

Symposium Summary

FARA-InterRidge Mid-Atlantic Ridge Symposium

Reykjavik, Iceland, 19th - 22nd June 1996
Conveners: Charles H. Langmuir and H. David Needham

This symposium, focused on the Mid-Atlantic Ridge (MAR) between 15° - 40°N, marked the completion of the FARA (French American Ridge Atlantic) project. Results obtained by FARA and other national and international projects in this region were reviewed. Eighty scientists from eight nations presented their recent research. The symposium incorporated some forty oral presentations and thirty posters and was planned primarily around sessions covering different portions of the ridge rather than by theme, hence emphasising the interdisciplinary nature of the research that has taken place. Generous time was allowed for discussion. A concluding session, preceded by introductory talks, was devoted to a brief review of current knowledge and to new perspectives. Several field trips provided opportunities for ridge scientists to familiarise themselves with the sub-aerial expression of the MAR and for further interaction with the geologists of Iceland.

Background

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

New Data

Results reported at the symposium complement those which have already been presented in scientific meetings or published, and offered an overview of observations made during the past 5 years. There is now virtually complete multibeam bathymetric coverage of 90% of the ridge axis in the 15° - 40°N region, with a few maps extending out to crustal ages of 10 Ma or more (30 Ma in the case of the ONR survey). Most of the recent surveys included underway geophysical, as well as bathymetric, data acquisition. Surface ship and deep-tow acoustic imaging has been achieved for significant portions of the ridge axis. In situ geophysical data were collected during micro-earthquake and seismic experiments near 29°N and 35°N. A submersible expedition was dedicated to seafloor gravity measurements in the 23°N area. There is new geochemical data from more than 250 surface ship sampling stations, particularly between 33°N and the Azores and in the 21° - 23°N area south of the Kane Fracture Zone. New fine scale volcanological and tectonic observations

and precise sampling have been carried out by submersibles in several regions. Several surface ship cruises were designed for detecting hydrothermal signatures in the water column. The number of known hydrothermal sites (two at the outset of the recent work) has been quadrupled. The biology and geology of four of the new sites (at 14°45'N, 29°N, 37°20'N and 37°50'N) have now been studied from submersibles. The inactive site on the axial volcano at 20°30'N has been investigated. Hydrothermal plumes have been identified near 36°N and 36°40'N. In addition, past hydrothermal activity between 33°-40°N has been investigated through studies of sediments.

Some General Results

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

The recently discovered hydrothermal sites which have been visited, and which include both black and white smokers, show variations in both the fluids and solid deposits as a function of water depth, volcanic and tectonic setting and source rocks. Properties of the two northern sites near the Azores (Menez Gwen at 37°50'N and Lucky Strike at 37°20'N) reflect their location on hot-spot crust enriched in incompatible elements, hence demonstrating direct links between mantle and hydrothermal signatures. The Logatchev site at 14°45'N is in an area of abundant peridotitic outcrops and is located at the faulted inner wall of the rift. The 36°N and 36°40'N plumes are at the ends of segments rather than near their centres, thus reinforcing the view that tectonics associated with rift-offset interaction can favour the location of hydrothermal activity, and that such activity is not always located near the mid-points of ridge segments. The methane anomalies which have been identified and mapped in the 15°N area are probably predominantly a product of serpentinisation. In the future, surveys will be needed to locate the sources of, and characterise, the hydrothermal signals which have, to various degrees, been detected along most of the ridge axis. Highly focused studies will be necessary to understand the properties of the hydrothermal sites, their geodynamic controls, and their variation through time.

The ecosystems at the new hydrothermal sites show limited species diversity of primary consumers. This low diversity, with either mussels or shrimps being the dominant organism, appears to be a characteristic of all Atlantic sites that have been investigated so far. The reason for this is not yet understood and is among the questions posed for future research concerning MAR biological populations. Is this low diversity a general Atlantic characteristic, and if so, why? How stable are the populations through time, and what are the environmental controls on the contrasting shrimp and mussel-dominated communities? Other important questions for the future are: How do organisms colonise and survive in the different sites? How do they adapt to toxic conditions? How much methane is necessary to meet the energy requirements? Do thermophilic CH₄-oxidizers exist? The question also still remains concerning the existence of a deep crustal biosphere in the Atlantic.

Striking aspects of the basement morphology include the segment provinces a few hundreds of kilometres in length combined with a great diversity in the various characteristics of individual segments. The exceptionally shallow segments at 37°50'N and 38°20'N in the Azores area, identified from magnetics data and acoustic imagery, are - together with the 21°30'N segment - extreme examples of barely rifted

segments that are not normally associated with the slow-spreading MAR. Elsewhere the now virtually complete bathymetric coverage of the axis displays the full range of segment and offset styles, including some segments dominated by tectonic extension and others by a high magmatic budget, and highlights common features such as the asymmetry of the rift valley walls. The contrast of thicker crust at segment centres than at segment ends, typically variable according to segment and offset lengths, appears to be confirmed as common and may be general. The model of active upwelling for the origin of these thickness variations has been tested both by geophysical (primarily gravity) and petrological modelling. Both approaches suggest that this model on the segment scale is not an adequate explanation for much of the data and that melt focusing towards segment centres may be substantial. High density rock sampling has also allowed a far better description of the effects of mantle heterogeneity in giving rise to the diversity of crustal compositions and has opened up new perspectives for deciphering relationships between the composition and temperature of mantle sources.

The surface ship and deep-towed side-scan sonar (and magnetics) results, coupled with the multibeam bathymetric data, have enabled fine-scale investigation of tectonic and volcanic features at the segment scale with implications for the distribution of magma within the crust. The deep-tow studies were conducted particularly in the area near the Azores and between 24°N and 30°N and include in some cases (the Broken Spur segment at 29°N) complete coverage of the greater part of the segment out to a crustal age of more than 2 Ma. These data allow basement sampling and composition to be related to specific volcanological and tectonic features on the seafloor with unprecedented precision for the Atlantic without the intervention of a submersible.

The combination of diverse geophysical datasets with rock sample analyses and seafloor observations has allowed unprecedented investigation of the geology of some portions of the MAR, particularly the region south of the Kane Fracture Zone. These studies are providing knowledge concerning faults and the surface distribution of rock types along and across segments that has to be incorporated into tectonic and magmatic models of spreading.

Future Directions

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

There is a clear need for a better geological understanding of the MAR: Iceland is a reminder of the dearth of geological information. For example, how does the geology of the MAR change from the Kane transform to the Azores hot spot? How does it vary with magmatic budget? Are segments a single species which changes through time, or are there distinct sets of segments each of which has its own restricted range of evolution? Research into these issues can draw on larger scale observations, such as those coming from detailed bathymetry and from whole mantle tomography and satellite altimetry, but concentrated studies on selected areas are also now essential and timely. Understanding how magmatic and amagmatic extension are distributed, how basaltic dykes, gabbros and serpentinite bodies are emplaced, appear now as urgent issues. Another is the testing of the low angle (detachment) fault model, still neither well confirmed or refuted, which was developed for the inside corner area of the segment immediately south of the Kane Fracture Zone. Does this model apply elsewhere as well? And how does such a model evolve temporally?

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

Symposium Abstracts

Extended abstracts of the meeting were published in the [Journal of Conference Abstracts: J. Conf. Abstr. 1\(2\), \(1996\), 749-888](#). To obtain a copy of the abstract volume contact the InterRidge Office at intridge@ori.u-tokyo.ac.jp.
AGU Volume

Following the Iceland Symposium, a volume of results from the 15°-40°N area of the Mid-Atlantic Ridge was planned for publication in the Maurice Ewing series through AGU. However not enough manuscripts were received to be able to complete a Ewing volume. The manuscripts are currently under review to be published in a special issue of *Earth and Planetary Science Letters*.