



Workshop on Marine Research Drilling (Magellan Workshop Series)

Cold-Water Carbonate Reservoir systems in Deep Environments (COCARDE).



A Pilot Industry-Academia Partnership in Marine Research Drilling

Fribourg, Switzerland, 21-24 January 2009



ESF Programme: Workshops on Marine Research Drilling (Magellan Workshop Series)

Cold-Water CARbonate Reservoir systems in Deep Environments (COCARDE)

A Pilot Industry-Academia Partnership in Marine Research Drilling

Fribourg, Switzerland, 21-24 January 2009

Report



Conveners

Prof. S. Spezzaferri, University of Fribourg, Switzerland (COCARDE-Forum)
Dr. A. Rüggeberg, IfM-GEOMAR Kiel, Germany (COCARDE-Science)
Dr. T. Freudenthal, MARUM, Bremen, Germany (COCARDE-Operations)
Dr. D. Van Rooij, RCMG, Ghent University, Belgium (COCARDE-Capacity)

Summary

Cold-water carbonate mounds supporting cold-water coral ecosystems, often dominated by *Lophelia pertusa* and *Madrepora oculata* are widespread along the Atlantic European margins. Since the late nineties, more and more cold-water coral carbonate mound and coral bank provinces have been reported along the European margins from Norway down to Mauritania.

In the past 10 years, the “modern cold-water coral carbonate mound research” community has accumulated new insights in (i) their occurrence along continental margins and their structural and basinal setting; (ii) their province landscapes, (iii) their size and composition, (iv) the key players in their development: external vs internal biogeochemical controls; related biotopes; (v) role of microbial communities in their development; (vi) possible primary templates for reservoir compartments, (vii) fluid migration pathways and implications for reservoir connectivity, (viii) early diagenesis, carbonate dissolution and precipitation, dolomitization, and hence (ix) controls on reservoir porosity – primary and secondary – permeability and compartmentalization. These topics are of particular interest for the hydrocarbon industry.

As part of the ESF Magellan Workshop Series on Marine Research Drilling, a workshop, entitled “Cold-Water CARbonate Reservoir systems in Deep Environments (COCARDE): A Pilot Industry-Academia Partnership in Marine Research Drilling”, was held in Fribourg, Switzerland on 21-24 January 2009. The workshop gathered together 35

scientists, some of whom are involved in two IODP Proposals (689 and 673) on related topics, as well as ESF EUROCORES, ESF EUROMARC and EU-FP6-7 projects.

The participants, representing a wide spectrum of disciplines in geosciences and biology, joined with the aim to discuss and plan future research strategies and joint project with the industry, ideas which have been germinated also within IODP. The themes of the workshop focused on 1) Palaeoenvironment; 2) The Microbial Filter; 3) Petrophysical Characterization; 4) Connectivity and Compartmentalization – the Fluid System; 5) Advancing our Insight in Phanerozoic Reef Systems – the Slope Niche.

One of the most important outcomes of the workshop was the identification of the need for combined research efforts on fossil and modern cold-water carbonate settings to provide the baseline reference standard for a better understanding of these exceptional systems and their potential as hydrocarbon reservoirs.

Meeting Venue and Participation

The COCARDE Magellan Workshop was held in Fribourg, Switzerland, on 21-24 January 2009. The workshop gathered 35 scientists from 9 European countries and 2 extra-European countries (Canada and Morocco), representing 20 research teams. All flagged participants from Industry had to cancel their (intention of) participation invoking temporary economic/policy constraints, but most of them (ENI, CHEVRON, TOTAL, SHELL, STATOILHYDRO, REPSOL, ONHYM) maintained close contact by e-mail and expressed the wish to be kept informed of the issue and forthcoming initiatives.

Programme and Outcome

Review of Workshop Goals: *Discovering Common Field Labs, Themes and Strategies in Cold-Water Carbonate Systems Research.*

Keynotes

Dullo, Wolf-Christian (Kiel): *European cold-water reef research: highlights and outlook.*

Titschack, Jürgen (Erlangen): *Cold-water carbonates through Geological Time.*

Foubert, Anneleen (Leuven): *IODP Exp. 307 – the tale of a recent Carbonate Mound*

Wheeler, Andrew (Cork): *CARBONATE projects: analysis of long core sequences through coral carbonate mounds – new perspectives and new directions.*

Freudenthal, Tim (MARUM Bremen): *What can we learn from the 2008 CARBONATE cruise: the driller's perspective.*

Panel 1 PALAEOENVIRONMENT

What expertise can Modern Cold Water Carbonate Science and Industrial Research exchange towards unraveling Palaeoenvironment ?

Panel chair and rapporteur: **Andres Rüggeberg (Kiel)**

Panel members: Veerle Huvenne (Southampton), Stephan Margreth (Fribourg), Furu Mienis (Texel), Andy Wheeler (Cork), Anneleen Foubert (Leuven)

Furu Mienis reported about environmental constraints on cold-water coral growth and carbonate mound formation. In particular, she addressed temperature, salinity, seasonal changes in current regime, food supply, transport mechanisms, nepheloid layers, pelagic sedimentation, coral framework acting as sediment trap, high OM concentration, fine particles and carbonate accumulation, growth and reproduction patterns.

Andy Wheeler discussed the application of sedimentary architecture and component analysis towards an understanding of the environment during the development of the carbonate system (sediment, particle and component analyses, fabric analysis, carbonate content). Records preserved in mound sediments are unique and not preserved elsewhere.

Veerle Huvenne reported on sediment dynamics in carbonate mound formation: influence on reef-builders and build-ups, on mound and off-mound deposits and on secondary processes. She also illustrated the environmental parameters on mound formation, sediment dynamics (grain size and (paleo)-currents), baffling, 3D internal mound structure, role of (sandy) contourites and waveforms as substrates.

Stephan Margreth showed how assemblage data are proxies for facies distribution and ecological conditions in cold-water coral ecosystems. Microfossils (benthic and planktonic foraminifera) describe facies and can be used as bioindicators for facies.

Andres Rüggeberg showed the use of geochemical proxies in carbonate mounds to unravel palaeoenvironmental conditions: geochemistry on corals and microfossils to reconstruct past temperature, salinity, seawater density, ocean circulation and climate.

Outcome of Panel 1

Carbonate mounds provide unique archives, and the understanding of the entire architecture is fundamental in the identification of past environmental changes. Recent carbonate mound systems stand as natural laboratories to link the buildup history and architecture to high-resolution sequence stratigraphy. Several studies describe environmental parameters controlling carbonate mound growth and development. The application of up-to-date analytical methods on drilled sample material makes it possible to reconstruct these environmental control parameters, from mound initiation to the present day. Additionally, modern mound drilling opens new insights into both the role of primary oceanic processes and early diagenesis on the shaping of the internal architecture of a mound reservoir. It is of importance that these cold-water coral mounds be recognized as mixed siliciclastic – carbonate systems, comprising both mounds and surrounding contourites. Finally, a comparison of warm- and cold-water carbonate factories in different settings calls for drilling both modern and ancient carbonate mounds, and analyzing the cores with comparable resolution and protocols.

Panel 2 THE MICROBIAL FILTER

What expertise can Modern Cold Water Carbonate Science and Industrial Research exchange towards unraveling the role of the Microbial World ?

Panel chair and rapporteur: **Alina Stadnitskaia (Texel)**

Panel members: Judy McKenzie (Zürich), Stefanie Templer (Zürich), Driss Chafiki (Marrakech), Jan Pawlowski (Geneva), Kai Mangelsdorf (Potsdam).

Major topics discussed within Panel 2 included microbial diversity and microbial processes acting within cold-water carbonate mounds. The main aspects of the discussion comprised two principal routes: (i) the role of the microbial framework and its impact in the carbonate mound development and (ii) the application of fundamental biogeochemical knowledge to petroleum industry, using carbonate mounds as a modern sculpt of a carbonate reservoir.

Jan Pawlowski introduced the importance of DNA barcoding, i.e. the use of short DNA sequences as molecular markers for identifying the diversity of microbial eukaryotes in marine sediments. The DNA barcoding has an advantage of documenting microbial assortments, to trace their distribution and abundance within certain marine environments, and to compare the past and present biodiversities and their interactions. The application of DNA barcoding to the sediments from cold water carbonate mounds would significantly increase our knowledge about structure, spatial distribution, and the relationships between large assemblages of microbes in the carbonate mound habitats.

Kai Mangelsdorf showed that lipid biomarkers are a challenging tool for both fundamental scientific and industrial research. Lipid biomarkers provide incisive indicators for the quality, type, and maturity of sedimentary organic matter, the origin of migrated hydrocarbons and the dynamics of deep microbial ecosystems. The distribution, molecular structure, and compound-specific stable isotope measurements can help to clearly assess if hydrocarbons serve as a food source for specific microbial communities, and significantly affect sedimentary diagenesis and mineral fabrics.

Alina Stadnitskaia discussed the biogeochemical consequences of microbial anaerobic oxidation of methane (AOM), viewed as the ultimate methane sink in the marine environment. The microbial community at gas venting locations appears to be able to oxidize also other hydrocarbons. The production of bicarbonate ions via AOM leads to an increase of alkalinity, inducing carbonate precipitation. Specifically, for the carbonate mounds in the Gulf of Cadiz, AOM-related carbonate formation might be one of the most challenging processes. A combination of lipid biomarkers, 16S rRNA gene sequences, hydrocarbon gas and interstitial water chemistry together with mineralogical and stable carbon and oxygen isotope studies were shown as the most profitable set of analytical tools to reveal fossil and modern methane-related microbial communities, associated carbonate fabrics, and putative carbonate formation scenarios.

In the Gulf of Cadiz, where carbonate mud mounds co-occur with seepage of deep-generated hydrocarbons, scenarios of mound evolution should be different, compared to those in the Porcupine Basin and in the Rockall Trough (De Mol et al. 2002; Van Weering et al. 2003; Freiwald and Roberts, 2005). The scatter of microbial assemblages in the mound sediments suggests that the methane-related and methane-independent

biogeochemical processes co-occur within a single structure. As giant biogeochemical reactors, carbonate mounds in the Gulf of Cadiz represent a unique and still non-unraveled complex of biogeochemical interactions between migrated methane and fluids in general, autochthonous pore waters, mineral fabrics (especially carbonates), and diversity of microorganisms, where the functionality and metabolic exchanges are still largely unknown. Besides, fossil carbonate mounds are known reservoirs that produce industrial quantities of oil and gas. In this view, mounds from the Gulf of Cadiz can be used as natural labs for the study of reservoir heterogeneity, lithofacies, internal microbial dynamics, flow baffles and barriers. The multidisciplinary, biogeochemical and geological study of the composition, growth and evolution of the carbonate mounds in general will offer reservoir information for modelling secondary/tertiary recovery methods. This links the fundamental research with direct industrial application.

Outcome of Panel 2

In recent years, microbial populations have been detected in environments, supposed for long to be hostile. Deepsea microbial populations relate to other “extreme” environments like polar- and permafrost areas, hot surface springs and hydrothermal vents, hypersaline and deep water lakes, mines and oil reservoirs. The deep sea and the deep subsurface of the Earth changed the idea on the limits of life on Earth drastically and opened the view to a largely unknown and unexplored microbial biosphere on our planet.

This intriguing new microbial world arouses the interest of many scientists focussing on questions like what kind of microbial communities inhabit these environments, how can they adapt to the “extreme” environmental conditions, what food sources do these communities use, which metabolic processes do these population conduct and what kind of life habitats do they occupy.

Concomitantly, the answers to these questions are also highly relevant for economic interests. New microorganisms, their biomolecules (e.g. enzymes) and metabolic degradation and/or formation capabilities are particularly useful for agricultural economy, oil and gas industry, chemical industry, renewable energy concepts, biotechnology, medicine and the bioremediation of polluted areas.

In return, industrial research partners in scientific projects (e.g. oil industry) often have access to a large set of geological and geochemical data concerning the study area. Such data like for instance seismic data, lithology, permeability and porosity data, maturity data of the buried organic matter and basin history/modelling data are valuable basic information for the characterisation of the unexplored microbial life and its life habitat.

Panel 3 PETROPHYSICAL CHARACTERIZATION

What expertise can Modern Cold Water Carbonate Science and Industrial Research exchange in the Petrophysical Characterization of Cold Water Carbonates, with emphasis on Porosity and Permeability ?

Panel chair and rapporteur: **Anneleen Foubert (Leuven)**

Panel members: Hans Pirlet (Ghent), Cees van der Land (Texel), Jürgen Titschack (Erlangen)

Hans Pirlet discussed the early diagenetic formation of gypsum and dolomite in a cold-water coral carbonate mound. Authigenic gypsum and dolomite were found in a gravity core retrieved from the top of Mound Perseverance, a cold water coral mound in the Porcupine Basin, SW off Ireland. Sedimentological, petrographic and isotopic evidence pointed to a diagenetic formation of the gypsum, related to oxidation of iron-sulfide minerals e.g. pyrite. This oxidation is attributed to increased bottom currents which caused erosion and enhanced inflow of oxidizing fluids into the mound sediments. The oxidation of pyrite produced acidity, causing carbonate dissolution and leading to pore-water oversaturation with respect to gypsum, and dolomite. The dissolution of carbonate most probably increased the porosity in the affected sediment layer and might have been responsible for lithification of the sediments at the sediment-water interface. Within the framework of this case study, the following questions were discussed: what is the impact of diagenetic oxidation events on coral preservation? How does this affect the petrophysical properties? Can diagenetic oxidation events lead to carbonate precipitation near the seabed? How important is the role of organic matter degradation in the early diagenetic processes? Can authigenic gypsum be used as an indicator for diagenetic oxidation events (“moving redox-front”)?

Cees van der Land was pointing out the difficulty to understand the formation of semi-lithified to lithified horizons in recent carbonate mounds: ‘the chicken or the egg – exposure leads to lithification, or erosion until a (pre-existing) lithified interval?’. One of the main questions considering lithified intervals in carbonate mound sediments is the timing of their formation. Do they form during periods of non-sedimentation and prolonged exposure of the sediments to the overlying seawater, or do they form in the subsurface where they build a barrier for later erosional processes? Thin section observations provide mineralogical evidence for the type of diagenetic fluids involved in the dissolution and cementation of the carbonate mound sediments. Can we date the formation of the authigenic carbonate cements?

Jürgen Titschack discussed the essential diagenetic processes to form porosity/permeability in cold-water carbonates. The factors necessary to preserve primary porosity and permeability were emphasized: early diagenesis (dissolution, lithification), primary mineralogical composition (calcite versus aragonite, dilution by siliciclastic material), oceanographic regime (active pore water pumping versus stagnating pore waters). The potential impact of burial diagenesis and associated processes shaping potential porosity and permeability were summarized as follow: compaction, pressure dissolution, cement formation in pressure shadows, dolomitisation and dissolution.

Rudy Swennen (Leuven) could not attend the meeting but provided some insights from an industrial perspective. The fact that recent carbonate mounds are a mixed siliciclastic –

carbonate system (with mudstone – grainstone variations) is of prime importance. Once they are formed, mound structures in general form heterogeneities in the subsurface. Therefore often they will (during later stages) either be more intensively fractured (= reservoir development) or they will be affected by preferential fluid flow, like dolomitisation. It is not so uncommon to find mound structures where there has been a preferential replacement of the primary mud by dolomite (e.g. Waulsortian type reservoir, Canada) while the larger fossils have not been affected by dolomitisation. However if the latter calcite fossils later dissolve while the dolomite is not affected then these systems become interesting for reservoir studies. Moreover, if these structures are then fractured, you have real reservoirs. Again the original architecture will control the reservoir distribution. In such systems it is important to understand the relation between macro (moldic, enlarged vug, etc. ...) and micro porosity. Recent mound systems might act as examples to understand the linkage of sedimentology and diagenesis (petrography) with petrophysics (from plug to large-scale). This is exceptional and should be translated versus the language used in the oil industry. Finally, early diagenetic overprinting (marine burial) is an interesting topic especially if framework stabilisation occurs. The latter will counteract burial compaction. This can be studied in the carbonate mounds and compared with other shallow water carbonate systems. To what degree all the carbonate mud is not recrystallised (neomorphosed) and to what extent primary signals are preserved?

Outcome of Panel 3

The petrophysical characterization of sub-recent cold-water carbonate mounds is mainly determined by two factors: (1) their primary sedimentary texture and (2) the influence of sub-recent diagenesis. The primary architecture of such mound structures, their (palaeo)environmental control, the sediment dynamics and the potential of reef-forming organisms, adapted to deep and cold-water environments (such as cold-water corals (*Lophelia pertusa*, *Madrepora oculata*), Bryozoa, sponges, etc...), to baffle and trap (in an active or passive way) sediments were the focus of panel discussion 1. The impact of early diagenesis on the petrophysical behaviour of carbonate mounds in space and through time was the main point of discussion in panel 3.

It was discussed how sub-recent mound systems might act (or not) as reservoir systems. When thinking in terms of reservoir systems (and their petrophysical characteristics), it should be mentioned that late diagenetic processes (burial diagenesis, hydrothermal processes), compaction and fracturation might play an important role. The better understanding of sub-recent diagenetic processes and their impact on the primary fabric and petrophysical characteristics of a mound might help to understand and predict the occurrence of later diagenetic processes.

Panel 4 CONNECTIVITY ISSUES AND COMPARTMENTALIZATION IN MIXED COLD WATER CARBONATE / SILICICLASTIC CONTOURITE SYSTEMS

What expertise can Modern Cold Water Carbonate Science and Industrial Research exchange towards understanding Connectivity Issues and Compartmentalization in Mixed Cold Water Carbonate / Siliciclastic Contourite Systems

Panel chair and rapporteur: **David Van Rooij (Ghent)**

Members: Lies De Mol (Ghent), A. Wheeler (Cork), Veerle Huvenne (Southampton)

Outcome of Panel 4

Singular Cold-water Carbonate Mounds (CCM) within a province can only connect with each other through proximity. Alternatively, the frequent association of CCM with contourite drifts may be the key for connectivity within a larger system. The embedding contourite deposits are predominantly fine-grained, although the importance of well-sorted sandy contourites may not be underestimated. They may be present as sand sheets between the mounds, ranging from 10 cm to locally thicker deposits within the drifts.

Connectivity issues can be identified at three levels:

-a- The moundbase unconformity is an important interface between the CCM and the deep subsurface. The palaeotopography of this erosive surface seems to co-determine the location of the CCM. Moreover, specifically in the Belgica mound province, the deposits directly underneath the mounds are high-energy, coarse-grained sediment waves. As such, this “sole layer” can provide a direct link between mounds, but also with the deep subsurface. It might easily connect to possible hydrocarbon migration pathways.

-b- Mound growth can be seen as a 4D stacking of thick coral rubble plates, which serve as sediment trap and as a template of a reservoir compartment. The clastic component caught within such plates also shares the lithological similarities with surrounding contourites.

-c- The mound-drift competition: increased sediment supply and decreased currents can cause burial of CCM. A predominantly fine-grained contourite drift cover will act as a seal, while sorted coarse-grained deposits can locally be expected as contourite sand sheets or veneers, but also as mass transport deposits along the flanks of CCM.

The association of CCM with contourites offers various opportunities of connectivity at several scales. However, the role of each component in this mixed system still remains unclear. More information regarding the reservoir potential of CCM can be studied from land sections, whereas the recognition of (especially sandy) contourites on land sections still remains enigmatic.

Panel 5 ANCIENT COLD WATER CARBONATE SYSTEMS AND POTENTIAL RECENT ANALOGS

Modern Mounds as Recent Analogs for Ancient Cold Water Carbonate Systems – which Ancient System should we target first ?

Panel chair: **Stéphanie Larmagnat (Laval)**.

Panel members: Elias Samankassou (Geneva), Naima Hamoumi (Rabat), Christian Dullo (Kiel), Roberto Barbieri (Bologna), Driss Chafiki (Marrakech), Menchu Comas (Granada), David Van Rooij (Ghent)

This Panel addressed cold water carbonate mound issues in the geological past, providing in particular a wide picture of fossil and modern examples from north-western Africa. The modern examples presented have recently been discovered and investigated off Moroccan coasts in both Atlantic and Mediterranean waters.

Naima Hamoumi reported on Ordovician cold-water carbonate mounds in the eastern Anti-Atlas.

Roberto Barbieri presented the spectacular outcrops of the Devonian Kess-Kess mounds.

Driss Chafiki reported on sponge-bearing mounds from the Jurassic succession of the High Atlas.

This set of presentations has demonstrated the abundance and variety of carbonate mounds from a relatively limited region of Morocco with excellent outcrop potential and the possibility of analyzing mounds in a wide variety of genetic settings.

Menchu Comas introduced recent results on a province of coral-bearing mounds associated with mud volcanism off Melilla (West Alboran Basin).

David Van Rooij presented the IODP 673-full proposal for drilling the Pen Duick carbonate mounds off Morocco.

Stéphanie Larmagnat addressed the potential and caveats of comparing recent and ancient mounds.

Outcome of Panel 5

Collectively, the panel provides modern and fossil examples useful for comparative purposes, as well as for investigation through a multidisciplinary approach that combines biological, geological and geophysical proxies.

COCARDE Field Seminars OVIEDO 2009

Elias Samankassou (Geneva) presented opportunities of organizing field seminars in the Cantabrian mounds (Spain), in cooperation with the universities of Oviedo and Leon. Outstanding outcrops of Carboniferous mounds are easily accessible, and document processes of microbial mediation in mound building.

SUMMARY OF CONCLUSIONS / ACTIONS

The last day of the workshop was devoted to the final discussion, the Forward Look and future initiatives of COCARDE. The workshop has been very productive and many initiatives will be taken in the years to come by the COCARDE members.

COCARDE Flag

- COCARDE will be proposed to IOC-UNESCO as a sub-programme of the Geosphere-Biosphere Coupling Processes (GBCP) Programme.

Action: J. P. Henriët will contact IOC-UNESCO.

COCARDE Science Plan

- Palaeoenvironment
- The Microbial Filter
- Petrophysical Characterization
- Connectivity and Compartmentalization – the Fluid System
- Advancing our Insight in Phanerozoic Reef Systems – the Slope Niche

Action: A. Rüggeberg and C. Dullo (COCARDE-Science) will co-ordinate the draft of a concise Science Plan, drawing from ideas brought forward in the Panel Leaders' reports.

Objective: to be available (after circulation) by the EGU Meeting in Vienna.

COCARDE in Marine and Continental Research Drilling

- IODP-INVEST: COCARDE generates a motion regarding a “Carbonate Factory” theme in marine and continental drilling.
- Recommendation: a significant participation in EGU workshop and INVEST conference in Bremen.

Action: draft of a “Carbonate Factory” theme for future IODP Planning during the Magellan workshop at EGU. Postdocs will be in the driving seat of the initiative, senior scientists in the back seat, Andy Wheeler volunteers as penholder.

Objective: to be available (after circulation) by the EGU Meeting.

- IODP-Melilla: M. Comas and L. Pinheiro will prepare an IODP Addendum to proposal 673-Full, with the objective of adding a Melilla mound drilling action.

Action: M. Comas and L. Pinheiro, in close contact with D. Van Rooij and J.P. Henriët.

- ICDP: COCARDE prepares a proposal for Continental Mound Drilling (various mound ages and settings, 3D structure, mound, substrate, off-mound), aiming at acquiring full-mound records with a continuity and resolution, comparable with marine mound records.

Action: R. Barbieri to explore scientific opportunities and build a proponents team. T. Freudenthal (COCARDE-Operations) to explore drilling options. Long-range objective.

COCARDE Forum

Fribourg meeting reporting:

- ECORD Newsletter
- EOS and other news releases.

Co-ordination: S. Spezzaferri.

- Marine Geology Special Issue: joint venture COCARDE-MiCROSYSTEMS

Co-ordination: S. Spezzaferri. *Elsevier has answered positively to the request and the special issue has been approved on 18 March, 2009.* Co-Guest Editors are: S. Spezzaferri, D. VanRooij, A. Rüggeberg, E. Samankassou, J.-P. Henriet,

- AAPG International Conference and Exhibition: Rio, 15-18 November 2009.

Action: submission of abstracts as soon as call opens.

J. P. Henriet furthers local contacts towards a possible COCARDE side event.

COCARDE Capacity

- Oviedo Workshop and Field Seminars: September 2009, tentatively 5 days.

Organizer: E. Samankassou in co-operation with colleagues at Oviedo and Leon.

Actions: J. P. to contact F. Neuweiler and J. Kenter for possibly teaming up.

Further fund raising initiatives to be taken, in particular within EuroDiversity, teaming up with MiCROSYSTEMS.

- 2010 Morocco Mounds Field Seminar (Ordovician to Jurassic sites) in preparation of a possible ICDP proposal component.

Action: R. Barbieri to co-ordinate initiative in cooperation with D. Chafiki, F. Neuweiler, N. Hamoumi, G.-G. Ori.

Fribourg, February 26th, 2009.

Prof. S. Spezzaferri

Dr. A. Rüggeberg

Dr. T. Freudenthal

Dr. D. Van Rooij

And all the participants to the COCARDE ESF Magellan Workshop

Meeting Program

Day 1 – Wednesday 21 January 2009

Afternoon/early evening

Arrival in Fribourg

Welcoming Apero (at free initiative)- Informal gathering of participants before dinner

Dinner (at free initiative) and preliminary discussion.

Day 2 – Thursday 22 January 2009

Morning Session

- 08h30-08h45 Welcome to Fribourg. A. Strasser (University of Fribourg - SEPM Council).
- 08h45-09h00 Logistics: Stephan Margreth (University of Fribourg).
- 09h00-09h30 Review of Workshop Goals: *Discovering Common Field Labs, Themes and Strategies in Cold-Water Carbonate Systems Research*. Silvia Spezzaferri (University of Fribourg) and Jean-Pierre Henriet (Ghent University).

Keynotes

Co-Chairs Jean-Pierre Henriet (Ghent University) and Silvia Spezzaferri (University of Fribourg).

- 09h30-10h00 Dullo W.C. (Kiel): *European cold-water reef research: highlights and outlook*.
- 10h00-10h30 Coffee Break
- 10h30-11h00 Titschack, J. (Erlangen): *Cold-water carbonates through Geological Time*.
- 11h00-11h30 Foubert, A. (Leuven): *IODP Exp. 307 – the tale of a recent Carbonate Mound*.
- 11h30-12h00 Wheeler, A. (Cork): *CARBONATE projects: analysis of long core sequences through coral carbonate mounds – new perspectives and new directions*.
- 12h00-12h30 Freudenthal, T. (Bremen): *What can we learn from the 2008 CARBONATE cruise: the driller's perspective*.

12h30-14h00 Lunch Break at the Pavillon Vert

Afternoon Session

Panels representing leading Oil Companies and European and extra-European research teams will introduce the debates with short provocative presentations.

14h00-15h30

Panel 1 PALAEOENVIRONMENT

What expertise can Modern Cold Water Carbonate Science and Industrial Research exchange towards unraveling Palaeoenvironment ?

Panel members: NN. (Industry), Andres Rüggeberg (Kiel), Veerle Huvenne (Southampton), Stephan Margreth (Fribourg), Furu Mienis (Texel), Andy Wheeler (Cork), Anneleen Foubert (leuven)

Introduction – overview – discussion points

Scientific expertise: sedimentology, proxies, fauna – related to mounds

Industrial expertise:

Furu Mienis (Texel):

Environmental constraints on cold-water coral growth and carbonate mound formation.

Keywords: current regime, food supply, nepheloid layers, pelagic sedimentation, baffling (coral framework), carbonate accumulation (composition)

Stephan Margreth (Fribourg):

Foraminiferal assemblage data as a proxy for facies distribution and ecological conditions in cold-water coral ecosystems. Keywords: benthic and planktonic foraminifera, facies, bioindicator

Andres Rüggeberg (Kiel):

The use of geochemical proxies in carbonate mounds to unravel palaeoenvironmental conditions. Keywords: coral geochemistry (Andres), foram geochemistry (Ben), palaeo-densities (Andres/Jacek), temperature, salinity

Veerle Huvenne (Southampton):

Sediment dynamics in carbonate mound formation: its influence on reef-builders and – build-ups, on mound and off-mound deposits and on secondary processes

Keywords: sediment dynamics (grainsize and (paleo)-currents), baffling, 3D internal mound structure, (sandy) contourites

Anneleen Foubert (Leuven):

Diagenetic overprint of paleoenvironmental and -climatic signals Keyword: diagenesis, environment, climate

Andy Wheeler (Cork): The application of sedimentary architecture and component analysis towards an understanding of the environment during the development of

carbonate systems. Keywords: particle size, fabric analysis, carbonate content, porosity, permeability

15h30-16h00 Coffee Break

16h00-17h30

Panel 2 THE MICROBIAL FILTER

What expertise can Modern Cold Water Carbonate Science and Industrial Research exchange towards unraveling the role of the Microbial World ?

Panel members: NN. (Industry), Judy McKenzie (Zürich), Stefanie Templer (Zürich), Fritz Neuweiler (Laval), Alina Stadnitskaia (Texel), Driss Chafiki (Marrakech), Jan Pawlowski (Geneva), Kai Mangelsdorf (Potsdam)

17h30-18h00 Discussion

19h00 Dinner and Leisure

Day 3 – Friday 23 January, 2009

Morning Session

The Morocco Cold-Water Carbonate Field Laboratories

08h50-09h10	Barbieri, R. (Bologna), Chafiki, D. (Marrakech), Hamoumi N. (Rabat) and Ori G.G. (Pescara- Marrakech): <i>Onshore opportunities for studying Carbonate Mound Systems in Morocco</i>
09h10-09h30	Comas, M. (Granada) and Pinheiro, L. (Aveiro): <i>Deep-water coral mounds in the Alboran Basin: Melilla Mound Field.</i>
09h30-09h50	Van Rooij, D. (Ghent): <i>IODP 673-Full Proposal on the Pen Duick Carbonate Mounds and Drift, off Morocco</i>
09h50-10h30	Discussion

10h30-11h00 Coffee Break

11h00-12h30

Panel 3 PETROPHYSICAL CHARACTERIZATION

What expertise can Modern Cold Water Carbonate Science and Industrial Research exchange in the Petrophysical Characterization of Cold Water Carbonates, with emphasis on Porosity and Permeability ?

Panel members: NN. (Industry), Anneleen Foubert (Leuven), Hans Pirlet (Ghent), Cees van der Land (Texel), Jürgen Titschack (Erlangen)

12h30-14h00 Lunch Break at the Pavillon Vert

Afternoon Session

14h00-15h30

**Panel 4 CONNECTIVITY ISSUES AND
COMPARTMENTALIZATION IN MIXED COLD WATER
CARBONATE / SILICICLASTIC CONTOURITE SYSTEMS**

What expertise can Modern Cold Water Carbonate Science and Industrial Research exchange towards understanding Connectivity Issues and Compartmentalization in Mixed Cold Water Carbonate / Siliciclastic Contourite Systems

Panel members: NN. (Industry), David Van Rooij (Ghent), Lies De Mol (Ghent)

15h30-16h00 Coffee Break

COCARDE SUMMER SCHOOL OVIEDO 2009

16h00-16h30

Samankassou, E. (Geneva): *Carbonate Mounds in Cantabria and Asturias – a COCARDE Summer School*

16h30-18h00

**Panel 5 ANCIENT COLD WATER CARBONATE SYSTEMS AND
POTENTIAL RECENT ANALOGS**

*Modern Mounds as Recent Analogs for Ancient Cold Water Carbonate
Systems – which Ancient System should we target first ?*

Panel members: NN. (Industry), Elias Samankassou (Geneva), Roberto Barbieri (Bologna), Naima Hamoumi (Rabat), Christian Dullo (Kiel), Stephanie Larmagnat (Laval).

18h00- 19h00 General discussion

Academia – Industry cooperation in Cold Water Carbonate Research

19h30 Dinner and Leisure

Day 4 – 24 January 2009

Morning Session

9h00 – 12h30

FORWARD LOOK - ACTIONS

COCARDE – Forum: Silvia Spezzaferrì, Stephan Margreth

COCARDE – Science: Andres Rüggeberg, Christian Dullo, Stephanie Templer, Menchu Comas, Andy Wheeler, Anneleen Foubert

COCARDE – Operations: Tim Freudenthal, Dierk Hebbeln

COCARDE – Capacity: Jean-Pierre Henriët, David Van Rooij, Veerle Huvenne

12h30 -14h00 Lunch Break at free initiative

Afternoon Session

Continuation of the discussion, writing of report.

Departure