Société Géologique de France

Société savante fondée le 17 mars 1830
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Réunion spécialisée de la SGF

Pockmarks et Ecosystèmes Benthiques

30 & 31 janvier 2020

Salle Van Straelen
77 rue Claude Bernard
75005 Paris

4 thématiques :

Modalités et fréquence d'expulsion des fluides

Nature et composition chimique des fluides expulsés et développement des communautés bactériennes associées

Exemples de pockmarks et écosystèmes (communautés) benthiques associés dans les grands fonds marins

Exemples de pockmarks et écosystèmes (communautés) benthiques associés dans la zone côtière

Livre des Résumés - Abstract Book

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77 rue Claude Bernard, 75005 Paris
(33) (0) 1 43 31 77 35 @ accueil@geosoc.fr

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Overview of the conference of the conference : Pockmarks and Benthic Ecosystems

The « Pockmarks and associated benthic ecosystems » thematic days were held at the Société Géologique de France (SGF) in Paris from 30-31 January 2020.

The global objective was to set up state-of-the-art knowledge on pockmarks and to improve interaction and collaboration between geological and biological scientific communities. Since 1990, several studies have focused on fluid circulation within the sedimentary column with a recent growing interest in pertaining global warming aspects. Fluids (e.g. methane, marine and fresh water, liquid hydrocarbons) migrate upwards possibly i) creating depressions on the seafloor: so-called « pockmarks » and ii) leading to fluid escapes in the water column.

In the deep sea (hundreds to thousands of metres water depth), the presence and development of benthic ecosystems have been largely investigated. These ecosystems remain closely constrained by the small amount of organic matter that reaches the seafloor. However, seep and fluid expulsion sites are there comparable to living « oases ». Associated with chemosynthetic organisms, these sites demonstrate the link between fluid escapes and ecosystems. Conversely, in coastal areas (from shore to continental slope), the multiplicity of nutrient sources makes the identification of benthic communities in association with fluid expulsions much more complex. Shallow-water depth pockmarks are often less investigated.

Around 50 specialists including geologists, ecologists and micro-biologists attended the conference with four invited speaker conferences, 17 communications on ongoing case studies and several multidisciplinary round tables (sgf-pockmarks.sciencesconf.org) examined several questions:

1. What is a pockmark?
2. What are the present-day indicators of pockmark activity?
3. How to investigate the past with regard to the history of pockmark formation and activity?

With regard to the implications of fluids in marine geo-hazards (e.g. slope instabilities) and in particular the growing interest in global warming, pockmark investigation is crucial. A global agreement of the assembly states that a pockmark must be defined not only by its morphology but also by its initiation and activity processes. It was agreed to highlight the need to involve several disciplines, to recognize and study these processes, both in their present state and in their past activity. We need to further explore their isotope chemistry including foraminifera to assess past activity and the biological aspects to highlight fluid-seep present-day activity. The community suggested a new (re)-investigation of the continuum land to deep-sea geomorphological domains (coastal areas, shelf platforms, continental slope, abyssal plains), with a « process-related view ».

At the end of the meeting, the idea emerged to create a Working Group, focused on pockmarks. The group plans to organize biennial meetings to strengthen the synergy of national and European scientific communities, and also participate in the international Gas in Marine Sediments (GIMS) congress.

Group photo of some participants (31/01/2020 SGF, Paris) from top to bottom:

1. L. Pastor, A. Baltzer, K. Olu, H. Niemann,
2. F. Cesbron, A. Murat, J.-C. Dauvin, B. Férré, S. Gontharet, G. Gregoire, N. Baux, I. Poirier, M. Hubert
3. G. Panieri, S. Dupré, D. Praeg, A. Gay

The « Pockmarks and associated benthic ecosystems » thematic days were organised by Agnès Baltzer, Stéphanie Dupré, Gwendoline Grégoire and Anne Murat in collaboration with the University of Nantes and the LETG - UMR6554, Ifremer and CNAM Intechmer. We would like to thank Ifremer and Ilico for their financial support and the SGF for their assistance and organisation of the event, as well as all the participants, in particular the keynote speakers, Aurélien Gay, Helge Nieman, Guiliana Panieri and Jean-Claude Dauvin.

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1. Processes and frequency of fluid expulsion

Le rôle des structures sur les échappements de fluides au sein d'une plate-forme carbonatée : les pockmarks géants et abyssaux des Bahamas

Thibault Cavailhes [1], Hervé Gillet [1], Léa Guiastrennec [1], Vincent Hanquiez [1], Thierry Mulder [1]

[1] Environnements et Paléoenvironnements Océaniques et Continentaux (EPOC) – CNRS : UMR5805 – Allée Geoffroy Saint-Hilaire -33615 Pessac cedex, France

Les données sismiques et bathymétriques issues de la mission océanographique CARAMBAR 2.0 ont permis de révéler l'existence de 29 pockmarks géants abyssaux jalonnant le pied du Blake Bahama Escarpement (BBE). Cet escarpement sous-marin, ayant un dénivelé pouvant atteindre 4200 m, constitue la transition entre la plate-forme carbonatée Bahamienne (-800 m) et la plaine de San Salvador (- 4900 m). Les pockmarks, pseudo-circulaires, sont observés à des profondeurs d'eau comprises entre - 4584 m to - 4967 m, ont des diamètres compris entre 255 m to 1819 m et montrent des dépressions centrales ayant des profondeurs décamétriques à hectométriques (30 m à 185 m). L'alignement de pockmarks est parallèle au BBE, exclusivement entre 2200 m et 5000 m de l'isobathe -4000 m, exprimant sur la zone d'étude le pied de l'escarpement. Un banc carbonaté sous-jacent, enfoui à l'aplomb des pockmarks a été clairement observé et contient, à environ 1000 m sous les structures étudiées, une anomalie sismique de haute amplitude. La densité de distribution des pockmarks est maximale dans la zone où les linéaments structuraux de la zone de Fracture de Sunniland recoupent le BBE et lui impose une courbure morphologique caractéristique ; Cette zone de fracture est héritée des épisodes de transtension à l'origine de la transition océan-continent.

L'ensemble des observations ci-dessus suggèrent une relation atypique entre la distribution spatiale des échappements de fluides sous-marins (pockmarks), les structures tectoniques héritées recoupant la plate-forme et le banc carbonaté enfoui en pied d'escarpement sous les hémipélagites et les contourites de la Plaine de San Salvador. Les entrées d'eaux météoriques pendant les phases de bas-niveau marins dissolvant les anhydrites de la plate-forme, la convection thermique dans cette dernière et les entrées salines d'eau de mer par l'escarpement sous-marin participent en proportion non quantifiées à la circulation et la corrosion des carbonates dans la plate-forme. Ces mécanismes sont particulièrement efficaces le long des hétérogénéités structurales du système (failles, fractures), se comportant comme des drains hydrauliques voire des zones de fuites, notamment à l'endroit où les pockmarks de cette étude ont été décrits.

Oral presentation

Cold seep hibernation in Arctic sediments during cold bottom water conditions

Bénédicte Ferré [1], Pär Jansson [1], Manuel Moser [1], Pavel Serov [1], Alexey Portnov [2], Carolyn Graves [3], Giuliana Panieri [1], Friederike Gründger [1], Christian Berndt [4], Moritz Lehmann [5], Helge Niemann [6]

[1] The Arctic University of Norway – Norway [2] School of Earth Sciences, The Ohio State University – United States [3] Centre for Environment, Fisheries and Aquaculture Science [Lowestoft] – United Kingdom [4] GEOMAR (GEOMAR) – Helmholtz-Zentrum für Ozeanforschung Kiel Gebäude 4 , Ostufer Wischhofstrasse 1-3 24148 Kiel, Germany [5] Department of Environmental Sciences [Basel] – Switzerland [6] Royal Netherlands Institute for Sea Research – Netherlands

Large amounts of methane are trapped within gas hydrate in sub-seabed sediments in the Arctic Ocean, and bottom-water warming may induce the release of methane from the seafloor. Yet, the effect of seasonal temperature variations on methane seepage activity remains unknown, as surveys in Arctic seas are mainly conducted in summer. Here, we compare the activity of cold seeps along the gas hydrate stability limit offshore Svalbard during cold (May 2016) and warm (August 2012) seasons. Hydroacoustic surveys revealed a substantially decreased seepage activity during cold bottom-water conditions, corresponding to a 43 % reduction of total cold seeps and methane release rates compared to warmer conditions. We demonstrate that cold seeps apparently hibernate during cold seasons, when more methane gas becomes trapped in the subseabed sediments. Such a greenhouse gas capacitor increases the potential for methane release during summer months. Seasonal bottom-water temperature variations are common on the Arctic continental shelves. We infer that methane-seep hibernation is a widespread phenomenon that is underappreciated in global methane budgets, leading to overestimates in current calculations.

Oral presentation

Dynamique d'expulsion des fluides dans les bassins sédimentaires

Aurélien Gay – *Keynote* [*1]

[1] Université de Montpellier (UM) – CNRS : UMR5243 – Place Eugène Bataillon -34095 Montpellier cedex 5, France

Depuis les années 80, l'exploration des marges continentales a révélé la remobilisation post-dépôt des matériaux à travers des cheminées de migration de fluides qui alimentent des zones d'expulsion sur le fond de la mer : pockmarks (fluides seuls), volcans de boue (fluides+boue) ou injectites (fluides + sable). L'arrivée dans le monde académique de la sismique 3D a permis de préciser la source des fluides et les chemins suivis à travers la colonne sédimentaire. C'est donc un véritable réseau de conduits interconnectés que l'on a appelé " la plomberie " des marges. Cela a induit l'idée que ces conduits fonctionnent comme des tubes ouverts à travers lesquels les fluides circulent à des vitesses souvent largement surévaluées. Pour des raisons évidentes de risque ces cheminées n'ont jamais été forées jusqu'à présent et encore moins monitorées. L'absence de mesures in-situ limite très fortement l'intégration des processus échelle de la sortie de fluides (évolution à l'évolution spatiale) ou au cours de sa vie (´temporelle. Quelle-que soit la méthode utilisée (imagerie géophysique, prélèvements in situ etc...) les résultats ne fournissent finalement qu'un instantané actuel des migrations de fluides, une sorte de photo qui fige la situation et conduit l'interpréteur `a glisser vers l'actualisme. L'un des moyens de palier `a ce problème est de se tourner vers les analogues fossiles. C'est l`a aussi une photo de la situation mais une fois que toute l'histoire de la migration a eu lieu, y compris celle de l'exhumation des séries hôtes. C'est un peu comme essayer de raconter la vie d'un homme en n'ayant à sa disposition que 2 photos de lui `a deux instants différents de sa vie. Une approche couplant expériences analogiques et numériques a permis de reproduire la formation de ces cheminées et de quantifier les mécanismes `a l'origine de leur formation. Les premiers résultats montrent une évolution en 4 étapes depuis le régime de surpression et fluidisation en profondeur jusqu'`a la mort supposée de la structure. Ce type d'approche, absolument indispensable pour définir l'état d'une sortie de fluides et donc définir à quel stade de son évolution elle se trouve lorsqu'elle est observée, est aussi d'une importance fondamentale dans l'évaluation des risques fond de mer car même si une zone de sortie de fluides semble inactive (pas de manifestations sur le fond) cela ne signifie pas qu'elle n'est plus chargée en gaz sous-jacent.

Oral presentation

Positive-relief carbonate pavements on the central Nile deep-sea fan: gas hydrate blisters or carbonate-filled pockmarks?

Daniel Praeg [1], Sébastien Migeon [2], Alexandre Dano [2], Jenny Trevisan [2], João Marcelo Ketzer [3], Luiz Frederico Rodrigues [4], Adolpho Herbert Augustin [4], Stephanie Dupré [5]

[1] Géoazur, 250 rue Albert Einstein, 06560 Valbonne, FRANCE – CNRS : UMR7329 – France [2] Géoazur, 250 rue Albert Einstein, 06560 Valbonne, FRANCE – CNRS : UMR7329 – France [3] Linnaeus University, 391 82 Kalmar, SWEDEN – Sweden [4] Pontifical Catholic University of Rio Grande do Sul (PUCRS), Av. Ipiranga 6681, 90619-900 Porto Alegre, BRAZIL – Brazil [5] Unité de recherche Géosciences Marines, Ifremer, FRANCE – Institut français de Recherche pour l'Exploitation de la Mer – France

The Nile deep-sea fan is rich in fluid vents, including a Central Province of acoustically reflective patches that correspond at seafloor to fractured carbonate pavements hosting chemosynthetic ecosystems. The backscatter patches (BPs) have been referred to as pockmarks, but several studies have noted positive relief. We examine the BPs by integrating older multibeam datasets (50-100 m DTMs) with sonar imagery of higher resolution acquired in 2010 (APINIL campaign) using a hull-mounted multibeam (30 kHz, 10-25 m DTMs) and a deep-towed sidescan (180 kHz, 1.5 m pixels. We recognise at least 450 BPs in water depths of 1550-2700 m, subcircular to elongate and 70-600 m wide, almost all of positive relief up to 7 m. The BPs vary in backscatter intensity on both 30 kHz and 180 kHz imagery, and differ in character between them. We attribute this to varying sediment penetration by the two systems, which respectively integrate impedance contrasts to depths of 3 m and 0.1 m. At local deposition rates, this corresponds to timescales of 5-100 ka. In the absence of erosion, backscatter variations and fractures observed on 180 kHz imagery suggest shifting patterns of carbonate growth and breakage over the last 5 ka. Four water column gas flares observed in 2010 in high backscatter areas suggest on-going carbonate cementation. Previous studies of the area indicate downward growth of carbonate pavements, at rates much less than those of burial, and it has been proposed that self-sealing drives the outward growth of broad pavements. However, such a process does not generate stress fields and should result in buried lenses of zero relief. We propose that the elevated and fractured seafloor carbonates we observed as BPs record interactions with underlying gas hydrates. One possibility is that BPs are 'hydrate blisters', comprising thin carbonates above growing gas hydrate lenses; however, the lack of deflated features (hydrate pockmarks) is puzzling. Another possibility is that fracturing in response to hydrate formation and dissolution allows fluid migration through recurrently buried pavements, resulting in the upward growth of mixed carbonate-sediment mounds that overfill hydrate pockmarks. We intend to test these hypotheses during the SEAGAL campaign of the RV Pourquoi pas ?, scheduled for September 2020. This work has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No. 656821

Oral presentation

Le Pliocène du Rio Stirone (Plaine du Pô, Italie) et le Miocène de la marge Hikurangi (Nouvelle-Zélande) : un même environnement à Cold seeps, mud volcanoes, pockmarks en contexte de zone convergent

Renaud Toullec [1], Gillian Bethune [2], Sofia Monlauzer [2], Pascal Barrier [1], Julien Bailleul [1], Eric Cauquil [3], Vincent Caron [4], Frank Chanier [5], Geoffroy Mahieux [6], Pierre Malié [7], Sébastien Potel [1]

[1] EA 7511, Bassins-Réservoirs-Ressources (B2R), département Géosciences, UniLaSalle, Beauvais, France – Institut UniLaSalle Beauvais – France [2] UniLaSalle – Institut UniLaSalle Beauvais – France [3] TOTAL-Scientific and Technical Center Jean Féger – TOTAL FINA ELF – France [4] EA 7511, Bassins-Réservoirs-Ressources (B2R), département Géosciences, UPJV, France – UPJV Université Picardie Jules Verne – France [5] Laboratoire d'Océanologie et de Géosciences (LOG) -UMR 8187 – Université de Lille, Centre National de la Recherche Scientifique : UMR8187 – France [6] EA 7511, Basins-Réservoirs-Ressources (B2R), département Géosciences, UPJV, France – UPJV Université Picardie Jules Verne – France [7] Géosciences Montpellier – Université de Montpellier : UMR5243 – France

Cold seeps, mud volcanoes, pockmarks sont autant de manifestations superficielles de l'activité en subsurface d'un système fluide impliquant éventuellement des hydrocarbures biogéniques ou thermogéniques. Ces structures diverses sont souvent les seuls témoins du fugace phénomène d'expulsion de fluides dans le registre fossile. Leur étude, couplée à l'analyse du contexte tectono-sédimentaire propre à chaque bassin, peut permettre de tracer l'origine des fluides jusqu'à leur source.

Afin d'illustrer ces objets singuliers, deux cas d'études sont proposés en zone convergente : le Pliocène du Rio Stirone (Plaine du Pô, Italie) et le Miocène de la marge Hikurangi (île nord, Nouvelle-Zélande). Le but de ces études est de préciser la nature et la chronologie des évènements de circulations fluides enregistrées dans les structures d'expulsions ainsi que les premiers résultats de travaux sur la production carbonatée chimiosynthétique dérivée du méthane, associée à ces expulsions.

A partir des données de terrain et des analyses sur lames minces des paragenèses (CL, MEB/EDX, δ13C, δ18O, analyses élémentaires), des caractères communs apparaissent entre ces deux bassins : les cheminées, témoins fossiles des circulations de fluides, concentrent localement sous forme de tubes bulbeux ou lisses de la calcite magnésienne, voire de la dolomite dans certains cas. Leur mode de mise en place fait intervenir, du moins pour les tubes de grands diamètres, des circulations de fluides per ascensum reliées à des accidents majeurs, dans un encaissant systématiquement constitué de marnes peu carbonatées. Les données paléobathymétriques indiquent un milieu bathyal avec des assemblages biologiques très peu diversifiés indiquant des conditions de stress. Enfin la pyrite fromboïdale est ubiquiste avec parfois des concentrations sous forme de couches isopaques au sein des tubes.

Les productions carbonatées de Nouvelle Zélande se rencontrent sous la forme de lumachelles (avec entre autres des *lucinidae*) parfois re-sédimentées et dont leur association avec des circulations de fluides est discutée.

En Italie, les macrofaunes sont représentées par des bivalves lucinoïdes associés à des coraux coloniaux. Une espèce particulière (*Solemya donderleini*) vivant en symbiose avec des bactéries fixatrices du soufre y a été décrite. Ces terrains pliocènes sont aujourd'hui affectés par des volcans de boue actifs, « Salse », comme à Spilamberto, à l'aplomb d'un des gisements pétroliers de la plaine du Pô.

Oral presentation

2. Nature et composition chimique des fluides expulsés et développement des communautés bactériennes associées

2. Nature and chemical composition of fluids and development of associated bacterial communities

Different pockmark systems and their potential importance for the hydrological and biogeochemical balance of a peri-alpine lake

Adeline Cojean [1], Maciej Bartosiewicz [2], Jeremy Zimmermann [1], Moritz F. Lehmann [2], Katrina Kremer [3], Stefanie B. Wirth [1]

[1] Centre for Hydrogeology and Geothermics, University of Neuchâtel, Rue Emile-Argand 11, CH-2000 Neuchâtel – Switzerland [2] Department of Environmental Sciences, University of Basel, Bernoullistrasse 30, CH-4056 Basel – Switzerland [3] Swiss Seismological Service (SED), ETH Z¨urich, Sonneggstrasse 5, CH-8006 Zürich – Switzerland

Pockmarks are crater-like depressions on the floor of oceans and lakes formed by the upward transport of fluids through the unconsolidated sediment column. The fluid flow through marine pockmarks is considered to enhance hydrological and biogeochemical exchanges between the sediments and the water body. While a similar relevance can be expected in lakes, the importance of lacustrine pockmarks in this regard is virtually unexplored. Lake Thun (48.3 km2 surface area), Switzerland, is an excellent system to study lacustrine pockmarks as it exhibits several sites with different geological and biogeochemical settings. One of the pockmark sites is characterized by evident methane (CH4) ebullition and high CH4 concentrations from ˜2.4 to 8.9 mM within the sediments beneath. A large pockmark with a diameter of 110 m is located adjacent to the rock wall of a karst system and might thus be associated with groundwater discharge into the lake. Finally, spikes in electrical conductivity detected during a survey with a remotely operated vehicle (ROV) at a third pockmark site suggest a hydrogeological connection with the groundwater system in the underlyingTriassic bedrock. This third pockmark site we are studying more closely. We observed that the sediments inside the pockmark were clearly more liquified as compared to those at a reference site (outside the pockmark), providing further evidence for groundwater discharge that might presently be active. Further chemical analysis of porewaters and the water column above the pockmark as well as molecular investigation (e.g. 16S rRNA) of the sediments will be performed at two different seasons of the year (in fall and spring during the snowmelt season). All together, these results should help us to better assess the influence of groundwater discharge via this pockmark site on the hydrological balance and on the biogeochemistry of the lake, as well as to expand our limited knowledge on the mechanism of lacustrine pockmarks in general.

Oral presentation

SUSANE, a device for sampling chemical gradients in the benthic water column

Joel Knoery [1], Bastien Thomas [2], Agnès Baltzer [3], Daniel Cossa [4], Jean Pierre Donval [5], Sylvain Rigaud [6]

[1] Laboratoire Biogéochimie des Contaminants Métalliques (LBCM) – Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), Centre atlantique, Nantes – Rue de l'Ile d'Yeu, 44311 Nantes, France [2] Laboratoire Biogéochimie des Contaminants Métalliques / Nantes – Institut français de Recherche pour l'Exploitation de la Mer – France [3] Littoral, Environnement, Télédétection, Géomatique – Université de Nantes – France [4] Institut des Sciences de la Terre – Université Grenoble Alpes – France [5] Laboratoire Géochimie et Métallogénie – Institut français de Recherche pour l'Exploitation de la Mer – France [6] Détection, évaluation, gestion des risques CHROniques et éMErgents (CHROME) / Université de Nîmes – Université de Nîmes – France

In aquatic environments, the benthic water column may exhibit concentration gradients of various substances. They result from transfers and chemical reactions that may occur both within this layer, and/or at the sediment–water interface (SWI). Characterization of these gradients yields important information for the quantification of such processes and transfers. However, it is difficult to actually sample these gradients in the field, since turbulence decreases their vertical scale. We describe a sampler designed to collect simultaneously 16 discrete water column samples at a centimeter-scale vertical resolution. This small device (40 × 40 × 60 cm) is reliable, safe to handle, and easily deployed from a small boat using a cable or a Scuba diver. With small adaptations, it may be deployed using a ROV or autonomous submersibles, at any depth. It is made of materials compatible with trace element and dissolved gases work, and simultaneously draws samples from various heights above the SWI into 60 mL syringes. The altitude of the sample inlets is field-adjustable. Sampling artifacts are minimized by in situ flushing of tubing dead volumes, by rapid and simultaneous sample collection, and by sampling an undisturbed water-column. Thus, this device can contribute to the characterization of vertical concentration gradients in benthic water-columns. Such gradients of various compounds and metals from two coastal sites (Quiberon Bay, Berre Lagoon, Loire river Estuary) are shown, illustrating the sampler's usefulness to describe and investigate processes in the benthic zone. Susane may be loaned : let's collaborate !

Oral presentation

Caractérisation des communautés bactériennes associées au remplissage sédimentaire dans des zones côtières soumises à des échappements de fluides (Baie de Concarneau et du Croisic) par métagénomique

Anne Murat [1,2], Gwendoline Gregoire [1,2], Isabelle Poirier [1,2], Marina Moletta-Denat [3], Agnès Baltzer [4], Jean-Baptiste Champilou [5], Livio Ruffine [6], Dominique Birot [6], Emmanuel Rinnert [6], Axel Ehrhold [7], Elodie Marches [8], Patrick Guyomard [8]

[1] Institut des Sciences et Techniques de la Mer (INTECHMER) – Conservatoire National des Arts et Métiers [CNAM] – France [2] Laboratoire Universitaire des Sciences Appliquées de Cherbourg – Université de Caen Normandie : EA4253 – France [3] INRA Transfert Environnement (IT-E) – Institut national de la recherche agronomique (INRA) – UR 50, Avenue des étangs 11100 Narbonne, France [4] Littoral -Environnement -Télédétection -Géomatique (LETG Nantes) – Université de Nantes, CNRS : UMR6554 – Campus Tertre BP 81227 44312 NANTES Cedex 3, France [5] LPG-BIAF (Bio-Indicateurs Actuels et Fossiles) – Université d'Angers, CNRS : UMR6112 – France [6] IFREMER, Département Ressources physiques et Ecosystèmes de fond de Mer (REM), Unité des Géosciences Marines et Unité des Etudes des Ecosystèmes Profonds, 29280 Plouzané – Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), Institut Français de Recherche pour l'Exploitation de la MER -IFREMER – France [7] Ifremer - Laboratoire de Géodynamique et Enregistrements Sédimentaires (Ifremer -REM/GM/LGS) – Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER) – ZI pointe du Diable CS 10070 29280 Plouzané, France [8] Service Hydrographique et Océanographique de la Marine – Ministère de la Défense – France

Ce travail a d'abord été effectué grâce à des financements Action Marges (2016) et en collaboration avec IFREMER, le SHOM, l'Université de Nantes et le CNAM-Intechmer/LUSAC. Le travail présenté correspond à une première analyse métagénomique des communautés bactériennes de sédiments associés à la thématique des sorties de fluides et en particulier des pockmarks. L'ADN génomique total a été extrait à partir de 0,3 g de sédiment grâce au kit d'extraction " DNeasy PowerSoil Kit " (Laboratoires Mo Bio, USA). Pour chaque extrait, la région variable V4-V5 du gène bactérien codant pour l'ARN ribosomique 16S a été amplifiée par PCR. Les amplicons ont ensuite été séquencés par séquençage haut débit (séquenceur MiSeq (Illumina)) et les séquences présentant au moins 97% d'homologie entre elles ont été regroupées en Unités Taxonomiques Opérationnelles (OTU). Le nombre d'OTU ainsi obtenu permet de rendre compte de la diversité de la communauté bactérienne. Les séquences ont ensuite été analysées par bioinformatique afin de les comparer aux bases de données internationales et d'identifier chaque OTU à différents niveaux taxonomiques : Domaine (Eubacteria et Archaea), Phylum, Classe, Ordre et parfois Genre. Cette méthode permet également de quantifier le nombre de séquences par OTU et donc de connaitre le pourcentage que représente chaque groupe taxonomique dans la communauté. Les échantillons utilisés proviennent à la fois de sédiments (1) de surface, prélevés par plongeurs, au niveau de trois pockmarks et des zones adjacentes, dominées par l'écosystème à *Haploops sp.* (Baies de Concarneau et du Croisic) et (2) de quatre carottages Kullenberg (Baie de Concarneau). Pour traiter cette très grande quantité de données, une analyse statistique par ACP a été utilisée. Les résultats montrent une différenciation claire de la zonation redox qui s'établit au cours de la diagenèse avec l'enfouissement : zone aérobie, zone de sulfatoréduction, zone de transition sulfates-méthane (SMTZ) et zone méthane. Les sédiments de la zone méthane étant très pauvres en matière organique, le gaz présent (masque sismique) pourrait provenir également de zones plus profondes. La cheminée du pockmark, actif le plus récemment, présente une communauté bactérienne particulièrement abondante (jusqu'à 42737 séquences à 5 cm de profondeur) et diversifiée (jusqu'à 3696 OTU).

Oral presentation

Microbes at cold seeps: how environmental factors determine their activity

Helge Niemann - *Keynote* [*1,2,3], Tim De Groot [1], Lea Steinle [4,5]

[1] NIOZ Royal Netherlands Institute for Sea Research – Netherlands [2] Utrecht University – Netherlands [3] Centre for Arctic Gas Hydrate, Environment and Climate, The Arctic University of Norway – Norway [4] University of Basel – Switzerland [5] CAGE -Centre for Arctic Gas Hydrate, Environment and Climate, The Arctic University of Norway – Norway

Cold seeps such as pockmarks, mud volcanoes and gas seeps are fascinating geosystems where reduced compounds, most dominantly methane, often together with geofluids migrate from greater depth to near surface sediments. There, a substantial fraction of the uprising methane is oxidised with seawater-born sulphate as the terminal electron acceptor through a process known as the anaerobic oxidation of methane – AOM'. AOM is typically mediated by methanotrophic archaea in association with sulphate reducing bacteria, though alternative electron acceptors can also be used by some anaerobic methanotrophs. The efficiency of the AOM filter system is dependent on several environmental factors such as flow rates of methane but also the bioirrigation activity of macrofauna. Cold seeps often support tremendous amounts of macrofaunal biomass which directly or indirectly, typically with the help of symbiotic microbes, can make use of methane or hydrogen sulphide, one of the end-products of the sulphate-dependent AOM. At highly active seeps, methane may bypass the AOM filter system and is then further oxidised by aerobic methanotrophic bacteria that may either occur in symbiosis together with macrofauna, or as free-living organisms in sediments or the water column. The aerobic methane oxidation (MOx) is thus an important final barrier, which can mitigate methane release from the ocean to the atmosphere where methane acts as a potent greenhouse gas. Water column MOx is strongly influenced by oceanographic parameters, for example current regimes and methane seepage activity, which can be influenced by tides and seasons. This presentation will provide an overview on the biogeochemical processes and key (micro) organisms at cold seeps, and will highlight how environmental factors determine their activity and efficiency to retain methane in sediments or the water column.

Oral presentation

Migration des fluides et réduction des sulfates en Baie de Concarneau : Quelle influence sur la distribution des pockmarks ?

Livio Ruffine [1], Lucie Pastor [1], Vivien Guyader [1], Dominique Birot [1], Emmanuel Rinnert [1], Morgane Hubert [1], Jean Pierre Donval [1], Christophe Brandily [1], Gwenael Jouet [1], Vincent Riboulot [1], Axel Ehrhold, [1]

[1] IFREMER, Département Ressources physiques et Ecosystèmes de fond de Mer (REM), Unité des Géosciences Marines et Unité des Etudes des Ecosystèmes Profonds, 29280 Plouzané – Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), Institut Français de Recherche pour l'Exploitation de la MER -IFREMER – France

La Baie de Concarneau est caractérisée par une morphologie de fond de mer très hétérogène (Ehrhold et al., 2006 ; Baltzer et al., 2014). Certaines zones sont caractérisées par la présence de très nombreux pockmarks dont la taille varie entre 2 et 30 m de diamètre. Ce sont des dépressions circulaires ou quasi-circulaires que l'on observe sur le fond marin, et dont la formation et l'évolution résultent de la migration des fluides dans la couche supérieure du sédiment (Hovland, 2003). Cette migration des fluides permet le transport d'espèces chimiques de leur zone source réactionnelles, permettant ainsi, lorsque les conditions thermodynamiques à des zones sont favorables, la mise en place d'une succession de réactions géochimiques (Berner, 1980). Dans le cadre de la mission SYPOCO, en avril et juin 2018, des carottes sédimentaires ont été prélevées afin d'étudier les liens entre la structure du sous-sol, la migration des fluides, les processus géochimiques de réduction des sulfates de l'eau de mer et la distribution des pockmarks. Les résultats préliminaires montrent que l'Oxydation Anaérobique du Méthane (OAM) est le processus prédominant de la réduction des sulfates, avec un intervalle de transition Sulfate-Méthane compris en 50 et 295 cm dans la colonne sédimentaire. Les profils de chlorures ont permis d'identifier une zone alimentée en eau douce, conduisant à une dilution de plus de 10 % de la teneur en chlorures de l'eau interstitielle. En parallèle de l'étude des fluides interstitiels, des anomalies positives en méthane dissout dans la colonne d'eau ont été mesurée, suggérant un transfert de la colonne sédimentaire à la colonne d'eau.

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Oral presentation

3. Exemples de pockmarks et écosystèmes (communautés) benthiques associés dans les grands fonds marins

3. Examples of pockmarks and associated benthic ecosystems in deep sea domain

Fluid seepages associated with benthic communities along the Zambezi Margin (Mozambique).

Eric Deville [1], Carla Scalabrin [2], Gwenael Jouet [2], Antonio Cattaneo [2], Anne Battani [1], Sonia Noirez [3], Hélène Vermesse [3], Martina Torelli [3], Lucie Pastor [2], Karine Olu [2], Laure Corbari [4], Marion Boulard [2], Tania Marsset [2], Delphine Pierre [2], Benoit Loubrieux [2], Maximo Dal'asta [5]

[1] IFP School – IFP Energies Nouvelles – France [2] Ifremer – Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), Institut Français de Recherche pour l'Exploitation de la MER -IFREMER – France [3] IFPEN – IFP Energies Nouvelles, IFP Energies Nouvelles – France [4] MNHN – Muséum National d'Histoire Naturelle (MNHN) – France [5] TOTAL – TOTAL, CSTJF, Pau – France

Evidences for active fluid seepages (water and gas) have been discovered along the Zambezi slope (offshore Southern Mozambique). These active seepages are mostly associated with pockmarks which are aligned along a trend parallel to the slope and running closely upstream of the head scrap of a wide zone of slope destabilization. The fluid seepages are interpreted as triggering slope destabilization. Acoustic anomalies within the water column have shown the activity of moderate bubble seepages. Punctually, acoustic anomalies in the water are interpreted as related to fluid seepages inside the destabilization zone. Exploration with the SCAMPI towed camera system in the widest pockmark (diameter 200 m wide) has shown fluid seepages associated to authigenic carbonate crusts and bacterial mats. These fluid seepages are also associated to the presence of chemiosynthetic organisms (Vesicomyidae, Thyasiridae, Siboglinidae). The sampled gas in the sediment correspond mainly to CH4 of microbial origin, generated by hydrogenation and reduction of CO2 from a substrate of organic origin, i.e. a conventional process of genesis of microbial gas in the marine domain. No evidence for thermogenic gas was detected. In all cases, d13C-CO2 values are indicative of an organic source consisting of solid organic matter and not related to the biodegradation of liquid hydrocarbons. Another type of pockmarks has been observed within the core of the slope destabilization zone. Most of these pockmarks are inactive in terms of fluid seepages at the present time and they are associated to carbonate buildings forming chimney geometries. They probably correspond to diagenetic chimneys of former fluid migration pathways that have been exhumed during the mass sliding and recurrent activity of strong lateral slope currents which have scoured the sediments around.

Oral presentation

Spatial distribution and dynamics of chemosynthetic communities contributed to characterize fluid flow regimes of a giant pockmark in the deep Congo Basin

Karine Olu [1], Hélène Ondréas [2], Yann Marcon [3]

[1] IFREMER -REM/EEP/Laboratoire Environnement Profond – Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER) – France [2] IFREMER-REM/GM/ Laboratoire Cycles Géochimiques et ressources – Institut français de Recherche pour l'Exploitation de la Mer – France [3] MARUM – Center for Marine Environmental Sciences, University of Bremen – Germany

Deep-sea active pockmarks are colonized by benthic ecosystems typically sustained by methane-rich fluid emissions (cold seeps) widely occurring along deep continental margins. Usually high biological production is based on methane and sulfide oxidation by microorganisms, sulfide compounds being produced in the upper sediment layers from sulphate-reduction. The invertebrate biomass is dominated by symbiont-bearing species, frequently siboglinid tubeworms, mytilid and vesicomyid bivalves, in aggregations visible on the seafloor. As these symbiont-bearing taxa either depend on methane and/or hydrogen sulfide for their nutrition, they are good indicators of fluid emissions distribution, characteristics and dynamics. The Regab giant pockmark, located north of the Congo deep-sea channel at 3160 m depth, was investigated by several ROV cruises, first in 2001 (Ondreas et al. 2005). This is an interesting case study, as colonized by diverse symbiotrophic species distributed in several coalescent pockmarks. Ten years later, it was re-visited with the Victor 6000 ROV equipped with a multibeam providing high resolution bathymetry and backscatter, as well as photo-and video-mosaicking from optical surveys.

All these data were combined to give a detailed view of the pockmark, resulting in defining different fluid flow regimes (Marcon et al. 2014a). The comparative distribution of faunal associations 10 years apart also gave insights on the dynamic of fluid emissions in the different zones of the pockmark (Marcon et al. 2014b). These studies deciphering relationships between fauna and geological processes, contribute to assess the role of the benthic biological filter on methane emissions through the seafloor to the water column.

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Oral presentation

In situ explorations of pockmarks and theirs ecosystems on the Sonora transform ridge (Guaymas basin)

Hélène Ondréas [1], Karine Olu [2], Carla Scalabrin [1], Yves Fouquet [1], Germain Bayon [1], Anne Sophie Alix [1], Anne Godfroy [2]

[1] Unité de recherche Géosciences Marines (Ifremer) – Institut français de Recherche pour l'Exploitation de la Mer – France [2] Unité Etudes Ecosystèmes Profonds – Institut français de Recherche pour l'Exploitation de la Mer – France

In the Guaymas basin along the Sonora transform ridge, multibeam bathymetry associated with acoustic anomaly mapping, were used to identify possible cold seep sites. Where water column anomalies exist, the AUV was deployed to produce fine scale bathymetry and backscatter maps of less than 2 m resolution. Based on these maps, the submersible Nautile conducted in situ visual explorations which helped us to identify the accurate location and type of seepages on the ridge and the dominant taxa associated with seeps (chemosynthesis-based, symbiont-bearing fauna).

-A pockmark 40 m in diameter and 3 m in depth was identified on the Madero site, where high-resolution data and in situ explorations produced unprecedented views. The chemosynthetic fauna sampled show Vesicomyidae bivalves (*Phreagena soyoae* and *Calyptogena pacifica*) with few bacterial mats within proximity. Gas and oil bubbles were observed escaping from carbonate blocks. -The summit area comprises two active vent fields: Ayala, located on the north-east facing wall and Juarez, on the south-west facing wall. The summit is constituted of massive carbonate outcrops reaching 5 to 7 m high, with isolated hard and dark pieces of rock sometimes stuck in the carbonates (possibly consolidated sediments). In situ investigations revealed the presence of a dense Vesicomyidae clam population at Ayala site (*P. soyoae* dominant, *C. pacifica, Archivesica gigas*) and *Siboglinidae polychaete* tubeworms (*Lamellibrachia barhami* and *Escarpia spicata*), on the Juarez area. -Two hundred meters west of the Vasconcelos site materialized by large white and grey bacterial mats and numerous Vesicomyidae bivalves (*A. gigas* dominant, *P. kilmeri*), lies "pockmark 4" 60 m in diameter and 2 m in depth. A quick overview of this site shows localised white patches of bacterial mats, with scattered, empty Vesicomyid shells. -The most western pockmark (950 m to the NW of Vasconcelos site), 100 m in diameter and 3 m in depth, is clearly identified on the bathymetry and backscatter data. Unfortunately, it was not explored in situ and no water column acoustic anomalies were reported at this site.

The discovery of several active fluid emission sites on the transform ridge of Sonora, highlights the different types of seeps and emphasizes the pockmark structure as one of the main types present here. The in situ explorations also revealed the diversity of chemosynthetic and symbiotrophic fauna that inhabit the seeps in this area

Poster presentation

Pockmarks in the Arctic Ocean: Recent insights

Giuliana Panieri - *Keynote* [*1]

[1]The Arctic University of Norway – Norway

Methane emissions from seafloor are phenomenon that occur globally and very often recognized by the presence of morphological expressions like pockmarks. In the Arctic Ocean, pockmarks are found in fjords (< 150 m) and deep oceans (1300 m), and the mechanisms for their formations are faults and fractures that act as a pathway for fluid migrations as well as climate-change induced destabilization of gas hydrates. The Vestnesa Ridge, in the eastern Fram Strait west of Svalbard (˜79◦N, 1200 m water depth), hosts a subsurface gas hydrate system that has been mapped via a widespread bottom-simulating reflector (BSR), together with significant amount of trapped biogenic and thermogenic methane. The methane is susceptible to seepage in response to tectonic stress. The crest of Vestnesa Ridge is pierced by active and inactive pockmarks up to 700 m in diameter and as deep as 10 m, occurring above chimney structures. The active pockmarks exhibit episodic seepage of gas at the seafloor that has been repeatedly documented as emanating from individual pits within the pockmarks and imaged as hydroacoustic anomalies in the water column. The pockmarks host extensive chemosynthetic communities that include filamentous sulfide-oxidizing bacteria and siboglinid tubeworms and carbonate deposits that represent a long history of precipitation and/or exhumation of carbonate deposits are indicated by scattered blocks of various size, pavements, and massive carbonate blocks.
This presentation will focus on recent investigations on micropaleontology and biomarkers, microfracture array, carbonates and sediment cores collected with the deep-sea drill rig MARUM-MeBo70 which allow to better understand the sources, migration pathways and carbon cycling processes at Vestnesa Ridge. This work is primarily funded by CAGE (Centre for Arctic Gas Hydrate, Environment and Climate), through its Centres of Excellence funding scheme Grant 223259.

Oral presentation

Effect of pockmark environmental conditions on metazoan meiofaunal community, the tiniest and most abundant benthic component

Nuria Sanchez [*1], Elisa Baldrighi [2], Karine Olu [1], Diego Cepeda Gómez [3], Daniela Zeppilli [1]

[1] IFREMER-Département Etude des Ecosystèmes Profonds – Institut français de Recherche pour l'Exploitation de la Mer – France [2] National Council of Research (CNR) – Largo Fiera della Pesca, Ancona, Italy [3] Universidad Complutense de Madrid [Madrid] – Spain

Organisms inhabiting at pockmarks are able to cope with the extreme conditions that characterize this kind of cold seep, such as high concentrations of reduced chemical compounds, low oxygen availability, high primary production, and habitat heterogeneity. This fauna is usually particularly sensitive to changes in the environmental conditions, making them good biological indicators. Particularly, meiofaunal component (organisms of small size, < 1mm) has several advantages for benthic ecological studies because of its worldwide distribution, high abundance and diversity, fast metabolic rates, and its extremely sensitivity to alterations due to the lack of pelagic larval dispersion. Despite meiofauna is the most abundant size class in the benthos and one of the most diversified component of the marine realm, its study has been often neglected. We investigated and compared several pockmarks to understand whether and how the environmental conditions (concentration of reduced compounds, organic carbon, and dissolved oxygen) and the organism's interaction affect metazoan meiofauna. Despite the extreme conditions, meiofauna at pockmarks usually reaches high abundances compared with the surrounding areas. Furthermore, we also explored the community structure of the dominant meiofaunal taxa, i.e. the phylum *Nematoda*, which usually dominates meiofaunal communities, as well as the phylum *Kinorhyncha*, one of the so-called rare meiofaunal groups that flourish at some pockmarks. Meiofauna assemblages, and particularly the referred phyla, indicate a pronounced replacement of taxa between sites located inside and outside the pockmarks, with a high percentage of exclusive taxa associated with the pockmarks. Therefore, gas emission seems to act as a key factor to determine meiofauna diversity, abundance and community composition, as well as for the two investigated phyla. Additionally, some taxa do not simply survive under the gas emissions and low oxygen availability at the pockmarks, but profit from a habitat with a lower competition, enhancing their density. This is the case of the *Nematoda* genus *Desmodora* and the Kinorhyncha *Echinoderes hviidarum*, which may be considered as potential bioindicator of seepages. Finally, pockmarks provide significant contributions to the regional meiofauna diversity and thus the protection of this habitat is highly important to the conservation of local biodiversity.

Oral presentation

Prospection inédite et récente d'une zone de Pockmarks lors d'une campagne océanographique menée au large du Liban

Sébastien Thorin [*1], Romain Le Gall [1], Tatiana Gusachenko [2]

[1]CREOCEAN – CREOCEAN – France [2]Total MS [Paris La Defense] – TOTAL FINA ELF – France

Une campagne océanographique au large des côtes libanaises a été menée par la société Créocéan. L'objectif de cette mission était de caractériser la richesse biologique des fonds pour un état initial du milieu préalablement à des forages offshores potentiels envisagés par la compagnie TOTAL pour le gouvernement Libanais. La campagne a été réalisée en mars-avril 2019 à bord du Janus, navire océanographique de la COMEX, au pied du talus continental dans des profondeurs de 1480 à 1750 m. Le programme prévoyait des prélèvements d'eau, de plancton, de sédiment, de la macrofaune benthique (29 stations d'échantillonnage), des vidéos transects au ROV et la surveillance de la fréquentation de la zone par les mammifères marins.

La zone de prospection (bloc 4) d'une surface de 1.911 km² est située à 6 km (pour sa partie la plus proche) au nord des côtes libanaises. Les fonds sont caractérisés par plusieurs monts sous-marins de 50 à 200 m de haut séparés par un système complexe de canyons sous-marins d'orientation nord-ouest. Ils sont constitués de vase pure (96% de particules fines), relativement pauvres en éléments organiques, azotés et phosphorés. Ils ne présentent pas de contamination chimique en métaux, en hydrocarbures aliphatiques ou aromatiques, en BTEX ou en PCB, à l'exception de concentrations élevées en arsenic, en cuivre et en nickel qui apparaissent de manière récurrente dans tout le bassin Levantin (CSA, 2016).

La faune benthique est très appauvrie : entre 4 et 15 espèces par station (0.3m² de surface de prélèvement) avec une densité moyenne de 38 ind./m² aussi bien sur les zones de plaine que dans les canyons ou leurs bordures. Elle n'est pas plus riche à proximité de la zone de pockmarks prospectée. La faune épigée observée au ROV est également réduite, essentiellement à des crevettes (probablement *Aristeus antennatus*) et quelques rares poisons à l'exception du poisson tripode (*Bathypterois dubius*) plus fréquent. Le seul site véritable atypique et biologiquement plus riche du bloc 4 est cette zone de pockmarks au débouché d'un canyon et qui se présente sous la forme d'affleurements rocheux noirs, avec des reliefs de forme arrondies, colonisés par des invertébrés sessiles (coquilles abondantes de bivalves, oursins blancs et crabes) et quelques poissons (*Diplocanthopoma cf brachysome, Lepidion sp*.).

Un petit film vidéo des images prises sur la zone des pockmarks sera présenté lors de la communication.

Oral presentation

4. Exemples de pockmarks et écosystèmes (communautés) benthiques associés dans la zone côtière

4. Examples of pockmarks and associated benthic ecosystem in coastal areas

Haploops settlements may be indicators of shallow pockmarks activity.

Agnès Baltzer [1], Jean-Baptiste Champilou [2], Marine Reynaud [3], Jean-Marc Rousset [4], Anne Murat [5], Gwendoline Grégoire [5], Quentin Dupuy [6]

[1] Littoral, Environnement, Télédétection, Géomatique (LETG -Géolittomer) – CNRS : UMR6554, Université de Nantes – BP 81227, 44 312 Nantes Cedex 3, France [2] Laboratoire de Planétologie et Géodynamique – Bio-Indicateur Actuels et Fossiles (LPG-BIAF) – UFR Sciences, Université d'Angers, 2 Boulevard Lavoisier 49000 Angers – CNRS : UMR 6112, Université Angers – France [3] Ecole Centrale de Nantes – Ecole Central Nantes – France [4] Ecole centrale Nantes – Ecole Centrale de Nantes – France [5] INTECHMER – Conservatoire National des Arts et Métiers (CNAM) – France [6] Laboratoire LETG – Université de Nantes, CNRS: UMR6554 – France

Haploops have been studied in the Bay of Concarneau from 1964 to the end of 1990 by Glemarec et Graal, (2003). Their expansion to the north has been observed along ten years but not to the North West due to the presence of *Amphiura filiformi* who destabilizes the sedimentary cover (Glémarec et al., 1987). The pockmarks field in the Bay of Concarneau has been reported by Ehrhold et al., (2006) in the frame of the REBENT program and eventually, the superimposition of the the pockmarks field and the *Haploops* settlement by Souron et al., 2009 and confirmed by Baltzer et al., 2014. Thus, it almost took 25 years to observe this spatial link. This overlapping has been observed in the Vilaine Bay, on the "Research Plateau" and since 2016 in the Loire estuary (Champilou et al., 2019). In each case, there are no *Haploops* outside the pockmarks fields and the densities of pockmarks and *Haploops* tubes are particularly high. The pockmarks are active ones and are superimposed, in the 3 areas to faulted Eocene calcareous outcrops. New results from geochemistry and microbiology should help us to understand the links between pockmarks and *Haploops*. In another way, *Haploops* settlement may indicate active pockmarks and their extension should follow the gas/fluid expulsion pathways. An integrate study of this specific relationship in different areas along the world, may helps us to better constrain the time-scale duration of these shallow pockmarks fields activity.

Oral presentation

The pockmarks-*Haploops* relationship in south-Brittany

Jean-Baptiste Champilou [1], Agnès Baltzer [2], Gwendoline Grégoire [3], Anne Murat [3], Marine Reynaud [4], Quentin Dupuy [5], Maria Pia Nardelli [1], Edouard Metzger [1]

[1] LPG-BIAF (Bio-Indicateurs Actuels et Fossiles) – Université d'Angers, CNRS : UMR6112, – France [2] Littoral, Environnement, Télédétection, Géomatique – CNRS : UMR6554, Université de Nantes – France [3] Cnam -Intechmer – CNAM-INTECHMER, LUSAC Laboratory, Caen Normandy University – France [4] Ecole Centrale de Nantes -SEM-REV –France [5] Laboratoire LETG – Université de Nantes, CNRS: UMR6554 – France

In at least 3 bays of south Brittany, in the Concarneau bay, offshore Le Croisic archipelago and in the external part of the Loire river estuary, dense settlements of several thousand individuals per square meters, of tubes dwelling amphipods, *Haploops antennata*, have been reported as being perfectly superimposed to fields of pockmarks (crater-like figures visible in soft sediment seafloor that mark fluids expulsions). This ecosystem's engineer species plays a sedimentological key role in the environmental processes and increases local biodiversity. This work presents results of the investigation of these 3 pockmarks-*Haploops* fields, where each area is characterized by different hydrodynamics and rivers inputs conditions, allowing us to strictly link the presence and development of *Haploops* to the venting activity of the pockmarks fields. Indeed, whatever the external inputs of organic and inorganic particles, the *Haploops* strictly developed inside the area of the pockmarks field.

Focusing on the settlement offshore Le Croisic, a two year space-time evolution monitoring (between 2017 and 2018) of the *Haploops* settlement, pockmarks field and gas movements into the sedimentary column have been conducted. Boundaries limits of the *Haploops* settlement have been defined and compared over these two years and a large expansion have been determined in the southwestern part of the settlement. There, around 1.7 square kilometer has been colonized by the amphipods. Manual count of the pockmarks has been carried out on representative areas and positive correlation were obtained between expansion zones and pockmarks apparitions. Moreover, pockmarks apparitions and activities may be linked with the depth of acoustic mask into the sedimentary column. The areas where the *Haploops* are expending corresponds to the areas where numerous pockmarks already exist or appear, and these pockmarks are located were the enhanced gas reflector (traducing the gas stopped under an impermeable layer) is shallower in the sedimentary column. As *Haploops* seem to not contain the necessary bacteria to directly consume methane, indirect explanation should be proposed. Pockmarks should thus either (i) directly expulse some nutrients necessary for *Haploops* development, or (ii) the upcoming methane induce chemical reactions at seafloor surface, which may be used to locally increase the primary production of phytoplankton.

Poster presentation

First record of foraminiferal faunas associated to *Haploops* settlements on the French Atlantic coast

Jean-Baptiste Champilou [1], Maria Pia Nardelli [2], Agnès Baltzer [3], Christine Barras [2], Frans Jorissen [2], Aurélia Mouret [2], Grégoire Maillet [4], Jean-Marc Rousset [5], Marine Reynaud [5], Edouard Metzger [2]

[1] LPG-BIAF (Bio-Indicateurs Actuels et Fossiles) – Université d'Angers, CNRS : UMR6112 – France [2] LPG-BIAF (Bio-Indicateurs Actuels et Fossiles) – Université d'Angers, CNRS : UMR6112 – France [3] Littoral, Environnement, Télédétection, Géomatique (LETG -Géolittomer) – Géolittomer – Faculté des Lettres BP 81227 44312 NANTES Cédex 3 - France [4] LPG-BIAF (Bio-Indicateurs Actuels et Fossiles) – CNRS : UMR6112, OSUNA, Université d'Angers – France [5] Ecole Centrale de Nantes – France

On the inner continental shelf (depth < 50 m close to the shore) of South Brittany (France) dense settlements of *Haploops* spp., tube dwelling crustacean amphipods, have been reported over the last decades. Their key-role as bio-engineer species, on the sediment dynamics and ecological niches is still poorly known. Recently, the perfect overlap of *Haploops* settlements on pockmarks field on three different sites along the French Atlantic coast arose the hypothesis that a link exists between the release of methane through active pockmarks and the presence of these organisms. The aim of the present study is to explore the foraminiferal faunas associated to these complex ecosystems and eventually the role of *Haploops* settlements as source of heterogeneity compared to the adjacent muddy substrates. Foraminiferal assemblages (> 125 µm) of three replicated cores collected inside the *Haploops* settlement in the adjacent muddy facies and inside a small pockmark crater (where the *Haploops* are scarce), were analyzed.

The three facies have a common species pool, but display major differences in terms of absolute abundances and biodiversity. The *Haploops* facies shows less dense and highly diverse faunas, compared to the assemblages in the bare muddy facies, where the assemblages are largely dominated by the species Elphidium selseyense. Compared to *Haploops* settlements, the pockmark facies exhibits similar abundances but a lower diversity. The main difference with *Haploops* facies concerns rare species, only present in the tube cover. Our results highlight a positive impact of *Haploops* ecosystems on the total diversity of the study area.

Oral presentation

Review of the genus *Haploops Liljeborg*, 1856 (Amphipoda, Ampeliscidae): from taxonomy to dynamic of dense populations

Jean-Claude Dauvin - *Keynote* * [1,2]

[1] Morphodynamique Continentale et Côtière (M2C) – Université de Caen Normandie : UMR6143 – 24 rue des Tilleuls -14000 Caen, France [2] Université de Caen -Normandie – Université de Caen – France

A review of the available data on the amphipod *Haploops* genus including taxonomy, biogeography, ecology and biology and some ways of research in the future on this genus of the *Ampeliscidae* family is given. Since the overview of the genus *Haploops* at the end of the 1980's, several new species of this genus had been described in the North Atlantic Ocean. So, the number of species has increased from 15 at the end of the 1980' to 27 nowadays. New records are mainly acquired during the BIOICE, BIOFAR and IceAGE programmes for the North Atlantic Ocean. With 19 species the North Atlantic Ocean is the richest. Only four species has been known for the south hemisphere. Moreover, some recent ecological studies mainly from the North-eastern Atlantic along the south Brittany coast in the north of the Bay of Biscay and in the North-Atlantic and Arctic Ocean have focused on the role of the dense *Haploops* density as an 'ecosystem engineer' in the macrobenthic communities functioning. Secondary production and relation with the pockmarks are studied in the north of the Bay of Biscay which show high link between the dense populations of the tubicolous *H. nirae* and the formation and the colonisation of the pockmarks. New biogeographical data concern also deep-sea species. *Haploops* are found from shallow water (10 m) to 3,800 m. Some ways of research in the future on this genus of the *Ampeliscidae* family on which a great confusion existed is proposed. The importance of a high taxonomy process based on precise descriptions, accompanied if possible by topographical and ecological data, as accurate as possible, is need to better understand the relationships between species and environmental variables. These data are of major efficiency in the context of a reasonable estimate of the temporal biodiversity changes and the need to understand the functioning, and propose preservation of this particular benthic marine habitat.

Oral presentation

The microbial methane fluid system of the Aquitaine Shelf

Stéphanie Dupré [1], Gazcogne Scientific Party

[1] IFREMER, Unité Géosciences Marines, Brest – IFREMER – France

Unprecedented high-resolution acoustic data have confirmed the existence of persistent gas releases and Methane-Derived Authigenic Carbonates (MDAC) at the Aquitaine Shelf edge (Dupré et al. 2014). This has made way to the discovery of an unknown widespread active and fossil fluid system exclusively associated with microbial methane (Pierre et al. 2017; Ruffine et al. 2017). MDACs are present over an area of 375 km^2 and are associated with more than 2600 gas bubble streams. The ecosystems at the Aquitaine Shelf are characterized by microbial mats including archea involved in anaerobic oxidation of methane, a scarce chemosynthetic megafauna and numerous fixed (sponges) and mobile organisms (fishes). Based on *in situ* flow rate measurements and acoustic data, and assuming steady and continuous fluxes over time, the methane entering the water column is estimated to 144 Mg yr^{-1}. This discovery highlights the importance of microbial methane generation, disconnected from deep thermogenic sources and gas hydrates, at continental shelves. The shelf edge may be viewed as a focus area for methane circulation and release and related diagenesis, all having an impact on the shaping of continental shelves and potentially on the oceanic and atmospheric carbon budget. The GAZCOGNE project is cofunded by TOTAL and IFREMER as part of the PAMELA (Passive Margin Exploration Laboratories) scientific project.

GAZCOGNE Scientic Party : Arnaubec A, Baltzer A, Battani A, Bayon G, Bignon L, Birot D, Blanc-Valleron MM, Bourillet JF, Brandily C, Breton C, Caprais JC, Croguennec C, Demange J, Deville E, Donval JP, Ehrhold A, Eugène T, Floodpage J, Gautier E, Godfroy A, Guérin C, Imbert P, Lescanne M, Lesongeur F, Loubrieu B, Noël P, Marsset B, Michel G, Noirez S, Ogor A, Olu K, Opderbecke J, Pernet EJ, Petit E, Pierre C, Pitel M, Ruffine L, Saout J, Scalabrin C, Thomas Y, Vermesse H

References :

Dupré S et al (2014) Fluid emissions at the Aquitaine Shelf (Bay of Biscay, France): A biogenic origin or the expression of hydrocarbon leakage? Cont. Shelf Res. 88:24-33.

Pierre C et al (2017) Authigenic carbonate mounds from active methane seeps on the southern Aquitaine Shelf (Bay of Biscay, France): Evidence for anaerobic oxidation of biogenic methane and submarine groundwater discharge during formation. Cont. Shelf Res. 133:13-25.

Ruffine L et al (2017) Gas Seepage along the Edge of the Aquitaine Shelf (France): Origin and Local Fluxes. Geofluids 2017:13.

Oral presentation

Methane, pockmarks and *Haploops*: a bio-geochemical connection

Edouard Metzger [*1], Jean-Baptiste Champilou [1], Alan Nicol [1], Meryem Mojtahid [1], Christine Barras [1], Agnès Baltzer , Marine Reynaud [2], Pia Nardelli [1], Aurélien Domeau [1], Eric Bénéteau [1], Sophie Sanchez [1], Patrick Launeau [3], Bruno Deflandre [4], Aurélia Mouret [1]

[1]UMR-CNRS 6112 LPG-BIAF Bio-Indicateurs Actuels et Fossiles – Université d'Angers – France [2]Ecole Centrale de Nantes – Ministère de l'Enseignement Supérieur et de la Recherche Scientifique – France [3]Laboratoire de Planétologie et Géodynamique UMR6112 – Centre National de la Recherche Scientifique : UMR6112, Université de Nantes, Nantes – France [4]UPR-CNRS 5805 EPOC – Université de Bordeaux – France

Geophysical investigations and space time evolution analysis of the pockmarks-*Haploops* association offshore Le Croisic strictly linked the methane venting activity of the pockmarks to the presence and development of the tube dwelling organism. The nature of this link is yet to be understood. In order to consider how the upward flux of methane from its reservoir influence the geochemistry of the superficial sediment and, in particular, the recycling of nutrients, the first 5 meters of sediment have been sampled in and outside the pockmarks-*Haploops* area. Well-defined sulfate-methane transition zones (SMTZs) have been observed in and outside the pockmarks-*Haploops* area. The core sampled inside the settlement showed a shallower SMTZ at 250 cm depth (around 70 cm closer to the water-sediment interface) indicating more intense mineralization processes within the pockmarks-*Haploops* settlement. Therefore, more important recycling of phosphate and ammonia was observed at depth within the pockmarks-*Haploops* area. This would normally generate a stronger vertical flux towards the water-sediment interface and therefore an important source of nutrients for primary production that would supply the resource of food for the colony to be sustainable independently of continental sources. However, chemical gradients at the sediment water interface indicated lower diffusive fluxes invalidating such model. Recent developments of porewater high-resolution imagery allowed us to show that the high density of abandoned tubes of *Haploops* created preferential circulation enhancing advective transport of nutrients that overtook transport by diffusion. Such transport process seems to efficiently transfer ammonium for instance from the sediment to the water column enhancing nitrification at the sediment water interface and possibly primary production within the water column

Oral presentation

List of participants

- Baltzer Agnès
- Barrier Pascal
- Baux Noémie
- Bodeur Yves
- Brandily Christophe
- Cavailhes Thibault
- Cesbron Florian
- Champilou Jean-Baptiste
- Cojean Adeline
- Daniel Praeg
- Dauvin Jean-Claude
- Deville Eric
- Dupré Stéphanie
- Ferré Bénédicte
- Gay Aurélien
- Gontharet Swanne
- Gregoire Gwendoline
- Hubert Morgane
- Knoery Joël
- Kowalewski Isabelle
- Metzger Edouard
- Mouret Aurélia
- Murat Anne
- Nardelli Maria Pia
- Niemann Helge
- Olu Karine
- Ondréas Hélène
- Padron Crelia
- Panieri Giuliana
- Pastor Lucie
- Pierre Catherine
- Poirier Isabelle
- Poort Jeffrey
- Reynaud Marine
- Ruffine Livio
- Sanchez Nuria
- Simonucci Caroline
- Thorin Sébastien
- Toullec Renaud

Programme Journées Thématiques
« Pockmarks et Ecosystèmes Benthiques »
30 & 31 Janvier 2020

Jeudi 30 Janvier 2020

09h00-09h30	***Accueil Café***	
	Axe 1 : Modalités et fréquence d'expulsion des fluides	
09h30-10h00	Dynamique d'expulsion des fluides dans les bassins sédimentaires	*Aurélien GAY* *Keynote*
10h00-10h15	Le Pliocène du Rio Stirone (Plaine du Pô, Italie) et le Miocène de la marge Hikurangi (Nouvelle-Zélande) : un même environnement à Cold seeps, mud volcanoes, pockmarks en contexte de zone convergent	*Renaud TOULLEC et al.*
10h15-10h30	Positive-relief carbonate pavements on the central Nile deep-sea fan: gas hydrate blisters or carbonate-filled pockmarks?	*Daniel PRAEG et al.*
10h30-10h45	Le rôle des structures sur les échappements de fluides au sein d'une plate-forme carbonatée : les pockmarks géants et abyssaux des Bahamas	*Thibault CAVAILHES et al.*
10h45-11h00	Cold seep hibernation in Arctic sediments during cold bottom water conditions	*Bénédicte FERRE et al.*
11h00-11h20	***Pause-Café***	
	Axe 2 : Nature et composition chimique des fluides expulsés et développement des communautés bactériennes associées	
11h20-11h50	Microbes at cold seeps: how environmental factors determine their activity	*Helge NIEMAN et al.* *Keynote*
11h50-12h05	Different pockmark systems and their potential importance for the hydrological and biogeochemical balance of a peri-alpine lake	*Adeline COJEAN et al.*
12h05-12h20	SUSANE, a device for sampling chemical gradients in the benthic water column	*Joël KNOERY et al.*
12h20-14h00	***Déjeuner***	
14h00-14h15	Migration des fluides et réductions des sulfates en Baie de Concarneau : Quelle influence sur la distribution des pockmarks	*Livio RUFFINE et al.*
14h15-14h30	Caractérisation des communautés bactériennes associées au remplissage sédimentaire dans les zones côtières soumises à des échappements de fluides (Baie de Concarneau et du Croisic) par métagénomique	*Anne MURAT et al.*
14h40-15h50	**Workshop sur l'Axe 1**	
15h50-16h10	***Pause-Café***	
16h10-17h20	**Workshop sur l'Axe 2**	
17h20-17h35	**Présentation des posters**	
	First record of foraminiferal faunas associated to *Haploops* settlements on the French Atlantic coast	*Jean-Baptiste CHAMPILOU et al.*
	In situ explorations of pockmarks and theirs ecosystems on the Sonora transform ridge (Guaymas basin)	*Hélène ONDREAS et al.*
17h35-19h00	***Posters et Apéritif***	

Programme Journées Thématiques
« Pockmarks et Ecosystèmes Benthiques »
30 & 31 Janvier 2020

Vendredi 31 Janvier 2020

08h30-09h00	***Accueil Café***	
	Axe 3 : Exemples de pockmarks et écosystèmes (communautés) benthiques associés dans les grands fonds marins	
09h00-09h30	Pockmarks in the Arctic Ocean: Recent insights	*Giuliana PANIERI* *Keynote*
09h30-09h45	Fluid seepages associated with benthic communities along the Zambezi Margin (Mozambique)	*Eric DEVILLE et al.*
09h45-10h00	Spatial distribution and dynamics of chemosynthetic communities contributed to characterize fluid flow regimes of a giant pockmark in the deep Congo Basin	*Karine OLU et al.*
10h00-10h15	Effect of pockmark environmental conditions on metazoan meiofaunal community, the tiniest and most abundant benthic component	*Nuria SANCHEZ et al.*
10h15-10h30	Prospection inédite et récente d'une zone de Pockmarks lors d'une campagne océanographique menée au large du Liban	*Sébastien THORIN et al.*
10h30-10h50	***Pause-Café***	
	Axe 4 : Exemples de pockmarks et écosystèmes (communautés) benthiques associés dans la zone côtière	
10h50-11h20	Review of the genus *Haploops Liljeborg*, 1856 (Amphipoda, Ampeliscidae): from taxonomy to dynamic of dense populations	*Jean-Claude DAUVIN.* *Keynote*
11h20-11h35	Space-time evolution of Le Croisic Haploops settlement (west coast of France)	*Jean-Baptiste CHAMPILOU et al.*
11h35-11h50	Methane, pockmarks and *Haploops*: a bio-geochemical connection	*Edouard METZGER et al.*
11h50-12h05	The microbial methane fluid system of the Aquitaine Shelf	*Stéphanie DUPRE et al.*
12h05-12h20	*Haploops* settlements may be indicators of shallow pockmarks activity	*Agnès BALTZER et al.*
12h20-14h00	***Déjeuner***	
14h00-15h15	**Workshop sur l'Axe 3**	
15h15-16h20	**Workshop sur l'Axe 4**	
16h20-16h40	***Pause-Café***	
16h40-17h20	**Table Ronde**	
17h20-17h30	Conclusion	

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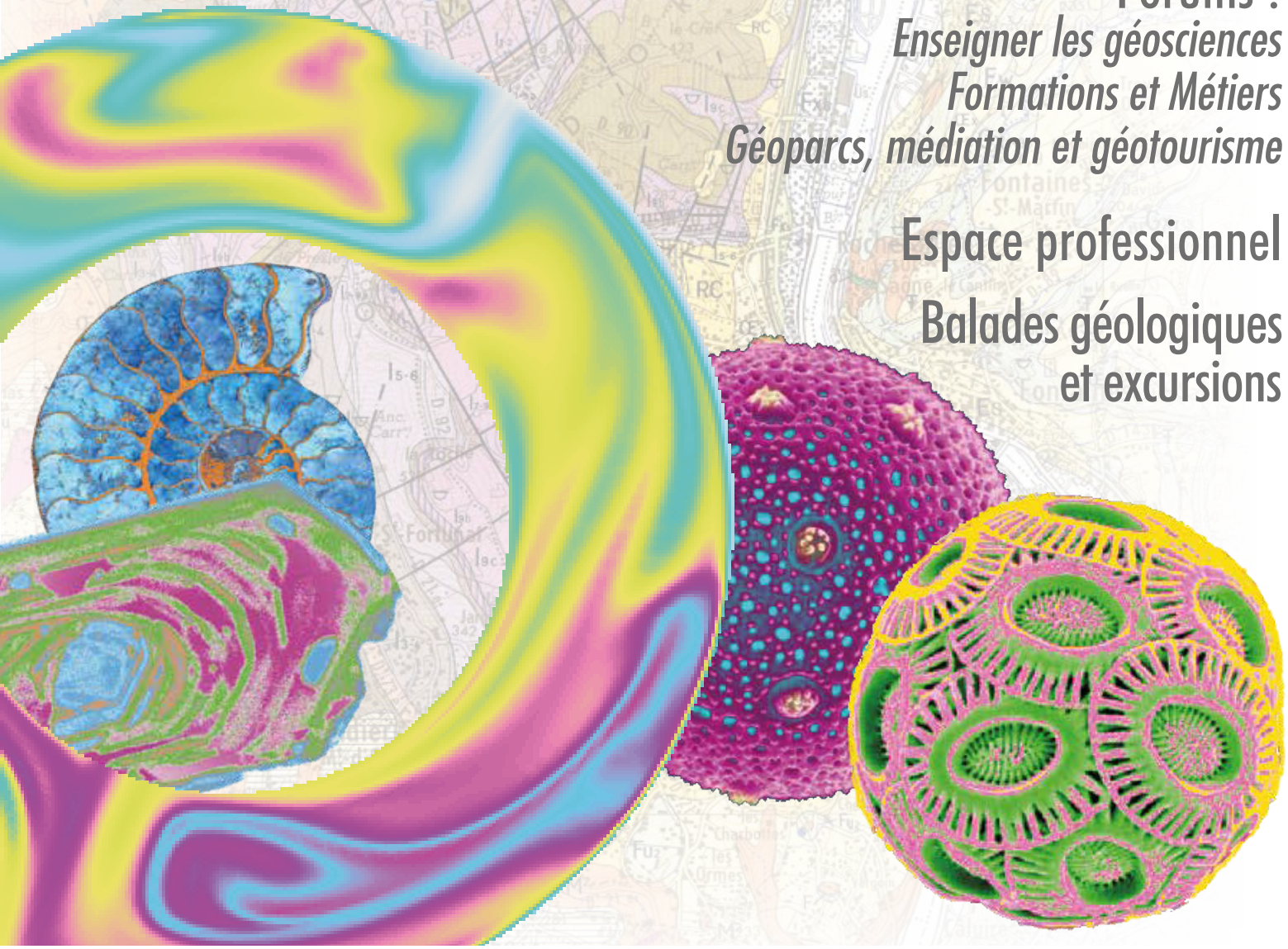

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