PROPOSITION DE SUJET DE THESE

Formulaire demande de financement : ARED - ISblue – Etablissement(s) - …

pour dépôt sur le serveur **SML — TEBL (doctorat-bretagneloire.fr)** *au format PDF*

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Acronyme : MICYFER

Présentation de l'établissement porteur (bénéficiaire de l'aide régionale)

Établissement porteur du projet : UBO ☐ UBS ☐ Institut Agro Rennes ☐ Ifremer ☒

IMTA ☐ ENSTA ☐ ENIB ☐

Ecole Doctorale : EDSML ☒

SPI BZH ☐ SPIN ☐ MATHSTIC Bretagne Océane ☐ pour les projets ISblue ☐

Identification du projet

Intitulé du projet	**Influence of hydrothermal activity on microbial communities involved in the iron cycle and interactions with minerals.**

Demande d'ARED

Se reporter à la notice ARED Région Bretagne et préciser :

Priorité régionale	OUI
DIS	1
Levier thématique	6
DIS secondaire	1
Levier thématique secondaire	5
Axe transversal	Transition environnementale et écologique

Organisme de tutelle : encadrement et unité de recherche

Porteur du projet HDR

Date obtention de l'HDR	Novembre 2007
Nom	CAMBON
Prénom	Marie-Anne

Unité de recherche	**Biologie et Ecologie des Ecosystèmes marins Profonds, BEEP, IUEM, Plouzané**
Adresse électronique	**Marie.Anne.Cambon@ifremer.fr**
Tel	**02 98 22 47 56**
Expérience d'encadrement	**Iván Hernández Ávila**, 2013-2016, co endadrement F. Pradillon: « Dispersion larvaire et cycles de vie en milieu profond ». Chercheur Université Autonome del Carmen, Campeche, Mexique **Vincent Apremont**, 2014-1017 co encadrement M. Zbinden « Etude des symbioses chez les Alvinocaridae, fonctionnement et adaptation aux variations physico-chimiques de l'environnement ». **Pierre Methou** 2016-2019, co endadrement F. Pradillon. « Cycle de vie de la crevette hydrothermale *Rimicaris exoculata*, de l'embryon au recrutement des juvéniles ». Post doctorat au Jamstec, Japon (3 ans) **Valérie Cueff-Gauchard**, 2019-2023 en cours. « Fonctionnement des communautés symbiotiques chez la crevette hydrothermale Rimicaris sp. par approches *in situ*». Collaboration with B Shillito. Ingénieure Ifremer **Marion Guéganton**, 2019-2023, co encadrement F. Pradillon. « Acquisition des partenaires symbiotiques: modalités et conséquences sur l'établissement, la distribution et l'écologie des sources hydrothermales ». En cours **Alicia Veuillot** 2021-2024, co-encadrement J Sarrazin et F Pradillon « Processus de COLONisation en périphérie des sources hydrothermales : Zones potentiellement convoitées pour leurs rEssources minérales ». En cours

Unité de recherche

Nom de l'unité	Laboratoire de Biologie et Ecologie des Ecosystèmes marins Profonds
Acronyme de l'Unité (umr xx, ….)	BEEP UMR9167
Nom et prénom du responsable	SARRADIN Pierre-Marie
Le cas échéant, nom de l'équipe de recherche	
Le cas échéant, nom du responsable de l'équipe de recherche	

Co-directeur de thèse – si nécessaire

Nom	
Prénom	
Unité de recherche	

Etablissement de tutelle	
Expérience d'encadrement	

Co-encadrant (s) de thèse – si nécessaire

Nom	MIESZKIN
Prénom	Sophie
Unité de recherche	**Biologie et Ecologie des Ecosystèmes marins Profonds, BEEP, IUEM, Plouzané**
Etablissement de tutelle	UBO
Expérience d'encadrement	**Eva Pouder**. Etudiante en thèse de l'université de Bretagne Occidentale. Financement UBO EDSML. Thèse co-dirigée par Karine Alain (40%) et moi-même (60%) (UMR6197). Sujet : Microorganismes impliqués dans le cycle du fer en contexte hydrothermal profond et chaud : diversité taxonomique, physiologique et fonctionnelle ». 1 er Octobre 2021 -> fin prévue en octobre 2024.

Nom	
Prénom	
Unité de recherche	
Etablissement de tutelle	
Expérience d'encadrement	

Description du projet : complément

Lieu principal de déroulement du projet en Bretagne : UBO, IUEM, UMR 6197 BEEP

Lieu principal de déroulement du projet si hors Bretagne :

Libellé (attention veiller à respecter le nombre de caractères imposés par le serveur de la Région)

Résumé synthétique du projet (2 000 caractères maximum)

In front of the **increasing societal demand for deep-sea mining and the future potential exploitation of the deep-sea mineral resources**, it is of importance **to better understand the contribution of the microbial compartment on the mineral alteration processes that can participate to the modification of the nature of mineral resources in active (with fluid outflow) and inactive (with no fluid outflow) deep-sea hydrothermal sites**. Active deep-sea hydrothermal vents emit fluids that are hot, anoxic, reduced and loaded with dissolved gases and metal ions. Hydrothermal deposits are then formed by successive precipitations of minerals present in the fluid when it mixes with the surrounding seawater. Overall, deep-sea hydrothermal vent sites are characterized by hard Seafloor Massive Sulfide (SMS) deposits enriched with a high content of base metals (iron (Fe), zinc, lead, and copper), sulfides and rare elements. Since several decades, these SMS deposits are attractive to mining companies that are encouraged by the increasing demand for mineral raw materials due to constant population growth, technological advance, and the transition to a low-carbon economy**. Despite the significant scientific resources deployed to study these deep-sea ecosystems**, **considerable efforts are needed to better characterize**

them and to anticipate the impact of future mining exploitations. Among metals present in SMS, **Fe is found at significant concentrations** in sulfide minerals and is involved in the energy metabolism of, still relatively unexplored microbial communities, as electron donor (Fe^{2+}) or acceptor (Fe^{3+}). However, these **microorganisms are among the dominant key players in hydrothermal ecosystems and their metabolic activity interacts with the surrounding environments affecting the formation and alteration of minerals**. Interestingly, there is to date, less information available regarding inactive SMS deposits (microbial diversity and microbe-mineral interactions) compared to active SMS deposits, while they are far more abundant.

The main aim of this thesis will be to improve our knowledge of active *versus* inactive deep-sea hydrothermal vent influence on the diversity and functions of microbial communities involved in the iron cycle and more broadly on the alteration of iron-rich minerals.

Hypothèses, questions posées, points de blocage, approche méthodologique, technique (4 000 caractères maximum)

Hypothesis: **active deep-sea hydrothermal vent has an impact on the taxonomic and functional structure of microbial communities involved in the iron cycle, therefore modifying the nature of minerals**.

There are 3 main questions :

1- What is the effect of the hydrothermal fluid level of activity (active *versus* inactive vent) on the diversity of microorganisms involved in the Fe-cycle?
2- What is the effect of the hydrothermal fluid on the activity rate of Fe microbial communities?
3- How do microorganisms interact with Fe-rich minerals?

The thesis will be supported by BICOSE3 cruise (20 Oct - 5 Dec 2023; MA. CAMBON chief scientist). This cruise will explore two hydrothermal fields located on the Mid-Atlantic Ridge (TAG hydrothermal vent fields). Some samples are also available in the lab and have been collected on TAG site during 2022 summer cruise HERMINE2.

The main technical challenge will be the last objective because visualization of microorganisms and their interactions with Fe-rich minerals will be a time-consuming step associated with a long period of development. However, BEEP laboratory own the microscopy skills and we have at our disposal different techniques and technologies in microscopy. The first objective is at low risk as BEEP own strong skills in meta-omics and knowledge on studying microbial communities from these ecosystems. The second objective is also at low risk as it relies on an experiment that is mastered in BEEP.

To answer our 3 main questions, we will apply an original and pluridisciplinary approach that combines omics analyses, geomicrobiology, activity rate measurements and microscopy.

<u>Step 1:</u> What is the effect of the hydrothermal fluid level of activity on the diversity of microorganisms involved in the Fe-cycle?

From the BICOSE3 cruise, sampling within the TAG hydrothermal site will be performed to collect 3 fragments of active hydrothermal chimney (reduced conditions), and 3 fragments of inactive hydrothermal chimney (oxidized conditions) subject (or have been subjected -for inactive chimneys-) to the same end-member hydrothermal fluid, to compare the microbial communities (at the meter scale) according to the mineralogy of active *versus* inactive chimney. In addition, the oxidized outer-part and the reduced-inner part of the active and inactive chimneys will be also compared to access the taxonomic and functional diversity within the sample (at the cm scale).

For each sample, taxonomic and functional diversity of microbial communities involved in the Fe-cycle will be investigated by performing: **(i) metabarcoding** targeting 16S rRNA gene sequences of *Bacteria* and of *Archaea*, and **(ii) metagenomic** analyses. *In situ* and *ex situ* physico-chemical parameters will be also measured as well as mineralogical information will be retrieved allowing to make correlations between microorganism's abundance and the physico-chemical parameters of this ecosystem.

<u>Step 2: To evaluate activity rate measurements</u>

To determine the contribution of Fe^{3+}-reducing and Fe^{2+}-oxidizing communities to the *in situ* microbial autotrophic and heterotrophic production at hydrothermal ecosystems, shipboard measurements (BICOSE3 cruise) of C fixation rates will be performed at *in situ* conditions (pressure and temperature) with and without supplementation of Fe^{2+} and Fe^{3+} (mM range). Fluids will be collected and coupled to the use of very small amounts of radiolabeled substrates ([^{3}H]-leucine, ^{14}C-bicarbonate) to measure C fixation rate.

Step 3: To visualize microbial assemblages

Microbial assemblages and their interactions with Fe-rich minerals will be visualized by using imagery techniques such as Deposition Fluorescence *In Situ* Hybridization (FISH) in combination with observations by epifluorescence and/or confocal microscopy and SEM. If the signal released by the probes needs to be amplified to better visualize the microorganisms, we will also use the Catalyzed Reporter Deposition Fluorescence *In Situ* Hybridization (CARD-FISH) technique.

Environnement scientifique, positionnement dans contexte régional/national/international (2 000 caractères maximum)

The BEEP laboratory masters the culture of anaerobic microorganisms and notably iron-reducers and iron-oxidizers, as well as omics approaches. Indeed the joint research unit BEEP is composed of microbiologists, bioinformaticians and biochemists.

At the international level, this work will be carried out in collaboration with the the Key Laboratory of Marine Biogenetic Resources (KLAMBR) of the Third Institute of Oceanography (TIO) State Oceanic Administration (SOA) of Xiamen (directed by prof. Zongze SHAO) (China), within the framework of the International Franco-Chinese Associated Laboratory MicrobSea (IRP 1211), which associates BEEP with (IRP 1211 Microbsea led by Dr. Karine ALAIN and Pr. Zongze SHAO).

At the regional level, this project is part of theme 2 (Ocean-Earth Interactions) of the EUR ISBlue (Interdisciplinary Graduate School for the blue planet).

At the local scale, we will collaborate with a mineralogical expert and specialist in isotopic geochemistry of metals of the UMR Geo-Oceans (Dr. Olivier Rouxel, UMR 6538).

Collaborations scientifiques (nature/partenariat/pays) et partenariat socio-économique envisagé

As detailed above, at the international level, this project will take place within the framework of the Franco-Chinese International Associated Laboratory Microbsea and will strengthen the links between the joint research unit BEEP and the Chinese partner KLAMBR of the 3rd Institute of Oceanography of Xiamen directed by Zongze Shao.

At the national scale, we will collaborate with Dr. Olivier Rouxel (geochemist from Geo-Ocean, UMR 6538) who is a mineralogical expert and a specialist in isotopic geochemistry of iron with whom we are collaborating in the frame of the ANR JCJC IRON2MI 'The IRON cycle in deep-sea hydrothermal vents: contribution of iron-reducing and iron-oxidizing MIcroorganisms and impact on MInerals alteration' (oct. 2022 – sept.2026), coordinator S. Mieszkin. BEEP and Geo-Ocean partners are also co-involved in a PPR Ocean & Climate project with a component on the theme of this thesis project (Project LIFEDEEPER: Living together in Future: vulnerability of DEEP-sea ecosystems facing potential mineral Resources exploitation; coordinator: Dr. Marie-Anne CAMBON).

Pour les demandes Région Bretagne

Adéquation du projet avec le DIS de Rattachement
Pour les demandes Région Bretagne (3 000 caractères maximum)

This thesis project is mainly in line with the **DIS 1 'Maritime economy for a blue growth'** and the **transversal axis 'Environmental and ecological transitions'**. Indeed, SMS deposits from deep-sea hydrothermal ecosystems are attractive to mining companies that are encouraged by the increasing demand for mineral raw materials due to constant population growth, technological advance, and the transition to a low-carbon economy. However, despite the significant scientific resources deployed to study these deep-sea ecosystems, considerable efforts are needed to better characterize them and to anticipate the impact of future mining exploitations. Thus, this thesis project will provide elements to the society to better manage these mineral resources and thus to enter into a process of sustainable management of these ecosystems that is mandatory to perform the transition to a low-carbon economy. In addition, the project fit also well with **the thematic lever** 'marine bioresources and biotechnologies' as this project focuses on the role of microorganisms in the alteration of minerals. Indeed, microorganisms involved in minerals alteration will be targeted and metabolic pathways will be studied.

Si priorité régionale, préciser (2000 caractères maximum)

The study of deep-sea ecosystems, and in particular the study of the role of hydrothermal vent activity on microbial communities and their interactions with minerals, can also be part of a **regional priority (mitigation and/or adaptation to climate change)** with the objective of valorization of natural resources (microorganisms and minerals) of a singular ecosystem (i.e. deep marine hydrothermal environment) that can have an indirect effect on the sequestration of CO2 in the oceans. Taking the example of iron, microbial iron uptake is a way for dispersing iron from deep-sea hydrothermal ecosystems throughout the oceans. This process can lead to the iron acquisition by marine phytoplankton and by extension to the CO2 sequestration.
In conclusion, a better understanding of the role of microorganisms in the alteration of minerals at active and inactive deep-sea hydrothermal sites will also make it possible to better assess the dispersion of iron in the ocean, allowing phytoplankton to sequester **CO2**, whose concentrations tend to increase with the accumulation of **greenhouse gases** and which therefore contribute to **climate change**.

Demande de (co)financement ISblue

Vous sollicitez un financement ISblue,

Précisez le lien du sujet avec les thèmes ISblue

This project is perfectly in line with Isblue theme 2 and especially the sub-theme "The living seabed: where fluids, minerals and extreme life interact". Indeed, this thesis topic aims at improve our knowledge of the active *versus* inactive deep-sea hydrothermal vent influence on the diversity and the functional activities of microbial communities involved in the iron cycle (a major biogeochemical cycle at deep-sea hydrothermal ecosystems) and more broadly on the alteration of iron-rich minerals. This, in frame of the potential future exploitation of hydrothermal polymetallic sulfide mining resources. This thesis topic should thus provide key elements to the society to better manage deep-sea mineral resources, that are consistent with a major objective of Isblue theme 2.

Thème ISblue	**Thème principal**	**Thème secondaire** (si nécessaire)	**Autre** (si nécessaire)

la régulation du climat par l'océan			
les interactions entre la Terre et l'océan	X		
la durabilité des systèmes côtiers			
l'océan vivant et les services écosystémiques			
les systèmes d'observation à long terme			

Expliquez/précisez <u>en quelques lignes</u> dans quelle mesure votre demande correspond à l'un ou plusieurs des critères ISblue ci-dessous :

1- Originalité, impact potentiel du projet (4 lignes maxi)

This project is original because it will make it possible better define the notions of active versus inactive processes in deep marine hydrothermal sites by combining two disciplines: microbiology and geology. In addition, it will bring knowledge on microorganisms involved in iron-cycle and on the alteration of iron rich minerals. Finally, it will also allow providing key elements to the society to better manage deep-sea mineral resources.

2- Positionnement international du sujet, cotutelle ou co-encadrement international (4 lignes maxi)

This project will take place within the framework of the Franco-Chinese International Associated Laboratory Microbsea and will strengthen the links between the joint research unit BEEP and the Chinese partner KLAMBR of the 3rd Institute of Oceanography of Xiamen directed by Z. Shao.

3- Effet intégrateur entre unités de recherche et / ou interdisciplinarités (4 lignes maxi)

We will collaborate with Geo-Ocean laboratory, UMR 6538, concerning geology/geochemistry analyses. This thesis will also be developed within the framework of the ANR IRON2MI (coordinator S. MIESZKIN) and LIFEDEEPER (coordinator MA CAMBON) which will allow the PhD student to meet scientists involved in complementary disciplines.

4- Potentiel d'insertion à un haut niveau dans la communauté académique ou non académique du docteur (4 lignes maxi)

The theme of microorganisms involved in the iron cycle in deep-sea hydrothermal environments is a young theme in the BEEP laboratory (started in oct. 2021) and has been strengthened recently by an ANR JCJC IRON2MI and partially in a task of the ANR LIFEDEEPER. This environment will be very favorable to the future PhD student and should lead to several publications of rank A allowing the PhD student to meet the criteria expected for a future hiring in academic research.

Financement du projet de thèse

En cas de financement à 50 %, le cofinancement est-il déjà identifié *(oui/non)* **:** oui

Si oui, préciser la nature du cofinancement (*ANR, partenaire privé, Ademe, etc.*) : ANR JCJC IRON2MI

Si le cofinancement n'est pas encore confirmé, date prévue de réponse du cofinanceur :

En cas de non-obtention du cofinancement demandé, une autre source de cofinancement est-elle identifiée *(oui/non)* **:**

Si oui, laquelle :

Sollicitez-vous un co-financement Is-Blue *(oui/non)* **?** oui

Important : Veillez à bien compléter les différents co financements sollicités sur le serveur Thèses en Bretagne Loire lors du dépôt de votre dossier.

Projet de thèse en cotutelle internationale

S'agit-il d'un projet de thèse en cotutelle internationale dans le cadre d'une convention *(oui/non)* **:** non

Si oui, préciser l'établissement pressenti (*et le pays de rattachement*) :

Ce projet de thèse fera-t-il l'objet d'un cofinancement international *(oui/non)* **:** non

(Rémunération du doctorant par l'établissement implanté sur le territoire régional (18 mois sur 36 mois), et l'établissement étranger, qui s'engage également à rémunérer le doctorant dans le cadre de son séjour à l'étranger, soit durant 18 mois -a minima-)

En cas de cofinancement international, préciser -*si vous en avez connaissance***- l'organisation du calendrier des périodes de séjour :**

Préciser quel est le stade du projet international (joindre une lettre d'engagement du partenaire)

Vous sollicitez un financement UBO EDSML qui sera porté à la décision du Conseil de l'ED

Indiquez le ici, oui ☒ **non** ☐ **et sur le serveur TEBL (indispensable)**

Le candidat

Profil souhaité du candidat (spécialité/discipline principale, compétences scientifiques et techniques requises) :

The candidate should have a Master degree in microbiology or an engineering degree in microbiology and the following skills:

In genomics: Metabarcoding, Metagenomics and Metatranscriptomics.

In microbiology, molecular ecology:

- Knowledge of Pasteurian microbiology, culture of aerobic and anaerobic microorganisms, thermophilic.
- Knowledge of microbial metabolisms
- Knowledge of microbial ecology of extreme marine habitats
- Basic knowledge of molecular biology (DNA extraction, PCR, Q-PCR)

Knowledge/skills in analytical methods will be appreciated

(e.g. chromatography, activity measurements with radiotracers)

Skills:

- Rigor, organization, autonomy.
- Ability to work in a team.
- Good interpersonal skills.

Language skills: English: Oral comprehension and written expression

ATTENTION : Tout dossier non déposé sur le serveur dans les délais indiqués, ne pourra être pris en compte notamment par les instances ISblue, conseil de l'EDSML.

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