In addition, there is inherent value in the exploratory aspects of making observations in unknown terrain. Every ridge that has been investigated thus far has yielded surprises that did not conform to our preconceptions. Until we begin to see some duplication of ridge properties, exploration is still necessary simply to know what variability and systematics exist that need to be explained by quantitative models. Crust formation is a multidimensional problem. Many data points are necessary to define the structure of the problem, and even simply to know its dimensionality.

There are other potential practical advantages for individual countries for a coordinated global effort. An example is provided by the situation for the UK. The UK currently does not have a multibeam vessel; and yet some segments of the ridge that it is particularly interested in, such as the Scotia sea and possibly parts of the South Atlantic, still require multibeam mapping.

Collaboration with another nation that could provide a multibeam ship would be desirable. At the same time, there are other portions of the global system that would be of great interest to British geochemists, but which they do not have the capability or opportunity to sample. Thus they might be interested in participating in expeditions to other oceans carried out by different nations. These kinds of practical advantages might serve to outweigh some of the inevitable compromises that would be necessary on the part of individual countries and investigators to make international collaboration in the global experiment work efficiently.

Approach

The strategy with which to carry out the global program must include consideration of tectonic, petrologic, geochemical, hydrothermal and biologic objectives. Although a particular strategy was proposed by the U.S. RIDGE planning process, the exact strategy must be reevaluated for an InterRidge program, with input from interested parties in the various countries that would be involved. Such a full discussion of the issues was not possible within the limited time available to the small working group at this meeting. Nonetheless, some aspects of possible strategies were discussed.

The problems for each discipline involved in the global experiment are not necessarily on exactly the same scale. It seems clear that the first step must be a bathymetric map of the portion of the ridge under investigation. Such a leg would emphasize the along-strike perspective.

On the basis of the results found at sea, a corridor would be selected somewhere within the region to carry out off-axis bathymetry and across-axis geophysical surveys, including magnetics, gravity, and possibly seismic reflection profiles. The recent development of mapping tools that may provide high-resolution data at wide swath widths makes an approach, including mapping and geophysics, feasible within the context of an individual leg.

The bathymetry/geophysics leg should be followed by legs to carry out rock and water sampling, and ultimately by biological investigations of individual hydrothermal sites. Rock sampling is currently possible, and technology is being tested for efficient water sampling. What is more difficult is how to carry out effective biological programs in the remote areas and harsh seas that are characteristic of much of the ocean ridge system that remains unexplored. Nonetheless, the scientific problems posed by global biological diversity along the ocean ridges are sufficiently compelling that the earlier stages of the program should endeavor to find specific sites that could be investigated by biologists, with the ultimate aim of biological sampling.

Some members of the Working Group felt that the construction of research-grade databases is an essential component of the program providing input into models and analysis.

InterRidge contributions

The definition of the global systematics of the ridge, and the implications of its internal structure, are aims that fit naturally into a multi-national program. Achievement of such an aim by InterRidge seems scientifically desirable for scientists from the various countries, indispensable from a practical standpoint in order to mount an effort of the required proportions, and politically salable as an international collaborative program. Nonetheless, there are formidable problems in developing an implementation strategy that provides a coordinated effort at the necessary intensity and at the same time provides individual countries sufficient freedom of action.

Development of scientific and political strategies for implementation will require a special working group with sufficient legitimacy to be able to propose mechanisms that would be possible for the individual countries involved. For the global experiment to succeed as an international program, it must have some coordination and central planning that is able to influence the actions of the individual countries involved.

Summary of near-term recommendations

The accomplishment of global scale observations by InterRidge will entail much more than the coordination of ship scheduling to avoid duplication of efforts already underway. It probably needs to include:

(1) some sort of central planning and coordination of efforts in the planning stage;
(2) sharing and exchange of ship time;
(3) sharing and exchange of sampling and surveying equipment;
(4) construction of digital data bases of underway geophysical data and geochemical data on rocks and waters;
(5) calibration and standardization of analytic facilities to ensure comparable data of high quality;
(6) independent funds to facilitate collaborative studies among scientists of different nations.

2. SPATIAL CHARACTERIZATION: MID-OCEAN RIDGES AT REGIONAL (INTERMEDIATE TO LOCAL) SCALES

(prepared by Robert Detrick from the contributions of the Working Group)

Working Group:
Jean-Marie Auzende
Enrico Bonatti
Henri Bougault
Robert Detrick
João M. Alveirinho Dias
Leonid Dmitriev
Jean Francheteau
Hiromi Fujimoto
Roger Hékinian
Thierry Juteau
Bramley Murton
Catherine Mevel

Rationale and objectives

An important long-term objective of ridge-related investigations is the identification of the key variables that affect the crustal accretion processes and related magmatic, hydrothermal and biological activity. Examples of such variables include spreading rate, mantle temperature, tectonic setting and spreading history. Addressing this objective will require a wide range of interdisciplinary investigations at spatial scales ranging from a few kilometers to hundreds of kilometers, although the primary focus is likely to be on studies at the scale of an individual spreading ridge segment (50-100 km). These studies include: 1) mapping and sampling to characterize the morphologic, structural, and compositional variability of the ridge, 2) geophysical studies to constrain crustal and upper mantle structure, 3) geochemical and geological observations to estimate hydrothermal fluxes at the segment scale, 4) biological studies of vent populations, species replacement and genetic exchange. These investigations will provide a critical link between efforts to understand crustal accretion processes on a global scale and highly site-specific studies such as those envisioned in the establishment of sea floor observatories.

Table 1 lists five important crustal accretion variables and representative portions of the mid-ocean ridge where these variables might be investigated. In each case it will be desirable to study several contrasting ridge segments and to obtain integrated, comprehensive, and comparable geological, geophysical, geochemical and biological datasets. **InterRidge strongly endorses national (e.g., U.S. RIDGE, U.K. BRIDGE) and multi-national or bi-lateral (e.g., French-American FARA) programs aimed at investigating these crustal accretion variables.** As a rough estimate, approximately 2 ship-years will be required each year for a decade in order to carry out a systematic investigation of these five key variables. This level of resources is clearly beyond the means of any one nation and will require a long-term, coordinated effort on an international scale. InterRidge can make three major contributions to this work through: 1) coordination of national and multi-national research programs, 2) establishment of an international data exchange catalogue, and 3) facilitating the international use of specialized or unique equipment or instrumentation.

Approach and InterRidge contributions

Coordination of national and multi-national research programs

Mid-ocean ridge studies at this scale have been very successfully carried out since the early 1970's by individual investigators or through bilateral programs like Project FAMOUS, and we anticipate that for the foreseeable future this will continue to be the case. However, in the past there has been little coordination of these different national efforts nor have they been part of any longer-term strategy for studying mid-ocean ridges. InterRidge can play a very important role in these studies by providing a long-term scientific framework within which individual national programs can be developed and by facilitating the coordination of national or multi-national programs through newsletters, regular meetings and workshops. **We thus recommend that InterRidge develop a long-term scientific strategy for mid-ocean ridge investigations and that an InterRidge Coordinating Office be established to collect and disseminate information about ridge-related activities to facilitate collaborative studies.**

International data exchange catalogue

Although many individual countries have established centers for cataloging and archiving marine geological, geophysical, geochemical and biological data, no mechanism presently exists for international data exchange. Thus it is difficult for a Japanese investigator to obtain French multibeam bathymetry data from the Indian Ocean or for a U.S. scientist to easily find out where Russian dredge stations are located in the central North Atlantic. For a scientist from a smaller country without a large oceanographic research program the situation is almost hopeless. The success of a long-term international ridge research program will require that standards be established for cataloging and archiving a wide range of different data types and that procedures be established for disseminating these data to investigators working on ridge-related research in many different countries.

We recommend that InterRidge produce an International Data Exchange Catalogue, and establish standard formats and procedures for data exchange. An International Data Exchange Catalogue would provide information by geographic area on the location of tracklines of available multibeam and geophysical data (gravity, magnetics, seismic), sample locations (water, rocks, biota), and where these data are being held. Ideally, this information should be available on-line via an international computer network, although a paper or electronic copy of the catalogue could be distributed to InterRidge scientists on a yearly basis. Individual investigators or groups of investigators in each nation will continue to archive specific datasets as they have in the past and data requests would have to be made directly to the individuals or groups concerned. However, to facilitate data exchange, InterRidge should help to develop standard formats for critical indexing information (e.g. position, date/time, data type) and, to the extent possible, procedures for data exchange. The development of an InterRidge Data Exchange Catalogue should be funded through contributions from each member country and be overseen by a standing InterRidge committee.

One critical data set, essential to nearly all InterRidge investigators, is multibeam bathymetry. As a first step in making these data more accessible to the international community, **we recommend that InterRidge endorse the development of a comprehensive database of multibeam bathymetry in the Atlantic.** This particular database will be extremely valuable to a number of national and bilateral ridge programs currently being carried out in the Atlantic (e.g., U.S. RIDGE, BRIDGE, TETHYS, FARA) and can serve as a prototype for future InterRidge efforts in this area.

Exchange of equipment and instrumentation

Shipboard equipment and instrumentation is becoming increasingly sophisticated and expensive, making it impossible for any nation, even those with large oceanographic research programs, to have all of the latest surveying, sampling and analysis tools. Examples of such equipment include GLORIA, Jason-Argo, multichannel seismic systems, deep-diving (>6000 m) submersibles, ROV and specialized ships (e.g., those with dynamic positioning). InterRidge should provide a means of facilitating the international use of specialized or unique equipment or instrumentation. This can be done in several ways. The InterRidge Coordinating Office can, as a first step, compile a list of available equipment and keep track of its scheduled use. InterRidge can also work with funding agencies in individual countries to establish procedures (e.g., through battering agreements) to exchange equipment or ship time.

Finally, InterRidge could establish a small fund to support the participation of scientists from one country in another country's cruises.

Summary of recommendations

- InterRidge strongly encourages national and multinational programs aimed at investigating selected crustal accretion variables.
- A long-term scientific strategy should be developed for mid-ocean ridge investigations.
- An InterRidge Coordinating Office should be established to collect and disseminate information about ridge-related activities to facilitate collaborative studies
- InterRidge should produce an International Data Exchange Catalogue, and establish standard formats and procedures for data exchange.
- A comprehensive database should be developed for multibeam bathymetry in the Atlantic.

TABLE 1

Crustal Accretion Variable	Examples of Geographic Areas
Spreading Rate	Arctic or S.W.I.R.; central North Atlantic, northern EPR; southern EPR (slowest) (slow) (fast) (fastest)
Mantle Temperature	Reykjanes Ridge; Australian/Antarctic discord (hotspot) (coldspot)
Sedimented/Non-Sedimented	Gorda/Juan de Fuca; Gulf of California, Red Sea
Tectonic Setting	Back arc (Lau, Mariana, Manus, Scotia Sea); Triple Junction or Microplate (Easter, Galapagos, Indian Ocean)
Spreading History	Propagating/failed rifts (Galapagos, Juan de Fuca, Southern EPR) Ridge jumps/failed ridges (Mathematician Ridge/Labrador Sea)

3. TEMPORAL VARIABILITY:

(A) Event Detection and Response
(B) Mid-Ocean Ridge Observatories

(Prepared by J. Cann from contributions of the Working Group)

Working Group:
Felix Avedik
Eric Bergman
Johnson Cann
John Delaney
Karl Gronvold
José Honnorez
Michael Keen
Hans-Ülrich Schmincke
Trileigh Stroh

(A) EVENT DETECTION AND RESPONSE

Rationale and objectives

Crustal construction in Iceland takes place very largely by discrete episodes of crustal stretching or of volcanic activity. Segments of the spreading axis may be inactive for a hundred years or more, and then they may experience a series of events spread over a few years. Events are accompanied by earthquake swarms in which magnitude seldom rises above 5, but in which there may be many earthquakes of magnitude 4 and above. Similar earthquake swarms have been detected on the Mid-Atlantic Ridge from 20°N-70°N between one and two times per year, on average, between 1960 and 1985. Five years had no events and one year (1984) had five. Many of the events were on segments which had hosted a previous event or would host a future event. One segment at 54°N had four events during the period. Perhaps all events are part of such linked sequences.

Presence of earthquake swarms indicates that a segment is in the course of an active period, and identifies it as a clear target for long-term studies. There is a clear advantage, in addition, in observing a segment during an event: to see the character of near-source seismic activity, to monitor the progress of submarine eruptions if they occur and to collect water samples for estimation of volatile compositions. Such studies cannot be made except during events, and are very important for our understanding of crustal construction processes.

Since events last from a few days to a few weeks, a very rapid response is necessary if an event is to be studied while it is in progress. Such a rapid response can only be achieved through international collaborative efforts.

Approach and InterRidge contributions

Detection of events

Teleseisms. Earthquakes from events can be detected by stations in surrounding continents or on oceanic islands. The first few hours of an event are usually marked by several earthquakes, so that the existence of an event can be established within perhaps twelve hours. Many seismic stations already maintain 24-hour or close to 24-hour coverage, and given the right priority could notify an appropriate contact within a few hours of the initiation of an event.

The National Earthquake Information System (NEIS) of the U.S. Geological Survey operates the Quick Epicenter Determination (QED) program for very rapid identification and location of earthquakes worldwide. InterRidge should begin consultations with the NEIS staff to use their capability as a cornerstone of the event detection program.

Local seismic networks. Local networks on oceanic islands or, eventually, on critical regions of ocean floor, may be able to give lower threshold detection. Such networks are especially valuable for observing the smaller earthquakes which are thought to be most diagnostic of magmatic activity at shallow crustal levels. InterRidge should encourage the installation of digital local seismic networks at appropriate sites.

Acoustic signals. Acoustic monitoring may have the capability of discriminating between different types of events, as, for example, between eruptions and fissuring without eruption. Acoustic monitoring is at present a solely military capability. InterRidge should investigate possibilities for gaining access to scientifically critical information on signals from acoustic networks; if access is possible, InterRidge should encourage research to be conducted on acoustic recognition and discrimination of such events.

Visual observation. Pilots and seamen are alert to sea-surface changes that may, in shallow water such as the vicinity of Iceland, or perhaps even in deeper water, represent surface effects of volcanic eruptions. Such sightings are routinely reported to air traffic control or to coast guards, and should be incorporated into any detection schedule.

Response to detected events

Alerting. Because many critical data are lost after the first few hours of an event, timely relay of information to potential responders is essential for an effective response. InterRidge should set up a facility dedicated to receiving reports of detected events and to alerting appropriate scientists to activate a response.

Aerial response. The most rapid response to an event will be aerial, if the event is within range of an appropriate airfield. Long range patrol aircraft are equipped to deploy sonobuoys and bathythermographs, and are thus very appropriate first tools for event response. A long-range patrol plane operating from Keflavik airport in Iceland was used in this manner to respond to a major seismic swarm in May-June 1989 on the Reykjanes Ridge, 500 km south of Iceland. US, UK, French, Canadian and possibly other air forces maintain patrols in the areas of interest. InterRidge should establish contacts with military sources in all appropriate countries to investigate possible rapid aerial response to events.

Ship response. Research ships of opportunity may chance to be close to an events when it occurs, and advantage should be taken where possible. It is unlikely that such a ship would be carrying appropriate instruments or, more important, technicians with the skills necessary to make required measurements.

The most effective response would be to arrange for the very rapid hiring of ship time at the closest possible port to the event and for the immediate air transport of instruments and scientists to this port. To make such a rapid response possible, a provisional fund dedicated to rapid response should be established. InterRidge should also contact the international ship coordination group to investigate potential collaboration.

Rapid Response Instrument Package (RRIP). Experience acquired during the response effort to the Reykjanes Ridge event of May 1989 suggested that unavailability of instruments may be the greatest hindrance to a rapid response. It is possible to specify a basic set of equipment which could be maintained in readiness for event response. This package (RRIP) might contain sonobuoys, OBSs, or OBHs, hydrocast equipment, bathythermograph (or CTD) instruments, a magnetometer, chemical analysis instruments, and sampling equipment, etc.

An InterRidge working group should be established to consider appropriate instrumentation for a RRIP. Packages should be assembled and maintained for immediate use at selected locations: Europe, the U.S. west coast, Iceland, Azores.

InterRidge should identify scientists willing to act quickly in response to detected events, and should arrange for their training in the use of RRIP's.

Follow-up efforts. After an event has occurred, geological and hydrogeological environments and biological habitats may change drastically, and new ones may be formed. InterRidge should develop plans for extended post-event characterization and monitoring of active segments.

Summary of near-term recommendations

Detection:

- Install digital local seismic networks at appropriate sites.
- Investigate the possibility of getting selected information on or access to signals from military acoustic networks; if access can be established, initiate research on acoustic recognition and discrimination of events.
- Develop protocol for using existing systems (such as the QED) for teleseismic event detection.

Response:

- Establish a facility dedicated to receiving event reports and alerting appropriate scientists to activate a response.
- Investigate rapid aerial response to events through military sources in selected countries.
- Explore potential collaboration with international ship coordination group for timely ship-based response efforts.
- Assemble and maintain Rapid Response Instrumentation Packages (RRIP's) for immediate deployment at appropriate locations (Europe, U.S. west coast, Iceland, Azores).
- Identify scientists willing to respond rapidly to detected events, and arrange for their training in the use of RRIP's.

Post-event monitoring:

- Develop plans for extended post-event monitoring of active segments.

(B) MID-OCEAN RIDGE OBSERVATORIES

Rationale and objectives

Assessment of the temporal variation and covariation of mid-ocean ridge processes is a major thrust of the InterRidge initiative. On a decadal scale, this may be accomplished through direct observation of short- and long-term changes in interactive seismic, tectonic, volcanic, and hydrothermal mid-ocean ridge processes. Some instruments may be used to make short-term observations or to conduct experiments under control from a ship. Other observatories may be used for deployments of several years' duration to study long-term changes.

Approach and InterRidge contribution

Countries involved with InterRidge will have varying requirements and interests for seafloor research. But all observatories will have elements in common and it is with these that InterRidge should be most directly concerned. InterRidge should facilitate execution of common elements among international observatory needs.

Modular design of observatories will allow the widest and most flexible use by a number of countries. One module, the base station, will supply power, control information flow and storage, and provide lighting where appropriate. To this base station, individual observation and experimental modules will be attached, depending on the application.

Observatory deployment should be organized in a similar way to construction of space stations. Teams of scientists would be responsible for construction of individual experimental or observational modules to be attached to the standard base station. After the deployment, each team would be responsible for analyzing and publishing the data collected by its module. Such a system would promote maximum effectiveness with minimal bureaucracy.

Observatories should be placed in accessible sites for easy servicing. They should be conceived in collaboration with the Ocean Drilling Program, to promote the most effective scheduling and implementation of observatory program components.

InterRidge coordination efforts could include design of the base module, establishment of standards for power supply and information exchange, and coordination of programs conducted at the observatory to ensure its most effective use.

Summary of near-term recommendations

- Seafloor observatories should be developed for use on mid-ocean ridges.
- A modular design for observatories should be strongly encouraged.

- International standards for power supply and information exchange should be set by an InterRidge working group.

Summary of longer-term recommendations

- Deployment of research packages at an observatory should be the responsibility of a group of scientific teams, each responsible for one observational or experimental module.
- InterRidge should coordinate activities carried out at the base observatory module.

4. BIOLOGY IN INTERRIDGE

(Prepared by the Working Group in collaboration with P.R. Dando)

Working Group:
G. Barbier
A. Fiala-Medioni
A. Southward
E. Southward

Rationale: Biology of hydrothermal systems

Biology is an essential component of any ridge program, especially when hydrothermal systems are being studied. The main aims of biological research on hydrothermal systems can be summarized as:

- understanding the origin and evolution of life on earth;
- assessing the role of hydrothermal processes in the productivity of the deep sea;
- identifying structures and processes adapted to survive in extreme conditions (nutrition, detoxification, reproduction);
- studying new species, including those with potential biotechnological value for production of thermostable macromolecules and enzymes.

Biological studies of hydrothermal systems can be grouped into five main topics, discussed below.

1. Composition of ecosystems, biogeography and evolution of species

Improving our knowledge of spatial variation of populations and species should lead to a better understanding of the history of life in the oceans and of systematic relationships between species (such data should also be of interest concerning the origin of life). These studies will include the latest techniques of molecular biology.

2. Functional aspects of the ecosystems and species adaptation to environmental conditions

This topic includes studies on microdistribution relative to chemical and physical parameters, determination of nutritional and reproductive strategies, morphological and physiological adaptations of biological functions (respiration, nutrition, reproduction), specificities of the environment (thermophily, bioaccumulation and detoxification of heavy metals) and adaptation of interfaces (membranes, teguments). Such studies are the essential first step towards quantifying the role of living organisms in hydrothermal fluxes.

3. Long-term evolution of hydrothermal vent ecosystems and influence of variations in ecological conditions

Vent populations are strictly dependent on hydrothermal fluids and are very unstable. Both short and long term aspects must be studied to understand the biology of vents and their chemical importance in the world ocean.

Problems of dispersion, growth patterns of species as well as colonization and regression of the sites in relation to the evolution of physical and chemical characteristics of the environment imply the use of "working sites" with instrumented stations or emplaced "observatories" to be visited repeatedly.

4. Fluxes associated with hydrothermal systems and their importance at the oceanic scale

An ultimate aim of studies of function of hydrothermal systems is to quantify transfers of carbon and energy through the biological compartments and identify their role in global organic and inorganic fluxes. Since chemical fluxes may stimulate production outside the venting areas, it is important to quantify export of elements and compounds.

5. Possible applications of species living in hydrothermal ecosystems

Thermophilic bacteria have great industrial potential. This field of work deals with specific questions about biochemistry (study and use of thermostable enzymes, molecular basis of thermostability), genetics (e.g. research on plasmids), technology (e.g. high temperature, high pressure, anti-corrosion reactors), etc.

6. Remark

Increased exploration at ridges, especially deep drilling and emplacement of "observatories" will have impact on the environment. Sites for such studies should have a preliminary biological survey and subsequent operations should take care to minimize disturbance of the fragile ecosystems.

Approach (Relationship between biology and earth sciences: comments on strategy)

Theme 1: Spatial characterization of the ridge crest

1A -- Global coverage of the spreading center network. Biologists need basic information on active sites from geologists. Direct involvement of biologists in a global strategy requires improved videosystems. Collection of organisms requires submersible facilities.

1B -- Regional (intermediate to local) studies of significant portions of the rift system. A biogeographical approach requires investigation of a sufficient number of sites considered to be models for geochemical, geophysical and biological processes. Experience during recent cruises showed that efficiency was significantly increased by the association of biology and geology cruises with exchange of information. Biologists particularly need concerted planning with geochemists before collection of chemical data.

Theme 2: Temporal characterization of the ridge crest

2A -- Major volcanic/tectonic events. Two types of events are visualized:

a) the opening of a new vent field is seen as the start of a time series, with less need for rapid response by biologists;

b) a collapse of an existing field with rich fauna needs more immediate response.

2B -- Permanent seafloor observatories. Temporal evolution studies need both repeated cruises and also long-term observatories in order to get information between cruises (videographic and photographic systems as well as chemical and physical probes). Consultation with geologists is also required at this level. The best location should be a well-known site (13°N, for instance).

Summary of recommendations

InterRidge could be an important framework to formalize and extend existing and necessary international cooperation.

Exchange of data could also be an important aspect for InterRidge. The type of data to be exchanged include: explored sites, site maps, future cruises, type of samples collected and their present location, research teams involved. This exchange of data requires a coordinating bureau.

InterRidge biological sampling would benefit from a recommended protocol of handling, preservation and storage of biological materials. We recommend that at least one biologist be invited to participate in any cruise where sea-bed geological sampling is proposed.

This is a preliminary contribution and we recommend the organization of a larger meeting for biologists involved in ridge studies.

IX. NATIONAL REPORTS

ON MID-OCEANIC RIDGE-RELATED RESEARCH ACTIVITIES

This section contains written materials prepared for the meeting or summarizing the oral presentations.

CANADA

FRANCE

ICELAND

JAPAN

PORTUGAL

UNION OF SOVIET SOCIALIST REPUBLICS

UNITED KINGDOM

UNITED STATES

CANADA

(Michael Keen)

Organizational

The Canadian Executive for the Ocean Drilling Program is being asked to assume the responsibility for InterRidge, and the response will be known by the end of 1990. This would have the merit of using an established organization, involving no extra bureaucracy, and will give substance to the feeling that ridge activities and Ocean Drilling have to be wholly complementary.

Science and technology

Microplates of the eastern Mediterranean: Memorial University has been funded by the Natural Science and Engineering Research Council for an extensive program of investigations in the region of the microplates of the eastern Mediterranean jointly with the USSR.

Ophiolites: Memorial University will be following up from Troodos investigations by looking at the related Baer Bassit massif in Syria, when the international climate is appropriate. The British Columbia Department of Mines and Natural Resources has an extensive program of investigation of ultramafic complexes in the Cordillera looking at crust-mantle interactions in suspect terranes. Mark St. Onge and Steve Lucas of the Geological Survey of Canada are leading an active program in the 2 billion year old Cape Smith ophiolites, seafloor which is now part of the Superior Province.

Plate kinematics: Compilations of potential field surveys are being made by the Geological Survey of Canada over various ridges, such as the Mid-Atlantic Ridge and the Nansen Ridge of the Arctic Ocean, with various other organizations. These are being successfully used to test models of plate kinematics, in the North Atlantic, for example.

Leg 138: Sedimented Ridges I: Middle Valley, Juan de Fuca Ridge: This mid-1991 Leg of ODP will tackle the problems associated with sedimented ridges, including their mineral deposits, with Earle Davis (co-chief), Jim Franklin and Wayne Goodfellow on board. The Leg will focus on the regional hydrologic character of the rift valley, using rotary coring techniques. A second leg is planned where diamond coring will be undertaken in sulfides. ODP (Keir Becker), the Geological Survey of Canada (Earle Davis) and Lehigh University (Bobb Carson) are developing a borehole seal system for the 1991 Leg and this will be left in one of the holes to monitor temperature changes and pressure changes below the seal. Samples of fluids and data will be recovered using ALVIN and later the Canadian ROV.

The Canadian ROV is being tested for 3000m use, and should be an attractive, relatively inexpensive tool for ridge investigations.

A transient EM system which can be used in multiple-receiver mode is being used now in shallow water to establish porosity in sediments. It may be adapted for deeper water, and would be a useful tool to investigate the physical properties of the upper crust beneath ridges.

Many other ridge-related activities are in progress, for example in Galapagos, Woodlark basin, and so on. A number focus on economically important processes: the behavior of gold, for example. Economically significant contents of gold have been found in the TAG, Woodlark and Juan de Fuca regions. Understanding of the processes responsible for these is providing guidelines of exploration for gold-rich massive-sulfide deposits in ancient terranes. Water depth controls the fluid boiling point, and boiling—phase separation—controls sulphur activity of the fluid. A high sulphur activity generates bi-sulfide complexing of gold. Bi-sulfide complexes are unstable in oxic environments. Thus interactions of these complexes with oxygenated cold seawater causes almost total precipitation of the gold, thus making gold-rich deposits.

FRANCE

(David Needham)

Mid-oceanic ridge research in France is conducted in many parts of the ocean, including the East Pacific Rise, Mid-Atlantic Ridge, Southwestern Pacific back arc basins, and Indian Ocean. Principal themes include:

- *Magmatic and tectonic processes of crustal generation:* (1) morphology and deep structure, origin and spatial and temporal organization of petrological units, geology of ridge-crest offsets and rift-fracture zone intersections, mantle-crust relationships, serpentinite diapirism; (2) distribution and temporal behavior of hydrothermal vents in different geodynamic settings, variability in composition of vent fluids, sulfide metallogenesis.
- *Along-strike variations in accretion patterns, lithospheric evolution and comparative studies:* (1) segmentation patterns and types of offsets, mantle geochemical signals, off-axis morphology, tectonics of fracture zones and transverse ridges, gravity and magnetic anomalies; (2) triple junctions (Indian Ocean, Azores, North-Fiji Basin), microplate kinematics (Easter Island).

The sea-going work has concerned mainly swath bathymetric mapping and geophysical surveys, rock dredging, and rock and water sampling and field observations from submersibles. Some efforts have involved the application of specific experimental or sampling techniques (deep-towed acoustic imagery, magnetometry, water sampling). Gravity measurements have been made from the submersible *Nautile* A recent seismic refraction experiment has been conducted using ocean bottom hydrophones.

Organization

Most ridge-crest research in France is carried out by IFREMER[1] and INSU[2] (CNRS[3], universities, IPG[4]). Principal partner institutions in the national effort are BRGM[5] and ORSTOM[6].

The cost of most technological developments and of operations at sea are met by IFREMER, acting as the principal national agency for research vessels (*L'Atalante, Suroit, Noroit, Nadir...*), submersibles (*Nautile, Cyana*) and heavy sea-going equipment. TAAF[7] provides time for research aboard the Marion Dufresne, which is particularly well equipped for dredging and sampling.

In general, each institute supports its own on-shore research. IFREMER has maintained a program of deep oceanic crustal studies for twenty years. INSU teams conducting similar projects can seek complementary support through the DBT (Dynamique et Bilans de la Terre) and IST (Imagerie et Structure de la Terre) programs.

Interest in oceanic hydrothermal processes and related metallogenesis and biological activity has helped in obtaining support for ridge research in France. The IFREMER/INSU *Programme National d'Etude de l'Hydrothermalisme Océanique* (PNEHO) has a small annual budget to promote individual initiatives, particularly concerning instrumentation, in earth science and biological studies. The Ocean Drilling Program provides a continuing opportunity for the geosciences community to be involved in oceanic ridge research.

Proposals for cruises on IFREMER ships are submitted at the beginning of January of each calendar year N. They are examined by the national commissions GGMO (*Géologies, Géophysique des Marges et des Océans*) and BPA (*Biologie, Pêche, Aquaculture*) which use peer group reviews to help establish priorities. The interdisciplinary *Commission de la Flotte* meets subsequently to propose a fleet program for the year N + 1 which is endorsed, with possible modification, by the IFREMER Scientific Committee at the end of June.

Technology

Mid-oceanic ridge research in France has benefitted from the availability of the two submersibles *Cyana* and *Nautile*, and of the SeaBeam system on the R/V *Jean-Charcot*. The R/V *L'Atalante*, the replacement vessel for the *Jean Charcot*, is fitted with the Simrad EM12 Dual system with broad swath bathymetric and side-scan sonar capability and will have a state-of-the-art computer network. The deep-towed side-scan sonar system SAR (*Systeme Acoustique Remorqué*) has been successfully used on the ridge in recent years. A multi-channel seismic system is now operational.

Relatively recent developments of specialized instruments include a prototype of a new ocean bottom vertical seismic array (OBVSA) and a deep-towed water sampler for hydrothermal investigations. Heat flow instrumentation has been maintained and improved. Some research in the engineering division of IFREMER (for example, use of lasers and real-time acoustic data transmission) could eventually contribute to the research effort in ridge studies. This division has also developed drill-hole re-entry capabilities from the submersible using the module *Nadia* (*Navette de diagraphie*). A ROV project is under study. Water and animal samplers, isotherm boxes and temperature probes have been developed for biological programs.

The computer division has created software for side-scan sonar and multibeam bathymetric data processing.

Biological studies

Since the early 1980's, French biologists have been involved in ecological and physiological studies of the vent communities. The biological diving cruises were focused on the 13°N/EPR vent field (1982, 1984, 1987) and on the South Western Pacific back arc basins (Lau basin and North Fiji basins) in 1989. In 1988, French research institutes (IFREMER and CNRS) started a program dealing with applied microbiology of extremophilic bacteria in oceanic hydrothermal vent environments. In the coming years a new program concerning the Mid-Atlantic Ridge is envisaged in cooperation with U.S. biologists under the FARA project.

French biologists have participated in the international effort dealing with exploration of back arc basins. During 1989, they joined in the geological survey of two South Western Pacific Back Arc Basins in the framework of France-Germany cooperation for the Lau Basin and France-Japan (IFREMER and S.T.A.) cooperation for the North Fiji Basin. Two biological cruises (BIOLAU and STARMER) were carried out using the submersible *Lautile* and her mother ship *Le Nadir*. Four main active vent fields (1) were explored on the Valu Fa and North Fiji Ridges, displaying both warm and very hot (>400°C) venting. Several "cold water" vent fields were also observed in the Lau basin.

Since 1988, two teams of French microbiologists (IFREMER/BREST and CNRS/ROSCOFF) have been involved within the scope of applied research in biotechnology, in the study of microbial communities living in the close vicinity of hydrothermal vents.

Sea-going activities and research areas

A. Geosciences (1984-1990)

During about the past 5 years, sea-going activities on the mid-oceanic ridge and on back-arc spreading centers have averaged about 5 months a year. This does not include participation in cruises on foreign vessels (e.g., 4 months of surface ship time on the Japanese vessel Kaiyo as part of a France-Japan bilateral project). The work at sea has been focused as follows:

- Indian Ocean: about 8-9 months with surface ships -- Central Indian Ocean Ridge, S.W. Indian Ocean Ridge, Triple Junction.
- Gulf of Aden (1 month submersible).
- Back-arc crustal accretionary provinces (North Fiji Basin in collaboration with Japan, Lau Basin in collaboration with FRG, Okinawa Basin, South China Sea): 4 months surface ship, 2 months submersible.
- East Pacific Rise (EPR): 3 months surface ship, 3 months submersible.
- Mid-Atlantic Ridge (MAR): 4 months surface ship, 2 months submersible.
- Experimental cruise: DSDP re-entry from *Nautile*.

Projected cruises include:

- EPR: 2 months submersible (1990-1991).
- MAR: 2 months surface ship + 1 month submersible (France-US Project FARA) (1991).
- A one-month cooperative cruise in 1990 with Japan's R.V. *Yokosaku*.

B. Biology (1982-1989)

French biologists developed their research programs soon after the discovery of hydrothermal populations in the Galapagos site:

- On the East Pacific Rise (EPR) near 13°N (Biocyatherm, 1982).
- Participation in the exploration of other sites on the EPR (21°N, Galapagos, Guaymas), Juan de Fuca and Explorer Ridges: U.S. cruises Oasis (1982) and Galapagos (1985) and Canadian cruises Schism (1983) and Guaymas (1985).
- Spatio-temporal evolution of 13°N populations was investigated in 1984 (Biocyarise) and 1987 (Hydronaut).
- Participation of French scientists was offered in U.S. cruises in the Galapagos (1989).
- Observations on the Mid-Atlantic Ridge during the Geosciences cruise Hydrosnake (1988).
- More recently, two west Pacific expeditions in the area of Tonga (Biolau, 1989) and Fiji Islands (Starmer, 1989), the latter cruise in cooperation with Japanese scientists.

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1 Institut Français de Recherche pour l'Exploitation de la Mer

2 Institut National des Sciences de l'Univers

3 Centre National de la RechercheScientifique

4 Institut de Physique du Globe

5 Bureau de Recherches Géologiques et Minieres

6 Institut Français de RechercheScientifique pour le Développement en Cooperation, *previously* Office de Recherche Scientifique et Technique Outre-Mer

7 Terres Australes et Antarctiques Françaises

ICELAND

(Karl Gronvold)

The unique geographical position of Iceland means that a substantial part of the geological and geophysical research is automatically ridge-related. Some of the research can also be referred to as hot-spot related. Geological mapping and petrological studies in the active volcanic zones are clearly of interest to ridge studies. The same applies to most of the geophysical research: seismic studies, monitoring of crustal movements and methods used to estimate crustal thickness and the various properties of crust and mantle. Monitoring of actual rifting episodes, earthquakes and volcanic eruptions, and reconstruction of older such events are highly relevant to studies of ridge dynamics.

Geothermal activity is of major scientific and economic significance. Studies of geothermal areas and their characteristics have been pursued intensely for a few decades. This applies both to the high-temperature activity (>200°C at < 1 km depth) within the presently active rift zones and the low temperature activity (<150°C at < 1 km depth) within the flank zones. The recharge waters of the thermal areas range from sea water to meteoric water resulting in sharp compositional contrasts. These studies are obviously highly relevant to studies of the ridge geothermal systems. The unusual fauna of the thermal springs with their reducing and warm environment is also being actively studied.

The neighboring submarine parts of the ridge system--the Reykjanes Ridge to the south and the Kolbeinsey Ridge to the north--have also received attention, although to a lesser degree. Seismic activity on the ridge system is monitored by the extensive on-land seismic network; samples have been collected, described and analyzed and various geophysical studies conducted, often by or in cooperation with foreign research groups.

Ridge studies as such are not at the moment specifically coordinated in Iceland. The administration of research has recently been reorganized and the newly established Icelandic Council of Science funds and supports basic research. Responsibility for participation in international research projects (such as ODP) and the granting of permits to foreign scientists and the coordination of their work in Iceland is also part of their duties.

Relevant institutions

The number of active geoscientists in Iceland is approximately 150. They are divided between a number of institutions that are responsible for different types of research but often with uncertain demarcations. The main relevant institutions are as follows:

- **The University of Iceland and the Science Institute of the University** address ridge-related fields of study including petrology, geochemistry of geothermal water, paleomagnetism, seismicity, tectonics and volcanology.
- **The Nordic Volcanological Institute** is closely associated with the University and mainly active in volcanology, geochemistry and crustal deformation.
- **The National Energy Authority** is responsible for all energy-related research, geothermal and hydroelectric, much of which is highly relevant for ridge processes.
- **The Marine Research Institute** is active in oceanographic research and marine geology.
- **The Icelandic Weather Bureau's** geophysics department is mainly active in seismic studies.
- **Museum of Natural History** conducts ridge-related studies in geologic mapping and petrologic research.

Major research projects

Major ridge research projects are usually carried out in cooperation between several institutes, often with strong participation of foreign research groups. Important projects in progress or recently finished include:

- **Geological map**

  A bedrock geology map of the whole country in scale 1:500 000 has recently been published (Jóhannesson and Saemundsson, 1989). The map shows the distribution of the main rock units, together with volcanic vents and major fissures and active faults along the plate boundaries.

- **Gravity map**
  A new gravity map was published recently, with an accompanying report on the gravity data (Thorbergsson et al., 1990). The map is based on measurements made in 1967-73 and 1985 with a distance of about 10 km between points, and shows the Bouguer anomaly contoured at 5 mgal intervals. The map scale is 1:1 000 000.
- **Magnetic map**
  Aeromagnetic and marine magnetic data of Iceland and surrounding ocean area have been compiled into one map of the residual magnetic field of the country (Kristjánsson et al., 1989, Jónsson et al., 1990). The map is in scale 1:1 000 000 and is color-coded with increments of 125 nT in residual field values.
- **Seismicity map**
  The local seismograph network in Iceland contains about 50 stations. Results of earthquake studies using the local network are summarized in an epicentral map and a paper (Einarsson and Saemundsson, 1987, Einarsson 1990). The map is in scale 1:750 000 and contains epicenters of the year 1981-85 superimposed on a map of the volcanic systems.
- **GPS surveying**
  Five major GPS-projects have been carried out in Iceland since 1986 (e.g., Foulger et al., 1987, Jahn et al., 1989). The main objectives of the surveys have been geodynamic ones, i.e., to determine crustal movements associated with the plate boundaries and active volcanoes. Furthermore, dense GPS observations in Iceland open up the possibility of determining directly and with high accuracy the geold height and its variation in the Iceland area by connecting ellipsoidal height determinations of GPS with direct sea level observations at coastal GPS control points. The present GPS network in Iceland consists of 135 points and covers most of the country. In the far east and west the distances between points are 60-80 km, but closer to the plate boundaries the distances are typically 5-20 km.
- **Magnetotelluric sounding**
  Magnetotelluric methods have been applied to studies of the resistivity structure of the lower crust and mantle in Iceland for over 20 years. The studies have revealed a low-resistivity layer at the base of the crust beneath most of the country (Björnsson, 1985). The layer coincides with the top of the anomalous mantle, characterized by low seismic velocities, anomalous velocity ratio and low density.
- **Deep refraction profile**
  A 150 km long refraction profile was shot across the plate boundaries in SW-Iceland in 1990. The main purpose was to elucidate the structure and nature of the crust-mantle boundary in this region. Digital three-component seismographs were applied at intervals of 0.5-1 km along the profile, each recording shots from 7-8 shot points.
- **Digital seismograph network and data acquisition system in the transform zone of S-Iceland**
  A digital data acquisition system has been installed in the South Iceland seismic zone, where a series of large transform type earthquakes is expected within the next decades. Eight three-component seismograph stations have been connected, but the system can accommodate other kinds of geophysical data as well. The main purpose of the system is to facilitate studies of processes preceding and accompanying large earthquakes, but the data are well suited for many kinds of ridge-related studies.
- **Ocean bottom seismic study on the crest of the Reykjanes Ridge**
  Eighteen ocean bottom seismographs were deployed at the crest of the Reykjanes Ridge for one month in 1990. The instruments were arranged along a 150 km section of the ridge, extending from the tip of the Reykjanes Peninsula, at depths of 140-760 m. The purpose of the experiment was to collect data for studies of local earthquakes. A similar experiment is planned for 1991 north of Iceland.
- **Study of geothermal activity on the Kolbeinsey Ridge**
  A geothermal area at about 100 m depth just off the island Kolbeinsey has been the target of considerable research. Topography, geochemistry of the geothermal fluid and the fauna surrounding the vents have been studied in some detail. Another thermal area was recently discov-

ered at about 400 m depth in the Tjörnes Fracture Zone.

Icelandic Sea Floor Studies Coordinating Group

In response to increasing pressure of various types and frequent activity on the Rekjanes ridge, a working group was established to help coordinate work among interested Icelandic groups and institutes and cooperation with foreign scientists. A suggested preliminary name is "The Icelandic Sea Floor Studies Coordinating Group." RIDGE and InterRidge were specially introduced at the meeting as well as at a recent U.S.-Icelandic meeting in Baltimore. The coordinating group is informal but members represent both different disciplines and come from most of the institutes concerned. Obviously the group wishes to strengthen the ties already established with RIDGE and InterRidge and related programs. A number of official ministries are responsible for the different institutes but it is hoped that as actual projects materialize, more effective organization can be established.

References

Bjornsson, A., Dynamics of crustal rifting in NE Iceland. J. Geophys. Res. 90: 10151-10162, 1985.

Einarsson, P., Earthquakes and present tectonics in Iceland. Tectonophysics, in press. 1990.

Einarsson, P. and Saemundsson, K., 1987. Earthquake epicenters 1982-1985 and volcanic systems in Iceland (map). In Í hlutarins eðli," Festschrift for Þorbjörn Sigurgeirsson, ed. Þorsteinn Sigfússon, Menningarsjóður, Reykjavík.

Feulger, C., R. Dilham, W.J. Morgan and P. Einarsson, The Iceland GPS geodetide field campaign 1986, Eos, 68, 1809, 1987.

Jahn, C.-H., G. Seeber, G. Foulger, and A. Björnsson, A GPS survey in the Northeast volcanic zone of Iceland 1987; first results, General Meeting of IAG, Edinburgh, August 1989.

Johannnesson, H., and K. Saemundsson, Geological map of Iceland. 1.500 000. Bedrock geology. Icelandic Museum of Natural History and Icelandic Geodetic Survey. 1989.

Jónsson, G., L. Kristjánsson, and M. Sverrisson, Magnetic surveys of Iceland, Tectonophysics, in press, 1990.

Kristjánsson. L., G. Jensson, and M. Sverrisson, Magnetic surveys at the Science Institute. Science Institute, University of Iceland, Report RH01.89, 40 pp. and a map, 1989.

Thorbergsson, G., I. Th. Magnússon, Gravity data and a gravity map of Iceland (In Icelandic) Orkustofnun (National Energy Authority). Report OS-90001/JHD-01, 33 pp. and a map, 1990.

JAPAN

(H. Fujimoto and K. Tamaki)

A. Studies of Mid-Ocean Ridges

1. Ministry of Education, Science, and Culture ("Monbusho")
   - (a) Ocean Bottom Seismography study on Reykjanes Ridge: Hokkaido University in cooperation with Iceland (see RIDGE *Events*, No. 1)
   - (b) Ocean Drilling Program in the Eastern Pacific (1991-92)

B. Studies of Back-Arc Spreading and Arc Volcanism

1. National Project
   - (a) Research program on prediction of volcanic eruption:
     - •Researches of volcanism on land or near the coast
     - •Observation of submarine volcanic eruption by HDJ
   - (b) EEZ mapping by Hydrographic Department, Japan (HDJ)

2. "Monbusho":Researches of Universities
   - (a) Ocean Drilling Program: Izu-Bonin Arc and the Japan Sea
   - (b) DELP (Japanese program of ILP, 1985-1990): Back arc basin MULTIER Program is pursued as a successor program.
   - (c) Geo-TOC (Geophysical use of Trans-Ocean Cable): ERI & IRIS
     - •Three observatories between Japan and Guam (1991-96)
   - (d) Hakuho-maru Cruises: "Izanagi," Sea Beam, MCS, Deep-tow TV
     - •KH-89-2 (130 days) Round trip
     - •KH-90-3 (October 30, 1990 Honolulu - December 14, Tokyo): Hydrothermal Survey in the Bismarck Sea
     - •KH-92-1 (January-March, 1992) Caroline/Mariana region

3. Science and Technology Agency of Japan (STA)
   - (a) STARMER Project (1987-1991): STA-IFREMER Joint Program: Geol. Surv. Japan (GSJ), Japan Mar. Sci. & Tech. Center (JAMSTEC), HDJ, Inst. Sci. & Tech. for Hazard Prev., etc.
     - •Survey of active spreading center in the North Fiji Basin
   - (b) Post-STARMER Project: pursued as a component of InterRidge
   - (c) Survey of hydrothermal vent in the Okinawa Trough: JAMSTEC with Submersible "Shinkai 2000"

C. Technological Development

1. "Monbusho"
   - (a) Downhole observatory: ODP Japan
     - •Downhole Seismometer in the Japan Sea
     - •Temperature monitoring in the Nankai accretionary prism
   - (b) Autonomous UROV (Pteroa 150; R1 project - 24h survey)
     - •Institute of Industrial Science, University of Tokyo

2. STA
   - (a) Submersible "Shinkai 6500"/ mother ship "Yokosuka": JAMSTEC
   - (b) Dolphin 10K (ROV to 10,000 m depth): JAMSTEC
   - (c) High temp. logging tool: JAPEX; GSJ (Sun Shine Project)
   - (d) Ocean acoustic tomography: JAMSTEC and WHOI (1989-96)
   - (e) Development of a drilling vessel: feasibility study

PORTUGAL

(A. Ribeiro, J.A. Dias)

In spite of the absence of a unified research plan for ridge research, several projects are being conducted, concerning mainly the Azores Triple Junction area.

The Azores islands are located in a special tectonic setting: three lithospheric plates (America, Eurasia and Africa) meet in this area. Several studies have been made, mainly in the marine geology and seismology fields. The tectonic structure of the islands, however, has never been the subject of study, although it is fundamental to understanding sea-bottom structure. Presently, the structural geology of the islands of Santa Maria, Pico, Faial and S. Jorge, located along the East-Southeastern branch of the Triple Junction, is being investigated.

Preliminary results indicate a transtensile regime for the Eurasian-African boundary west of Gloria Fault. Thus, the Azores Triple junction probably is a ridge-ridge-leaky transform junction.

Another project is the Aeromagnetic Survey of Azores, covering both sides of the Mid-Atlantic Ridge, at a mean altitude of 600 m and with a 3 km offset between flight lines. Almost 50% of data acquisition is already made and data processing is underway. The next targets of this project are processing of bathymetric data of the area (for aeromagnetic inversion techniques and for geomorphological studies) and to relate them to satellite gravity data.

Other significant projects concern paleomagnetic measures in several islands and also resistivity sounding and gravimetric studies for geothermal exploration in S. Miguel Island.

Azores ridge-related studies are mainly related to geologic mapping based on volcanic-stratigraphic criteria and petrological research. In addition:

-- Seismic monitoring with a micro-seismicity network is also being carried on.

-- Geothermal activity is also a major scientifically and economically significant project.

-- Studies of crustal movements using GPS are also being conducted.

The number of active geoscientists working on ridge-related research in Portugal is not far from 50. They are divided among a number of institutions often with uncertain demarcations.

Following is a list of the relevant institutes and contact persons.

Universidade de Lisboa
-- Departamento de Geologia
Faculdade de Ciéncias da Univ. Lisboa
Bloco C2 - 5° piso
Campo Grande
1700 LISBOA
Contact persons: A. Ribeiro, A. Madeira

Universidade de Lisboa
-- Centro de Geofisica
Rua da Escola Politécnica, 58
1200 LISBOA
Contact persons: M. Victor, Miranda

Universidade dos Acores
-- R. Mae de Deus
9502 PONTA DELGADA CODEX
Contact person: Victor Rugo Forjaz

Universidade de Coimbra
– Centro de Geociéncias
Largo Marqués de Pombal
Apartado 3014
3049 COIMBRA CODEX
Contact persons: P. Ferreira, A. Martins

Instituto Hidrográfico
-- R. das Trinas, 49
1200 LISBOA
Contact persons: J. Alveirinho Dias, M.M. Matos

Serviços Geológicos
-- R. da Academia das Ciências de Portugal
19 - 1°
1200 LISBOA
Contact person: *H. Monteiro, M. Ramalho*

Universidade do Porto
-- Faculdade de Ciencias da Univ. Porto
Pra. Gomes Teixeira
4000 PORTO
Contact person: *J. Osório*

UNION OF SOVIET SOCIALIST REPUBLICS

(L. Dmitriev with J. Casey)

Four Institutes of the USSR Academy of Sciences, including the Vernadsky Institute of Geochemistry (lead Institute), the Geological Institute, the Institute of Physics of the Earth, and Institute of Oceanology are working together on a National Project called "Tethys." The aim of the project is directed at reconstruction of the history of ocean floor generation during the last 200 million years using an interdisciplinary approach. One of the most important study areas is the Atlantic Ocean where relicts of the Mesozoic "Tethys" Ocean are still preserved. The Atlantic also contains many tectonic features that reflect changes in relative plate motion and plate configuration and that can often be related to the evolution and closure of Tethys.

Project Tethys fits well within the framework of InterRidge because one of its components encompasses quantitative modeling of zero-age lithosphere. Tethys, however, also includes the history of accretionary processes through time and plate kinematics during the opening of the Atlantic. Many of these projects will therefore involve extension of surveys from the ridge axis to older parts of the ocean basin. The Soviet Program has targeted the same regions of the Mid-Atlantic Ridge chosen by InterRidge for detailed studies and the aims of the programs are complementary.

For example, a US-Soviet cooperative study under the framework of the Bilateral US-USSR Agreement on World Oceans Study is now underway to document tectonic and geochemical segmentation along the Mid-Atlantic Ridge between the Hayes and Atlantis Transforms (30°-34°N). This cooperative program was the first sea-going field program under the US-Soviet Cooperative Oceans Agreement signed in late 1988.

As part of a long-term program, two previous cruises (1989 and 1990) of the R/V *Akademik Boris Petrov* of the Vernadsky Institute, USSR Academy of Sciences, were conducted to the 30° to 34°N region of the Mid-Atlantic Ridge. These cruises have completed 7000 km of GPS-navigated multibeam, gravity and magnetic surveys centered on a segment of the ridge just north of the Atlantis Fracture Zone (approximately 30°20'N to 32°25'N). Several segments and types of axial discontinuities have now been identified in the region. Detailed and reconnaissance sampling of the ridge axis and two bounding transforms has also been completed between 30° and 34°N based on segmentation defined by bathymetric and geophysical surveys. Both long- and short-wave length geochemical variations have been documented and are often coincident with bathymetric segmentation.

A cruise of the R/V *Akademik Boris Petrov* is now scheduled for three months during the summer of 1992 to the 30° to 34°N region, and a proposal for a simultaneous cruise involving the *ALVIN* submersible for work on an intra-segment scale has been submitted as part of the US-Soviet Cooperative. The Petrov program will complete all near-ridge multibeam, geophysical and sampling surveys between 30° and 34° along a 70 km wide region centered on the ridge axis and will also extend coverage off-axis along a 1-2° length of the ridge axis to create a 220 km wide survey area. Eight thousand kilometers of new survey track is anticipated in 1992. During the 1992 program hydrothermal water column sampling and detailed rock sampling on an intrasegment scale in the same region will be completed. Off-axis sampling along flow lines related to individual segments will also begin. This hierarchal approach of investigation is to: 1) allow documentation of the basic ridge bathymetric and geophysical architecture as well as regional and local geochemical variation of zero-age crust, 2) conduct more detailed intra-segment-scale surveys on zero-age crust, and 3) conduct off-axis studies along flow lines in an effort to understand ridge segmentation through time in accordance with the conceptual framework of project Tethys.

Another area of detailed study is the equatorial Atlantic. Within the framework of both Tethys and InterRidge, this project is called Equa-RIDGE and has focused on the region between 40° and 16°N. Many Soviet cruises over the last several years have completed work in the vicinity of the Romanche, Doldrums, Marathon, and 15°20' Fracture Zones. These studies have also involved US and French Cooperatives. In the region of the equatorial Atlantic, several cruises of the Institute of Geology, Institute of Oceanology and the Vernadsky Institute have concentrated on this region with multibeam, geophysical, and sampling surveys. Here, studies of basalt chemistry have shown the existence of strong geochemical gradients. A recently discovered anomaly between 12°and 18°N has been documented, and detailed studies of ridge segments and fracture zones in the equatorial zone by the Soviets (seven legs) and French (two legs) are now in progress.

Laboratory-based studies of samples recovered have concentrated on the geochemical signature of the anomalous region centered on a topographic high between 14° and 14°30'N. Geochemical data show the region is characterized by E-type along zero-age crust at the anomaly center and also a strong enrichment near the 15°20' Fracture Zone with steep flanking gradients and minima in enrichments (N-MORB) at 12.4°N and 17.5°N. Geochemical data suggest that this anomaly has originated from an embryonic mantle plume enriched in incompatible elements and volatiles which is nearly 600 km in diameter.

Several detailed bathymetric surveys have now been completed along short ridge segments and major long-offset fracture zones in this equatorial region. The most recent cruises are GPS navigated. Dredging in the region indicates the possibility of foundered continental material (non-spreading blocks), and this will be a subject of further investigation. The equatorial region will also be the focus of upcoming Soviet cruises by the *Akademik Nikolai Strakov* (Institute of Geology, September 1991 to January 1992) and the *Akademik Mstislev Keldysh* with *MIR* submersibles (Institute of Oceanology, November 1991 to January 1992).

In addition to these areas of detailed study, the regime of MORB fractionation for the Mid-Atlantic Ridge is being estimated statistically based on the glass compositional data collected in the USSR, from the Smithsonian collection, and additional literature references. In particular, the pressure regime of fractionation is being calculated and results interpreted in terms of long-wave length ridge segmentation. The regularity of pressure regimes calculated for the Mid-Atlantic Ridge emphasizes long-wave length ridge segmentation. In particular, the region of the Mid-Atlantic Ridge chosen for detailed studies between 30° and 36°N appears to mark a transition zone between two mega-segments with contrasting pressure regimes. Similar syntheses are now underway for other spreading centers.

Soviet Cruise Schedule (InterRidge) 1991-1992

During the next year approximately nine months of ship time aboard vessels of the Soviet oceanographic fleet will be devoted to sea-going activities along the Mid-Atlantic Ridge in the two areas of focus described above. They are listed below:

Ship:
Akademik Nikolai Strachov
(Geological Institute)

Dates:
September 1991 to January 1992 (125 days)

Objectives:
a. MAR near the 15°20' Fracture Zone; wide angle seismic reflection and swath mapping on the eastern ridge-transform intersection.
b. Romanche and Doldrums Fracture Zones; multibeam and dredging with equatorial fracture zones and ridge segments.

Ship:

Akademik Mstislev Keldysh and *MIR* submersible (Institute of Oceanology)

Dates:

November 1991 - January 1992 (90 days)

Objectives:

Detailed studies of hydrothermal activity and geochemical anomaly near the 15°20' Zone; approximately 20 to 30 dives planned.

Ship:

Akademik Boris Petrov (Vernadsky Institute of Geochemistry)

Dates:

June to August 1992 (90 to 165 days)

Objectives:

Multibeam, gravity, magnetics, hydrothermal and sampling survey of the MAR between 30° and 34°N; a joint Soviet-US program with the University of Houston, Woods Hole Oceanographic Institution and the USGS. The study will concentrate on ridge segmentation on zero-age lithosphere and its evolution through time. A simultaneous cruise of the R/V *Atlantis II* and *ALVIN* has been proposed as part of this cooperative effort.

UNITED KINGDOM

(J.R. Cann)

British research on mid-ocean ridges is being focussed through the BRIDGE Initiative, which is the product of a consortium of over 60 mid-ocean ridge scientists within the UK from a wide range of disciplines. The consortium produced a major research grant proposal for submittal to NERC which has been very highly rated after international peer review. The proposal requested over £14M spread over four years, of which about 50% would be new money. This proposal has been submitted by NERC to government in the current round of expenditure bids with a high priority. We will know the outcome of the bid early in 1991, and if it is successful our spending under the bid will start in April 1991.

Meanwhile, British mid-ocean ridge research has already been strongly influenced by the BRIDGE initiative. The high priority assigned to the initiative by NERC means that there will be a bonus to be gained by stressing multi-disciplinary characteristics in any future proposals.

Recently Harry Elderfield was able to acquire submersible days by exchange and took part in the cruise to the TAG area in the Mid-Atlantic Ridge, where he worked on problems of mixing of hydrothermal solutions and precipitation of solid phases.
Specifically British initiatives will start with a cruise to the Reykjanes Ridge south of Iceland in September of this year, when a UK group of scientists, headed by Lindsay Parson at IOSDL, will use the new US research ship, Maurice Ewing, to conduct a reconnaissance multi-beam survey of two areas of the Reykjanes Ridge followed by deep-towed sidescan sonar surveys using the new UK deep-towed package TOBI. The sonar is designed to initiate a programme of British research on the Reykjanes Ridge and will be followed up by more detailed studies depending on the results that arise. One of the areas of interest covers the region where a swarm of earthquake events were detected in May 1989, possibly associated with newly erupting lavas. Deep-towed camera surveys of this area should reveal whether lavas did reach the seafloor.

Further ahead there will be a cruise in the spring of 1991 to an area north of the Kane Fracture Zone in the Mid-Atlantic Ridge, in which the key scientists will be Roger Searle and Julian Pearce. Again, TOBI will be used within the compass of the recent US multi-beam survey of the axial valley from the Kane Fracture Zone north to the Atlantic Fracture Zone. The cruise also plans dredging to investigate petrological relationships, and especially the relationship of petrology to the morphological structure that has been revealed by the muti-beam survey.

In the course of the next year, the British scientists will be participating in US funded cruises and American scientists will be participating in British cruises. We would be interested to develop further multi-national links, especially in areas which we have identified in the BRIDGE proposal as of significant interest to ourselves. We see the BRIDGE effort as being necessarily international and as developing over the years into a programme in which we will produce more together than we could do separately, both in terms of multi-disciplinary science and international science.

UNITED STATES

(R. Detrick)

Ridge-crest research in the United States is conducted world-wide and encompasses a diverse spectrum of studies involving geologists, geophysicsts, geochemists, and marine biologists. This research is supported by a number of different Federal agencies, including the National Science Foundation (NSF), the Office of Naval Research (ONR), the National Oceanic and Atmospheric Agency (NOAA) and the U.S. Geological Survey (USGS). The following is a brief description of how ridge-crest research is organized in the U.S., the availability of specialized instrumentation and shipboard equipment for ridge-crest research, and examples of some major field programs planned for the 1991-92 time frame.

I. Organization

NSF. The largest supporter of University-based ridge-crest research in the U.S. is the NSF/Ocean Sciences Division. For many years ridge-crest research at NSF has been supported out of core funds, based on unsolicited, investigator-initiated proposals. These proposals are typically for two or three year grants and include both the cost of operations at sea and shore-based studies. Currently proposals may be submitted twice a year with submission deadlines of 1 November and 1 May. In most cases, proposals requiring use of a research vessel need to be submitted at least one year in advance. All proposals are peer-reviewed and current proposal acceptance rates rare running about 30%. In recent years, the NSF has also supported a number of ridge-related studies as part of the U.S. contribution to the Ocean Drilling Program.

With the advent of the U.S. RIDGE Initiative new funds are now available within the Ocean Sciences Division for ridge-crest research. In FY91 funding for RIDGE currently stands at $3.94 M, 80% of which supports marine geological and geophysical research, the remaining 20% going to biological investigations at ridge crests. Proposals designated as related to RIDGE program objectives can compete for these new funds, as well as for the core funds described above. Proposals can be submitted twice a year, with deadlines of 1 April and 1 October. The earlier submission dates allow an additional review of these proposals to be carried out in order to determine their priority and timeliness in the context of the long-term scientific goals of the RIDGE program. These goals are established by the U.S. RIDGE Steering Committee and are periodically published in the form of a Program Announcement issued by NSF.

ONR. The ONR does not have a focused ridge crest research program, but supports a number of programs that are related to the longer term goals of the ridge community. One such program is a Special Research Program (SRP) to advance understanding of acoustic scattering from the ocean bottom and subbottom over long propagation paths. A major component of this SRP will be a detailed sea floor mapping and subbottom physical property characterization in a corridor extending off-axis from Mid-Atlantic Ridge in the central North Atlantic. A complementary off-axis corridor is also being planned for the northern East Pacific Rise. ONR also is funding the construction of a large number of state-of-the-art ocean bottom seismometers which can be used in ridge-related studies.

NOAA. For the past six years NOAA has been carrying out a long-term, inter-disciplinary hydrothermal research program known as VENTS. This program involves NOAA geologists, geochemists, geophysicists and physical oceanographers and collaboration with about twenty non-NOAA scientists from academia and other government agencies. The program is primarily focussed on the Juan de Fuca and Gorda spreading centers in the Northeast Pacific and typically utilizes 60-70 days of surface shiptime each year, augmented by submersible operations using *Alvin* or *Sea Cliff*, when available.

USGS. The USGS Branch of Pacific Marine Geology has an ongoing project focussed on tectonic, magmatic, hydrothermal and sedimentary processes at spreading centers and how these processes interact to form hydrothermal deposits on the sea floor. A related goal is to apply this knowledge to investigations of analogous mineral deposits on land. The primary study areas are the Juan de Fuca and Gorda spreading centers; other areas of interest include the Blanco fracture zone, the Reykjanes Ridge, Lau Basin and the Marianas island arc and backarc. USGS scientists are also actively involved in studies of the Mid-Atlantic Ridge, especially through a cooperative program with the USSR. Ridge-related studies are also carried out the the USGS through their Exclusive Economic Zone (EEZ) mapping project.

II. Technology

An increasingly wide array of specialized instrumentation is available to ridge crest researchers in the U.S. Two UNOLS research vessels are currently equipped with SeaBeam multibeam echosounding systems (*Washington, Atlantis II*). Second-generation multibeam systems are, or will soon be, available on three other UNOLS research vessels: Hydrosweep on the *Ewing* and *Thompson* and SeaBeam 2000 on the *Melville*. In addition the University of Hawaii operates a SeaMARC II system and the USGS has a GLORIA long-range side scan mapping system. The *Ewing* is also equipped with a state-of-the-art multichannel seismic profiling system including an ~8000 cu. in. airgun array and a 4-km-long digital streamer. The submersible *Alvin*, despite its age, remains a workhorse for ridge-related studies.

New technology is being introduced or developed by various U.S. laboratories that promise to significantly improve the capabilities of ridge-crest researchers. These include a variety of seafloor work systems such as Jason/Argo and a portable, tethered rock drill, *in situ* chemical sensors, sea floor geodetic instrumentation, broadband, long-endurance ocean bottom seismometers, and innovative sensing devices capable of deployments for periods of months to years.

III. Plans for 1991-92

Among the programs that U.S. scientists will mount in the 1991-92 time frame are the following (by no means a comprehensive list):

•Northeastern Pacific: Jason/Argo survey on the Juan de Fuca Ridge; *Alvin* submersible study of hydrothermal venting on the EPR between 9°N and the Clipperton fracture zone; a near-bottom seismic experiment on the EPR near 9°30'N; submersible biological sampling efforts on the Juan de Fuca Ridge, EPR near 13°N and in the Guaymas Basin.

•Southeastern Pacific: a two-ship multichannel seismic study of the EPR south of the Garrett fracture zone; a Hydrosweep/gravity survey of the EPR between 7 and 9°S; a SeaBeam/Sea MARC II exploration of the Pacific-Antarctic Ridge; a Sea Beam/Sea MARC II off-axis survey of the EPR near 18°S.

•Mid-Atlantic Ridge: up to 5 months of surface ship studies that are part of the bilateral FARA Program (French-American Ridge Atlantic). U.S. projects include an OBS microseismicity study of the MAR, a side-scan survey of the Kane fracture zone, a SeaMARC study of the Vema transform, a petrologic and water column survey of the MAR south of the Azores, and off-axis mapping of the flanks of the MAR south of the Atlantis fracture zone.

Additional programs for 1992 are still pending.