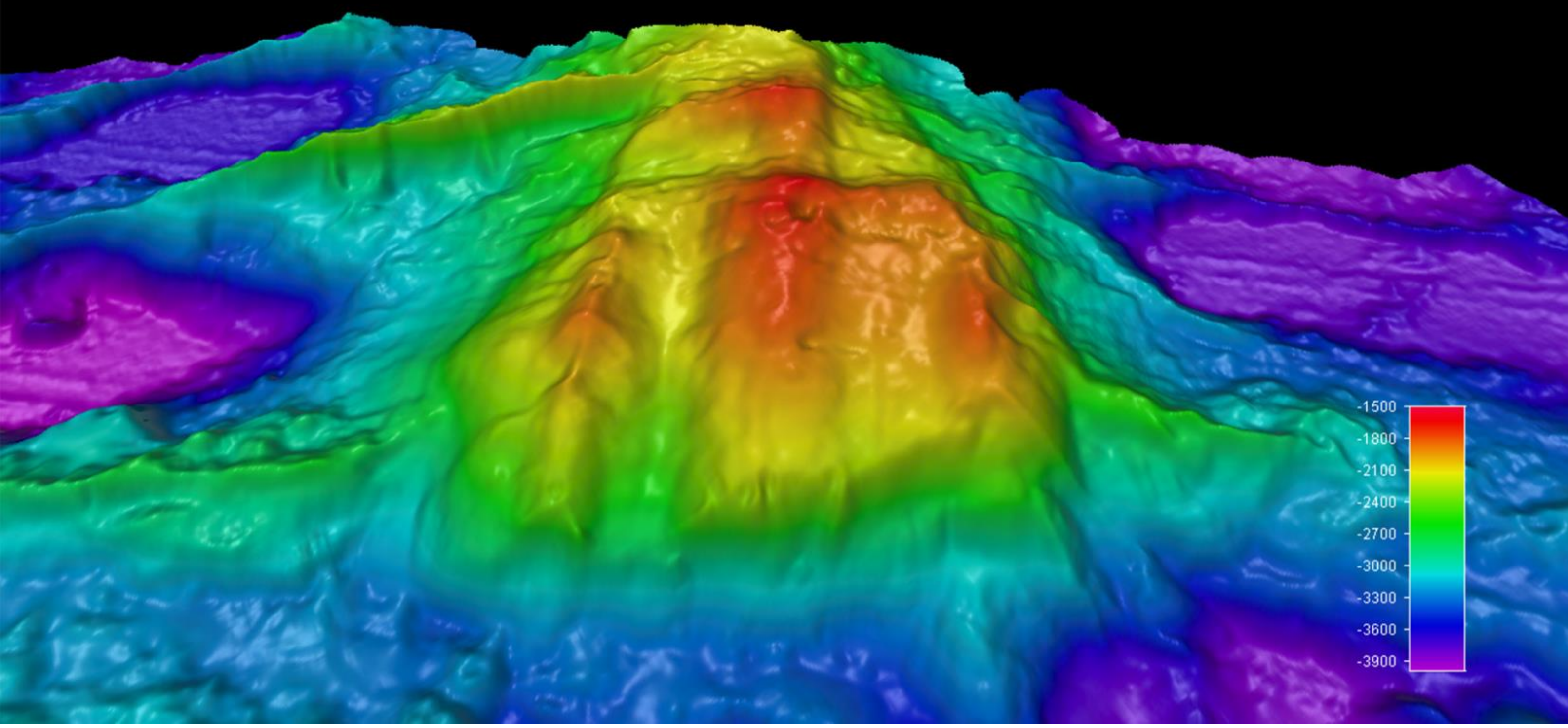
InterRidge News

Promoting international cooperation in ridge-crest studies



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Please send all items for publication via email to the InterRidge Coordinator. Text should be in Microsoft Word format. Figures should be sent in high resolution (minimum width of 1000 pixels, 2000 is preferable), in eps or tif format for optimal printing, although other formats are accepted.

DEADLINE FOR INTERRIDGE NEWS
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31 SEPTEMBER 2015

From the office

Letter from the Chairs

John Chen and Jiabiao Li
Chair and Co-Chair of InterRidge

John Chen and Jiabiao Li in Peking University

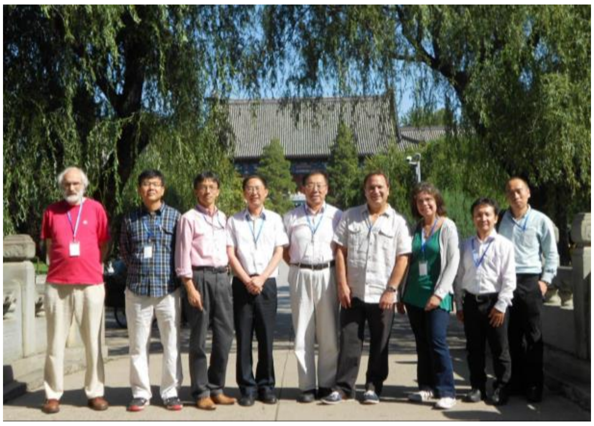
On January 1, 2013 the InterRidge Office moved from the National Oceanography Centre in Southampton (UK) to Peking University in Beijing (CHINA). We would like to take this opportunity to thank the previous InterRidge Office team, Bramley Murton (Chair), Jon Copley (Co-Chair) and Debbie Milton (Coordinator), for their successful efforts to lead the InterRidge community and activities over the past three years. Under their leadership the UK InterRidge Office has expended IR national memberships by adding Canada and Portugal to the Associate Member list and has started new initiative such as the cruise bursary scheme, which benefited dozens of young students at the very beginning of their scientific career.

Continuing the current policies, we will devote substantial effort and resources into nurturing collaboration within the IR community, particularly involving developing countries and countries of emerging economies. We strongly believe that the InterRidge should act as an active coordinator for facilitating the exchange of scientists and their ideas among the scientific community.

We had adopted a reform plan (attached in the following) for the new structure of the InterRidge membership fees and privileges of each member countries at the 2014 InterRidge Steering Committee in Beijing, China on 27-28 2014. It was a consensus at the IR StCom meeting that the reform of InterRidge is necessary to lead the InterRidge forward and to better implement the "third decadal plan" (http://interridge.org/thirddecade) in order to meet the challenges at the current funding situation at its member countries.

The IR StCom meeting calls for proposals for new Working Groups which had been proved to be an effective way to mobilize the InterRidge community to focus on important scientific problems of InterRidge.

The IR StCom meeting approved for an InterRidge Workshop/Third InterRidge Theoretical Institute in 2015 to focus on the first two themes in the "InterRidge Third Decadal Plan" with the title as "Magmatic and Tectonic Processes and Seabed Resources at Mid-Ocean Ridges". It will be organized by InterRidge Office and will take place in Hangzhou, China on September 25-27, 2015.



IR Steering Committee meeting in Beijing China, Sep 2014, From left to right: Richard Hobbs, Sung0Hyun Park, Nobukazu seama, Jiabiao Li, John Chen, Kim Juniper, Marcia Maia, Toshiya Funikura, Zengxi Ge

Third InterRidge Theoretical Institute on "Magmatic and Tectonic Processes and Seabed Resources at Mid-Ocean Ridges"

Location: Hangzhou, China
Date: September 25-27, 2015

The theoretical institute focuses on the first two themes of the InterRidge Third Decadal Plan with the chairs and co-chairs for each of the two themes who will lead the scientific programs of the theoretical institute which is organized by the InterRidge Office. Call for abstracts will be sent out in Jan 2015.

Theme One: Magmatic and Tectonic Processes
Theme Two: Seabed Resources

Reform of InterRidge in 2014

A reform plan for the new structure of the InterRidge membership fees and privileges of each member countries was adopted at the 2014 InterRidge Steering Committee in Beijing, China on 27-28 September 2014.

Twenty-two year after its birth in 1992, InterRidge has continued to evolve based on the principle of collaboration. It is an international organization that pools the resources of its member countries to coordinate oceanic ridge research in a way that is cost-effective, cooperative and proven to be successful. InterRidge is supported by its member countries via membership fees that support the InterRidge Office and various InterRidge initiatives and activities.

To improve implementation the "Third Decadal Plan" (link to the plan at the IR web page) the Steering Committee has approved the following reform of the InterRidge structure to meet the challenges of the current funding situation in its member countries.

1. InterRidge Steering Committee and member country fees

Principal Member Countries

Each Principal Member Country has two representatives in the InterRidge Steering Committee.

Each Principal Member Country pays annual fee of $25000 which includes $20000 for the InterRidge general fund and $5000 as the contribution for maintaining of the InterRidge Office.

Regular Member Countries

- Each Regular Member Country has one representative in the InterRidge Steering Committee.
- Each Regular Member Country pays annual fee of $5000 as the contribution for maintaining of the InterRidge Office.
- Corresponding Member Countries
- Each Corresponding Member Country has one national correspondent who is welcomed to sit in at the annual meeting of InterRidge Steering Committee as an observer.

2. InterRidge Office

1. InterRidge Office rotates between the Principal Member Countries on a three-yearly term. A Regular Member Country can apply to host the next InterRidge Office on the condition that they plan to become a Principal Member Country. If the application is approved by the InterRidge Steering Committee the Regular Member Country has to become the Principal Member Country in order to host the InterRidge Office.
2. The Principal Member Country that is hosting the InterRidge Office can use all the contributions of $5000 from each member country for maintaining the InterRidge Office; including the salary of the Scientific Coordinator of InterRidge, costs of setting up the office and other expenses to keep the office running on a daily basis.
3. The Principal Member Country that is hosting the InterRidge Office needs to provide any additional funds necessary to maintain the InterRidge Office.

Note: that this change will effectively absorb the difference in costs of maintaining the IR office amongst the Principal member countries and stabilize the general funds to promote the science activities of the InterRidge.

3. Privileges of Principal Member Country

The Principal Member Country shall benefit from the following services and activities funded by InterRidge: (Note: these benefits may be for services or activities to or from the Principal Member Country.)

- InterRidge fellowships
- InterRidge Mobility Awards for science cruise participation to graduate students and postdocs.
- InterRidge sponsored meetings and workshops.

The ISA fellowships are an exception that are for recipients from emerging countries only.

The InterRidge Office should present the budget at the annual InterRidge Steering Committee meeting for approval.

Notes:

From the office

1. A rule adopted at the InterRidge Steering Committee 27-28 September 2014 is that a Principal Member Country can remain as a member country for a period of up to 5 years after its paying the Principal Member fee pending the approval by the InterRidge Steering Committee. This rule is set up to deal with the variation in funding environment at each Principal Member Country.

2. This new funding structure will commence in January 2015.

Coordinator update

Zengxi Ge

January 2013 marked the move of the InterRidge (IR) Office from the National Oceanography Centre, Southampton, UK to Peking University, Beijing, China. We would like to thank the UK office, and those involved at PKU, for the very efficient changeover of the website – in particular, Xianbing Zhang in Peking University. Also, Debbie Milton (IR Coordinator 2010-2013) and Stace Beaulieu (IRcoordinator 2007-2009) have provided invaluable advice and support to the new office during this first year – thank you!

Membership

Individual membership is currently ~ 2600, representing 62 nations and regions. The new office took the opportunity of refreshing the mailing list of members but found some undeliverable addresses. If your email is changed please send a notice to the office or update it on the website. During the two years, about 60 new members joined Interridge, mainly from China.

Please check the details we have for you by logging in at: http://www.interridge.org and going to "My Account". From here, apart from changing any details, you can sign up to support the Statement of Responsible Research (under "Edit/Other Info").

The "interridge-mail" e-news is sent to >1200 members on a biweekly basis and disseminates news pertinent to the ridge community. Our website doesn't open for individual registration since there are so much spam trying to login. If you or any of your colleagues would like to join interridge, please feel free to send an email to coordinator@interridge.org. I will add you to our member area and mailing list soon after I receive your request!!

Steering Committee

The IR Steering Committee (StComm) meeting was held in Victoria, Cananda in August 2013 and in Beijing China in September 2014. The reports of both meetings are posted at: http://www.interridge.org/stcom/reports.

Two members rotated off the StComm in 2013: we thank Jérme Dyment of France and Junichiro Ishibashi of Japan, for their service to IR. Dr. Marcia Maia attended as the new StComm member and National Correspondent for France and Toshiya Fujiwara attended as the new StComm member of Japan.

National Correspondents

In INTERRIDGE NEWS each year, we report on ridge-related activity around the world, through the National News section of this volume. This is the chance to tell the IR community about cruises, conferences and workshops that have been organised or attended by your national members, as well as reporting on general scientific achievements and technologies. Currently we have 31 Correspondents, but many more nations and regions are represented by individual members for whom there is no Correspondent and so we have not heard their news!

Education and Outreach

InterRidge Continues to provide Cruise Bursaries and fellowships to provide research and collaboration opportunities to early career scientitists. During 2013-2014, 9 students received IR/ISA fellowships and 10 were awarded cruise bursaries. In 2015, InterRidge will plan to provide 5-6 fellowships and 5-6 cruise bursaries.

New working group

In the 2014 StComm meeting, a new working group "Ecological Connectivity and Resilience" is accepted by the Steering Committee. The chairs of the working group are Anna Metaxas (Dalhousie University, Canada) and Lauren Mullineaux (Woods Hole Oceanographic Institution, USA). This group will focus on a hot topic "the ecological connectivity of vent communities, and their resilience in the face of disturbance".

China national update 2013

Y. John Chen and Jiabiao Li

The China ridge community pays more attention to the geological and ecological processes of the global mid-ocean ridges and their hydrothermal vents, completed several ridge cruises and developed some deep sea scientific equipment in 2012-13.

Ridge-Crest Surveys

In 2012, Chinese scientists used two research vessels to conduct their ridge-crest survey. Geology and ecosystem for active hydrothermal vents have been investigated during 6 consecutive ridge cruise legs on the Carlsberg Ridge and Mid-Atlantic Ridge on board R/V "*Dayang Yihao*" in April to October 2012. At the same time, a geophysical survey including multibeam bathymetry, gravity, and magnetics were conducted on the Carlsberg Ridge in the Indian Ocean using the R/V "*Zhukezhen*" in May to June 2012.

For 2013-14 the Chinese ridge program will be using four research vessels for the researches in the Indian and Mid-Atlantic ridges. R/V "*SONNE*" will be rent by COMRA to make a seafloor massive sulfide drilling and AUVs acoustic survey in the Southwest Indian Ridge in late 2014. Scientists from Germany, Cameroon, Zambia, Kiribati, and Argentina, are invited to participate in some of the cruise legs for joint research.

During the cruises, we revisited the TAG hydrothermal field in MAR. Six lines of TEM (Transient Electro-Magnetic) survey were deployed, with four of which across the ODP 158 drilling area. Besides, and other two lines of SP (Self-Potential) survey were also across the ODP drilling area for their comparison. Preliminary results show that the TEM and SP methods are capable of revealing the horizontal and vertical distribution of the seafloor hydrothermal fields. Then a dive was conducted by the ROV *Ocean Dragon II* dived at a deep-sea hydrothermal field on the Southern Mid-Atlantic Ridge, to be used to clarity the characteristics of the geology, ecosystems, and the environmental conditions around the hydrothermal field. Some evidence for a new hydrothermal vent was collected in equatorial Mid-Atlantic Ridge.

In the Carlsberg Ridge, a new hydrothermal vent was found and one sediment trap has been moored in the vicinity of this active hydrothermal vent to study the composition and sedimentation of hydrothermal plume particles. The morphotectonic characteristics of the northern part of the Carlsberg Ridge near the Owen Fracture Zone have been preliminary studied and 9 oceanic core complexes have been identified. Our observation displays that vigorous tectonic extension occurred in the segment of Carlsberg Ridge between 10.4°N - 8.8°N. Further geological sampling would provide information on the nature of the potential OCC formation for the study of the emplacement and evolution of lower ocean crust and upper mantle of the investigated area of Carlsberg Ridge.

The IODP proposal 735-CPP titled "Opening of the South China Sea and its implications for Southeast Asian tectonics, climates, and deep mantle processes since the early Mesozoic" (*by Chunfeng Li, Pinxian Wang, Dieter Franke, Jiabiao Li, et al.*) was submitted to IODP in late 2011 and received in 2012. In 26 Jan-30 March 2014, IODP Expedition 349 *(P.I. Chunfeng Li and Jian Lin*) will drill the oceanic crust to present investigations and new insights of Mesozoic pre-rifting tectonic background, Cenozoic rifting mechanisms, ages and sequences of seafloor spreading, and their climatic and deep mantle aftermaths.

New Device and Equipment

In July 2012, the Chinese manned submersible *Jiaolong* has completed six dives to 7000 m depth in Mariana Trench. In June 2013, the submersible *Jiaolong* has been planned to eight dives in the northern South China Sea (SCS) to investigate the chemosynthetic communities, biology and geochemical system of the cold seeps, and to explore the volcanic seamounts in the deep sea basin of SCS with a focus on geochemical and geological processes of the basin. After that, the submersible *Jiaolong* is scheduled to explore and sample the benthos in the polymetallic nodules exploration area of China's contract in the Pacific Ocean in August 2013.

Symposiums and National Conference

1. One international symposium "Unlocking the Opening Processes of the South China Sea" was held on January 31-February 1, 2012, at Tongji

University, Shanghai. About sixty scientists participated in the symposium to boost further international collaborations in geological researches in SCS and refine both regional questions related to East Asian geology and fundamental issues regarding continental breakup and basin formation.

2. The 2nd national conference of "Deep Sea Research and Earth System Science Symposium" was held in Shanghai on July 2-4, 2012. Over 800 scientists and students participated in this national conference. This conference strongly focused on interdisciplinary studies in ocean science including biological evolution and environment, ocean and climate, biogeochemical cycle, deep-sea resource and technology, and dynamic process of deep earth.

3. The 41st Conference of the Underwater Mining Institute "Marine Minerals: Finding the Right Balance of Sustainable Development and Environmental Protection" was held in Tongji University, Shanghai, 15-20 October, 2012. Over 100 scientists participated in this international conference. Co-sponsor of COMRA, Mr. Jiancai Jin, and co-chair and host of the conference, Dr. Huaiyang Zhou were invited to give key-note speeches discussing issues for the exploration of metal resources and its impact in the deep-sea environment. After the meeting, a field guide provided geological and mineralogical perspectives of the landscape in the Xinqiao Cu-S-Fe-Au Deposit (large-scale polymetallic deposit) in Anhui Province, China.

4. The 4th symposium of "Global Mid-ocean Ridge Spreading Processes and Implications for the South China Sea Evolution" organized by Dr. Zhen Sun, was held at South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, 12-14 September, 2012. Over 100 scientists and students from various parts of China participated in this symposium. Distinguished international keynote speakers included Dr. Henry Dick, Dr. Jian Lin (Woods Hole Oceanographic Institution, USA), and Dr. Yaoling Niu (Durham University, UK).

Fifth dive to depth 7062 m by HOV Jiaolong in the Mariana Trench, July 2012. (Photo by pilot Jialing Tang)

Germany National update 2013

Colin. Devey

As in 2012, Germany still has no centrally-organized ridge program since the SPP1144 ended in 2009, nevertheless there is significant ridge-related research occurring and planned in the near future. The possibility of Germany being able to continue paying IR fees in the future (and even in 2013) is becoming increasingly unlikely, however, both because of this lack of a centrally-organized project and also because of the limited visibilty of InterRidge in the German ocean science community at present.

Ridge-related cruises carried out since the last report include: MSM25 (with RV Maria S Merian, PIs Colin Devey and Maren Walter) to the Southern Mid-Atlantic Ridge (33-13°S) using AUV and CTD to investigate the linkages between volcanism, hydrothermalism and tectonics and the influence of ridge structure on deep-water oceanography; a recent cruise with RV "Sonne" to the Mariana back-arc (PI Karsten Haase, Erlangen) investigating volcanism and hydrothermalism there. German ridge research in the polar regions increased with several cruises with the RV Polarstern taking place or planned: a) Vera Schlindwein from the AWI will lead a second cruise to the ultra-slow spreading Southwest Indian Ridge in Dec 2013, b) Gerhard Bohrmann from MARUM led a cruise to the Sandwich Plate/Scotia arc in March 2013.

Ridge research in Germany (and other EU countries) received a boost with funding through EU initiatives related to marine mining and its environmental impacts. Particularly the Blue Mining consortium (involving industry partners mainly from the Netherlands and scientists from UK, Germany, Portugal and elsewhere) which will examine possible sulphide mining processes and their impacts, will bring attention to bear on the TAG area of the Mid-Atlantic Ridge.

France National update 2013

Marcia Maia

In 2013, the French ridge community is pursuing several projects over different spreading centres around the world. The projects cover a wide panel of themes, including deep-sea observatories, hydroacoustics, ridge magmatic and tectonic processes, vent ecology and biology. Some projects developed in the scope of an international collaboration, such as RHUM-RUM (Germany) and COLMEIA (Brazil).

As in the previous years, much effort was focused on the study of the Mid-Atlantic Ridge, especially on the MoMAR (Monitoring the MAR) deep-sea observatory, located on the Lucky Strike volcano, south of the Azores. The annual cruise targeted to service the stand-alone observatory (MOMARSAT 2013) took place on board the R/V Pourquoi Pas? with the ROV Victor 6000 in August-September 2013 (P.I.s M. Cannat and P.-M. Sarradin). During the 16 days of the cruise, the two seafloor SEAMON (Sea Monitoring) seafloor stations and their connected instruments, i.e. a 3-components seismometer, two pressure probes for geodetic measurements, a turbidimeter, a video camera, a dissolved-iron analyzer, and an optode (oxygenand temperature probe) for ecological time-studies, were maintained and reinstalled. Sensors not connected to the SEAMON stations were also maintained (one pressure gauge, four OBS) as well as several microbial colonizers and 20 temperature probes. The BOREL transmission buoy, equipped with GPS and meteo station was also maintained. This buoy is used to transmit data from the seafloor stations to the Ifremer node of the EMSO (European Multidisciplinary Subsea Observatory) data center. The MoMAR site, part of the EMSO network, is one of the priorities for the French ridge studies. Another cruise targeting the study of the Lucky Strike ridge segment and related to the MoMAR site was ranked high in the priorities for 2014, HYDROBSMOMAR 2 (P.I. J.Perrot), with the objective of redeploying the hydrophone network moored in 2011-2012 to monitor the seismicity of the Azores area. Still in the Azores area, the study of the hydrothermal mussel Bathymodiolus azoricus was the objective of the BIOBAZ cruise, on R/V Pourquoi Pas? and with ROV Victor 6000 in August 2013 (P.I. F. Lallier).

Other cruises targeted the study of the accretion processes and vent ecology on the Mid-Atlantic Ridge. The COLMEIA cruise (P.I.s M. Maia, S. Sichel and R. Santos) took place on board the R/V L'Atalante in January -February 2013, as part of a collaboration between France and Brazil for the study of the Equatorial Mid-Atlantic Ridge. The cruise surveyed and dredged the ridge portion inside the St. Paul FZ system and the St. Peter-St. Paul mylonite ridge. Five hydrophones were moored in the area to monitor the seismic activity as well as whale vocalizations and will be retrieved with a Brazilian ship mid-2014. OCEANOGRAFLU cruise (P.I. F. Lucazeau, R/V L'Atalante, June-July 2013) investigated the heat flux on the area of the Oceanographer FZ. ODEMAR cruise (P.I. J. Escartin) is scheduled for November-December 2013 on board R/V Pourquoi Pas?. Its objective is the detailed study of the structure of the OCCs mapped at 15°N, using ROV Victor 6000. BICOSE (P.I.s M.A. Cambon and M. Zbinden), scheduled for early 2014 on the Pourquoi Pas?, also with the ROV Victor 6000, will study the ecology of the TAG and the Snake Pit hydrothermal fields.

The Indian Ocean mid-oceanic ridges were also important targets for the French community. The OHA-SIS-BIO experiment aims the monitoring of the seismic activity of the three Indian ridges as well as whale vocalizations through an array of hydrophones, moored between Réunion Island and the French Austral and Antarctic Territories (TAAF). The network is annually serviced during the R/V Marion Dufresne cruises for maintenance of the TAAF stations in Crozet, Amsterdam and Kerguelen islands. This year, due to technical problems with the ship, the cruise took place in

February-March. This site is also considered as one of the priorities for French ridge studies. Another important experiment is RHUM-RUM (P.I.s G. Barruol and K. Sigloch), a collaboration between France and Germany for the study of the deep mantle of the Indian Ocean, including imaging the Réunion plume and ridge-hotspot interactions with the Central Indian Ridge. 55 OBS were deployed in 2012 using the R/V Marion Dufresne and will be retrieved in October-November 2013 using FS Meteor. Still in the Indian Ocean, SISMOSMOOTH cruise (P.I. M. Cannat), to investigate the structure of the SWIR using OBSs, as part of the effort to study this ultraslow spreading center, and STORM (P.I. A. Briais), to investigate the structure of the ridge between Tasmania and Antarctica and the mantle flow between the Pacific and Indian oceans, were ranked as priority cruises for the next years.

No cruises took place in the Pacific Ocean in 2013, after a year of intense efforts, especially on the exploration of hydrothermalism and mineral resources in the French EEZ of Wallis and Futuna Islands, (Futuna cruises) supported by the industry. It is expected a continuation of this project for the following years.

Concerning deep-sea mineral exploration, France has asked ISA for a permit to explore mineral resources in an area on the Mid-Atlantic Ridge south of the Azores.

Completed in the end of 2012 and beginning of 2013		Scheduled for the end of 2013 and beginning of 2014	
RHUM-RUM, 21/09-26/10/2012, Réunion-Réunion	Marion Dufresne	MOMARSAT 2013 23/08-07/09/2013 Horta-Horta	Pourquoi Pas ?
COLMEIA, 23/01-28/02/2013 Recife-Recife	L'Atalante	ODEMAR 15/11-20/12/2013 Cap Vert-Point à Pitre	Pourquoi Pas ?
OHA-SIS-BIO (MD 139), 02-03/2013, Réunion-Réunion	Marion Dufresne	BICOSE Early 2014	Pourquoi Pas ?
OCEANOGRAFLU 04/06-03/07/2013 Ponta Delgada-Ponta Delgada	L'Atalante	Expected in 2014-2015	
BIOBAZ 02/08-21/08/2013 Horta-Horta	Pourquoi Pas ?	MOMARSAT 2014, SISMOSMOOTH, HYDROBSMOMAR 2, OHASIS-BIO, STORM	

Japan national update 2013

Kyoko Okino

The InterRidge-Japan program continues efforts to promote ridge-related studies in Japan and to expand our community. The outline of the ongoing project and other activities are described below.

Domestic Meeting

We designated the incoming IR steering committee member, Toshiya Fujiwara (JAMSTEC), as Hidenori Kumagai's successor. He will be in charge from 2013 to 2016.

We had a business meeting on May 22, 2012, at a Japan Geoscience Union Meeting 2013, where we shared information on a budget of the IR, cruises, workshops and international affairs, and discuss the InterRidge-Japan annual activity plan. We are forced to get along without an umbrella project supporting the annual contribution to IR in FY2013 and try to find a way to continue our activity. We held a research meeting entitled "Ecology of Hydrothermal System: Ecosystem Research and Environmental Impact Assessment" on May 27,28 2013 at AORI, University of Tokyo.

Closure of Project "TAIGA"

The interdisciplinary research project TAIGA, Trans-crustal Advection and In-situ biogeochemical processes of Global sub-seafloor Aquifer, funded by MEXT (Ministry of Education, Culture, Sports Science and Technology), ended March 2013.

During 5 years project, we focused on subseafloor fluid advection which carries huge heat and chemical fluxes from the interior of the earth and supports growth of biosphere (beneath and on the seafloor). Three integrated study sites were selected: the southern Mariana Trough as TAIGA of sulfur and iron, the Indian Triple Junction as TAIGA of hydrogen, and the Okinawa Trough as TAIGA of methane. More than fifty scientists joined the project, and many seagoing studies were conducted, mainly in the integrated study sites. Further information can be checked at the project web site (http://www-gbs.eps.s.u-tokyo.ac.jp /~taiga/en/index.html). A part of our results was presented in last AGU Fall meeting and we are preparing an open access e-book that compiles our achievements in the project. The book will be published on-line from Springer in March 2014.

Finished and ongoing cruises FY2012-2013

The R/V Yokosuka cruise in the Indian Ridges were conducted in Jan. to Mar. 2013. Dives of Shinkai 6500 are planned to clarify the characteristics of geology, geochemistry and ecosystem around the hydrogen-rich Kairei hydrothermal site and two newly discovered hydrothermal sites in Central Indian Ridge Segment 15/16. Although we were forced to downscale the dive plan significantly due to bad weather condition, we could get many valuable data sets and samples. We also conducted the crust and upper mantle imaging around the triple junction by OBSs and OBEMs. This cruise is dedicated to the memory of Prof. Kensaku Tamaki, the former IR chair, and his pioneering works in Indian Ridge system. Several short cruises in the hydrothermal areas in the Okinawa Trough and the Izu-Ogasawara-Mariana arc/backarc are also conducted.

The R/V Yokosuka with Shinkai 6500 is now going on a cruise around the world. The outline and recent results (including the surveys at Indian Ridges in March) are posted at the web site (http://www.jamstec.go.jp/quelle2013/e/ index.html). The ship is now in the world deepest ridge, the Mid-Cayman.

A new 1200t-class multi-purpose research vessel Shinsei-Maru has just been launched. The ship is owned by JAMSTEC and is used as an inter-university research facility in academic community. The ship is equipped state-of-art instruments, various winches and onboard laboratories. The Shinsei-Maru will be dedicated mainly for surveys in off-Sanriku area, where M9 large earthquakes and the following tsunami and nuclear plant accident destroyed the marine environment and ecosystem. But we have a chance to use the new ship for backarc and hydrothermal studies near Japan.

United Kindom National Update 2013

Richards Hobbs

A major change this year is the transfer of the InterRidge office from the UK to China. So Bramley Murton at Southampton is free of duties! The work of the past three years whilst the office has been based in the UK is summarised in InterRidge News volume 21 but I highlight a few items here:

Enlarged InterRidge membership;

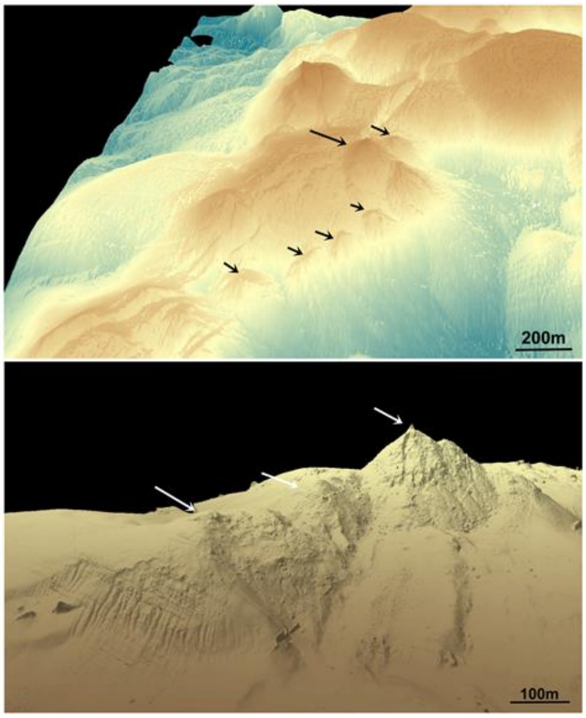
Broadened remit to include arc and backarc systems;

Fellowships and bursaries to encourage young researchers and give them experience on cruises.

Also we have had a new funding arrangement for the UK subscription. The UK research council (NERC) withdrew its direct funding of schemes like InterRidge. Bramley approached the universities and institutes that had a strong interest in ocean ridge research and we now raise a Principal Member subscription direct from those that benefit from interaction with InterRidge ($5k from each of Universities of Durham, Plymouth & Southampton, National Oceanographic Centre and the NERC)

Mid-Cayman Spreading Centre

In February Jon Copley and Bramley Muton (NOC/Southampton) were aboard the RRS James Cook on research cruise JC82 which spent 18 science days at the Mid-Cayman Spreading Centre (MCSC). The cruise was the sequel to RRS James Cook research cruise JC44 in April 2010, which pinpointed and sampled the two confirmed hydrothermal vent fields of the MCSC (Connelly et al., 2012, Nature Communications, 3: 620) based on water column plumes indicated by previous CTD casts by our US colleagues. Cruise JC82 completed 6 ROV dives at the Von Damm Vent Field (depth ~2300 m) and 5 dives at the Beebe Vent Field (depth ~5000 m), with the UK's Isis ROV achieving a total of 196 hours of bottom time. During which time Isis collected: data to make ultra high-resolution bathymetry maps; samples of the mineral deposits and vent fauna; water and gas samples from the vents; and deployed temperature loggers. The deepest hydrothermal activity was observed at 5015m. Other JC82 activities included CTD profiles, plume sampling, and rock dredge sampling at the base of an Oceanic Core Complex. The cruise is part of the multidisciplinary NERC project on "Hydrothermal activity and deep-ocean biology of the Mid-Cayman Rise" and on-going collaborations with US and Japanese colleagues studying the MCSC. Cruise JC82 also included the first live video links from RRS James Cook at sea to outreach audiences ashore, at the Natural History Museum and schools in the UK and France. Parts of the cruise were filmed by a BBC news team, with live broadcast and commentary from the ROV control van being fed to the two most popular news slots at 6pm and 10pm. Footage was also incorporated in a BBC documentary by BBC Science correspondent David Shukman discussing the issue of deep-sea resources and their potential impact from future exploitation. Work is now underway by a dedicated research team at the National Oceanography Centre to unravel the biogeography of the fauna, the origin of the unusual fluid composition and the nature of the mineral deposits at the two sites. Dr Jon Copley was the chief scientist for the cruise, the master of the James Cook was Captain Peter Sarjent, and the research was funded by two NERC research grants awarded to Copley and Murton (NE/I01442X/1 and NE/F017758/1).



The figure shows 3D perspective views of the bathymetry (at 20cm resolution) of (i) the Beebe Vent Field, viewed towards the southeast, with areas of vent fluid emissions and sulphide deposits indicated by the black arrows; (ii) the Von Damm Vent Field, viewed towards the west, with hot vent fluid emissions indicated by the white arrows.

East Scotia Ridge

Results from the NERC funded consortium grant ChEsSO (NE/DO1249X/1) and cruises JC042 and JC055 that studied the vent ecology on the East Scotia ridge, continue to be published and presented at conferences. The latest cruise, JC080 (December 2012 – January 2013), used the Isis ROV to map site E2 (56° 5.3' S, 30° 19.1 W), using multibeam together with CTD casts (see www.bodc.ac.uk/data/information_and_inventories/cruise_inventory/report/11599/ for a full cruise report). Abstract to report reads "JC 80 was to sample the vents sites at E2 and E9 on the East Scotia Ridge, and the Kemp and Adventure craters at the southern end of the South Sandwich Islands. The sampling programme at E2 was very successful completing all the objectives assigned to that site. In addition, we found evidence of an additional vent site at E2 north. It was not possible to access the southern sites at E9 and the Kemp and Adventure craters because the sites were covered in ice as a result of the very hard austral winter, although we were optimistic this would be possible before the end of the cruise. As we were about to complete the study at E2 a crew member became ill and after 24h observation it was decided to evacuate him to land. The ship set sail to Montevideo, considered the most convenient port, which effectively ended the JC80 scientific programme."

An international 3-day meeting took place in Grenada, Spain, to discuss geodynamic and multidisciplinary topics related to the evolution of the Scotia Sea was held in May 2013. The region is of critical importance because of its role as a major ocean gateway which opened during Eocene-Miocene times, and because of its impact on global ocean circulation, with possible importance for Palaeogene-Neogene palaeo-environmental change, early phases of development of Antarctic ice sheets, gene flow, and resulting biodiversity. The Scotia Sea includes several major spreading centres, minor ocean basins and volcanic arcs, whose evolutions are the subject of ongoing debate.

Other research

Palaeomagnetic constraints on lower oceanic crustal processes (IODP Expedition 345 Hess Deep Plutonic Crust (Antony Morris, Plymouth, Andrew McCaig, Leeds). Generation of ocean lithosphere by seafloor spreading at mid-ocean ridges is one of the fundamental geological processes operating on Earth. One of the most important yet most intractable problems is to understand how the magma reservoir beneath ridges generates the lower crust, especially at fast spreading rates. Gabbroic rocks from the lower crust are normally inaccessible, but are exposed tectonically on the flanks of the Hess Deep rift in the Pacific Ocean. IODP Expedition 345 aims to provide a unique suite of lower oceanic crustal samples from this locality that will yield insights into magmatic and tectonic processes involved in seafloor spreading. (gtr.rcuk.ac.uk/project/7C9FF93B-A37F-4B5E-9032-B6612C6184FB).

Hydrothermal systems, thermal boundary layers and detachment faults in slow-spread ocean crust Andrew McCaig (Leeds). Over the last 12 years improved sonar surveys of the mid Atlantic Ridge have revealed a new mode of seafloor spreading where a significant part of the plate divergence is taken up by slip on long-lived, convex upward detachment faults, rather than mainly by magmatic intrusion. In this project we are investigating this boundary layer more thoroughly, as well as the complex interrelationships between faulting, magmatism and hydrothermal circulation at slow spreading ridges. We are addressing this problem by building thermal and hydrothermal numerical models to predict both the asymmetric thermal structure produced by detachment faulting and the hydrothermal circulation patterns associated with permeable fault zones and localised magmatism. Complex interactions between the ocean and the crust that occur as a result of this process. The project is also modelling the Lost City Hydrothermal Field. (gtr.rcuk.ac.uk/project/A9EBE81E-4438-4B88-A28D-669154B7FB9C)

The evolution of mid-ocean ridge magma chambers and the growth of slow-spreading oceanic crust (Johan Lissenberg (Cardiff), MIT & University of Hawaii). Recovered sections of lower oceanic crust have provided much information on crustal accretion mechanisms, but the key element of time has remained largely unconstrained due to the absence of precise dating tools. As a result, the temporal evolution of the accretion process has remained enigmatic. Combining high-precision zircon dating with trace element analyses, we will reconstruct how long magma chambers along a slow-spreading ridge segment were active, how they evolved over time and how quickly they cooled by analysis of samples from the lower oceanic crust recovered from the Vema Lithospheric Section (11 degrees N, Mid-Atlantic Ridge). This will provide an unprecedented view of the evolution of mid-ocean ridge magmatic systems over time. The pattern of the age variation of the samples with distance from the spreading ridge will constrain where magma was delivered to the crust. This allows a test of our hypothesis that slow-spreading oceanic crust forms in two fundamentally different modes, one dominated by symmetric spreading and melt delivery at shallow levels (inferred for Vema), and the other by asymmetric spreading, detachment faulting and deep magma emplacement. (gtr.rcuk.ac.uk/project/2CC07F42-1FDC-490C-8CC3-20F2A401B9AB).

Reactive melt migration in the lower oceanic crust and its implications for the evolution of mid-ocean ridge basalt (Johan Lissenberg (Cardiff)). Mid-ocean ridge basalt (MORB) is the most abundant magma on Earth. It is generated beneath mid-ocean ridges by decompression melting of upwelling mantle, and, following processing in lower crustal magma chambers, erupted onto the seafloor. For more then four decades igneous petrologists and geochemists have relied upon MORB as their major window into the mantle, deriving its composition, melting processes and melt migration mechanisms from the erupted lavas. However, this approach assumes that modification of melts in crustal magma chambers occurs exclusively by fractional crystallisation, and can thus be easily corrected for. Within the last decade evidence has emerged that melt may react extensively with existing cumulus crystals as it migrates through mid-ocean ridge magma chambers. If so, this requires a fundamental reassessment of MORB petrogenesis and its use as a messenger from the mantle. Thus, in order to understand MORB petrogenesis, and its implications for mantle studies, a robust model that fully characterises the nature and extent of reactive flow in oceanic magma chambers is required. I will obtain extensive textural and mineral chemical analyses, acquiring the first systematic dataset on reactive melt migration in the lower oceanic crust. The melt-rock reaction history as deduced from the rock record will then be modelled, allowing its role in MORB evolution to be quantified. Combined, the data and models will provide an unprecedented view of reactive melt migration through mid-ocean ridge magma chambers and its role in the evolution of MORB. Ultimately, this will determine the fidelity of MORB as recorders of mantle properties and processes. (gtr.rcuk.ac.uk/project/9BAA5C4D-67A4-4F34-AA70-F89BC18EF9F5)

The Louisville Ridge-Tonga Trench collision: Implications for subduction zone dynamics Christine Peirce (Durham) & Tony Watts (Oxford) with IGNS New Zealand and Universite Pierre and Marie Curie Paris. Subduction zones provide the mechanism for the destruction of oceanic lithosphere but are also responsible for the construction of arc lithosphere whose features include some of the largest and most active volcanoes on Earth and the majority of large earthquakes. Understanding the dynamics of this system is complicated by the diversity in the age, morphology and tectonic setting of the material that is entering the subduction zone, and yet it is the influence of this material which is a major factor in determining the architecture and composition of the entire trench, island arc, and back-arc system. Between ~5S-35S in the SW Pacific, the Tonga-Kermadec Trench subduction system has a deep, linear topographic depression at which Cretaceous Pacific oceanic crust is subducting beneath the Indo-Australian plate. However, at ~25S the Tonga Trench intersects with the Louisville Ridge, a linear chain of seamounts that runs obliquely to and is being subducted at the fastest rate of plate convergence on Earth (~80 mm/yr). Subduction of this ridge locally deforms the trench, and the point of collision is progressively moving north-to-south at ~118 mm/yr due to the oblique subduction geometry. Gepphysically derived images of the crust, uppermost mantle and seabed will allow us to determine how the crust was constructed, modified and deformed, and how the plate boundary system is evolving over time in response to the subduction of significant plate topography. (gtr.rcuk.ac.uk/project/617D42A8-21AC-4E05-86AF-722896DA874D)

Upcoming Cruises and projects

OSCAR-Oceanographic and Seismic Characterisation of heat dissipation and alteration by hydrothermal fluids at an Axial Ridge. NERC consortium grant (NE/I027010/1) (Richard Hobbs & Christine Peirce (Durham); Miguel Angel Morales Maqueda, David Smeed & Alexis Megann (NOC); Vincent Tong (UCL); Christopher Ballentine (Oxford); together with international partners Marion Jegen (Geomar), Bob Lowell (Virginia Tech), Rob Harris (Oregon State) & Sue Humphris (WHOI)) has been scheduled for January/February 2015. This two-ship programme will investigate the the heat and mass transfer through the seabed at the Costa Rica Ridge and its flanks out to crustal age of about 6 Ma using both geophysical and oceanographic measurements. The geophysical model will be tied to the ODP hole 504B (about 200 km from the ridge). The geophysical data will focus on two 3D Ocean Bottom Seismometer (OBS) surveys at the ridge and hole 504B tied together with three long-offset (>9 km) controlled source seismic profiles with MT (electrical resistivity) and potential field data (gravity and magnetics). The oceanographic data will sample the water inflowing into the basin along the Ecuador trench, current/tidal flows over the Carnegie ridge, map the temperature/salinity structure and turbulence within the Panama Basin. (gtr.rcuk.ac.uk/project/F6313720-CB84-47E4-A2A5 -8B167A6C5170)

Role and extent of detachment faulting at slow-spreading mid-ocean ridges Chris MacLeod (Cardiff), Tim Reston (Birmingham), and Christine Peirce (Durham) (together with Roger Searle, technically as 'consultant'). We will utilise a variety of seismic techniques, at the Mid-Atlantic Ridge axis in the 13°N area, to test competing models for the nature and significance of detachment faults and associated oceanic core complexes. We will combine a passive micro-earthquake study with active source experiments to attempt to document the sub-surface geometry and continuity of detachment faults at depth and the spatial/temporal relationship between melt emplacement and faulting. The project will require two cruises, in order to give sufficient duration for the passive experiment. The cruises are not yet scheduled. (gtr.rcuk.ac.uk/project/B6389C92-8A3E-4DEB-83A1-D913492FFB6F)

Volatile Recycling at the Lesser Antilles Arc: Processes and Consequences (NE/K010824/1) (a project involving UK Universities of Durham, Southampton, Liverpool, Bristol, Imperial, East Anglia & Leeds with international partners University of the West Indies, ETH Zurich, Potsdam & the NSF-funded GeoPRISMS program, project is led by Jon Davidson at Durham) proposes an innovative multidisciplinary experiment to track volatiles at a subduction zone. Questions to be answered include: How do volatiles influence the types and amounts of magmas generated? How do they control where volcanoes, such as Le Soufriere, Montserrat and Mt Pelee, Martinique, are located and how explosive they are? How do volatiles dictate where ore deposits are formed? How do volatiles mediate the seismogenic behaviour of subduction zones - whether there are large "megathrust" earthquakes like Japan and Sumatra or whether slip is less violent? The plan is to use novel seismic approaches complemented by geochemical analyses and integrated using numerical models to identify and quantify where volatiles are in the down-going plate, where they are released at depth, and how they are transported from the subducting plate through the mantle wedge to the arc. Together with a unique suite of rocks from deep in the crust which have been carried up in volcanoes to help understand how magmas evolve, and what allows them to concentrate ore metals. Mapped water pathways will be compared with seismic and volcanic activity, as well as with those inferred at other subduction zones. (gtr.rcuk.ac.uk/project/B98BE408-BEA0-43EB-B069-B7FCBD04BC43)

Korea National Update 2013

Sung-Hyun. Park

Korea Polar Research Institute (KOPRI) had 3rd cruise on Australian-Antarctic Ridge, easternmost Southeast Indian ridge in January this year (2013) using RV Araon. The one of purposes of this cruise was to locate the hydrothermal vent site more precisely, which was found and briefly located by former two cruise. As well as locating the vent site, we did more mapping on the ridge including the seamount in the south of the ridge and got the magnetic data using proton magnetometer. We also did dredging and rock coring to get rock and biological samples.

The cruise was very successful. Using CTD Tow-yo, we confined the vent site (“Araon vent field”) with in 2 km circle. CTD Tow-yo was very effective because we attached OBS and ORP sensors into seabird in collaboration with NOAA. The CTD water samples were analyzed and strong 3He, CH4, Mn, and Fe were detected, confirming OBS and ORP anomalies originated from hydrothermal vent. We also found very interesting features in the bathymetry, gravity and magnetic anomalies. In the geochemistry, very unique mantle heterogeneity was found. Highlight of this cruise is finding of new hydrothermal vent biology using dredging: Kiwa crab and seven arm starfish. DNA analysis was done for these biology and we can confirm they are new species. Probably these vent biology were taken for the first time from the long mid-ocean ridge system in southern ocean from Rodriguez triple junction in Indian Ocean to western end of Pacific Antarctic ridge. We think these new species have similarity with the vent biology reported in East Scotia Sea rather than western Pacific one.

We think first stage of KOPRIDGE project successfully complete its mission and it should advance to next step. We are planning ROV cruise on the new vent site "Araon" and expand the research area to further east where still only a few research survey was done.

Norway national update 2013

Rolf Pedersen

In Norway, researchers from the Centre for Geobiology (CGB) at the University of Bergen continue to undertake most of the ongoing ridge research activity. The ridge research carried at CGB comprises studies of crustal accretion processes and hydrothermal systems - including seafloor and subseafloor geomicrobial activity and vent fauna ecosystems. The ultraslow spreading Arctic ridges are the primary field area. The research on ridge accretion processes is currently focusing on: 1) interactions between the multiple mantle domains present below the Arctic ridges; 2) dynamics of oblique spreading and core complex formation; and 3) the evolution and architecture of axial volcanic ridges. The latter is partly based on the acquisition of microbathymetry using AUV. Our studies of hydrothermal activity have for the last years focused on the Soria Moria, Troll Wall and Loki's Castle vent fields that were discovered in 2005 and 2008. The cruise this summer aimed at locating new vent fields, and at estimating the hydrothermal activity over larger ridge segments. By searching for bubble plumes using hull-mounted multibeam echo sounder systems, two new vent fields were located at the relative shallow parts of the ridge system close to the Jan Mayen. In the deeper parts of the ridge system to the north, three other venting areas were found by searching for chemical signatures in the water column.

Studies of water-rock-microbe interaction and geomicrobiology are presently focused on low-temperature Fe-oxyhydroxide and baryte deposits that are associated with the Arctic vent fields. These studies involve microbial growth experiments, metagenomics, microtextural and geochemical analyses - including heavy stable isotope systematics. A comparison of these modern deposits with Archaean examples is also ongoing. This year, two bioprospecting projects that target novel enzymes in the thermophiles and hyperthermophiles are starting up with industry support.

Following the 2008 discovery of the Loki's Castle vent field and an associated novel vent fauna, a major objective for the Norwegian ridge research program has been to characterize and document this vent fauna. As of today, 20 new species have been found at the Loki's Vent field. With this year's discovery of several new vent fields occurring at water depth from 150 to 2500 m, the diversity of this Arctic vent fauna province will be further explored in the coming years.

In early August this year, the Norwegian Minister of Environment visited the University of Bergen to learn more about the deep-sea and the part of the ridge systems that is present within Norwegian waters. One of the issues that were raised at the meeting was whether Norway should and could proceed towards establishing deep-sea marine sanctuaries at some of these vent fields.

Russia National Update 2013

Sergei Silantyev

The biennial workshop of Russian-Ridge was held in St.-Petersburg on 24-25 June 2013 in VNIIOkeangeologia, St. Petersburg. The topic of this workshop was "The Mid-Oceanic Ridges - new data on geology and mineral deposits". Workshop brought up for discussion most important results of multidisciplinary investigations of the Mid-Oceanic Ridges obtained by Russian scientists during last two years, R-Ridge activities as well as upgrade of the R-Ridge web-site.

Among the most important results of investigations of ridge processes carried out by Russian scientists during 2012 - 2013 and presented on Russian Ridge Workshop'13 it should be to highlight the following:

Mid-Atlantic Ridge Hydrothermal ore deposits

Information on main results of investigations of MAR Sulfide Ore Deposits obtained during 2011-2012 at Russian exploration area has been reported.

In July 2011 on the 17-th session of International Seabed Authority of UN (ISA) Russian application was granted for exploration of polymetallic sulfides at the Atlantic ocean at the area situated at the axial zone of Mid-Atlantic Ridge between latitudes 12°48,36'N and 20°54,36'N was considered and approved. In November 2012 Russian Federation signed the contract with ISA, giving sole priority during 15 years to operate searches and explorations at the limits of declared location, hereinafter called Russian exploration area. The main contractors are Polar Marine Geosurvey Expedition ("PMGE") and "VNIIOkeangeologia n.a. I.S. Gramberg". Russian exploration area embraces 100 blocks about 10 × 10 km in size and total square 10 000 sq. km. By 2010 seven important ore objects were identified at the territory of Russian exploration area: ore cluster "Ashadze" (12°58'-12°59'N); ore cluster "Semyenov" (13°31'N); ore cluster "Logachev" (14°43'-14°45'N); ore field "Krasnov" (16°38'N); ore field "Peterburgskoye" (19°52'N); ore field "Zenith - Victory" (20°08'N) and ore field "Pui-de-Folle" (21°30'N). Total predicted ore deposits until today are estimated at 88—89 ml. tons (Beltenev V., Ivanov V., Samovarov V., Sergeev M. - PMGE and Sevmorgeo, St. Petersburg).

A practical approach to the classification of sulfide ore deposits and new data on their mineralogy and composition in the Russian Prospection Area of MAR has been presented (Andreev S., Babaeva S., Stepanova T. - VNIIOkeangeologia, St. Petersburg).

A relationships between age of ore deposits and their size were established by 230Th/U dating of sulfide ores (Черкашёв Г., Кузнецов В., Бельтенёв В. - VNIIOkeangeologia, PMGE, University of St. Petersburg)

New method for prospecting of hydrothermal ore deposits in MAR has been proposed. This method based on the detecting discharged and strained areas of the oceanic crust (Petukhov S., Aleksandrov P., Kolchina N. - VNIIOkeangeologia, St. Petersburg)

Current situation with data bases and information analysis for support of works in the Russian prospecting area have been discussed. To implement the Russian Contract for prospecting deep-sea polymetallic sulfides (DSPS) in the MAR (2012—2026) at all stages, an information analysis support is provided for the geological prospecting and environmental works at all stages. The information analytical supports of geological prospecting and environmental works enables efficient studies in the International section of the ocean at all stages of prospecting. The Data Bank serves as a basis for compiling maps, prediction of useful minerals, processing and interpretation of geological and geophysical data, evaluating and calculating DSPS reserves. It includes an informative data base, reference base, DBMS, database inquiry library, and application software library. The DB is a relational one; it operates in the Microsoft Access 2007 environment. The basic information on DSPS ore nodes and fields was obtained during 33 cruises in 1986—2012 to the MAR region, carried out by FGUP PMGRE. The data arrays contain information from 2026 geological stations (850 by box sampler, 222 - by grab (tv- grab), 655 - by dredge, 51 - by flow pipe), as well as from 711 rhydrological stations. The data contained in the DB allow not only evaluating the existing hydrothermal nodes and fields, but also show the possible ways of their extension. (Kolchina N., Petukhov S. - VNIIOkeangeologia, St. Petersburg)

Petrology and Geochemistry of igneous rock assemblages in the Mid-Oceanic Ridges

Relations between MAR tectonic features and igneous rocks geochemistry for region between 13o -14oN have been examined. The work is based on melt compositional varieties revealed by analyses of quench basalt glasses from 55 sites. At least 6 compositional melt groups using new data on TR were established in this region. All reported melt compositions are not significantly affected by crystallization, but are mostly the functions of the source composition and degree of melting. The prominent melt compositional variations between 13°30'–13°35'N suggest heterogeneous mantle source of Rift Valley magmatism in MAR segments examined. (A.Pertsev, Bortnikov N., Beltenev V., Shatagin K. - IGEM, Moscow; PMGE, St. Petersburg).

Synthesis petrologic and geochemical data on Zircon from oceanic crust was undertook for reconstruction accompanied petrogeneitic conditions (An example of Sierra-Leone RTI – Markov Deep, 6oN). MAR area at 6oN represent an example of oceanic core complex where altered mafic-ultramafic plutonic rocks are exposed on oceanic floor. Obtained data indicate that zircon in the rocks of oceanic lithosphere is not ideal "container", but together with host rocks is incorporated in all tectono-metamorphic processes and experiences recrystallization. By the example of the zircon populations from altered gabbros of the Sierra Leone at least three types of transformations have been established: 1) related to the recrystallization of primary magmatic zircon under conditions of high-temperature ductile deformation; 2) zircon grains in relation with granite formation often contain numerous inclusions of secondary silicate minerals and acid glass; 3) Porous rims, which overprint both primary and already transformed zircons. The interaction with weakly saline aqueous solutions of elevated alkalinity may facilitate the extraction of high-field TR thus causing simultaneous crystallization of zircon and baddeleyite and increase of Ti content in zircon. Partial or complete recrystallization of primary magmatic zircon and growth of a new zircon generation may proceed in diverse settings typical of core oceanic complexes of the slow-spreading ridges. The formation of plagiogranites during partial melting of gabbros is accompanied by crystallization of zircon from acid melt. Thus, the complex study of structural-morphological and geochemical features of oceanic zircons, inclusions (ingrowths) in them, and phase composition of the host rocks provide insight into processes leading to the crystallization and subsequent evolution of this mineral under conditions of oceanic lithosphere. (Zinger T., Aranovich L., Sharkov E., Bortnikov N. - Institute of Precambrian Geology and Geochronology RAS, St. Petersburg, IGEM RAS, Moscow).

Analysis of Origin of the compositional and isotope Variety of MORB from Equatorial MAR was presented (Skolotnev S. - Geological Institute RAS, Moscow).

Data on existence of regional and local geochemical anomalies of Rift Zone magmatism in the South Atlantic and Scotia Sea have been discussed (Sushevskaya N., Belyatsky B., Dubinin E. – Vernadsky Institute, Moscow; Institute of Precambrian Geology and Geochronology RAS, St. Petersburg; Moscow State University).

In close cooperation with German colleagues from GEOMAR new data on peridotites from Stalemate FZ (NW Pacific) were reported. Samples of ultramafic rocks examined were dredged during German R/V Sonne cruise SO201-KALMAR Leg 1b in frames Russian-German Project KALMAR. The Stalemate Fracture Zone (SFZ) is characterized a 500 km at length, SE-NW strike and situated between the northernmost late-Cretaceous Emperor Seamounts and the Aleutian Trench. The data reported suggest that lherzolites dredged at SFZ are mantle residues after near-fractional melting of mantle source. The mantle melting started in the garnet stability field at a depth more than 100 km and then continue in the spinel stability field. The close location of the Stalemate Fracture Zone to the Hawaiian-Emperor Volcanic Chain suggest the influence by Hawaii Plume on the geochemical peculiarities of peridotites exposed along the SFZ and on the melting process that took place 100 Ma ago. (Krasnova E., Portnyagin M., Silantyev S., Werner R., Hoernle K. - Vernadsky Institute, Moscow; GEOMAR, Kiel, Germany.

Geophysics data and Tectonic in the Mid-Oceanic Ridge Crest Zones The peculiarities of tectonics, structure-forming and magmatism of ultraslow spreading ridges are considered on example of Reykjanes, Kolbeinsey, Mohns, Knipovich, Gakkel and South-West Indian ridges. It is shown that the decisive role in formation of structural plan of their rift zones belongs to temperature of mantle, thickness of crustal brittle layer, and obliquity of spreading. (Dubinin E., Kokhan A., Sushchevskaya N. - Moscow State University, Vernadsky Institute, Moscow).

Voluminous geophysical data obtained in South-Eastern Indian Ocean are presented. Study is focused mainly on the Antarctic part of this Basin. Totally about 30 000 km of seismic, gravity and magnetic data as well as more than 60 sonobuoys have been acquired here by Russian, Australian, Japanese, USA and French Antarctic Expeditions. During pre-oceanic (rift) stage the studied region was developed as a result of extreme crustal extension and mantle unroofing. The zone of exhumed mantle is well defined by linear long-wavelength gravity and magnetic anomalies. The western part of the Oceanic Basin (both on the Australian and Antarctic sides) is complicated by conjugate chains of oblong basement highs which formed during the Paleogene time. These chains are interpreted to be peridotite (partly serpentinized) and gabbro core complexes representing amagmatic accretionary paleoridge segments which are common features of slowly divergent plates. (Leitchenkov G., Guseva Yu. Varova L. – NIIO keangeologia, St. Petersburg; PMGE, St. Petersburg

Listed above data are presented in more detailed design on the web-site of Russian Ridge as abstract volume of Workshop-RR’13 (open access): http://russianridge.ihed.ras.ru

China National Update 2014

Jiabiao Li and Y. John Chen

The China ridge program pays more attention to the geological, ecological and mineralization processes not only on the mid-ocean ridge but also on the seamount in the Area, and completed three cruises on the Southwest Indian Ridge (SWIR), West Pacific as well as the South China Sea in the past year. In addition, some new deep sea scientific equipments have been developed in 2013-2014.

Ridge and Seamount Surveys

On November 2013 to May 2014, Chinese scientists used the R/V "Dayangyihao" to conduct their ridge-crest survey on the polymetallic sulfides exploration area which located on the SWIR between 46°S and 53°S. During this cruise, ten hydrothermal sites have been confirmed using the deep-tow system, MAPR, and ROV, etc. Near-bottom exploration technology system which ROV, near-bottom electro magnemeter and magnetometer system involved was firstly conducted on the Longqi, Changbaishan, and Duanqiao hydrothermal field. In addition, a 6-meter drilling system was also firstly used in this cruise; however, the recoveries of the drilling core need to be improved in the future.

On January to March 2014, the IODP (International Ocean Discovery Program) 349 expedition on board the R/V "JOIDES Resolution" firstly visited the South China Sea to determine the age of the this marginal sea, and to resolve ongoing controversy over how it formed. About 1,500 m long of the sediment core and 100 m long of the mid-ocean ridge basalt samples have been recovered in this cruise. These samples provides the researchers a great chance not only to tell precisely when the seafloor started to spread and when the process ended, but also to pinpoint which of the continental break-up hypotheses is the most likely.

In addition, the manned submersible "Jiaolong" with R/V "Xiangyanghong 9" visited the two seamounts in the West Pacific on June to August 2014. "Jiaolong" completed ten dives, and collected some ferromanganese crusts, cobalt nodules as well as zoobenthos samples to help the scientists understand the distributions, geological characteristics of the crusts and nodules mineralization with their biochemical environment on the Caiwei and Weijia Seamount.

Forthcoming cruises

For 2014 to 2015, the China ridge program will be using three research vessels for the researchers along the SWIR and Carlsberg Ridge. The research vessel "Dayangyihao" and the manned submersible "Jiaolong" will visit the Southwest Indian Ridge to explore the known hydrothermal sites and understand the linkage between hydrothermalism and volcanism on the ultraslow-spreading ridge. The research vessel "Zhukezhen" will revisit the slow-spreading Carlsberg Ridge in the north of Indian Ocean in early 2015 to collect new evidences of the hydrothermal activities in order to understand the occurrence of axial (e.g., neo-volcanic ridge) and off-axial (e.g., oceanic core complex) massive sulfides along the Carlsberg Ridge.

Photo of the hydrothermal fauna in the Longqi hydrothermal field on the SWIR

New Device and Equipment

The AUV "Qianlong-1" which working depth up to 6,000 m, has completed nine dives in the West Pacific on September 2014. Another newly building AUV "Qianlong-2" which working depth up to 4,500 m and sidescan sonar, multibeam, camera, and chemical sensors are installed, has been developed in early 2014, and will map the Longqi and Changbanshan hydrothermal fields on the SWIR in late 2014.

Symposiums and National Conference

1. The 3nd national conference of "Earth System Science Symposium" was held in Shanghai on July 2-4, 2014. Over 900 scientists and students participated in this national conference. This conference strongly focused on interdisciplinary studies in ocean science including biological evolution and environment, ocean and climate, biogeochemical cycle, deep-sea resource and technology, and dynamic process of deep earth. Two sessions "Modern seafloor mineralization and comparison with their ancient analogs" and "Deep structure of South China Sea and its genesis" were organized by China ridge program.

2. The 4th international symposium on "Scientific and Legal Aspects of the Regimes of the Continental Shelf and the Area" was held in Xiamen on April 22-23. Over 150 scientists and officials from the institutes, universities and international organizations (e.g., International Seabed Authority and Commission on the Limits of the Continental Shelf) attended in this conference. Prof. Edward Baker (NOAA, USA) and Prof. Roger Searle (Durham University, UK) were invited by China ridge program to give two talks on the mid-ocean ridge and exploration for hydrothermal plumes in this conference respectively.

United Kingdom National Update 2014

Richard Hobbs

At the NOC Bramley Murton continues its research into the Mid-Cayman Spreading Centre (MCSC) through two NERC-funded research grants to Copley and Murton. Work on the MCSC hydrothermal systems have revealed unusual chemistry and composition of vent fluids from the Vonn Damm vent field situated on the upper slopes of Mt Dent (Hodgkinson et al., submitted), a large massif on the mid-western flanks of the MCSC, and the Beebe Vent Field (the deepest known) in the northern volcanic zone of the MCSC (Webber et al., in prep.). Comprising gabbros and serpentinised peridotite, Mt Dent has many of the features of an oceanic core complex (OCC). Analysis of high-resolution imagery data from the AUV Autsub6000 (Murton and Haughton, in prep) shows active slip on the detachment fault at the toe of Mt Dent with the formation of klippen (detached fragments of the hanging wall) that are stranded on the foot wall (Figure 1). These klippen are made of pillow lavas and lie directly on peridotites exposed on the foot wall of the OCC - and are analogous to the Eastern Limassol Forest Complex, Cyprus, as described by MacLeod and Murton, 1993 (Geol Soc, Lond, Sp Pub. Vol 76, p. 141-176). Continuing analysis of the high-resolution AUV data across the entire width of the Mt Dent OCC has revealed a complex tectonic evolution for the OCC with extensional faulting in the footwall at both the toe and crest of the OCC, and compression at the breakaway zone and in the hanging wall at the toe of the OCC.

The NOC is a joint leader of a 15M euro, EC-supported, research programme focused on seafloor mineral resources. The programme, called 'Blue Mining' (http://www.bluemining.eu), is led by a Dutch industrial consortium and involves German, Portugease and British researchers and industries. Its aim is to understand the formation and evolution of seafloor mineral resources, especially massive sulphides, and assess their viability as potential resources. 'Blue Mining' has a sister programme, called 'MIDAS' (http://eu-midas.net) that is examining the potential ecological impacts of seafloor mineral resource exploitation. Both programmes have a mid-ocean ridge focus and aim to assess the question of responsible and environmentally sustainable mineral extraction for the deep-ocean.

Research at Cambridge (Nicky White's group) identified a seismic gap on the Reykjanes Ridge south of Iceland as well as a similar gap at the same radial distance from Iceland on the Kolbeinsey Ridge to North. The gap is real and coincides with a set of geochemical and tectonic observation which suggest that we have caught a hot mantle ripple `in the act' of expanding away from Iceland plume centre.

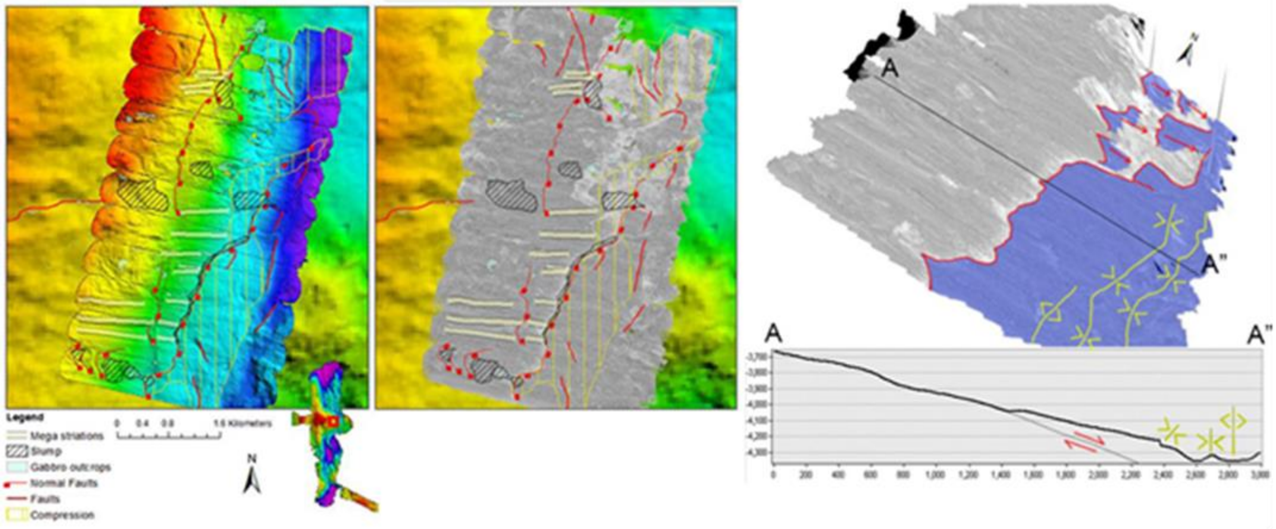


Figure 1: left: high resolution (1m2) AUV derived swath sonar bathymetry (combined with a background of 50m2 ship-derived multi beam bathymetry) of the toe of Mt Dent showing corrugations, slides and faulting on the foot wall, the trace of the low-angle detachment fault, and zones of compression on the hanging wall. Centre: acoustic backscatter from the AUV acoustic imagery showing recent areas of faulting (light grey) and older surfaces with a thin veneer of sediment (darker areas). Right: Perspective view of acoustic backscatter draped over high-resolution bathymetry showing exposure of sediment free areas of foot-wall along the trace of the low-angle detachment fault and offsets in the fault zone forming klippen of hanging wall all indicating the Mt Dent OCC is still tectonically active and in the process of growth.

Parnell-Turner, Ross and White, Nicky and Henstock, Tim and Murton, Bramley and Maclennan, John and Jones, Stephen M. (2014) A Continuous 55 Million Year Record of Transient Mantle Plume Activity Beneath Iceland. Nature Geoscience. (In Press)

Parnell-Turner, R. E. and White, N. J. and Maclennan, J. and Henstock, T. J. and Murton, B. J. and Jones, S. M. (2013) Crustal Manifestations of a Hot Transient Pulse Beneath the Mid-Atlantic Ridge near 60°N. Earth and Planetary Science Letters, 363. pp. 109-120.

Though Jon Copley's group at the University of Southampton this year has had no research cruises this year, Dr Verity Nye took part in a research cruise with Japanese colleagues to the Okinawa Trough (KY14-01, Jan 2014), as a guest of JAMSTEC colleagues. Ridge-related publications include a study of the reproductive biology of a new shrimp species discovered at a vent field on the Mid-Cayman Spreading Centre (Nye & Copley, 2014)

Nye V E & Copley J T (2014). The reproductive biology of Lebbeus virentova (Caridea: Hippolytidae) at the Von Damm Vent Field, Mid-Cayman Speading Centre, Caribbean. Marine Biology, 161: 2371-2380, doi:10.1007/s00227-014-2512-9.

Neil Michell, at Manchester, has published work on the Red Sea spreading centre (Michell & Park, 2014).

Mitchell, NC, Y Park (2014). Nature of crust in the central Red Sea, Tectonophysics, 628, 123-139.

Recent geodynamical modelling of combined continental collision and opening of backarc basins by Jeroen van Hunen group at Durham University explains their observed relationship (Magni et al., 2014, Geology): focussing of roll-back forces at the edges of colliding continental blocks provide the required stress field to open back-arc basins and induce slab tearing.

Magni, V., Faccenna, C., van Hunen, J. & Funiciello, F. (2014). How collision triggers backarc extension: Insight into Mediterranean style of extension from 3-D numerical models. Geology 42(6): 511.

Richard Hobbs cruise to investigate heat and mass transfer at a mid-ocean ridge will start in in

December this year (2014). The multidisciplinary project will collect physical oceanography data (led by Miguel Morales NOC), heat-flow (led by Rob Harris, Oregon state funded by NSF), geophysics (led by Richard Hobbs) in the Panama Basin. The cruise will have benefit from an Interridge cruise bursary for Gavin Haughton. Qunshu Tang from the South China Sea Oceanography Institute, as well as scientists from Colombia, Costa Rica and Ecuador will be involved.

Other ridge related projects funded in 2014, abstracted from the RCUK website.

A nutrient and carbon pump over mid-ocean ridges (RidgeMix).

University of Liverpool, United Kingdom (Lead Research Organisation)

National Oceanography Centre, United Kingdom (Project Partner)

Woods Hole Oceanographic Inst, United States (Project Partner)

Monterey Bay Aquarium Research Institute, United States (Project Partner)

In this proposal, we address the problem of how deep nutrients are transported into the surface waters in mid-latitudes. We propose to test a new view: tides passing over the mid-Atlantic ridge generate enhanced turbulence and mixing, which in turn provides a nutrient supply to the upper thermocline waters. These nutrients are then transported horizontally along density surfaces over the western side of the basin, probably being swept along the Gulf Stream and eventually passing into the winter mixed surface layer. When this surface layer shallows and warms in spring, the nutrients are then available to the phytoplankton. The work plan involves two main components. We will carry out a field programme collecting measurements of the turbulence and nutrient concentrations over and adjacent to the mid-Atlantic ridge. This fieldwork will involve collecting data from a novel long-term moored array of instruments on the ridge along with a focused 5 week research cruise. Our work involves sampling sufficiently quickly to be able to resolve tidal changes in currents and mixing over the ridge: this has never been done before, and we have brought together scientists with expertise in tidal measurements in shallower shelf seas with others who are expert in deep ocean mixing and transports in order to do this. The 2nd component of our work will use computer models of circulation in the Atlantic to explore the wider implications of the fieldwork observations, allowing us to decide whether or not mixing over the mid-Atlantic ridge really does provide enough nutrients to explain the phytoplankton production in the mid-latitude N Atlantic.

http://gtr.rcuk.ac.uk/project/6AA4E607-6491-4530-A39F-22B1F5069839

Role and extent of detachment faulting at slow-spreading mid-ocean ridges

Durham University, United Kingdom (Lead Research Organisation)

Cardiff University, United Kingdom (Lead Research Organisation)

We propose to obtain these data in a comprehensive seismic and seabed magnetic survey of the MAR in the 13N region, where detachment faults are active at the ridge axis today. We will use a large array of ocean-bottom seismographs (OBSs) to image 3D velocity variations related to different rock types using 'seismic tomography' - akin to medical CT scanning - and conduct a multi-channel reflection survey, which will image sub-surface discontinuities - like a simple X-ray. We will then leave the OBSs (to be recovered on a later cruise) to record the locations of natural micro-earthquakes in the region. These will show directly the 3D geometry and linkage of active faults. Finally, we will deploy the autonomous robot vehicle Autosub 6000, which will be programmed to make very detailed maps of magnetic field reversals (yielding seafloor age and spreading rate) and seafloor topography (helping structural interpretations) while we perform the seismic experiments.

http://gtr.rcuk.ac.uk/project/28686396-43F6-4FA2-A9EC-040391AF9C81

Accretion of the lower oceanic crust: Reconciling evidence of hydrothermal fluid fluxes with mineral cooling rates from ODP Hole 1256D, IODP Exp335

University of Southampton, United Kingdom (Lead Research Organisation)

From studies of ophiolites, pieces of the ocean crust that are now emplaced on the continents, two end member models for the accretion of the lower crust have been proposed, the "gabbro glacier" and "sheeted sills" models. They primarily differ in the location of melt intrusion and crystallisation. The removal of the heat within the melt has to be effectively achieved within a few kilometres of the ridge axis, and places strict thermal constraints on the feasibility of the accretion models. Heat from the lower crust can be extracted by conduction into the surrounding rock and by heating seawater-derived hydrothermal fluids that percolate into the crust and convect heat away to the seafloor. The hydrothermal fluids are recorded in the igneous rocks by fluid-rock chemical reactions that create new secondary minerals. These minerals are present both replacing primary igneous minerals and filling fractures to form hydrothermal veins. The thermal feasibility of the two accretion models is intimately linked to the magnitude and distribution of hydrothermal fluids in the ocean crust, with the multiple sills model requiring extensive hydrothermal cooling in the lower crust. Samples recovered from an intact section of the lower crust will provide opportunity to test these models.

http://gtr.rcuk.ac.uk/project/CC188601-FE37-4252-B3C9-CBD803A07472

France National Update 2014

Maria Maia

In 2014, the French ridge community started several new projects over different spreading centres around the world and continued its research on the MoMAR deep-sea observatory. The projects cover a wide panel of themes, including hydroacoustics, ridge hydrothermal, magmatic and tectonic processes, mantle geochemistry, vent ecology and biology, from regional to local scales and using several different technologies. An important event for the French ridge community was the elaboration of a report on the environmental impact of deep-sea mining activities under the guidance of the Ministry of Environment.

Several cruises targeted the study of the Mid-Atlantic Ridge, including the MoMAR (Monitoring the MAR) deep-sea observatory, located on the Lucky Strike volcano, south of the Azores. The annual cruise targeted to service the stand-alone observatory (MOMARSAT 2014) took place on board the R/V "Pourquoi Pas?" with the ROV Victor 6000 in August-September 2013 (P.I. P.-M. Sarradin). This year, the cruise serviced the two seabed monitoring nodes, the acoustic surface buoy, installed four OBS, one OBM and one OBT in the geophysical node and several temperature and colonizing devices and performed a complementary sampling program on fluids, rocks, fauna and microorganisms aimed at increasing the spatial resolution of the study. The geophysical node, installed in the center of the lava lake hosts an OBS and a permanent pressure gauge. The second node, dedicated to the study the links between faunal dynamics and physico-chemical factors is installed at the base of the Tour Eiffel active vent. This node is composed of a HD video camera, 4 LED lights, an Aanderaa optode, an in situ chemical analyser and an instrumented microbial colonization device. The observatory system is nested in arrays of autonomous sensors (OBSs, pressure probes, temperature probes in selected smokers, current meters and temperature probes in the water column), and colonization devices for time-integrated faunal studies. Since the MoMAR site, part of the EMSO network, is one of the priorities of the French ridge studies, the 2015 and 2016 cruises (MOMARSAT 2015, 2016) area already scheduled. HYDROMOMAR (P.I. J. Perrot), in July 2013 recovered and redeployed five hydrophones around the Lucky Strike segment to monitor the seismic activity in the area of the MoMAR observatory, an experiment that started in 2010. The instruments will be recovered in 2016. A second, short term, hydroacoustic deployment in the Equatorial MAR ended in May 2014 with the recovery of the five instruments moored in January-February 2013 during the COLMEIA cruise. The five instruments were recovered with the help of the Brazilian Navy using the patrol ship "Araguari". Still in the MAR, the BICOSE cruise (P.I. M.A. Cambon) targeted the study of the biodiversity of the TAG and the Snake Pit hydrothermal sites in order to understand the life cycles and larval dispersal at two differently mature sites.

The Indian Ocean mid-oceanic ridges were also important targets for the French community. The OHA-SIS-BIO experiment aims the monitoring of the seismic activity of the three Indian ridges as well as whale vocalizations through an array of hydrophones, moored between Réunion Island and the French Austral and Antarctic Territories (TAAF). The network is annually serviced during the R/V Marion Dufresne cruises for maintenance of the TAAF stations in Crozet, Amsterdam and Kerguelen islands. In 2014, the OHA-SIS-BIO cruise took place in January-February. This site is also considered as one of the priorities for French ridge studies and the servicing cruises for 2015 and 2016 area already scheduled. Early 2015 the STORM cruise (P.I. A. Briais) will investigate the mantle flow between the Pacific and Indian oceans and its influence on the ridge structure between Tasmania and Antarctica, as well as search for new hydrothermal sites.

France has been granted by ISA the permit to explore mineral resources in an area on the Mid-Atlantic Ridge between 10 and 20°N and the final contract is under signature.

Completed in the end of 2013 and beginning of 2014	
ODEMAR 15/11 – 31/12/2013 MAR 15°N	Pourquoi Pas ?
OHA-SIS-BIO 6 VT 135 04/01-17/02/2014 Indian Ocean	Marion Dufresne
BICOSE 10/01 – 11/02/2014	Pourquoi Pas ?
COLMEIA-HYDRO 22/05-29/05/2014 Equatorial MAR	Araguari (Brazilian Navy)
HYDROBSMOMAR 07/06 – 21/06/2014 MoMAR observatory	Le Suroit
MOMARSAT 2014 13/07 – 31/07 2014 MOMAR observatory	Pourquoi Pas ?
SISMOSMOOTH 19/09 – 02/11/2014 SWIR	Marion Dufresne
Scheduled for end 2014 and beginning of 2015	
STORM 31/12/2014 – 01/02/2015 AAD	L'Atalante
Expected in 2015-2016	
OHA-SIS-BIO 7	Marion Dufresne
MOMARSAT 2015	Pourquoi Pas ?
FUTUNA	L'Atalante

Japan national Update 2014

Kyoko Okino

The InterRidge-Japan program continues efforts to promote ridge-related studies in Japan and to maintain our community. The outline of the ongoing project and other activities are described below.

Domestic Meeting

We had a business meeting on May 1, 2014, at a Japan Geoscience Union Meeting 2014, where we shared information on a budget of the IR, cruises, international affairs, and discuss the InterRidge-Japan annual activity plan. We are forced to get along without an umbrella project supporting the annual contribution to IR in FY2014. Most members don't satisfy the present condition of IR and are skeptical of keeping full membership. We realized that IR is currently at a critical stage and it's time to discuss how to reorganize the organization. We have received the benefits from IR activity for long time and hoped to maintain the international network that IR has nurtured. We decided to propose a new IR model with slim budget in coming StCom meeting.

Publication of Project "TAIGA"

The interdisciplinary research project TAIGA, Trans-crustal Advection and In-situ biogeochemical processes of Global sub-seafloor Aquifer, funded by MEXT (Ministry of Education, Culture, Sports Science and Technology), and ended March 2013.

We edited a book to deliver all results of the TAIGA project at a glance and the book will be soon published on line (open access) from Springer. The results of the project have been summarized comprehensively in 50 chapters, and this book provides an overall introduction and relevant topics on the mid-ocean ridge system of the Indian Ocean and on the arc-backarc systems of the Southern Mariana Trough and Okinawa Trough.

See "Subseafloor Biosphere Linked to Hydrothermal Systems", Ishibashi, Okino and Sunamura (Eds.)

http://www.springer.com/earth+sciences+and+geography/earth+system+sciences/book/978-4-431-54864-5

Finished and ongoing cruises FY2013-2014

As a part of QUELLE2013, the R/V Yokosuka cruise around the world with Shinkai 6500, the southern Central Indian Ridge and the Mid-Cayman Trough were investigated. The outline and preliminary results are posted at the web site (http://www.jamstec.go.jp/quelle2013/e/). In FY 2014, many cruises were conducted or now going on in the hydrothermal areas in the Okinawa Trough and the Izu-Ogasawara-Mariana arc/backarc.

Canada National Update 2014

Kim Juniper

2013-2014 Activities

Over the past year, Canadian ridge researchers have not undertaken any dedicated ridge research cruises. Activities have been mostly limited to work on existing data and samples from the Endeavour Segment of the Juan de Fuca Ridge, by University of Victoria graduate students (Juniper and Tunnicliffe laboratories).

1) Biological studies have concentrated on bacterial symbiosis and population biology of the tubeworm Ridgeia piscesae, and on exploiting data from the NEPTUNE observatory camera and sensors in the Main Endeavour vent field. The observatory work is examining species responses to habitat variations, and involves a collaboration between the University of Victoria, Ifremer and Washington State University.

2) Ocean Networks Canada undertook a maintenance cruise to the Endeavour vent fields in May 2014, with the remotely-operated vehicle ROPOS on board the Canadian Coast Guard ship John P. Tully. The cruise serviced and redeployed instruments in the Main Endeavour field, and conducted seafloor tests of failed extension cables that connect the array of four regional circulation experiment moorings to the NEPTUNE network. During this cruise, sediment samples were collected throughout the area, to support a study of the spatial distribution of hydrothermal plume precipitates by a graduate student from the Coogan lab at the University of Victoria.

Upcoming Activities

1) In November 2014 the Juniper and Tunnicliffe labs from the University of Victoria will participate in a cruise to hydrothermal vents on several Mariana Arc volcanoes. This cruise, which will use the remotely-operated vehicle Jason on the R/V Thomas G. Thompson, will be led by Craig Moyer of Western Washington University. The Mariana Arc volcanoes offer contrasting geological and hydrothermal settings, and associated biological communities that have been studied since 2004.

2) Ifremer and Ocean Networks Canada will conduct a joint workshop in Brest, France during the week of November 24, 2014. This workshop will bring together researchers who use observatory infrastructure at the Lucky Strike site on the Mid-Atlantic Ridge and the Main Endeavour field on the Juan de Fuca Ridge. The goals of the workshop are to share research results and develop ideas for comparative studies that can use the observatory technology at the two sites.

3) An Ocean Networks Canada maintenance cruise is planned for August 2015 to begin replacement of failed extension cables and prepare for a major expansion of the observing system at Endeavour Segment that has been funded through a Canada Foundation for Innovation award to Laurence Coogan of the University of Victoria, and a U.S. National Science Foundation award to Daniela Diorio of the University of Georgia. When complete, this project will nearly triple the online observatory instrumentation at Endeavour Segment, and expand the observing system from the Main Endeavour field to include the High rise and Mothra vent fields to the north and south, respectively.

Norway National Update 2014

Filipa Marques and Rolf Peterson

In Norway, research in the Arctic Mid-Ocean Ridge system is mostly done by the Center for Geobiology (CGB) at the University of Bergen (UiB). The CGB team is truly multidisciplinary and research topics carried by CGB scientists in ridge systems comprise crustal accretion processes, seafloor and sub-seafloor sulfide mineralization, natural fluid and gas emissions, geomicrobial activity, water-rock-microbe interactions, and vent fauna ecosystems. All areas merge into one mutual purpose, to better understand oceanic systems.

Year 2014 marks the establishment of the Norwegian Marine Robotics Facility (NORMAR) as a joint effort by University of Bergen (UiB), Institute of Marine Research (IMR), and Christian Michelsen Research (CMR). NORMAR will provide a state-of-the-art marine robotic infrastructure to a large marine science community that addresses basic research, as well as industrial and socially relevant research challenges. Funding for the acquisition of a Remotely Operated Vehicle (ROV) was granted late in 2013 and it will be made available for the ocean-going fleet of research vessels in 2015.

The CGB - UiB is one of the 32 partners in the MIDAS project (Managing impacts of deep sea resource exploitation) that covers a very broad range of disciplines (ecosystem studies, ecotoxicology, geological and geotechnical studies, geochemical analyses, stakeholder engagement, socio-economics, legal and policy related aspects). This project started in November 2013 and will last for 36 months. CGB researchers will deal with identifying the nature and scale of the expected geological impacts arising from deep-sea mining by: (1) investigating weathering of sulfides with focus on weathering rates and mobilization of metals in relation to deep-sea mining; and (2) investigating hydrothermal fall out deposits and the biogeochemical processes as an analogue for potential fall out during deep-sea mining.

During this year's cruise CGB 2014 (PI Rolf Pedersen, UiB-CGB) researchers on-board the R/V G.O. Sars surveyed and explored the Northern Kolbeinsey Ridge and the Mohns Ridge. Throughout 1 month, 114 ship-based operations were executed including ROV survey and sampling, AUV-SAS mapping, high-resolution multibeam bathymetry, TOPAS, gravity corers, macro-biology trawls and sledges, rock dredging, and CTDs.

The CGB team has explored, for the first time, two seafloor hydrothermal systems. These two vent fields have been located in the summer of 2013 by searching for bubble plumes using multi-beam systems. The first field, on the Northern segment of the Kolbeinsey Ridge, is a shallow system named "Seven Sisters". The second field, close to Jan Mayen vent field, on the Southern Mohns segment, was named "Perle og Bruse".

The main achievements of the CGB2014 cruise on the Arctic Mid-Ocean Ridge (AMOR) system were as follows:

- Multi-resolution acoustic mapping in support of at sea operations and geological mapping of seafloor hydrothermal systems and ocean core complexes.

- Better constrain the geology of the northern sector of Kolbeinsey ridge by defining volcanically and tectonically active areas in order to continue the study on crustal accretion processes, evolution and architecture of axial volcanic ridges.

- Map and characterize the diversity of ore-forming processes on the AMOR by ROV surveying and sampling of hydrothermally altered rocks and massive sulfides from distinct seafloor hydrothermal systems.

- To continue studies of water-rock-microbe interaction and geomicrobiology focused on low-temperature Fe-oxyhydroxide and barite deposits that are associated with the Arctic vent fields.

- To gather information on the geochemical stratification of the full water column in the Arctic areas as well as on the distribution of hydrothermal water column signatures over time and space.

- To characterize the composition of the fluids and gases venting at the newly discovered vent fields at the Kolbeinsey Ridge and at the Jan Mayen vent fields as well as gather more information about diffuse venting at the already known Loki´s Castle and Jan Mayen vent fields.

- To understand the chemical processes ongoing in sediment cores from different locations along the Arctic ridge system. These studies involve heat flux measurements, microbial growth experiments, metagenomics, microtextural and geochemical analyses, and sulfate reduction (SRR) rate estimates by isotope incubation.

- Access faunal communities by sampling of macrofauna (ROV, Trawl, Sledge, Dredge) from new vents on Northern Kolbeinsey and Southern Mohns Ridges, Loki's Castle, Schulz massif, and from surrounding waters.

- Set up several MIDAS experiments in two different seafloor hydrothermal systems with contrasting depths and settings. On the following years, the experimental apparatus will be recovered and studied.

Philippines National Update 2014

Graciano P. Yumul Jr.

The past year saw the Philippine ridge community's involvement in international ridge–related activities. These activities included the convening and hosting of an international symposium in the Philippines and participation of Philippine geoscientists in a marine scientific cruise. New laboratories housing an electron probe microanalyzer and a set of paleomagnetic equipment, the first in the country, became operational this year.

International Symposium and Fieldwork

The 2nd International Symposium of the International Geoscience Programme Project (IGCP) 589 in Boracay Island, Philippines last 4-7 November 2013. Papers about the Tethyan realm were presented. Participants to the symposium and post-symposium fieldwork were from China, Japan, Thailand, Malaysia, Poland, Iran and the Philippines (Figure 1). The geodynamic evolution of the Philippine archipelago, emplacement and tectonic history of Mesozoic ophiolites, magmatic and metamorphic processes, and sedimentological and paleontologic studies of east and southeast Asian region are among the topics highlighted during the symposium. Post-symposium fieldwork was conducted around the western portion of the Buruanga Peninsuala of the Panay Island. Participants were introduced to the different sedimentary sequences and ophiolitic terrane in the Island.

Ophiolite complex in southern Samar. Major mineral chemistry of spinel and olivines in the dunite suggests composition typical of oceanic mantle peridotites (Figure 2). The whole rock geochemical data and mineral chemistry data indicates that the Samar Ophiolite Complex exhibits an affinity to mid-oceanic ridge and supra-subduction zone settings.

Figure 1. The IGCP 589 symposium and fieldwork was held last November 4-7, 2014 in Boracay and Panay islands.

Cruises

Philippine scientists joined the three-week cruise of the Marine Scientific Research (MSR) joint project aboard the R/V Ocean Researcher 5 (R/V OR5) of the Taiwan Ocean Research Institute. Bathymetric, gravity, magnetic and seismic reflection data were collected within the Manila Trench region from June 23 July 13, 2014. From the marine geophysical data, attempts will be made to characterize the seafloor and subsurface features of the Manila Trench system. An assessment will also be made for the potential of the Manila Trench to generate mega-earthquakes and trigger the attendant seismic hazards such as tsunamis.

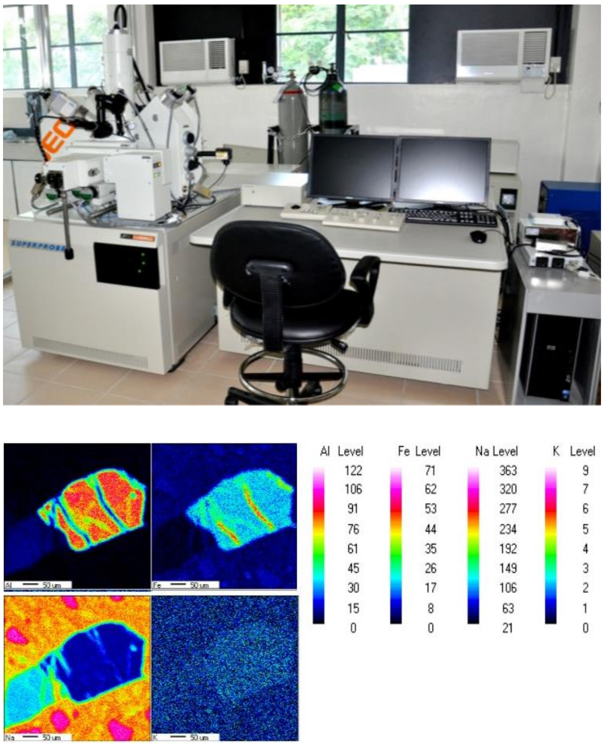


Figure 2. JEOL JXA-8230 at the National Institute of Geological Sciences, University of the Philippines (left) and compositional maps obtained using the EPMA (right).

New Laboratory Equipment

The first and only Electron Probe Microanalyzer (EPMA) in the Philippines is currently housed at the National Institute of Geological Sciences, University of the Philippines (NIGS-UP). The EPMA is being used to analyze the mineral chemistry of samples from the ophiolite complexes in the Philippine island arc system. Recent geologic expeditions have been conducted to examine the The paleomagnetic laboratory was also recently set up at the NIGS-UP and includes an AGICO JR6A dual spinner magnetometer, Molspin alternating field demagnetizer, TD-48SC thermal demagnetizer, IM10 impulse magnetizer, μ-metal bucket shield and degaussing wand. The paleomagnetic laboratory is being utilized to determine the paleolatitude of different rock formations, and thereby establish spatial constraints on the tectonic reconstruction of the archipelago.

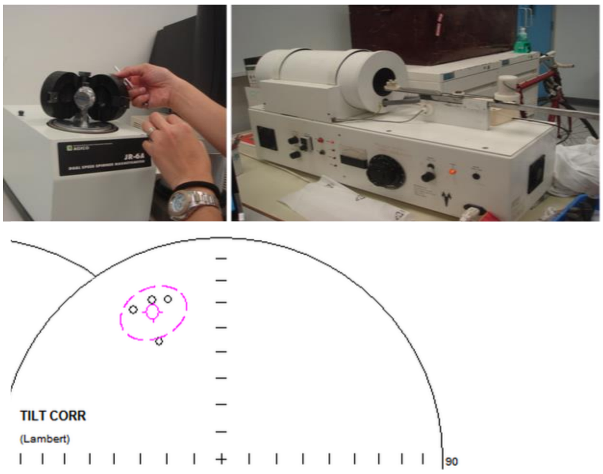


Figure 3. Data from the spinner magnetometer (left) and alternating field demagnetizer (middle) are plotted on equal-area stereonets (right). The paleomagnetic results constrain the paleolatitudes of the islands which will be useful in palinspastic reconstructions.

New Zealand National Report 2014

Richard Wysoczanski, Christian Timm and Malcolm Clark

The past two years, since the last New Zealand national report, has seen a number of internationally collaborative voyages conducted with plans for further voyages as well as IODP drilling planned. Much of the research has extended the focus of New Zealand research beyond the kermadec arc, with intensive studies of the Colville and Kemadec Ridges, the Louisville Seamount chain and the Reinga Basin. Also in this time, Wellington hosted a NSF co-funded GeoPRISMS workshop on the New Zealand subduction systems, which is a focus site of the GeoPRISMS implementation plan. Finally two special issues of Economic Geology that highlight InterRidge research were published.

Research voyages

Investigations of the Colville arc

In October 2012, the research voyage TAN1213 ('NIRVANA') was completed by R/V Tangaroa (Voyage Leader Richard Wysoczanski, NIWA). This was a joint study between the National Institute of Water and Atmospheric Research (NIWA), GNS Science and the University of Auckland that built on previous work undertaken during TAN1007 ('KARMA'). A primary focus was to investigate the little explored Colville Ridge, which together with the Kermadec Ridge is a remnant arc that predates the modern Kermadec arc. Multibeam echosounder (MBES) using a Kongsberg EM302 echosounder, imaging revealed an extinct volcano ('Colville volcano') on the ridge. The volcano was sampled for rock and biological specimens, which showed the Ridge to consist of old Mn-encrusted volcanic rocks and sediments that are host to biological assemblages distinct to the Kermadec arc. Multi-channel seismic profiles were also conducted, including a continuous line across the Havre Trough, between the Colville and Kermadec Ridges.

A second major objective was to explore Havre volcano, which erupted a few months earlier in July 2012. MBES surveys showed the growth of several new cones up to 220 m in height on the south and southwestern flank of the caldera that sourced the eruption. Also notable was a large bulge in the western caldera wall and shallowing of the ~5 km wide caldera by up to 50 m. Sampling revealed a suite of eruption products ranging from dark rhyodacite to while pumice, that latter being the same material that comprised the massive pumice raft that originated from Havre volcano and spread across the Pacific. Also f note was the complete absence of biological material in the epibenthic sled deployments.

The first research voyage to systematically map the southern part of the Miocene Colville Ridge offshore New Zealand and collect magnetic and gravity data and rock samples with R/V Tangaroa (Colville'13) was been undertaken between 15 November and 1 December 2013 (VL Cornel de Ronde, GNS Science). Generally, the weather was fine although some rough patches forced us to change the ship's heading to be able to acquire high quality bathymetric and geophysical data. To ground truth the collected shipboard data 15 dredges hauls were conducted along the mapped segment producing volcanic and sedimentary rocks.

Figure 1. Bands of floated pumice 80 NM west rom the source, Havre volcano. The main pumice raft was 25,000 sq. km. Credit: R. Stewart, NIWA.

Joint Japan-New Zealand research

In October 2013 New Zealand scientists from NIWA, GNS Science and Victoria University of Wellington joined Japanese colleagues on board the JAMSTEC vessel R/V Yokosuka (YK13-11: VL Shinji Tsuchida, JAMSTEC) for its New Zealand leg of "Quelle2013" (Quest for the limit of Life, a global expedition exploring deep-sea environments). The voyage sampled two areas: the northern section of the Louisville Seamount Chain, and part of the northern Kermadec Arc.

The Louisville seamounts have seen considerable geological and geophysical research in the past, but the biodiversity and ecology of the area is poorly known. The dives by the Shinkai 6500, and deployment of a deep-towed camera system, enabled the first detailed biological investigation of two of the northern-most seamounts. The objectives of this part of the voyage were to determine benthic biodiversity of the seamounts, as well as investigate whether the seamounts, as they are subducted deeper and deeper into the Kermadec trench could sustain communities that normally would only exist in shallower waters. The data are still being worked up from the dives, but extensive information has been collected on the distribution of fish and invertebrate species from depths of 2700 m on the flanks of the seamounts to 1200 m towards their summit. Some of the animals were known from seamounts closer to New Zealand (e.g., tulip sponge), but several species appear to be new to science,

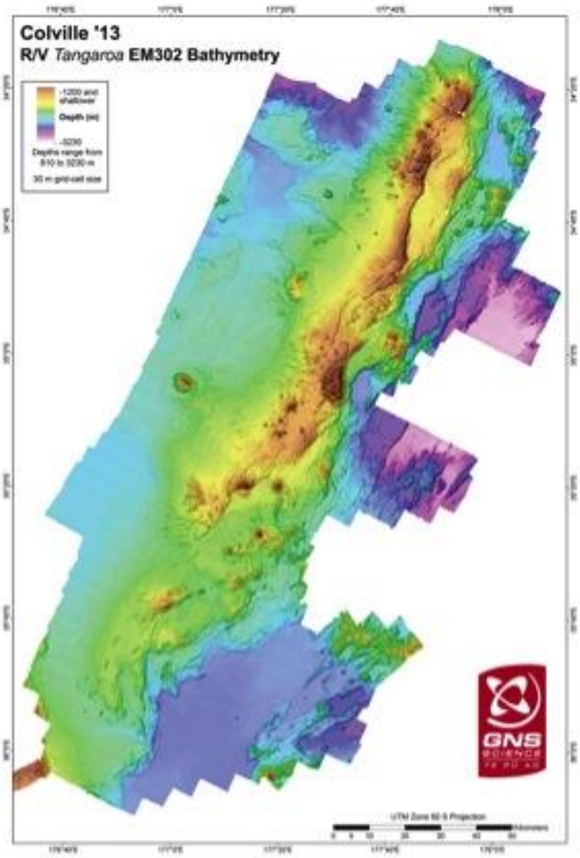


Figure 2. Bathymetric map of the southern Colville Ridge generated from R/V Tangaroa's Kongsberg EM302 mulitbeam system during the Colville'13 expedition. Credit: GNS, S. Merle.

The second area studied was a submarine volcano on the Kermadec Arc, at a latitude in between areas to the north and south that had previously been well surveyed. The main objectives here were to locate areas of hydrothermal venting indicated by previous geochemical surveys over the volcano, and map their geological, chemical, and biological characteristics. Active venting was found on Hinepuia volcano, at a depth of about 350 m. The faunal communities were dominated by bathymodiolid mussels (see figure), which are characteristic of the New Zealand region, although the species can vary. Of interest also were small symphurid flatfish, which are associated with areas of diffuse venting through the sediments.

Further studies on the Louisville Seamount Chain

The Louisville seamounts were the subject of a second voyage, by NIWA's R/V Tangaroa, in February 2014 (VLs Malcolm Clark and Ashley Rowden, NIWA). This was unrelated to the JAMSTEC survey, and was directed at ground-truthing predictive modeling of what are known as Vulnerable Marine Ecosystems (VMEs)-deep-sea ecosystems that are highly vulnerable to human activities such as fishing or mining. The South Pacific Regional Fishery Management Organisation (SPRFMO) Convention includes specific provisions to protect VMEs, but there are few data available on the distribution of VMEs and so models have been developed that evaluate the likelihood of certain indicator taxa being present in an area, based on the inferred suitability of the habitat derived from environmental data.

Six seamounts were surveyed, with sampling sites being positioned in 5 strata on each seamount, which corresponded to different preliminary model outputs. The main sampling tool was a towed underwater camera system, taking video and still photographs of the seafloor and benthic fauna from a height of 2-3 m. In total there were 119 camera tows, which were supported by 25 direct samples of fauna taken with a small epibenthic sled. Detailed bathymetric and topographic data were collected by MBES surveys of 5 of the 6 seamounts, and fine-scale environmental information (CTD) was collected from each camera deployment. In addition there were six targeted CTD and rosette casts, at which water samples were taken throughout the water column.

The key VME indicator taxon modeled for the survey, habitat-forming stony corals of the Order Scleractinia, were localised and patchy in their distribution, with substrate type and fine-scale topography being particularly important drivers of distribution. The corals were much deeper than typically found around New Zealand. Samples of live coral were collected, and are still alive in aquaria at NIWA for experiments on their environmental tolerance as ocean acidification develops. Data from the voyage are still being worked up to enable a thorough evaluation of the preliminary models, but a lot was gained to improve our understanding of the drivers of community distribution.

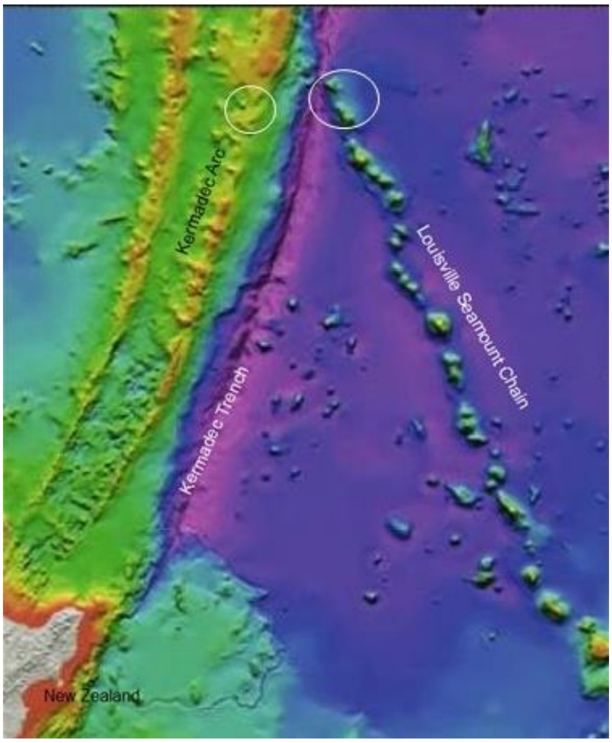


Figure 3: Location map for R/V Yokosuka voyage YK13-11 to the northern Kermadec arc and western edge of the Louisville Seamount chain. Dive sites in circled areas.

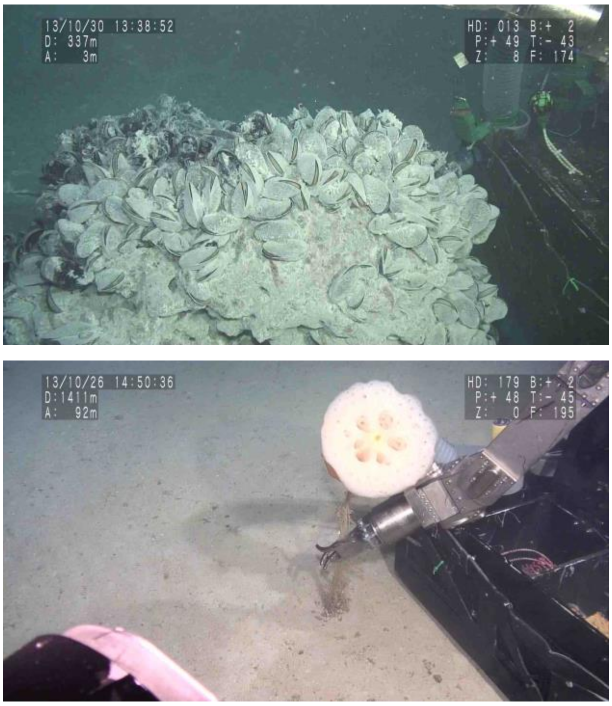


Figure 4. Mussel beds from Hinepuia volcano and tulip sponge as observed by Shinkai 6500 during YK13-11.

Reinga Basin and ridges

In late October to mid-November 2013, reconnaissance sampling of the Reinga Basin, NW of New Zealand, was again conducted with R/V Tangaroa (VL's Francois Bache and Rupert Sutherland, GNS Science). The main aim was to dredge sedimentary and volcanic rocks to reconstruct the tectonic and sedimentary evolution of the Reinga Basin.

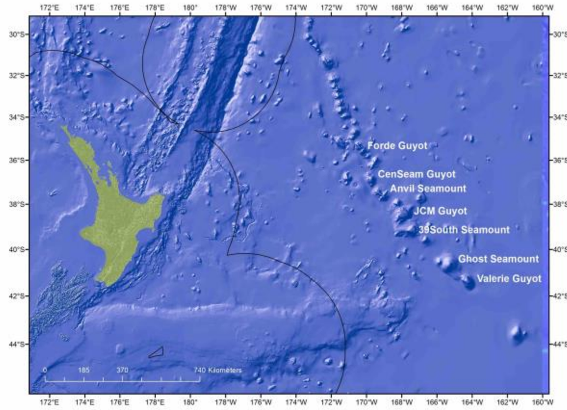


Figure 5 Location map for R/V Tangaroa voyage to the Louisville Seamount Chain (TAN 14-02).

Figure 6. Stony coral and associated fauna. Image taken by DTIS underwater camera during TAN14-02.

Future international voyages

Havre volcano

In April-May 2015 a voyage to Havre volcano will be conducted by R/V Roger Revelle to explore the deposits and changes in the seafloor associated with the 2012 Havre eruption (VL, Rebecca Carey, U.Hawaii). This voyage will build on the discoveries of the 2012 NIRVANA voyage, and include ROV and AUV dives and collection of marine cores. The expedition is NSF funded, and in collaboration between University of Hawaii, Woods Hole Oceanographic Institute, University of California at Berkeley (USA), NIWA, University of Otago (NZ) and University of Tasmania, (Australia).

R/V Sonne expeditions

Three joint New Zealand-German (involving collaborators from GNS, NIWA, Otago University and Victoria University) seagoing expeditions to use the new R/V Sonne around New Zealand have been funded by the German Ministry of Education and Research:

The Thermadec expedition will sample vent fluid, rock and biota and undertake bathymetric mapping on specific hydrothermally active volcanoes at the mid to southern Kermadec arc to investigate element flux into the ocean and its influence on the marine habitat,

1. The Chatham Rise expedition aims to investigate the mantle and crustal dynamics during the breakup of Zealandia from Gondwana through seismics, magnetics and gravity measurements and geochemical analyses of rock samples, and
2. The Vitiaz Arc expedition will conduct mapping and reconnaissance rock sampling at the Kermadec forearc, Colville Ridge and Havre Trough to investigate the timing of Vitiaz Arc (proto-Kermadec arc) subduction initiation and its temporal and geochemical evolution.

New Zealand-related IODP activities

In the offshore region around New Zealand three full IODP proposals have been or will shortly be submitted for drilling with New Zealand scientists as principal proponents.

Hikurangi Subduction Margin. The Hikurangi Subduction Margin project involves GNS Science, NIWA, UoA and VUW proponents. It is a multiphase drilling and monitoring proposal to investigate subduction earthquake and slow slip event processes offshore the eastern North Island.

Tasman Frontier. This GNS-led proposal is linked to the collaborative Geoscience Australia and New Caledonian Geological Survey proposal, Tasman Frontier. It aims to recover sediment cores from the poorly known Lord Howe Rise to understand regional tectonics and climate history for the last 70 million years. In addition the drilling will ground-truth seismic data from offshore regions northwest of New Zealand.

Gateway to the sub-arc mantle (Brothers Volcano). GNS-led with many international and NIWA proponents, this project aims to drill several sites of the active hydrothermal system at Brothers Volcano. This will add the 3rd dimension to studies of sub-seafloor fluid flow, transport of metals, metal enrichment and microbiological processes in active arc hydrothermal systems.

GeoPRISMS Planning Workshop

In April 2013, Wellington was host to a planning workshop for the New Zealand primary site of the NSF funded GeoPRISMS program. The meeting was held at Te Papa, the National museum of New Zealand, and attended by ~ 170 scientists from 10 countries. One focus of the meeting was subduction volcanism associated with the Kermadec Arc and Havre Trough. Increased international collaboration in Kermadec arc research has resulted from the meeting, with a number of voyage proposals resulting from the meeting submitted. A miniworkshop to follow up on the GeoPRISMS workshop was held at AGU in December 2013 (Convenors, Adam Kent (Oregon State), Mark Reagan (University of Iowa) Laurent Montési (University of Maryland) and Kaj Hoernle, GEOMAR).

2nd Special Issue of Economic Geology

After publication of 11 papers in the 1st special issue on the metallogeny of intraoceanic arcs in December 2012, Cornel de Ronde (again as chief editor, GNS) edited the 2nd special issue on the metallogeny of intraoceanic arcs in Economic Geology. Eleven papers were accepted and the special issue will appear in December 2014. This in turn follows on from a 2008 special issue about active magmatic, tectonic and hydrothermal processes at intraoceanic arc submarine volcanoes in JGR with fifteen papers with GNS scientist C. de Ronde as coeditor of issue.

Russia National Update 2014

Sergei Silantyev

Russian R/V "Professor Logachev" (Ship owner is Polar Marine Geosurvey Expedition - PMGE, St.Petersburg) has continued detailed surveying in MAR areas which was granted and approved by 17-th session of International Seabed Authority of UN (ISA) for Russian exploration of sulfide ore deposits at the ridge axial zone between latitudes 12°48,36'N and 20°54,36'N. Newly obtained during 36-th cruise of Professor Logachev" (MAR, 17o – 21oN) data of electrical prospecting and sample collection in this time are under multidisciplinary study in PMGE and "VNIIOkeangeologia - St.Petersburg, and Vernadsky Insitute and Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry (IGEM) – Moscow.

Close cooperation of Russian and German scientists in the network collaborative study of sample collection gathered during expedition MARSUED IV of the French R/V Atalante at the MAR intersection with the 5° S Fracture Zone allow obtain new data on petrogenesis conditions in this insufficiently explored South MAR region. Big sample from collection examined on which most of studies were focused, was taken from the lower part of the near-rift slope of the inner corner high at a water depth of 2800 m. This sample is valuable because it is a large fragment of rock from a contact zone between the gabbronorite and a large plagiogranite (OPG) vein and, hence, offers an opportunity of reliably reproducing the certain parameters of the petrogenetic processes that formed the OPG of the MAR oceanic core complex at 5°10' S.

Newly obtained data on the geochemistry and age of gabbronorite–plagiogranite association in the oceanic core complex of the Mid-Atlantic Ridge at 5°10_ S suggest close genetic relations between these rocks in this segment of the ridge. The U/Pb zircon age of an oceanic plagiogranite sample is 1.059 ± 0.055 Ma and is in good agreement with the zircon age of plutonic rocks in the oceanic core complex of northern MAR. A distinctive geochemical feature of the rocks is their unusually depleted 87Sr/86Sr and 143Nd/144Nd ratios, which suggest that the plutonic rocks of the gabbronorite–plagiogranite association in MAR at 5°10' S could be derived from the most strongly depleted mantle reservoir of all known to occur beneath the axial MAR zone. The numerical thermodynamic simulation of the possible crystallization links between the plagiogranite and gabbronorite from the MAR segment at 5°10' evidences for the leading role in the origin of the plagiogranite was played by a two-stage process: the partial melting of the gabbronorite and the subsequent fractionation of the newly generated melt. The regional differences between the isotope geochemical parameters of MAR plagiogranites can, perhaps, reflect local specifics of so-called hydrothermal anatexis, such as the geochemical features of the rocks involved in this process and the parameters of the hydrothermal process, for example, variations in the W/R ratio (for more details see in Petrology, 2014, Vol. 22, No. 2, pp. 109–127

Development of different modes of detachment faulting, 16.5N at the Mid-Atlantic Ridge

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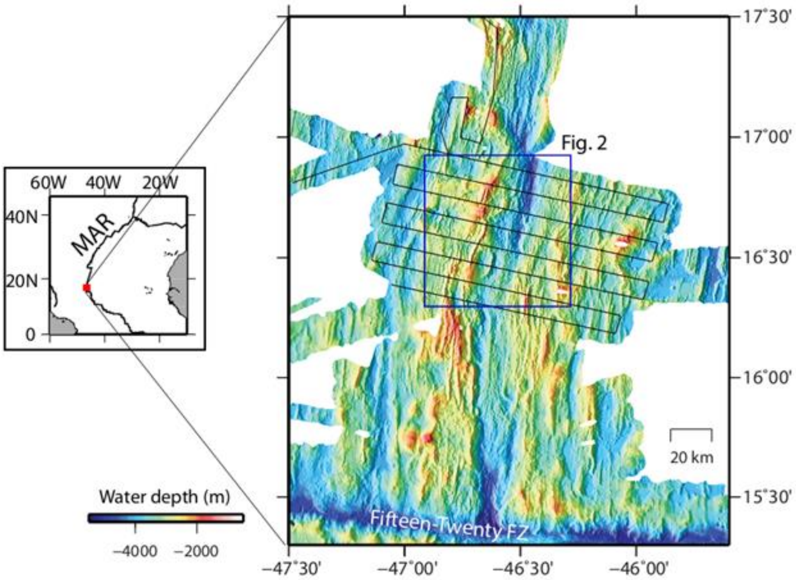

Figure 1. Location of the study region near 16.5N at the MAR. Regional survey track lines are shown in black. The location of Figure 2 is marked by the box.

Abstract

During May and June of 2013, we surveyed and sampled a region of the Mid-Atlantic Ridge (MAR) centered on 16.5N. In this region detachment faulting occurs along ~120 km of the western flank of the ridge axis which exhibits varying local magmatic budgets. The study area presents excellent examples of several different modes of active detachment faulting. Regional multibeam bathymetry, gravity, and magnetic data were collected out to about 60 km (~5 Ma) on each side of the axis to understand the spreading history. Autonomous Underwater Vehicle (AUV) Sentry collected high-resolution multibeam bathymetry, side-scan, magnetic, chirp, and water column data in critical locations complemented by photographs from the WHOI Towcam. We also completed an extensive dredging program in the region. The data are being used to characterize fault terminations, assessing where detachment faults are active, how they evolve off-axis, whether they link along the axis, and their relationship to magma budget at the axis. Here we present a preliminary description of four modes of detachment faults that accommodate extension of the western rift valley wall.

Study area

Figure 1 shows the location of the study area near 16.5N at the MAR. A previous study identified two distinctive, parallel linear ridges (East and West Ridges, Figures 2 and 3) on the west side of the axis as the rotated tops of detachment faults (breakaways) [Smith et al., 2008]. East Ridge, because it is closer to the volcanic axis, was interpreted as a newly emerging detachment fault forming a rafted block sitting on the top of the older West Ridge detachment. The corrugated massif at the south end of West Ridge was identified as a core complex. On the east side of the ridge axis at 16.63N, Krasnov, a large, extinct hydrothermal vent field (Figure 3), has been the focus of several studies [e.g., Cherkashov et al., 2008].

The 16.5N region has a high rate of seismicity. There are 29 teleseismic events listed in the NEIC catalog (http://earthquake.usgs.gov/earthquakes/eqarchives/epic/). In addition, 391 hydroacoustically-recorded events were identified during four years of monitoring [Smith et al., 2003] yielding an astonishing average of about one earthquake (roughly > magnitude 2.5-3.0), every three days. Based on the seismicity rate and their interpretation of the morphology, Escartín et al. [2008] concluded that the west flank of the 16.5N area is one of active detachment faulting.

Data

During R/V Knorr Voyage 201 Leg 05, regional SeaBeam multibeam bathymetry, gravity, and magnetic data were collected out to ~5 Ma on each side of the axis (tracklines, Figure 1) to understand the spreading history. Corrugations west of North and West Ridge detachment faults (labeled on Figure 3) indicate that in this region detachment faulting has dominated the west flank of the ridge for at least 3 Ma.

AUV Sentry completed 14 dives and collected Reson 7125 multibeam bathymetry (~1 m horizontal resolution compared to ~100 m for SeaBeam), side-scan (125kHz and 400kHz), magnetic, Edgetech chirp, and water column data in each of the survey boxes shown in Figure 2. Sentry seafloor photographs were obtained along short lines during two of the dives (box immediately east of East Ridge and the westernmost box over the North detachment fault, Figure 2). In addition, bottom photographs and water column data were collected in areas of interest during 9 dives of the WHOI Towcam (short blue lines, Figure 2). Finally, an extensive dredging program was completed in the region. Rocks were obtained in 73 dredges adding to the samples previously collected by our Russian colleagues (G. Cherkashov personal communication). The types of rocks collected and their locations are shown in Figure 2 (smaller circles indicate Russian samples). Dredges and Towcam dives were run during and between AUV Sentry surveys. The extensive suite of data collected in the 16.5N region allows us to interpret detachment faults and core complexes with confidence.

Detachment faulting at 16.5N

Here we describe the characteristics of the faults on the western flank of the MAR in the 16.5N area.

South core complex is a classic, corrugated, domal massif. The corrugations have wavelengths varying between 400 and 1600 m, and relief of 50-100 m. The exposed footwall close to where it emerges from beneath the hanging wall has a dip of < 10o. The termination of South core complex fault is located ~8 km from the axial volcanic ridge (AVR), which is broad (~4.5 km wide) and has a relief of about 300 m. Towcam photographs at the top of the AVR (short blue line, Figure 2) show pillow flows with varying degrees of sediment between the pillows. Despite several attempts, we were unable to sample the lower footwall of South core complex, which we speculate is due to it consisting of a massive smooth fault surface that exposes gabbro. Similar sampling problems have been encountered at other oceanic core complexes exposing massive gabbro that have not been broken by mass wasting and cross-faulting.

East Ridge is a medium-offset normal fault that is active close to the spreading axis. Its termination lies ~3.5 km from the AVR, which is consistent with a new normal fault dipping at 60o that cuts the base of a 6-km thick crust at a point beneath the magmatic axis. We think that the section of older detachment (West Ridge, Figure 2) behind East Ridge ceased being active when extension on East Ridge detachment fault was initiated. We interpret the corrugated surface behind East Ridge as the abandoned section of West Ridge detachment fault. Several dredges on the inward facing slope of East Ridge recovered pillow basalts indicating that the fault throw is insufficient as of yet to expose lower crust or dikes.

The dip of the outward-facing slope of East Ridge is ~20o and the axis-facing scarp 30-40o yielding a normal fault with an initial dip angle of between 50-60o (obtained by summing the inward and outward dips) and indicating significant flexural fault rotation [Buck, 1988]. The AVR adjacent to East Ridge is approximately 3 km wide with a relief of 300 m, similar to the AVR just to the south. Towcam photographs of the AVR (short blue line, Figure 2) show pillow flows also similar to what was seen to the south.

The dip of the footwall of West Ridge detachment fault near the termination is about 18o, which is steeper than observed at South core complex (<10o). The termination of West Ridge fault is about 5 km from the AVR. Numerous dredges on the inward facing slope of West Ridge detachment fault recovered peridotite, diabase and pillow basalt. The rougher terrain and ease with which it was dredged indicates that this terrain was more easily disrupted by faulting and mass wasting than the penecontemporaneous uniformly smoothly corrugated footwall of South core complex. This is consistent with a stratigraphy of massive serpentinized peridotite cut by diabase dikes overlain by scattered pillow basalts. The AVR adjacent to West Ridge fault is narrower (1.5-2 km wide) than to the south, but its relief is the same (300 m). In addition, the top of the AVR is on average a few hundred meters deeper than the AVRs in front of South core complex and East Ridge. Towcam photographs (short blue line, Figure 2) of the AVR appear similar to those obtained to the south. Volcanism may be weaker in this section or the AVR may be currently building.

The North detachment fault borders a deep, narrow rift axis (Figure 3), which suggests that this section of the ridge is magma starved. On the west flank of the ridge, three fault blocks have been carried off axis. West of these fault blocks is a massif from which we sampled gabbro and peridotite. We interpret the western flank of the axis in this region as a detachment fault that may be covered by short-lived rider blocks, with a basement composed of small gabbro intrusions in serpentinized peridotite overlain by scattered pillow basalts.

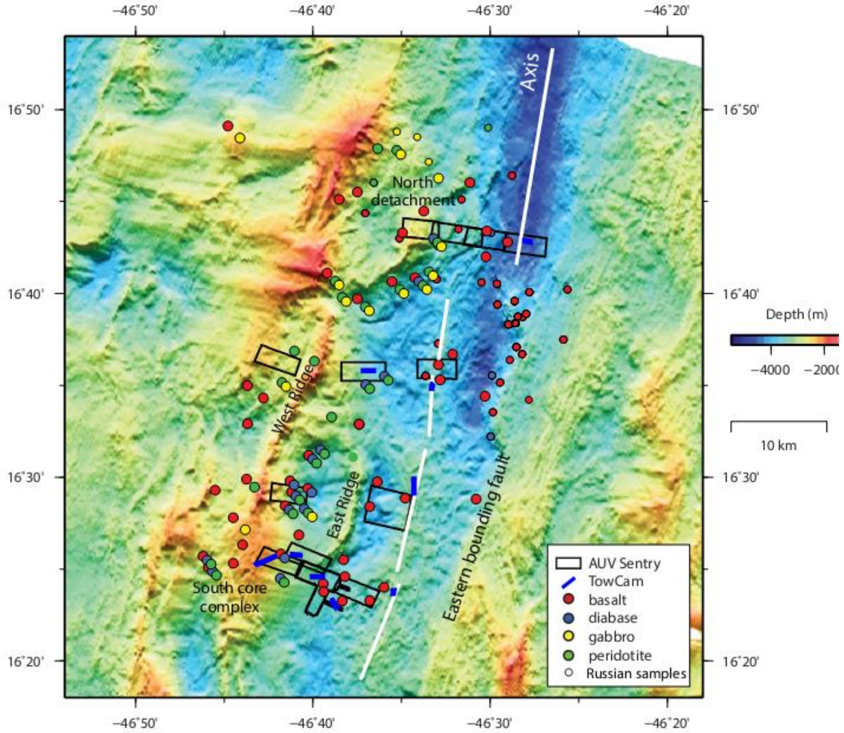

Figure 2. Bathymetry map showing the locations of the AUV Sentry dives, Towcam dives, and rock samples obtained during R/V Knorr 210-05. Also included are sample locations from the Russian data archive. The Russian samples are primarily located on the eastern side of the axis and in the north.

Discussion

Here we summarize some of the preliminary results from the Knorr 210-05 cruise within the context of previous studies. Numerical modeling has suggested that long-lived detachment faults form primarily in regions of reduced magma supply [Buck et al., 2005; Olive et al., 2010; Tucholke et al., 2008], and this is supported by their common occurrence at the end of segments where it is inferred that magma supply is low [Tucholke et al., 2008]. In our study region, however, these ideas do not hold up. In fact, the most robust AVR appears to be adjacent to South core complex suggesting abundant volcanism and high magma supply.

These observations are opposite to what has been previously proposed (i.e., that corrugated surfaces form in regions of low magma supply and rider blocks form toward the center of the segment where local magma budget is high [e.g., Reston and Ranero, 2011]). Our preliminary results suggest that variations in local magma budget may not be the only mechanism controlling the surface expression of detachment faults.

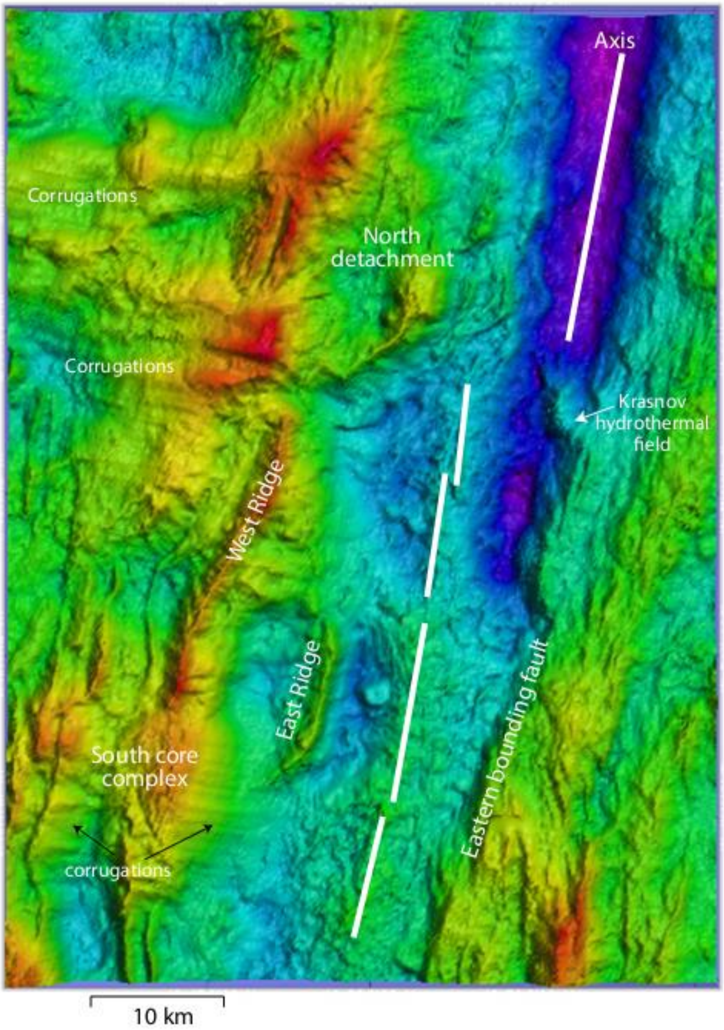

Figure 3. Bathymetry map centered on 16.5N. Major features near the axis are labeled. Straight white lines indicate the spreading axis.

Acknowledgments: We would like to thank the captain and crew of the R/V Knorr for their hard work during the cruise. The over-the-side operations (Sentry, Towcam, dredging) were handled efficiently and with expertise, and allowed us to meet our demanding schedule.

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InterRidge Vents Database joins the semantic web of Linked Data

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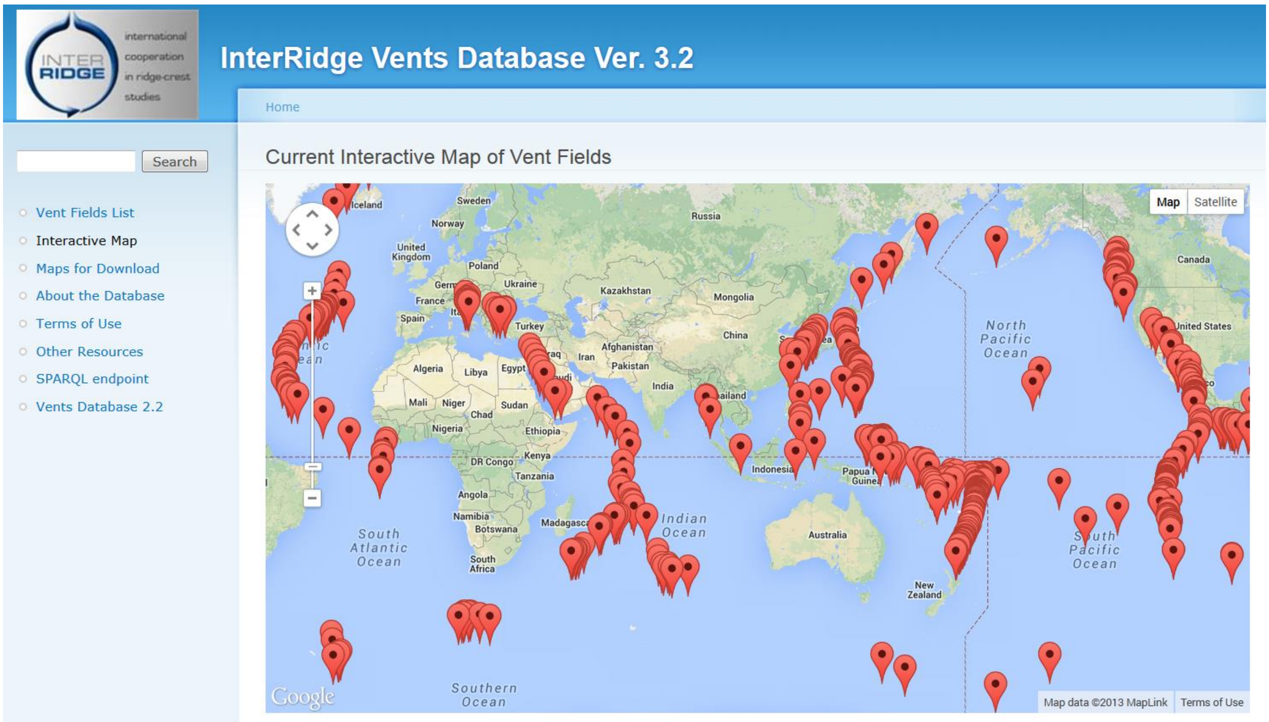

Figure 1: Screenshot of the interactive map on the database online at: http://vents-data.interridge.org

Abstract

The InterRidge Vents Database underwent a thorough makeover earlier this year. You may have noticed the new interactive mapping feature – but you probably didn't notice something that happened out of sight "behind the scenes" – the database is now part of the world wide semantic web of data.

You may have noticed that a revised, new version of the InterRidge Vents Database is available now at: http://vents-data.interridge.org. What you may not know – because it is happening "behind the scenes" – is that this new version of the database has joined the semantic web of Linked Data. The semantic web refers to a global collaborative initiative, led by the World Wide Web Consortium

(W3C), to utilize standard technologies to support a "web of data" (for more information, see: http://www.w3.org/standards/semanticweb/). To join the "web of data" - also known as Linked Data- much of the information in the vents database is coded in a standard way, using Resource Description Framework (RDF), and matched to authoritative vocabularies published on the web by others using Linked Data. Effectively, by joining others who are using the same technologies and vocabularies, the InterRidge Vents Database is now part of a global, federated database, meaning that it can be queried and associated automatically with content in many other databases out on the world wide web. In particular below, we will highlight the connection with the Integrated Ocean Drilling Program (IODP). An ultimate goal is to enable interoperability with many other oceanographic databases including the U.S. Biological and Chemical Oceanography Data Management Office (*BCO-DMO*) and Rolling Deck to Repository (R2R) databases.

The purpose of the InterRidge Vents Database (full name: InterRidge Global Database of Active Submarine Hydrothermal Vent Fields) is to provide a comprehensive list of active and inferred active (unconfirmed) submarine hydrothermal vent fields for use in academic research and education. A manuscript is currently in peer review for the listings in Version 2.1, which is comprehensive through the end of 2009 and forms the bulk of the listings in the new, live database. In the upgrade to Version 3, the database was migrated to Drupal 7, an open source content management system with RDF web services in its core. We implemented additional contributed modules for query over the web using the SPARQL standard. Most database content and taxonomy terms are mapped to default RDF namespaces, with three important exceptions: we mapped the "vent field" content type to (1) an rdf:type for hydrothermal vents in a semantic knowledge base (http://yago-knowledge.org/resource/) and (2) to an rdf:type for geographical features from the Open Geospatial Consortium (http://www.opengis.net/rdf#), and (3) we mapped the latitude and longitude positions of the vent fields to a semantic vocabulary for the WGS84 geodetic reference datum (http://www.w3.org/2003/01/geo/wgs84_pos#). Another new feature in Version 3 is live Google mapping of vent field positions (Figure 1). A new Google Earth kml file for Version 3.2 will soon be posted to the "Maps for Download" page on the website.

Other databases using semantic web technologies can seamlessly link to the content in the vents database because elements such as latitude and longitude are coded as Linked Data. This can enable other databases to plot vent field locations as if that information was contained in their own database - when actually this is the federation of data from distributed servers. We reached an exciting milestone in performing a query of the InterRidge and IODP databases together, to ask "Where in the world are there IODP drill sites within 100 km of known vent fields?" The query was performed using SPARQL to access the vent field positions in the InterRidge Vents Database, which were loaded into the IODP database to perform a geospatial SPARQL query, and a subset of the results is shown in Figure 2. In the future, this particular query can be performed all-at-once and without requiring any local upload, when the Drupal software can accommodate the GeoSPARQL standard, a geographic query language for RDF data. Figure 2 is actually showing the results of three different SPARQL sources – two from the IODP database and one from InterRidge.

This work represents an important step forward towards linked and open data for our scientific community. We are engaged with international working groups to continue to build the web of federated databases in the

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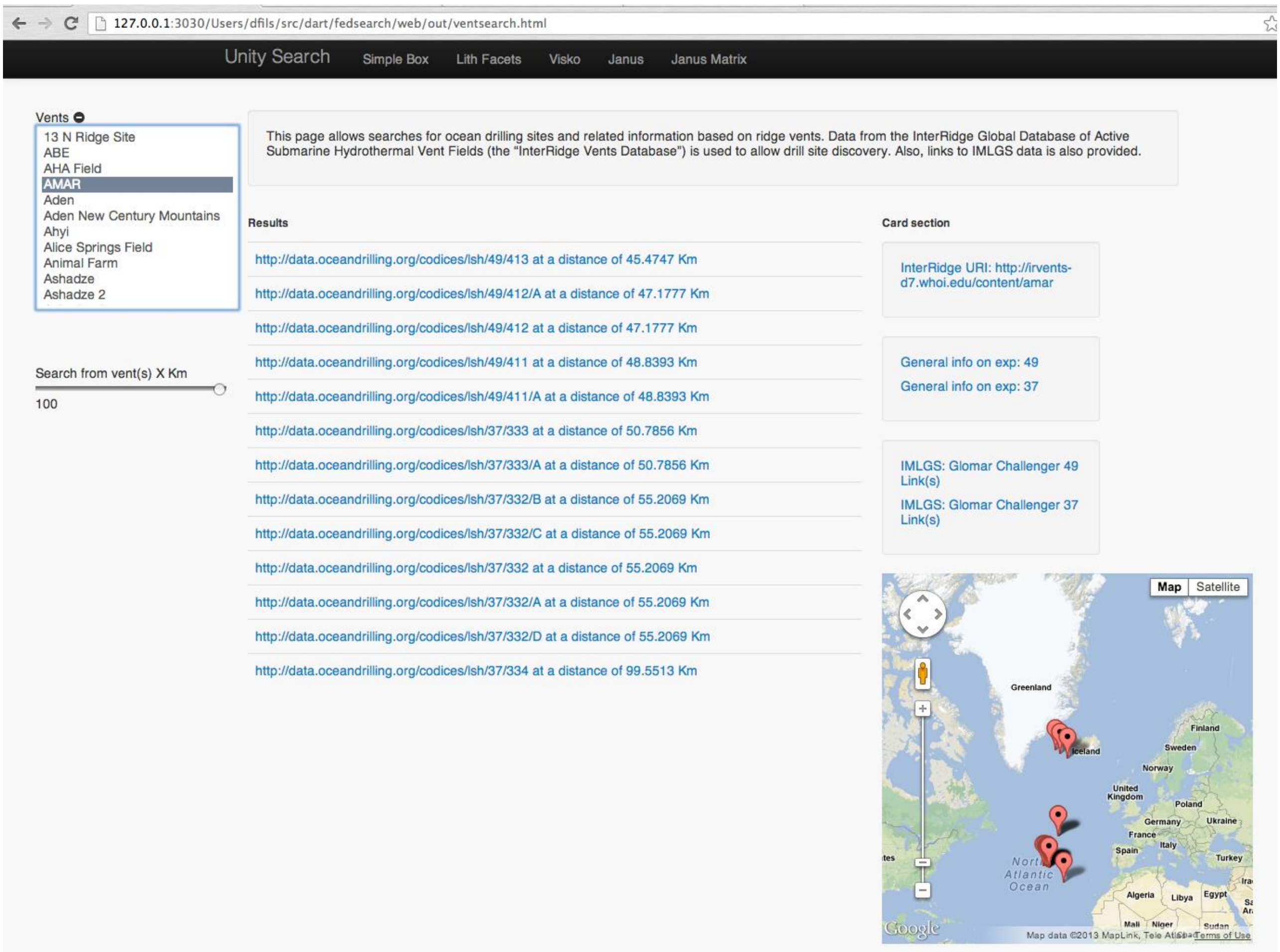

Figure 2 Screenshot of the results of the query: "Where are the IODP drill sites within 100 km of a known vent field?"

First data on composition of the NW Pacific Oceanic Lithosphere exposed along the Stalemate Fracture Zone

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Introduction

The nature of oceanic basement in the northwestern Pacific is still poorly known and remains a gap in our knowledge of the geological history of the Pacific Ocean. An important feature of this region is the preservation of a small fragment of the Kula plate, which was previously believed to have been entirely subducted [1]. The most thorough interpretations of the geodynamic evolution of the lithosphere beneath the Northwest Pacific derived from geophysical data and are presented in [1-5]. According to paleomagnetic data, Kula–Pacific spreading ceased at approximately 43 Ma [1]. The fossil Kula-Pacific spreading center is bounded by the Stalemate Fracture Zone in the South, which is the northwestern termination of the Kula-Pacific paleotransform (Fig.1).

The Stalemate Fracture Zone (FZ) includes a 500 km long SE-NW trending transverse ridge which originated by flexural uplift of Cretaceous (?) oceanic lithosphere along a transform fault boundary [1]. Sampling at the Stalemate FZ and the fossil Kula-Pacific Rift Valley was carried out during the German R/V SONNE cruise SO201

Leg 1b in July 2009. A broad spectrum of rocks including serpentinites (DR37), gabbro (DR7, 40), dolerites, gabbro-diorites and diorites (DR7) and basalts (DR38,41) were obtained. These rocks are thought to represent a complete section of oceanic lithosphere of Paleogene (fossil Kula-Pacific spreading center) to Cretaceous (Stalemate FZ) age. A study of these rocks allowed us to place new constraints on the magmatic and metamorphic history of the oceanic basement in the NW Pacific.

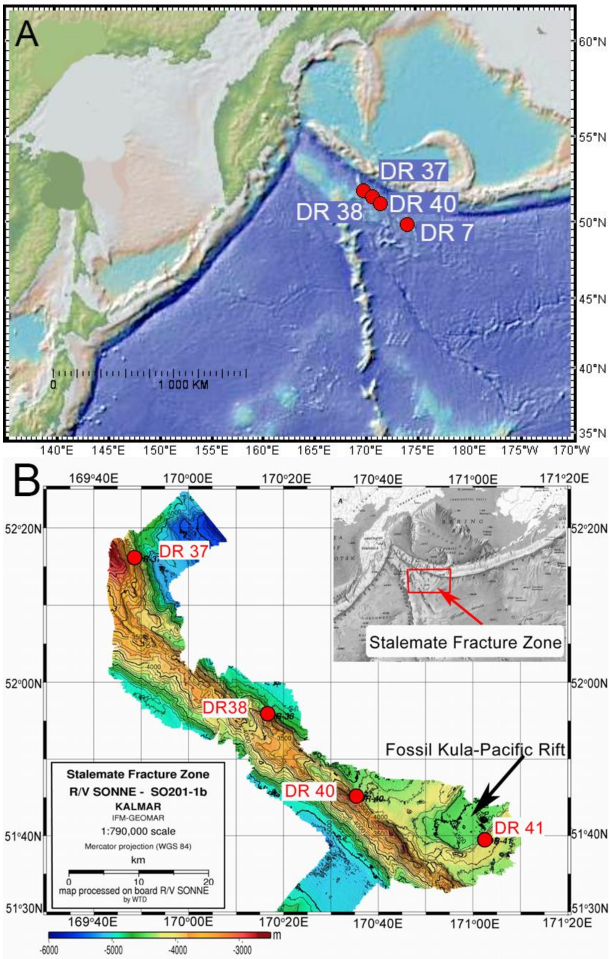

Fig. 1. Overview maps of A: the North West part of Pacific ocean and the Stalemate Fracture Zone, B: the northern part of the Stalemate Ridge; and SO201-KALMAR Leg 1b dredge locations

Magmatic History of lithosphere section along the Stalemate FZ

Ultramafic Rocks. Variably altered mantle peridotites were dredged from the eastern slope of the northwestern segment of the Stalemate Ridge. Dredging was carried out at depths of 4360–3955 m (Fig. 1). At site SO201-DR37, we sampled 14 strongly to moderately altered mantle peridotites [6]. According to on-board description and petrographic investigations, two major groups of samples were distinguished: (1) pyroxene-rich lherzolites, and (2) pyroxene-poor dunites (Fig.2). In order to reconstruct initial compositions of the peridotites, we analyzed relics of primary minerals (spinel, clinopyroxene and orthopyroxene). The compositions of the primary minerals change systematically from lherzolites to dunites. Spinel in lherzolites has higher Mg#, NiO, lower Cr#, Fe^{3+}# and TiO_2 (Mg#=0.65-0.68, NiO=0.26-0.34 wt%, Cr#=0.26-0.33, Fe^{3+}#=0.021-0.030, TiO_2=0.04-0.09 wt%) than spinel in dunites (Mg#=0.56-0.64, Cr#=0.38-0.43, TiO_2=0.19-0.28 wt%, NiO=0.19-0.26%, Fe^{3+}#=0.027-0.043) (Fig. 2). Clinopyroxene in lherzolites is less magnesian but enriched in NiO, depleted in TiO_2 and Na_2O and has lower Cr# (Mg#=91.7-92.4, Cr#=0.12-0.16, TiO_2=0.06-0.15 wt%, Na_2O=0.19-0.41 wt%, NiO=0.06-0.09 wt%) compared to clinopyroxene from dunite DR37-3 (Mg#=93.7, Cr#=0.16, TiO_2=0.23wt%, Na_2O=0.85wt%, NiO=0.06wt%). In general, the mineral compositions form continuous trends with end-members represented by lherzolite DR37-13, on the one side, and dunite DR37-3, on the other side. According to our modeling the lherzolites from the Stalemate FZ could result from 10-12% near fractional melting of a depleted DMM-like mantle [7]. The dunites originate through interaction of the residual lherzolites with Na- and Ti-rich melts and likely represent fragments of a network of dunite channels in the shallow mantle. The moderately refractory composition of minerals in the Stalemate FZ lherzolites distinguishes these rocks from strongly depleted peridotites from the East Pacific Rise and indicates the existence of slow- to intermediate-spreading mid-ocean ridges in the Pacific Ocean during the Cretaceous-Paleogene time [7].

Gabbro, gabbro-diorite, and diorite. Plutonic rocks occur along the entire length of the Stalemate FZ and are represented by separate gabbro fragments and those in lithoclastic breccia at site SO201-1bDR40 in the northwest and gabbro-diorite and diorite at site SO201-1b-DR7-7 in the southeast (Fig. 1). Gabbro at site DR40 is represented by angular fragments of mostly coarse-grained rocks of gabrophitic texture, consisting of plagioclase, clinopyroxene, magnetite, and secondary amphibole and chlorite. Some of the gabbro fragments are almost completely replaced by amphibole and can be classified as a typical gabbroamphibolite. Some other gabbroic fragments dredged from this site occur as clusts in lithoclastic breccia, which contains also fragments of strongly altered dolerite. These rocks differ from separate gabbro fragments from the same site and are more strongly recrystallized and extensively replaced by uralite and contain abundant actinolite, chlorite, albite, and epidote. The SO201-1b-DR40 gabbro have a major element composition typical of MORB-type gabbro and fall within the compositional field of gabbro belonging to well studied Oceanic Core Complexes of the Mid-Atlantic Ridge (MAR) (8). The REE and incompatible-element patterns of the SO201-1b-DR40 gabbroes provide further support for their similarity with the N-MORB gabbro family: (La/Sm)cn = 0.06-0.19, La/Yb = 0.40-0.75. However, gabbro clasts from breccia are more likely plutonic analogues of more enriched MORB with (La/Sm)cn = 1.31-1.46, La/Yb = 1.65 at K2O content of 1.07-1.30 wt %. Sr, Nd, and Pb isotopic composition of gabbro from Site SO201-1b-DR40 confirmed MORB affinity of these rocks (8).

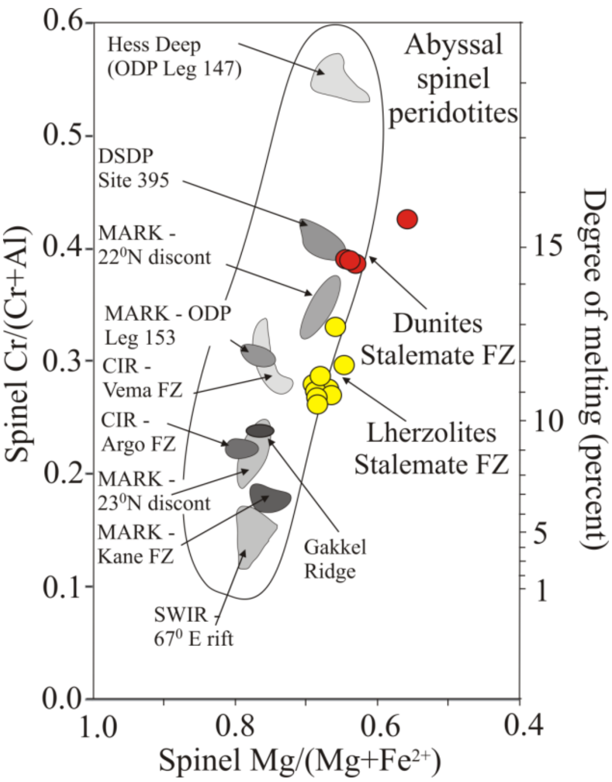

Fig. 2. Composition of Cr# = Cr/(Cr+Al) and Mg# = Mg/(Mg+Al) in Spinel. Spinel compositions from varioys abyssal peridotites are shown after (12).

Gabbrodiorite and diorite dredged at SO201-1b-DR7 consist of plagioclase, potassic feldspar, clinopyroxene, and secondary actinolite, sphene, epidote, chlorite, and scapolite (found in single sample only). Gabbro-diorites additionally contain biotite. All the rocks exhibit undeniable evidence of variable metamorphic recrystallization. The gabbro-diorites and diorites have compositions different from those of typical MORB gabbro (8). Similar to several OPG (Oceanic Plagiogranite) in mid-oceanic ridges, gabbro-diorite and diorite from Site SO201-1b-DR7 are enriched in LREE (e.g. (La/Sm)cn = 2.8-4.1, La/Yb = 6.4-11.1). These rocks are however different from typical OPG due to essentially higher concentrations of K2O and other Large Ion Lithophile Elements (K2O = 1.14 -3.82 wt %, Ba = 294-674 ppm, and Rb = 15-126 ppm) and extremely high 87Sr/86Sr and low 143Nd/144Nd ratios (εNd = +2). Apparent similarity of these rocks to granitoids of continental provenance calls into question their in-situ origin in MOR setting. On the other hand, the diorites of exotic composition were found in several angular fragments, which have variable composition, and their origin via ice rafting of continental rocks is unlikely. The origin of intermediate plutonic rocks with continental-like geochemical features in the NW Pacific remains an important question for further studies.

Metamorphic history of lithosphere section along the Stalemate FZ

Ultramafic Rocks The strongly altered dunites are light red rocks with rare (<3%) macroscopically visible spinel relicts. The petrographic examination of these rocks revealed a texture typical of altered dunites. However, the main mineral of the altered dunites is quartz rather than serpentine. There are very subordinate amounts of chlorite, serpentine, and iron hydroxides and rare relicts of primary reddish brown spinel and bottlegreen clinopyroxene. The almost complete silicification clearly distinguishes the serpentinized dunites from the known products of hydrothermal alteration and low temperature (seafloor) weathering of peridotites in the oceanic crust. Serpentinized lherzolites of the Stalemate Fracture Zone show evidence for moderate temperature oceanic metamorphism. It should be pointed out that some samples of serpentinized herzolites contain quartz (or amorphous silica), the content of which is much lower than that in the altered dunites. Secondary alteration of the peridotites included serpentinization and also silicification of the dunites (Fig.3) caused strong enrichment of the rocks in fluid mobile elements (U, Li, Sb, Ba) (9). The enrichment of amorphous silica and quartz and unusually high SiO_2 (up to 88.7 wt %) and low MgO (up to 1.4 wt %) clearly distinguish these rocks from the known products of the hydrothermal alteration and low-temperature weathering of peridotites in the oceanic crust. There are two type of evolution: submarine and subaerial. In order to determine which of the two environments was responsible for the silicification of the Stalemate Ridge peridotites we used a thermodynamic model in the GEOCHEQ program package (10, 11). The model data indicate also that the geochemical and mineralogical effects observed in the silicified dunites of the Stalemate FZ are most similar to the expected results of the low-temperature alteration of oceanic serpentinites under subaerial conditions. The results of numerical modeling and the analysis of published data allowed us to suppose that the geochemical and mineralogical effects observed in the silicified dunites of the Stalemate Fracture Zone are consequences of the low-temperature deserpentinization of oceanic rocks under subaerial conditions. Hence, the peridotites could not be weathered under the conditions corresponding to their present day submarine occurrence at depths of approximately 4000 m. This implies that the oceanic crustal block of the northwestern Pacific perhaps since the time of its formation had movements with amplitudes of several thousand meters.

Gabbro, gabbro-diorite, and diorite All of our gabbro samples from Site SO201-1b-DR40 contain actinolite with 0.3-5.3 wt % Al_2O_3, chlorite, and albite. This mineral assemblage is typical of several MAR gabbroids and was produced under greenschist-facies conditions of oceanic metamorphism. Gabbrodiorite and diorite from Site SO201-1b-DR7 also display traces of metamorphic recrystallization: the rocks contain secondary actinolite, sphene, chlorite, epidote, and single dioritic sample additionally contains scapolite. These rocks could be metamorphosed in the presence of highly saline $NaCl-H_2O$ fluid, as follows from mineralogical lines of evidence and from the elevated Na_2O concentration in the scapolite-bearing diorite sample.

Geodynamic evolution of the Cretaceous--Paleogene Lithosphere in the Stalemate FZ

Data briefly presented above allowed us to reconstruct the formation conditions of the basement rocks and to interpret their tectonic evolution. The genesis of gabbros found among plutonic rocks composing the Cretaceous-Paleogene lithosphere in the Stalemate FZ was related to magmatism at an ancient spreading center and provides record of the evolution of the parental magmatic melts of N-MORB. Along with related peridotites, basalts, and dolerites, these rocks can be attributed to the disintegrated the Cretaceous-Paleogene oceanic lithosphere of the Pacific Ocean. Spinel lherzolite–dunite assemblage recognized in Stalemate FZ is typical for spreading centers characterized by moderate spreading rate. The gabbro-diorite and diorite are not genetically related to the rocks of the Cretaceous-Paleogene basement of the Northwest Pacific. Thereby, the Stalemate Fracture Zone possibly reflects the complicated structure of the tectonic collage of rocks of different age. These rocks are produced in different geodynamic environments and were later tectonically brought together near the frontal portion of the Aleutian Island Arc. Judging by the isotopic-geochemical characteristics of these rocks, they cannot be classified as belonging to the family of oceanic plagiogranites. Deformations of the oceanic basement can be discerned throughout the whole Stalemate Fracture Zone as brecciation and large-amplitude vertical displacements within the oceanic lithosphere.

Acknowledgments

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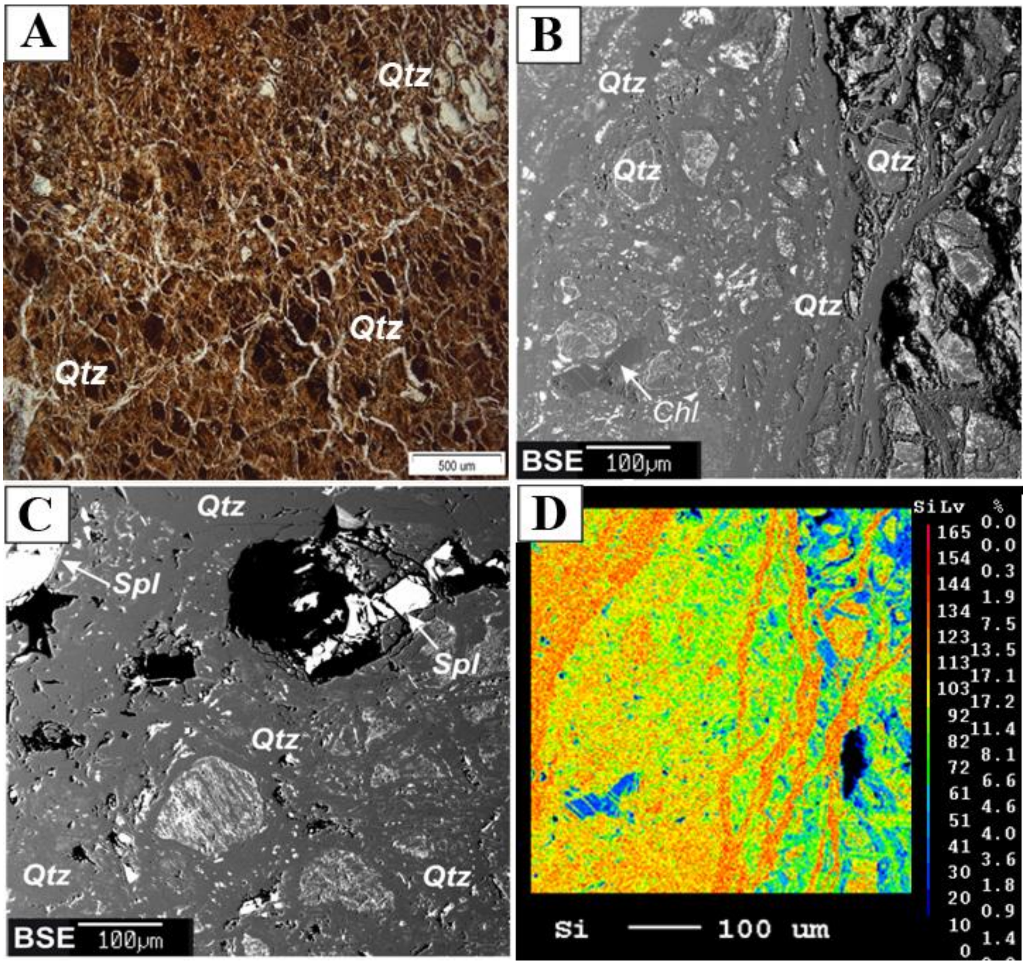

Fig. 3. Silicified dunites from the Stalemate Fracture Zone. (a) Microphoto of a fragment of sample DR37-2. The bulk SiO2 content in this rock is 87 wt %. Olivine cores are replaced by a microcrystalline aggregate of quartz (b)–(d) Fragment of sample DR37-4 from a transition zone between the brecciated (right) and massive (left) zones. (b, c) back-scattered electron image; (d) distribution of Mg contents.

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Crustal thickness variation from gravity signatures of Central Philippines ophiolitic basement complexes

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Abstract

Recent mapping in the Central Philippines revealed ophiolites and ophiolitic units of different ages serving as basement of this region. Acquired geophysical data across the region shows an increasing trend of gravity anomalies to the southeast. Upward continuation of the gridded gravity anomaly data was carried out to isolate the signatures of deep sources. The trend observed in the regional Bouguer anomaly map is found to persist through depth, suggesting that the signatures are caused by the regional structure. Since the basement rocks are of essentially uniform character, the low gravity anomalies to the west of the region are attributed to a deeper high density contrast between the crust and the mantle. High gravity anomalies, on the other hand, are explained by a shallow mantle and a thinner crust. Knowledge on crustal configuration of the region can be used in refining its tectonic history.

Introduction

Our research team has been concentrating on studying the geology of the Central Philippines to identify the effects of the collision of the Palawan Microcontinental Block (PCB) and the Philippine Mobile Belt (PMB) (Dimalanta et al., 2009; Canto et al. 2012; Concepcion et al. 2012). To complement field mapping campaigns carried out in different islands, we gathered significant geophysical information that allows the imaging of subsurface conditions in the region. Integration of the measurements across the Central Philippines provided new and interesting insights on the variation of subsurface characteristics.

Ophiolites of the Central Philippines

The Central Philippines is composed of the islands of Mindoro, Tablas, Romblon, Sibuyan, Panay, Negros, Cebu, Bohol, Leyte, Samar and Masbate. The Negros trench borders the west of the region, along which, the southeast subbasin of Sulu Sea plate is being consumed. To the east of the region lies the Philippine Trench where the Philippine Sea plate is being subducted. Leyte and Masbate are traversed by the strike-slip Philippine Fault Zone, while the Sibuyan Sea Fault lies off-shore and north of the Romblon Island Group.

Regional geologic mapping in these islands (Dimalanta et al., 2006; 2009) revealed ophiolites and dismembered ophiolitic fragments comprising the basement of most of the islands. Previous works have reported a westward younging trend of the age of these ophiolite and ophiolitic units (Tamayo et al. 2004). The ophiolites observed in the region will be briefly discussed subsequently.

The easternmost ophiolite unit in the region is the Samar Ophiolite in southern Samar. It is composed of harzburgites and dunites, isotropic gabbro, sheeted diabase dike/sill complex and basaltic pillow and sheet flow deposits. Vitorfus campbelli pessagno and Sciadiocapsa sp. from the overlying chert gave an Early to Late Cretaceous age for the ophiolite (Dimalanta et al., 2006).

In Northeastern Leyte, a northwest-southeast trending complete ophiolite sequence composed of harzburgites, layered to isotropic gabbros, sheeted diabase and basalt dike complex, and pillowed and massive basaltic lava flow deposits, is collectively named as the Tacloban Ophiolite Complex (Suerte et al. 2005). U-Pb isotopic dating of zircons extracted from a gabbro showing orthocumulate texture gave an Early Cretaceous age for this ophiolite (Suerte et al. 2005).

The southern portion of Leyte is underlain by the Malitbog Ophiolite Complex, which is composed of harzburgites, lherzolites, occasional dunites, pyroxenites, gabbros, diabase dike swarms and pillow lava deposits (Dimalanta et al. 2006). This is believed to be Late Cretaceous in age based on the foraminifera found in the micritic limestones overlying the pillow lava deposits (Florendo 1987).

To the west of southern Leyte lies Bohol island wherein the South East Bohol Ophiolite Complex (SEBOC) is located. It is made up of harzburgites with occasional lherzolites, massive to layered gabbros, sheeted dike complex, basaltic to andesitic sheet flows and pillow lavas (De Jesus et al. 2000). SEBOC is overlain by pelagic chert deposits dated Early Cretaceous based on radiolarians and foraminiferal assemblages (Baretto et al. 2000).

Recent field mapping on Masbate Island revealed a NE-SW trending ophiolitic unit dominantly composed of pillow basalts with minor diabase dikes and isotropic gabbros. Radiolarians extracted from the overlying chert and siliceous mudstones provided an initial Early Cretaceous age.Further west of Masbate Island lies the Romblon Island Group (RIG) which is composed of the Tablas, Romblon and Sibuyan islands. The RIG is underlain by dismembered units of harzburgites and dunites, isotropic and layered gabbros, dike swarms and volcanic rocks (Dimalanta et al. 2009; Payot et al. 2009a, Payot et al. 2009b, Payot et al. 2011). These units are intercalated with Jurassic to Cretaceous chert (Maac and Ylade, 1988).

To the south of Tablas island, the Antique Ophiolite is exposed along the length of the Antique range. It is composed of serpentinized harzburgites, layered gabbros with thin dunites, isotropic gabbros, rare sheeted dikes, and basaltic pillow lavas and sheet flow deposits (Dimalanta et al. 2006; Tamayo et al. 2001). The volcanic units are overlain by marine clastic and calcareous sediments, which are dated to be Early Cretaceous in age (e.g Rangin et al. 1991).

The Middle Oligocene Amnay Ophiolite is exposed in Mindoro island which lies to the northwest of Panay. It consists of serpentinized harzburgites, dunites, isotropic gabbros, sheeted dike complex and pillow lavas (e.g Perez et al. 2013). The age of the Amnay Ophiolite is taken from the nannoplankton found in the capping pelagic mudstones (Dictyococcites dictyodus, Discoaster deflandrei, Cyclicargolithus abisectus, Sephenolithus moriformis) (Canto et al. 2012; Rangin et al.1985).

Since these ophiolites and ophiolitic units comprises the basement of the Central Philippines, we expect to find regional geophysical signatures in the region which could be attributed to the presence of these suite of rocks.

Geophysical Techniques

Ground gravity data across the Central Philippines were gathered using a Scintrex CG-5 Autograv gravity meter in different geophysical campaigns from 2006 to 2013. Airborne gravity data was taken from JICA (1990) for Leyte Island. The data was integrated with the acquired ground gravity data for the interpretation of the gravity characteristics in the region. The gravity data were subjected to instrumental drift, latitude variations, Free air and Bouguer Spherical cap corrections. After standard data reduction was applied, calculated Bouguer anomalies were gridded using the Kriging algorithm of the Geosoft Oasis Montaj (version 6.3) and a Bouguer anomaly map of the region was then produced. To further investigate the deep characteristics of the subsurface, the gridded Bouguer anomalies were upwardly continued. This filtering technique eliminates signals caused by shallow density contrasts, allowing the interpretation of anomalies caused by deep-seated sources.

Gravity Signatures of the Central Philippines

After standard data correction and reduction, gravity anomalies of the Central Philippines were found to range from -69mGals on Mindoro Island to 134mGals on Southeast Bohol (Figure 3A). An increasing trend of the anomalies to the southeast is evident on the Regional Bouguer Anomaly (RBA) map (Figure 3A). Usually, the differences in gravity signatures can be explained by the density contrasts of the underlying rocks. In this case, however, the composition of the underlying rocks is uniform, when viewed in a regional scale. Deep-seated anomalies that are not explained by the differences in composition and density contrasts of the lithologies may be attributed to the crust-mantle configuration.

In order to isolate gravity signatures that would be used to investigate crustal geometries, RBA is subjected to a mathematical filter that removes short-wavelength gravity anomalies. This filter, called the upward continuation, produces the gravity signature of deep sources, which in turn, characterizes the regional structure of the subsurface.

The increasing trend to the SE of the gravity anomalies observed in Figure 3A is found to persist through depth, as shown in the upward continued map (Figure 3B). The low gravity anomalies over the ophiolites of the western Philippines possibly indicate that the mantle is deeper in that region. High gravity anomalies in the eastern Philippines are interpreted to correspond to a mantle that is closer to the surface, translating to a thinner crust.

Conclusions

The Central Philippines is underlain by ophiolites and ophiolitic basement. Despite the uniformity in their regional composition, there is an observed significant increase of gravity anomalies towards the southeast. This is attributed to the regional crustal structure, where the low gravity anomalies signify deeper mantle and high gravity anomalies translates to a shallow one. The crust in the Central Philippines therefore possibly thins towards the southeast.

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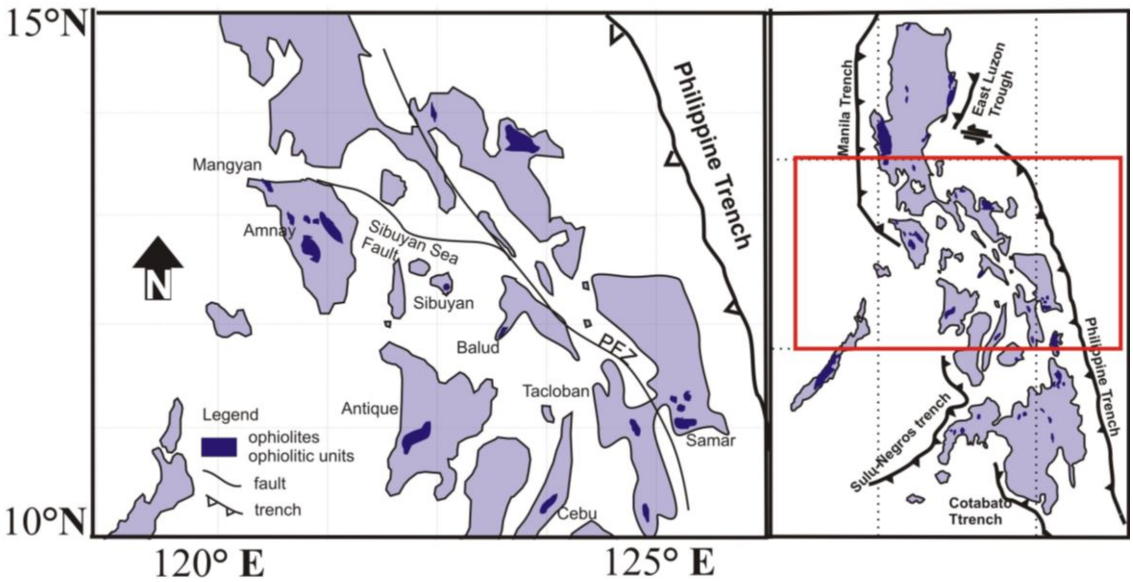

Figure 1: The Central Philippines, composed of the islands of Mindoro, Tablas, Romblon, Sibuyan, Masbate, Panay, Negros, Cebu, Bohol, Leyte and Samar, is bordered by the Negros trench to west and by the Philippine trench to the east. It is underlain by ophiolites and ophiolitic units of different ages.

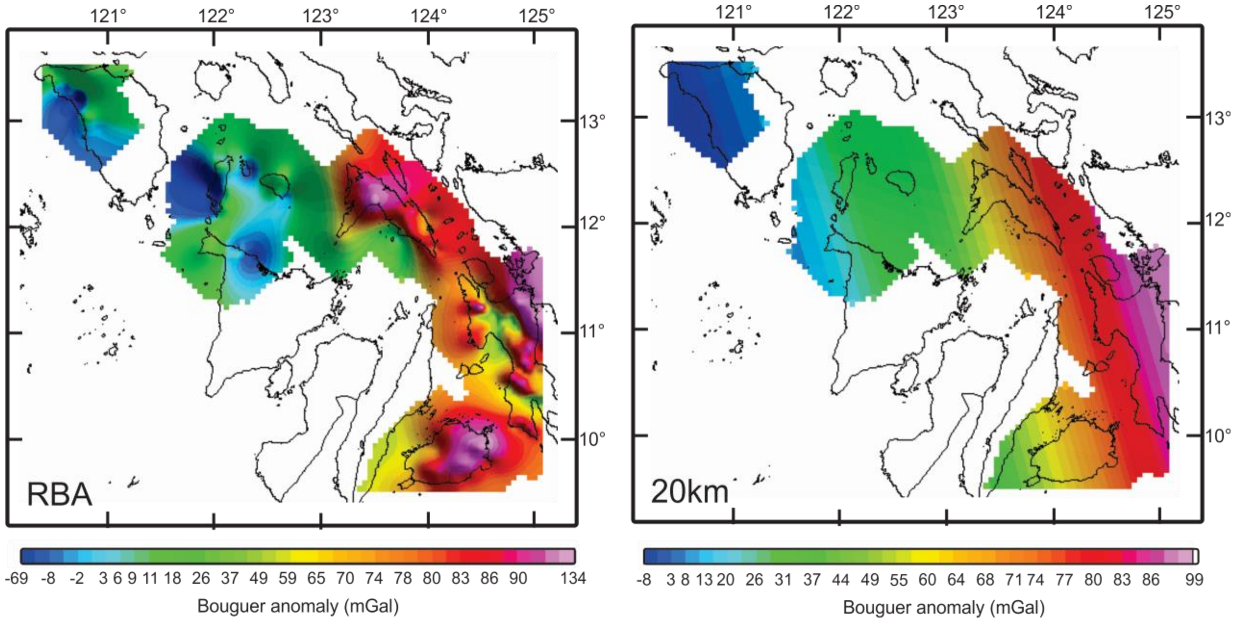

Figure 2: Bouguer anomalies across Central Philippines. A) Regional Bouguer Anomaly (RBA) B) Upwardly continued Bouguer Anomaly map up 20 km.

Table 1. Summary of the ages of different ophiolites and ophiolitic units in Central Philippines

Ophiolite/ Ophiolitic Unit	**Dating Techniques**	**Age**	**References**
Antique	Radiolarians from the overlying chert	Late Cretaceous	Rangin et al. 1991
Malitbog	Foraminifera of overlying limestone	Late Cretaceous	Florendo et al. 1987
Samar	Radiolarians from the overlying chert	Early to Late Cretaceous	Dimalanta et al. 2006
Tacloban	U-Pb isotopic dating of zircons extracted from gabbro	Early Cretaceous	Suerte et al. 2005
SE Bohol	Radiolarians and foraminifers of overlying chert	Early Cretaceous	Barreto et al. 2000
Balud	Radiolarians from intercalated chert	Early Cretaceous	This study
Sibuyan	Radiolarians from intercalated chert	Jurassic to Cretaceous	Maac and Ylade, 1988

MARINER: Seismic Investigation of the Rainbow Hydrothermal Field and its Tectono/Magmatic Setting, Mid-Atlantic Ridge 36° 14'N – A Report from RV *M.G. Langseth* Cruise MGL1305

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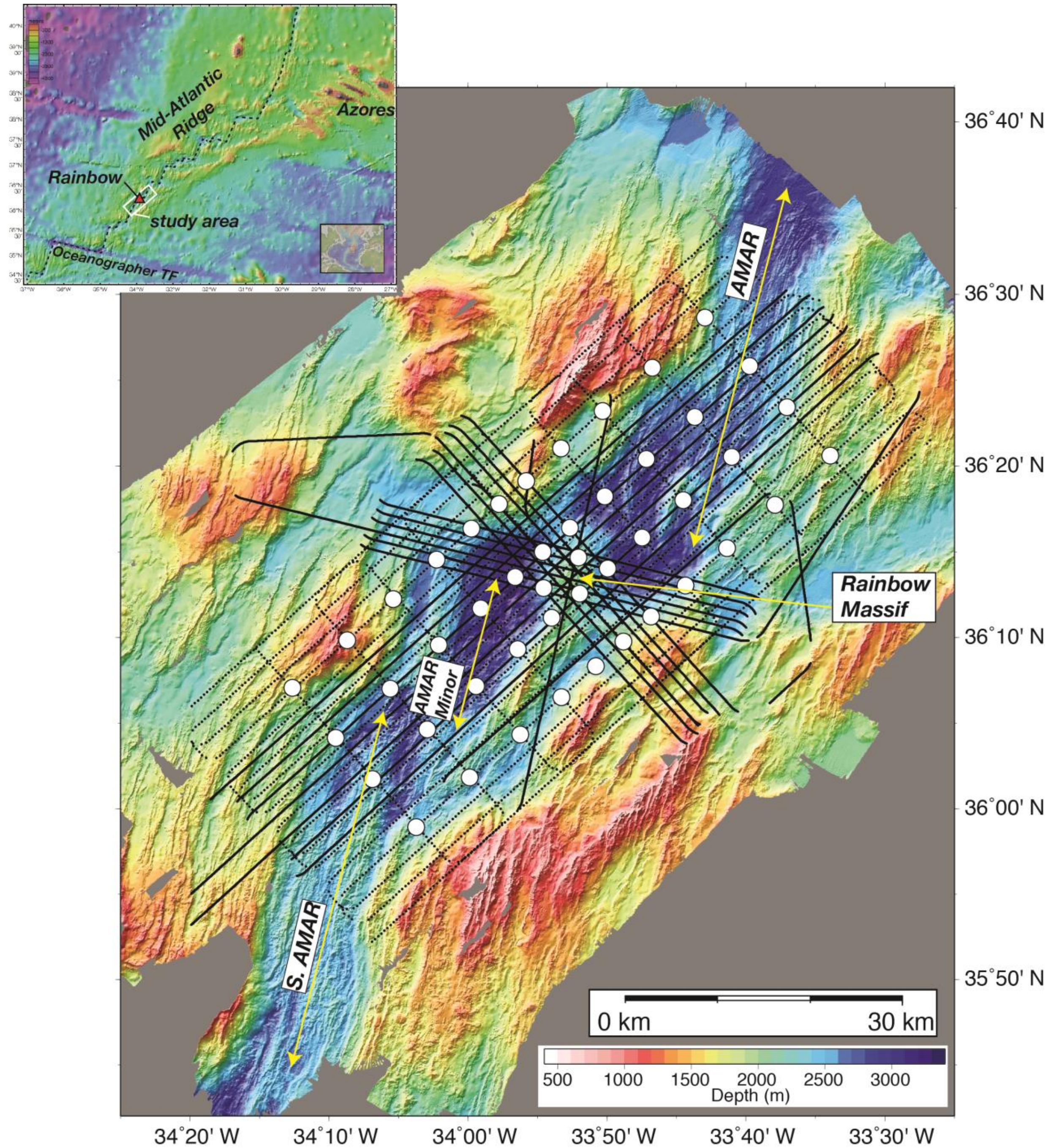

Figure 1. Shaded bathymetry map of the MAR at the Rainbow NTD (data from cruise MGL1305). Open circles and dots are OBS and shot locations, respectively, for the 3D active-source tomography experiment. Solid lines are MCS profiles. Top-left inset shows location of the study area in the MAR south of the Azores.

Scientific motivation and project objectives

Hydrothermal systems extract approximately one third of the global Earth's yearly heat loss through mid-ocean ridges (MORs) and are a primary means of chemical exchange between the solid Earth and the oceans. Hydrothermal circulation occurs when seawater penetrating the lithosphere through fractures is heated through its contact with hot rock, undergoing chemical alteration. As it penetrates deeper, its temperature increases and the water becomes buoyant, rapidly rising back to the seafloor. Sections of MORs with greater magma supply, and hence greater heat flux, are thought to host a greater abundance of hydrothermal systems. This simple conceptual model provides a framework within which to understand hydrothermal heat generation and extraction, yet leaves open the question of the nature of heat sources and the physical mechanisms controlling hydrothermal fluid flow [e.g., Wilcock and Delaney, 1996].

Most of our understanding of hydrothermal systems along ridges results from studies of the materials output by this process [e.g., Humphris et al., 1995; Von Damm, 1990]. In contrast, the deeper distributions of melt that may drive these systems and the general tectonic and thermal structure around them are inadequately known and have been studied in only a few locations, most of them along fast and intermediate spreading ridges like the East Pacific Rise and the Juan de Fuca Ridge. In these settings, hydrothermal systems are mainly located within the axial zone of a spreading segment, hosted in basaltic rock, and are primarily driven by heat extracted from crystallization of mid-crustal melt sills [e.g., Canales et al., 2006; Haymon et al., 1991; Singh et al., 1998; Van Ark et al., 2007]. In contrast, hydrothermal systems along slow spreading ridges like the Mid-Atlantic Ridge (MAR) show a great variety of venting styles and host-rock lithology, and are located in diverse tectonic settings like axial volcanic ridges, non-transform ridge discontinuities (NTDs), the foot of ridge valley walls, and off-axis inside corner highs [e.g., German and Parson, 1998; German and Lin, 2004]. Here the relative roles of magmatic heat input, tectonic heat advection, and faulting in controlling ridge thermal structure and hydrothermal circulation are still poorly understood [e.g., Cannat et al., 2004].

The Rainbow hydrothermal field (RHF) is a major high-temperature hydrothermal system that is located within one such setting, a non-transform discontinuity of the MAR [German et al., 1996] (Figure 1). It is hosted in an ultramafic massif, venting methane-, hydrogen- and iron-rich fluids [e.g., Holm and Charlou, 2001] that support diverse macrofaunal and microbial communities [e.g. Desbruyères et al., 2001; O'Brien et al., 1998]. The tectonized setting of the NTD apparently lacks significant volcanic features, yet the RHF vents high-temperature fluids (up to 365 °C) at high flow rates [German et al., 1996], which is difficult to explain without a magmatic heat source. This conundrum stands in the way of our ability to develop a model for the origin and functioning of the Rainbow vent field as well as inhibits development of more general models for the roles of magmatic heat input and tectonic faulting on controlling thermal structure and hydrothermal circulation, particularly for hydrothermal systems in regions dominated by ultramafic lithologies, which are common at slow and ultra-slow MORs [e.g., Cannat et al., 1995; Dick et al., 2003].

Starting in 2013 with funding from the US NSF, we began a multi-faceted geophysical investigation of the MAR region between latitudes 35°50'N and 36°30'N (approx., Figure 1). This section of the MAR includes, from south to north, spreading segments South AMAR, AMAR Minor, and AMAR [German et al., 1996], and the Rainbow NTD, Massif and associated hydrothermal fields. The fundamental question we aim to address in this project is: What are the relationships between magmatism, faulting, substrate lithology, and hydrothermal circulation at the Rainbow hydrothermal field? By addressing this question and investigating the subsurface structure of this unique system, we aim to advance understanding of the relationships between magmatic processes, hydrothermal circulation, and the thermal and tectonic structure of a ridge discontinuity, which will be applicable to other regions. In particular, understanding the mechanisms and processes that result in hydrothermal circulation at Rainbow will allow us to understand how high-temperature hydrothermal fluids can be generated in tectonized, ultramafic terrains (e.g., Logatchev and Ashazde fields in the MAR [Bel'tenev et al., 2005; Krasnov et al., 1996], and to make predictions about how common similar hydrothermal systems (i.e., hosted in ultramafic rocks, venting hydrogen, methane, and iron-rich high-temperature fluids) might be along other slow- and ultra-slow spreading ridges.

We will use geophysical observations to test a specific hypothesis against two alternates:

Hypothesis: The heat driving hydrothermal circulation at Rainbow is provided by a magma body underlying the ultramafic rocks exposed on the massif, and steep normal faults crosscutting the massif provide permeability pathways for fluid circulation. If this hypothesis is correct, then Rainbow may be experiencing a phase of enhanced melt supply from the mantle, therefore providing an excellent opportunity to investigate delivery and emplacement of melt beneath a NTD, where long-term magma supply should be very low [e.g., Cannat et al., 1995; Phipps Morgan and Forsyth, 1988]. In addition, this hypothesis predicts that at least part of the Rainbow massif could be mafic in origin, despite indications suggesting is predominantly ultramafic [e.g., Fouquet et al., 1997].

Alternate 1: The heat driving hydrothermal circulation at Rainbow is extracted from the magmatic system(s) of the neighboring segment(s), and fluids are transported relatively large lateral distances on possibly low-angle fault(s). An alternative to hypothesis 1 is that the NTD is currently magmatically starved, but fluids are taping magmatic heat from the neighboring segments [German et al., 1996], possibly via low-angle faults that provide pathways for fluids to travel from the ends of the neighboring segments to the center of the NTD. Thus, this hypothesis does not require presence of a significant component of mafic lithologies beneath the massif, consistent with seafloor observations and exit fluid chemistry.

Alternate 2: Detachment faulting controls hydrothermal circulation and uplift of the Rainbow massif. There is increasing evidence that a variety of hydrothermal venting styles are intimately linked to detachment faulting and formation/evolution of oceanic core complexes [McCaig et al., 2010]. It has been proposed that the RHF sits on the footwall of a detachment fault [Gràcia et al., 2000], and some of the geological characteristics of the massif are consistent with this hypothesis [Gaill et al., 2007; Ildefonse et al., 2008]. In this scenario fluids could extract heat from the hot (and possibly partially molten) deep region of the mantle where a detachment fault roots, and/or from the exhuming footwall. If uplift of the massif is not the result of detachment faulting, then buoyant diapirism driven by serpentinization is a possible alternative [e.g., Bonatti, 1976], as substantial hydration of the mantle beneath the massif would be accompanied by volumetric expansion and reduced density.

Report

To test these hypotheses we conducted in April-May, 2013 a geophysical survey of the Rainbow area onboard the US RV Marcus G. Langseth (cruise MGL1305). The acquired data will allow us to carefully image the subsurface architecture (which is intimately linked to hydrothermal flow processes) around and beneath the RHF and map, in 3D, the seismicity associated with the vent field and the NTD. Our geophysical survey of the Rainbow area consisted of:

(1) A large-scale 3D high-resolution active-source seismic tomography experiment using 46 ocean bottom seismometers (OBSs) and airgun sources (36-element, 6,600 cu.in. total volume) (Figure 1). This dataset will be used for determining the 3D seismic velocity structure of the crust and upper mantle. About 3,800 shots were triggered along ~1,700 km of profiles with a nominal shot spacing of 450 m. Airgun sources were towed at a nominal depth of 12 m. OBS had 4 components (geophone plus hydrophone) and recorded at a sampling rate of 200 Hz, and were provided and operated by the US Ocean Bottom Instrumentation Pool (OBSIP).

(2) Twenty-one 2D multichannel seismic (MCS) reflection profiles using one 8-km-long hydrophone streamer and airgun sources (36-element, 6,600 cu.in. total volume) (Figure 1). This dataset will be used for high-resolution 2D tomography of the shallowmost lithosphere as well as for depth imaging of faults, melt bodies, and other major structural discontinuities. About 1,300 km of MCS profiles consisting of ~35,000 shots at a nominal spacing of 37.5 m were acquired. Each shot was recorded in 636 channels (12.5 m group spacing) in 12-second-long records at 2 ms sampling rate. Both, hydrophone streamer and airgun sources were towed at a nominal depth of 12 m.

(3) Deployment of a network of 15 OBSs for long-term monitoring (~7-8 months) of the microseismicity of the Rainbow Massif and NTD (Figure 2). This dataset will be used for locating active faults and determine their 3D geometry, and for investigating hydrothermal processes along fluid flow paths. Recovery of this OBS network is scheduled for January 2014.

(4) Multibeam bathymetry and backscatter echosounding data were acquired with full coverage within a 65km x 100km area centered on the Rainbow Massif, encompassing the seismic survey area (Figure 1). This dataset will provide the morphological context within which the other datasets can be interpreted. We used a hull mounted 1ºx1º Kongsberg EM-122 multibeam system with 432 soundings per swath and two swaths per ping cycle for up to 864 soundings, transmitting at a frequency of 12.0 kHz with maximum angular coverage of 150°. For this cruise the system was run with an angular swath width of 124˚ to 130˚ in an equal area mode, where the beamformer projects beams of varying angle across the swath to create equal size sonar footprints on the seafloor, resulting in a footprint of roughly 20

m in 2500m of water. The resulting swath width is between 2.5 and 3.5 times the water depth, corresponding to 1000-12,000 m in our survey area.

(5) Underway potential fields (gravity and magnetics) data were acquired along profiles coincident with both the OBS and MCS shooting profiles. These datasets will contribute towards improving our knowledge on variations in sub-surface density and magnetization (and therefore structure) of the study area, and age of the morphological features. Gravity data were acquired with a Bell Aerospace BGM-3 marine gravimeter. Surface magnetic data were acquired with a Geometrics 882 magnetometer, towed at a distance of 140 m from the ship, with a frequency of 10 samples per second.

In addition to the geophysical measurements described above, we conducted 35 XBT vertical profiles, and we collected a few sediment samples of opportunity from OBSs that returned to the surface with enough seabed material preserved in their frames.

MARINER Cruise Science Party consisted of a multi-disciplinary team of scientists from institutions and universities from several countries, and included two postdoctoral researchers, three Ph.D. graduate students, and three undergraduate students. We will be working together over the next couple of years towards developing a consistent model of the architecture, heat supply and tectonics of a ridge NTD. Data processing and modeling is currently underway. Data and results will be reported at international scientific meetings and publications in the coming months. More details about this project and cruise achievements can be found at: http://www.whoi.edu/sites/rainbow. Questions about this project should be directed to the co-PIs R.A. Dunn (dunnr@hawaii.edu), J.P. Canales (jpcanales@whoi.edu), and R.S. Sohn (rsohn@whoi.edu).

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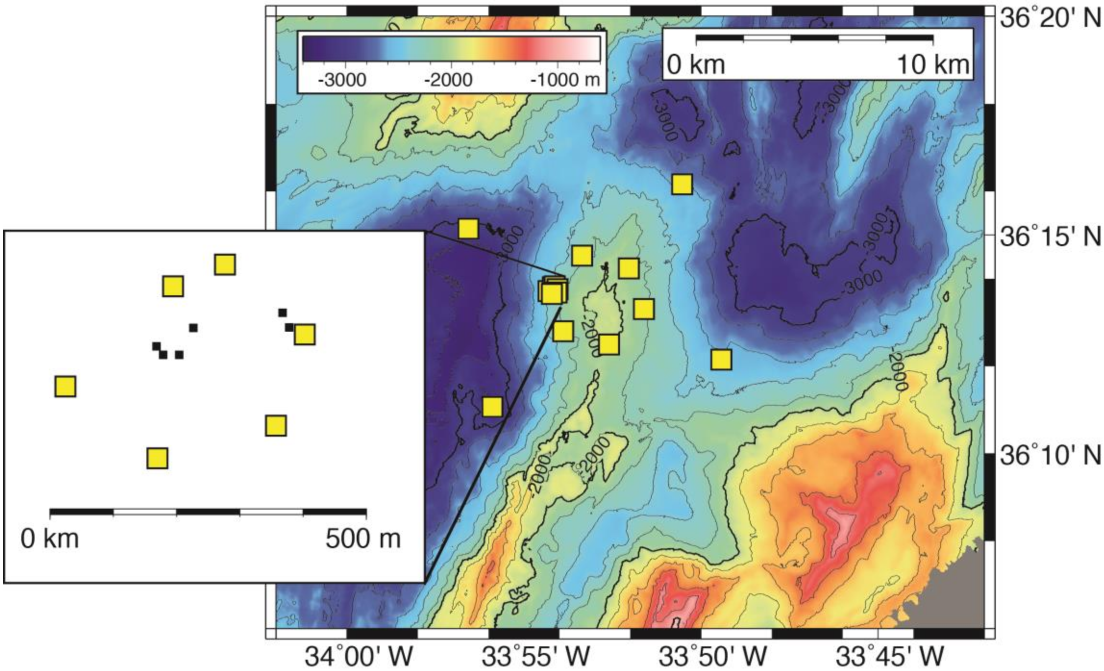

Figure 2. Bathymetry map of the Rainbow NTD and OBS network for passive seismic monitoring. Yellow squares are OBS drop positions. Black squares in inset are location of active hydrothermal vents from Dyment et al. [2009]

Preliminary report on the COLMEIA Cruise, Equatorial Atlantic Recife, January 24 - Recife, February 28, 2013

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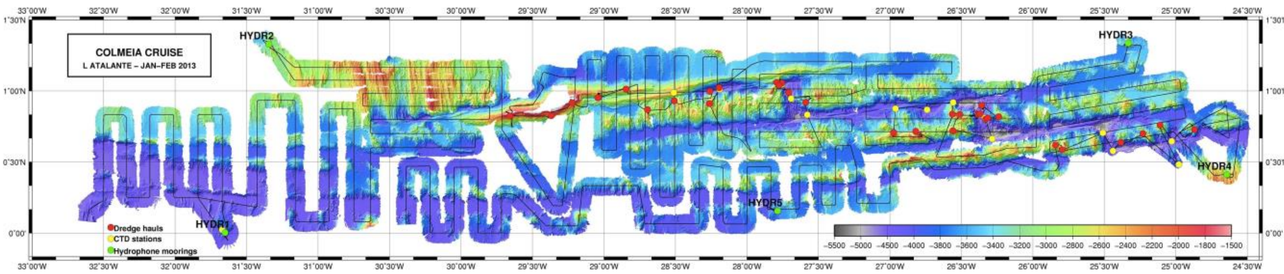

Figure 1. Multibeam bathymetry of the study area with location of the dredge sites in red, the CTD sites in yellow and of the five hydrophone moorings, in green. Scale en meters.

Abstract

The COLMEIA cruise, held in the Equatorial Atlantic, in the area of the St. Paul transform system, is part of a joint effort between France and Brazil for the study of the Mid-Atlantic ridge near the St. Peter St. Paul's Rocks. During the cruise we acquired multibeam echosounder bathymetry, backscattering, water column acoustic data, gravity, magnetics and seismics. Thirty-one successful dredges returned a wide variety of rocks, including gabbros and peridotites. Fifteen CTD stations with nephelometric profiles were cast and a hydrothermal plume signal was found, with a source probably located in the Mid-Atlantic Ridge segment south of the St. Paul transform system. Both the bathymetry data and the rocks recovered by dredging suggest that the image of a regional amagmatic Mid-Atlantic ridge is a simplistic view of the processes active in the St. Paul system. Significant variations in the spreading style were recognized, with a more magmatic northern segment and comparatively less magmatic central and southern segments where long-lived asymmetric core complexes were found. A most important result is the evidence for compressive stresses across the area, which can be linked to the uplift of the Saint Paul mylonitic massif.

Introduction

The COLMEIA Cruise was held between January 24 and February 28, 2013 on board the research vessel L'Atalante, in the area of the Saint Paul fracture zone in the Equatorial Atlantic. The scientific objective of the cruise was to study in detail the temporal evolution of the complex Saint Paul transform plate boundary, and the origin of the St. Peter -St. Paul mylonitic massif. We carried out a complete survey of the area with multibeam echosounder bathymetry, backscattering, water column acoustic data, gravity, magnetics and seismics. We also performed thirty-one successful dredges and fifteen CTD stations. Five autonomous hydrophones were moored in the SOFAR channel around the study area in order to monitor the seismic activity and will be recovered mid-2014 (Figure 1).

The Equatorial Atlantic is characterized by the presence of major transform faults that offset the Mid-Atlantic Ridge axis for hundreds of kilometers. The most peculiar feature of this region is probably the tiny archipelago of St Peter-St Paul Rocks, located inside the St Paul transform and fracture zone system. On these islands, stronlgy mylonitized peridotites emerge above sea level, a unique feature in the world's ocean. The St. Paul transform and FZ system is a complex, multi-fault transform boundary displaying three small accreting segments, less than 20 km long, separated by large offset transform faults, forming an « intra-transform » ridge geometry (Schilling et al., 1995; Hékinian et al., 2000).

This area of the Mid-Atlantic ridge has long been recognized as a mantle "cold spot" (e.g. Bonatti, 1990; Bonatti et al., 1993; Schilling et al., 1995). The ridge axis reaches its deepest values along the St Paul intra-transform ridge segments. Basalts dredged along the ridge axis revealed low degrees of melting and temperatures (Schilling et al., 1995). Peridotites dredged at different locations along the equatorial transforms (Bonatti et al., 1993, 2001; Seyler and Bonatti, 1997) also revealed low mantle melting regimes. Thus, petrology and geochemical data suggest that the melting regime in the Equatorial Atlantic is lower than the nearby ridge regions. The source of the anomalously low melting rates beneath the equatorial MAR is supposed to be linked to a thermal and/or compositional anomaly in the mantle beneath the Equatorial Atlantic (Bonatti, 1990; Bonatti et al., 1993; 2001; Schilling et al., 1995). Bonatti (1990) proposed that the delamination of continental lithosphere during the opening of the Equatorial Atlantic, could explain the chemistry of the samples and the inferred low degree of melting, while Sichel et al. (2007) suggest that the anomalous mantle results from fragments of a subducted slab in the upper mantle. Recent work suggests that the mantle beneath the Equatorial MAR may have already experienced some amount of melt extraction before the present times (Brunelli and Seyler, 2010), which is in agreement with the high Os model ages (Esperança et al., 1999).

The main objectives of the COLMEIA cruise were:

1. To verify whether the Equatorial Mid-Atlantic ridge segments are undergoing a cold accretion regime, thus explaining the emplacement of deep crust and mantle rocks at the seafloor and in the St Peter St Paul Rocks;
2. To understand the exhumation processes of these deep rocks;
3. To understand the processes at the origin of the peridotite massif and its connection with the ridge segments;
4. To understand the nature of the equatorial upper mantle;
5. To map and characterize hydrothermal active areas in the active parts of the system.

Preliminary results

Multibeam bathymetry data collected during the COLMEIA cruise confirm the existence of three small intra-transform ridge segments at the St. Paul system. The segments are short and narrow, with deep axial valleys. Axial depths are below 4000 m on average, and reach 5400 m in some nodal basins. There is no evidence for a clearly defined neo-volcanic ridge on the axial valley floors, but a few round volcanoes were observed in the axial valley of the central segment. The pattern of off-axis abyssal hills is highly variable from one segment to another. The northern segment displays a long sequence of magmatic abyssal hills. The central segment shows both hummocky ridges probably of magmatic origin, but also ridges where peridotites have been dredged. The southern segment shows few short, symmetric ridges made of peridotite and gabbros. Both the central and the southern segments display asymmetric core complexes nucleating at segments ends. This variety of off-axis morphologies suggest that accretionary processes along the intra-transform segments are unstable and highly variable in space and time. Two remarkably long-lived core complexes were observed on the western flanks of the central and southern segments.

The new bathymetry data also provide insights into the tectonic setting of the St Peter-St Paul peridotite massif. The massif is currently located on the western flank of the northern intra-transform segment, near the northern transform limit of the system, on the south-American plate. It probably corresponds to a transverse ridge, such as observed in other fracture zones, especially in the Central Atlantic (Hékinian et al., 2000). Evidence for compressive features is observed along the base of the massif, suggesting that uplift is linked to a regional compressive field, consistent with the compressive focal mechanisms reported for this area (Wolfe et al., 1993). Seismic reflexion data show the existence of thick sedimentary layers deposited in the discontinuities between the short ridge segments. Several profiles suggest a highly fractured basement beneath the sediments, suggestive of deformation during the tectonic evolution of the system.

Rock samples were collected by dredging at the axis and flanks of the intra-transform segments, and on the submersed base of St Peter-St Paul massif. A wide variety of rock types, have been recovered. A few structures yielded peridotite with different degrees of serpentinization and deformation. Fresh basalt were recovered from all segments along with gabbros particularly associated to some off-axis features. The abundance of magmatic rocks may lead to re-evaluate the idea that mantle rocks are dominant in the area and suggest that the Mid-Atlantic ridge inside the St. Paul system may not correspond to a near-amagmatic regime with regional mantle exhumation.

Fifteen CTDs with nephelometric profiles were cast at the axial valleys and transform faults of the area but no signal suggestive of a hydrothermal plume was detected on the ridge segments inside the St. Paul system. Three stations yielded a weak nephelometric signal, confirmed by both methane and manganese analyses performed on board, but the signal distribution suggests a source located close to the northern end of the Mid-Atlantic ridge segment immediately south of the St. Paul system.

The five hydrophones moored in the area form a local network aiming to monitor the seismic activity, which is intense in the large offset equatorial transforms. The instruments will be recovered in May 2014 with a Brazilian ship.

During the Expedition three Marine Mammal Observers (MMO) searched for marine mammals. The observations started at sunrise and continued until the sundown on the basis of two hours watches, always with two MMOs on duty. The observers used binoculars (7x50) calibrated for distance evaluation to search for the animals and photographs were taken using a 70-300mm lens. The species was identified using field guides whenever possible or else by exchanges of photographs with other marine mammal researchers. Over a period of 29 days 330.68 hours of observations were made (117.27 hours with the air guns on operation). Fourteen groups of cetaceans were observed (0.04 groups per hour of effort). Nine groups could not be identified at species level because of the distance of the sighting. There were four groups of Pilot Whales and one group of five Sperm Whales (Physeter macrocephalus). Given the occurrence area it is probable that the pilot whales were of the species Globicephala macrorhynchus.

General conclusions

The preliminary results of the COLMEIA cruise revealed that the image of a regional amagmatic mid-Atlantic ridge is a simplistic view of the processes active in the St. Paul system. Instead, significant variations in the spreading style were recognized, with a more magmatic northern segment and comparatively less magmatic central and southern segments. However, the existence of long-lived core complexes at the western flanks of these latter segments suggests that, instead of an amagmatic regime with mantle exhumation, we are observing a reduced melt extraction regime probably controlled by a cold, thick lithosphere where magma is retained in the crust to create large gabbro bodies. Another striking result is the evidence for compressive stresses across the area, which can be linked to the uplift of the Saint Paul mylonitic massif.

Acknowledgements

The COLMEIA cruise is part of the collaboration between France and Brazil for the study of the Equatorial Mid-Atlantic ridge. We thank Captain Gilles Ferrand and his crew as well as the technical staff from GENAVIR-IFREMER for their invaluable assistance during the cruise. The cruise was funded by the French Government through grants to IFREMER, Flotte Océanographique. The project also benefitted from grants from CNRS-INSU, LABEX MER, IFREMER and Laboratoire Domaines Océaniques on the French side and from CPRM and Universidade Federal Fluminense on the Brazilian side.

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Seismic investigations on the extinct Mid-Ocean Ridge in South China Sea.

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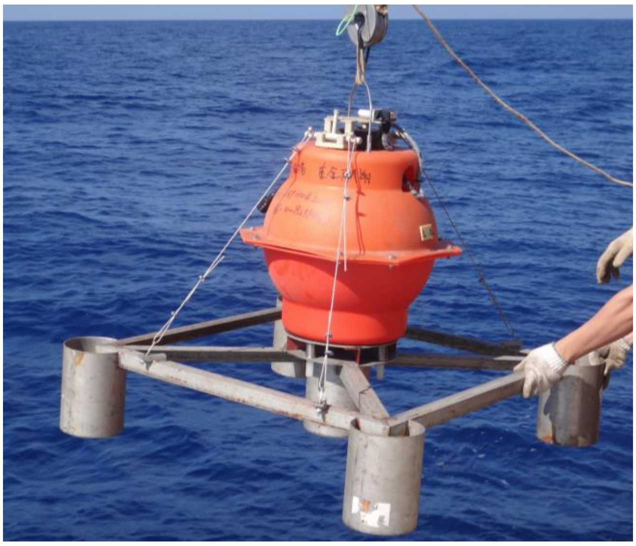

Figure 1. Deploying the I-4C OBS

The extinct ridge in South China Sea (SCS), manifested by the Huangyan-Zhenbei, or Scarborough, seamount chain, represents an extreme case of global mid-ocean ridge system where the magmatism continues for many million years after cessation of spreading. To understand this unique process, the South China Sea Deep (SCSD) program of National Natural Science Function of China (NSFC) funded a seismic project deploying a passive source OBS array to study the lithosphere beneath the extinct ridge and the deep basin (Fig. 1). This project involved four institutes in China, including State Key Laboratory of Marine Geology at Tongji University, The First Institute of Oceanography, SOA, South China Sea Institute of Oceanology, CAS, and Peking University. The experiment was carried out in two phases. In the first phase of the experiment, 18 passive source OBSs, including 15 Guralp CMG-40T and 3 I-4C, were deployed at the central basin of the SCS along the seamount chain in April, 2012, and 11 of them were recovered one year later (Fig. 2). This array recorded over seven month global earthquake data. Analyses of this dataset are underway.

Figure 2. The Seismic team with the first recovered Guralp CMG-40T OBS.

To fill the gap of data coverage due to the failure of unrecovered OBSs, the second passive-source OBS array was deployed, which contains 12 I-4C and 5 Guralp CMG-40T, at the central sub-basin of the SCS using the R/V Dong Fang Hong 2 operated by China Ocean University. The Ship-time Sharing Program of NSFC sponsored the cruise, which lasted for 18 days in July 2014. The recovery cruise has been scheduled to take place in April 2015 using the R/V Tian Long of Guangdong Ocean University at Zhanjiang. The combined OBS stations in phase I and II of the experiment (Fig. 3) will provide uniform data coverage to image the lithospheric structure beneath the extinct Mid-Ocean Ridge in South China Sea

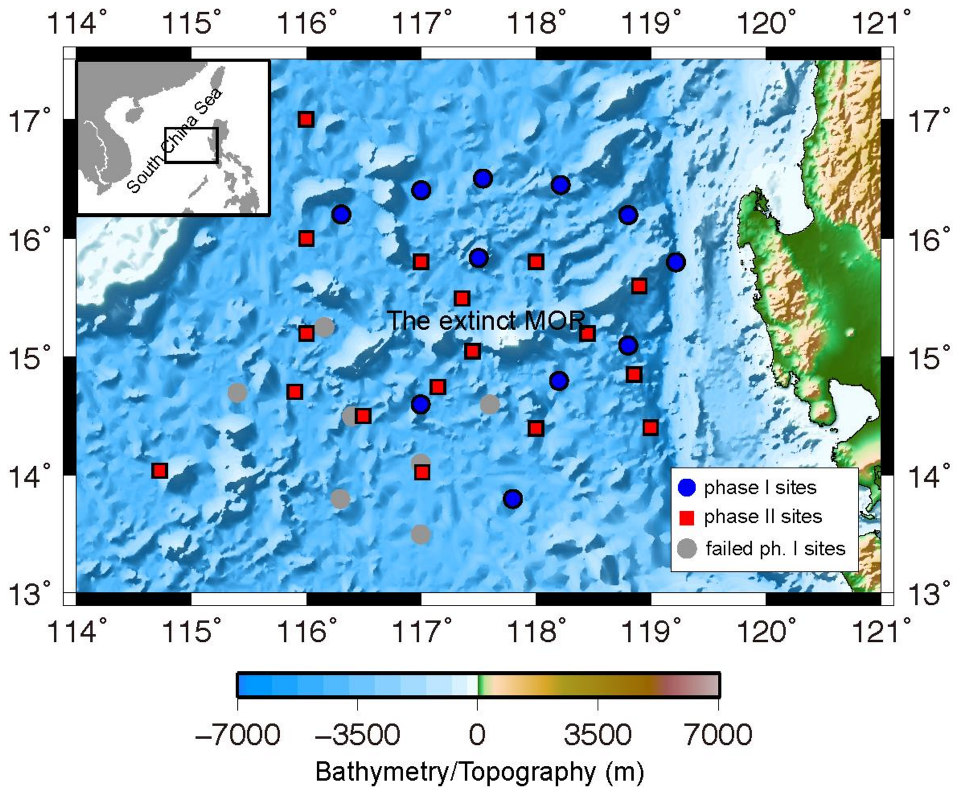

Figure 3. Locations of OBS sites in Phase I and II of the passive-source seismic experiment at the SCS.

Engaging public audiences with deep-sea vents on the Science On a Sphere

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Abstract

The Woods Hole Oceanographic Institution, in collaboration with the Ocean Explorium, created new content for NOAA's Science On a Sphere® (SOS) that interweaves imagery obtained by deep-diving vehicles with global datasets including the InterRidge Vents Database. The SOS is a room-sized digital globe that can be used to tell a story with global datasets. SOS systems are installed at science museums in 19 countries around the world. We invite public audiences to explore the deep sea with the "Global Viewport to Deep-Sea Vents," datasets and movies for spherical display systems. Our two stories – "Life Without Sunlight" and "Smoke and Fire Underwater" – both are effective in enhancing scientific literacy and exciting viewers about the deep ocean frontier.

Introduction

Spherical display systems, also known as digital globes, are new technologies that, in person or online, can inspire students and public audiences to learn about earth system processes. We were particularly interested in educating and exciting the public about geophysical and biological processes and exploration in the deep ocean. We developed a partnership between the Woods Hole Oceanographic Institution and the Ocean Explorium in New Bedford, Massachusetts, USA (http://oceanexplorium.org/) to create new content for NOAA's Science On a Sphere® (SOS) (http://sos.noaa.gov/What_is_SOS/). The Ocean Explorium is one of over 100 science museums in 19 countries around the world that presently host an SOS (http://sos.noaa.gov/What_is_SOS/sos_map.html).

Our project was called the "Global Viewport to Deep-Sea Vents" in honor of the launching of the new HOV *Alvin* in 2014 with its improved viewports for scientific observations. We created content using global datasets, including locations of Earth's known deep-sea hydrothermal vents from the InterRidge Vents Database, and imagery from deep-sea vehicles, including HOV *Alvin*, HOV *Shinkai 6500*, ROV *Jason II*, ROV *Quest 4000*, and more. Ultimately, we developed two educational pieces, "Life Without Sunlight" and "Smoke and Fire Underwater" – each focusing on a different set of Earth Science and Ocean Literacy Principles. Here we describe the design, evaluation, and distribution of the new content for the SOS, some of which has also been adapted for other spherical display systems.

Content design

We developed our content through a process similar to an iterative software development process, in which: "A use case is a collection of possible sequences of interactions between the system under discussion and its Users (or Actors), relating to a particular goal" (Fox and McGuinness 2008). Our use case was to develop an educational package for spherical display systems that would excite the public while advancing scientific literacy. Our design process involved a small team with diverse skills, including a lead scientist, educators at both institutions, graphic artists, and a professional evaluator. Ultimately, we decided to construct two stories, each highlighting three known deep-sea vent fields, and each targeting a different set of three principles relating to geology, biology, and exploration from Earth Science Literacy Principles (http://www.earthscienceliteracy.org/) and Ocean Literacy Principles (http://oceanliteracy.wp2.coexploration.org/).

Our two educational pieces, "Life Without Sunlight" (LWS) and "Smoke and Fire Underwater" (SFU), were produced as movies matched to interactive, docent-led presentations (Fig. 1). LWS dives beneath the sunlit ocean to the darkness of deep-sea vents, where food webs are fueled by chemosynthesis, and specifically targets OLP 5.g.: "There are deep ocean ecosystems that are independent of energy from sunlight and photosynthetic organisms. Hydrothermal vents rely only on chemical energy and chemosynthetic organisms to support life." SFU asks if the viewer knows that there are volcanoes in the deep sea with vents spewing hot water, and specifically targets ESLP 4.5.: "Many active geologic processes occur at plate boundaries. Plate interactions affect the locations of volcanoes and the distribution of resources and living organisms." We conducted front-end and formative evaluations during content development. We were limited to approximately 4 minutes per movie, given previous research indicating the amount of time that the public interacts with stand-alone SOS exhibits (Mitchell et al., 2012), and about 20 minutes for an auditorium presentation.

For docent-led presentations, we provided both a static and an animated version of the InterRidge Vents Database as well as site-specific movies to NOAA's SOS Users Network. At a recent workshop for the SOS Users Network, we found that an effective way to show how the locations of most of the known vents align with plate boundaries – is to show the static dataset on a black globe without any context of land masses or bathymetry. The animation shows the discoveries of vents through time since 1977. The site-specific movies are for Axial Seamount, Galapagos Rift, Loihi, Mariana Back-Arc, Mid-Cayman Rise, and Mata volcanoes.

Both educational pieces integrate a number of other datasets available for the SOS, including bathymetry, Volcano Locations Globally, and Age of the Seafloor. Each educational piece is also matched to a hands-on, K-12 field trip program at the Ocean Explorium. Additional details on the iterative design and development of the content are provided by Beaulieu et al. (2013; click on link to poster).

Content evaluation

We conducted a summative evaluation to test the effectiveness of the completed products, focusing on two NSF Informal Education Impact Categories: "Awareness, knowledge or understanding" and "Engagement or interest." We gathered data via a survey questionnaire to evaluate both the knowledge gained within these literacy principles and the level of excitement generated by interacting with our materials (Fig. 2). Respondents, who remain anonymous, also provided demographic information related to age, home town, and educational attainment.

We conducted a post-test only design with quantitative data based on self-reporting on a scale from "Not at All" to "Quite a Bit." A total of 75 adults and 48 youths responded to our questionnaire, distributed into test groups that saw either of the two stories delivered either as a movie or as an interactive presentation. Here, we report preliminary results for the youths, the majority (81%) of whom live in towns with lower income and lower levels of educational attainment as compared to other towns in Massachusetts. For both narratives, there was knowledge gained for all literacy principles. The mode in responses to knowledge gained was "Quite a Bit" for both the movie and the interactive presentation for four of the principles (LWS geology, LWS biology, SFU geology, and SFU exploration), and "Some" for SFU biology. Only for LWS exploration was there a difference in mode between the interactive presentation ("A Little") and the movie ("Quite a Bit"). Both narratives also generated "Quite a Bit" of excitement about the unexplored deep ocean frontier.

We conclude that our content for digital globes is effective in teaching the literacy principles and engaging interest in deep-sea research and exploration. We attribute this success to the tight collaboration between scientists, educators, and graphic artists in developing the content for public audiences. We are presently compiling our summative evaluation, which will be delivered to the NOAA SOS program, informalscience.org, and at the 2014 AGU Fall Meeting (Beaulieu et al., 2014 submitted) and summarized in a manuscript for a peer-reviewed journal.

Content distribution

The full package is available for download at the Woods Hole Open Access Server (Beaulieu et al., 2014), and previews for the site-specific and educational compilation movies are posted at YouTube (https://www.youtube.com/playlist?list=PL1CGd4Scv4GJsaaFRzItk-btFI757bH8f). The datasets and movies formatted specifically for the SOS will soon be available from the NOAA SOS Data Catalog (http://sos.noaa.gov/Datasets/index.html). The two compilation movies were also formatted for recent versions of the Magic Planet (http://globalimagination.com/). Additional information and artwork is provided from our project website (**http://www.divediscover.whoi.edu/sos**).

Figure 1. In a darkened auditorium, the SOS digital globe appears to hang in mid-air. Here, you can see the silhouette of the presenter, and the light from bathymetry on the SOS illuminates the audience.

Acknowledgements

We would like to thank the U.S. National Deep Submergence Facility and many scientific colleagues who helped in selecting imagery and providing information for the educational materials. Please refer to the closing credits in our movies for detailed acknowledgments. Our work was funded by U.S. NSF #1202977.

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Figure 2. Our survey questionnaire was available online at a kiosk just outside the auditorium (see the SOS in upper right).

Colville Volcano: Geohabitat of the first discovered intact volcano of the Miocene-Pliocene Colville Arc, SW Pacific.

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Abstract

The Miocene-Pliocene Colville Arc was the predecessor to the present day Kermadec Arc, yet prior to 2012 no individual Colville Arc volcanoes had been identified. A multibeam survey of a portion of the Colville Ridge (centered on 30° 11' S, 179° 44' E) during the RV Tangaroa TAN1213 voyage revealed a dissected largely flat-topped volcanic massif– the first volcano of the remnant Colville Arc to be discovered. Colville volcano (informal name) rises 1800 m from the seafloor, however its eroded summit plateau suggests that it was at least 2000 m high. Smaller volcanic cones pepper the summit of the massif and extend at least 10 km to the north where this portion of the Colville Ridge is also similarly flat-topped. These appear to be significantly younger than Colville volcano and may have formed during opening of the Havre Trough, indicating that post-rift volcanism occurred on the Colville Arc possibly up to 2 Ma or younger. As rifting of the Colville Arc occurred in its forearc, further volcanoes and any associated metallogenic deposits of the remnant Colville Arc are more likely to be present on the Colville Ridge than on the Kermadec Ridge.

Biological sampling has revealed a number of new records of invertebrate species for the New Zealand region, or species that are new to science. These include squat lobsters, plexaurid corals, and sponges. Although sampling was very limited, there appear to be differences between the faunal communities of the Colville and Kermadec Ridges. The occurrence of tropical species on Colville volcano suggests there could be an important oceanographic distinction between the two ridges.

Introduction and setting

The currently active Kermadec Arc is part of the continuous New Zealand – Kermadec – Tonga subduction system (Figure 1, inset). It is the latest in a series of volcanic arcs that have been active in northwest New Zealand and offshore during

Cenozoic times. Prior to the creation of the Kermadec Arc a number of volcanic arcs had established themselves, only to eventually cease with a new volcanic arc initiating to the east. The last of these extinct volcanic arcs occurred on the present day Lau-Colville Ridge and extended as far north as Fiji. The southern portion of this ridge (the Colville Ridge) represents the remnants of the Colville Arc, which was active from at least the Early Miocene (Ballance et al., 1999; Mortimer et al., 2010). Opening of the Havre Trough is thought to have commenced at ~ 5-6 Ma (Wright, 1993), resulting in the division of the Colville Arc into two remnant ridges either side of the Havre Trough: the Colville Ridge to the west and Kermadec Ridge to the east. Volcanism along the Kermadec Arc then commenced on or westward (~20-30 km west) of the Kermadec Ridge.

Rifting of the remnant Colville Arc is thought to have occurred on the forearc side, with the Kermadec Ridge consisting of back tilted volcaniclastic sediments of the remnant forearc (Eccles et al., 2012). An important implication of this observation is that it is the Colville Ridge that represents the proto-Kermadec Arc, with the Kermadec Ridge being the proto-forearc. Any volcanoes of the Colville Arc, and metallogenic deposits associated with them, are therefore likely to occur on the Colville Ridge.

Despite recent advances in volcanic arc and backarc basin reconstructions in the Kermadec Arc and Havre Trough (KAHT) region (e.g. see Mortimer et al. (2010) and Wysoczanski et al. (2010) and references within), the geomorphology, age and composition of the Colville Ridge remains largely unknown. This is mostly due to the large areal extent and linear shape of the region, which makes extensive mapping and sampling time consuming and expensive. Furthermore, the vast majority of previous research has been focused on the active volcanoes of the Kermadec Arc, which make up only 4 % of the KAHT system areal extent: by contrast the Colville and Kermadec Ridges (the old Colville Arc) make up 30 % of the surface area of the KAHT (Wysoczanski and Clark, 2012). As a result little is known of the Colville Ridge, including the extent of its ancient volcanoes and magmatic activity.

On the 2012 'NIRVANA' voyage of RV Tangaroa (TAN1213), a portion of the central Colville Ridge was mapped using a 30 kHz Kongsberg EM302 multibeam echosounder (MBES). Here we present MBES data, morphological descriptions and geological and biological sampling information for the first intact stratovolcano of the now extinct Colville Arc to be discovered, which we informally term 'Colville volcano'.

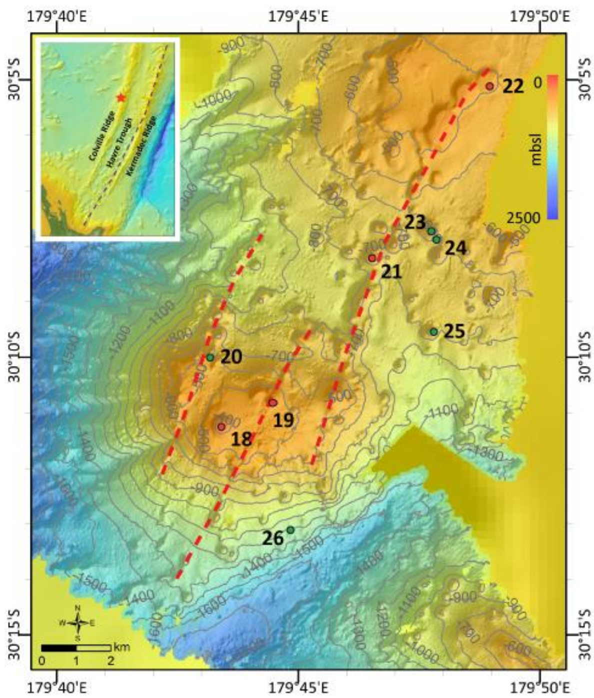

Figure 1: Bathymetric map of Colville volcano showing sampling stations (red dot = epibenthic sled, green = rock dredge) and tectonic lineaments (red dashed lines). Data collected using Kongsberg EM 302 MBES, and gridded to 25 m using World geodetic System (WGS84). Inset shows location of Colville volcano (red star), with North Island New Zealand at bottom. Also shown are the bathymetric highs of the Colville and Kermadec Ridges, separated by the bathymetric low of the Havre Trough, and the modern day Kermadec Arc front (purple dashed line).

Bathymetry and structure of the Colville Ridge

Previous published bathymetric data for the Colville Ridge is sparse. Early work was limited to a few seismic lines across the ridge (e.g. Karig, 1970; Caress, 1991; Ballance et al., 1999). A 1988 survey of the New Zealand – Tonga system was undertaken by the RRS Charles Darwin using GLORIA side scan sonar. However, only minor sections of the Colville Ridge were mapped, and data on only the very southern extremity of the Colville Ridge were published (Wright et al., 1990). The first bathymetric mapping of the Colville Ridge was undertaken in 1994 by R/V Giljanes using the University of Hawaii MR-1 towed sonar array (Wright, 1997). The survey mapped the entirety of the Colville and Kermadec Ridges south of 33° 30' S. These early surveys resulted in the first bathymetric profiles and tectonic models of the ridge, but individual volcanic edifices were not identified.

Higher resolution MBES mapping since then was restricted to a few single swath transits that crossed the Colville Ridge. In 1998, the R/V Sonne (SO135) mapped the top and eastern flanks of the Colville Ridge at ~30° S. Earlier, the 1997 RV Yokosuka voyage YK97-01 ran a 400 km single swath using a Furuno HS-10 MBES along the eastern edge of the Colville Ridge south of ~ 31° S. A 2006 survey by the same vessel (YK06-14) mapped the western Havre Trough centered on 34° 30' S, using a 12 kHz SEABEAM 2000 MBES. This survey found two volcanic cones nearly 1 km high on the western flank of the Colville Ridge, as well as a large backarc volcano (Gill volcano) 30 km to the west within the Havre Trough (Wysoczanski et al., 2010). The 2010 'KARMA' (TAN1007) voyage of RV Tangaroa revisited these cones and surveyed a small section of the Colville Ridge using a Kongsberg EM300 MBES (Lamarche et al., 2010). This portion of the ridge and one of the cones first mapped in 2006 were also sampled (Handler et al., 2011).

Subsequent to the MBES survey during the NIRVANA voyage presented here, a > 200 km section of the Colville Ridge was extensively mapped during TAN1313 (see the New Zealand National Report in this issue), making it the largest expanse of the Colville Ridge surveyed to date.

Colville Volcano

Morphology

Multibeam surveying of the Colville Ridge during the NIRVANA voyage revealed a large eroded stratovolcano centered on 30° 11' S, 179° 44' E (Figure 1). The basal diameter is ~ 20 km, with the full extent of the constructional volume of the edifice difficult to constrain as its north and northeastern sides sit on a platform at 800-900 mbsl. The nature of this platform is uncertain and may be basement to the volcano, or comprised of eroded infill from the volcano sitting on basement of unknown depth. Regions of low backscatter reflectivity immediately north and northeast of the edifice (Figure 2) suggest that there is indeed some sediment cover in these regions, although subsurface imaging would be required to ascertain its thickness. On its western and southeastern sides, Colville volcano rises 1800 m and 1400 m, respectively, to a high of 375 mbsl.

The summit region of Colville volcano is characterized by a flat 5 km wide eroded plateau sitting at 475-500 mbsl, upon which several smaller volcanic cones sit. As such, Colville volcano has a guyot-like shape, similar to most extinct submarine SW Pacific volcanoes. Upward extrapolation of the flanks of the volcano indicate that it could have been over 200 m higher prior to erosion, giving it a pre-eroded relief of ~ 2000 m. The highest point on the volcano is a cone with an eroded top, 700 m wide and rising 90 m above the summit plateau. Despite erosion of the edifice summit region there is little evidence for erosion or sector collapse of Colville volcano except for several deep (up to 100 m) gullies on the western flank.

The Colville Ridge ~ 10 km northeast of Colville volcano is also flat-topped with a summit plateau sitting at the same level as Colville volcano (~ 500 mbsl). Both of these regions show high backscatter reflectivity suggesting either exposed hard substrate and/or thick Mn crusts (Figure 2). A field of volcanic cones (including the highest point on Colville volcano) up to 100 m high extend northeast from Colville volcano across the Colville Ridge. They sit on the summit plateaus of the Colville Ridge suggesting that they were formed after erosion of the ridge to the present day level, and are significantly younger than Colville volcano. The cones lie on NNE-tending lineaments (Figure 1) that parallel the strike of the major faults of the Colville Ridge (Wright, 1997) yet they themselves are not faulted, suggesting that their formation was associated with rifting of the Havre Trough and that post-rift magmatism occurred on the Colville Arc. The highest of these cones are also flat topped and eroded to a level of ~ 400 mbsl, further suggesting that post-rifting subsidence occurred to this level.

Sampling and composition of Colville volcano.

A total of 9 attempts were made to sample geological and biological specimens from Colville volcano and surrounding cones (Figures 1 and 2). Of these, four were epibenthic sleds towed downslope to maximize the biological sample return, and five were rock dredges, towed upslope to maximize rock sampling. Two (stations 23 and 26) were unsuccessful due to steep terrain and heavy Mn coating at the sampling sites.

Rock samples recovered were a variety of lithologies indicating the presence of an old eroded Mn-encrusted volcano (Figure 2a-c). These included porphyritic basalts, vesicular basalts, indurated sandstone and breccia and microcrystalline plutonic rocks. The clasts varied from moderately to highly altered although some had fresh interiors surrounded by altered rims several cm deep. Mn coating of clasts were typically 3-5 mm thick, although indurated breccia from stations 18 and 19 had Mn coatings up to 15 mm thick. Some samples from station 19 (on a volcanic cone from the summit plateau) were only slightly altered and had only thin (up to 2 mm) Mn crusts. This included a vesicular basalt (Figure 2a), suggesting that this volcanic cone is significantly younger than Colville volcano. Notably, although both the cones and faulted scarps of the Colville Ridge show high reflectivity (Figure 2), the cones are less reflective suggesting thinner Mn deposition and a younger age for the cones than the scarps. Although the age of the cones cannot be constrained here, they could conceivably be younger than 2 Ma, based on an Ar-Ar age of 1.2 ± 0.8 Ma obtained on an andesite on the western margin of the Colville Ridge by Mortimer et al. (2007), which they considered to represent the westernmost expression of Colville volcanism. Similarly young K-Ar ages of 1.3 ± 0.3 to 2.0 ± 0.3 Ma were obtained on the western flanks of the Kermadec Ridge at ~32° 20’ S (Ballance et al., 1999), consistent with the occurrence of post-rift volcanism along the inner flanks of both the Colville and Kermadec Ridges.

Fresh white pumice clasts (some over 25 cm in size) were also recovered from all sampling stations except station 20 (Figure 2d). These were identical in appearance to pumice floating in the water at this location that was derived from the July 2012 eruption of Havre volcano over 130 km to the east (Carey et al., 2014; Jutzeler et al., 2014). The volume of pumice recovered comprised up to half of the haul at each station attesting to the large volume and widespread dispersal of pumice from the 2012 Havre volcano eruption, which serves as a warning that pumice from dredge hauls may not necessarily be derived from the area sampled.

Biological assemblages

Epibenthic sled and dredge deployments on Colville volcano and the adjacent ridge recovered over 1000 specimens, the vast majority being invertebrates, but also the occasional fish (see Figure 4, Table 1). The invertebrates were from 9 phyla, and to date 154 separate putative species have been identified. These covered a diverse range of faunal taxa, and it will be some time before taxonomic experts have completed examination of all the catch. Corals (especially the fan like plexaurids and primnoids, and the hydrocorals), echinoderms (in particular ophiuroids- the brittle stars), and sponges (mainly the soft Demosponges) were the most species-rich groups, and also the most abundant. 200 and 84 specimens of the small brittle stars Asterochema ?bidwillae and Ophiocantha fidelis respectively were caught in single sled tows on the ridge. Similarly, relatively large numbers of plexaurids were taken in one sled tow on Colville volcano, with 29 individuals of a species of Placogorgia, and 52 of an undescribed plexaurid genus.

A number of the specimens are new records of species for the New Zealand region, or even globally. Several squat lobster specimens appear to be tropical species that are not normally found as far south as New Zealand. The plexaurid corals are believed to include 2 new genera, and 6 new species; and with sponges there is one new genus, and 13 new species.

The number of tows was small, and hence it is not possible to make any strong comparisons with other regions of New Zealand. However, the high proportion of new species for New Zealand is surprising, given that some of the volcanoes and seamounts of the Kermadec Arc to the east have been intensively sampled (see Wysoczanski & Clark 2012). The occurrence of tropical species suggests there could be an important oceanographic distinction between the two ridges. It is perhaps also notable that the coral fauna was dominated by gorgonian groups (the primnoids and plexaurids), and not reef or thicket-forming scleractinian (stony) corals. This is similar to coral composition on the Kermadec Ridge, and confirms the more southern dominance of stony corals in the New Zealand region.

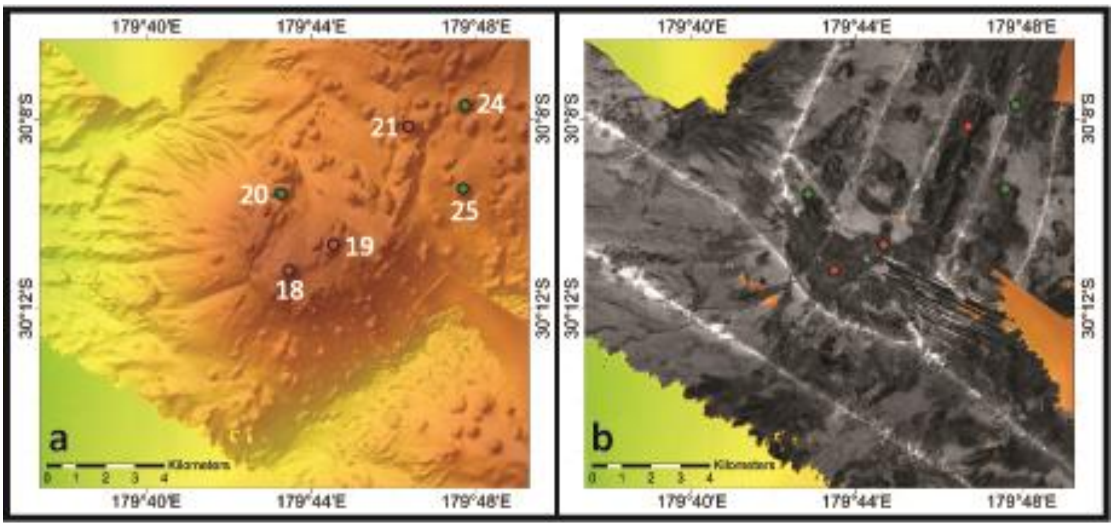

Figure 2: Bathymetric map (a) and backscatter map (b) of Colville volcano. Symbols as for Figure 1. For (b), dark = high reflectivity, white = low reflectivity.

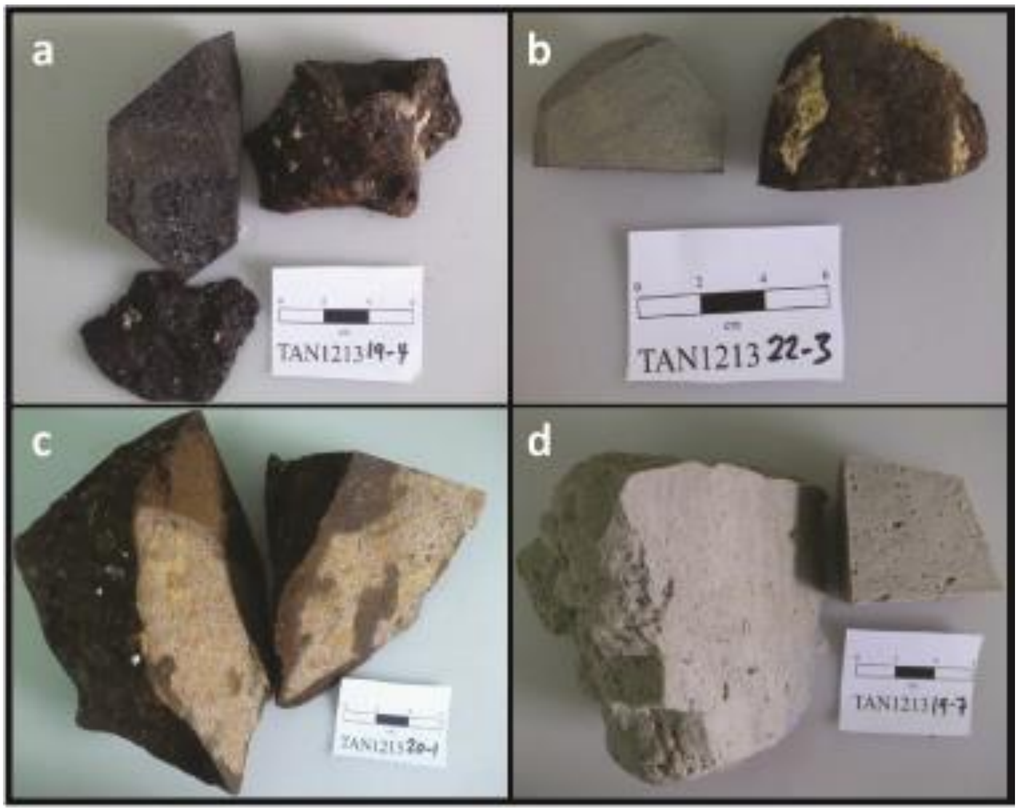

Figure 3: Rock samples collected from Colville volcano and Colville Ridge, with sample numbers and scale shown. (a) Weakly altered vesicular basalt from a summit cone. (b) Microcrystalline igneous rock from a volcanic cone on the summit of the Colville Ridge. (c) Indurated volcaniclastic breccia from the summit plateau of Colville volcano. (d) White, angular pumice clast dredged from a summit cone from Colville volcano, but sourced from the 2012 eruption of Havre volcano.

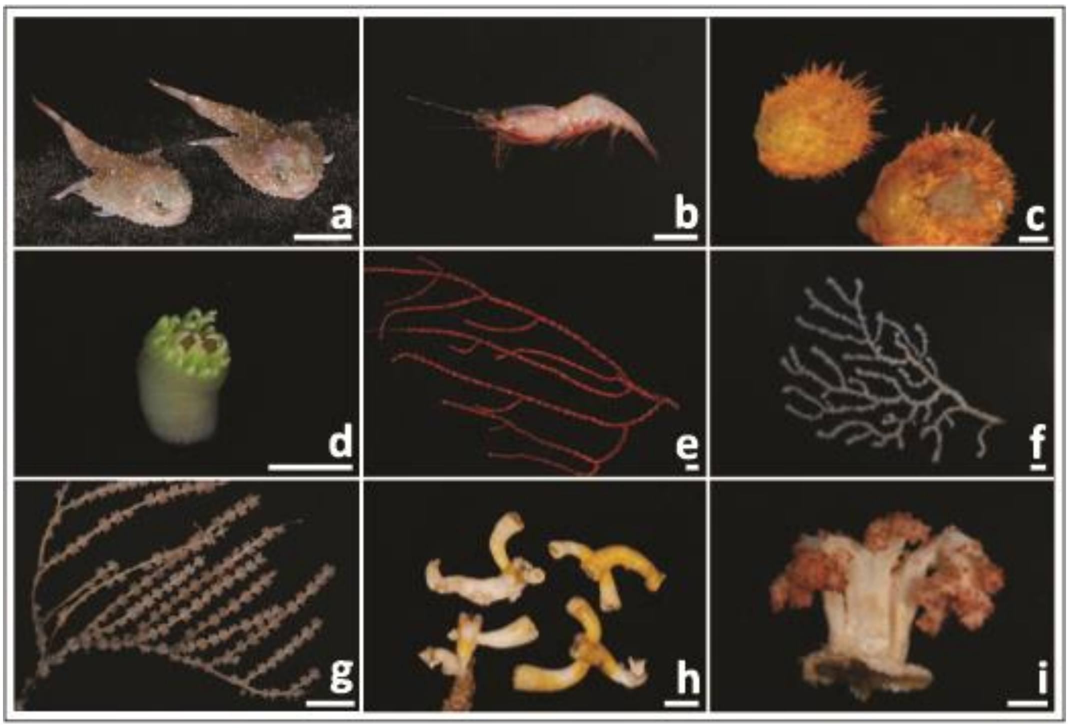

Figure 4: Examples of biological specimens recovered from Colville volcano, and photographed on board when fresh. White lines are 1 cm scale. (a) Batfish, Malthopsis asperatus. (b) Pandalid shrimp, Heterocarpus sp. (c) Glycymerid bivalve. (d) Sea anemone. (e) Plexauridid gorgonian fan. (f) Primnoid gorgonian fan. (g) Primnoid gorgonian fan. (h) Branching coral Euguchipsammia japonica. (i) Soft alcyonacean coral.

Colville Arc volcanism

The discovery of the first volcano from the relict Colville Arc suggests that others may still occur along the Colville Ridge. The Kermadec Arc, which succeeded the Colville Arc and is equal in length, hosts over 40 volcanoes (Smith and Price, 2006; Graham et al., 2008; Wysoczanski et al., 2010; Timm et al., 2014). The Colville Arc is likely to have hosted a similar or even greater number, given its inferred longer period of activity.

The lack of volcanoes of the Colville Arc identified to date is simply due to the lack of MBES surveys along the length of the Colville Ridge and perhaps coalescence, erosion and/or faulting of the edifices. The most surveyed section of the Colville Ridge is its southern portion (New Zealand National Report in this issue). Notably the Colville Ridge is substantially narrower here compared to north of 31° S, where it widens dramatically. Steep fault scarps along the southern portion of the ridge also suggest significant tectonic activity with large scale faulting dissecting the ridge. Any volcanic edifices are likely to have been dissected and eroded by this activity, although the steep fault scarps present may reveal volcanic interiors. Previous sampling in this region (Ballance et al., 1999; Mortimer et al., 2010; Handler et al., 2011) has returned sedimentary and volcanic rocks including porphyritic basalts, demonstrating that the remnants of Colville Arc volcanoes and related basins can be successfully analysed and dated.

Colville volcano sits on the wider northern section of the Colville Ridge. This less dissected region most likely provides the best opportunity to identify individual volcanoes of the remnant Colville Arc. A previous dredge haul at 30° 27'S (south of Colville volcano) during a RV Aleksandr Nesmeyanov survey in 1989 returned similar samples to those reported here, including basalt, dolerite, gabbro, vitroclastic breccia, tuff and sandstone, suggestive of a volcanic environment (Ballance et al., 1999). Also in the dredge haul were algal rhodoliths, whose shallow water habitat led Ballance et al. (1999) to suggest subsidence of the ridge by up to 750 m. As noted above, Colville volcano is a guyot with a flat top at 475-500 mbsl. This indicates that Colville volcano was subaerial and that flattening of the summit plateau, and subsequently of the cone summits, was due to wave erosion. Minor cones then formed on the plateau after erosion and planation.

Acknowledgements

We thank the captain (Evan Solly), crew and scientific party on board the R/V Tangaroa NIRVANA voyage. Nick Mortimer is thanked for a review of this article. This voyage and research was funded by NIWA under the Coasts and Oceans Marine Physical Resources Programme (2012/13 SCI). Biological material has been examined under NIWAs "Vulnerable deep-sea communities" research programme (contract CO1X0906). Thanks to the taxonomists involved, and Sadie Mills (NIWA) for the data extract. CT was supported by public research funding to GNS from the Government of New Zealand

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Table 1. Major invertebrate faunal groups sampled from the volcano and adjacent Colville ridge stations (11 fish were caught, not included here).

Phylum	Main taxa	No. putative species	No. animals
Annelida (worms)		1	11
Arthropoda (crabs, shrimps etc.)		21	85
Brachiopoda (lamp shells)		2	2
Bryozoa (lace corals)		1	1
Cnidaria (anemones, corals)		54	398
	Plexauridae	14	106
	Primnoidae	6	83
	Hydrozoa	16	76
	Scleractinia	3	8
Echinodermata (seastars, urchins etc.)		46	421
	Ophiuroidea	27	144
	Echinoidea	8	16
Mollusca (snails, shellfish)		2	9
Nemertea (worms)		1	1
Porifera (sponges)		26	118
	Demospongiae	22	105
TOTAL		154	1046

The Jeddah Transect Project: Extensive mapping of the Red Sea Rift

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Abstract

The slow- to ultra-slow spreading Red Sea Rift (<1 – 1.6 cm/yr spreading rate), was the target of two research cruises performed within the framework of the multidisciplinary "Jeddah Transect Project" carried out in cooperation between the Helmholtz Centre for Ocean Research Kiel (GEOMAR) and King Abdulaziz University in Jeddah, Saudi-Arabia (www.jeddah-transect.org). The German R/V Poseidon (cruise P408 in 2011) and the Dutch R/V Pelagia (cruises 64PE350/351 in 2012) were used to map large parts of the Red Sea Rift (RSR) by ship-based multibeam on 5 separate legs, which resulted in an overall coverage of >28,600 km2. New seafloor mapping results include the northern Mabahiss Deep area (25.5°N), large parts of the Nubian-Arabian Rift between 23.3°N and 17°N, some areas of the Danakil triple junction at 16.7°N, as well as two crossings of the Danakil-Arabian Rift at 16.5°N.

Bathymetric Mappings of the Red Sea Rift

Figures 1 to 3 show overview maps of the multibeam data from Poseidon cruise 408 (Legs 1-3) and Pelagia cruises 64PE350/351 at a resolution of 100 m. RV Poseidon is equipped with an ELAC Nautic Seabeam SB3050 echo sounder, which works in the 50 kHz-frequency band at water depths to approximately 3000 m. RV Pelagia operates a 30 kHz Kongsberg Maritime AS EM302 echo sounder system for water depths of up to 7000 m. The bathymetric data were post-processed and gridded mainly after the cruises. They yield spatial resolutions of 35 to 5 m depending on the weather conditions during the surveys and water depths. The highest resolutions are achieved for the shallow areas around Eliza Shoals (Fig. 2), with a cell size of 5 m, and at Mabahiss Mons (Fig. 1), which can be gridded with a resolution of 10 m. Some of these high-resolution maps have already been introduced at international conferences (Feldens et al., 2012; Metz et al., 2013; van der Zwan et al., 2013) or published in peer-reviewed journals (Augustin et al., 2014). Some of the data are currently in preparation with a yielded publication in 2015 (Augustin et al. in prep). The deep areas where water depths are below 2000 m are commonly gridded with cell sizes of 30 to 35 m. Backscatter data are only available from the Pelagia expeditions 64PE350/351 and have been published in Augustin et al., 2014. The Jeddah Transect Project had its main focus on the area between Jeddah and the Atlantis II Deep and the deeps North and South of it, therefore the main bathymetric surveys were performed in the central Red Sea between 23°N and 19.5°N, containing, e.g., the Thetis, Hadarba, Hatiba, Atlantis II, Shagara, Aswad, Erba, Port Sudan and Suakin Deeps (Figs. 2, 3). In the area of the Thetis and Hadarba Deeps the bathymetry presented here partially overlaps the dataset of the R/V Urania RS05 Expedition from 2005 (Mitchell et al. 2010; Ligi et al., 2012), but extends much further southwards.

Transits to sampling sites close to the Al-Wajh Reef enabled the mapping of parts of the Mabahiss Deep with adjacent salt flow structures and a detailed mapping of the Mabahiss Mons volcano, an axial dome volcano with a distinct caldera (Fig. 1, see also Metz et al. 2013). Transits towards the Farasan Islands in the southern Red Sea resulted in some additionally mapped stripes covering parts of Red Sea Rift between 19.5°N and 16.5°N, including the Danakil triple junction, where the Danakil micro-continent (Collet et al., 2000; Eagles et al. 2002) divides the Red Sea Rift into the northern Nubian-Arabian Rift and a southern Danakil-Arabian Rift.

Preliminary Results and Outlook

The new high-resolution data reveal new information about the volcanic terrain in the Deeps (van der Zwan et al., 2013) and the presence of giant salt glaciers that occur around the Deeps, slump towards the central graben and partially blanket the rift in the so-called Inter-trough zones (Feldens et al. (2012); Augustin et al. (2014), see also Figure 2). Between the Atlantis II Deep area and the Saudi Arabian coast at the Eliza Shoals and south of it the bathymetry shows extensive sedimentary lineaments and deformation patterns which may also be connected to the salt movements. Other interesting features that we (partially) mapped are large pockmark fields around 19.8°N, from which we additionally collected EM302 water column data (included in the *.all format). Unprocessed SB3050 water column data are also available for large parts of the P408 cruises in *.wci format.

Due to this large and continuous mapping we have also been able to update the record of the names given to the Red Sea Deeps as presented in the literature. As there are inconsistencies in the details on Deeps between the most comprehensive listing of Red Sea Deeps compiled by Gurvich (2006) and older literature, particularly concerning the positions of the Hadarba and Hatiba Deeps, which subsequently lead to some confusion in later works, we are presenting a new list of the Red Sea Deeps with their names and coordinates after available publications and databases, which were cross-checked with the most recent bathymetric mappings from the P408, 64PE350/351 and also RS05 cruises (Table 1). In addition to all previously described Red Sea Deeps, we are listing several newly mapped deeps named after the research vessels Poseidon and Pelagia as well as - in the case of the Saso Deep - after the closest island.

Seafloor sampling, e.g. for geological ground truthing, was carried out with gravity corers, a van veen grab sampler, wax corers, and dredges in sedimentary and volcanic environments. The sampling has recovered basaltic rocks, carbonates and partially metalliferous sediments and has yielded one of the most complete sets of basaltic samples, with samples from all of the major Deeps. Some Video-CTD casts in combination with water sampling have provided additional information on the visual aspects of the seafloor. All details about sampling locations, the used equipment and the disciplines involved are contained in the respective cruise reports (Schmidt et al., 2011 and 2013), which are available online as GEOMAR Reports from www.geomar.de.

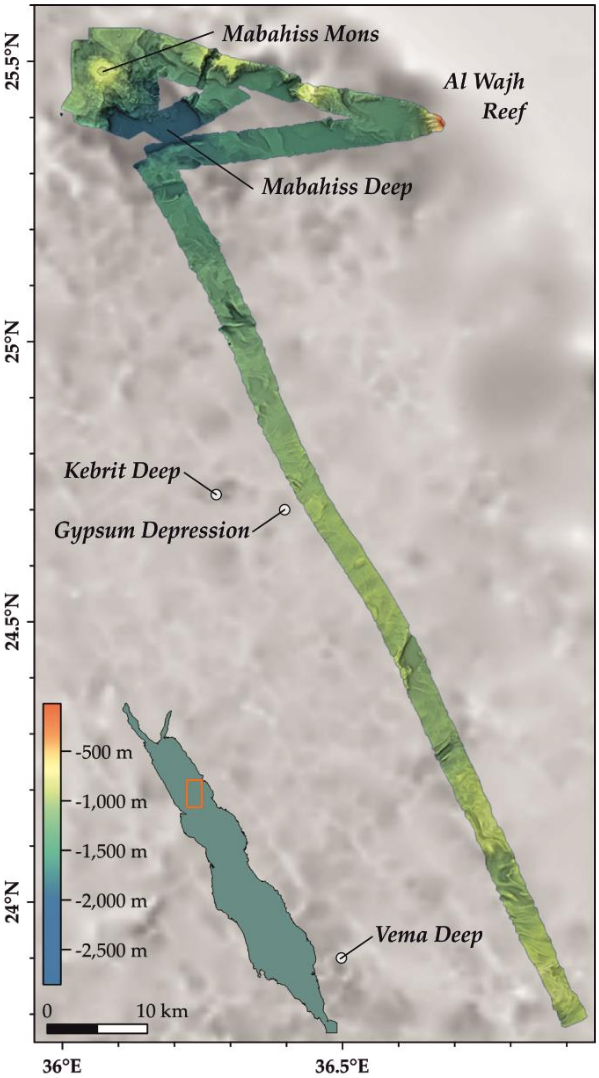

Figure 1: Overview of the northern mappings of cruise 64PE351 including parts of the Mabahiss Deep and a detailed survey of the Mabahiss Mons Volcano. The single stripe south of the Mabahiss Deep mainly shows well established sedimentary flow structures which are most likely to be connected to the movement of Miocene salt below the sediments.

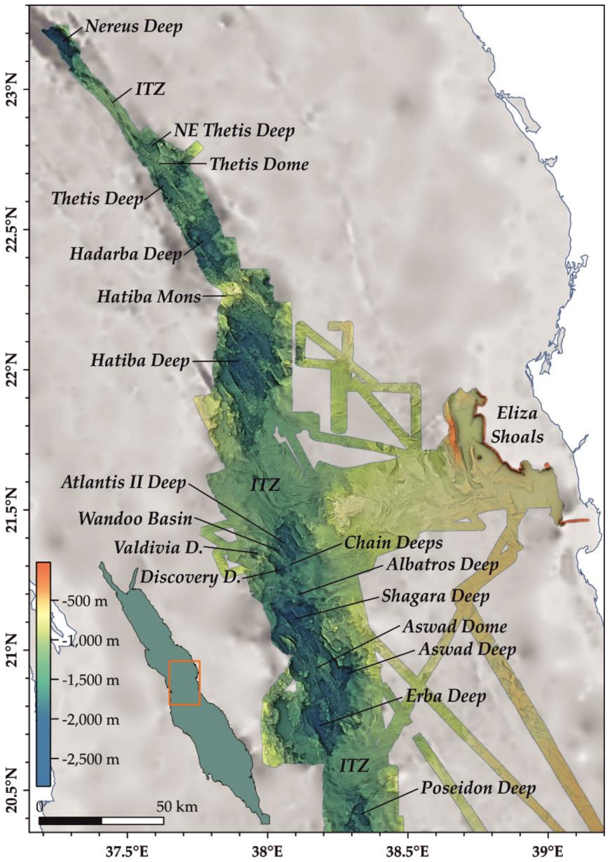

Figure 2: The main parts of the mappings focused on the central Red Sea, in particular the area around the Atlantis II Deep. The map shows the two large troughs Thetis-Hadarba-Hatiba (northern part) and Shagara-Aswad-Erba (southern part), which are physically separated by large salt glaciers blanketing the rift graben in the so-called Inter-Trough Zones (ITZ) and reveal the typical morphology of (ultra)slow-spreading oceanic rift zones.

From early 2015 on the bathymetric data will be available at request from the corresponding author or from the chief scientists of the cruises P408 and 64PE350/351 (see Schmidt et al., 2011 and 2013). Available raw data formats are Hypack *.hsx (P408) and Kongsberg *.all (64PE350/351). Additional post-processed products are ungridded *.xyz ASCII data and diverse gridded formats. In addition, the authors will support a speedy integration of the data in public available online services such as GeoMapApp and GoogleEarth.

Acknowledgements

We thank the captains and crews of R/V Poseidon and R/V Pelagia for their support during cruises P408 and 64PE350/351. The Jeddah Transect Project between King Abdulaziz University and GEOMAR Helmholtz-Center for Ocean Research was funded by King Abdulaziz University (KAU), Jeddah, Saudi Arabia, under grant No. T-065/430.

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Table 1 | Overview of Red Sea Deeps

Deep Name	Lat	Long	Comments
Ras Muhammad	27.58	34.1	Uchupi & Ross (2006)
Exxon	27.23	34.38	GeoMapApp, MGDS (Ryan et al., 2009)
Klauke	27.05	34.66	Ehrhardt et al. (2005)
Conrad	27.04	34.72	Cochran et al. (1986), Ehrhardt et al. (2005)
Oceanographer	26.28	35.01	Degens & Ross (1969), Pautot (1983), Coutelle et al. (1991)
Shaban N	26.25	35.31	Cocherie et al. (1994), Botz et al. (2007); aka: Jean Charcot Deep
Shaban S	26.23	35.38	
Mabahiss	25.37	36.16	Guennoc et al., (1988); aka: Al Wajab Deep
Kebrit	24.72	36.28	Pautot, 1983; Guennoc et al. (1990), Botz et al. (2007)
Gypsum Depression	24.70	36.41	Pautot, 1983; Guennoc et al. (1990)
Vema	23.88	36.48	Pautot, 1983; Bicknell et al. (1986), Guennoc et al. (1990)
Bannock	23.55	36.72	Guennoc et al. (1990)
Nereus	23.19	37.23	Pautot (1983), Blanc et al. (1990), Coutelle et al. (1991)
NE Thetis	22.79	37.59	Gurvich (2006), Pierret et al. (2010), Mitchell et al. (2010)
Thetis (main deep)	22.66	37.63	
Hadarba E-Basin	22.47	37.78	Blanc et al. (1990), Coutelle (1991), GeoMapApp, MGDS (Ryan et al., 2009)
Hadarba W-Basin	22.42	37.69	
Hatiba N-Basin	22.10	37.93	Blanc et al. (1990), Coutelle (1991), GeoMapApp, MGDS (Ryan et al., 2009)
Hatiba S-Basin	22.00	37.91	
Atlantis II	21.38	38.07	Bäcker & Richter (1973); Pautot (1983)
Valdivia	21.34	37.95	Bäcker & Richter (1973), Zierenberg & Shanks (1986)
Wandoo E	21.35	38.04	Bäcker & Richter (1973), Zierenberg & Shanks (1986), Gurvich (2006)
Wandoo W	21.36	38.03	
Chain A	21.31	38.08	Bäcker & Richter (1973), Zierenberg & Shanks (1986)
Chain B	21.30	38.08	
Chain C	21.29	38.08	
Discovery	21.28	38.05	Bäcker & Richter (1973), Zierenberg and Shanks (1986)
Albatross	21.20	38.12	Pautot (1984), Blanc et al. (1990); Gurvich (2006) and references therein
Shagara	21.14	38.10	Pautot (1984), Blanc et al. (1990); Zierenberg and Shanks (1986)
Aswad	20.92	38.28	Pautot (1984), Blanc et al. (1990)
Erba	20.73	38.18	Gurvich (2006) and references therein, GeoMapApp, MGDS (Ryan et al., 2009)
Poseidon	20.41	38.34	discovered during RV Poseidon cruises P408-1 and -2
Port Sudan	20.07	38.51	Pautot (1984), GeoMapApp, MGDS (Ryan et al., 2009)
Volcano	20.02	38.45	Pautot et al. (1984), Blanc et al. (1990)
Suakin NE	19.63	38.77	Baumann et al. (1973), Zierenberg & Shanks (1986)
Suakin SW	19.62	38.72	
Pelagia	19.33	39.03	Augustin et al. (2014), discovered during RV Pelagia cruise 64PE351
Saso Deep	16.54	41.12	partially mapped during RV Pelagia cruise 64PE351, SE of Saso Island (Farasan Banks)

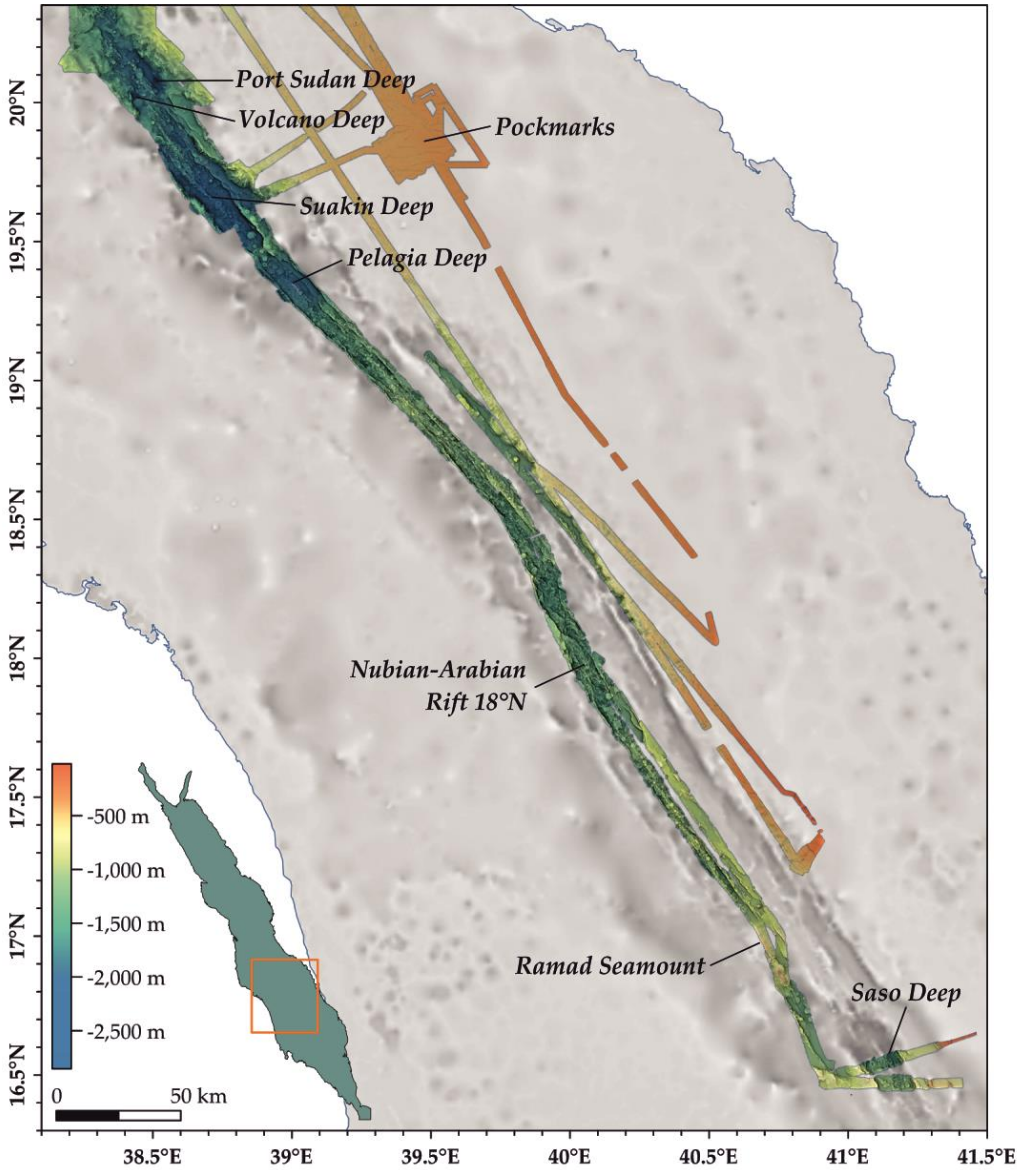


Figure 3: The multibeam surveys become less dense towards the south but still contain precious high-resolution bathymetric information such as the positions of salt glacier flow fronts and the change from the Nubian-Arabian Rift to the Danakil-Arabian Rift. In addition, a detailed survey of a near-shore Pockmark field was carried out.

Call for proposals for New Working Groups

The InterRidge StCom meeting calls for proposals for new Working Groups which had been proved to be an effective way to mobilize the InterRidge community to focus on important scientific problems of InterRidge.

Contact coordinator@interridge.org for details.

Vent Ecology

Co-Chairs: Stephane Hourdez (France) and Yoshihiro Fujiwara
Group Members (Austria, Canada, China, Germany, Japan, Korea, Portugal, Russia, UK, USA) - Maria Baker, Monika Bright, Ana Colaço, Nicole Dubilier, Sergey Galkin, Peter Girguis, Jung-Ho Hyun, Crispin Little, Anna Metaxas, Katsu Fujikura, Xiang Xiao.

Third decadal plan

The Vent Ecology WG has been active in drafting the InterRidge third decadal plan (2014-2023). The contribution of the WG is entitled 'Past, present, and future of vent ecosystems'. Exploration rights granted to different mining companies has raised concerns in our community. A lot remains to be learned about these ecosystems and the species that are part of it to better understand their susceptibility to perturbations. The third decadal plan therefore focuses on the history and the resilience of the vent communities. The primary questions on which the plan focuses are:

1) What are the molecular bases for physiological and life history adaptations to hydrothermal vent conditions? When did these adaptations occur?
2) How did these adaptations affect and yield the diversity of vent organisms?
3) How did past global environmental changes (e.g. global deep-sea anoxia) affect the evolution of vent species?
4) How does the dynamic nature of hydrothermal vents affect the evolution of species?
5) How resilient are vent species/communities and how may they be affected by deep-sea mining?
6) Could global change affect vent species and their function in the ecosystem? On what time scales?
The whole decadal plan can be found at this address
http://www.interridge.org/thirddecade

Deep-sea Mining

In November 2012, Nautilus has announced that the construction of its seafloor production system was terminated as a result of a commercial dispute with the government of Papua-New Guinea (see http://www.nautilusminerals.com/s/Projects-Solwara.asp for a statement from Nautilus Minerals). Other Nations in the Western Pacific may still proceed with hydrothermal vent minerals mining.

High-throughput

The high-throughput page is dedicated to sequencing efforts on hydrothermal vent species, and includes species of invertebrates and bacteria (free-living and symbiotic), for a total of 23 entries. To have a look at the list of projects, go to http://www.interridge.org/highthroughput, and if you would like to add to the list, go to http://www.interridge.org/node/add/highthroughput. The goal is to promote exchanges between researchers in the community and to avoid duplicating efforts.

Meetings

Two main meetings to which the vent biology community participates take place this year.

The 13th International Deep-Sea Biology Symposium was held in Wellington, New Zealand 3-7 December 2012. Held every 3 years, this general deep-sea meeting includes presentations on hydrothermal vents and cold seeps. The vent biology community was well represented.

The 5th International Symposium on Chemosynthesis-Based Ecosystems will be held in Victoria, BC Canada August 18-23, 2013. For more details, see http://www.neptunecanada.ca/cbe5/

Hydrothermal Energy and Ocean Carbon Cycles

Co-Chairs - Nadine Le Bris (IFREMER, France), Christopher R. German (WHOI, USA)

Group Members - Wolfgang Bach (Univ. Bremen, Germany); Loka Bharathi (National Institute of Oceanography, India); Nicole Dubilier (Max Planck Institute Marine Microbiology, Germany); Katrina Edwards (Univ. Southern California, USA); Françoise Gaill (CNRS, Paris, France); Toshi Gamo (Univ. Tokyo, Japan); Peter Girguis (Harvard Univ., USA); Xiqiu Han (Second Institute of Oceanography, SOA, China); Julie Huber (Marine Biological Laboratory,

Woods Hole, USA); Louis Legendre (LOV-UPMC, Villefranche, France); George W. Luther III (University of Delaware, USA); William E. Seyfried Jr. (Univ. Minnesota, USA); Stefan Sievert (WHOI, USA); Ken Takai (JAMSTEC, Japan); Andreas Thurnherr (Columbia Univ., USA); Margaret K. Tivey (WHOI, USA).

The Working Group has organized its third meeting in Vienna, Austria, in the context of the European Geosciences Union General Assembly 2014. The WG meeting was held on April 28th, with the primary aim of discussing the review papers that are proposed as deliverables in the WG terms of references.

The primary aim of the meeting was to discuss the progress of review papers to be finalized by the end of this year. S. Sanders, L. Legendre and C.R. German have lead a first review paper focussing on hydrothermal plume interaction with the oceanic water masses. A review outline set up and was discussed for the second paper. In addition to synthesizing the current knowledge, the aim of this review is to identify gaps, which will justify the development of a large scale in situ interdisciplinary experiments and the necessary adaptation of instruments and methods to the particularly extreme conditions of these deep-sea environments in the upcoming years.

The tighly constrained agendas of most WG members who are involved intensifying at-sea programmes (IODP, GEOTRACE...) impeded the organization of a workshop as we first planned. The EGU conference offered an alternative to present the different research activities lying behind the theme of 'Hydrothermal energy transfer and its relation to ocean carbon cycling'. In addition to the WG meeting, on May 2nd, an oral communication and poster session were hold in the Biogeoscience programme of EGU (session abstract and presentation list below). The session also included flash poster presentations on April 30.

These events constituted an opportunity to gather 8 of the WG members together with 6 young scientists (PhD student or post-docs) covering the various disciplinary aspect and topics of the WG theme. It was given the young scientists the opportunity to be included in the discussion and in the preparation of the review. Their works, in collaboration with different group members, are indeed of high relevance to the review process. Support was allocated by InterRidge under the form of travel grants to two young scientists, considering the originality of their works and relevance to the WG theme : A. Das (India) and G. Ramirez (USA).

The activities following EGU involved the resubmission of the paper on the biogeochemical impacts of hydrothermal plumes (German et al. Submitted to EPSL), and the drafting of the six sessions of the review that were discussed in Vienna. This second task is still under progress.

Participants to the meeting

Working group members : Nadine Le Bris, Sylvia Sander, Louis Legendre, Katrina Edwards, Sylvia Sander, Xiqiu Han, Loka Bharathi P.A., Chris R. German

Young scientists : Anindita Das (coll. L. Bharathi) , Gustavo Ramírez (PhD student, K. E. Edwards), Charles Vidoudez (Post-doc P. Girguis and coll. W. Bach, N. Dubillier), Mustafa Yücel (coll. G.W. Luther, and coll. N. Le Bris), Sarah Bennett (coll. C.R. German), Solveig I. Bühring (coll. S. Sievert).

EGU session BG7.2 Convener: Nadine Le Bris, Co-Convener: Chris German

Hydrothermal energy transfer and its relation to ocean carbon cycling: from mechanisms and rates to services for marine ecosystems

Hydrothermal systems in the deep ocean have been studied from the past 37 years, but their impact on the ocean biogeochemistry and related ecological processes is far from being understood. Vent ecosystems were long described as largely independent from the photosynthesis-driven biosphere, a paradigm which no longer stands. Today we have a slightly clearer picture of the role energy transfer from hydrothermal circulation could play on ecosystems across a range of depths and on subseafloor carbon sequestration. At a time the exploration and exploitation of deep-sea mineral resources is rapidly developing, with potential impacts to habitats and biodiversity, there is a urgent need to consider the potential 'services' that is provided by these systems to the ocean.

The aim of this session is to synthesize the most advanced knowledge on:

1) carbon-fixation pathways in the different compartments influenced by hydrothermal activity,

the metabolic diversity sustaining them and their dependence on oceanic processes,

2) Biotic and abiotic drivers of productivity of related seafloor and subseafloor ecosystems, their natural dynamics and sensitivity to disturbance,

3) hydrothermally-derived fluxes of micronutrients and exported DOC and their potential influence on ocean biogeochemistry at larger scale.

4) Integration of these processes into conceptual models of energy transfer and carbon cycling.

Our objective is also to enlarge the discussion outside the field of vent research with a broader scientific community and determine the opportunities to bridge scientific efforts focussing on these environments with larger marine science programmes in view of a future assessment the potential contribution that they may make to the ocean ecosystems and carbon cycle at different scales. This session is organized as part of the InterRidge and SCOR WG135 working group activities.

Oral presentations

EGU2014-6262, Coupled cycling of Fe and organic carbon in submarine hydrothermal systems: Impacts on Ocean Biogeochemistry? Christopher German, Sylvia Sander, Louis Legendre, Nathalie Niquil, and Working Group 135

EGU2014-16229, Ridge Flank Hydrothermal Systems and their relationship to the oceanic carbon cycle, Katrina Edwards

EGU2014-16708, An Interdisciplinary And Multinational Program To Study Microbial Energy Transfer And Chemosynthetic Carbon Fixation At Deep-Sea Vents, Stefan Sievert, Dionysis Foustoukos, Jeffrey S. Seewald, Ramunas Stepanauskas, Craig D. Taylor, Costantino Vetriani, Nadine Le Bris, Niculina Musat, Thomas Schweder, and Fengping Wang

EGU2014-9955, Constraining geochemistry and biological primary productivity in hydrothermal systems via in situ mass spectrometric geochemical mapping, Charles Vidoudez, Yann Marcon, Wolfgang Bach, Nadine Lebris, Nicole Dubilier, and Peter Girguis

EGU2014-4526, Stabilization of dissolved trace metals at hydrothermal vent sites: Impact on their marine biogeochemical cycles. Sylvia G. Sander, Zach D. Powell, Andrea Koschinsky, Stefan Kuzmanovski, and Charlotte Kleint

EGU2014-16711, Environmental controls on chemo-autotrophic primary producers at deep-sea vents, Nadine Le Bris, Lauren Mullineaux, and Stefan Sievert

EGU2014-208, previously unsuspected dietary habits of hydrothermal vent fauna: the bactivorous shrimp Rimicaris hybisae can be carnivorous or even cannibalistic, Emma Versteegh, Cindy Van Dover, and Max Coleman

EGU2014-8108, Carbon fluxes from hydrothermal vents off Milos, Aegean Volcanic Arc, and the influence of venting on the surrounding ecosystem. Paul Dando, Stefano Aliani, Nike Bianchi, Hilary Kennedy, Peter Linke, and Carla Morri

EGU2014-4186, Coupled cycling of Fe and organic carbon in submarine hydrothermal systems: Modelling approach, Louis Legendre, Christopher R. German, Sylvia G. Sander, and Nathalie Niquil

EGU2014-14622, The hydrothermal CH4 and δ3He anomalies along the Southwest Indian Ridge between 49°E to 56°E, Xiqiu Han, Zhongyan Qiu, Yejian Wang, and Yingyu Lu

EGU2014-15834, Propidium Monoazide-based Method for Identifying Phylogenetic Association of Necromass Near Hydrothermal Systems, Gustavo Ramírez and Katrina Edwards

EGU2014-15842, Geochemistry driven trends in microbial diversity and function across a temperature transect of a shallow water hydrothermal system off Milos (Greece), Solveig I. Bühring, Jan P. Amend, Gonzalo V. Gómez Sáez, Stefan Häusler, Kai-Uwe Hinrichs, Thomas Pichler, Petra Pop Ristova, Roy E. Price, Ioulia Santi, and Miriam Sollich

EGU2014-16710, Dynamic drivers of a shallow-water hydrothermal vent ecogeochemical system (Milos, Eastern Mediterranean), Mustafa Yücel, Stefan Sievert, Donato Giovanelli, Dionysis Foustoukos, Emelia DeForce, François Thomas, Constantino Vetriani, and Nadine Le Bris

EGU2014-326, hydrothermal energy transfer and contribution to autotrophic CO2 fixation down sediment core in Central Indian Basin, Anindita Das and LokaBharathi P.A.

EGU2014-3929, the influence of vent fluid chemistry on trophic structure at two deep-sea hydrothermal vent fields on the Mid-Cayman Rise, Sarah Bennett, Cindy Van Dover, and Max Coleman

Oceanic Detachment Faults Working Group

J. Pablo Canales

The main activity of the Oceanic Detachment Faults Working Group was to convene a special session at the 2013 AGU Fall meeting:

Session T21. Oceanic Deatchment Faulting and Associated Processes at Mid-Ocean Ridges

Conveners: J. Pablo Canales, Andrew McCaig, and Nicholas Hayman

The session received 24 abstracts (8 oral presentations, 16 posters) and was very well attended. It presented results from completed studies as well as preliminary reports from recent experiments targeting oceanic core complexes.

In addition to this session, we have continued acting as Guest Editors for the Oceanic Detachment Faults Theme of the journal Geochemistry, Geophysics, Geosystems. Publications during the last year in this speciality collection are:

Grevemeyer et al. (2013), Microseismicity of the Mid-Atlantic Ridge at 7° S-8° 15′ S and at the Logatchev Massif oceanic core complex at 14° 40′ N-14° 50′ N, Geochem., Geophys., Geosyst., 14(9), 3532-3554.

Hansen et al.(2013), Mylonitic deformation at the Kane oceanic core complex: Implications for the rheological behavior of oceanic detachment faults, Geochem., Geophys., Geosyst., 14(8), 3085-3108.

Zhao et al. (2013), Three-dimensional seismic structure of the Dragon Flag oceanic core complex at the ultraslow spreading Southwest Indian Ridge (49° 39′ E), Geochem., Geophys., Geosyst. 14(10), 4544-4563.

Andreani et al. (2014), Tectonic structure, lithology, and hydrothermal signature of the Rainbow massif (Mid-Atlantic Ridge 36° 14′ N), Geochem., Geophys., Geosyst., 15, doi:10.1002/2014GC005269.

Castelain et al. (2014), Fluid evolution in an Oceanic Core Complex: A fluid inclusion study from IODP hole U1309 D—Atlantis Massif, 30°N, Mid-Atlantic Ridge,Geochem., Geophys., Geosyst., 15(4), 1193-1214.

Maffione et al. (2014), Magnetic properties of variably serpentinized peridotites and their implication for the evolution of oceanic core complexes, Geochem., Geophys., Geosyst., 15(4), 923-944.

Durning the last year, international research on oceanic detachment faults has been very active, as exemplified by several oceanic detachment related cruises involving international cooperation:

- Rainbow non-transform offset at the MAR (USA funded)
- MAR 16°N detachments (USA funded)
- coordinated work at the 13°20'-30'N detachments along the Mid Atlantic Ridge (France and UK funded)

At the same time, a workshop for the drilling of Rainbow is being planned for Spring-Early summer 2015, and ECORD will coordinate a drilling expedition to Atlantis Massif in late 2015, both along the Mid-Atlantic Ridge.

Circum-Antarctic Ridges

Anne Briais

Chairs: Anne Briais, Jian Lin, Sung-Hyun Park

Other members of the Working Group: Edward Baker, Doug Connelly, David Graham, Hide Kumagai, Phil Leat, Yoshi Nogi, Daniel Sauter, Chunhai Tao, Huaiyang Zhou, Vera Schlindwein and Serguey Merkouriev/German Leitchenkov

CRUISES

After a workshop in September 2011 in Toulouse, France, the working group members and colleagues interested by the CAR have mostly submitted proposals and organized cruises, especially on the Southwest Indian Ridge and the Southeast Indian Ridge, including its southeasternmost part, the Australian-Antarctic Ridge.

SPECIAL SESSION AT 2014 AGU FALL MEETING

We have proposed a special session at the 2014 Fall AGU meeting, which was then merged with the session "Deep submergence science in the SW Pacific Ocean". Our original special session was:

Circum-Antarctic Ridges: Tectonic, Hydrothermal, and Ecological Processes

Description: The Circum-Antarctic Ridges (CAR) represent about one-third the length of the global oceanridge system, and yet they remain the least known part of Earth's spreading centers. This session provides a forum to address fundamental geological and biological processes of the CAR, including (1) geological boundaries and fluxes between the Pacific, Atlantic and Indian mantle domains; (2) along-axis variability in ridge tectonics, magma supply, and geochemistry; (3) hydrothermalism in diverse ridge settings, and (4) diversity and migration of deep-sea ecological communities. We welcome the latest results and insights from field programs and shore-based investigations, as well as comparative studies with global ocean ridges.

Co-conveners:

Anne Briais, Obs Midi-Pyrenees, Toulouse, France
Jian Lin, Woods Hole Oceanographic Institution, USA

Sung-hyun Park, Korea Polar Resarch Institute, Korea

Edward Baker, Joint Institute for the Study of the Atmosphere and Ocean, Seattle WA, USA

We have received 19 abstracts. The variety of the abstracts reflects the large amount of work which has been done on the southern ridges, and the major results concerning all scales, from deep mantle to tectonic processes to hydrothermal vents and biological studies:

A View of the Marble-Cake Mantle from the Southeast Indian Ridge, Barry B Hanan1, David W Graham2, Christophe Hemond3, Janne Blichert-Toft4 and

Francis Albarede4, (1)San Diego State University, Geological Sciences, San Diego, CA,

United States, (2)Oregon State University, College of Earth, Ocean, & Atmospheric Sciences, Corvallis, OR, United States, (3)Université de Brest, CNRS UBO, Laboratoire Domaines Océaniques, Plouzané, France, (4)Ecole Normale Supérieure Lyon, Laboratoire de Géologie de Lyon, Lyon, France

The Marion and Bouvet Rises: Remelting Gondwana's Mantle, Henry J Dick, WHOI, Woods Hole, MA, United States, Huaiyang Zhou, Tongji University,

State Key Laboratory of Marine Geology, Shanghai, China and Jared Jeffrey Standish, ACS, Washington, DC, United States

A New Species of the Genus Kiwa (Decapoda: Anomura) from the Hydrothermal Vent of the Australia-Antarctic Ridge, Yong-Jin Won, Ewha Womans University, Department of Life Science, Seoul, South Korea, Sang-Hui Lee, MBIK Marine Biodiversity Institute of Korea, Seochun-gun, South Korea and Won-Kyung Lee, Ewha Womans University, Division of EcoScience, Seoul, South Korea

Abundant Hydrothermal Venting in the Southern Ocean Near 62°S/159°E on the Australian-Antarctic Ridge, Edward T Baker1, Doshik Hahm2, Tae Siek Rhee2, Sung-hyun Park2, John E Lupton3, Sharon L Walker4 and Hakkyum Choi2, (1)Joint Institute for the Study of the Atmosphere and Ocean, Seattle, WA, United States, (2)KOPRI Korea Polar Research Institute, Incheon, South Korea, (3)NOAA/PMEL, Newport, OR, United States, (4)NOAA/PMEL, Seattle, WA, United States

Chemistry of Hydrothermal Plumes at 159°E on the Australian-Antarctic Ridge, Doshik Hahm1, Edward T Baker2, Tae Siek Rhee1, John E Lupton3, Joseph A Resing4 and, Sung-hyun Park1, (1)KOPRI Korea Polar Research Institute, Incheon, South Korea, (2)Joint

Institute for the Study of the Atmosphere and Ocean, Seattle, WA, United States, (3)NOAA/PMEL, Newport, OR, United States, (4)Joint Institute for the Study of the Atmosphere and Ocean, and NOAA/PMEL, Seattle, WA, United States

Experimental Study on Hydrothermal Plume Dynamics in a Stratified Salt Water Tank, Wei Zhang1, Zhiguo He1 and Houshuo Jiang2, (1)Zhejiang University, Hangzhou, China, (2)WHOI, Woods Hole, MA, United States

Geophysical Characteristics of the Australian-Antarctic Ridge, Seung-Sep Kim1, Jian Lin2, Sung-hyun Park3, Hakkyum Choi1,3 and Sang-Mook Lee4,

(1)Chungnam National University, Daejeon, South Korea, (2)Woods Hole Oceanographic Inst, Woods Hole, MA, United States, (3)KOPRI Korea Polar Research Institute, Incheon, South Korea, (4)Seoul National University, Seoul, South Korea

Mantle domain and segmentation at the Australian-Antarctic Ridge, Sung-hyun Park1, Charles H Langmuir2, Jian Lin3, Seungsep Kim4, Doshik Hahm1, Peter J Michael5, Sean R, Scott6 and Kenneth W W Sims6, (1)KOPRI Korea Polar Research Institute, Incheon, South Korea, (2)Harvard Univ, Cambridge, MA, United States, (3)Woods Hole Oceanographic Inst, Woods Hole, MA, United States, (4)Chungnam National University, Daejeon, South Korea, (5)University of Tulsa, Tulsa, OK, United States, (6)University of Wyoming, Laramie, WY, United States

Heat Flow on the South West Indian Ridge at 14°E and the Consequences for Microbiological Activity

Norbert E Kaul1, Massimiliano Molari2 and Antje Boetius2,3, (1)University of Bremen, Bremen, Germany, (2)Max- Planck-Instutute for Marine Microbiology, Bremen, Germany, (3)Alfred-Wegener-Institute for Marine and Polar Research, Geomicrobiology, Bremerhaven, Germany

Geo-Morphological Analyses of the Gakkel Ridge and the Southwest Indian Ridge, Boris Dorschei, Vera S. N. Schlindwein, and Graeme Eagles, Alfred Wegener Institute Helmholz-Center for Polar and Marine Research Bremehaven, Bremehaven, Germany

Characteristics of Hydrothermal Mineralization in Ultraslow Spreading Ridges Huaiyang Zhou, Wunhui Yang, Fuwu Ji, and Henry J. Dick, Alkalic Basalt in Ridge Axis of 53°E Amagmatic Segment Center, Southwest Indian Ridge, Huaiyang Zhou, Jixin Wang, Yang Liu, Fuwu Ji, and Henry J. Dick

Hydrothermal Activity on ultraslow Spreading Ridge: new hydrothermal fields found on the Southwest Indian Ridge, Chunhui Tao, Huaiming Li, Xianming Deng, Jijiang Lei, Yuan Wang, Kai Zhang, Jianping

Zhou, and Weiyong Liu, Second Institute of Oceanography, State Oceanographic, Administration of China, Key Laboratory of Submarine Geosciences, Hangzhou, China

SWEAP: Southwest Indian Ridge Earthquakes and Plumes: First Results from a Comparative Seismicity Study of Magmatic and Amagmatic Spreading, Vera S N Schlindwein, John-Robert Scholz and Florian Schmid, Alfred Wegener Institute Helmholtz-Center for Polar and Marine Research Bremerhaven, Bremerhaven, Germany

Geodynamic and Geochemical Modeling of Mantle Processes along the Southwest Indian

Ridge at 35°E–40°E: A Hotspot-Mid-Ocean Ridge Interaction Region

Mark Oscar Larson, Kioko Okino, and Laurent Montesi, Seafloor Hydrothermal Activity at the Galapagos Triple Junction, East Pacific Ocean, Huaiming Li1, Zenghui Yu2, Guoying Zhang1, Chunhui Tao1 and Sheng Chen1,3, (1)Second Institute of Oceanography, State Oceanographic Admini-stration of China, Hangzhou, China, (2)Ocean University of China, Qingdao, China, (3)JLU Jilin University, Changchun, China

Seismic structure at the Kairei Hydrothermal vent field near the Rodriguez Triple Junction in the Indian Ocean, Hiroyoshi Takata1, Toshinori Sato2, Yuki Imai2, Taiyu Mori2, Yui Noguchi1, Akihiro Kono1, Tomoaki Yamada3 and Masanao Shinohara3, (1)Chiba University, Chiba, Japan, (2)Faculty Science Chiba Univ, Chiba, Japan, (3)University of Tokyo, Bunkyo-ku, Japan

Seismicity at the Kairei Hydrothermal Vent Field Near the Rodriguez Triple Junction in the Indian Ocean, Toshinori Sato1, Hiroyoshi Takata2, Yuki Imai1, Taiyu Mori1, Yui Noguchi1, Akihiro, Kono1, Tomoaki Yamada3 and Masanao Shinohara3, (1)Faculty Science Chiba Univ, Chiba, Japan, (2)Chiba University, Chiba, Japan, (3)University of Tokyo, Bunkyo-ku, Japan

The non-transform discontinuity on the Central Indian Ridge at 11°S: The transtensional basin formation and hydrothermal activity, Sang Joon Pak, Hyun-Sub Kim, Juwon Son, Jonguk Kim, Jai-Woon Moon and Seung-Kyu Son, KIOST Korea Institute of Ocean Science and Technology, Ansan, South Korea

FUTURE DEVELOPMENTS

A new special session will probably be organized at the 2015 Fall AGU Meeting, along with a Working Group meeting.

There is still a need to better coordinate the work on cruises in the Southern Oceans. Efforts will be made to increase communication between chief scientists before cruises, possibly through the InterRidge Working Group web site.

New working group: Ecological Connectivity and Resilience

Chairs: Anna Metaxas (Dalhousie University, Canada) and Lauren Mullineaux (Woods Hole Oceanographic Institution, USA)

Steering committee: Stephane Hourdez (Station Biologique de Roscoff, France), Andreas Thurnherr

(Lamont-Doherty Earth Observatory, USA), Hiromi Watanabe (JAMSTEC, Japan), Yong-Jin Won (Ewha Womens University, Korea)

Other members (have expressed interest to date following a coordinating meeting at the 5th International Symposium on Chemosynthesis-Based Ecosystems): Shawn Arellano (Western Washington University, USA), Chuck Fisher (Pennsylvania State University, USA), Breea Govenar (Rhode Island College, USA), Ana Hilario (University of Aveiro,Portugal), Lisa Levin (Scripps Institute of Oceanography, USA), Steffan Sievert (Woods Hole Oceanographic Institution, USA), Andrew Thurber (Oregon State University, USA), Verena Tunicliffe (University of Victoria, Canada)

Motivation

The ecological connectivity of vent communities, and their resilience in the face of disturbance, has been a hot topic of research ever since their discovery. Of late, this topic has become particularly timely and societally relevant as plans for deep-sea mining progress toward implementation. It is also directly relevant to management decisions under consideration for recently designated deep Marine Protected Areas (MPAs), such as those on the Endeavour Segment, in the Marianas region, on the mid-Atlantic Ridge off the Azores, and in the Guaymas Basin and Eastern Pacific Rise. These topics were also identified in InterRidge's third decadal plan.

Objectives

We propose to form an InterRidge Working Group with two main objectives:

1. Generate a synthesis of scientific data on vent community connectivity. To ensure the research evidence meets the needs of potential stakeholders, we will engage organizations who are tasked with advising, managing and conducting activities related to seafloor mining and MPAs.

   Specifically, we will circulate a draft set of approaches and topics, along with the target products, to potential stakeholders (e.g., International Seabed Authority, NGOs involved in deep-sea conservation, the deep-sea mining industry, and other groups involved in the use and management of resources at deep-sea vents) for comment. The intent is to assemble a group of objective scientists with broad expertise in this field (including physical oceanography, larval biology, environmental geochemistry, microbial ecology, population genetics, metacommunity dynamics and biogeography) to assemble existing data, interpret it in the context of human disturbance, and disseminate it to the scientific community, the public, and policy makers. Part of this effort will be to identify and evaluate potential ecosystem services from vent communities. These efforts will focus on hydrothermal vent communities in settings where exploitation is possible, but will also include other chemosynthetic-based ecosystems for comparison. Some of the data that may be available include: habitat classification; community typing; source-sink dynamics; species classification in terms of functional groups in a community (e.g. foundation species); valued ecosystem components.

2. Use the data synthesis from (1) to identify gaps in our knowledge and facilitate international cooperation in future research in fields relevant to this topic. InterRidge provides an ideal platform from which to coordinate cruise objectives and schedules and to link modeling efforts. For these coordinating efforts, and for outreach to stakeholders, we plan to cooperate with other international efforts, such as DOSI and INDEEP. Most international efforts (including INDEEP and DOSI) have often discussed the need for a working group with goals such as the one we propose, but none has undertaken the research effort. We are foremost a science group; this is InterRidge's strength and we believe that this approach gives us the best shot at objectivity. We will coordinate with DOSI directly in identifying potential stakeholders to whom our research evidence will be useful. Both DOSI and INDEEP can facilitate the dissemination of our results back to the stakeholders. We will conduct coordination and outreach activities through email and virtual conferencing, in a focussed, task-oriented workshop, and as session chairs in a widely attended scientific conference (e.g. Ocean Sciences).

Outputs

This IR working group aims to produce the following products by the end of its 3-year tenure:

1. a short, high profile publication in refereed journal highlighting what our synthesized data tell us about how to manage seafloor mining and MPA management
2. an in-depth synthesis of data on ecological connectivity and community resilience in the context of human disturbance, intended for wide dissemination as peer-reviewed article
3. a plan and initial efforts to coordinate international research on connectivity, resilience and metacommunity dynamics

WG composition

The Chairs and Members of the Steering Committee represent a wide spectrum of disciplines: larval and community ecology (Metaxas, Mullineaux, Watanabe), population genetics (Watanabe, Won), physiology (Hourdez), and physical oceanography (Thurnherr). They represent six countries on three different continents, and are at various stages of their careers. Linkages with relevant international initiatives are ensured through WG membership (DOSI: Levin, Fisher, Tunnicliffe; INDEEP: Metaxas, Thurber). (All members are confirmed and can expand

Education and Outreach

In its second decade plan, IR pledged its commitment to education, outreach, and capacity building. By investing the time, energy and resources necessary to build a successful Education and Outreach program, InterRidge will ensure that its message of responsible exploration and discovery of the world's deep ocean is heard by students, the future stewards of the environment worldwide; policy-makers; and other members of the general public. The hope is that reaching out, educating and motivating people to learn more about the mysteries of the deep sea - a place few will ever see in person - will engender a healthier respect for the Earth system at large.

InterRidge Student and Postdoctoral Fellowship Program

As part of InterRidge's mission to promote international, collaborative, and interdisciplinary studies of oceanic spreading centers, we invite proposals for InterRidge Student and Postdoctoral Fellowships of up to $5000 US each. These Fellowships are designed to encourage international collaboration on any aspect of ridge-crest science by graduate students or postdoctoral researchers, fostering long-standing partnerships for their future careers. The Fellowships can be used for any field of ridge-crest science. In particular these awards are encouraged to be used for international cruise participation, international laboratory use, and adding an international dimension to the Fellow's research. We expect to offer a number of Fellowships each year. Fellowships funded by InterRidge are open to graduate students or postdocs from any nation. Two Fellowships per year are funded by the International Seabed Authority (ISA) Endowment Fund, with the requirement that the graduate student or postdoc is either from a developing country or will assist in training those of a developing country. The ISA Endowment Fund is a new program for collaborative marine scientific research, with details and brochure available at: http://www.isa.org.jm/en/efund/. The mission of the ISA Endowment Fund is to support the participation of qualified scientists and technical personnel from developing countries in marine research activities and to provide opportunities for collaboration by these persons. For more information on the partnership with the ISA for the InterRidge Student and Postdoctoral Fellowship Program, please see: http://www.interridge.org/isapartnership.

InterRidge fellow 2013

Lily Muller

Lily Muller is a second year phD student in University of Oxford. Her primary research involves the ultraslow spreading Southwest Indian Ridge. I am currently using multibeam SWATH bathymetry and shipboard gravity data to characterise the geomorphology, evolution and lithospheric flexure at seamounts on the southwest Indian Ridge for the first time. In addition backscatter data and seafloor video are used to characterise the geology and structure of the axial crest region including faulting and collapse features. I am also using satellite gravity and bathymetry to assess the large scale variations in mantle and surface processes along the length of the ridge. My aim is to gain insight into the small scale (seamounts) and large scale (ridge) processes and the relationship between them. This work collaborates with Professor Alex Rogers who is studying the biology of these seamounts.

Phillipp Nasemann

Philipp Nasemann is a PhD student at the Centre for Chemical and Physical Oceanography - Department of Chemistry at the University of Otago in New Zealand and is supervised by Drs. Sylvia Sander and Claudine Stirling.

He just returned from a research voyage on RV Sonne to the New Hebrides island arc in Vanuatu where a new hydrothermal vent field was studied and sampled. His participation has been sponsored by Prof. Andrea Koschinsky from Jacobs University in Bremen, which he will visit as well to carry out further analyses.

According to his proposal "Fractionation of iron isotopes in Island Arc and Backarc Hydrothermal Systems" focus of the research will be on the alteration of the isotopic signature of iron along its transport from hot vent fluid to the open ocean. Therefore a comprehensive set of samples was collected to determine the initial iron isotopic compositions of host rock and hot vent fluid in this new vent field, and to monitor iron through the buoyancy process all the way into open ocean seawater. Studying iron isotopes and parameters such as iron/sulphur ratios will allow investigating whether significant amounts of iron are actually being exported from hydrothermal vent sites. The results will bring us one step closer to our goal of using iron isotopes as a tool to fully explain importance of different iron sources and the effect they have on the oceanic iron budget.

"I am doing a PhD in isotope geochemistry and marine biogeochemistry of iron. My main aim is to investigate the potential iron isotopes provide as a tracer for marine biogeochemical processes. This InterRidge Fellowship gives me the opportunity to expand my understanding of the biogeochemistry of iron into the field of hydrothermal processes and broaden my knowledge of oceanic iron cycling in general. This is crucial for my PhD and will enhance my ability to develop a career in marine geochemistry."

Szitkar Florent

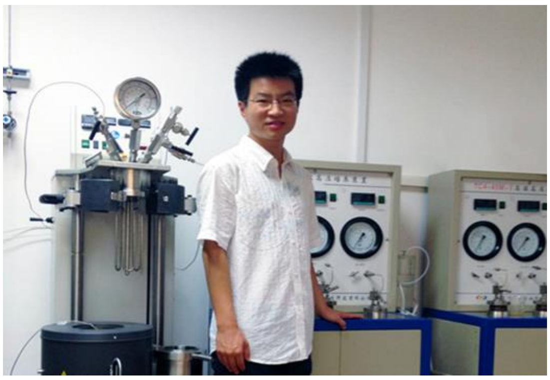
Florent Szitkar is working with deep-sea, high-resolution magnetic data collected on hydrothermal sites along oceanic ridges worldwide. During his PhD at Institut de Physique du Globe de Paris (IPGP), he became familiar with different methods to process and interpret these data. His work reveal that ultramafic-hosted hydrothermal sites are characterized by a high magnetization resulting from chemical processes during serpentinization, whereas alteration is the main cause of the low magnetization observed at basalt-hosted sites. He successfully used this knowledge to help locating hydrothermal deposits during two cruises in the French exclusive economic zone in the Pacific Ocean.

After his PhD defense in May 2013, he continued his work as a post-doc in IPGP to prepare several articles while maintaining international collaborations with prestigious research institutes around the world, including WHOI (USA), GNS Science (New Zealand), and AORI (Japan). He is presently looking for a post-doctoral position starting at the beginning of 2014.

The Inter Ridge project aims to widen his expertise by applying a new inversion scheme developed by Dr. Chie Honsho from AORI (The University of Tokyo, Japan) which avoids the upward-continuation (i.e. the loss of resolution) of other methods. He plans to compute high-resolution magnetization maps over several hydrothermal sites of the Mid Atlantic Ridge, taking full advantage of the near-seafloor measurements and allowing a precise interpretation.

"I have always been interested in Earth Sciences. Even if it's not easy to choose the research topic, the best choice I did was to apply for this thesis project, not only because it's really exciting but also because I have always enjoyed really friendly and warm relationships with my supervisor, Dr. Jérôme Dyment. Under his supervision, I had the opportunity to learn how to become a scientist and prepare papers for prestigious journals. With the professional skills he gave me, I'm now ready to hug a really interesting scientific career! ".

Xinxu Zhang



I have always been fascinated by the microbial life inhabiting oceanic crust since I started my PhD in oceanic crust microbiology and biogeochemistry. This fellowship gives me a great opportunity to investigate the microbial diversity and mineral-microbe interactions of North Atlantic crustal biosphere with top scientists and state-of-the-art technologies. The result will help on understanding the roles of microbes in ocean crust weathering and I will gain extensive experience in studying microbial transformations of earth materials which is crucial for my future research.

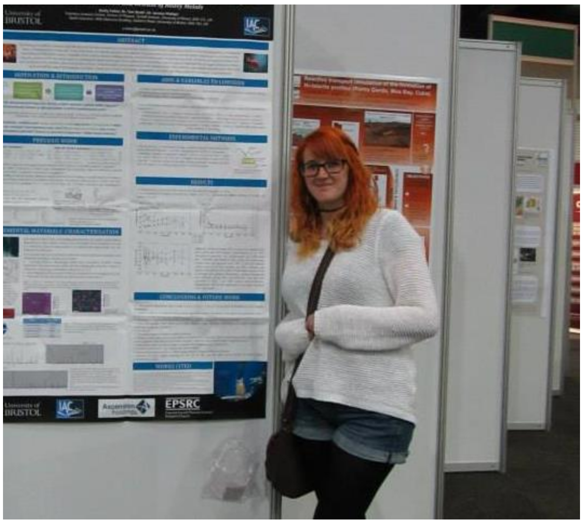
R. Rajasabapathy

"Knowledge on Methanotrophic bacterial diversity in the vent regions is of foremost significant because of the chemotropic mode of adaptation. But the diversity of these groups in the vent sites has been complicated to identify due to its limitation in the phenotypic and chemotaxonomic properties. I have always been interested in studying the diversity of marine bacteria especially identifying the functional groups from the shallow water hydrothermal vents. The IR/ISA fellowship will give me an opportunity to explore the methanotrophic bacteria from shallow hydrothermal vent in Azorean Island through methane monooxygenase genes (sMMO)".

Rajasabapathy is currently doing his Ph.D on "Molecular diversity of shallow water hydrothermal vent (Azores) bacteria, their adaptation and biotechnological potentials" under the guidance of Dr. C. Mohandass at CSIR-National Institute of Oceanography, Goa, India. He will visit IMAR-Dept. Oceanography and Fisheries-University of Azores to work on "Forecasting of Methanotrophs by methane monooxygenase genes (sMMO) from the shallow water vent Espalamaca" under the supervision of Dr. Ana Colaco.

InterRidge Fellow 2014

Emily Fallon



I (Emily Fallon) am currently a first year PhD student at University of Bristol, UK. I am supervised by Dr. Tom Scott, Dr. Jeremy Phillips and Dr. Richard Brooker from the University of Bristol. My PhD research focuses on seafloor massive sulphide (SMS) ore deposits and the economic and environmental feasibility of mining such deposits. The continuing global demand for metals has given mining companies cause to consider the deep ocean as a source of mineral wealth. In order to support this future economic prospect, our knowledge and understanding of such deposits requires significant improvement with an associated need for study of the environmental impact that any future endeavours may have.

The focus of this study is the galvanic dissolution of sulphide minerals in the water column, formed from particulate plumes generated by mining. Sulphides from various tectonic settings will be characterised in order to identity the trace elements, heavy metals and potential toxins that may be contributed to the water column. Subsequent high pressure, cold temperature experiments will seek to determine dissolution rates and characterise heavy metal release of natural sulphides during active mining conditions and understand the variables that control this process.

I have been fascinated by earth sciences and chemistry from a young age, which led me to an undergraduate degree in Geology at the University of Bristol. A big turning point was my year abroad at the University of Oregon, North America where I particularly enjoyed aqueous geochemistry, volcanology and economic geology where they were applied to real world applications that had an impact on society. My fourth year MSci project was a product of that fascination where I undertook experimental petrology research that focused on exsolving volcanic gases and their role in the formation of ore deposits. My love of research and experimental petrology, and in particular, research that is important and has a major relevance to both science and society, has led me to my PhD topic today.

This Fellowship will provide me with the opportunity to collaborate with, train with and learn from world class experts in this field of research at both GEOMAR, University of Kiel and NOC, Southampton. Furthermore, the Fellowship provides access to world class LA-ICPMS and solution ICPMS facilities that will help build both a fully characterised sample database prior to experiments and analysis posterior to high pressure dissolution experiments. GEOMAR and University of Kiel's analytical facilities are some of the best in the world for sulphide minerals and will allow for detection of environmental toxins and heavy metals that would not otherwise be detected during my PhD research but could be having a significant impact. The Fellowship will provide access to GEOMAR and their samples from a wide variety of locations and tectonic settings that can be utilised in experiments. In this regard, the research is enhanced as the variability in sulphide composition is fully considered.

Overall, the platform this Fellowship provides, in terms of collaborating with leading scientists, the development of skills and facilitating my active participation within the InterRidge Society, will be instrumental for shaping my future career. The Fellowship will not only significantly progress this research but also underpin further research in the future.

Matthew Hodgkinson

Matthew Hodgkinson is a Ph.D student at the National Oceanography Centre, Southampton and is supervised by Dr. Bramley Murton and Professor Steve Roberts. His research project is focused on the origin and processes driving hydrothermal activity on oceanic core complexes and especially those that form non-sulphide dominated mineral deposits. In pursuit of his research, Matt has joined two research cruises to the Mid-Cayman Spreading Centre, Caribbean (on the RV Atlantis and the RRS James Cook) as part of a multi-disciplinary effort to sample recently discovered hydrothermal systems and their biology. Dr. Frieder Klein who is based at the Woods Hole Oceanographic Institute where Matt will visit later this year sponsors his application for an IR fellowship.

Matt's proposal states that 'The discovery of seafloor hydrothermal systems in 1979 fundamentally changed our understanding of crust – seawater interaction, ocean chemistry and the evolution of chemosynthetic life. The Von Damm Vent Field, located on the Mid-Cayman Spreading Centre, represents a highly unusual system consisting of the magnesium silicate mineral talc. It is situated on the flanks of a mid-ocean ridge, on an oceanic core complex. These large, low-angle detachment faults are widespread at ridges with slow-medium spreading rates, yet are poorly explored in the resolution required for hydrothermal vent field discovery and could play a role in cooling the oceanic crust and global geochemical cycles'.

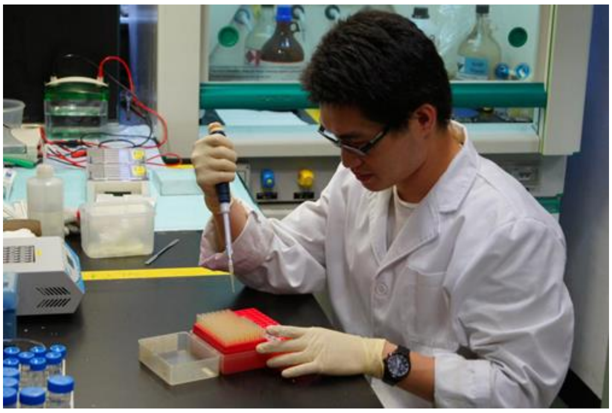
He says, "For my PhD I am currently studying the recently discovered Von Damm Vent Field situated in the Mid-Cayman Rise. The aim of my research includes expanding our knowledge of how detachment faulting enhances hydrothermal circulation at slow-spreading ridges, and the influence of oceanic core complexes and lower crustal lithologies on vent field geochemistry. This fellowship will give me the opportunity to work with, and analyse, samples from other parts of the Mid-Atlantic Ridge that are archived in the WHOI sample collection and discover the extent to which the processes that form the Von Damm Vent Field occur elsewhere.'

Michele Paulatto

I am Post-Doc at Geoscience Azur, University of Nice Sophia Antipolis sponsored by the AXA research fund. I am marine geophysicist and I focus on the study of tectonic and volcanic processes at active plate margins. During my PhD at the University of Southampton I worked on seismic tomography and thermal modelling to constrain the magma storage region and magmatic flux at Montserrat, on the Lesser Antilles arc. More recently at the University of Oxford I have investigated the effect of seamount subduction on the seismicity and structure of the Tonga-Kermadec subduction zone. Currently I am working on joint active-source and local earthquake tomography to image the crust, slab and upper mantle in the central Lesser Antilles, with the aim of constraining the geometry and physical properties of the megathrust fault and the overlying forearc crust.

This InteRidge fellowship will give me the opportunity to learn new techniques and expand my knowledge on mid-ocean ridge processes. In 2013 I joined a scientific expedition to the Rainbow hydrothermal field, on the mid-Atlantic ridge. The cruise had the aim of collecting seismic, multi-beam bathymetry and potential field data over the Rainbow massif and the surrounding ocean floor. Rainbow is a high-temperature hydrothermal system hosted on ultramafic rocks on a non-transform offset of the ridge. The high-temperature suggests the presence of a magmatic heat source, but the location of Rainbow at a ridge offset and the tectonized seabed morphology suggest that the region should be magma-starved. On the cruise I was responsible for the multi-beam and potential field data, which I processed and merged with existing datasets. I will study the potential field and multibeam bathymetry data to determine the relative contributions of tectonic and magmatic accretion along the ridge and reconstruct the long term evolution of the Rainbow non-transform offset. I will visit the Woods Hole Oceanographic Institution where I will work with J. P. Canales, M. Tivey and M Behn.

Jin Sun



Jin Sun got his PhD in 2013 at Department of Biology Hong Kong Baptist University, and is currently working as a research associate under the supervision of Dr Jian-Wen Qiu. During his PhD study, he mainly study on the adaptation and evolution of the notorious invasive apple snail using next-generation sequencing (NGS) and proteomics approaches. After graduation, he was fascinated by the deep-sea samples collected by manned submersible Jiaolong and decided to move into this new field. His current project is regarding the physiological adaptation and population connectivity of deep-sea mussels *Bathymodiolus platifrons* using functional genomics and proteomics approaches. His proposal is "Genetic connectivity of deep-sea mussels in Western Pacific examined by population genomic approach". "Studying genetic connectivity can reveal the genetic diversity of populations and provide information for the designation of marine protected areas." In the proposal, he said "This is a rare opportunity for me to study deep-sea mussels collected from different regions of the Western Pacific. Without this regional collaboration, it would be impossible to conduct a genetic connectivity study on deep-sea mussels. What's more, the fellowship will allow me to establish connection with experts in this field of study. The experience gained from this fellowship program will allow me to start a career in the exciting area of deep-sea research, and contribute to the conservation of deep-sea biodiversity. " In June and July 2013, his research group took part in the manned submersible Jiaolong's first scientific cruise, during which samples of *B. platifrons* were collected in South China Sea. He will travel to JAMSTEC to study several other *B. platifrons* populations in collaboration with Prof. Ken Takai and Dr. Hiromi Watanabe in the next two years.

Former InterRidge Fellowship reports

InterRidge Postdoctoral fellowship: report 2012

Baby Divya, 2010 interridge fellow, National Institute of Oceanography (NIO), Goa, India

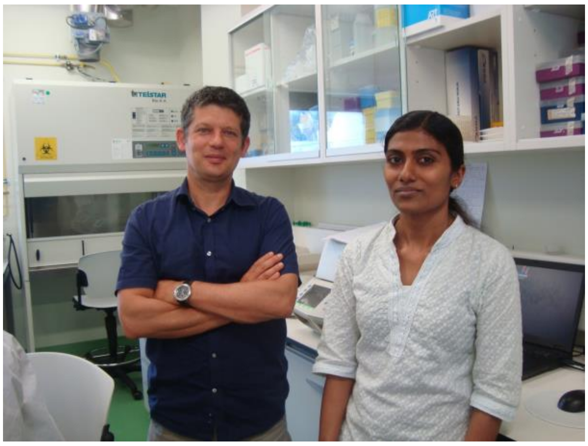


Photo: Drs. Raul Bettencourt and Baby Divya at Genetics Laboratory, University of Azores, Horta

Host Institution: Institute of Marine Research (IMAR), University of Azores, Portugal, Period of Visit: 24th January 2012 - 10th July 2012

Supervisor in India: Dr. Shanta Achuthankutty, Micro-biology Laboratory, NIO, Goa, India, Supervisor in Portugal: Dr.Raul Bettencourt, Genetics Laboratory, IMAR, University of Azores, Portugal

Under the InterRidge fellowship, I studied the bacterial gene expression kinetics in the hydrothermal vent bivalve Bathymodiolus azoricus at the University of Azores, Portugal. B. azoricus mussels are found as large animal communities in the hydrothermal vents around the Azores region and are considered as model organism to study the physiological adaptation to extreme physical and chemical conditions. These animals from the shallowest hydrothermal vent, Menez Gwen are maintained in controlled aquarium system, called LabHorta, for monitoring physiological characteristics in seawater.

My study involved the understanding of the variation of bacterial symbiont gene expression in the host gills tissues during their maintenance in the laboratory. Initially, about 20 genes involved in the bacterial metabolism were screened at 12 hour intervals and also after seven days. Out of these bacterial genes, those involved in the chemoautotrophic metabolism such as SOX (sulphur oxidation), MMO (methane oxidation) and Cbb (carbon fixation) were selected for the expression analysis using qPCR. Quantitative gene expression was pursued to understand the individual variation in expression in animals at different time points and between different time points. The salient findings were 1) the expression of SOX (sulphur oxidation), MMO (methane oxidation) and Cbb (carbon fixation) genes varied significantly between individuals and 2) this variation was time dependant and decreased within hours of maintenance of the host animals in sea water. The presence of the expression of genes in the different sections of the gill were confirmed by Fluorescence in situ hybridization (FISH) suggesting their obligate relationship by way of chemosynthesis.

My work under the guideship of Dr. Raul Bettencourt, the eminent geneticist and invertebrate immunology specialist at the University of Azores helped me in getting an exposure to the latest state-of-art techniques at the cellular and molecular level techniques for symbiotic studies. Moreover, I got hands on training with the various instruments within the University of Azores, Horta. My scientific concepts were honed by my constant interaction with my host supervisor, scientists and researchers who were the team members of the shallow water missions. This scientific interaction would help me in my future research and has also enabled me in fostering future collaborative work between my institute, National Institute of Oceanography, India and University of Azores, Portugal. It is my greatest pleasure to thank my supervisor and Project Leader at NIO, Dr. Shanta Achuthankutty, a distinguished marine microbiologist and ecologist, for her untiring help, guidance, encouragement and support throughout the course of the work. I would also like to take this opportunity to thank the InterRidge Coordinator of Initiative for International Cooperation in Ridge Crest Studies for considering me for the award of this fellowship which enabled me to conduct this fascinating piece of work on symbiotic association between higher organism and bacteria.

The role of the melt supply variability in the development of a detachment fault system

Fellow: Dr. Alessio Sanfilippo; Università degli Studi di Pavia (now at Kanazawa University)

Sponsor: Dr. H.J.B. Dick; Woods Hole Oceanographic Institution

The InterRidge Fellowship 2012 allowed me to take part into the Cruise KN210-05 (May-June 2013) at the 16.5ºN area of the Mid Atlantic Ridge and to spend additional time at Woods Hole Oceanographic Instituion (USA) (November 2013 and January 2014) to study the rock samples. The area investigated during this cruise is characterized by a complex detachment faulting system, where neo-volcanic zone are associated with zone of active detachment, and can thus be considered an ideal place where the link between detachment faulting a magmatism can be explored.

During the cruise, I was mainly devoted to the collection, curation, description, and interpretation of the rock samples. In the months after the cruise (September and October 2013), all the recovered gabbroic samples were studied under the optical microscope and ~20 samples were selected for the chemical analyses. Up to date, I determined the major element mineral composition of these samples through Electron Microprobe analyses (Università di Milano); the trace element mineral compositions of the major mineral phases are in phase of characterization by Laser Ablation Mass Spectrometry. This preliminary geochemical study, integrated with the high-resolution mapping and geophysical survey obtained during the cruise, resulted in two main discoveries:

the gabbroic rocks exposed at the ocean core complexes in our mapping area show a “bimodal” compositional distribution (i.e. large proportion of rocks crystallized either from chemically primitive and evolved magmas and lack of chemically intermediate cumulates), which is hardly reconcilable with that expected for crystallization of a mid-ocean ridge basalt magma. During my visit at WHOI (Novermber 2013 - January 2014), under the advisement of Dr. H.J.B. Dick, we found a scenario that might explain why this anomalous compositional distribution characterizes our study area. Using the theoretical free-energy minimization modelling program Melts we showed that a similar bimodal compositional distribution of the lower crust can be produced if mantle melts are intruded into the mantle, rather than into a thick pre-existing layer of gabbro. Given that the input of this model is the proportion and composition of the erupted basalts in the area, we created a powerful tool for assessing the architecture of the lower crust at ocean ridges, where it cannot be accessed directly. These results have been presented at the Goldschmidt Conference 2014 and are discussed in a manuscript in preparation.

The highly deformed primitive gabbroic rocks (troctolite ultra-mylonites) are mineralogically and chemically distinct from the host rocks (porphyroclastic to mylonitic troctolites) and contain large amount of hydrous silicate phases such as amphibole. The preliminary geochemical characterization of these rocks indicates that the high-temperature deformation occurred during the late magmatic stages, in concomitance with the ingress of considerable amount of water into the magmatic system. Together with Dr. H.J.B. Dick and Dr. H. Marschall (WHOI), we discussed on the origin of these rocks convening that detailed analyses including trace element compositions and Li and B isotopes of amphiboles are necessary to define if and at what extent seawater is involved at the onset of the detachment faulting.

Given the multidisciplinary characters and the high impact of these preliminary results, it is not difficult to imagine how the InterRidge Fellowship 2013 is enhancing my career. The data I obtained during the cruise and during the working period at WHOI already provided shocking results that will be likely published on major international journals. Importantly, some of these preliminary results will be used as fundamental starting point for detailed studies in collaboration with scientists from WHOI. This is enabling long-standing relationships and has the potential to create an important net of collaborations between WHOI and my past (Università di Pavia) and present (Kanazawa University) institutions.

Nonetheless, thanks to this fellowship I co-authored a manuscript and several conference papers based on the results obtained during the cruise.

I hope this reports fully express my gratitude to InterRidge for such a unique opportunity.
Alessio Sanfilippo

Dr. Alessio Sanfilippo
School of Natural System,
College of Science and Engineering,
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Preliminary results:

Smith D, Schouten H, Dick HJB, Cann J, Salters V, Marschall H, Sanfilippo A et al. Development and evolution of detachment faulting along 50 km of the Mid-Atlantic Ridge near 16.5N. Geochemistry Geophysics Geosystems, under review.

Sanfilippo A., Dick H.J.B. (2014). A quantitative model to explain the bimodal distribution of gabbros from the 16.50°N core complex: an attempt to explain the compositional heterogeneity of the lower oceanic crust. Goldschmidt 2014, Sacramento USA.

Dick H.J.B., Salters V., Sanfilippo A., Shouten H., Smith D. (2014) Focused Melt Flow and Abyssal Magmatism at Lower Magma Supply Rates. Goldschmidt 2014, Sacramento USA.

Sanfilippo A., Palmiotto C., Dick H.B.J., Smith D., Schouten H., et al. (2013). Linkage between detachment faulting and magmatism in the central Mid Atlantic Ridge (16.5° N region, Atlantic Ocean): preliminary data of the cruise KNR 210-5 (part II). Congresso Nazionale Società Geologica Italiana, Pisa (Italy)

Palmiotto C., Sanfilippo A., Smith D., Schouten H., Dick H.B.J., et al., (2013). Linkage between detachment faulting and magmatism in the central Mid Atlantic Ridge (16.5° N region, Atlantic Ocean): preliminary data of the cruise KNR 210-5 (part I). Congresso Nazionale Società Geologica Italiana, Pisa (Italy).

Srinivas Rao Arvapalli, 2011 InterRidge student fellow

National Institute of Oceanography (CSIR), Goa, India.

Deputation Report of visit to University of Bremen, Bremen, Germany.

I carried out the proposed research project entitled "Distribution of hydrothermal sources over the slow spreading Indian mid oceanic ridges" under the supervision of Dr. Maren Walter, at University of Bremen, Bremen, Germany, as an InterRidge student fellow. The objective of my proposal of study is to 'Identify the hydrothermal source using the water column physical data collected under the Indian Ridge program on hydrothermal exploration. The data was collected in various cruises with CTD (Conductivity, temperature and depth), MAPR (Miniature Autonomous Plume Recorder with Eh sensor) and AUV (Autonomous Under water Vehicle) over the Carlsberg and Central Indian Ridges in Indian Ocean.

"Indian ridge program 2010" selected a 40 mile segment at 10°S, to explore hydrothermal activity on central Indian ridge. We conducted expedition onboard RV Sagar Nidhi (SN-48) to acquire the hydrographic data in water column using CTD, turbidity sensors and AUV. CTD hydrocasts were planned based on the tectonic and geo-morphological features observed in the bathymetric map of the study area. From Continuous observations of turbidity signatures from the back scatter sensors, we conducted AUV dives to find the location of the provenance of hydrothermal signatures.

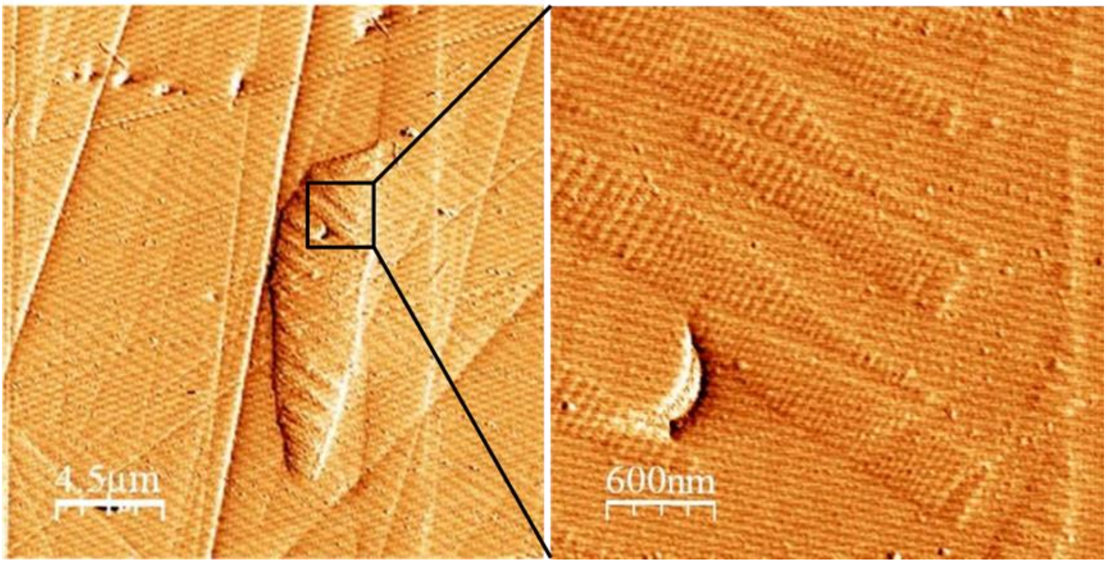
During my visit I learned the techniques for processing and analysis of hydrographic data. First I started work on AUV data. The deltaE values along the AUV tracks and vertical profiles of MAPRs have been calculated from Eh (Oxidation and Redox Potential) data. Significant ΔE anomaly values are important to understand and find the possibility of source locations of the hydrothermal vents. Similar procedure I applied to calculate the temperature anomaly ($\Delta\Theta$) for AUV tracks data.

Only minor $\Delta E \& \Delta \Theta$ values are observed in the tracks on AUV apart from there are no significant variations in the data. Lupton (1985) method was used to find out the hydrographic (CTD-potential temperature and salinity) anomalies in all the observed hydrothermal plume depth stations. The results of these hydrography anomalies revealed an idea of the physical properties of this plume. I estimated the heat flux of volume of possible source in this study area by using MTT model (Morton et al 1956). I also acquired knowledge on data visualization (AUV and CTD data) and interpretation of the results. The hydrothermal plume spreaded up to 15km in the water column observed through the turbidity data with constant potential density. From the results of heat flux and spreading distance values are cross checked with the other known vents data, we presumed to be a large vent field existence in this slow spreading central Indian ridge, Indian ocean. We found the results are very interesting from this work.

Acknowledgment

I am indebted to Dr. Maren Walter, my dissertation mentor for her guidance and providing support and first- rate resources for this dissertation project Dr. Maren, in particular has been exceedingly generous with her time, laboratory space and equipment. Her expertise in hydrothermal vent studies was an asset to my project. I am also grateful to Dr. Christian Mertens for providing many useful insights into my project and directions to conduct the further research and have always been a good friend. Particularly, I extend my sincere thanks to my Ph.D guide and project leader Dr. K. A. Kamesh Raju for his long-lasting source of support, encouragement and advice throughout my time. I would like to thank Dr. Debbie Milton, InterRidge coordinator for her kind assistance throughout the process. I want thank many of my friends, colleagues and teachers from NIO and University of Bremen who offered me lot of help and support, this work would not has been possible without help from them. This research was supported by "Interridge/ISA fellowship program" and I am very thankful to Interridge/ISA fellowship program for giving me this wonderful opportunity for the advancement of my research career. This experience and knowledge is very useful to upcoming Indian Ridge program on hydrothermal studies.

InterRidge Fellowship Report for Jessica Till



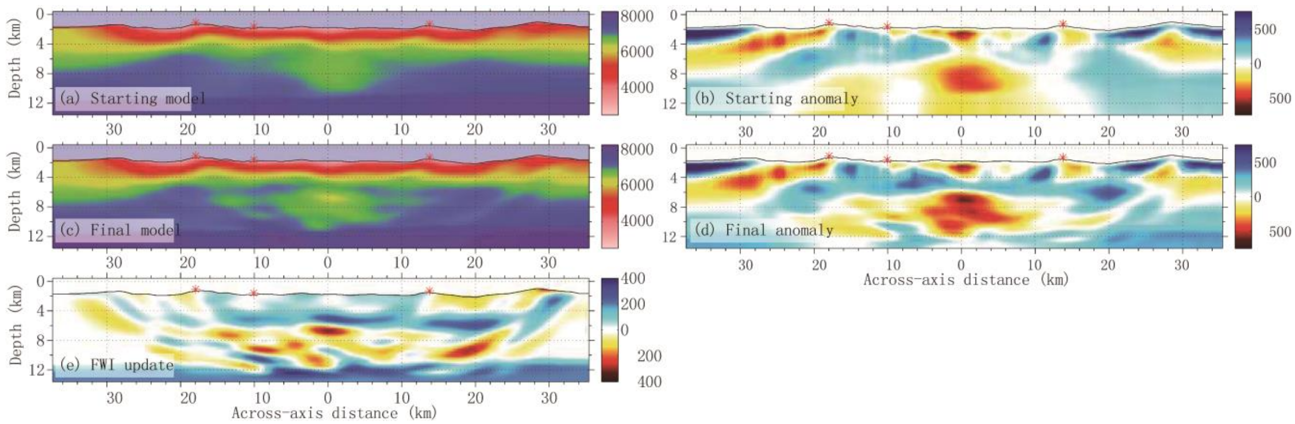
Scanning probe microscope images of nanoscale lamellar magnetic Fe-oxide particles in a pyroxene grain representing multiple generations of oxide mineral exsolution.

During my InterRidge fellowship I visited Imperial College London in 2013 to work with Dr. Adrian Muxworthy. During the visit we conducted nanoscale characterization of magnetic minerals in gabbros from both slow - and fast - spreading ridges in order to help determine how exsolution microtextures reflect temperature - dependent diffusive processes. Our results will be used to help constrain variations in cooling rates of the lower oceanic crust. One particularly interesting discovery was the unexpected complexity of silicate‐hosted Fe‐oxide particles in gabbros from oceanic core complexes. These nanoscale particles appear to be the product of multiple generations of exsolution and mineral "unmixing". This tells us that cooling rates in these rocks must have been very slow and that the growth process of the Fe‐oxide minerals is much more intricate than previously thought.

During the fellowship I also had the opportunity to travel to Bochum, Germany to attend a workshop where I learned a variety of techniques for creating numerical models of diffusion data in mineralogical processes at the Ruhr Universität. The workshop provided a wealth of skills that are currently being applied to better understand how diffusion processes produce the mineral textures we observe. Modeling work will help explain the variation in exsolution textures between gabbros formed at slowspreading and fast‐spreading ridges and how these textures record the thermal history of the rocks. Many thanks to the InterRidge program for an excellent research experience that has provided a foundation for continuing work and for the opportunity to interact with a range of international colleagues and experts that has enriched my professional network.

Imaging of Lower-crustal Magma Chambers at an Ultraslow Spreading Ridge Segment using Elastic Waveform Inversion of a Sparse Refraction Dataset

Hanchao Jian, InterRidge 2012 Fellow



Result of the 2-D FWI of real data. (a) Starting and (c) final models; (b) starting and (d) final anomalies with respect to the 1-D average of the 3-D tomographic model; and (e) model update from the FWI. Across-axis distance of zero corresponds to the ridge axis. Both velocity and anomaly images show high resolutions at the top boundary of the AMC in the final result.

Working progress

I started this project since March, 2014. I have being learning the theories of FWI, including waveform modelling, adjoint method and inversion theory. At the meantime, I used synthetic tests to help understanding and being familiar with the code. The real data analysis has been started in May, 2014. I did plenty of tests of data processing and inversion to seek the way to overcome the difficulties posed by the sparsity of data. Now, the inversion of long-offset data is successful, whose result is also very encouraging. The initial plan had two objectives: to improve both images of the LVZ and the shallow faulted zones. I present the preliminary result for the first part in this report, whereas the second part is proved to be impractical due to the extremely poor data coverage of the sparse dataset at the shallow part.

However, it is still necessary to include as much data as possible, considering the small amount of data we have. For instance, including data at nearer offset should improve the result by increasing the data coverage and resolution around the AMC and suppress the artefact due to mapping of Moho uncertainties through PmP wavepaths. Then I will finalise this project by publishing a scientific paper.

Budget

The 5000$ IR/ISA fellowship has been spent in flight ticket from Beijing to Paris (about 800$ each way), and lodging and living subsistence during the more than half-year time staying in Paris, while an additional financial support from Peking University covered the rest cost of lodging and living subsistence in Paris.

Impact on my career

I really appreciate the opportunity to study at Institut de Physique du Globe de Paris and conduct this project. The application of FWI and other adjoint-method based inversion techniques to real data for a scientific purpose is drawing more and more attentions in recent years, owing to the development of computational resources and seismic acquisition. Indeed, the significant improvement of resolution resulting from the FWI is very attractive. It will serve much better the geological interpretation than other inversion techniques, once the nonlinearity problem can be tackled. Learning the FWI theory and application at this stage will help me a lot in the future research work.

My PhD thesis is about the seismic image for the magmatic process at an ultraslow spreading ridge segment. The presence of the magma body is one of the most important discoveries. Now, the high-resolution image of the AMC essentially enhances my PhD thesis.

Cruise Travel Bursaries

Purpose

- To encourage new collaborations across the InterRidge member nations.
- To enable early-career, ridge-crest scientists to participate in mid-ocean ridge research cruises.
- To develop new research directions.

The award

Up to $2000 USD will be awarded for travel and subsistence costs to facilitate cruise participation. Successful applicants will be asked, on their return, to:

- Produce a report for the IR website in **English**
- Deliver an ambassadorial seminar in their institution, explaining the enabling role of the InterRidge bursary in their work

How it works

There are two possible routes:
A) Initiated by early-career scientist
1. Identify a cruise on which you wish to participate, and a scientist onboard (host) with whom you would like to collaborate.
2. Contact host by email, asking if there is a spare berth.
3. Host scientist checks with the cruise Chief Scientist.
4. If all are in agreement, download the bursary application form (see bottom of page - to be completed by host scientist /applicant), and submit it to the InterRidge Office as an email attachment, together with your CV and letter of support from your manager/university/laboratory.
B) Initiated by host scientist
1. If you are interested in establishing new collaborations relating to the cruise on which you are participating, contact your Chief Scientist for information on spare berths, and permission to open discussions with interested parties. Send information on spare berths into the InterRidge Office and we will put it on the website.
2. Early-career scientists - check the InterRidge website (http://www.interridge.org/berths) to see which cruises have spare berths and contact the host scientist. OR
A host scientist may already know of an eligible applicant, in which case they may proceed with the application, subject to approval by the Chief Scientist.
3. If all (Chief Scientist, host scientist (if different), and early-career scientist) are in agreement, download the bursary application form (see bottom of page - to be completed by host scientist / applicant) and submit it to the InterRidge Office as an email attachment,together with the applicant's CV and letter of support from his/her manager/university/laboratory.

What will you do onboard?

Participate in the planned science programme.
Carry out your collaborative research.

2013-14 Cruise bursary recipients

During 2013-2014, 12 early career scientis have been awarded the cruise bursaries to gain first experiece on cruise (Please see the table below for details).

Call for spare berth for early career scientists.

In 2015, InterRidge office will continue provide cruise bursaries for early career scietists to participate in mid-ocean ridge research. We encourage chief scietists and national correspondents to provide information of spare berth to our office.

2013-14 Cruise bursary recipients

Host Scientist	Cruise location and time	Recipients
Doug Wiens(USA)	Eastern Lau Spreading Center (Jan 2013)	Hanchao Jian(China)
Juan Pablo Canales(USA)	the Rainbow hydrothermal field area (April-may, 2013)	Omar Benazzouz(Portugal) Michele Paulatto(UK) Maja Fabeta(Ireland)
Francis Lucazeau(France)	Oceanographer-Hayes 1 (OH1, Fig. 1), at 35°N. (May,2013)	Aldina Piedade (Cardiff University,UK) Ana Hipólito (Universidade dos Açores. Portugal)
Kim Juniper (CANADA)	Endeavour(June,2013)	Daphne Cuvelier (UK)
Dr Hiromi Watanabe and Dr Ken Takai (Japan)	KY14-01/Jan 08-30, 2014/Iheya North hydrothermal vent field, Okinawa Trough	Chong Chen, (Hongkong China)
Dr. Richard Hobbs	JC112, Jan 2015, Costa Rica	Gavin Haughton,(UK)
Dr. Craig Moyer	RR1413, Nov 29-Dec 21, Mariana volcanic arc. Port of Guam	Sheryl Murdock, (Canada)

InterRidge Student and Postdoctoral Fellowships

$5000 USD

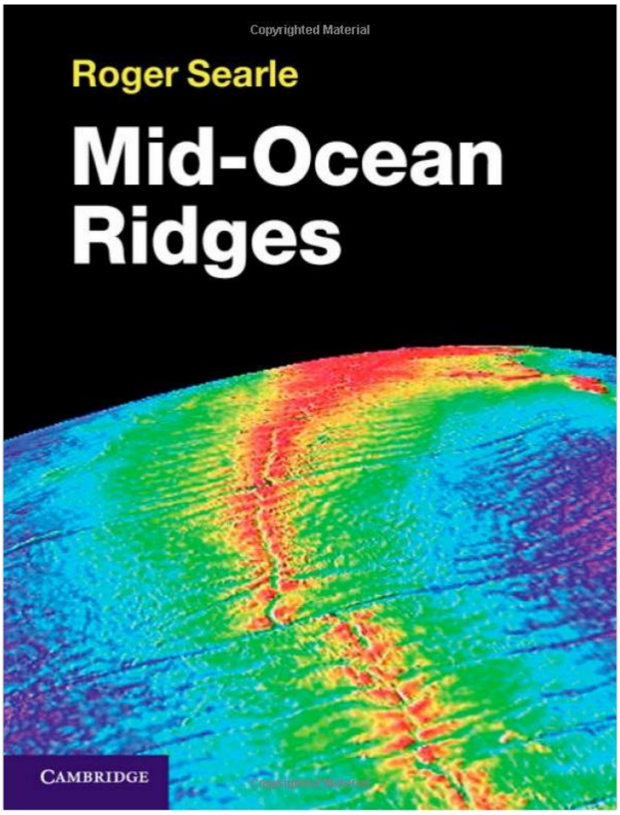
http://www.interridge.org/fellowship

Call for Proposals for the 2015 Fellowships will be released in January 2015.

Deadline: 31 March 2015

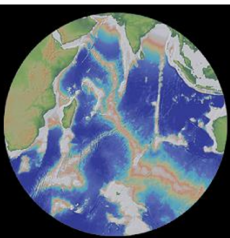
Awards announced in August 2015

Mid-Ocean Ridges by Former InterRidge Chair Roger Searle



Roger Searle is Emeritus Professor of Geophysics at Durham University. He has spent forty years studying mid-ocean ridges, and was a pioneer in the use of side-scan sonar to study their geodynamic, tectonic and volcanic processes. In his research he also uses topographic analysis and gravity and magnetic modelling to understand ridge structures. He was awarded the Royal Astronomical Society's Price Medal in 2011 and elected a Fellow of the American Geophysical Union in 2012.

This coursebook presents a multidisciplinary approach to the science of mid-ocean ridges - essential for a complete understanding of global tectonics and geodynamics. An ideal introduction to a key global phenomenon for graduate and advanced undergraduate students and professionals working in marine geology, plate tectonics, geophysics, geodynamics, volcanism and oceanography.



Indian Ocean Crust & Mantle Drilling

WORKSHOP FOR SCIENTIFIC DRILLING IN THE INDIAN OCEAN CRUST & MANTLE

May 13th to 16th, 2015 Woods Hole MA, USA Register @ http://web.whoi.edu/indian-ocean-drilling

US - China International Ocean Discovery Program Workshop

Workshop Goals Include:

- Provide an overview of the origin and evolution of the Southwest Indian Ridge & the results of recent research
- Obtain community input into science planning for Expedition 360: the start of the SloMo Project to drill through the lower crust to Moho in the Indian Ocean.
- Form a proponent group for drilling the tectonic and geologic evolution of the Dragon Flag Hydrothermal Area on the Southwest Indian Ridge.
- Promote new objectives for a 2ND round of JOIDES Resolution drilling in the Indian Ocean
- The workshop will include a wide range of invited talks on tectonics, geochemistry, petrology and crustal accretion in the Indian Ocean as well as contributed talks and a poster session.

For more information contact the convenors: Henry Dick (hdick@whoi.edu) or Hyaiyang Zhou (zhouhy@tongji.edu.cn)

IODP INTERNATIONAL OCEAN DISCOVERY PROGRAM · IODP-CHINA · NATIONAL SCIENCE FOUNDATION NSF · COMRA · CONSORTIUM FOR Ocean Leadership DISCOVERY • UNDERSTANDING • ACTION

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Updated Oct. 2014

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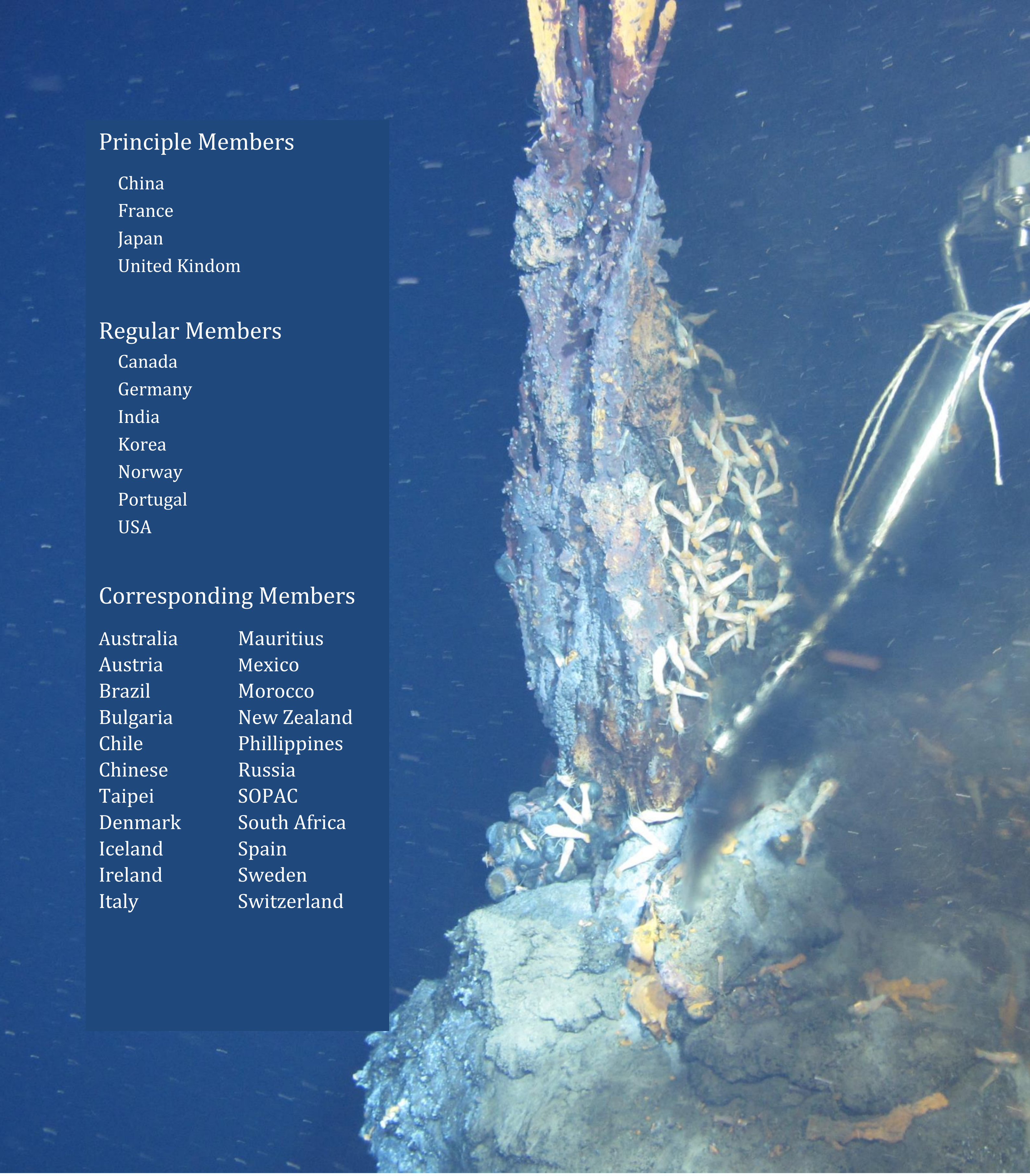

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Front Cover Photo: Bathymetry of an oceanic core complex at the slow spreading Carlsberg Ridge.

Back Cover Photo: Black smoker chimney, Dragon Flag Field, SW Indian Ridge, depth ~2800m; image taken by Sea Dragon II ROV during Dayangyihao DY30 cruise, February 2014.

Both photos are provided by The Second Insititute of Oceanography, SOA, China.