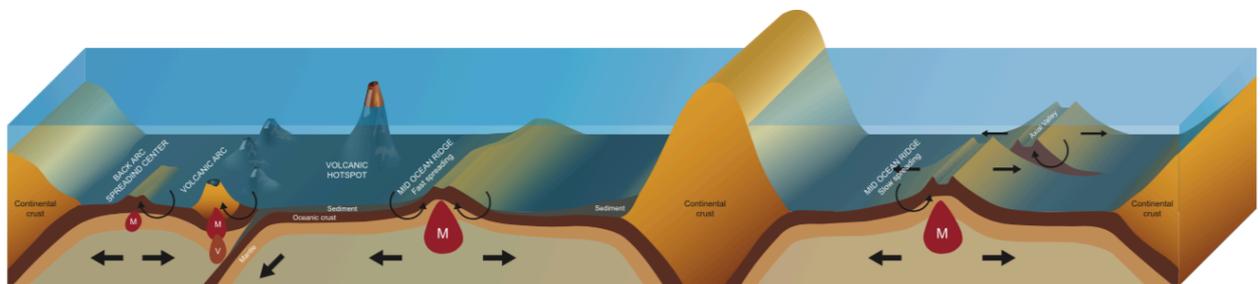


# 4<sup>th</sup> InterRidge Theoretical Institute



## Hydrothermalism in 4D: current challenges and emerging issues



N. Le Bris/V. Domien 10.3389/fmars.2018.00531

18-21 November 2019, Banyuls-sur-Mer, France



## Scope and goals

This 4<sup>th</sup> Theoretical Institute of InterRidge builds on the current scientific momentum and addresses emerging themes related to hydrothermal systems and how they interact with other oceanic components. New scientific challenges have been raised about the links between tectonic complexities and magmatic-hydrothermal processes, the hydrothermal contribution to global ocean budgets (e.g. heat, carbon, iron), the dynamics and mechanisms of long-range interactions of vent systems as well as their role on deep-sea ecosystem functions, stability, and resilience to local disturbance and global change.

Building an integrated vision of hydrothermal processes over space and time on which quantitative approaches and predictive models could be based is crucially needed. Beyond the opportunity for an exchange of information on new knowledge, methods and transdisciplinary issues, this 4<sup>th</sup> Theoretical Institute aims to contribute setting up the scene for the next decade plan of InterRidge. Bringing together ideas, concepts, expertise and know-how will help us developing strategies and international collaborations to fill gaps in the understanding of hydrothermal systems and the processes driving their spatial and temporal variability

The ultimate goal of discussions and writing sessions of the Theoretical Institute is to draft a position paper that will help strengthening the fundamental frame of our research field, underlining critical knowledge gaps and perspectives from the current research momentum. While a growing scientific community is addressing economic and societal issues related to the ocean floor and its biodiversity, ensuring that appropriate fundamental knowledge of hydrothermal systems is available to other stakeholders is also a key mandate for this InterRidge Theoretical Institute.

## Programme

The Theoretical Institute proposes a set of lectures during the first day, followed by four workshop sessions in the next two days. Workshop sessions keynote talks, short talks and flash-presentations of posters will be followed by panel discussions. The last day will be dedicated to draft the outline of a position paper in writing groups and wrapping up in plenary. A young-scientist poster session is organized with a best-poster award selection.

**Invited lectures** are open to all participants. Targeting young scientists, they will address crossed methodological and theoretical issues at the forefront of current research. Lectures will propose syntheses of recent works on key themes accessible from different disciplinary background, bridging methodological and theoretical advancements.

**Workshop sessions** are organized on four emerging themes on the field of hydrothermal research. Keynotes will introduce discussions by presenting recent advances from both geoscience and ecology-biology perspectives and will be complemented by short talks and poster presentations. Discussions aim to identify emerging issues and topics, and future needs of basic knowledge and help structuring the writing groups and precise their objectives. <sup>1</sup>

## Committees

*Scientific committee:* Nadine Le Bris (CNRS-Sorbonne U), Jérôme Dymont (CNRS IPGP), Melissa Anderson (U. Toronto), Philipp Brandl (GEOMAR), Cédric Hamelin (U. Bergen), Stéphane Hourdez (CNRS), Shinsuke Kawaguchi (JAMSTEC).

*Organization committee:* Kamil Szafranski, Nadine Le Bris,



## PROGRAMME

### Day 1 – 18/11/2019

- 9:00 - 9:15 Welcome (Nadine Le Bris, Sorbonne Univ. Jérôme Dymont, Kamil Szafranski, CNRS-IPGP)
- 9:15 - 10:15 Hydrothermal vent geodiversity: seafloor and sub-seafloor processes. Dionysis Foustoukos, (Carnegie Inst.). *Invited Lecture.*
- 10:15 -10:30 *Coffee break*
- 10:30 – 11:30 Vent microbiomes with combined NGS and experimental approaches. Constantino Vetriani, (Rutgers Univ.). *Invited Lecture.*
- 11:30 – 12:30 Ecosystem dynamics: repeated observation and time-series. Majorlaine, Matabos (Ifremer). *Invited Lecture.*
- 12:30 – 14:00 *Lunch*
- 14:00 – 15:00 Connectivity and larval dispersal: metapopulation approach. Lauren Mullineaux.(WHOI). *Invited Lecture.*
- 15:00 – 16:00 Subseafloor hydrothermal alteration of massive sulfide deposits. Melissa Anderson, (U. Toronto). *Invited Lecture.*
- 18:00 *Ice-breaker at the 'Biodiversarium' - apéritif / dégustation of local wines*

### Day 2 – 19/11/2019

- 9:00 – 9:30 Introduction of the workshop and objectives. Hydrothermalism in 4D: current challenges and emerging issues (Nadine Le Bris)

#### Session 1 'Export of vent-derived chemicals: from near-vent reactivity to long-range transport'

##### *Chair Dionysis Foustoukos*

- 9:30-10:15 Mustafa Yücel (Middle East Tech. Univ.). Factors controlling metal export to oceans from hydrothermal vents: Towards an integrated understanding involving subseafloor, near-field plume and water column processes. *Keynote talk.*
- 10:30 -10:45 *Coffee break*
- 10:45- 11:30 Kawagucci Shinsuke (JAMSTEC). Serpentinization-involved geofluid systems. *Keynote talk.*
- 11:30-11:45 Coleen Hoffman (U. Washington). Redefining far-field: the transformation of particulate iron along the Southern East Pacific Rise hydrothermal plume. *Talk*
- 11:45 – 12:30 Panel discussion
- 12:30 – 14:00 *Lunch*

#### Session 2 'Chemosynthetic carbon: drivers of productivity at active and inactive vents'

##### *Chair Kawagucci Shinsuke*

- 14:00 – 14:45 Mirjam Perner (GEOMAR). The uncultured microbial majority and its chemosynthetic potential". *Keynote talk.*
- 14:45-15:00 Foustoukos, D.I and Perez-Rodriguez I. Lithotrophic Nitrate Reduction and  $^{15}\text{N}/^{14}\text{N}$  Systematics in High-pressure Cultures. *Talk*
- 15:00-15:15 Costantino Vetriani. *Talk*
- 15:15- 15:25 *Poster presentation:* Deep-sea environment filters for similar functional entities at inactive habitats whereas hydrothermal activity enhances functional richness on early colonization stages of meio- and macroinvertebrates. Joan Alfaro-Lucas (Ifremer).
- 15:25-16:15 Panel discussion.
- 17:00 – 20:00 Poster session (hall of the amphitheatre) – *tapas/snacks and drinks*



### Day 3 – 20/11/2019

#### Session 3 ‘ Basin-scale distribution of hydrothermally-driven processes from ridges to subduction zones’

##### *Chair J. Dymant*

- 9:00 - 9:45 Nobukazu Seama. (Kobe U., Japan). Basin scale water circulation inferred from geophysical evidences and numerical modelling. *Keynote talk.*
- 9:45 -10:30 Lauren Mullineaux (WHOI). *Keynote talk.*
- 10:30 -10:45 *Coffee break*
- 10:45 - 11:30 Chong Chen (JAMSTEC). Discoveries from Indian and Southern oceans: New vents, new animals, new evolutionary adaptations. *Keynote talk.*
- 11:30-11:45 Stéphane Hourdez (CNRS). CHUBACARC: A multidisciplinary cruise to explore the drivers of species distribution in back-arc basins. *Talk*
- 11:45- 12:05 *Poster presentations:*
- Preliminary results of the morphostructural analysis of Mount Orca submarine volcano. Osse Pellegri Gino Luciano (Universidad Caólica del Norte).
  - A Global Classification of Chemosynthetic Biogeographical Provinces of the World: The role of the Arctic vents. Lisette Victorero (Museum National d’Histoire Naturelle)
- 12:05- 12:45 Panel discussion.
- 12:45 – 14:00 *Lunch*

#### Session 4 ‘Massive Sulfide deposition, alteration and biological diversity’

##### *Chair S. Hourdez*

- 14:00 – 14:45 Shingo Kato (RIKEN). Microbial ecology of hydrothermally-inactive sulfide deposits in deep-sea hydrothermal fields. *Keynote talk.*
- 14:45 – 15:30 Melissa Anderson (U. Toronto). Tectonic evolution of intraoceanic back-arc basins and the development of focused magmatic-hydrothermal systems. *Keynote talk.*
- 15:30 – 15:45 *Coffee break*
- 15:45-16:30 Wolfgang Bach (MARUM, U. Bremen) How fluid-rock reactions support microbial life in the seafloor. *Keynote talk.*
- 16:30-16:40 *Poster presentation:* Characterizing the distribution of hydrothermal vent communities through space and time using high-resolution 3D image reconstructions. Fanny Girard (Ifremer).
- 16:40-17:30 Panel discussions.
- 19:00 *Conference dinner*

### Day 4 – 21/11/2019

- 9:00-10:00 Transversal themes and key issues for future international research. Plenary discussion and composition of writing groups - objectives and guidelines
- 10:00 – 12:30 Writing sessions in small groups
- 12:30 – 14:00 Lunch
- 14:00 – 16:00 Presentation of WG outlines. Wrapping up –publication plans and agenda for position paper preparation
- 18:00 *Optional – visit of wine cellars in Banyuls*



## Participant list

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# POSTER ABSTRACTS

- 1) A Global Classification of Chemosynthetic Biogeographical Provinces of the World: The role of the Arctic vents. *Lisette Victorero et al.*
- 2) From chimney to plume: characterizing organic ligands in hydrothermal systems. *Colleen L. Hoffman et al.*
- 3) Melt inclusions study of degassing metal fluxes at Rumble III volcano at Kermadec Arc. *Avrinder Singh Sandhu & Wolfgang Bach*
- 4) Characterizing the distribution of hydrothermal vent communities through space and time using high-resolution 3D image reconstructions. *Fanny Girard et al.*
- 5) Fluid inclusions in hydrothermal precipitates from the NW Caldera hydrothermal vent field, Brothers volcano: evidence for subcritical (and supercritical?) phase separation. *Diehl A., de Ronde C.E.J., Bach W.*
- 6) Assessment of Heavy Metal Pollution in the Sediments of Nizampatnam Bay - Lankevanidibba Coast, East Coast of India. *B. Lakshmana et al.*
- 7) Preliminary results of the morphostructural analysis of Mount Orca submarine volcano. *Osses G et al.*
- 8) Deep-sea environment filters for similar functional entities at inactive habitats whereas hydrothermal activity enhances functional richness on early colonization stages of meio- and macroinvertebrates. *JM Alfaro-Lucas et al.*
- 9) Are sponges living on the periphery of hydrothermal vents adapted to the vent environment? *Magdalena N. Georgieva et al.*
- 10) Hydrothermal activity along the eastern Southwest Indian Ridge (63°-68° E): evidence from Fe-Mn crusts. *L. Surya Prakash and P. John Kurian*
- 11) Structure and evolution of the George V Transform Fault, South-East Indian Ridge, 140°E, and implications for mantle dynamics. *Rim Jbara et al.*
- 12) The North Fiji Basin: Literature overview and evolution models. *Alysse Bebin and Seung-Sep Kim*
- 13) Integrated Numerical Modeling Approach for Hydrothermal Circulation at Seamounts. *Je-Hyun Song and Seung-Sep Kim*



## 1) A Global Classification of Chemosynthetic Biogeographical Provinces of the World: The role of the Arctic vents

Victorero L.<sup>1,2,3,4,5</sup>, Hilario A.<sup>4</sup> & Ramirez-Llodra E.<sup>5,6</sup>

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Current analyses of vent communities have defined 11 biogeographic provinces, but their validity is still under debate, with a notable lack of data from the deep Arctic basin. Despite data deficiencies, preliminary investigations have suggested that the remote deep Arctic ecosystems on the Gakkel Ridge could act as a contemporary or evolutionary pathway for larval dispersal between ocean basins. In 2019, the Hot Vents in an Ice-Covered Ocean (HACON) – project will conduct the first full-scale study of Arctic hydrothermal vents under permanent ice cover. This project will test the hypothesis that the Gakkel Ridge provides a connecting pathway between the Pacific and Atlantic oceans, acting as a stepping stone or a hybridisation zone, or if, on the contrary, its vent fauna has evolved in isolation and delimits its own biogeographic province. In order to assess the biogeographic role of the Arctic vents, we aim to produce an open-source global database, which will include species distribution and phylogenetic data for chemosynthetic macro- and megafauna. The basis of our data compilation will be obtained from ChEssBase and sFDvent databases, but in order to update and expand the existing records, we invite the international community to contribute species distribution and phylogenetic data from vents, cold seeps and whale falls. The second phase of the project will consist of a global biogeography analysis to determine the position of the Aurora vent community in a global biogeographic context. The results from the open-source database and the subsequent global analyses will improve upon the current landscape of deep-sea and chemosynthetic biogeographical provinces.



## 2) Characterizing organic ligands in hydrothermal plumes along the Mid-Atlantic Ridge

Colleen L. Hoffman<sup>1,2</sup>, Alastair Lough<sup>3</sup>, Maeve Lohan<sup>3,4</sup>, Alessandro Tagliabue<sup>5</sup>, Joseph Resing<sup>1,2</sup>,  
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In the surface ocean iron (Fe) is a growth-limiting nutrient for microorganisms, impacting their ability to remove carbon from the atmosphere and surface waters. While there are several sources of Fe to the ocean, hydrothermal vents are emerging as potentially significant and one that is insensitive to changes in climate. However, it is unknown whether deep ocean Fe can be stabilized long enough to reach the euphotic zone. Recent geochemical studies have demonstrated multiple potential mechanisms that would allow hydrothermally-derived Fe to be protected and transported within the buoyant and non-buoyant plume. However, whether hydrothermal vents impact the global Fe budget, particularly in the surface ocean, has been difficult to constrain, as the mechanisms for the sources and sinks of hydrothermal Fe are still poorly understood. As part of the 2018 FeRidge cruise, samples for trace metal and organic ligand analyses were collected at or around 11 known venting locations to identify and characterize organic ligands associated with Fe in hydrothermal fluids along the Mid-Atlantic Ridge. The binding strength and concentrations of organic Fe-binding ligands were quantified using competitive ligand exchange cathodic stripping voltammetry (CLE-ACSV) within the hydrothermal fluids and in the water column in the buoyant plume. Unique venting regimes (e.g. diffuse, alkaline, black smoker) were observed to have distinct excess total ligand values but similar excess strong ligand (L1) concentrations. The identity of these strong ligands was probed further using liquid chromatography coupled to inductively coupled plasma mass spectrometry and electron spray ionization mass spectrometry (LC-ICP/ESI-MS) in order to further characterize and identify the sources of organic ligands associated with Fe. This work suggests that organic complexation is unique in different venting sites, suggesting that the impact of organic matter in stabilizing hydrothermal Fe can vary depending on the venting regime.

### 3) Melt inclusions study of degassing metal fluxes at Rumble III volcano at Kermadec Arc

*Avrinder Singh Sandhu & Wolfgang Bach*

*University of Bremen*

The main agent of transport in Volcanic Massive Sulphides (VMS) is an aqueous fluid. However, there are evidences from volcanic compositions, geothermal systems and vapour-rich fluid inclusions that a magmatic vapour phase is an additional important source for the formation of such deposits. Melts that are affected by effective metal loss show depletion of such metals. This loss of metals from the melt is stored in the melt inclusions which are trapped by the crystallizing phases and hence act as a proxy to know about the degassing of elements. Basaltic andesite samples were collected from the Rumble III volcano at the Southern Kermadec arc. The hand specimen and also the thin sections show high vesicularity which record the magmatic history of the magma. Out of the four samples studied, only two samples had clear melt inclusions while daughter crystals were present in the melt inclusions of other two samples. Apart from plagioclase, other phases present are olivine and clinopyroxene. Temperature value calculated from olivine and clinopyroxene phenocrysts is about 1130 °C and a pressure value of about 1 kbar ( $\pm 1.5$  kbar). A volatile rich magma is indicated by high concentration of H<sub>2</sub>O wt % (average, 2.8 %), and Cl (0.21-0.38 wt %) present in the inclusions in phenocrysts of basaltic andesite. The composition of Sulphur and H<sub>2</sub>O of the melt inclusions is higher when compared to the composition of the same components in matrix glass. This difference in composition indicates degassing of these elements. However, metal degassing is not observed at this volcano. The concentration of volatile elements (Cu, Pb, Zn) in the matrix glass remains same as it is in the melt inclusions. Which implies, no metals escaped even though degassing occurred with sulphur and water. This could be because of the saturation of olivine-clinopyroxene-plagioclase prior to the saturation of magnetite which would inhibit the generation of metal hydrogen sulphides which preferably support the metals to partition and escape from the magma chamber. Therefore, under temperature values of 1130 °C, low pressure values (1kbar), and with crystallization of plagioclase-olivine-clinopyroxene phases, degassing of only very volatile components occurs and not of the metals.

#### 4) Characterizing the distribution of hydrothermal vent communities through space and time using high-resolution 3D image reconstructions

Fanny Girard<sup>1</sup>, Jozée Sarrazin<sup>1</sup>, Aurélien Arnaubec<sup>2</sup>, Mathilde Cannat<sup>3</sup>, Pierre-Marie Sarradin<sup>1</sup>, Benjamin Wheeler<sup>3</sup>, Marjolaine Matabos<sup>1</sup>

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Hydrothermal vent environments are characterized by strong environmental gradients that structure communities' spatial distribution. If the role of vent fluid temperature and chemical composition on species distribution is now well understood, the effects of the complex topography generally typical of sulfide edifices have rarely been investigated. Here, we used a novel approach combining 3D photogrammetric reconstruction, in situ environmental data and modeling to characterize assemblage distribution on the active edifice Eiffel Tower (Lucky Strike, Mid-Atlantic Ridge). We found that assemblage distribution along with hydrothermal activity varied with their position on the edifice. Distance from fluid exits could explain the distribution of most assemblages, while physical terrain variables only played a minor role. However, these variables failed to predict the distributions of medium-sized *Bathymodiolus azoricus* mussel assemblages and microbial mats, the dominant assemblages on the edifice. Using data on bottom currents, bathymetry and fluid exit locations, we modeled the dispersion of hydrothermal plumes around the edifice, and showed that assemblages located meters away from smokers could be exposed to plume material. In particular, we demonstrated that differential exposure to currents bringing plume discharge from neighboring vents could explain differences in mussel size and fully accounted for the distribution of microbial mats on the edifice. These results suggest that the interaction between bottom currents, topography and smoker location should be considered as important structuring factors at vents and considered in future spatial and temporal studies. The novel non-destructive approach presented here is particularly well suited for monitoring hydrothermal edifices or any environment where topography and currents interact to form complex oceanographic patterns.

## 5) Fluid inclusions in hydrothermal precipitates from the NW Caldera hydrothermal vent field, Brothers volcano: evidence for subcritical (and supercritical?) phase separation

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At the NW Caldera hydrothermal vent field of Brothers volcano, southern Kermadec arc, seawater-dominated black smoker-type hydrothermal vents form a large vent area extending from near the caldera floor (~1,700 mbsl) up to the crater rim (~1,300 mbsl). The vent field is situated within an area occupied by several fault scarps that expose an underlying stockwork zone. The common occurrence of sulfate mineralization in chimneys and host rock to the stockwork has allowed us to conduct microthermometric studies on samples collected during two research expeditions (R/V Sonne SO253 and R/V Thompson TN350).

Fluid inclusions were investigated in anhydrite, barite and quartz recovered from chimneys and stockwork rocks.  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios were determined in sulfates/bulk-rock samples using thermal ionization mass spectrometry (TIMS).

We calculated isobaric-isenthalpic mixing trends between co-existing subcritically phase-separated vapors and brines with seawater considering temperature, salinity and  $^{87}\text{Sr}/^{86}\text{Sr}$ , and found a common process of phase separation affecting buoyant hydrothermal fluids at temperatures and pressures of ~350 °C and ~170 bar. Our modelling shows that the vast majority of fluid inclusion salinities and formation temperatures are consistent with boiling fluids ascending beneath the NW Caldera site to some 10s mbsf within the caldera wall. A small subset of fluid inclusions does not fall on these mixing trends. Mixing models between co-existing supercritically phase separated fluids (at depths between 1200 and 1700 mbsl) and seawater can explain the temperature salinity variations in these inclusions. Our data suggest that subcritical phase separation occurs as a ubiquitous feature, whereas potential supercritical phase separation is a transient feature within the NW Caldera wall vent field. These results provide insights into growth conditions and mixing regimes during the formation of gangue minerals in submarine arc hydrothermal vents and their underlying stockwork.

## **6) Assessment of Heavy Metal Pollution in the Sediments of Nizampatnam Bay - Lankevanidibba Coast, East Coast of India**

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The concentrations of Pb (ppm), Zn (ppm), Mn (ppm), Ni (ppm), Fe (ppm), Cd (ppm), Cu (ppm), Cr (ppm) elements in the 30 bottom sediments were studied in an attempt to establish their concentration in the study area. It revealed that the majority of the heavy metals elements have been introduced anthropogenically into the Nizampatnam Bay - Lankevanidibba Coast, East Coast of India. The river inflows that are also affected by the of industrial, ship breaking yard, gas production plant, and urban wastes. The concentration of heavy metals was measured using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) (Perki Elmer; Model: Optima 14300DV). The highest concentrations for several heavy elements were thus recorded which generally decrease with distance from the coast. It was observed that the heavy metal concentrations in the sediments generally met the criteria of international marine sediment quality. Similarly, sediment pollution assessment was done using the Geoaccumulation Index (Igeo), Enrichment Factor (EF), and Pollution Load Index (PLI). The values suggested the elevation of some metal concentration in the region is a source sign of marine pollution. Continuous monitoring of the study area, sediment with a view to minimize the risk of health of the population and the detriment impacts on the aquatic ecosystem is mandatory.

Keywords: Bottom Sediments, Heavy metals, ICP-OES, Igeo, EF, PLI, Ecosystem.

## 7) Preliminary results of the morphostructural analysis of Mount Orca submarine volcano

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It is important to study in depth the morphostructural characteristics involved in underwater volcanism in order to understand the evolution of these volcanic centers with respect to their tectonic environment. Particularly, this study focuses on the Mount Orca submarine volcano, which is located at the Bransfield Strait (Antarctica), facing King George Island, and whose volcanic build reaches 650m high over a platform at 1340m deep, although the tectonic framework of the area is quite interesting, the interaction between three plates (Nazca, Scotia and Antarctic), the structural system that controls volcanism is unknown, mainly due to technological limitations or difficulty of access.

This work presents a preliminary characterization of the morphology and structures associated with this underwater mount, through the digital elevation models obtained during the ANTARXXVI campaign with an EM 122 multibeam ecosystem and analyzed with CARIS Easy View and ArcMap 10.3, with the In order to identify different events and tectonic processes within the strait, their relationship with the activity of the different plates involved and how they have influenced volcanism in the area. In-depth knowledge of the morphostructural characteristics of this submarine volcano will better understand the volcanic location in the oceanic crust and its relationship with the tectonic environment.

This project was carried out thanks to INGEMMET and the BAP Carrasco crew during the ANTARXXVI campaign.

## **8) Deep-sea environment filters for similar functional entities at inactive habitats whereas hydrothermal activity enhances functional richness on early colonization stages of meio- and macroinvertebrates**

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Little is known on the effects of productivity and environmental stress on early community assembly processes in the deep sea. Here we studied the colonization of substrata deployed along a hydrothermal vent gradient by meio- and macroinvertebrates, at two hydrothermally active and inactive areas at 1700 m depth in the Lucky Strike vent field. We expected (1) hydrothermal activity to constrain functional diversity, (2) to find more similar composition and structure of species and functional entities within active and inactive sites, respectively, and (3) to reveal different mechanisms driving  $\beta$ -diversity for meio- and macroinvertebrates due to the lower specialization of little fauna. However, we observed that hydrothermal activity enhanced functional richness and that environment at some inactive sites filtered for specific traits reducing functional richness despite high species diversity. Compositional and functional turnover drove the low dissimilarity between active sites for meio- and macrofauna. Unexpectedly, the exclusive species and functional entities associated to particular inactive sites led to a high turnover between these sites producing some of the highest  $\beta$ -diversities in general. In consequence, some inactive sites contributed more than expected to the total species and functional  $\beta$ -diversity for both meio- and macrofauna. Overall, compositional and functional nestedness were more important in meio- than in macrofauna partially supporting our hypotheses. We found evidence of productivity at active sites to support more energetically-expensive traits and that some of this productivity may be exported to inactive assemblages. We arise awareness that inactive areas may be especially sensible to potentially environmental changes such those produced by mining or other anthropogenic-induced impacts.

## 9) Are sponges living on the periphery of hydrothermal vents adapted to the vent environment?

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During Earth history, hydrothermal vents have been continually colonised by various animal lineages that were not previously adapted to the vent environment, such as bathymodiolin mussels which diversified at vents within the last 50 million years. While modern day vents host highly-specialised metazoans that are already vent-adapted, for abundant taxa often observed living on the periphery of hydrothermal vents it is not clear in what way they might be benefitting from vent environments. Could these lineages also be demonstrating adaptation to vents? This effect may be enhanced at seafloor settings such as back-arc basins that create new but often geologically short-lived vents, which may act to promote the adaptation of previously non-vent-adapted animal lineages to the vent environment. This study aims to explore whether two types of distantly-related sponges living on the periphery of active hydrothermal vents at two distinct geological settings (*Cladorhiza* sp. from the East Scotia Ridge and *Polymastiidae* sp. from the Juan de Fuca Ridge), are exhibiting signs of adaptation to vent environments. This was explored through the use of phylogenetics to assess evolutionary history, the examination of sponge microbiomes to determine if the sponges may be associating with vent-specific microbes and their functional roles, and isotopic analysis to determine sources of sponge nutrition. Our preliminary results indicate that *Cladorhiza* sp. individuals contain abundant gammaproteobacteria closely related to chemoautotrophic symbionts of bathymodiolin mussels, while a vent-specific microbiome signal was not observed for the other sponge, identified as *Spinularia* sp. Additional insights into vent adaptation from phylogenetics, functional analysis of microbiomes and isotopic analyses will be discussed to shed insights into the relationship between the sponges and their vent-peripheral habitat, as well as the process of metazoan adaptation to vents.

## **10) Hydrothermal activity along the eastern Southwest Indian Ridge (63°-68° E): evidence from Fe-Mn crusts**

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Till date no hydrothermal activity is reported from the ultra-slow spreading eastern (from 63°-68° E) Southwest Indian Ridge (SWIR). Ferromanganese crusts from SWIR are studied for the first time to identify evidences of seafloor hydrothermal activity and also for their genesis. The high concentrations of iron, manganese cobalt, nickel, copper, zinc and REE in these crusts suggest that they are of hydrogenous origin (formed from the seawater). Although the high REE concentrations are of typical hydrogenous nature, few crusts are characterized by the negative cerium anomalies ( $Ce/Ce^* \leq 1$ ) in the shale normalized REE pattern. This is a clear indication of possible influence of hydrothermal activity. The excess cerium (Cexs) is calculated to quantify the degree of decoupling of Ce from its strictly trivalent REE. The relatively low concentrations of cerium and Cexs/Cebulk ratios ( $\sim 0.8$ ) suggest that these crusts were under influence of hydrothermal plumes. The high REE fractionation (chondrite normalized ratio of Nd/Yb = 2.5 to 4.0) with negative cerium anomalies confirms the presence of high temperature hydrothermal plume fall-out in these crusts. End-member mixing model of cerium anomaly is established to quantify the contribution of hydrothermal plumes. Based on the Ce mixing calculations, it is estimated that the hydrothermal contribution to these crusts may be about 70-80%. The present study provides evidences for the hydrothermal activity in the less studied SWIR and suggests the possibility of high temperature hydrothermal venting in ultra-slow spreading SWIR.

## 11) Structure and evolution of the George V Transform Fault, South-East Indian Ridge, 140°E, and implications for mantle dynamics

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The 300 km offset George V Transform Fault (TF) is the westernmost of the major, right-stepping transform faults that offset the South-East Indian Ridge between 140°E and 155°E. These TFs have multiple shear zones with intra-transform ridge segments (ITRS). The data collected during the STORM cruise (South Tasmania Ocean Ridge and Mantle) reveal a complex interaction between tectonic and volcanic processes at the plate boundary. The western TF shear zone consists of two segments offset by a 50 km-long, 15 km-wide, up to 2000 m-high massif including ultramafic breccia with serpentine. We infer that the massif results from transpression along the transform, due to the lengthening of the western ITRS, with a mechanism similar to the processes currently uplifting the mylonitic massif along the St. Paul TF in the Equatorial Atlantic (1). Boulart et al. (2) report evidence for active hydrothermal venting along the 130°-140°E section of the SEIR and more precisely a low-temperature hydrothermal circulation along the uplifted massif with a CH<sub>4</sub> anomaly suggesting water circulation in ultramafic rocks.

The western ITRS is relatively shallow and magmatically robust, which is very unexpected as TF systems are generally associated to low magma supply. The bathymetric and backscatter maps also reveal a series of recent off-axis oblique volcanic ridges, where picrites have been sampled. These observations suggest that the TF there is not magma starved like many mid-ocean ridge transforms, but is the locus of significant primitive melt supply, which we infer might be related to the presence of a mantle thermal anomaly beneath the easternmost SEIR, and/or to a western flow of mantle across the TF. We use satellite-derived gravity maps to trace the evolution of the TF system.

(1) Maia et al. 2016 Nature Geo. doi :10.1038/ngeo2759

(2) Boulart, C., et al. 2017 Geochem. Geophys. Geosyst., doi:10.1002/2016GC006683.



## 12) The North Fiji Basin: Literature overview and evolution models

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The North Fiji Basin (NFB), a back-arc basin situated between the Australian and Pacific plates, was the target of intensive oceangoing expeditions between the 1970s and the 1990s. However, since then, research in this area has stalled and few new datasets have been acquired.

Previous studies date the formation of the basin back to 10 Ma. Since then, the NFB has quickly expanded and evolved. Different evolution models have been proposed and improved upon since the early 1970s, and the most up-to-date tectonic models were published in 1993 and 1995. In order to examine the viability of these proposed evolution models, we have utilized a new global bathymetry and vertical gravity gradient to map out the regional tectonic structures of the NFB and the Gplates software to model the evolution of the NFB. From this experiment, we were able to provide a timed tectonic evolution of the NFB compatible with previous models and global plate rotation history, as well as identify the areas where further research is needed to fully understand the evolution of the NFB.

A 2016 expedition conducted by the KIOST acquired new near-bottom high-resolution data on the Central Spreading Ridge of the NFB, sparking new interest in the complex area. New bathymetry, shipboard and remotely operated vehicle (ROV) magnetic data on parts of the CSR show circular depressions on the ridge axis of unknown origin. The data are being processed to constrain an explanation for these depressions.

### **13) Integrated Numerical Modeling Approach for Hydrothermal Circulation at Seamounts**

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Heat is continuously escaping from the interior of Earth since its inception. According to previous studies, considerable amount of heat flow is accommodated through oceanic plates. In particular, hydrothermal circulation at ridge flanks is responsible for more than 30% of the heat flow. Recent researches have also demonstrated that hydrothermal circulation can occur actively through highly permeable basaltic seamounts. The seamounts protrude above the impermeable sediment and are therefore a major escape route for heat and fluids. In addition, ridge-flank circulation extracts heat advectively from most of the seafloor through large-scale lateral flow up to a mean crustal age of 65 Ma, whereas hydrothermal circulation through seamounts contribute to a local to regional influence.

In this study, we focus on hydrothermal circulation at seamounts, which can constitute a significant fraction of lithospheric heat loss. Therefore, we aim to numerically model the mechanism of the hydrothermal circulation occurring in and around the highly permeable seamounts. In addition, the structure of seamounts will be composed of dense-core and edifice layers in order to approximate the geological inner structure of seamounts. The presence of dense-core body will interfere with fluid circulation and hence may contribute to focusing or diffusing outward flow patterns at seamount surface. In this presentation, we compare the various numerical model set-ups for hydrothermal circulation at seamounts and propose our new geologic concept of numerical seamount model.





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