Annual SCOR Working Group Report to SCOR

1. Name of group

WG135_Hydrothermal energy transfer and its impact on the ocean carbon cycle

2. Activities since previous report to SCOR (e.g., virtual or in-person meetings, email discussions, special sessions). Limit 1000 words

Email discussions to finalize the last review paper.

3. Documents published since previous report to SCOR (e.g., peer-reviewed journal articles, reports, Web pages) and should be limited to publications that resulted directly from WG activities and which acknowledge SCOR support

German et al. 2015 - German, C.R., Legendre, L.L., Sander, S.G., Niquil, N., Luther, G.W., Bharati, L., Han, X., Le Bris, N., 2015. Hydrothermal Fe cycling and deep ocean organic carbon scavenging: Model-based evidence for significant POC supply to seafloor sediments. Earth and Planetary Science Letters 419, 143–153. doi:10.1016/j.epsl.2015.03.012)

2nd review submission planned for the last review by the end of 2017.

4. Progress toward achieving group's terms of reference. List each term of reference separately and describe progress on each one. Limit 1000 words

Terms of references of the WG were:
・*to synthesize current knowledge of mechanisms and rates of chemosynthetic carbon fixation and transfer of phytoplankton-limiting micronutrients to the open ocean*
・*to integrate these findings into conceptual models of energy transfer and carbon cycling through hydrothermal systems in view of a future assessment of the contribution of these systems to the global-ocean carbon cycle*
・*to identify critical gaps in quantification of the impact of deep-sea hydrothermal systems on ocean carbon cycles and to propose a strategy for future field, laboratory, experimental and/or theoretical studies to bridge these gaps.*

WG135 had 3 internal meetings during its formal 4-year lifetime.
- 1rst meeting in Woods Hole, USA, 23-24/11/2009 at WHOI. We discussed the Terms of Reference, agreed on the agenda of activities, and set priorities for 1-2 position papers and organize multidisciplinary writing sub-groups, defined our interface with other major international initiatives.

- 2nd meeting in Hangzhou, 10-11/10/2011 at the Second Institute of Oceanography, State Oceanic

Administration of China. We discussed the two WG review papers that aimed at synthesizing knowledge on: 1) carbon fixation processes at the seafloor and shallow subseafloor and the contribution of the different biological pathways in ecosystem primary production, 2) export of iron from the subseafloor to the upper ocean and the related impact of vent emissions on ocean carbon budgets. The second objective was to discuss the integration of this information into conceptual models aimed to address the role of ridge hydrothermal systems on ocean C biogeochemistry on a more quantitative basis.

- **3rd meeting in Vienna, Austria**, **28/04/2014** at the European Geosciences Union General Assembly 2014. The primary aim of the meeting was to discuss the progress of review papers. In addition to synthesizing the current knowledge, the aim of this review is to identify gaps, which will justify the development of a large scale in situ interdisciplinary experiments and the necessary adaptation of instruments and methods to the particularly extreme conditions of these deep-sea environments in the upcoming years. The second aim was to engage young scientists in the WG activities. 3 of them have been supported to attend the meeting and associated session at EGU.

A session was organized a the General Assembly 2014 Vienna | Austria | 27 April – 02 May 2014
EGU BG7.2 '*Hydrothermal energy transfer and its relation to ocean carbon cycling: mechanisms and rates to services for marine ecosystems'* Convener: Nadine Le Bris Co-Convener: Chris German
15 communications have been presented as part of this session.

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

Ridge Flank Hydrothermal Systems and their relationship to the oceanic carbon cycle. Katrina Edwards

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

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

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

Environmental controls on chemoautotrophic primary producers at deep-sea vents
Nadine Le Bris, Lauren Mullineaux, and Stefan Sievert

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

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

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

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

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

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

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

Hydrothermal energy transfer and contribution to autotrophic CO2 fixation down sediment core in Central Indian Basin. Anindita Das and LokaBharathi P.A.

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

5. WG activities planned for the coming year. Limit 500 words

Submit the review paper **'Hydrothermal energy transfer and organic carbon production on the deep-seafloor'** N. Le Bris, P.A. LokaBharathi, M. Yücel, A. Das, and the SCOR WG135

A complete draft text has been circulated recently to the WG members. The paper is planned to be submitted to Frontiers in Marine Science by end of October.

Abstract: *Over the last 4 decades, hundreds of deep-sea hydrothermal vents vent fields hosting outstanding densities of symbiont-bearing invertebrates have been discovered widely distributed over the ocean floor. Biomasses of tens of Kg per square meter have attracted attention on their potential role to larger deep-ocean scales. Their contribution to the labile organic resources available to deep-sea biota over large oligotrophic areas is yet poorly constrained. Despite intensifying observation and experimentation efforts, and the advent of molecular techniques and in situ technologies, the factors that drive the capacity of seafloor communities to convert hydrothermally-driven chemical energy into biomass, are largely unknown. The review points out the complex mechanisms governing energy transfer, bridging subseafloor and seafloor processes, and their tight linkages with the turnover of primary producers associated with instable hydrothermal systems, in diverse geologically settings. Thermodynamics has been applied to estimate the most energetic reactions available for chemolithotrophs for a given high-temperature end-member fluid (EMF) at different mixing ratios with seawater (SW/EMF). Purely abiotic considerations however does not account for 1) abiotic constraints on microbes able to use these energy sources, 2) non-conservative processes that might limit or enhance of the available energy in different thermal niches. Here, we revisit the factors modulating the efficiency of the biological conversion of inorganic energy into organic carbon resources, from a refined conceptual model of diffuse flows. The first section of this paper synthesizes our current knowledge of the diversity of 'geofuels' transported to the ocean floor. The second section emphasizes the capabilities of vent biota to scavenge this energy, through the microbial CO_2-fixation. Adding environmental filtering to these geophysical and biological drivers, we discuss the factors that might favor biomass production in free-living, endo- or ecto-symbiotic modes. Current knowledge of habitat properties highlight contrasted abiotic constraints on primary producers for the two types of diffuse flows generated by the hydrothermal convection double-loop. On this basis, we discuss the potential for sustained organic matter production and export accounting for successive biomass-dominant*

producers stages in the light of the natural instability of hydrothermal ecosystems, from pioneer to climax vent communities of exceptional productivity to long-term low-activity systems. We conclude that a conceptual model of energy transfer and organic carbon production should be set on relevant temporal bases and crucially requires further studies and observations, considering the large diversity of geological settings, particularly on ABA, and wide range of environmental instabilities.

6. Is the group having difficulties expected in achieving terms of reference or meeting original time schedule? If so, why, and what is being done to address the difficulties Limit 200 words

WG networking activities have ceased in 2015 after the publication of one of the review papers
The outline of the second review had been drafted in June 2014, with the paper structure and lead authors identified. Yet, the completion of this plan faced difficulties due to the availability of lead authors. The SCOR Steering Committee has allowed to expand the time schedule to finalization of this second review ''**Hydrothermal energy transfer and organic carbon production on the deep-seafloor'**. The draft version currently transmitted to the WG members was written by a small group, including 2 of the young scientists invited to the EGU dedicated session has drafted the review and we are currently in the last stage of this process (see above).

Difficulties in completing the initial workplan were mostly due to the commitments of WG members in the leadership of several research programmes at the time the working group started its activities (i.e. US-GEOTRACE, TAIGA, SYMBIOMICS, IODP-CDEBI) and a number of collaborative projects and cruises. Those projects had foci relevant to the WG theme and have produced a number of published items. Through not strictly an outcome of the WG, interdisciplinary discussions have undoubtedly benefited those works and led to international collaborations as illustrated by the following papers published:

German CR *et al*. 2016 Hydrothermal impacts on trace element and isotope ocean biogeochemistry. *Phil. Trans. R. Soc. A* **374**: 20160035. http://dx.doi.org/10.1098/rsta.2016.0035
German, C.R., Seyfried, W.E., 2014. Hydrothermal Processes, in:Treatise on Geochemistry.Elsevier, pp.191-233.
Nakamura, K., Takai, K., 2015. Geochemical Constraints on Potential Biomass Sustained by Subseafloor Water–Rock Interactions, in: Ishibashi, J., Okino, K., Sunamura, M. (Eds.), Subseafloor Biosphere Linked to Hydrothermal Systems. Springer Japan, Tokyo, pp. 11–30.
Takai, K., Nakagawa, S., Reysenbach, A.-L., Hoek, J., 2006. Microbial ecology of mid-ocean ridges and back-arc basins, in: Christie, D.M., Fisher, C.R., Lee, S.-M., Givens, S. (Eds.), Geophysical Monograph Series. American Geophysical Union, Washington, D. C., pp. 185–213.

Multiple options to coordinate a workshop have been explored but proved impossible in terms of availability of suitable venues in Europe at dates that did not conflict with the organisers' own schedules and/or other IR-related events.

7. Any special comments or requests to SCOR. Limit 100 words.

Our ultimate goal was to define a roadmap for a large-scale international initiatives and make propositions for capacity building and developing coordination. The WG could not formely achieve this goal but have provided inspiration and collaborations in several large programmes (e.g. GEOTRACE) and are continuing to do so through international initiatives dedicated to the deep ocean ecosystems and their functional role: DOSI the deep-ocean Stewardship initiative, and the DOOS (Deep Ocean Observing Strategy) as part of GOOS.

Additional information can be submitted and will be included in the background book for the SCOR meeting at the discretion of the SCOR Executive Committee Reporter for the WG and the SCOR Secretariat.