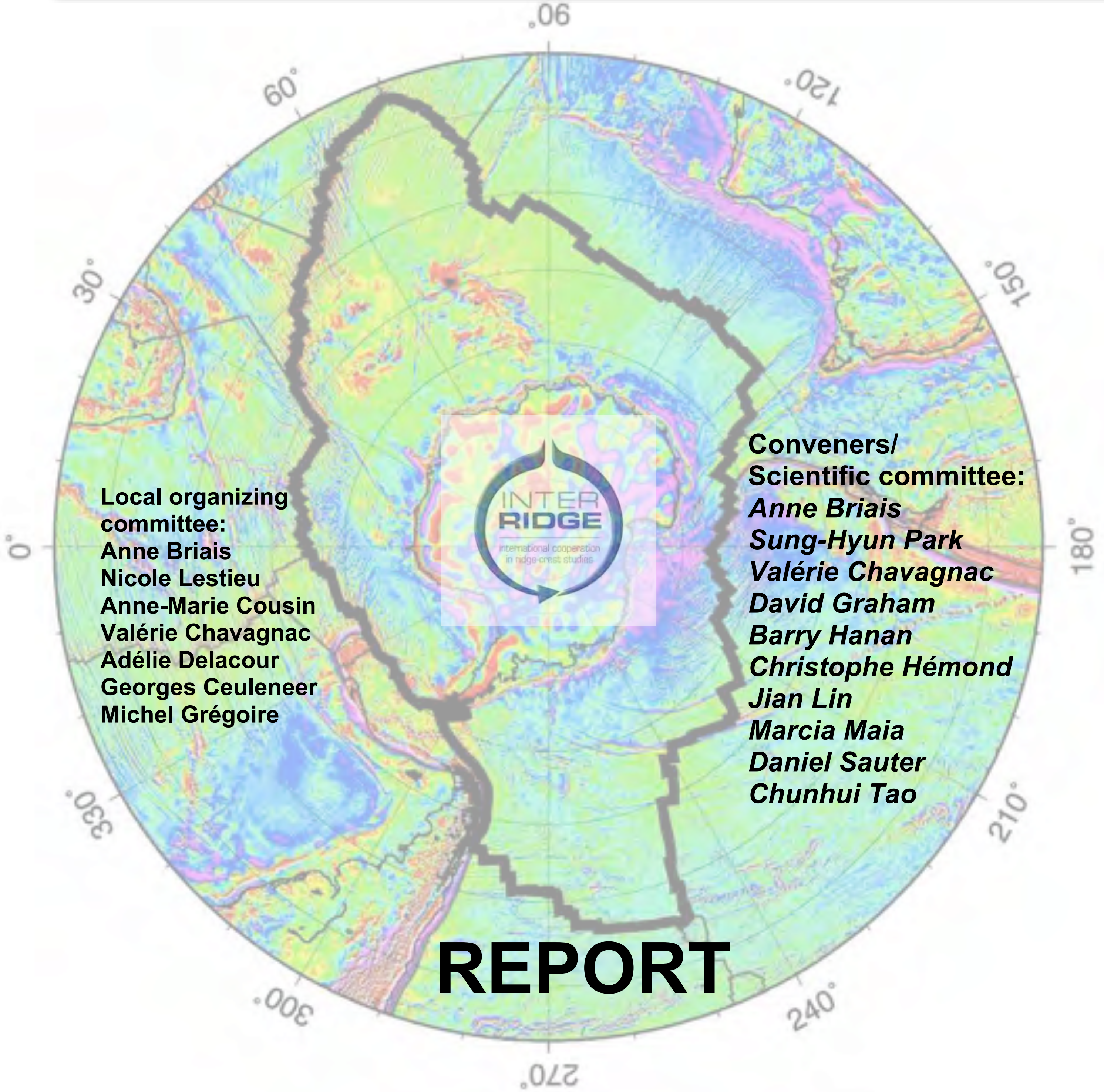
InterRidge International Workshop

Circum-Antarctic Ridges

28-30 September, 2011, Toulouse, France



Local organizing committee:
Anne Briais
Nicole Lestieu
Anne-Marie Cousin
Valérie Chavagnac
Adélie Delacour
Georges Ceuleneer
Michel Grégoire

Conveners/ Scientific committee:
Anne Briais
Sung-Hyun Park
Valérie Chavagnac
David Graham
Barry Hanan
Christophe Hémond
Jian Lin
Marcia Maia
Daniel Sauter
Chunhui Tao

REPORT

Workshop sponsored by InterRidge and Université Paul Sabatier

1. Introduction

The mid-ocean ridges around Antarctica have been poorly surveyed, mostly because of their location in high latitudes and areas of rough seas. However, circum-Antarctic Ridges are unique by their shallow water depths, ultra-slow or intermediate spreading rates, and complicated series of transform offsets compared to low-latitude ridges. A number of scientific issues at various scales in space and time are ideally addressed in these areas, such as:

- the boundaries and fluxes between the Pacific, Atlantic and Indian mantle domains
- the along-axis variability in ridge morphology, magma supply and basalt chemistry at constant spreading rate
- the migration and exchanges between biological communities

Circum-Antarctic ridges represent over one third of the global mid-ocean ridge system. They remain the least known sections of the global mid-ocean ridge system, but a lot of scientific cruises occurred in the southern ocean, involving mostly oceanographic studies. It is time to focus an international effort to survey these ridges, to discover new tectonic contexts, new hydrothermal vents, new species and new ways to connect all these. These ridges will most probably have an important place in the InterRidge (IR) research objectives for the next decade. It was essential that the community discuss these issues prior to the December 2011 meeting to plan the next decade program.

The InterRidge workshop «Circum Antarctic-Ridges» had a series of talks reviewing the state of the art of the mid-ocean ridge research in the Southern ocean. The presentations summarized the results on specific areas, or on major scientific issues addressed in the southern oceans. The abstracts of all presentations (oral or poster) are included in this report.

Then the participants discussed the major issues that are unique, or that would be ideally addressed in the southern mid-ocean ridges, and the specific techniques required to survey the ridges in high latitudes, and the essential coordination of cruise plans.

The objectives of the Circum-Antarctic ridges InterRidge Workshop were to:

- Review the state of the art of the research on Circum-Antarctic ridges
- Review important scientific issues covering geosciences to biology
- Review the latest tools and technical possibilities which can allow work in these challenging latitudes
- Encourage a collaborating effort between various IR countries to address these specific issues
- Form an IR Working group on Circum-Antarctic ridge research

2. State of the art

2. a. Ridge structure, tectonics and mantle processes

A number of presentations described the latest results and provided information on the last cruises on the Circum-Antarctic Ridges. Encouraged by the IR working groups on the **Southwest Indian Ridge** (SWIR), and then on the Ultra-Slow spreading ridges, a number of cruises surveyed the SWIR. Daniel Sauter, Henry Dick, Huaiyang Zhou, Daniele Brunelli, Taishi Sato, Hiroshi Sato and co-workers showed results concerning the structure of the ridge, including large areas of mantle outcrops, and the complex production of magma under this ultra-slow spreading ridge.

The **Southeast Indian Ridge** was surveyed systematically between the Saint Paul-Amsterdam hotspot area and the Australian-Antarctic ridge. David Graham, Barry Hanan, Christophe Hémond and Marcia Maia presented results of recent cruises and large-scale investigations showing ridge morphology variations, geochemical changes, and hints of new hydrothermal vent fields locations from recent MAPR surveys combined with wax coring. The easternmost section of the SEIR, the Australian-Antarctic ridge south of Tasmania was surveyed very recently. Sung-Hyun Park presented preliminary results on mapping and sampling the two easternmost segments of the ridge, KR1 and KR2.

The **Pacific-Antarctic Ridge** (PAR) has been surveyed down to south of the Pitman transform fault. Anne Briais presented the structural characteristics of the southern PAR, and Cédric Hamelin presented the geochemical characteristics of the PAR and EPR based on a synthesis of sample analyses.

The **Chile Rise** was surveyed by recent cruises. Donna Blackman showed the interaction of the ridge with the subduction processes.

Several presentations pointed out the large variations of magma production along the axis of the Circum-Antarctic ridges, and the variations in time of the magma supply along some of the SWIR corridors, or of the interaction between the St Paul Amsterdam hotspot and the SEIR. The off-axis surveys were essential in revealing such variability. The origin of the variations, mantle temperature or composition, and the scale of these variations, are not understood yet and should be the object of future investigations.

2. b. Hydrothermal vents and biology

The most striking observation about hydrothermal vents and biology on Circum-Antarctic Ridges is the small number of sites already discovered. Ed Baker showed that given the distribution observed on the other mid-ocean ridges as a function of spreading rate, a lot more vents should be observed. Vent fields have been described on the SWIR (presentations by Chunchui Tao, Jian Lin, Ed Baker), on the Bransfield basin and the East Scotia Sea (Douglas Connelly), and on Kerguelen Island (Valérie Chavagnac). Signatures of vent fields have also been detected from MAPR measurements on other locations of the SWIR, on the Australian-Antarctic ridge and the PAR. Studies of the vent field fauna have been presented (Yong-Jin Won), for the BB (Alfred Aquilina), ESS (Jeff Hawkes, Catherine Cole, Christopher Sweeting) .

3. Some points of discussion

3. a. Ridge tectonics and mantle processes

Because they are created at various spreading rates, the Circum-Antarctic ridges display a large range of morphologies and magma budgets. The workshop presentations pointed out that the diversity of basalt and mantle rock depends not only on mantle reservoirs and spreading rate or mantle temperature, but also on poorly-known melting processes and mantle heterogeneities.

Presentations and discussions came up with important issues:

-> How heterogeneous is the mantle ? Where and how should we collect samples to improve our understanding of mantle heterogeneities? What is the role of mantle heterogeneities in the variability at the axis, compared to that of mantle temperature?

-> How do the three large mantle domains (Atlantic, Indian, Pacific) meet under the Circum-Antarctic ridges? These ridges represent a unique window on mantle processes at such a large spatial scale.

-> How do ridge processes vary with time? A few off-axis observations reveal significant evolutions in time, but off-axis surveys and sampling are still too rare.

3. b. Hydrothermal vents and biology

The major point about Circum-Antarctic hydrothermal systems is that most of them are still to be discovered! Only a few sites (9 active sites, many promises) have been found so far (Bransfield, East Scotia, SWIR, PAR). Studies of biogeography are waiting for more sites to be identified. The major issues of how and how far species can disseminate are only envisaged near BB and ESS.

One important question at global scale is the role of Fe released at hydrothermal vents on the global budget.

4. Future steps

All participants agreed that InterRidge can and should help with the survey of Circum-Antarctic Ridges, to launch new projects, coordinate existing cruise projects, and share information.

4. a. Future cruises planned around Antarctica

To constrain the investigations in the remote southern ocean, we discussed the plans already existing in the different countries. Several groups are committed or planning to survey sections of the Circum-Antarctic Ridges.

- Indian ridges (Yoshi Nogi) : Japanese ice-breaker crosses the Indian ocean to reach the Antarctic bases, and could include scientific survey south of 55°S.

- SEIR south of Tasmania (Sung-Hyun Park) – Scheduled cruise to complement the geophysical survey and sampling along the segments KR1 (160°E) and KR2 (152.5°E) of the SEIR with the icebreaker Aaron.

- SEIR south of Tasmania (Jérôme Dyment) : a series of 6 transits of N/O L'Astrolabe betwen Tasmania and Dumont D'Urville (Antarctica) will collect magnetic profiles from margin to margin.

- SEIR axis, off-axis volcanoes 135-150°E and part of George V transform fault system (Anne Briais): mapping and rock/water column sampling; proposal submitted.

- SWIR (Huaiyang Zhou) : One leg per year to survey the centre of SWIR for polymetallic sulfides.

- SWIR in the Andrew Bain transform fault (Sato and Dick). Also surveys of the Conrad Rise.

- SWIR (Mathilde Cannat and Sylvie Leroy): seismic cruise on the smooth, non-volcanic seafloor of the SWIR: proposal submitted.

- PAR south of 60°S near Macquarie triple junction (Jian Lin)

4. b. Requirements/wishes from the participants

For many practical issues, coordination at the InterRidge level would greatly help further investigations. For examples:

- Sharing of rock samples after 3 years

- Protocols to compare vent fauna

- Information about cruises

- Participation in cruises

One point should be considered in the discussions about interdisciplinary participation to cruises. Some themes (bio-geochemistry cycles, vent processes…) require long-term observations on a few sites, whereas some others (geophysics, petro-geochemistry, biodiversity…) benefit from a more systematic surveying and sampling on and off-axis. The strategies will therefore be different according to the goals. The more coordination and sharing of information, the more opportunities to get that special observation that will lead to a scientific revolution!

5. Need for a specific working group

Because coordination appears to be a key to improve the surveys of Circum-Antarctic ridges, participants suggested the creation of a new working group (WG). The area is so vast that no single nation can make large scientific advances at the Circum-Antarctic ridges.

Specific points on which InterRidge can help through a WG:

- Sharing information

- Use dynamic modes of communication – Web site, Blog/wiki. Divide the web site into topical and geographical sub-sites of discussion, and have one for cruises.

- Also use new ways of communication like Facebook

We discussed the pros and cons of having a focused WG on "Circum-Antarctic Ridges" versus a broader WG on "High-Latitude Ridges", which will include both the Antarctic and Arctic ridges. The participants have varying opinions. Many people felt that since the Circum-Antarctic ridges are of great length and the required science tasks are already numerous, it might be of advantage to have a focused new WG on "Circum-Antarctic Ridges".

A tentative plan for a meeting of the working group would be Fall AGU 2013, after some cruises are scheduled.

Workshop Agenda

WEDNESDAY, SEPTEMBER 28 :

7 :15 Excursion on Lherzolites (Etang de Lhers, French Pyrenees) ; back around 4 PM

16 :00 – 16 :30 Registration

16 :30 – 17 :00 Presentation of the objectives of the workshop
Debbie MILTON, Sung-Hyun PARK, Anne BRIAIS

17 :00 – 18 :00 Posters

18 :00 Ice breaker

THURSDAY, SEPTEMBER 29 :

8 :30 – 10 :30 Ridge structure and dynamics

8 :30 Daniel Sauter
The Southwest Indian Ridge
9 :00 Hidenori Kumagai
Heterogeneous sub-seafloor structure near RTJ: Seismic reflection and dive observation
9 :30 Jean-Yves Royer
Results from a hydroacoustic experiment in the Southern Indian Ocean
10 :00 Henry Dick
Ocean Drilling on the Circum-Antarctic Plate Boundary

10 :30 – 10 :45 Coffee break

10 :45 Dave Graham
Geochemical signals along the Southeast Indian Ridge
11 :15 Anne Briais & Cédric Hamelin
The *Pacific-Antarctic Ridge*
11 :45 Sung-Hyun Park
Preliminary Results of a Recent Expedition to the Australian-Antarctic Ridge
12 :15 Donna Blackman
Southern Chile Rise- influences of east flank subduction on axial processes
12 :45 Yoshifumi Nogi
Japanese Marine Geophysical Activities in the Antarctic Ocean under the Japanese Antarctic Research Expedition

13 :15 – 14 :15 Lunch and posters

14 :15 – 17 :45 Tectonics and Mantle processes

14 :15 Barry Hanan
The Southeast Indian Ridge : Scale and source origin of heterogeneity
14 :45 Christophe Hémond

The Southeast Indian Ridge : detailed study of 1600km of an isotopically peculiar ridge and thermally intermediate between MAR and EPR ridges.

15 :15 Marcia Maia

SEIR near the St Paul-Amsterdam hotspot

15 :45 – 16 :00 Coffee break

16 :00 Henry Dick

Thin Crust Over the Marion Rise: Remelting the African Superplume

16 :30 Daniele Brunelli

Melting regime fluctuations beneath the Eastern and Western SWIR segments

17 :00 Charlie Langmuir

Indian ocean MORB in a global context

17 :30 – 18 :30 General discussion on main tectonic issues

Workshop dinner

FRIDAY, SEPTEMBER 30 :

9 :00 – 13 :15 State of the art and major issues – Hydrothermal processes and vent biology

9 :00 Ed Baker

Circum-Antarctic Ridges: The forgotten--or avoided--hydrothermal frontier

9 :30 Jian Lin

First active hydrothermal vents discovered on the ultraslow-spreading Southwest Indian Ridge

10 :00 Douglas Connelly

Venting in high latitudes: Hydrothermal activity in the Antarctic

10 :30 Alfred Aquilina

Hydrothermal flow through a sediment hosted volcanic ridge in the Central Bransfield Basin

11 :00 – 11 :15 *Coffee break*

11 :15 Jeff Hawkes & Catherine Cole

Hydrothermal plume chemistry at the East Scotia Ridge, Antarctica

11 :45 Valérie Chavagnac

Kerguelen hot springs : new microbial ecosystems and dissolved iron supply to the Southern Ocean

12 :15 Yong-Jin Won

Application of Next Generation Sequencing Technology for Studying Deep-Sea Hydrothermal Vent Organisms

12 :45 Christopher Sweeting

Biology of the East Scotia Ridge hydrothermal vents: Biogeographic and trophic perspectives

13 :15 – 14 :00 *Lunch and posters*
14 :00 – 15 :00 General discussion on hydrothermal processes and biology
15 :00 – 16 :00 General discussion - Conclusions

Poster presentation list

Hydrothermal Activity at the East Scotia Ridge: A Rare Earth Element Story
Cole, C., James, R. and Connelly, D.
National Oceanography Centre, University of Southampton

Using M/V *L'Astrolabe* for plate tectonic studies between Tasmania and Antarctica: the TACT project
Dyment, J. and Granot, R.
Institut de Physique du Globe de Paris & CNRS-INSU, Paris, France

Chemistry of newly-discovered hydrothermal systems in the East Scotia Sea.
Green, D., James, R., Connelly, D. and the JR224, JC042 and JC055 Science parties.
National Oceanography Centre, University of Southampton

Progressive geochemical variation along the Pacific-Antarctic Ridge and the East Pacific Rise
Hamelin, C.*[1], Dosso, L.[2], Hanan, Barry B[3]. and Moreira, M.[1]
*[1] IPGP, 1 rue Jussieu, 75252 Paris cedex 05, France. *correspondence: hamelin@ipgp.fr; [2] CNRS UMR6538, IFREMER, 29280 Plouzané, France ; [3] Department of Geological Sciences, S.D.S.U., 5500 Campanile Drive, San Diego, CA 92182-1020, USA.*

Sulfide Mineralogy and Sediment Geochemistry of the Kemp Caldera, East Scotia Sea
Hepburn, L.[1], Mills, R.A.[1], Aquilina, A.[1], Copley, J.[1], Stock, M.[1], Boyce, A.[2] and the ChEsSo consortium.
[1]National Oceanography Centre Southampton, University of Southampton, Waterfront Campus, European Way, Southampton, SO14 3ZH, England; [2]Scottish Universities Environmental Research Centre, East Kilbride, Lanark, G75 0QF, Scotland

Volcanoes of the submarine South Sandwich arc revealed by new bathymetric survey
Leat, P.T.[1], Tate, A.J.[1], Deen, T.J.[1]*, Day, S. J.[2], Owen, M.J.[3], Tappin, D.R.[4] and Fretwell, P.T.[1]
[1]British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, UK (ptle@bas.ac.uk); [2]Aon Benfield UCL Hazard Research Centre, Department of Earth Sciences, University College London, London WC1E 6BT, UK; [3]Environmental Change Research Centre, Department of Geography, University College London, Gower Street, London WC1E 6BT, UK; [4]British Geological Survey, Kingsley Dunham Centre, Keyworth, Nottingham NG12 5GG, UK; [*]Present Address: CSIRO, Hobart, Tasmania, Australia

The macrofauna of the ESR hydrothermal vents
Linse, K.[1], Sweeting, C.J.[2], Tyler, P.A.[3] & the ChEsSO consortium.
[1]British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET UK; [2]School of Marine Science & Technology, Ridley Building, Newcastle University, Newcastle upon Tyne, NE1 7RU UK; [3]School of Ocean and Earth Science, University of Southampton, Waterfront Campus, Southampton, SO14 3ZH UK.

Foraminifera of SW Indian Ocean : Implication to paleoecology
Jayaraju. N.
Department of Geology & Geoinformatics, Yogi Vemana University, Kadapa, India

Igneous, ultramafic, and metamorphic rocks on and around the Southwest Indian Ridge
Sato, H.[1], Senda, R.[2], Nakamura, K.[2], Kumagai, H.[2], Machida, S.[3], Morishita, T.[4], Tamura, A.[4], Umino, S.[4], Kanayama, K.[4] and Ishizuka, H.[5]
[1]Senshu Univ.; [2]JAMSTEC; [3]Waseda Univ.;[4]Kanazawa Univ.; [5]Kochi Univ.

Faulting and magmatic activity at Southwest Indian Ridge 35-400E, based on geophysical study

Sato. T.[1], Okino, K.[2], Sato, H.[3], Mizuno, M.[4], Hanyu, T.[5], Seama, N[6]
[1]Geological Survey of Japan, AIST, [2]Atmosphere and Ocean Research Institute, the University of Tokyo,
[3]Senshu University, [4]Chiba University, [5]The Graduate University for Advanced Studies, [6]Kobe University

Intra-population variation in key species of the East Scotia Ridge hydrothermal vents

Reid, W.D.K., Sweeting, C.J., Polunin, N.V.C. & CHESSO consortium.
Ridley Building, School of Marine Science & Technology, Newcastle University, Newcastle, NE1 7RU, UK

Hydrothermal vents on the ultraslow spreading Southwest Indian Ridge

Tao Chunhui[1] Li Huaiming[1] Lin Jian[2] DY115-19 &20 Science Party
[1]Key Laboratory of Submarine Geosciences, Second Institute of Oceanography, SOA, Hangzhou 310012, China;
[2]Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543, USA

ABSTRACTS

Hydrothermal fluid flow through a sediment hosted volcanic ridge in the Central Bransfield Basin

Alfred Aquilina[1], Laura Hepburn[1], Rachel A. Mills[1] & the ChesSo consortium

[1] National Oceanography Centre Southampton, University of Southampton, Waterfront Campus, European Way, Southampton SO14 3ZH

The Bransfield Strait is a slow spreading (ca. 1cm y^{-1}) sedimented marginal basin between the South Shetland Island Arc and the Antarctic Peninsula. No high temperature hydrothermal vents have been observed in this region but there is significant evidence from water column anomalies [1] and seafloor mineralisation [2] for extensive hydrothermal activity. A 4.5 m long gravity core collected from 1150 m water depth near the crest of Hook Ridge contains multiple slumped coarse sulfide layers indicating intermittent hydrothermal activity at this site. Short (<50 cm) mega cores collected from volcanic highs in the Central Basin provide evidence of mixing of advected hydrothermal fluid with diagenetically-altered sediment pore water at Hook Ridge, but not at The Axe and Middle Sister. Evidence for hydrothermal fluid flow includes down-core depletion in dissolved chloride (488 mM), magnesium (46 mmol/kg) and $^{87}Sr/^{86}Sr$ ratios (0.7088) relative to seawater values. On Hook Ridge, vertical redox gradients result in variable hydrogen sulfide fluxes through the upper sediment. H_2S flux appears to determine the distribution of chemosynthetic species such as siboglinid polychaete *Sclerolinum sp.*, which occur in patches and with their tubes partly buried in the metalliferous sediment.

Interstitial fluids contain extremely high concentrations of reduced Fe and Mn, with maximum values of 548 µmol/kg and 97 µmol/kg, respectively, occurring within 10 cm subsurface (Fig. 1). These high concentrations are consistent with elevated inputs of Fe and Mn, which become mobilised below the redox front, leading to fluxes towards the sediment-seawater interface where dissolved Fe and Mn may be oxidised and redeposited in the sediment. However, dissolved Fe and Mn that escapes subsurface oxidation could reach the overlying water column and may become available for transport to the deep basin.

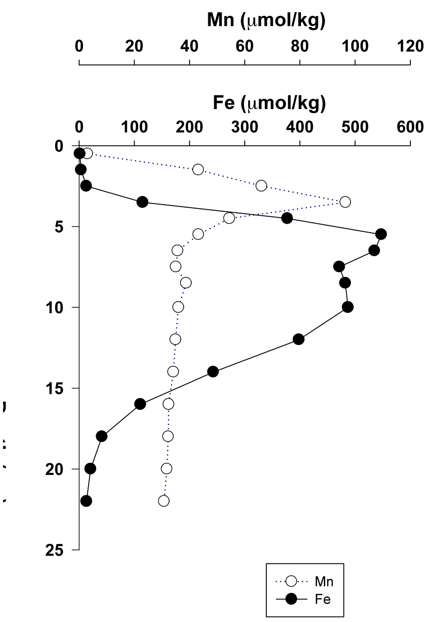


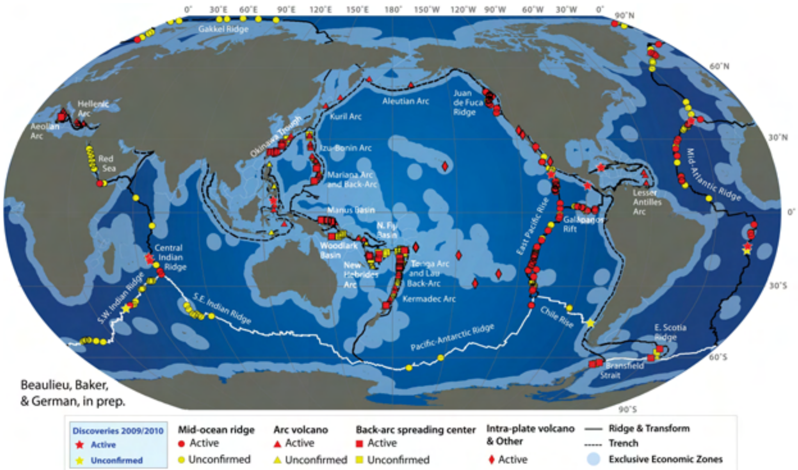
Figure 1. Downcore dissolved Fe and Mn pore water profiles at Hook Ridge, all other sites have negligible Fe and Mn content.

[1] Klinkhammer *et al.* (2001) *EPSL* 193: 395-407 [2] Petersen *et al.* (2004) *Miner Deposita* 39: 358-379

Circum-Antarctic Ridges: The forgotten—or avoided—hydrothermal frontier

Edward Baker, NOAA PMEL, Seattle edward.baker@noaa.gov

Hydrothermal exploration in every ocean over the past 35 years has discovered some 550 active vent sites, about half of which have been visually confirmed. Spreading ridges host 70% of all active sites, with another 25% on volcanic arcs. The known distribution of these sites is strongly controlled by exploration patterns. Almost 60% of known sites occur on eastern Pacific spreading ridges, the Kermadec-Tonga arc and backarc, and the northern Mid-Atlantic Ridge. Because targeted exploration produces a non-random sampling distribution, there is a poor correlation (r^2 = 0.28) between vent inventory and spreading rate when binned at 10 mm/yr rate increments. However, when binned into five broader spreading rate categories, from ultra-slow to superfast, the correlation rises to r^2 = 0.90. This result supports the long-standing hypothesis that the primary control on the spatial density of venting is the rate of magma supply.



During three decades of hydrothermal exploration, circum-Antarctic ridges (white lines in the figure) have been a frontier forgotten, largely because of logistical and weather challenges. Only 31 active vent fields have been identified south of 40°S, and only 4 of those have been visually confirmed (not including several unpublished data sets). Despite their challenges, circum-Antarctic ridges are compelling research targets. At a total length of ~22,000 km they contain one-third of the global spreading-ridge length, including segments with spreading rates ranging from 16 to 100 mm/yr. Perhaps their most important resource is new and crucial information on vent fauna biogeography.

Over the next decade, before the anticipated availability of very long-range AUVs, the search for new hydrothermal sites on remote circum-Antarctic ridges will require efficient, multi-disciplinary operations to maximize ship use. One example is hydrothermal plume sensors that can be used autonomously on deep-tow vehicles (e.g., sidescan sonar) and vertical casts (e.g., rock cores). The table compares several common hydrothermal tracers, which have pronounced differences in sensitivity, range, life span, and data availability. An effective survey will sense both long-range tracers to detect distal plumes and short-range sensors to more precisely identify source locations.

Tracer	Hydrothermal sensitivity	Spatial range	Life span	Data availability
Heat	Moderate; low signal/noise	Several km	Conservative	In situ, requires CTD
Optical	High; other sources exist	10s of km	Weeks-months	In situ
Eh/ORP	Very high	<~1 km	Hours-days	In situ
CH_4	Moderate; other sources	Several km	Days-weeks	Ship or shore analysis
Mn	High	10s of km	Weeks-years	Ship or shore analysis
^3He	Very high	1000s of km	Conservative	Shore analysis

Southern Chile Rise- influences of east flank subduction on axial processes

Donna Blackman, *Scripps Institution of Oceanography*

The Southern Chile Rise extends north from the Chile triple junction to the Valdivia fracture zone system as a series of spreading segments that increase in distance from the Chile trench. This plate boundary geometry provides a natural laboratory for investigation of the interplay between surface tectonics and underlying asthenospheric processes, specifically mantle upwelling patterns and associated magma production that supplies new crust along the spreading center. Detailed morphologic patterns observed within the axial zone of the four southernmost segments, seen in bathymetric data acquired during the INSPIRE 2010 cruise and in prior French studies (J. Bourgouis, Y. Lagabrielle et al.), provide insights into aspects of this interplay. There is a persistent clockwise rotation of trends in the southern ends of three successive segment axes. I will provide an overview of the tectonic setting, present updated maps of detailed axial morphology along Segments 1-4, report on hydrothermal plume chemistry results from INSPIRE (C. German et al), and discuss aspects of axial and some seamount lava petrology, in order to frame questions that future InterRidge studies along the Southern Chile Rise could address.

The tectonic evolution of the Pacific-Antarctic Ridge: geophysical and geochemical results from Pacantarctic 1&2 cruises

Louis Géli[1], Hélène Ondréas[1], Laure Dosso[2], Anne Briais[3], Frauke Klingelhoefer[1], Cédric Hamelin[2], Daniel Aslanian[1] and the Pacantartic 1 & 2 scientific parties

[1]Marine Geosciences Department, BP 70, 29280, Plouzané, France
[2]CNRS/IUEM, UMR6538, 1 Place Copernic, 29280 Plouzané, France
[3]GET, BGI, Obs. Midi-Pyrenees, 14 Ave E. Belin, 31400 Toulouse, France

Due to the proximity of the Euler pole of rotation between the Pacific and Antarctic plates, the spreading rate at the Pacific-Antarctic Ridge (PAR) increases rapidly from 54 mm/yr near Pitman Fracture Zone (FZ) up to 76 mm/yr near Udintsev FZ, resulting in three domains of distinct axial morphologies: an axial valley south of Pitman FZ, an axial high north of Saint Exupéry FZ, and in between, a transitional domain extending over 650 km.

Two expeditions conducted with R/V L'Atalante in 1996 and 2004 studied the geophysical and geochemical characteristics of the Pacifc-Antarctic Ridge. The first expedition (february 1996) collected multibeam bathymetric data and rock samples between the Pitman FZ and the Udintsev FZs. Swath bathymetry and magnetic data show that clockwise rotations of the relative motion between the Pacific and Antarctic plates over the last 6 million years resulted in rift propagation or in the linkage of ridge segments. This axial rearrangement has propagated southward for the last 30 to 35 million years, leaving trails on the seafloor along a 1000-kilometer-long V-shaped structure south of the Udintsev fracture zone, explained by: (1) increase in spreading rate above a threshold value producing changes in axial morphology; and (2) in the transition zone, rift propagation or transitions from fracture zones to non transform discontinuities, leaving trails on the seafloor that presently delineate the V.

North of the Udintsev FZ, small kinematic changes in plate motions also play a key role, producing deformation processes and off-axis, oblique volcanic structures, such as the Hollister Ridge, located between the Udintsev FZ and the Eltanin FZ, and volcanic alignments on both parts of the Menard FZ. The second expedition (december 2004 – january 2005) surveyed and densily sampled the ridge crest as well as obliquely oriented, off-axis structures between the Vacquier FZ (52°30'S) and 42°S. Analysis of the bathymetric, gravity and geochemical data reveal three ridge segments separated by overlapping spreading centers south of the Menard transform fault (MTF) and five segments north of it. Calculation of the cross-sectional area allows quantification of the variation in size of the axial bathymetric high. Together with the calculation of the mantle Bouguer anomaly, these data provide information about variations in the temperature of the underlying mantle or in crustal thickness. Geochemical analyses of samples dredged during the survey show a correlation of high cross-sectional area values and negative mantle Bouguer anomalies in the middle of segments with relatively less depleted basalts.

Briais, A., H. Ondréas, F. Klingelhoefer, L. Dosso, C. Hamelin, and H. Guillou, Origin of volcanism on the flanks of the Pacific-Antarctic Ridge between 41°30'S and 52°S, Geochem. Geophys. Geosyst. p. 10, Q09001, doi:10.1029/2008GC002350, 2009.

Briais, A., Aslanian, D., Geli, L. and Ondreas, H., 2002. Analysis of propagators along the Pacific-Antarctic Ridge: evidence for triggering by kinematic changes. Earth Planet. Sci. Let., 199(3/4): 415-428.

Dosso, L. et al., 2005. The Pacific-Antarctic Ridge between 41°15'S and 52°45'S: Survey and sampling during the PACANTARCTIC 2 cruise. InterRidge News, 14: 6.

Géli, L. et al., 1997. Evolution of the Pacific-Antarctic Ridge south of the Udintsev Fracture Zone. Science, 278: 1281-1284.

Géli, L. et al., 1998. Location of Louisville hotspot and origin of Hollister ridge: geophysical constraints. Earth

Planet. Sci. Lett., 164: 31-40.
Klingelhoefer, F., Ondreas, H., Briais, A., Hamelin, C. and Dosso, L., 2006. New structural and geochemical observations from the Pacific-Antarctic Ridge between 52°45'S and 41°15'S. Geophys. Res. Let., 33(21): L21312, doi:10.1029/2006GL027335.
Moreira, M.A., Dosso, L. and Ondreas, H., 2008. Helium isotopes on the Pacific-Antarctic ridge (52.5°–41.5°S). Geophys. Res. Let., 35: L10306, doi:10.1029/2008GL033286.
Ondréas, H., Aslanian, D., Géli, L., Olivet, J.L. and Briais, A., 2001. Variations in axial morphology, segmentation, and seafloor roughness along the Pacific-Antarctic Ridge between 56°S and 66°S. J. Geophys. Res., 106: 8521-8546.
Vlastelic, I. and Dosso, L., 2005. Initiation of a plume-ridge interaction in the South Pacific recorded by high-precision Pb isotopes along Hollister Ridge. Geochemistry Geophysics Geosystems, 6.
Vlastelic, I. et al., 1998. Geochemistry of the Hollister Ridge: relation with the Louisville hotspot and the Pacific-Antarctic Ridge. Earth Planet. Sci. Lett., 160: 777-793.
Vlastélic, I. et al., 1999. Large-scale chemical and thermal division of the Pacific mantle. Nature, 399: 345-350.
Vlastélic, I. et al., 2000. Chemical systematics of an intermediate spreading ridge: The Pacific-Antarctic Ridge between 56°S and 66°S. J. Geophys. Res., 105: 2915-2936.

Melting regime fluctuations beneath the Eastern and Western SWIR segments

Daniele Brunelli[1], Monique Seyler[2], Emanuele Paganelli[1], Anna Cipriani[1,3]

[1]Dipartimento di Scienze della Terra, Università di Modena, Italy
[2]UFR Sciences de la Terre, CNRS FRE 3298, Géosystèmes, Université Lille 1, France
[3]Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY 10964, USA

Abstract

Melting beneath a mid ocean ridge is generally interpreted as a near fractional process. Melt extraction is thought to be very efficient from the initial stage of porosity interconnection at very low melting fractions to the final stage of melt focussing by dissolution instability. Generally, at the end of the process, only a small melt fraction is retained in the rock[1,2]. For a very efficient melt extraction, the process is approximated by a fractional melting model in which the amount of melt extracted approaches the total amount of melt produced. Geochemical compositional trends, from the ridge to the fracture zone length scale, generally match the expected fractional melting trends. However, along the ultraslow (ultracold) segments of the South West Indian Ridges we observe that, at the critical kilometre length-scale (an average dredging length), incompatible elements in residual mantle clinopyroxenes display crosscutting compositional trends[3]. The increasing of incompatible/compatible trace element ratios in the residual phases are paired with Na2O enrichment at increasing Cr# (=Cr/(Cr+Al), a widely accepted reliable indicator of mantle degree of melting beneath a spreading segment[4,5].

In the REE compositional space, the trends cross cutting the melting model trends appear as rotational patterns around a mid-point. Based on open-system melting model[6,7] we derive that the intensity of the rotation and the position of the pivot element is primarily controlled by the ratio between input and output melt flux and by the enrichment of the percolating melt with respect to the depleted screen. Varying the residual porosity of the system (∅) with respect to the degree of melting F results in variations of the nature of the melting process. At low ∅/F the process behaves as near-fractional while at high ∅/F the process behaves as near batch. In an open melting system scenario the effect of an enriched melt fluxing a portion of the melting region can be strongly enhanced by melt stagnation i.e. approaching a near-batch process with low melt output. Model trends show a strong enrichment of Sm_N/Yb_N at decreasing Yb_N values. At high ∅/F even Yb_N increases along with Sm_N/Yb_N. These trends well fit measured cross cutting trends at the km lengthscale. Our observations suggest that in some portions of the melting region the vertical porosity profile can vary resulting in a variation of the nature of the melting process from near-fractional (when extraction prevails) to near batch (when stagnation prevails). Percolation of enriched melts through a parcel of melting mantle results in REE pattern rotation whose intensity and midpoint depend on ∅/F, mixing factor and, obviously, the composition of the melt itself. Our preliminary results suggest that melts generated deep in the mantle are delivered out of equilibrium to shallower portions of the melting region and redistributed to the rock porosity. Moreover, porosity barriers are present at depth resulting in melt accumulation and stagnation in the spinel facies of the melting region. The presence of permeability barriers in the melting region beneath ultraslow spreading centres is possibly due to porosity consumption after melt/rock reactions enhanced by garnet breakdown energy competition.

1. Seyler, M., et al., *Geology* **29**, 155-158 (2001).
2. Brunelli, D., et al., *Journal of Petrology* **47**, 745-771 (2006).
3. Seyler, M., et al., Geochemistry Geophysics Geosystem **12**, (2011).
4. Dick, H. J. B. & Bullen, T. *Contributions to Mineralogy and Petrology* **86**, 54-76 (1984).
5. Hellebrand, E., et al., *Nature* **410**, 677-681 (2001).
6. Ozawa, K. & Shimizu, N. *J. Geophys. Res.* **100**, 22315-22335 (1995).
7. Liang, Y. & Peng, Q. *Geochimica et Cosmochimica Acta* **74**, 321-339, (2010).

Kerguelen hot springs : new microbial ecosystems and dissolved iron supply to the Southern Ocean

Valérie Chavagnac[1,*], Cédric Boulart[1], Damien Guillaume[1], Audrey Gramain[2], Marc Le Romancer[2]

[1] Université de Toulouse, Observatoire Midi-Pyrénées, Géosciences Environnement Toulouse, GET UMR5563 (CNRS/UPS/IRD/CNES), 14 Avenue Édouard Belin, F-31400 Toulouse, France

[2] Institut Universitaire Européen de la Mer, UMR 6197, Technopôle Brest-Iroise, Avenue Dumont D'Urville, F-29280 Plouzané, France

Primary productivity as a direct drawdown process of atmospheric carbon dioxide is dependent on the annual supply of dissolved iron. The global oceanic dissolved Fe cycle model argues that hydrothermal source has the potential to act as an important dissolved iron source for the Southern Ocean, maintaining also the biological pump as an acting process when dust iron supply is limited. Deep-sea hydrothermal activity represents an important source of oceanic dissolved iron while being considered inaccessible to phytoplankton in the surface waters due to particulate formation. Here, we report the chemical characteristics of low temperature (<100ºC) hydrothermal fluids linked to the present day volcanic activity on the Kerguelen Islands. We show that hydrothermal discharges are all immature waters due to water-rock interaction at different pressure, temperature and water-rock ratio while being rich in hydrocarbon emissions (CO_2, H_2 and CH_4) produced by Fischer-Tropsch reactions at depth. These fluids are associated with exotic and previously unidentified microbial communities leading to two new genera within the *Thermofilaceae* and *Desulfurococcales* archaeal lineages. Based on the dissolved iron concentration of the hydrothermal discharges, we estimate a dissolved iron flux of 0.7 x 10^8 mol.yr^{-1} which is of the same order of magnitude as the deep-sea hydrothermal activity. This flux is being delivered to the surface waters of the Kerguelen Islands, suggesting the crucial role of hydrothermal chemical fluxes in the global Fe geochemical cycle.

Hydrothermal Activity at the East Scotia Ridge: A Rare Earth Element Story

Catherine Cole, Rachael James, Doug Connelly

National Oceanography Centre, University of Southampton

As indispensable components of green and smart technologies, rare earth elements (REE) have experienced a sharp rise in economic profile in recent years. These elements are also highly sensitive geochemical tracers of numerous ocean and earth processes. In hydrothermal environments, the unique fractionation patterns of the REEs can provide information on the source of fluid constituents; the evolution of fluids during circulation through the reaction cell; the thermal and redox conditions of mineral deposition; and the transport and fate of plume particulates.

Analysis of hydrothermal fluids from the East Scotia Ridge (ESR), a back-arc spreading centre in the Southern Ocean, reveals three distinct patterns of rare earth element behaviour. Along two segments of the ridge, E2 and E9 South, vent fluids exhibit light-REE enrichment and a strong positive europium anomaly, typical for mid-ocean ridge vents. E9 North deviates from this characteristic pattern as LREE enrichment is less pronounced, and Eu behaves similarly to neighbouring REEs. Vent fluid temperatures at this site are the highest observed on the ESR (380 ¡C) and extensive subsurface deposition of anhydrite may be assimilating Eu more efficiently. Anhydrite dissolution by low-temperature fluids may explain the recovery of the Eu signal in the diffuse fluids at this site. Kemp Seamount Caldera, located to the southeast of the ESR, shows very different REE behaviour. Flat, unfractionated REE patterns suggest incorporation of magmatic volatile gases during subsurface circulation, which can profoundly influence the mobility of REEs in solution. This hypothesis is consistent with the widespread observation of elemental sulphur at this site, and the high toxicity of fluids to marine life.
I will present initial REE results from a complementary suite of high-temperature and diffusely venting fluids, buoyant and non-buoyant plume water, chimney sulphides and anhydrite collected during two cruises to the ESR in January 2010 and 2011. These samples show clear evidence for a variety of venting regimes along the East Scotia Ridge.

Venting in high latitudes: Hydrothermal activity in the Antarctic

D.P. Connelly, P. Tyler, A. Rogers, J. Copley, R. James, R. Mills and the JR224, JC042 and JC055 Science parties.

The discovery of hydrothermal vents and their associated chemosynthetically driven biological communities challenged the orthodoxy of photosynthesis being the sole energy source for life on earth. The comparison of the communities between vent sites within, and between, oceans has highlighted our lack of understanding of the biogeographic constraints on such communities. The identification of vent sites in areas that represent potential transoceanic stepping stones for organisms are key to furthering our understanding connectivity between disparate vent sites. We have focused our work on the location of hydrothermal vents in the Southern Ocean, an area of potential exchange between the Pacific and Atlantic vent communities. Here we report the first data from three vent systems in the Southern ocean, two on the East Scotia Ridge and one in a submarine collapsed volcano to the east of the spreading centre. The first vent sites were located on two segments of the intermediate-spreading East Scotia Ridge, in the Scotia Sea. In each segment we located deep-sea hydrothermal vents hosting high temperature black smokers up to 382.8°C) and diffuse venting. The third vent site was a high temperature site (>200°C) in the McIntosh caldera immediately to the west of the Kemp Seamount. The venting location and the chemistry of the vent fluids is extremely unusual and represents a potentially new class of vent site, in an area that would not usually be explored for active venting.

Ocean Drilling on the Circum-Antarctic Plate Boundary

Henry JB Dick, Woods Hole Oceanographic Institution
Woods Hole, MA 02543-1539, hdick@whoi.edu

Scientific ocean drilling along the circum-Antarctic Plate boundary has been limited by its remoteness, and generally rough sea conditions. ODP Leg 187 drilled at Site 1152 to 1164 to trace the boundary between the Indian and Pacific mantle isotopic provinces across 10 to 30 Ma old ocean crust from the Australian-Antarctic discordance where it is sharply defined and migrating west at ~40 mm/yr. This drilling found that a discrete mantle boundary comparable to the present day couldn't be mapped through the 14-28 Ma time interval drilled, though comparable boundaries existed for relatively short discrete time intervals. The Leg 187 scientists concluded that over the long term the boundary closely corresponded to the eastern edge of the residual depth anomaly. Ocean Drilling Legs 118 drilled numerous test holes at Sites 732 to 734 in the Atlantis II FZ, failing to obtain significant basement penetration on the walls and floor of the transform valley. At Site 735B on the top of Atlantis Bank flanking the transform valley the JOIDES Resolution did a hard rock spud-in into massive foliated gabbro, and drilling 500.4 meters into basement, with 87% recovery in 26 days. Subsequently the site was re-occupied by ODP Leg 176, and drilled to 1508 mbsf, again with 87% recovery. At 1508.4 m, the Resolution was spacing out pipe during a storm with the drill string hanging off the deck, when it hit a ledge in the hole during the passing of a large swell, resulting in the drill pipe breaking off at the top of the hole, and free-falling ~ 500 m to the bottom of the hole. The pipe cork-screwed on impact, permanently blocking the hole, which remains open only to ~600-m. The 1300-m of core recovered revealed a complex stratigraphy unlike anything expected for the lower ocean crust. It consisted on numerous small gabbro units from centimeters to 100's of meters in length, recording numerous intrusive events, and subsequent melt infiltration by pervasive and focused melt flow. The upper 500-m was extensively deformed, during which late iron-titanium rich melts were localized in the zone of deformation, followed by later hydrothermal alteration in the middle and upper amphibolite facies. The section was drilled into an oceanic core complex that is ~12 Ma, exposed on a single long-lived detachment fault rooted in a crystal mush zone in the lower crust beneath the sheeted dikes. Situated on old crust, with an identified Moho beneath the bank, it is an ideal location for drilling to the crust-mantle boundary in a fully magmatic ridge segment, and to test whether or not the Moho is the crust-mantle boundary or a serpentinization front.

Thin Crust Over the Marion Rise: Remelting the African Superplume

Henry JB Dick, Woods Hole Oceanographic Institution
Woods Hole, MA 02543-1539, hdick@whoi.edu

Huaiyang Zhou, School of Ocean and Earth Science
Tongji University, Shanghai, 200, China

The Marion Rise is a ~3100-km long section of the SW Indian Ridge that runs up from ~5600-m depth near the Rodriguez Triple Junction to ~860-m depth north of the Marion Hotspot. It is characterized by a deep rift valley along most of its length, and numerous large-offset transforms. These characteristics are inconsistent with the rise being supported by sub-axial asthenospheric flow down the ridge axis from the Marion Plume. The large-offset transforms would block such flow even if the plume had sufficient flux to support the rise. Moreover, abyssal peridotites are abundant along the entire length, with nearly amagmatic spreading occurring well up the rise. This and the deep rift valley both indicate that the crust is thin or even missing along nearly its entire length. At the same time, basalt glasses and mantle peridotites show striking along axis variations in chemistry that indicate they are the complimentary residues of increasingly high degrees of mantle melting as the crest of the rise is approached. The thin crust along the rise, however, is inconsistent with increased melt production, and can only be accounted for as the result of remelting a previously depleted mantle residue centered on the Marion Plume. Mantle anisotropy and tomography (e.g.: Behn et al., EPSL 2004) are consistent with the northward movement of southern Africa over the last 100 Ma, such that the Marion Hotspot would appear to be a vestigial remnant of the African Super Plume. This, as well as isotopic data from the ridge (Meyzen et al., G3 2005) indicate that the present-day mantle beneath the ridge is the residue of the generation of the Karoo flood basalts in which the present day hotspot is imbedded. Thus, the Marion Rise is supported by an isostatic anomaly due to emplacement of the depleted plume head associated with eruption of the Karoo basalts into the asthenosphere beneath southern African.

The correlation of basalt and peridotite chemistry with ridge depth along the ridge indicating melting of an increasingly refractory mantle residue towards hotspots, is similar to variations up the Azores Rise, suggesting a similar origin for the latter. These correlations dominate the 'global' correlation of Klein and Langmuir (1987), but are not found in the Pacific or a significant portion of the Atlantic, suggesting that a different convective regime and mantle history exists elsewhere. Thus there is no global correlation, but rather a correlation that only directly relates to the emplacement of mantle plumes into the asthenosphere.

Using M/V L'Astrolabe for plate tectonic studies between Tasmania and Antarctica: the TACT project

Jérôme Dyment and Roi Granot
Institut de Physique du Globe de Paris & CNRS-INSU, Paris, France

The TACT (Tasmania-Adelie land Corridor Transits) project aims to take advantage of repeated transits of M/V L'Astrolabe, the supply ship of the French Antarctic station Dumont d'Urville, to conduct a detailed magnetic survey in the Tasman-Balleny corridor, a key area to study the kinematics evolution of the southwest Pacific region. Current plate reconstruction models suffer from important caveats that arise from severe lack of data in few key locations, including this area. This new data set will provide crucial age constraints to understand the seafloor spreading history in this part of the World, which has important oceanographic, climatic, and geological implications such as the age of circum-Antarctic seaway formation and of the climatic isolation of Antarctica. This dataset will also help us to constrain the motions between East and West Antarctica and their consequences on the relative motion of the Pacific versus Indo-Atlantic hotspots, the history of the Macquarie microplate, and the evolution of on the Alpine fault of New Zealand.

These expected scientific results have to be compared to the low cost of the operations to be conducted, which represent only two days of additional ship time to any standard rotation of the ship. So far, after the proposal has been ranked the highest by the French evaluation committee for the scientific fleet, an arrangement has been made with IPEV, the French Polar Institute, for two valorised transits to take place in February and March 2012, to be followed by further transits in the next austral summers. Other difficulties include the reduced number of berths and the lack of dedicated scientific equipment for marine geosciences on M/V L'Astrolabe. Although we purchased a surface scalar magnetometer to achieve our goals, we will miss multibeam bathymetric data which would greatly help to plan the routes. Furthermore, the southernmost part of the corridor lies in area which requires an icebreaker, beyond reach of M/V L'Astrolabe. For these reasons, we plan to collaborate with our Korean colleagues, as a short transit of R/V Araon would advantageously complement our effort.

The Southeast Indian Ridge: a Geochemical Mesocosm of the Global Mid-Ocean Ridge Spreading System

David Graham
College of Oceanic & Atmospheric Sciences
Oregon State University
Corvallis, OR 97331 USA
dgraham@coas.oregonstate.edu

The Southeast stretches from the Rodrigues Triple Junction (25.6°S, 70.1°E) to the Macquarie Triple Junction (62°S, 151°E). Between 76°–78°E it crosses the Amsterdam–St Paul (ASP) Plateau, a pronounced bathymetric swell associated with relatively hot mantle upwelling beneath the Amsterdam and St Paul islands, while between 120° E and 128°E it crosses the Australian-Antarctic Discordance (AAD), a region of deep bathymetry (>4000 m) associated with relatively cold mantle and low melt production. Notably, over a distance of ~2500 km, between 86°E and 120°E, there is a regular eastward decrease in axial depth from 2300 to 5000 m, and a morphological transition from axial high to axial valley due to decreasing melt production rate and crustal thickness. This depth gradient occurs at intermediate and uniform spreading rate (70–75 mm yr^{-1} full rate) and in the absence of large transform offsets and nearby mantle hotspots. The range in axial depth and ridge morphology is similar to the global range for spreading ridges away from hotspots, making the SEIR a regional-scale analogue of the 60,000-km-long global ocean ridge system.

Geochemical studies have established that Pb, Sr, Nd, He and Hf isotope variations along the SEIR are primarily controlled by variation in the depth of melting of isotopically heterogeneous mantle. Elevated $^3He/^4He$ (>15 R_A) is present near the the ASP Plateau due to the presence of deep mantle plume in that region. East of the ASP plateau there is long wavelength decrease to the AAD, with local peaks that may be associated with small-scale convective structures in the upper mantle. All SEIR lavas west of the AAD are true 'Indian-type' (e.g., having elevated $^{208}Pb/^{206}Pb$ ratios). Hf isotopes between 88°E and 110°E show a bimodal distribution, interpreted to reflect the presence of streaks in the upper mantle beneath the SEIR. The bimodality is not observed in other geochemical parameters such as Nd isotopes, suggesting that the streaks carry a cryptic memory of ancient chemical fractionation that is now only apparent in the time-integrated Lu/Hf ratio. Spatially, the heterogeneity (streaks) may be described by a Poisson distribution, in which the number of isotope 'toggles' between the bimodal groupings is proportional to the length of ridge sampled.

U-series disequilibria in SEIR basalts show systematic along axis variations in melting conditions that also reflect gradients in upper mantle temperature and composition. ($^{230}Th/^{238}U$) is not correlated with axial depth. However, ($^{238}U/^{232}Th$) and ($^{230}Th/^{232}Th$) in SEIR basalts span most of the global range for MORBs, and are strongly correlated on an equiline diagram (R^2=0.9). U-series signatures also vary coherently when divided into four groups based on ridge morphology. Melting rate co-varies with melt supply in the western and central regions, decreasing eastward along the SEIR, but melt supply and melting rate vary inversely from the central to the eastern regions, because the cooler eastern mantle contains a few percent of fusible garnet pyroxenite that melts productively to generate melts with high Th–U–Ra concentration but low ^{230}Th and ^{226}Ra excesses.

The veins contribute only a small proportion to the total melt volume from mantle that is >95% peridotite. Collectively, the Th, Pb and He isotopic gradients are consistent with a changing proportion of enriched pyroxenite veins along axis that have a roughly 0.5 to 1 Gyr model age.

References

Graham, DW, KTM Johnson, LM Douglas Priebe and JE Lupton (1999) Hotspot-ridge interaction along the Southeast Indian Ridge near Amsterdam and St. Paul islands: helium isotope evidence. Earth Planet. Sci. Lett. 167, 297-310.

Graham, DW, JE Lupton, FJ Spera and DM Christie (2001) Upper mantle dynamics revealed by helium isotope variations along the Southeast Indian Ridge. Nature 409, 701-703.

Graham, DW, J Blichert-Toft, CJ Russo, KA Rubin and F. Albarède (2006) Cryptic striations in the upper mantle revealed by hafnium isotopes in Southeast Indian Ridge basalts. Nature 440, 199-202.

Hanan, B, J Blichert-Toft, DG Pyle, and DM Christie (2004) Contrasting origins of the upper mantle revealed by hafnium and lead isotopes from the Southeast Indian Ridge. Nature 432, 91-94.

Klein, EM, CH Langmuir, A Zindler, H Staudigel and B Hamelin (1988) Isotope evidence of a mantle convection boundary at the Australian-Antarctic Discordance. Nature 333, 623-629.

Mahoney, JJ, DW Graham, DM Christie, KTM Johnson, LS Hall and DL VonderHaar (2002) Between a hot spot and cold spot: isotopic variation in the Southeast Indian Ridge asthenosphere, 86°-118°E. J. Petrol. 43, 1155-1176.

Nicolaysen, KE, FA Frey, JJ Mahoney, KTM Johnson and DW Graham (2007) Influence of the Amsterdam/St. Paul hotspot along the Southeast Indian Ridge between 77° and 88°E: correlations of Sr, Nd, Pb and He isotopic variations with ridge segmentation. Geochem. Geophys. Geosys. 7. doi:10.1029/2006GC001540.

Pyle, DG, DM Christie and JJ Mahoney (1992) Resolving an isotope boundary within the Australian-Antarctic Discordance. Earth Planet. Sci. Lett. 112, 161-178.

Russo, CJ, KH Rubin and DW Graham (2009) Mantle melting and magma supply to the Southeast Indian Ridge: the roles of lithology and melting conditions from U-series disequilibria. Earth Planet. Sci. Lett. 278, 55-66.

Chemistry of newly-discovered hydrothermal systems in the East Scotia Sea.

Darryl Green, Rachael James, Douglas Connelly and the JR224, JC042 and JC055 Science parties.

The East Scotia Ridge (ESR) is an intermediately spreading back-arc basin in the Southern Ocean. The ESR consists of 9 second-order ridge segments (E1 to E9), separated by non-transform discontinuities. A cruise in 2009 detected high levels of particulate material and strong Eh anomalies in the water column at E2 and E9. On further investigation, as part of that study, a towed camera system observed black smoker chimneys at E2, and a diffuse venting area on E9. We returned to the ESR in 2010 and 2011. In 2010 focused and diffuse vent fluids were observed and sampled for the first time at both segments E2 and E9. The maximum recorded temperatures of the fluids are, respectively, 353 and 383°C, and the chemical compositions of the end-member fluids are distinctly different. The hydrothermal end-member at E2 has a chloride concentration ([Cl-]) that is similar to ambient seawater, while at E9, [Cl-] is distinctly lower than seawater and is ~100 mM.. Investigation of a submarine crater to the east of the spreading centre revealed further hydrothermal activity. Fluids vent from friable chimney structures at temperatures of up to 212°C; preliminary analyses indicate that these fluids have exceptionally high levels of hydrogen sulphide (>40 mM), and [Cl-] is lower than seawater. In 2011 we returned to the Scotia Sea and sampled the hydrothermal plumes in the water column. In addition, we explored further south into the Antarctic and investigated areas postulated as hosting hydrothermal activity in the Bransfield Strait. We did not find any active focused venting but found evidence of hydrothermally altered sediments and diffuse venting fluids in the area.

Progressive geochemical variation along the Pacific-Antarctic Ridge and the East Pacific Rise.

CÉDRIC HAMELIN*[1], LAURE DOSSO[2],
BARRY B. HANAN[3], MANUEL MOREIRA[1]

[1] IPGP, 1 rue Jussieu, 75252 Paris cedex 05, France. *correspondence: hamelin@ipgp.fr
[2] CNRS UMR6538, IFREMER, 29280 Plouzané, France.
[3] Department of Geological Sciences, S.D.S.U.,
5500 Campanile Drive, San Diego, CA 92182-1020, USA.

Samples collected during the PACANTARCTIC 2 cruise fill a sampling gap from 53° to 41° S along the Pacific Antarctic Ridge (PAR). Sr, Nd, Pb, Hf and He isotopic compositions of this mid-ocean ridge basalt collection are shown together with published data from 66°S to 53°S along the EPR. Based on the incomplete sampling of the ridge, a previous study led to the identification of a large scale division of the south Pacific mantle with a limit at the latitude of Easter Island [1]. The complete dataset reveals a different geochemical profile. Along the Pacific ridge, a large scale variation reaches an extremum which corresponds to a less "depleted" isotopic signature at the Juan Fernandez microplate latitude. Hot spot-ridge interactions are marked by anomalies superimposed on this curve.

Recent advances in analytical mass spectrometry techniques dramatically increases the number of isotopic data. Nowadays, the complete analysis of Sr, Nd, Pb, Hf and He isotopic compositions for a set of samples has become common. Working with such a multidimensional dataset implies a new approach in data interpretation, preferably based on statistical analysis techniques. Principal Component Analysis (PCA) is a powerful mathematical tool to study this type of multidimensional data set. The goal of PCA is to reduce the number of dimensions in a data set by keeping only those that contribute most to its variance. Using the PCA tool, it becomes possible to get a statistical picture of the geochemical variations along the entire PAR, from the Australian Antarctic Discordance (AAD) to the Juan Fernandez microplate. The PCA method allows to interpret the large scale variation observed by the different isotopic systems as a progressive geochemical change of the depleted matrix of the mantle. This variation is unrelated to the effect of the hot spot-ridge interactions.

[1] Vlastélic *et al.* (1999) *Nature* **399**, 345-350.

The Southeast Indian Ridge: Scale and Source Origin of Heterogeneity

B. Hanan[1], J. Blichert-Toft[2], C. Hemond[3]

[1]San Diego State University, San Diego, CA 92182-1020, USA
(*correspondence:Barry.Hanan@sdsu.edu)
[2]Ecole Normale Supérieure, 69007 Lyon, France
[3]University of Brest-CNRS, IUEM, 29280 Plouzané, France

Our understanding of mantle convection is based mainly on rheological and thermal constraints rather than direct observations of mantle materials. The premise of current geochemical and geodynamic models is that lithospheric plates sink into the mantle at subduction zones, are stretched and folded, and retain much of their chemical and isotopic identity over timescales of 10^8 to 10^9 years. As predicted by the kinematics of stretching and folding, observed isotope variations in mid-ocean ridge basalts show patterns of spatial heterogeneity in the form of periodically spaced blobs or streaks in their underlying mantle source. The use of MORBs as probes of upper mantle chemical and isotopic composition and melting conditions is contributing toward a rich, quasi-3D picture of upper mantle heterogeneity, yet the characteristic scales and origins are not well known. Advancing our understanding of mantle heterogeneity at scales below that of individual ridge segments requires high sampling density with high precision analyses of multiple isotopic systems.

The He, Pb, Sr, Nd and Hf isotope variations along the SEIR are primarily controlled by changes in the depth and degree of melting of isotopically heterogeneous mantle. All SEIR lavas west of the Australian-Antarctic Discordance (AAD) are true Indian-type as indicated by their high $^{208}Pb/^{206}Pb$ ratios. High $^{3}He/^{4}He$ (>15 R_A) associated with the Amsterdam–St Paul (ASP) Plateau indicates upper mantle pollution from a deep mantle plume in that region. The ε_{Hf} for MORB glasses from the SEIR ranges from +5.5 to +17.8. The extreme values occur on the ASP Plateau (5.5) and in the westernmost AAD (17.8). Overall, Hf and Nd isotopes show the typical positive correlation seen in oceanic basalts. However, over a distance of 2000 km between 88°E and 110°E, the Hf isotope compositions are strikingly bimodal, with a population division at $\varepsilon_{Hf} \cong 11.5$. This new sample suite, collected at relatively high-density intervals of 5-10 km, shows strong spatial resolution suggesting the presence of mantle striations, or streaks, beneath the SEIR. The striations are spatially well described by a Poisson distribution and have a mean thickness of ~ 25 km. The bimodality in Hf isotopes is not observed in other geochemical parameters, indicating that the streaks carry a cryptic memory of Lu/Hf fractionation at some time in the past. The Hf and Pb isotope systematics collectively suggest that the low ε_{Hf} group may represent a mantle source origin involving continental material. Hf and Pb isotope data from across the Indian-Pacific mantle boundary (120°E and 128°E) in the AAD region of the SEIR show that the Indian upper-mantle isotope signature in this region is affected mainly by lower continental crust entrained during Gondwana rifting, whereas the isotope signature of the Pacific upper mantle is influenced predominantly by ocean floor subduction-related processes. The Poisson distribution of heterogeneities is anticipated for a well-stirred upper mantle where heterogeneity is continually introduced by plate tectonic recycling, and redistributed by viscous stretching and convective refolding.

References

Graham, DW, KTM Johnson, LM Douglas Priebe and JE Lupton (1999) Hotspot-ridge interaction along the Southeast Indian Ridge near Amsterdam and St. Paul islands: helium isotope evidence. Earth Planet. Sci. Lett. 167, 297-310.

Graham, DW, JE Lupton, FJ Spera and DM Christie (2001) Upper mantle dynamics revealed by helium isotope variations along the Southeast Indian Ridge. Nature 409, 701-703.

Graham, DW, J Blichert-Toft, CJ Russo, KA Rubin and F. Albarède (2006) Cryptic striations in the upper mantle revealed by hafnium isotopes in Southeast Indian Ridge basalts. Nature 440, 199-202.

Hanan, B, J Blichert-Toft, DG Pyle, and DM Christie (2004) Contrasting origins of the upper mantle revealed by hafnium and lead isotopes from the Southeast Indian Ridge. Nature 432, 91-94.

Hanan, B, J Blichert-Toft, K Sayit, A Agranier, C Hemond, A Briais, M Maia, D Graham and F Albarède, A High-Resolution, Multi-Isotopic Study of Mantle Heterogeneity beneath the Southeast Indian Ridge: Preliminary Pb and Hf Results, Mineralogical Magazine, Vol. 75 (3), 2011.

Klein, EM, CH Langmuir, A Zindler, H Staudigel and B Hamelin (1988) Isotope evidence of a mantle convection boundary at the Australian-Antarctic Discordance. Nature 333, 623-629.

Mahoney, JJ, DW Graham, DM Christie, KTM Johnson, LS Hall and DL VonderHaar (2002) Between a hot spot and cold spot: isotopic variation in the Southeast Indian Ridge asthenosphere, 86°-118°E. J. Petrol. 43, 1155-1176.

Nicolaysen, KE, FA Frey, JJ Mahoney, KTM Johnson and DW Graham (2007) Influence of the Amsterdam/St. Paul hotspot along the Southeast Indian Ridge between 77° and 88°E: correlations of Sr, Nd, Pb and He isotopic variations with ridge segmentation. Geochem. Geophys. Geosys. 7. doi:10.1029/2006GC001540.

Pyle, DG, DM Christie and JJ Mahoney (1992) Resolving an isotope boundary within the Australian-Antarctic Discordance. Earth Planet. Sci. Lett. 112, 161-178.

Hydrothermal vent chemistry at the East Scotia Ridge, Antarctica

Jeff Hawkes and Catherine Cole
National Oceanography Centre, University of Southampton

The East Scotia Ridge (ESR) is a back-arc spreading centre in the Atlantic sector of the Southern Ocean. In 2010, high-temperature (≤382.8 ¡C) hydrothermal activity was observed for the first time at three distinct vent sites along the ESR, at E2 and E9 ridge segments, and within Kemp seamount caldera. Extensive sampling campaigns by CTD and ROV were conducted in 2010 and 2011 at the three sites, collecting comprehensive suites of high-temperature vent fluid, diffuse flow samples, plume water and particulate material. Samples were analysed for methane, various metal size fractions, organic and inorganic carbon, rare earth elements, and complex organic matter.

The main focus of our presentation will be the observed processes within the hydrothermal plumes. Plumes are responsible for the mass transport of hydrothermal material, the scavenging of hydrothermal and ambient elements into particles and may host large microbiological communities. The understanding of hydrothermal plumes and their impact on the deep-sea is very important in assessing the significance of hydrothermal activity on global geochemical cycles, and these sites represent a new 'island' from which to make estimates about the impact of hydrothermal activity in different ocean conditions.

Concurrent with its position in the global ocean conveyer, background oxygen concentrations at the East Scotia Ridge (175 µmol kg-1) are intermediate between North Atlantic (250 µmol kg-1) and North Pacific (104 µmol kg-1) levels at plume depth (2200m). Elemental scavenging processes in hydrothermal plumes are largely driven by the oxidation rate of iron to form oxy-hydroxide particles, therefore we expect plume chemistry at the ESR to reflect iron oxidation and particle formation rates between Atlantic and Pacific vent sites.

Our talk will focus on the sampling regime that was conducted, our expectations of analyses to be performed and our initial results. We will discuss our data in the context of previous results from other vent sites and consider the validity of currently accepted assessments of hydrothermal iron oxidation rates and plume particle compositions.

Iron colloids in hydrothermal plumes: An alternative hypothesis for the stabilisation of hydrothermal iron

Jeff Hawkes, Doug Connelly, Eric Achterberg
National Oceanography Centre, University of Southampton

Three recently discovered hydrothermal vent plumes from the Atlantic sector of the Southern Ocean were sampled for total, particulate (>0.2µm), dissolved (<0.2µm) and soluble (<0.02µm) iron, manganese and copper. Iron colloids (defined as material >0.02µm and <0.2µm) were present to varying degrees in all samples, often representing a large portion of the dissolved iron.

Colloid formation allows fine, oxidised particles to be transported over long distances without settling. This may account for several recent observations of hydrothermal iron at great distances from vent fields. The observation of iron colloids in hydrothermal plumes corresponds well to the recent observation of ultra fine Fe-S nanoparticles in vent fluids, and may provide an alternative or complimentary hypothesis to the organic ligand stabilisation of Fe(III) in hydrothermal plumes.

The rate of iron colloid formation and particulate aggregation will be considered in these hydrothermal vent plumes in relation to data from other vent sites around the world. Generally, it is thought that colloid formation is rapid in comparison to particulate aggregation, so this stabilisation process may be ubiquitous across all vent fields regardless of local water chemistry (oxygen concentration, temperature, pH). The potential impact of colloid stabilisation of iron on the deep-sea will be considered.

The Southeast Indian Ridge : detailed study of 1600km of an isotopically peculiar ridge and thermally intermediate between MAR and EPR ridges.

Ch. Hemond[1], A. Briais[2], D. Graham[3], B. Hanan[4] and M. Maia[1].

[1] IUEM-UMR, University of Brest, 29280 Plouzané, France
[2] CNRS-UMR, BGI, 31400 Toulouse, France
[3] COAS, Oregon State University, Corvallis, OR 97331, USA
[4] San Diego State University, San Diego, CA 92182-1020, USA

Radiogenic isotope variations along Indian ridges were identified as related to interactions with hotspots. Later, Graham et al.(2006) have revealed some peculiar variations along the Southeast indien Ridge (SEIR) that appeared bimodal. These variations could be attributed to the presence of a laminar recycled components such as recycled oceanic crust. In order to confirm this, a new sampling at higher and variable frequency was realized using a newly designed waxcore. Two scientific cruises (GEISEIR 1, january 2009, and 2 january 2010) have led to sample the SEIR between 81 and 99°E every 5km along a 300km long segment and every 10 kilometers along several contiguous segments for a total length of 1650km. More than 175 sampling sites were efficiently sampled either using the new Waxcore (150) or by dredging (25). Preliminary Hf and Pb isotope data were presented recently (Hanan et al. 2011) and supported the model proposed ealier by Graham et al. Nd and Sr data were produced on the same partial set of samples which bring complementary enlightment on the nature of the mantle heterogeneities. Trace element data will follow shortly. Once composition heterogeneities will have been maped, U series will be subject of a PhD next year. The variations of the ridge morphology (See Briais et al here) are linked to thermal budget changes that should be seen on U series isotope fractionation.

Graham et al. (2006), *Nature* **440**, 199-202
Hanan et al. (2011) Goldschmidt conference, Prag, Abstract volume.

Sulfide Mineralogy and Sediment Geochemistry of the Kemp Caldera, East Scotia Sea

Laura Hepburn[1], Rachel A. Mills[1], Alfred Aquilina[1], Jon Copley[1], Mike Stock[1], Adrian Boyce[2] and the ChEsSo consortium

[1]National Oceanography Centre Southampton, University of Southampton, Waterfront Campus, European Way, Southampton, SO14 3ZH, England
[2]Scottish Universities Environmental Research Centre, East Kilbride, Lanark, G75 0QF, Scotland

The Kemp caldera is situated at the southern end of the South Sandwich Island Arc. In 2009, the *JCR224* cruise suggested the caldera as a putative site of active hydrothermal venting. This observation was confirmed a year later when *JC42* returned to a submarine volcano on the south-western flank of the crater with the ROV *Isis* and discovered: chemosynthetic *Calyptogena* sp. clustered in areas of low temperature (21 ºC) diffuse-flow; extensive microbial mats; white smoker hydrothermal vent fields (emitted fluids < 115 ºC); and a community of *Osedax* sp. endemic to a sulfophilic whale fall. In this study, geochemical and mineralogical analyses of hydrothermal chimney sulfides and sediment samples collected during *JC42* are used to constrain the distribution and impact of dominant biogeochemical processes – specifically sulfur cycling – in this novel, newly-discovered, chemosynthetic habitat of the Southern Ocean.

Chalcopyrite, pyrite and sphalerite are ubiquitous throughout the sulphide specimens, dispersed throughout a predominantly pyrite / sphalerite matrix. Anhydrite dominates the gangue mineralogy of the Kemp chimney sulfides, though the use of gamma spectroscopy has identified the presence of barite in some samples. Hydrothermal fluid penetrating the newly-deposited, porous chimney wall is inferred to form covellite and other secondary sulfides. Chimney fragments from the 'Great Wall' are comprised solely of elemental sulfur (respective fluid H_2S and SO_4 concentrations of 8.5 mM and 25.5 mM accompany this sulfide sample).

The sediment cover within the Kemp Caldera is thin and largely comprises basalt and shell fragments. The Rare Earth Element composition of these sediments implies unaltered basaltic input with some limited seawater alteration and overprinting in the upper few cm of the cores. The pore fluid composition resembles that of seawater and indicates a lack of significant redox changes occurring within these sediments. Preliminary investigation of stable sulfur isotope ratios ($\delta^{34}S$) in the solid phase detects a potential bacteriogenic signal (an isotopically-light $\delta^{34}S$ signal of -6.4 ‰) at a depth of 20 cmbsf in the area of *live* clams. The thin sediment cover and limited input of weathered sulphide material to Kemp Caldera sediments implies relatively recent onset of hydrothermalism at this site.

Foraminifera of SW Indian Ocean : Implication to paleoecology:

Jayaraju. N
Department of Geology & Geoinformatics, Yogi Vemana University, Kadapa, India

Knowledge of foraminiferal ecology is largely based on natural distributions. Five grab samples from the southwestern part of the Indian ocean were collected by ORV Sagar Kanya during the third expedition to the southern Indian ocean in June 2009. The sediment samples have been analyzed and recorded 36 benthic foraminiferal species belonging to 21 genera and 3 suborders. All the species were taxonomically identified. Deep sea-benthic foraminiferal species at different locations of South of West India Ocean (3150-4125 m water depth) is examined in terms of number of species (n) and diversity (d). The observed depth ranges of benthic foraminifera have been documented to recognize their bathymetric distribution. The valves of these parameters reached their maximum at 3190 m water depth. Productivity continued in the Indo-Pacific Ocean (the biogenic boom) and the Oxygen minimum zone (OMZ) intensified over large parts of Indian Ocean continually. The diversity values show more abrupt trend as depth increases. Species like Epistominella exigua and Pullenia bulloides occur at both 3150 m & 3465 m depths indicating depth persistence. Further, Oridorsalis umbonatus and Melonis sphaeroides occur at both 3150 m & 3465 m depths. Species like Gyroidina sp an indicate of low oxygen environment and Uvigerina hispida-costata indicative of high organic carbon are found to occur at 3150 m & 3740 m respectively. Factor analysis and Pearson correlation matrix were performed on foraminiferal census data of 10 highest ranked species which are present in at least one sample. 3 factors were obtained accounting for 72.81% of the total variance. Thus the study suggests that fluctuations in species diversity at the locations of the present study were related to changes in productivity during the geological past.

Heterogeneous sub-seafloor structure near RTJ: Seismic reflection and dive observation

Hidenori Kumagai, Kentaro Nakamura (JAMSTEC)**, Hiroshi Sato** (Senshu Univ.)**, Takeshi Tsuji** (Kyoto Univ.)**, Tomoaki Morishita** (Kanazawa Univ.)**, Takazo Shibuya, and Ken Takai** (JAMSTEC)

The Circum Antarctic ridge system has various types of Triple junctions. Among them, Rodriguez Triple Junction (RTJ) is R-R-R type one where three ridges meet; two have intermediate-spreading rate (CIR and SEIR) and one does ultraslow spreading rate (SWIR). According to several models on tectonic evolution near RTJ, a predicted subseafloor structure is hereterogeneous at least laterally because geometry of the triple junction periodically changes. As widely known, there is an active hydrothermal field, Kairei-field (KF), on the Hakuho-knoll within 20 miles from the triple junction. A tight relationship between unique assemblages of the microorganism and fluid chemistry has been observed at KF; its fluid is characterized as remarkably high concentration of hydrogen regardless of the CIR has intermediate spreading rate. It is quite unique character because other known hydrogen rich hydrothermal fields are mostly located along a slow spreading ridge, MAR.

Single Channel Seismics (SCS) as the part of the comprehensive geophysical survey was performed to investigate the shallow structure around KF: total shooting time reaches 66 hours. Besides the well imaged high angle normal faults, systematic changes were found in the appearances in the records. By comparison with dive observation, such variation seems to correlate with shallow lithology reflecting some seismic property beneath the seafloor. The area where ultramafic rocks were exposed, SCS reflections are strong and rather deep penetration with abundant scatterer. The area where gabbros were exposed, e.g. surface of 25°S OCC, shows very strong reflections limited at the seafloor and poorly penetrated into deep. The area covered by pillow lavas show very weak reflections as a whole. Further, the predicted lithology, where neither submersible dives nor dredge sampling had not performed, was fairly confirmed by the later dredging or submersible dives; certain exposures of ultramafic rock were confirmed at behind the Hakuho-knoll (Yokoniwa-rise), or median high in the CIR-2 valley. Consequently, the SCS mapping reveals the quite heterogeneous shallow structure in northern RTJ area.

Volcanoes of the submarine South Sandwich arc revealed by new bathymetric survey

P.T. Leat[1], A.J. Tate[1], T.J. Deen[1*], S. J. Day[2], M.J. Owen[3], D.R. Tappin[4], P.T. Fretwell[1]

[1]*British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, UK (ptle@bas.ac.uk)*
[2]*Aon Benfield UCL Hazard Research Centre, Department of Earth Sciences, University College London, London WC1E 6BT, UK*
[3]*Environmental Change Research Centre, Department of Geography, University College London, Gower Street, London WC1E 6BT, UK*
[4]*British Geological Survey, Kingsley Dunham Centre, Keyworth, Nottingham NG12 5GG, UK*

[*]*Present Address: CSIRO, Hobart, Tasmania, Australia*

The mainly submarine South Sandwich arc is situated within the Scotia Sea, and is the volcanically most active area in the Scotia Sea. It is a prime example of an intra-oceanic arc in an entirely oceanic setting. Its submarine part has recently been mapped at ~50 m horizontal resolution for the first time using multibeam sonar. The multibeam bathymetry data is merged with ASTER GDEM topographic data on a background of satellite-derived bathymetry data. The new survey shows nine main volcanic centers and ca. 20 main seamounts in the 540 km long volcanic arc. The central seven centers are 3-3.5 km high and emerge as the main South Sandwich Islands. Three prominent, NE-SW-trending seamount chains extend from the volcanic front into the rear-arc in the central part of the arc between Zavodovski and Saunders islands, and contain seamounts up to 3 km high. The northernmost center, around Protector Shoal, is a partly silicic cluster of seven 400-1400 m high stratovolcano seamounts and a 15 km diameter volcanic plateau. One of these seamounts (PS7[1]) has a 3 km diameter summit caldera. The southernmost, entirely submarine, center includes the newly found 5 km diameter Adventure Caldera to the east of Kemp Caldera. Although dominantly basaltic, the arc contains many silicic components, and these appear to be preferentially preserved in submarine seamounts from which they have not been stripped away by erosion. Recent eruptions from both PS7 and Adventure calderas are rhyolitic, indicating that they may overlie long-lived magma chambers driving hydrothermal systems. The volcanoes have been affected by a range of mass wasting phenomena, including debris avalanches, slumps, erosion at sea level and sediment dispersal by mass flows. There is abundant evidence of slope instability and landsliding of volcanoes. There are also abundant large, striking, sediment wave fields that have wavelengths of 2-4 km and amplitudes of 50-150 m on the ca. 2°-3° submarine slopes These were sourced by turbidity currents fed by sediments derived from high subaerial and coastal erosion rates.

[1] Leat, P.T. et al., 2010, Marine Geology, 275, 110-126.

The macrofauna of the ESR hydrothermal vents

Katrin Linse[1], Christopher J. Sweeting[2], Paul A. Tyler[3] & the ChEsSO consortium

1. British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET UK
2. School of Marine Science & Technology, Ridley Building, Newcastle University, Newcastle upon Tyne, NE1 7RU UK
3. School of Ocean and Earth Science, University of Southampton, Waterfront Campus, Southampton, SO14 3ZH UK

In 2009 the ChEsSO consortium discovered hydrothermal vents in two segments of the East Scotia Ridge in the Southern Ocean. Revisiting the sites in 2010 with the British ROV ISIS enabled us visually study the vent assemblage and to collect specimens for further taxonomic, genetic and ecological analyses. The chemosynthetic ecosystems hosted by these vents are dominated by yeti crabs, stalked barnacles, limpets, peltospiroid gastropods and anemones. The associated macrofauna, especially mobile species, seen in the diffuse flow fields and vent periphery comprises known Antarctic deep-sea taxa as well as species new to science. Here we present the current status of taxonomic identifications.

Japanese Marine Geophysical Activities in the Antarctic Ocean under the Japanese Antarctic Research Expedition

Yoshifumi Nogi

National Institute of Polar Research, Tokyo, Japan

Japanese new Icebreaker Shirase has been put into operation in 2009. Main purpose of the ship is to transport the personnel and cargo to Japanese Antarctic Station, Syowa, once a year under the JARE (Japanese Antarctic Research Expedition). Swath mapping (seabeam 3020), gravity and vector geomagnetic anomaly measurements have been conducted on her route mainly to understand the process of Gondwana fragmentation in the Indian Ocean. The ship also cross the Southeast Indian Ridge every year almost along longitude of 110E and 150E, because of biological monitoring study of surface water. TR/V Umitaka Maru of Tokyo University of Marine Science and Technology are also used for biological and oceanographic studies in the Antarctic Ocean between Australia and Antarctica, recently. On the other hand, wide scale mantle imaging by using OBEM (Ocean Bottom Electro-Magnetometer) are planned between Southern Kerguelen Plateau and Western Australia across western part of the Southeast Indian Ridge under the JARE. We are now arranging the feasible plan, but cooperation with the other research vessels may be required due to the restriction of biological monitoring study. Marine geophysical researches including future plan under the JARE and availability of Icebreaker Shirase for the research on Circum-Antarctic ridges will be presented. The other Japanese research activities related to Circum-Antarctic ridges will also be briefly introduced.

Preliminary Results of a Recent Expedition to the Australian-Antarctic Ridge

Sung-Hyun Park[1]*, Charles Langmuir[2], Jian Lin[3], Doshik Hahm[1], Seung-Sep Kim[4], Soon-Gyu. Hong[1], Yung Mi Lee[1], Peter Michael[5]

[1]Korea Polar Research Institute, Incheon, Korea
[2]Harvard University, Cambridge, MA, USA
[3]Woods Hole Oceanographic Institution, Woods Hole, MA, USA
[4]Seoul National University, Seoul, Korea
[5]University of Tulsa, Tulsa, OK, USA

The Australian-Antarctic Ridge (AAR) is the largest unexplored expanse of the global mid-ocean ridge system. In early 2011, the Korea Polar Research Institute (KOPRI) conducted a short survey of two segments at 160°E (KR1) and 152.5°E (KR2) using the icebreaker Araon (Figure 1). As a result, we have a multi-beam map and 16 rock core samples from the two segments. Also, we found strong signals of hydrothermal venting using MAPR (Miniature Automatic Plume Recorder) profiles from the ridge.

The spreading rate of the AAR is intermediate and its axial depth is relatively shallow (~2100m). The axial morphology varies from an axial high (west) to well-developed rift valley (east) in the KR1 segment, suggesting magma supply has varied on short spatial scales. Magma supply of the western end of KR1 segment is high, as indicated by flat-topped plateau morphology. The western end abuts a transform with a strike towards the Balleny Islands, providing a possible source of excess magma supply leading to the morphology and the shallow axial depth. Segment KR2 is deeper than KR1 and can be divided into two segments by an offset at 152.30E. East of this offset there is a rift valley, while to the west there is an axial high. A Small seamount is located very close to the axis in the north of the western segment. Magma supply also varies in this segment, but it is lower than KR1.

Major and trace elements were analyzed to characterize the magma processes, mantle sources, and melting processes in this ridge. MgO varies from 1.72 to 7.63 wt. %, mostly between 6~7 wt. %. Fe-Ti basalt and dacite are at the western end of the KR1 segment where magma supply appears most robust. Most samples from the western and central KR1 are slightly enriched except one sample from the western end. On the other hand, samples from the eastern segment are slightly depleted. The KR2 segment samples are more primitive than KR1. Samples from the eastern segment of KR2 (rift valley) are depleted and one sample is Fe-Ti basalt. Two of three samples from the western segment of KR2 (axial high) are enriched. Depleted sample is located between the two enriched samples locations. Enriched samples may be related to the seamount in the north of the segment.

In the KR1 segment, it appears that hydrothermal vents are mainly distributed in the central and eastern part of the segment as four MAPR profiles from that part show strong signals. One MAPR profile shows double peaks at different depths, suggesting that this site is influenced by at least two strong separate sources that have different buoyancy. Hydrothermal activities may be quite robust in this area. However, these profiles do not show a significant change in oxidation-reduction potential (dEh/dt), suggesting hydrothermal vent source is not close by. To further constrain the vent locations, more dense MAPR profiles are required. In the KR2 segment, hydrothermal vent signals were mainly found in the western part of the segment. Three MAPR profiles of this segment show significant anomalies up to 300 m thick near the seafloor. Among them, the western most profile shows a significant change in oxidation-reduction potential. The source of hydrothermal vent may be located west of this site and probably close by. It is noteworthy that vent signals were not found in the excessive magma supply area, but in the intermediate magma supply area.

Late this year, we will revisit the KR1 and KR2 to obtain more rock samples, MAPR profiles, CTD and multi-beam data. KOPRI is now planning multi-years surveys on the AAR including AUV and ROV cruises.

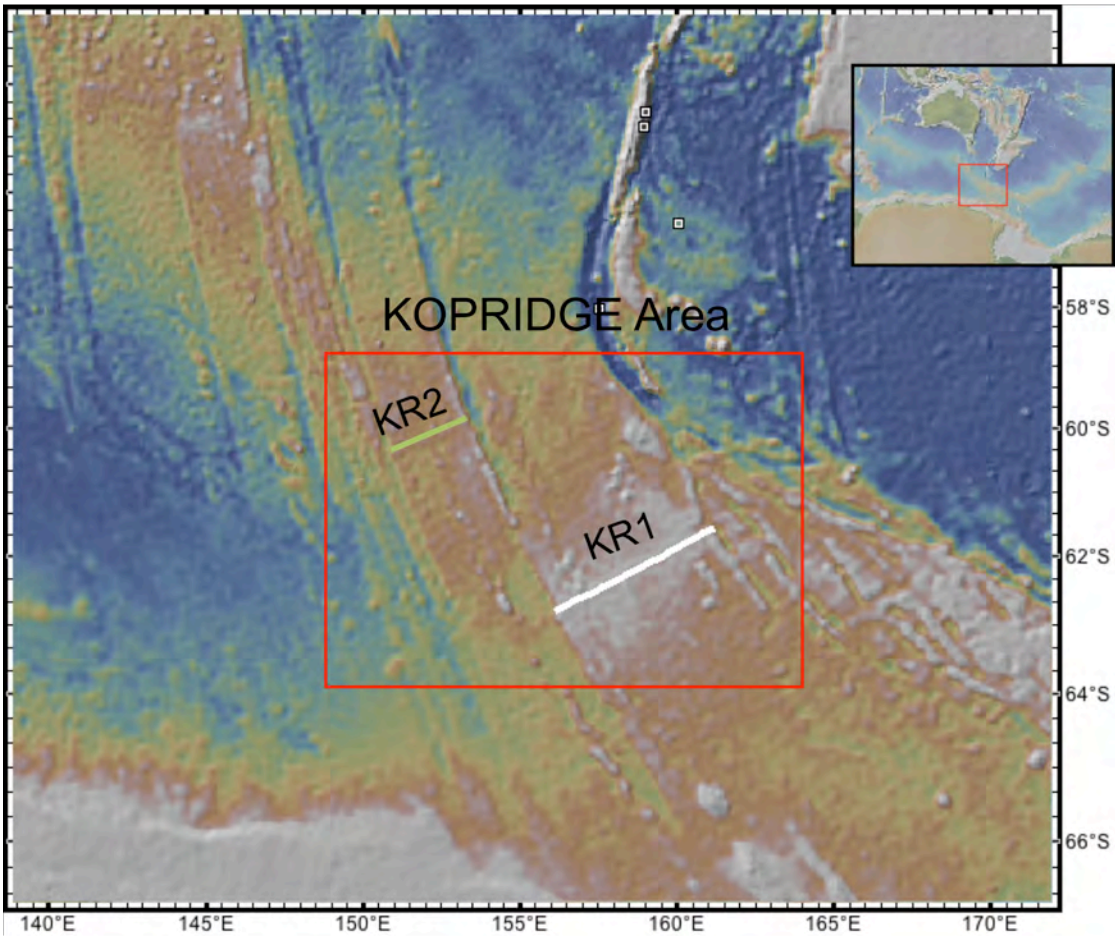


Figure 1 2011 KOPRIDGE area

RESULTS FROM AN HYDROACOUSTIC EXPERIMENT IN THE SOUTHERN INDIAN OCEAN

J.-Y. Royer 1 (jyroyer@univ-brest.fr), R. Chateau [1] & R. P. Dziak [2]
[1] Lab. Domaines Océaniques, CNRS/Univ. Brest - UEB, 29280, Plouzané, France
[2] Pacific Marine Environment Lab, NOAA/OSU, Newport, OR, 97365

From October 2006 to January 2008, an hydroacoustic experiment in the Indian Ocean was carried out by the CNRS/University of Brest and NOAA/Oregon State University to monitor the low-level seismic activity associated with the three contrasting spreading ridges and deforming zones in the Indian Ocean. Three autonomous hydrophones were moored in the SOFAR channel by R/V *Marion Dufresne* for 14 months in the Madagascar Basin, and northeast and southwest of Amsterdam Island. This array was complemented by two permanent hydroacoustic stations of the Comprehensive nuclear-Test-Ban Treaty Organization (CTBTO) located near Diego Garcia Island and off Cape Leeuwin and which helped improving the location of the hydroacoustic events and reducing their uncertainties.

During these 14 months of continuous acoustic recording, about 9000 acoustic events were detected, consisting mostly of earthquake generated T-waves and also including ~4500 cryogenic tremors from breaking-glaciers and drifting icebergs, off the Antarctic margin. Within the triangle defined by the temporary array, the three Indian spreading ridges exhibit contrasting seismicity patterns. Along the Southeast Indian ridge (SEIR), the 272 acoustic events (vs 24 events in the NEIC catalog) occur predominantly along the transform faults; only one ridge segment (76°E) displays a continuous activity for 10 months. Along the Central Indian Ridge (CIR), seismicity is distributed along fracture zones and ridge segments (269 events vs 45 NEIC events), with two clusters of events near the triple junction (24-25S) and south of Marie-Celeste FZ (18.5S). Along the Southwest Indian Ridge (SWIR), the 222 events (vs 31 NEIC events) are distributed along the ridge segments with a larger number of events west of Melville FZ and a cluster at 58E. The immediate vicinity of the Rodrigues triple junction shows periods of quiescence and of intense activity. Some large earthquakes events (Mb>5) near the triple junction (SEIR and CIR) seem to be preceded by several acoustic events that may be precursors. Finally, off-ridge seismicity is mostly detected in the southern part of the Central Indian Basin as a result of the intraplate deformation between the Capricorn and Australian plates.

Other signals of interest are identified such as a 6-week long series of broadband (1-125 Hz) explosive signals detected only by the instrument located between Kerguelen and Amsterdam islands. Many cryogenic tremors are easily recognizable from their varying tones and harmonics, some of which can be precisely located off the Antarctic shelf. Finally, whale calls attributed to four different whale species are found to be highly seasonal, occurring mainly from April to October with subspecies variations.

A new experiment is underway since January 2010 until 2013 with an array of 9 hydrophones covering large sections of the Southwest and Southeast Indian ridges with the objective to acquire longer time series on their “background” tectonic and volcanic activity, as well as on the presence and migration pattern of large baleen whales in the Southern Ocean.

Igneous, ultramafic, and metamorphic rocks on and around the Southwest Indian Ridge

Hiroshi SATO (Senshu Univ.), Ryoko SENDA, Kentaro NAKAMURA, Hidenori KUMAGAI (JAMSTEC),Shiki MACHIDA (Waseda Univ.), Tomoaki MORISHITA, Akihiro TAMURA, Susumu UMINO, Kyoko KANAYAMA (Kanazawa Univ.), Hideo ISHIZUKA (Kochi Univ.)

Recent investigations by Japanese vessel, R/V Hakuho-maru, on and around the Southwest Indian ridge (SWIR) recovered igneous, ultramafic, and metamorphic rocks. These rocks have several keys to understand the magmatism beneath the SWIR as well as the tectonics around the arctic region.

Melting source beneath the SWIR, 36-41° E (KH-07-4, KH-09-5 cruises)

Mid-ocean ridge basalts (MORB) were recovered from the orthogonal and oblique spreading ridge segments at 36-41° E along the SWIR. Slightly enriched (e.g. (La/Sm)n ~2 times chondrite) MORBs are sampled westward V shaped height (36-38°E) and 39°E segment. Geochemical variations of MORB at 36-38°E segment can be explained by the souce heterogeneity beneath the ridge rather than the differences of melting conditions, such as pressure and temparature.

MORB from eastern part of the investigated segment (38-40° E) have higher Sr isotope ratio (0.7038 to 0.7049) which is consistent with previously reported tendency of the “DUPAL” signature (e.g., Meyzen et al., 2005). However, highly plagioclase porphyritic basalt recovered from west of the fracture zone have highest Sr ratio (0.70498), implying that the source heterogeneity would be spreaded beyond the fracture zone.

Mantle peridotites beneath the SWIR, 36-41° E (KH-07-4, KH-09-5 cruises)

Congremerate including mantle peridotite clasts were recovered along the Prince- Edward fracture zone and oblique segment at 37°E. Mantle peridotite clasts from the Prince-Edward fracture zone are highly altered, but they are originally lherzolite judged from relict primary silicate mineral (olivine, orthopyroxene, clinopyroxene, etc) modal compositions. REE compositions of Cpx have strongly LREE-depleted signatures with high-HREE abundance, suggesting that mantle melting started at the garnet-field followed by spinel-field melting. Spinel grains scattered within matrix of conglomerate have depleted Os isotope ratio with model ages up to 1 billion year. Cpx compositions and spinel Os isotope ratio indicate that ancient refractory mantle materials without any refertalization or metasomatism have preserved for long time.

Metamorphic rocks along the SWIR and at the Conrad rise (KH-09-5, KH-10-7 cruises)

Metamorphic (biotite-orthoclase-plagioclase-quartz+/-muscovite+zircon+apatite) rocks and sedimentary rocks (quartzite) were dredged at the south of oblique spreading ridge segments at 36-41° E along the SWIR during KH-09-5 cruise.

Up to 30 kg of igneous and metamorphic rocks were recovered from the Conrad. Of these, the metamorphic rocks typically include the mineral assemblage of garnet + sillimanite + symplectite (cordierite + spinel), which indicates the P-T evolution of isothermal decompression during the retrograde stage. U-Pb age of zircon and CHIME age of monazite yield the peak metamorphic event of about 1000 Ma, a Grenvillian age. While most dredged igneous rocks are basalt to trachy-basalt, previous Russian investigation reported more silica-rich trachytic rocks (Borisova et al., 1996). Chemical variations from basalt to silica-rich trachytic rocks at the Conrad rise can be explained by fractionation. Although the idea that the metamorphic rocks were ice-raft origin sould be considered, it is plausible that the metamorphic rocks at the south of the SWIR and the Conrad rise are fragment of the Rodinia supercontinent such as reported from Eastern Ghats of India and Rayner complex of East Antarctica.

Faulting and magmatic activity at Southwest Indian ridge 35-40°E, based on geophysical study

Taichi Sato[1], Kyoko Okino[2], Hiroshi Sato[3], Mariko Mizuno[4], Tomoko Hanyu[5], Nobukazu Seama[6]

[1]Geological Survey of Japan, AIST, [2]Atmosphere and Ocean Research Institute, the University of Tokyo, [3]Senshu University, [4]Chiba University, [5]The Graduate University for Advanced Studies, [6]Kobe University

Abstract

The Southwest Indian Ridge (SWIR) is an ultraslow spreading ridge, where the spreading rate is almost constant over the whole system; 14-16 mm/yr. In spite of constant spreading rate, wide varieties of seafloor structure have been observed. We conducted geophysical survey at a first-order segment of SWIR between Prince Edward and Eric Simpson Fracture zone (35°- 40° E), which is considered to receive more melt than the other part of SWIR because of low Na8.0 and influence of Marion Island, the nearest hotspot (37°51' E 46°52' S). Using new swath bathymetry, magnetic and gravity data, we revealed that the segment is composed of total five second-order subsegments (three melt-focused subsegments and two melt-starved subsegments), magmatic/tectonic activity for each subsegment is not synchronized and it changes spatially and temporally. A westward V-shaped topographic high was discovered at the western subsegment but the structure is different from that is often found at a hotspot-ridge interacted area. Combining with geochemical features, the hotspot-ridge interaction between SWIR and Marion hotspot is considered not to be occurred at present. At the east of V-shaped topographic high, oblique spreading ridge was discovered. According to the seafloor age from magnetic anomaly identification, theoblique subsegment started to be formed after C2An, without any change of spreading rate and direction. This implies that the melt supply variation can induce a change of ridge segmentation. Our pertrological data suggest that the melt supply variation is likely caused by the small degree of heterogeneity and heterogeneous distributions of both enriched portion and refractory portion in the source mantle beneath the western and oblique subsegments. In addition, the micro-seismic study within the axial valley of oblique subsegment implies that the delivered melt is re-distributed and form third-order orthogonal spreading subsegments, although the second-order subsegment seem to be oblique to the spreading direction.

The Southwest Indian Ridge

Daniel Sauter[1] and Mathilde Cannat[2]

(1) Institut de Physique du Globe de Strasbourg IPGS UMR 7516 CNRS/UdS, 1 rue Blessig, 67084 Strasbourg cedex, France
(2) Institut de Physique du Globe de Paris, CNRS UMR 7154, 1, rue Jussieu, 75238 Paris Cedex 05, France

The Southwest Indian Ridge (SWIR) is among the world's slowest-spreading ridges with a full spreading rate of ~14 mm/yr (at 64°E/28°S) varying only slightly from the Bouvet triple junction in the southern Atlantic ocean to the Rodrigues triple junction in the Indian ocean. The compilation of geophysical and geochemical data along the SWIR reveals a large-scale variation of the density and thermal structure of the axial region. The easternmost part of the SWIR (to the east of Melville Transform Fault) appears to be among the deepest part of the oceanic ridge system and it is thus inferred to represent a melt-poor end-member for this system. Both the easternmost and westernmost parts of the SWIR (to the east of the Melville and the Shaka transform faults, respectively) reveal a ridge segmentation that differs greatly from what is observed at the faster spreading ridges like the Mid-Atlantic Ridge. The apparent absence of volcanic activity on >100 km-long stretches of the ridge axis where large expanses of mantle-derived peridotites are exposed in the axial valley is one of the striking contrasts between the SWIR and these faster-spreading ridges. Off-axis geophysical data in the deep magma poor part of the SWIR reveal a new type of seafloor which has no equivalent at faster spreading ridges. This non-volcanic ocean floor has been called "smooth seafloor" because it occurs in the form of broad ridges, with a smooth, rounded topography and corresponds to thin crust with little to no volcanism. Very large volcanic centers with thick crust occur between these non-volcanic sections of the ridge and have much higher relief to length ratios than the segments of the Mid-Atlantic Ridge. These volcanic centers receive more melt than the regional average while each segment of the Mid-Atlantic Ridge is supplied with close to the regional average amount of melt. Melt supply thus appears to be more highly focused beneath these volcanic centers of the SWIR. Melt focusing could result from a combination of melt migration near the base of the lithosphere and rapid melt extraction through dikes rooted in melt-rich regions.

Biology of the East Scotia Ridge hydrothermal vents: Biogeographic and trophic perspectives.

Christopher J Sweeting[1]*, William DK Reid[1], Alex D Rogers[2], Paul A Tyler[3], Nicholas VC Polunin[1], & CHESSO consortium

1 Ridley Building, School of Marine Science & Technology, Newcastle University, Newcastle, NE1 7RU, UK
2 Department of Zoology, University of Oxford, South Parks Road, Oxford, OX1 3PS
3 School of Ocean and Earth Science, University of Southampton, Waterfront Campus, Southampton SO14 3ZH

*corresponding author christopher.sweeting@ncl.ac.uk

Exploration of the East Scotia Ridge (ESR) identified hydrothermal vent communities dominated by a yeti crab, stalked barnacles, limpets, peltospiroid gastropods, anemones and a sea star. Together with an absence of the characteristic vent fauna of other oceans, we propose the ESR to be a previously unrecognised biogeographic province. Based on stable isotope technique we describe the trophic structure (food chain lengths and sources of production) of the ESR province vent system and its and constituent fauna. We then explore the functional equivalence of ESR vent fauna trophodynamics with more extensively studied vent communities.

Intra-population variation in key species of the East Scotia Ridge hydrothermal vents

William DK Reid*, Christopher J Sweeting, Nicholas VC Polunin, & CHESSO consortium

1Ridley Building, School of Marine Science & Technology, Newcastle University, Newcastle, NE1 7RU, UK

*corresponding author w.d.k.reid@newcastle.ac.uk

Yeti crabs, peltospiroid gastropods and stalked barnacles are three key species associated with hydrothermal vents on the East Scotia Ridge and dominate chimney surfaces and areas of diffuse flow. These species are hypothesised to have separate feeding techniques with the yeti crab grazing on epi-symbionts, peltospioid gastropods utilising endo-symbionts and stalked barnacles feeding on suspended free-living bacteria. Stable isotopes were used to determine the degree of intra-population variation and whether this varied as a function of size and/ or location. The results suggest that size and location are important determinants in the variability of stable isotope values of vent fauna but their relative importance varies over scales of hundreds of metres to hundreds of kilometres.

Hydrothermal vents on the ultraslow spreading Southwest Indian Ridge

Tao Chunhui[1] Li Huaiming[1] Lin Jian[2] DY115-19 &20 Science Party

[1]*Key Laboratory of Submarine Geosciences, Second Institute of Oceanography, SOA, Hangzhou 310012, China*
[2]*Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543, USA*

The cumulative length of the Earth′s ultraslow spreading ridges, where the full seafloor spreading rate is less than 16 mm/yr, is more than 15,000 km, representing about 20% of the global mid-ocean ridge system. Because of their remote locations, most ultraslow ridges, which include the Gakkel Ridge in the Arctic Ocean and the Southwest Indian Ridge (SWIR), have remained extremely difficult to investigate.

In February-March 2007, during the Chinese DY115–19 cruise, we determined the precise location of the first active vent field at 49°39¢E using a combination of water-column surveys, deep-tow video imaging, and three phases of investigation using the autonomous underwater vehicle ABE *(*Autonomous Benthic Explorer) on the ultraslow spreading center. Subsequently, the inactive vent site at 50°28′E, two more vent sites (at 51º0.55′E, 37º36.48′S and 51°43.92′E, 37°27.96′S) and two water column anomalies (at 51°24.6′E, 37°25.8′S and 51°37.2′E, 37°26.4′S) were found in the section of the SWIR between 49°-52°E during the following Legs 5–7 of the Chinese DY115–20 expedition. Taken together, the calculated hydrothermal site frequency along this 49°-52°E section is ~2.5 sites per 100 km, similar to that of the MAR at 36°-38°N, where local magmatic supply is also robust. We hypothesize that local magma supply and crustal permeability play a primary role in controlling the distribution of hydrothermal activities. This implies that along slow and ultraslow ridges, the sections where excess heat is available from enhanced magmatism but the crust is still of suitable permeability, might be the most promising areas for searching hydrothermal activities and sulfide deposits. Such sections could occur at distance of tens to hundreds of kilometers from hotspots.

The SWIR provide the only known route for migration of chemosynthetic deep-sea vent fauna between the Atlantic and Indian oceans. It is surprising that the special vent fauna found on the SWIR appear to indicate some complex affinity to those on the Central Indian Ridge, Southern Mid-Atlantic Ridge, and Southwest Pacific Ocean

First active hydrothermal vents discovered on the ultraslow-spreading Southwest Indian Ridge

Chunhui Tao[1*], Jian Lin[2*], Shiqin Guo[3], Yongshun John Chen[4], Guanghai Wu[1], Xiqiu Han[1], Christopher R. German[2], Dana R. Yoerger[5], Ning Zhou[3], Huaiming Li[1], Xin Su[6], Jian Zhu[4], and the DY115-19 (Legs 1–2) and DY115-20 (Legs 4–7) Science Parties

[1]*Key Laboratory of Submarine Geosciences, Second Institute of Oceanography, SOA, Hangzhou 310012, China; taochunhuimail@163.com*

[2]*Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543, USA; jlin@whoi.edu*

[3]*China Ocean Mineral Resources R&D Association, Beijing 100860, China*

[4]*Department of Geophysics, School of Earth & Space Sciences, Peking University, Beijing 100871, China*

[5]*Department of Applied Physics and Ocean Engineering, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543, USA*

[6]*China University of Geosciences, School of Ocean Sciences, Beijing 100083, China*

The ultraslow-spreading Southwest Indian Ridge is a major tectonic province, representing one of the important end-member mid-ocean-ridge types for its very slow and oblique spreading, and providing the only known route for migration of chemosynthetic deep-sea vent fauna between the Atlantic and Indian Oceans. We report the investigation of the first active high-temperature hydrothermal field found on this ultraslow spreading center. Located on the Southwest Indian Ridge at 37°47'S, 49°39'E, it consists of three zones extending ~1000 m laterally, and it is one of four recently discovered active and inactive vent sites within a 250-km-long magmatically robust section. Our results provide the first direct evidence for potentially widespread distribution of hydrothermal activity along ultraslow-spreading ridges—at least along magmatically robust segments. This implies that the segment sections with excess heat from enhanced magmatism and suitable crustal permeability along slow and ultraslow ridges might be the most promising areas for searching for hydrothermal activities. It is surprising that the special vent fauna appear to indicate some complex affinity to those on the Central Indian Ridge, southern Mid-Atlantic Ridge, and the southwest Pacific Ocean.

Application of Next Generation Sequencing Technology for Studying Deep-Sea Hydrothermal Vent Organisms

Yong-Jin Won[1], Eunji Park[1], Soon Gyu Hong[2], Robert C. Vrijenhoek[3]

1 Division of EcoScience, Ewha Womans University, Seoul, 120-750 Korea
2 Division of Polar Life Sciences, Korea Polar Research Institute, Incheon, 406-840 Korea
3 Monterey Bay Aquarium Research Institute, Moss Landing CA 95039 USA

The vast area of the Pacific-Antarctic Ridge (PAR) remains mostly unexplored yet, posing an important missing piece in our understanding of evolutionary connection of hydrothermal vent endemic organisms along the global Mid-Ocean Ridge (MOR) systems. The unique geographic location of the PAR has long intrigued us with the potential existence of vent communities and fauna and the role of the PAR as a pathway of dispersal of vent animals over geologic time scale between the other relatively well-studied biological provinces in the East Pacific Rise, the West Pacific Bac-Arc systems. This interesting but not yet undertaken question calls our research efforts to the PAR. Recently, Korea launched an icebreaking research ship *Araon* and began to use it for expeditions to the ocean at high latitudes. This year our multidisciplinary international team started to explore the region between New Zealand and the Antarctic, which aimed to discover new venting sites, if any, and to collect biological and geological specimens from the candidate site under a long-term research project. In this presentation we will describe on-going works in our team intended to understand the genetic connectivity among hydrothermal vent communities in the Pacific and Antarctic Oceans. This includes the development of new multiloci genetic markers by next generation sequencing technology from hydrothermal vent invertebrates and their endosymbiotic bacteria. We will present methodological model cases of tube-dwelling polychaete worm *Alvinella pompejana* (Annelida: Polychaeta) and sulfur-oxidizing endosymbiotic bacteria of deep-sea hydrothermal vent mussel *Bathymodiolus thermophilus* (Mollusca: Mytilidae). Additionally, new analytical methods designed for inferring spatial, temporal, and demographic parameters of population genetics upon genetic data of these cases will be discussed.

List of participants

Name	Institution	Email
Alfred Aquilina	National Oceanography Centre, Southampton	a.aquilina@noc.soton.ac.uk
Ed Baker	NOAA PMEL	edward.baker@noaa.gov
Donna Blackman	Scripps Institution of Oceanography	dblackman@ucsd.edu
Cedric Boulart	CNRS	cedric.boulart@get.obs-mip.fr
Anne Briais	CNRS, Univ. Toulouse	anne.briais@get.obs-mip.fr
Daniele Brunelli	University of Modena	daniele.brunelli@unimore.it
Georges Ceuleneer	Geosciences Environnement Toulouse	georges.ceuleneer@get.obs-mip.fr
Valérie Chavagnac	Géosciences Environnement Toulouse	valerie.chavagnac@get.obs-mip.fr
Cathy Cole	National Oceanography Centre	catherine.cole@noc.soton.ac.uk
Doug Connelly	National Oceanography Centre	dpc@noc.soton.ac.uk
Adélie Delacour	Geosciences Environnement Toulouse	adelie.delacour@get.obs-mip.fr
Henry Dick	Woods Hole Oceanographic Institution	hdick@whoi.edu
Jérôme Dyment	IPGP & CNRS-INSU	jdy@ipgp.fr
David Graham	Oregon State University	dgraham@coas.oregonstate.edu
Darryl Green	National Oceanography Centre	drhg@noc.soton.ac.uk
Michel Grégoire	Geosciences Environnement Toulouse	michel.gregoire@get.obs-mip.fr
Cédric Hamelin	IPGP	ced.hamelin@gmail.com
Barry Hanan	San Diego State University	barry.hanan@sdsu.edu
Jeff Hawkes	National Oceanography Centre	j.hawkes@noc.soton.ac.uk
Christophe Hemond	University of Brest	chhemond@univ-brest.fr
Laura Hepburn	National Oceanography Centre, Southampton	l.hepburn@noc.soton.ac.uk
Jack Hitch	National Oceanography Centre, Southampton	jnh1g08@soton.ac.uk
Soon Gyu Hong	KOPRI (Korea Polar Research Institute)	polypore@kopri.re.kr
Hide Kumagai	IFREE, JAMSTEC	kumagai@jamstec.go.jp
Charles Langmuir	Harvard University	langmuir@eps.harvard.edu
Phil Leat	British Antarctic Survey	ptle@bas.ac.uk
Jian Lin	Woods Hole Oceanographic Institution	jlin@whoi.edu
Katrin Linse	British Antarctic Survey	kl@bas.ac.uk
Marcia Maia	CNRS-IUEM	marcia.maia@univ-brest.fr
Joseph Martinod	Toulouse University, France	joseph.martinod@get.obs-mip.fr
Rachel Mills	National Oceanography Centre Southampton	rachel.mills@soton.ac.uk
Debbie Milton	NOC Southampton	coordinator@interridge.org
Dr. N.Jayaraju	Yogi Vemana University	nadimikeri@gmail.com
Yoshi Nogi	National Institute of Polar Research	nogi@nipr.ac.jp
Sung-Hyun Park	Korea Polar Research Institute	shpark314@kopri.re.kr
Jean-Yves Royer	CNRS-Univ. Brest	jean-yves.royer@univ-brest.fr
Hiroshi Sato	Institute of Natural Sciences, Senshu Univ.	satohiro@isc.senshu-u.ac.jp
Taichi Sato	Geological Survey of Japan, AIST	taichi-sato@aist.go.jp
Dan Sauter	Institut de Physique du Globe de Strasbourg	daniel.sauter@unistra.fr
Dr Chris Sweeting	Newcastle University	christopher.sweeting@ncl.ac.uk
Yong-Jin Won	Ewha Womans University	won@ewha.ac.kr
Huaiyang Zhou	School of Ocean & Earth Science, Tongji Univ.	zhouhy@tongji.edu.cn