



## Research Networking Programmes

### Science Meeting – Scientific Report

*Proposal Title: First MD194 EuroFLEETS Gateways post-cruise meeting; the Late Pleistocene Carbonate Mound Record along the Mediterranean-Atlantic Gateway*

*Application Reference N°: 5900*

#### 1) Summary

The first MD194 post-cruise meeting, held at the Faculty of Sciences at the University of Rabat (Morocco), gathered together 67 scientists and students (PhD, Master, Bachelor) from eight different countries. Scientists presented their latest results of on-going projects on different disciplines like geophysics, sedimentology, palaeontology, oceanography, and geochemistry with the aim to better understand the complex environmental dynamics influencing cold-water coral mound growth on both sides of the Gibraltar gateway. Future initiatives were discussed in order to reach the objectives of the Eurofleets project and fill the identified gaps of knowledge. Furthermore, a lot of participants were also able to actively join the RCMNS Interim Colloquium on the “Mediterranean-Atlantic Gateways” directly after the MD194 post-cruise meeting which addressed the deep-water ecosystems as a unique point-of-view on the gateway processes.

#### 2) Description of the scientific content and discussions at the event

The MD194 post-cruise meeting was held in Rabat, on the 5<sup>th</sup> of May 2015, to present and discuss the preliminary results of a multidisciplinary study aimed at a better understanding of the complex environmental dynamics influencing cold-water coral mound growth on either side of the Gibraltar gateway.

The meeting was attended by 28 scientists from Belgium, Germany, Italy, Japan, the Netherlands, Portugal, Spain and Switzerland (Annex 1). Additionally, 22 Bachelor and 4 Master students from the University of Rabat, and 13 PhD students from European countries participated (Annex 1). The attendance of 5 young researchers (Eline Feenstra, University of Fribourg; Stanislas Delivet and Thomas Vandorpe, Ghent University; Louis Lopez Alcaide, University of Granada; Quentin Dubois-Dauphin, University of Paris, see Annex 2) was funded by the ESF European Research Network “COCARDE”

The meeting consisted of three main scientific sessions (Annex 3) and was opened by David Van Rooij who presented an overview of the objectives of the MD194 EuroFLEETS cruise, the results of the cruise and the distribution of the cores and samples.

### **Session 1: Physical Forcing**

The session was opened by Joao Vitorino and Ines Martins, who were not affiliated to the actual MD194 cruise, however, they provided valuable data and information with respect to the preparation with a focus to the physical oceanography. Low salinity data is present near the El Arraiche area, proving the absence of Mediterranean Outflow Water (MOW), pointing at the Antarctic Intermediate Water (AAIW). However, on the Moroccan Mediterranean margin, the physical oceanography and the sediment dynamics are less constrained and need more attention.

The following three presentations focused on the long- and short-term effects of these bottom currents on the sedimentation processes and patterns of the Moroccan Atlantic margin. The work of T. Vandorpe shows an interesting coupling between the physical oceanography and seismic stratigraphy. Important for the cold-water corals is their occurrence in depths under the influence of AAIW and therefore the nutrient content of AAIW is an important parameter to investigate. Similar patterns, but on shorter time scales, are also recognized in cores where glacial periods prove to be erosive (especially near escarpments). The reason for this needs to be sought in the AAIW palaeoceanography that has a stronger flow dynamics during glacial periods. However, this work is still more advanced on the Atlantic side, compared to the Alboran side.

### **Session 2: Environmental Forcing - Palaeoceanography**

The second session focused on the reconstruction of paleoceanographic changes through the application of geochemical and macro-micropaleontological proxies. Most of the reconstructions are focused on cold-water coral mounds.

Preliminary paleontological results hint at important faunistic modifications at around 11-10 ka BP on both studied mound field areas (Pen Duick Escarpment, PDE, and Melilla). Up to 11 ka BP, *Lophelia pertusa* seems to be the dominant species of coral mounds on both sides of the Gibraltar Strait. Afterwards the PDE coral communities are dominated by dendrophylliid corals whereas the Melilla Mound ones are mostly characterized by *Madrepora oculata*. Currently there are study in progress to correlate these changes in the coral fauna to sedimentological and micropaleontological modifications. Another topic discussed during the meeting was the use of source tracers, such as Nd. It was requested whether for the Moroccan Atlantic any discharge patterns of the nearby Nebou river were already studied.

### **Session 3: The Mound Record**

During this session presentations mostly focused on sedimentological and geochronological studies carried out on cores collected in the coral mound area off-shore the Mediterranean Moroccan margin. Additionally, Eline Feenstra presented her PhD project on temporal and spatial variability of early diagenesis in carbonate mounds.

### **3) Assessment of the results and impact of the event on the future directions of the field**

The main discussion was intended to reflect upon the strengths, weaknesses, opportunities and future perspectives for the data acquired during the MD194 EuroFLEETS cruise. In the first places, collaborations with ONHYM should be endeavoured. They may have more in-depth seismic data, allowing to pierce through the base of the mounds and observe their position in a basin setting. Beside this, more insight in the physical oceanography of the Alboran Sea will be needed to better assess the processes affecting cold-water coral mound growth patterns. In

order to better process the samples and interpret the data, this meeting has clearly indicated that multidisciplinary thinking is actually very important, and the concerned scientists should try to work more together.

As a weakness, studies related to the sources were indicated, which may be dealt with focuses on several levels – *sources of water masses* and *sources of sediments*. Another weakness is the scientific coordination to overview the collaborative processes. Unfortunately, this is not a really funded project, lacking a project manager who could keep overview. One of the issues concerns the many dated samples and methods. Common protocols should be used for sampling, documentation and dating technique. The idea aroused if such a protocol for coral age determination could be realized by participants of this post-cruise meeting.

Furthermore, a plea was stated for the continuation of such bottom-up research and projects as provided by Eurofleets. This platform is very important and guarantees access to shiptime for land-locked nations and smaller institutions and should therefore being continued. However, regarding opportunities for further research, not a lot of possibilities were indicated, except for national initiatives for funding or shiptime.

The need of a follow-up meeting was expressed after 2 years. The most feasible meeting place would be Granada, to be hosted by Francisca Martinez-Ruiz.

#### **4) Annexes**

##### **1) Participant list**

##### **2) Reports of the COCARDE grantees**

##### **3) Programme and Abstract Book**

## Annex 1: Full list of speakers, poster presenters and participants of the first MD194 Post-Cruise Meeting

### Speakers and poster presenters

Name	Institute	Country	Oral / Poster
Abed, Zakaria	Université Mohamed V	Morocco	Poster
Delivet, Stanislas	Ghent University	Belgium	Oral
Dubois-Dauphin, Quentin	Université de Paris-Sud	France	Oral
Feenstra, Eline	University of Fribourg	Switzerland	Oral
Hamoumi, Naima	Université Mohamed V	Morocco	Welcome
Henriet, Jean-Pierre	Ghent University	Belgium	Oral + Poster
Houari, Rajaa	Université Mohamed V	Morocco	Poster
Lopez-Alcaide, Luis	CSIC-University of Granada	Spain	Oral
Martins, Ines	Instituto Hidrográfico	Portugal	Oral
Nidali, Hanane	Université Mohamed V	Morocco	Poster
Rachid, Jihad	Université Mohamed V	Morocco	Poster
Rüggeberg, Andres	University of Fribourg	Switzerland	Oral for Stalder and El Kateb
Schroeder-Ritzrau, Andrea	University of Heidelberg	Germany	Oral
Terhzaz, Loubna	Université Mohamed V	Morocco	Oral
Vandorpe, Thomas	Ghent University	Belgium	Oral
Van Rooij, David	Ghent University	Belgium	Introduction, Oral for Llave
Vertino, Agostina	Universita' di Milano	Italy	Oral, also for Lo Iacono
Vitorino, Joao	Instituto Hidrográfico	Portugal	Oral
Wienberg, Claudia	MARUM, Bremen University	Germany	Oral

### Participants

Nom et prénom	Institution	Country
Abdelkrim Louya	Faculté des Sciences de Fès	Morocco
Aberkane Mohamed	Faculté des Sciences Rabat	Morocco
Aicha El Mouichni	Faculté des Sciences Rabat	Morocco
Azedine Dahaoui	Marine Royale	Morocco
Driss Chafiki	Faculté des Sciences Semlalia Marrakech	Morocco
Echerki Rjimat	Ministère de l'Energie, des Mines, de l'Eau et de	Morocco
El Mostapha Lotfi	ENSET, Mohammed V University	Morocco
Fatima Oumalch	ONHYM	Morocco
Francis Jimenez Espejo	JAMSTEC Japan	Japan
Francisca Ruiz Martinez	Instituto Andaluz de Ciencias de la Tierra Granada	Spain
Gert De Lange	University of Utrecht	The Netherlands
Haddou Jabour	Office National des Hydrocarbure et des Mines (ONHYM)	Morocco
Mahamed Idrissi	Institut National de la Recherche Halieutique	Morocco
Menchu Comas	Instituto Andaluz de Ciencias de la Tierra Granada Spain	Spain
Miloudi Hajfani	Faculté des Sciences Rabat	Morocco
Mohammed Achab	Institut Scientifique de Rabat	Morocco
Nadia Mehmedi	Institut Scientifique de Rabat	Morocco
Rachid Essamoud	Faculté des Sciences Benmsik Casablanca	Morocco
Saida Niazi	Faculté des Sciences Rabat	Morocco
Touria Hssaïda	Faculté des Sciences Benmsik Casablanca	Morocco

## Students

Nom et prénom	Institution	Country	Status
Belkhayat Zaine	Faculté des Sciences Rabat	Morocco	PhD
El Houssaine El Kabouss	Faculté des Sciences Rabat	Morocco	PhD
Hando-laur Habicht	University of Tartu	Estonia	PhD
Jamal Khatouf	Faculté de Droit de Rabat	Morocco	PhD
Jemily Linda	Faculté des Sciences Rabat	Morocco	PhD
Raki Amine	Faculté des Sciences Rabat	Morocco	PhD
Trune Post	University of Tartu	Estonia	PhD
Aboulkacem Hassina	Faculté des Sciences Rabat	Morocco	Bachelor
Aboutoufail Salma	Faculté des Sciences Rabat	Morocco	Bachelor
Achnkour Radia	Faculté des Sciences Rabat	Morocco	Bachelor
Adonay Monene	Faculté des Sciences Rabat	Morocco	Bachelor
Bah Aboulay	Faculté des Sciences Rabat	Morocco	Bachelor
Belkadi Ilham	Faculté des Sciences Rabat	Morocco	Bachelor
Belqadi Ahmed	Faculté des Sciences Rabat	Morocco	Bachelor
Bribri Yassin	Faculté des Sciences Rabat	Morocco	Bachelor
Chaibi Karima	Faculté des Sciences Rabat	Morocco	Bachelor
Charki Ahmed	Faculté des Sciences Rabat	Morocco	Bachelor
Chebli El Houssin	Faculté des Sciences Rabat	Morocco	Bachelor
Colibali Yaya Sody	Faculté des Sciences Rabat	Morocco	Bachelor
Diouani Saida	Faculté des Sciences Rabat	Morocco	Bachelor
El Ammari Fatima	Faculté des Sciences Rabat	Morocco	Bachelor
El Hassani Hafid	Faculté des Sciences Rabat	Morocco	Bachelor
El Marzouki Soukaina	Faculté des Sciences Rabat	Morocco	Bachelor
El Mesbahi Abderrahmane	Faculté des Sciences Rabat	Morocco	Bachelor
Labrahimi Ayoub	Faculté des Sciences Rabat	Morocco	Bachelor
Msaadi Lina	Faculté des Sciences Rabat	Morocco	Bachelor
Rachad Mehdi	Faculté des Sciences Rabat	Morocco	Bachelor
Taleb Soukaina	Faculté des Sciences Rabat	Morocco	Bachelor
Zdaïdat Souad	Faculté des Sciences Rabat	Morocco	Bachelor

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**Date**  
26.05.2015

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**Concerning:** report to **MD-194 post-cruise meeting**, ESF-funded CoCaRDE grant.

Dear Andres, Silvia,

During the course of March 2015, I had the pleasure to request for a CoCaRDE participation grant to the First MD194 EuroFLEETS Gateways post-cruise meeting, to be held in the University Mohammed V, Rabat (Morocco). Following the later agreement, I have the pleasure to confirm you the successful attendance to this meeting.

The meeting gathered a wide range of scientific discipline, from physical oceanography, geomorphology, to cold-water-coral and sedimentary archives. This held the key in giving new perspectives, refining and maturing the complete outreach of some research, often carried out within somehow isolated laboratories.

Presented results regarding different sediment cores, we recognized as not much encouraging, received a particular attention from researchers of other fields. Such different point of view unlocked the understanding of the El Araich mud volcano province history in a more comprehensive way. In that sense, this meeting motivated a certain pooling of results that I hope to initiate within the following week, with future collaborators.

Travel expenses			
N°	Item of expenditure	currency	
		euro	Dirham (MAD)
2	Brussels Airlines travel	300.84	
2	Brussels/Gent train travel	30.40	
1	Taxi Rabat – Casablanca airport		216.00
1	Hotel Casablanca airport		900.00
1	BELERE Hotel Rabat (from May the 4 <sup>th</sup> to the 6 <sup>th</sup> )		2049.45
sub total		331.24	3165.45

*Table 1: overview of claimed travel expenses.*

Expenses related to the venue to the meeting were reduced to the strict minimum (cf. table 1). Please receive enclosed a numeric version of each tickets. Additionally, I wish to confirm the original receipt have been addressed to **Dr. Andres Rüggeberg** at the University of Fribourg (Switzerland).

Hereby, I declare that the expenses claimed above are not being reimbursed from any other source.

I remain available for any complementary information and/or document that may be needed,

Sincerely,

Stanislas Delivet

Eline Feenstra  
University of Fribourg  
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COCARDE-ERN  
Dr. Silvia Spezzaferri  
University of Fribourg  
Email: [silvia.spezzaferri@unifr.ch](mailto:silvia.spezzaferri@unifr.ch)  
Dr. Agostina Vertino  
University of Milano-Bicocca  
Email: [agostina.vertino@unimib.it](mailto:agostina.vertino@unimib.it)

**Subject: Report MD194 post-cruise meeting, 5<sup>th</sup> of May 2015, Rabat, Morocco**  
Date: 12 May 2015, Fribourg, Switzerland

I would like to thank the COCARDE-ERN Committee for accepting my application and providing me with the opportunity to participate in the MD194 post-cruise meeting on the 5<sup>th</sup> May 2015 in Rabat, Morocco. Participation in the meeting was successful in the following ways:

- I presented preliminary results and project proposal of the PhD project 4D-Diagenesis@Mound, which are based on gravity core samples collected during the MD194 cruise.
- In communications, several topics were discussed that are directly relevant to my project. For example, there is an apparent need for standardization of age dating techniques to correlate samples (gravity, calypso and box cores).
- I learned much about different research projects on the same samples, providing an interdisciplinary context to place my work in.
- I have extended my network, which might be useful for future collaboration.

Yours sincerely,

Eline Feenstra



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26.05.2015

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**Concerning:** Report MD13-194 meeting Rabat

The MD13-394 post-cruise meeting in Rabat lasted for one day (5/08/2015) and most of the attendees presented their ongoing research orally. The progress on the work on the cores taken during this campaign was discussed topic by topic, including the afore-gathered geophysical and sedimentological data. In my case, the ongoing research regarding the sparker seismic lines, hydrographic measurements and multibeam data has been presented. This in order to better frame the region and locate the cores taken in the Pen Duick area. Positive comments and helpful feedback was provided by the attendees. The conclusion of the first session (in which my talk was positioned) was that hydrographic measurements are a big asset in the Pen Duick area and that they have to be taken as well in the Alboran regions (e.g. Brittlestar region). Only in this way, a better understanding of the hydrographic conditions in which cold-water corals thrived and contourites grew/grow are possible. Future work on the Pen Duick area from my side include the refinement of the seismic stratigraphy and a better implementation of the hydrographic data in the overall picture. This will be published in the upcoming Marine Geology Special Issue. Attending this meeting helped in having an overall picture of the ongoing research and to frame my research into this bigger picture.



# Final Report

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Dear Madam,

I participated to the *MD194 EUROFLEETS Gateways Post-Cruise Meeting* in Rabat, on May 5<sup>th</sup>. This meeting allowed me to present the first results I obtained on seawater collected during the cruise in June 2013, by giving an oral presentation titled “*Nd isotopes for tracking past circulation in the Mediterranean Sea*”. I analyzed neodymium isotopic composition on five seawater profiles in order to constrain the isotopic signature of the intermediate water masses. This study has been presented together with all-new results from deep-sea corals and foraminifera in the Alboran Sea that provide important insights on the past water mass mixing through the Holocene and during the Sapropel deposit.

I was particularly interested in the session 2 “*Environmental Forcing – Paleoceanography*” as well as the preliminary results on the MOW quaternary evolution in the Gulf of Cadiz. Anyway, each oral presentation was of high quality and I was happy to have the opportunity to see again my co-workers on the EUROFLEETS cruise and observe how their works have progressed.

The atmosphere was very friendly as we took advantage of the nice city of Rabat and its soft climate. A special thank goes to the nice organization of this event.

I am therefore extremely pleased that I have taken part in this meeting which is very important to facilitate follow-up the different studies for this cruise to be successful.

I want to give warm thanks to the ESF COCARDE for the funding covers.

Yours sincerely,

Quentin Dubois-Dauphin

Luis López Alcaide

### **First MD194 EuroFleets Gateways post-cruise meeting report:**

I attended the first MD194 post-cruise meeting on May 4-5, 2015 held at the Faculty of Sciences of the Mohammed V University in Rabat.

In June 2013 I participated the MD194 Cruise and since then we have been working on the retrieved cores. Our research focuses on coral and foraminifera dating, porewater geochemistry, hydrocarbon gas chemistry and chemical composition of solid phases. Our preliminary results were presented during the post-cruise, which was also a great opportunity to discuss with other participants and researchers involved in MD194 core analyses about the controlling factors of the cold-water coral mound growth and also to compare results from the Pen Duick Escarpment and the Melilla cold-water coral areas.

My presentation, entitled “Variations in porewater and sediment composition in mound of the Melilla cold-water coral Province (Alboran Sea)”, was focused on the origin and development of the Melilla cold-water coral mounds as well as related early diagenetic processes. The talk was included in Session 3: “The Mound Record”.

Other than the welcome and introduction, the meeting scheduled 3 sessions with 15 oral presentations in total and 3 posters.

Session 1 – Physical Forcing (from oceanography to sedimentary record).

During this session João Vitorino and Inês Martins presented results from observations of the North-west Morocco margin. They characterized the circulation in this area, and developed a numerical model used in the elaboration of water mass distribution and circulation maps. Thomas Vandorpe introduced part of his work in the contourites of the Gulf of Cadiz, associated to mud volcanoes and cold-water coral mounds. Then Estefania Llave presentation (given by Dr. D. van Rooij) pointed out the importance of the Mediterranean Outflow Water in the evolution of the Gulf of Cadiz slope. Finally, Stanislas Delivet showed his results on the hydrodynamics of the Moroccan Atlantic margin.

Session 2 – Environmental Forcing- Paleoceanography.

The second session started with the presentation of Quentin Dubois Dauphin and the studies about past circulation of the Mediterranean Sea based on neodymium isotopic composition. In the talk of Claudio Stalder (given by Andres Rüggeberg) the stable isotope analyses of several foraminifera species, from different water depths, was used to reconstruct the possible stratification of the Western Mediterranean. Agostina Vertino compared the benthic carbonate associations from the Pen Duick Escarpment and the Melilla Mound Field to establish the environmental conditions in the

development of these communities. Pictures and information about the new foraminifera *Schackoinella spina* were introduced in a short talk made by Claudio Stalder. The last talk of this session was run by Andrea Schröder Ritzrau, who reported the first results on U/Th dating on corals and  $^{14}\text{C}$  in sediment cores.

Session 3 – The mound record.

After the lunch break the last session started. Claudia Wienberg introduced in detail the Melilla cold-water coral Province and established the coral growth periods. This presentation was especially interesting for me since we both work in the same area. Agostina Vertino gave Claudio Lo Iacono presentation about the West Melilla and Cabliers cold-water areas. Before my talk, Loubna Terhzaz presented the study of the sediments associated to the cold-water coral mounds. After my talk, the last oral presentation by Eline Feenstra presented some results from early.

I presented preliminary data and interpretations of the Melilla cold-water coral province mounds. The U/Th ages were shown and compared to the paleoenvironmental record. In the same way, an overview of the porewater preliminary data was also introduced. Question and clarifications followed the presentation.

The feedback with the rest of participants was an excellent opportunity to learn and discuss research topics, as I expected. My experience has been absolutely satisfactory and I consider the meeting great success.

I would like to express my gratitude to the ESF-funded travel grants and the COCARDE European Research Network Programme for this opportunity.

Thank you, Luis López Alcaide



## **First MD194 EuroFLEETS Gateways post-cruise meeting: Late Pleistocene Carbonate Mound Record along the Mediterranean-Atlantic Gateway**

**4-5 May 2015**

**Mohammed V University, Rabat, Morocco**

# **Programme and Abstract Book**

### **Conveners**

*David Van Rooij* (Gent, Belgium)

*Naima Hamoumi* (Rabat, Morocco)

*Andres Rüggeberg* (Fribourg, Switzerland)



## Welcome

We cordially welcome you to the first MD194 post-cruise meeting at the Faculty of Sciences of the Mohammed V University in Rabat! This meeting aims to present and discuss the preliminary results of our unique multidisciplinary study to better understand the complex environmental dynamics influen-



cing cold-water coral mound growth on either side of the Gibraltar gateway. This meeting will also address the effects of the Neogene gateway processes on deep-water ecosystems and is therefore associated to the RCMNS Interim Colloquium “Mediterranean-Atlantic Gateways (Neogene to Present)” held at the La Tour Hassan Hotel in Rabat from 5<sup>th</sup> to 8<sup>th</sup> May 2015.

## Scientific background of the meeting

The “Pen Duick Escarpment” (PDE) and Melilla cold-water coral (CWC) mounds, located at either side of the Gibraltar Strait on the Moroccan margin, may be regarded as models to understand the early development stage of CWC mounds, such as those found in the Belgica mound province (IODP 307). It was postulated that the Moroccan margin holds the key to the origin and early development of the Porcupine mound provinces and comparable cases along the European continental margins. Both the “Subseafloor Ocean” and shallow “Deep Biosphere” significantly contribute to the early diagenesis and consolidation of modern, cold-water coral associated mounds, concurrent with their development: this process plays a key role in sustaining mound growth to giant proportions, such as the Melilla mounds. This has led to a 10 days research cruise on board of R/V Marion Dufresne, organized within the framework of 2 funded ship time projects submitted to the EC FP7 “Research Infrastructures” EuroFLEETS project, as well as a 24h add-on funded by the Swiss University of Fribourg.

The study areas are on the crossroads of (a) cold-water coral carbonate systems, with sequences covering the Plio-Pleistocene interval, (b) contouritic processes driven by vigorous and dynamic intermediate water masses and (c) seepage and fluid flow processes. Both on- and off-mound records will document the gateway dynamics and its influence on deep-water ecosystems, with the following research objectives:

**Objective 1:** Exploring the present-day interface between reef and mound,

**Objective 2:** Understand the past and present (palaeo)oceanographic drivers,

**Objective 3:** Spatial and temporal variability of biogeochemical processes.

The MD194 mission started in Cadiz (Spain) on 10<sup>th</sup> June 2013 and ended on 20<sup>th</sup> June 2013 in Lisbon (Portugal). It explored the Moroccan Atlantic margin and the Alboran Sea during the EuroFLEETS GATEWAYS leg and the Tore Seamount area in the Portugese EEZ for the EuroFLEETS TORE leg. The MD194 scientific team was composed out of an international team of 42 scientists, among which 15 “young scientists” (BSc, MSc, PhD students) from the following nationalities: Belgium, France, Germany, Spain, Portugal, Morocco, Italy, Tunisia, United States, Poland, Romania.

The entire mission was a success on all levels, acquiring a total length of over 250 m of sediments in water depths ranging from 250 to 5500 m (22 gravity cores, 6 Calypso cores, 6 boxcores, 7 CTD casts and 1 CASQ cores). Its general purpose was to:

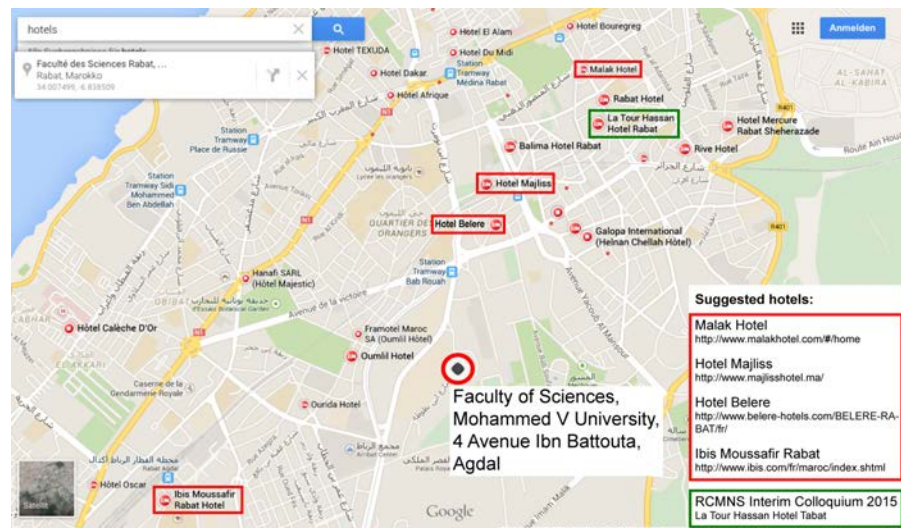
- 1) collect a variety of 11 m gravity cores in cold-water coral mound for sedimentological, palaeoceanographic and biogeochemical studies,
- 2) acquire a number of CALYPSO cores (26,50 m and 36 m) in off-mound sediments or within the TORE seamount basin,
- 3) collect a CASQ core (12 m long),
- 4) sample cold-water coral rubble using the giant square boxcorer,
- 5) perform water column profiling and sampling using CTD with 24 bottles, and
- 6) acquire additional geophysical data using multibeam echosounder and sub-bottom profiler.

This dataset has been studied in the past 1.5 years on a most multidisciplinary way, involving geophysics, sedimentology, palaeontology, oceanography, geochemistry. Therefore, this meeting convenes the shipboard and shorebased scientists of the MD194 campaign, presenting preliminary results of the acquired data as oral and/or poster presentations (see programme). Special emphasis is laid upon the participation of young and early-career scientists. **ESF-funded travel grants** through the COCARDE European Research Network Programme ([www.cocarde.eu](http://www.cocarde.eu)) have been awarded to six student participants:

- Eline Feenstra (Fribourg University, Switzerland)
- Akram El Kateb (Fribourg University, Switzerland)
- Thomas Vandorpe (Ghent University, Belgium)
- Stanislas Delivet (Ghent University, Belgium)
- Quentin Dubois Dauphin (Paris University, France)
- Luis López (UGR-CSIC, Spain).

### Meeting venue

The meeting will be held at the Faculty of Sciences of the Mohammed V University, 4 Avenue Ibn Battouta, BO 1014 RP, Rabat, Morocco. Meeting venue and suggested hotels, as well as the RCMNS Colloquium, are indicated in the google-map.



On Monday, May 4, 2015 starting at 5 p.m.: **Registration** and **Ice Breaker** at the Faculty of Sciences, 4 Avenue Ibn Battouta, Rabat, Morocco (see page IV).

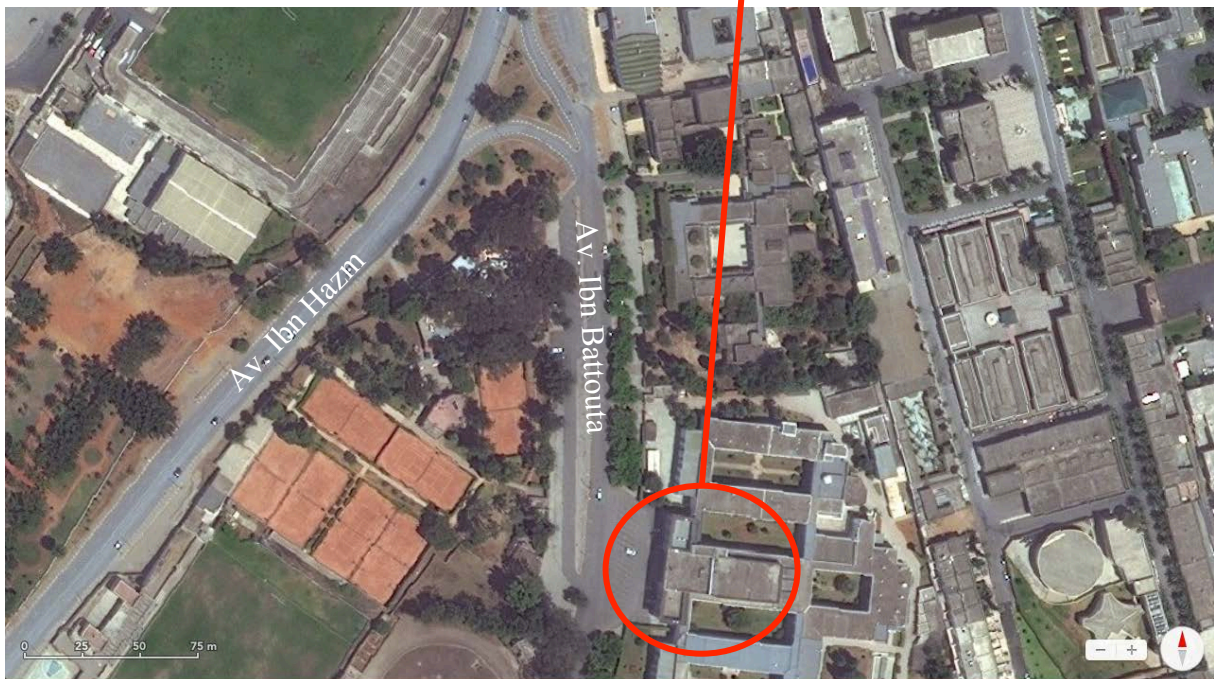
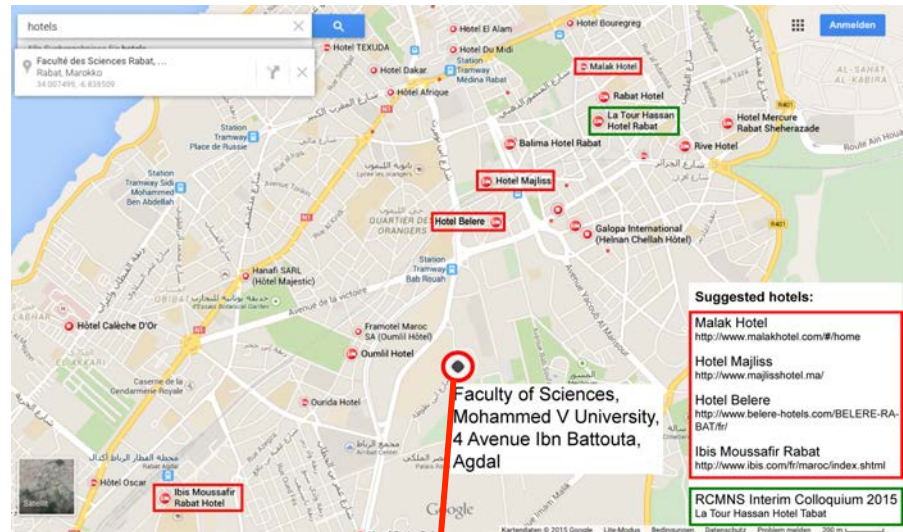
## Program of MD194 Post-Cruise Meeting on Tuesday, May 5, 2015

Each oral presentation is allocated 15 minutes including 3 minutes of discussion! Please take this into consideration when preparing your presentation.

<b>Begin</b>	<b>Presenting author</b>	<b>Title</b>	<b>Page</b>
08h30	N. Hamoumi	Welcome	
08h40	D. Van Rooij	Introduction	
<b>Session 1 – Physical Forcing (from oceanography to the sed. record)</b>			
08h50	J. Vitorino	Circulation patterns along the NW Moroccan margin	1
09h05	I. Martins	Physical Processes affecting the El-Arraiche Mud Volcano field	2
09h20	T. Vandorpe	Contourites in the El Arraiche area and their link with cold-water corals	3
09h35	E. Llave	MOW Quaternary evolution on the southern Gulf of Cadiz	4
09h50	S. Delivet	Understanding the large scale benthic hydro-dynamic variability along the Moroccan Atlantic	5
10h05		SESSION DISCUSSION	
<b>10h30 COFFEE BREAK</b>			
<b>Session 2 – Environmental Forcing – Paleoceanography</b>			
11h00	Q. Dubois-Dauphin	Nd isotopes for tracking past circulation in the Mediterranean Sea	6
11h15	C. Stalder	Multi-species stable isotope analyses of foraminifera as potential tool to reconstruct paleo-water-masses in cold-water coral settings in the Alboran-Cadiz system	7
11h30	A. Vertino	Late Pleistocene to modern benthic macrofauna from cold-water coral mounds on either side of the Strait of Gibraltar	8
11h45	A. El Kateb	<i>Schackoinella spina</i> , a new benthic foraminiferal species from cold-water coral ecosystems of the Alboran Sea and the Gulf of Cádiz	9
12h00	A. Schröder-Ritzrau	Holocene coral presence across the Strait of Gibraltar (MD194 Eurofleets)	10
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## Meeting venue



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## **Circulation patterns along the NW Moroccan margin**

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A multidisciplinary program of observations of the NW Morocco margin was conducted by Instituto Hidrografico from the 11<sup>th</sup> to the 24<sup>th</sup> June 2009, onboard NRP Almirante Gago Coutinho. One of the major goals of this program was to characterize the circulation of the NW Morocco margin during upwelling conditions, giving particular emphasis to the recirculation of the eastward extension of the Azores Current into the Canary Upwelling Current and to the presence and fate of the poleward slope current along the NW Morocco slope. Surface to bottom CTD measurements were collected in the global area of interest. A numerical model with data assimilation was used to build synoptic maps of the main physical fields from the rather non-synoptic CTD coverage. These maps reveal the main aspects of the circulation and water mass distribution along this margin and enable to analyze in detail the different processes involved. The results from this approach are compared with independent measurements collected either at specific locations (current meter moorings placed at 3 positions along the slope) or in the global area (current profiles collected by a lowered ADCP system coupled to the CTD probe or by the vessel mounted ADCP system). The numerical model is also used to describe the evolution of the conditions along this margin during the transition from spring to summer.

## Physical Processes affecting the El-Arraiche Mud Volcano field

Inês Martins & João Vitorino

*Instituto Hidrográfico - Portugal*

One of the main goals of the multidisciplinary program of observations conducted in June 2009 by Instituto Hidrográfico on the NW Morocco was the characterization of the physical, sedimentary and chemical conditions affecting the El-Arraiche Mud Volcano field. Surface to bottom CTD profiles complemented with current profiles (collected both by Lowered ADCP and by vessel mounted ADCP systems) and water samples were collected in the global area where the MV field is located. In addition, 3 current meter moorings were deployed along the 500 m isobath, one in the middle of the MV field and the others respectively north and south of it. The circulation and water mass distribution on the global area was characterized using a numerical model with assimilation of the CTD profiles. Here a high-resolution domain of this model, nested in the larger scale model, is used to detail the circulation patterns inside the MV field. The current profiles collected by the LADCP and VMADCP systems allow refining this picture. The current meter time series are used to further extend the analysis, detailing the range of physical processes affecting the near bottom conditions inside the MV, particularly the impact of internal tides.

## Contourites in the El Arraiche area and their link with cold-water corals

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The El Arraiche area is situated in the southern part of the Gulf of Cádiz, roughly between 35° and 35°45' north and 6°30' and 7°15' west. This area contains mud volcanoes, cold-water coral (CWC) mounds, contourite drifts and tectonic ridges. Several small-scale drift deposits are present and they are all the result of deflection of bottom currents by the topographic obstacles. Both the tectonic ridges (resulting from the compressive regime in the area) and the mud volcanoes generate mounded sediments at their bases. A link has been established between the slope of the tectonic ridges and/or their curvature. When slopes exceed values of about 12°, drift deposits are present around the Renard ridge. The bottom currents in the region are both (modified) Antarctic Intermediate Water and North Atlantic Central Water, as indicated by nutrient data. It is in this setting several CWC mounds are present at the foot of the Pen Duick Escarpment. Core MD13-3446G revealed the presence of many CWC fragments. Variation of fragments throughout the core shows several periods of intensified coral growth with in general a higher amount of fragment in the lower parts of the core compared to the upper parts.

## **MOW Quaternary evolution on the southern Gulf of Cadiz**

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The role of the Mediterranean Outflow Water (MOW) on the evolution of the southern continental slope of the Gulf of Cadiz is still misunderstood. A correlation of the recent results obtained from the IODP Expedition 339 (grain size, physical properties, and seismic profiles analyses) with MD194 EuroFLEETS Gateways data have been carried out. The present study allows some differentiation between sandy contourites in the Quaternary sedimentary record, on the basis of grain-size characteristics, providing an evaluation of the link between tectonic, climate, bottom currents, and sedimentary facies, which have controlled the sedimentary evolution for the CDS in the northern and southern margins. A similar stacking pattern is observed on both margins, with a main and erosive discontinuity, evident in seismic profiles, at the Mid Pleistocene (MPD), characterised in seismic by high amplitude reflectors, which correlates with an increasing in grain size, density and magnetic susceptibility. Above MPD, slope progradation and sandier contourites start to be dominated. This study provides a long-term palaeoceanographic background, where the prevalence of contourites shows enhances bottom-current. A significant difference in the sedimentation rates is observed between both margins, being about 60 cm/kyr on the southern Spanish margin, close to the strait of Gibraltar, and of ~ 10 cm/kyr on the Moroccan margin, close to the Strait to Gibraltar, and reaching lower values (2.5 cm/kyr) towards the south. Future work integrating other proxies and a more detailed age control will be essential for a higher resolution sedimentary analysis of the sandy contourites along the Moroccan and Spanish margin.

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## Understanding the large scale benthic hydrodynamic variability along the Moroccan Atlantic margin

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Within the proximal Gibraltar Atlantic domain, the northern and southern Gulf of Cádiz show a relatively distinct and independent hydrologic and climatic history. Focusing on the southern part, several authors pointed out the occurrence of distinct oceanographic fronts and dramatic shifts of the northeastern trade winds regime associated with global climate variations. The even more striking contrast in intermediate water masses, from north to south, is related to the AntArctic Intermediate Water (AAIW) and the Mediterranean Outflow Water (MOW) dynamics. First because the former is recycled within the MOW when flowing north of Gibraltar and does no longer exist as such. Secondly because the Coriolis influenced MOW does not “naturally” propagates south of Gibraltar, where it nevertheless currently forms of a giant meddy.

The complex Cold-Water Coral (CWC) occurrence seems to periodically thrive and decay within well-defined periods as evidenced from seismic data identified buried mounds. Since the CWC ecosystems and enhanced hydrodynamic co-occurrence widely prevails, such observation likely points out radically different hydrodynamic conditions over relatively large time-scales.

The preliminary results of two MD194 “off-mound” core sites are presented. The approximately 24 m long cores bear very low sedimentation rates, presumably providing up to 900 kyr record. Extremely well expressed sub-Milankovich variability prevails during glacial periods whereas interglacial intervals (i.e. MIS 1, 5, 7, 9 etc...) seem more stable with reduced terrigenous content. Despite the low time resolution, the record might provide essential data in understanding the local hydrologic variability since the middle Pleistocene.

## Nd isotopes for tracking past circulation in the Mediterranean Sea

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The Mediterranean Sea is highly sensitive to rapid climatic changes. Indeed, modifications of the Mediterranean Sea circulation occurred since the beginning of the last glacial period, especially during the Heinrich and Dansgaard-Oeschger events of the North Atlantic, supporting the idea of a strong relationship between the North Atlantic climate and the Mediterranean Sea hydrology. It has been suggested that this basin could play a significant role in triggering a switch from a stadial to an interstadial mode through the Mediterranean Outflow Waters, injecting saline waters in the northern Atlantic at times of weak AMOC. The aim of this study is to reconstruct the hydrology of the Mediterranean Sea during the Holocene characterized by a collapse or a reduction of deep convection during the deposit of Sapropel S1 (10,000-6000 yrs) and to determine potential impact of such variations on the AMOC. Neodymium isotopic composition ( $\epsilon\text{Nd}$ ) has been measured on seawater collected during the EuroFLEETS-GATEWAY cruise, to constrain the present day seawater  $\epsilon\text{Nd}$ . In addition, fossil deep-sea corals (*L. pertusa* and *M. oculata*) and foraminifera from the Alboran Sea and Siculo-tunisian Strait (between 280 and 465 m) have been investigated to reconstruct the past water mass mixing through the Holocene. The Mediterranean Sea displays a wide range of  $\epsilon\text{Nd}$  values between the Atlantic inflow (-11.8) and much more radiogenic eastern intermediate water masses (~-5). Cold-water coral fragments have been dated from present day to 25 kyr.

Preliminary results indicate that  $\epsilon\text{Nd}$  analysed on deep-sea corals from the Alboran Sea do not change significantly through time (between -8.5 and -9.2). Such values are consistent with two  $\epsilon\text{Nd}$  seawater profiles further west (between -8.9 and -9.6; Tachikawa et al., 2004). This suggests no major changes of the hydrology of the LIW during the late and early Holocene and the Bølling-Allerød which are characterized by rapid growth of the deep-sea corals in the Alboran Sea. Foraminifera of one core located in the Balearic Islands will be investigated to complete the seawater  $\epsilon\text{Nd}$  record of the Holocene in order to test if the beginning of the Holocene is associated with major reorganisation of the Mediterranean hydrology.

Conversely,  $\epsilon\text{Nd}$  from deep-sea corals of the siculo-tunisian strait range from -4 to -8 during the last 25 kyr. Living and glacial cold-water corals are characterized by  $\epsilon\text{Nd}$  values around -7/-8. However, we notice more radiogenic peaks at 7 and 22 kyrs that could be induced by an increase in intermediate water production, a greater discharge of the Nile River and/or process of boundary exchange.



## Multi-species stable isotope analyses of foraminifera as potential tool to reconstruct paleo-water-masses in cold-water coral settings in the Alboran-Cadiz system.

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Previous multi-species stable isotope analyses have demonstrated that variations in the oxygen and carbon isotope ratios of the shells of various species of foraminifera can be used to infer their relative habitat depths (e.g., Pearson and Wade 2009). Although diagenesis can alter the isotopic composition in foraminiferal shells to varying degrees it can reduce but not obliterate the interspecific differences, therefore, the relative ordering of the different species in the oxygen- and carbon-isotope cross-plot is generally robust for inferring their life habitats in the water column (Spezzaferri and Person, 2009). In particular, when the isotopic composition of several species is measured in different species from the same sample, the lightest  $\delta^{18}\text{O}$  probably indicates test calcification in the warmest/superficial (i.e., the surface mixed layer) waters and species with heavier  $\delta^{18}\text{O}$  values might have calcified in cooler/deeper waters. Conversely,  $\delta^{13}\text{C}$  are linked to symbiotic relationships, metabolic effects in foraminiferal shells but also primary productivity at the surface and remineralization of organic matter at depth. Therefore, not only the paleo-depth habitat of foraminifera can be inferred from multi-species stable isotope analyses but also water mass characteristics and their environmental significance (e.g., Niebler et al., 1999).

We present here a multispecies isotope investigation from 48 samples from two cores recovered during the MD194 EuroFleets Gateway and TTR-17 cruises, with the aim to reconstruct and trace the possible stratification of water masses in the Eastern Alboran Sea and the Gulf of Cadiz. Samples from the two regions have been chosen according to their dominant faunal content: e.g., from bryozoans, *Lophelia pertusa*, *Madrepora oculata* and pelagic facies respectively spanning the last 13,000 years.

For the oxygen- and carbon-isotope cross-plot we used the following planktonic species: the surface/mixed layer dwellers *Globigerinoides ruber* and *Globigerina bulloides*, the lower thermocline species *Globorotalia inflata* and the deep dweller *Truncorotalia truncatulinoides* and the benthic species *Lobatula lobatula*.

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## Late Pleistocene to modern benthic macrofauna from cold-water coral mounds on either side of the Strait of Gibraltar

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Coarse carbonate sediments of cold-water coral (CWC) mounds are almost exclusively produced by scleractinian corals and associated calcifying organisms. Due to the sensitivity of several species to environmental changes, variations of benthic carbonate associations (BCA) through time can provide important insights on mound development stages.

This study focuses on the BCA collected, through box- and gravity cores, from CWC mounds located in the Melilla Mound Field (MMF) and Pen Duick Escarpment (PDE). The main goal of this work is to characterize the composition of modern and fossil BCA and to relate its variation through time to oceanographic changes at regional and/or global scale. Our preliminary results are based on the analysis of samples collected during the MD 194 cruise and previous oceanographic expeditions (MD 169 and Belgica 09/14b). Observations on modern fauna from the PDE mounds have been carried out also on ROV videos collected during the Belgica 07/13 and 09/14b cruises.

The modern BCA of the two examined mound areas are rather different. The PDE mound biocoenoses are characterized by scarce and low-diverse calcifying organisms that colonise dense (mostly fossil) dendrophylliid frameworks or rubble sparse in mud-dominated sediment. The modern MMF BCA are more diversified, dominated by *Madrepora oculata* and particularly rich in molluscs and bryozoans. Similarities found in the faunistic assemblages of the examined sediment cores hint at comparable environmental conditions in the past that favoured the development of *Lophelia*-dominated communities on both sides of the Gibraltar Strait.

## ***Schackoinella spina*, a new benthic foraminiferal species from cold-water coral ecosystems of the Alboran Sea and the Gulf of Cádiz**

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*Schackoinella spina* n. sp., has been found in the eastern Alboran Sea at five different stations in water depth ranging from 258 m to 330 m, as well as in one 532 m deep station in the Gulf of Cádiz, north-eastern Atlantic Ocean. Three stations have been sampled with a giant box core (BC) and two stations with a gravity core (GC) system. The sediments of the BCs and the GCs are characterized by cold-water coral (CWC) debris and a high abundance of biogenic components (e.g., bryozoans, echinoderms, bivalves, gastropods, serpulids, foraminifera). The surface samples from the BCs were treated with an ethanol-Rose Bengal solution following standardized sampling protocol. In the BC samples the specimens of *Schackoinella spina* n. sp., were collected from the surface (0–1 cm). In particular, one BC sample (MD13-3456BC) contained six living (stained) specimens and a relatively high abundance of non-stained specimens (52 per 50 cm<sup>3</sup> sediment). The new species was found at several sediment depth intervals corresponding to a mid-late Holocene age.

The occurrence of this small (60–120 µm) species in the Alboran Sea and Gulf of Cádiz has likely been overlooked in this region. Although not straightforward, the presence of this species in association with cold-water coral fragments and its absence in fine-grained pelagic sediments may suggest a relation to this ecosystem.

This research is a contribution to Swiss National Science Foundation Project 200020\_153125. CS also acknowledges the Johanna Resig Cushman Award 2014.

## Holocene coral presence across the Strait of Gibraltar (MD194 Eurofleets)

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During the MD194 Eurofleets (Gateways) cruise coral bearing sediments have been sampled along the Moroccan Atlantic margin and within the Alboran Sea. Understanding the sedimentological, palaeoceanographic and biogeochemical linkage of coral mounds across the Strait of Gibraltar, implies a solid understanding of the timing of coral growth. Cold-water coral bearing sediments were collected using gravity cores and a giant square boxcore.

Here we report on the first results of U/Th age determination and additional <sup>14</sup>C dating on six sediment locations. Wienberg et al. (2010) has previously demonstrated the occurrence of deep sea corals, in particular of the framework forming species *L. pertusa*, which is dominant during the last glacial and prior glacial periods in the Gulf of Cádiz. Fink et al. (2013) showed the presence of *L. pertusa* during the Holocene within the Alboran Sea. The newly collected U-series ages (Figure 1) reveal coral growth during the Younger Dryas, and Early Holocene at both sides of the Strait of Gibraltar.

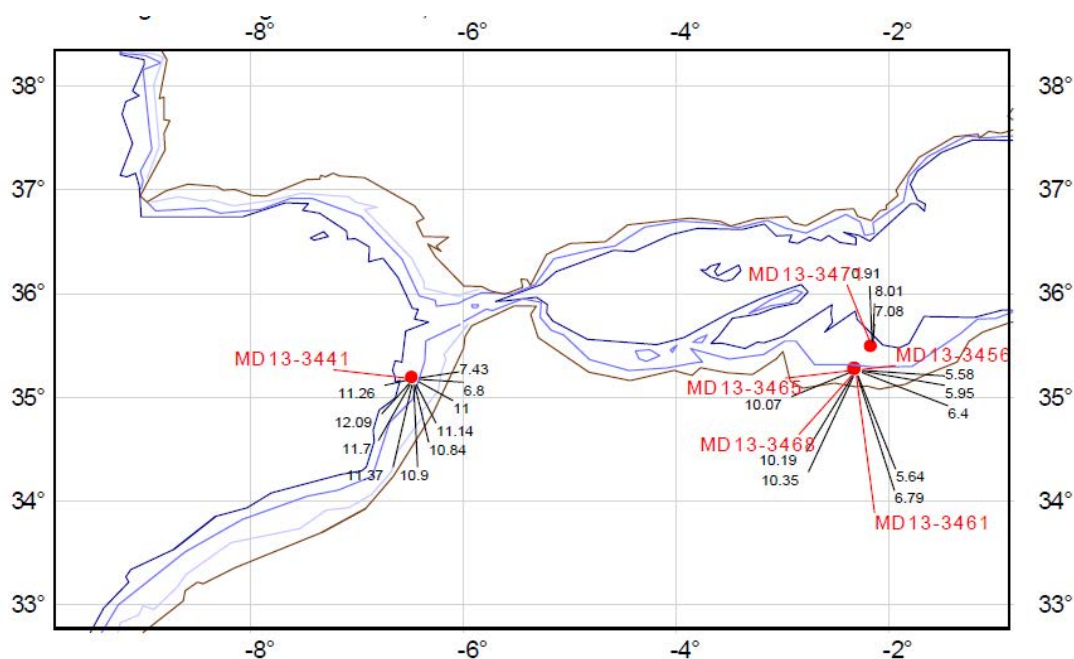


Figure 1. U/Th ages of corals from box cores.

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## The eastern Melilla Cold-water Coral Province (Alboran Sea)

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After the initial discovery of cold-water corals (CWC) in the eastern Melilla coral province (EMCP) (Comas & Pinheiro, 2007), much effort has been conducted to unravel their spatial and temporal occurrence, and to identify the environmental controls steering their proliferation in this area. Living CWC exhibit today a rather scattered distribution, but seem to have been much more prolific during the geological past as indicated by coral mounds of 20-40 m in height, and coral-bearing sedimentary units of several metres in thickness that constitute the upper parts of steep elongated ridges (Brittlestar ridges; height: 50-150 m). Datings revealed that CWC colonised the EMCP during most of the Holocene, mainly steered by enhanced productivity (Fink et al., 2013). Due to a lack of appropriate material, no information exists to date on their occurrence prior to the Holocene, hence for the last full glacial-interglacial cycle. Two 'long' MD-cores collected from the above mentioned ridges (MD13-3460G/3467G) will likely provide 'deeper' insight into the temporal development of CWC in the EMCP prior to the Holocene. For both cores CT-scan data and U-series datings are currently processed. Additionally, a coral-barren core (MD13-3457) collected south of the ridges offers a unique archive for environmental changes probably covering the last 200 kyrs as indicated by XRF data. An age model ( $\delta^{18}\text{O}$ ,  $^{14}\text{C}$ ) will be established soon followed by various proxy studies.

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## The West Melilla and Cabliers CWC Mounds (Alboran Sea) – State of the art and future perspectives

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The West Melilla Cold-Water Coral (CWC) Mound Field and the Cabliers CWC Mound (Eastern Alboran Sea) have been mapped in 2012 through high-resolution swath-bathymetry (MELCOR Cruise) and eventually sampled through 4 gravity cores during the GATEWAYS MD194 Cruise in 2013. The two gravity cores collected on the West Melilla Mounds show different densities of the CWC frameworks, mainly composed of *Lophelia pertusa*, suggesting a different evolution at least during the last stages of their development. Despite these differences, radiocarbon dating proved that the two mounds covered the same time span within the same thickness, with the base of both cores (5.2 m, 5.8 m) up to 12.45 kyr BP old. An abrupt demise of CWC reefs occurs at around 9.1 kyr BP and mainly coincides with the end of an Organic Rich Layer largely described in the Alboran Sea. A major shift from *Lophelia*- to *Madrepora*-dominated associations is also evident towards the shallower section of the core. The Cabliers Mound is a 15 km long CWC ridge, where thriving CWC reefs have been observed on its summit through ROV videos. The two gravity cores collected on the Cabliers Mound have a maximum penetration of 11.8 m and display thick and dense CWC frameworks mainly composed of *Lophelia pertusa*. High resolution CT scans of the cores showed densities of CWC vs sediments of up to 35%. Ongoing and future studies on the collected cores include taxonomic and paleoecological analysis (University of Milano Bicocca), paleo-temperature analysis on benthic forams (University of Barcelona), radiocarbon, U/Th dating and geochemical analysis (National Oceanography Centre), automatic analyses on CT Scans (University of Southampton). Finally, during the SHAKE Cruise (ICM-CSIC, April-May 2015) AUV bathymetry, ROV videos, L-ADCP, gravity cores and Sparker seismic data will be acquired along the Cabliers Mound.

## **Sedimentological study of cold-water-coral mounds: Brittlestar Ridge I and Cabliers mound (Moroccan Alboran margin)**

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This paper presents the results of the sedimentological study of sediments associated to cold-water-coral mounds, from Box-cores taken at the Brittlestar Ridge I and Cabliers Mound along the Moroccan Alboran margin, off Melilla, during cruise MD194 / Euro-FLEETS Gateways on board the R/V Marion-Dufresne (10-21 June 2013).

The sedimentological study based on the analysis of sedimentary facies, the calcimetry, the X-ray diffractometry (total rock and clays) and geochemistry of major elements were undertaken to precise the sources of sediment supply and the factors that controlled the formation of those cold-water-coral mounds.

These results allow to precise the mineralogical and chemical composition of the sediments and enable to identify two main sediment sources: an intrabasinal biogenic source and a land source, the Bou Areg plain in the Nador region.

## Variations in porewater and sediment composition in mounds of the Melilla CWC Province (Alboran Sea)

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Cold Water Coral (CWC) mounds from the Melilla Province (Southeast Alboran Sea) have been studied for their porewater and sediment composition. Our results from geochemical analysis performed on selected cores from the Serpent Mound and the Zigzag Ridge collected by the MD194 cruise will be presented and compared to those from the BigOne Ridge recovered by the GASALB Cruise (R/V Pelagia, 2011). Our investigations include U/Th coral ages, porewater geochemistry, mineral and chemical composition of solid phases, and methane contents. The U/Th ages of the coral reveal distinct periods of CWC growth: The Serpent Mound shows two periods, namely 7-15 kyr and 106-115 kyr; the Zigzag Ridge shows at least two periods of growth at 14 kyr and ~ 310 kyr and the BigOne Ridge denotes two periods, 14-43 kyr and 208-244 kyr. At a first glance, periods of intense growth seem mainly related with deglaciation intervals. In addition, higher rates in mound growth appear to occur at discrete mounds located in shallower waters at the Moroccan slope. Environmental- and climate-controlled conditions are therefore thought to be significant factors for their formation. Hence, water depth, seawater temperature and currents dynamics are amongst the parameters that may determine favorable conditions for mound's growth. Deviations of mound size and growth rate compared to similar structures in the Gulf of Cadiz (and elsewhere) must be related to particular geological features of the seafloor and the more oceanographic restricted nature of the Alboran Sea. In contrast to the episodic CWC growth periods, the porewater geochemical composition appears to express active early diagenetic processes at the studied mounds. This suggests that episodic changes in fluid dynamics trigger variation in the geochemical trends. Amongst these they are organic matter degradation and carbonate equilibrium processes. Such active diagenetic processes are expressed by in particular the porewater profiles of alkalinity, DIC,  $\text{SO}_4^{2-}$ ,  $\text{NH}_4^+$ ,  $\text{Ca}^{2+}$ , and  $\text{Sr}^{2+}$ . Remarkable differences occur between the distinct carbonate mounds and between them and a reference site. Early diagenetic features appear to be much more severe in some sites, whereas in other sites later carbonate recrystallization seems to play a larger role. In this presentation not only the origin and development of CWC mounds will be outlined and discussed, but also the various porewater characteristics and associated early diagenetic processes.

## **Understanding the temporal and spatial variability of early diagenesis in cold-water coral carbonate mounds**

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Cold-water coral carbonate mounds are considered as unique palaeo-environmental records of the mid to deep ocean. However, past geomicrobiological investigation in the ‘deep-biosphere’, i.e. the sub-seafloor sediments, has shown that metabolic processes substantially impact biogeochemical cycles and cause dissolution and precipitation of solid mineral phases, a process referred to as early diagenesis, changing the architecture of the mound. On one side, this elucidates the link between microbial processes and the formation and growth of carbonate mounds, and on the other side it poses important questions regarding how this affects the sedimentary record by overprinting the primary environmental record.

4D-DIAGENESIS@MOUND aims to decipher the temporal and spatial variability of early diagenesis in carbonate mounds influenced by a shallow sulphate-methane transition zone (SMTZ). Therein the study is two-fold. At first instance, the spatial variation will be deciphered through characterization and quantification of (microbial-mediated) diagenesis of gravity cores taken along core transects on Recent to Sub-recent (Plio-Pleistocene) mounds on Pen Duick Escarpment in the Gulf of Cadiz and Melilla Mound Field in the Alboran Sea. The cores have been recovered within the framework of the EuroFLEETS campaign ‘The Mediterranean-Atlantic Gateway Code: The Late Pleistocene Carbonate Mound Record’ aboard the R/V Marion Dufresne.

The second phase of the project will focus on in-vitro flow experiments by means of a bioreactor. In the bioreactor, a mixture of microbial communities and carbonate mound sediments will be subjected to low pressure, moderate temperatures and continuous fluid flow, i.e. methane flux, to monitor dissolution and precipitation of mineral phases through time. During the entire project, special attention will be paid to the 3D-visualization of diagenetic phases within the mound sediments by means of multi-scaled nanotomography.



## **Calcimetric study of sediments associated to cold-water-coral mounds along the Moroccan Atlantic margin off Larache (MD13-3444G and -3447C cores)**

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Two off-mounds sediment cores (MD13-3444G and MD13-3447C) were selected for calcimetry study (59 samples), which were taken during cruise MD194 / Euro-FLEETS Gateways on board the R/V Marion-Dufresne (10-21 June 2013) in close vicinity to cold-water coral mounds along the Moroccan margin in the Gulf of Cadiz, off Larache city.

Samples of the MD13-3447C are organized into 3 main percentage classes of carbonate content (1, 2, and 3), while samples of the MD13-3444G are organized into 2 main percentage classes (2 and 3). The carbonate content of the first class varies between 19% and 26% (high values). The values of the second class vary between 12% and 18% (moderate values). The values of the third class are inferior to 11% (low values).

The varying carbonate contents supported by the lithological description of the cores, and the quantitative study of planktonic foraminifera, allowed to assess the origin of carbonate supply:

- samples with high to moderate carbonate contents are supplied mostly by a terrigenous source and an intra-basin biogenic source,
- samples with low carbonate contents are alimented principally by continental terrigenous source.

## **The Moroccan Carbonate Mound Route: a view on 500 million years of Oceanic Gateway functioning**

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The increasing confrontation of observations and insights between researchers of the modern carbonate systems and those of the fossil record calls for a common forum, a broadband field laboratory which can be turned into a reference site for science and an instrument for ocean literacy. A most remarkable and accessible spectrum of carbonate factories in Morocco strikingly illustrates the rise and demise of carbonate mounds over the full span of Phanerozoic times, up to the present. They line up along a route which stretches from the Anti-Atlas in the south to the Rif, Gibraltar and Betic Cordillera in the north.

Morocco has indeed repeatedly occupied a privileged position, a room with a view on key oceanic basins and gateways, where major reef and mound provinces developed. Meanwhile, it migrated through all climatic belts from boreal regions, across the equator to its present latitude.

A first segment of the carbonate mound route comprises the Anti-Atlas, from the Souss Basin to the Tafilalt. In Cambrian to Ordovician times, early carbonate build-ups grew on the high-latitude, southern rifted margin of the Rheic Ocean. In the Carboniferous, mounds on a ramp setting faced the eastern section of the moribund Rheic seaway, which definitively would close when the Armorican and Betic assembly east of Morocco encroached on the Rheic Ocean floor to finally dock with Laurentia-Baltica, in the great continental collision known as the Variscan orogeny.

The Jurassic mounds of the High Atlas along the second segment of the route interestingly document the switch from Tethyan to Atlantic influence between Early and Mid Jurassic, after Morocco and Nova Scotia had started to drift apart.

The recent mounds off Melilla in the Alboran Sea and off Larache on the Atlantic margin stand as sentinels on either side of the Rifian corridor, which – together with the Betic corridor in the north – formed the gateways between Mediterranean and Atlantic prior to the onset of the Messinian event. Both corridors host a variety of Tortonian (Late Miocene) coral reefs. The present Gibraltar Strait is a hotspot of cold-water coral ecosystems.

A planned set of three documented maps or “docu-maps” will guide the interested voyager along a ramble following this route, a travel through space, time, Geosphere processes and Biosphere evolution. They form the base for the preparation of a submission of this route as UNESCO World Heritage.

## **Preliminary results of the study of planktonic foraminifera along the Moroccan Atlantic margin off Larache (MD194 cruise)**

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The study of planktonic foraminifera were conducted on ten samples of MD13-3444G and MD13-3447 off-mounds cores taken during cruise MD194 / Euro-FLEETS Gateways on board the R/V Marion-Dufresne (10-21 June 2013), in close vicinity to cold-water coral mounds along the Moroccan margin in the Gulf of Cadiz, off Larache city.

The monitoring of the frequency of dextral and sinistral *Globorotalia truncatulinoïdes* and the appearance of *Globigerinoides ruber rosea* var, allow to achieve the following results:

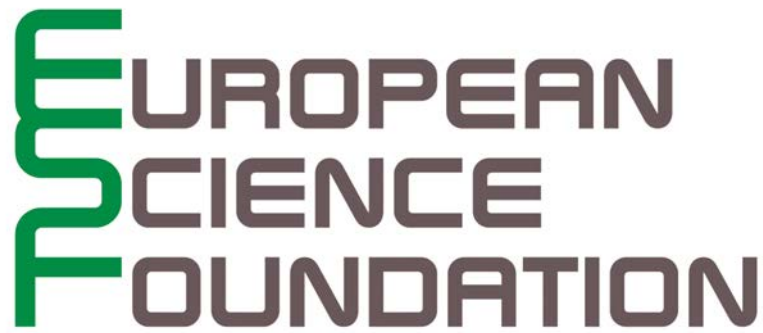
- The two core samples are generally of Early Pleistocene age, except the first 10 cm from the top of MD13-3444G and the first 40 cm from the top of the MD13-3447, which are of Late Pleistocene age.
- Alternating " Hot / Cold " episodes at both the base and to the top of the core: Q, R, S, T (Ericsson and Wollin climatic zones) for the MD13-3444G and P, Q, R, S, T for the MD13-3447.
- Microfaunal content indicate a hydrodynamic sorting of the seabed during the cold period S.
- The almost absence of Late Pleistocene in both cores suggests existing very energetic environment during the second part of the Quaternary.

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