COCARDE Workshop and Field Seminar
Denmark, 10–13 June 2014

Cold-water Carbonates at high palaeolatitudes from the Palaeozoic to the Recent

Combining outcrops studies with core studies and geophysical imaging

June 10th to 13th, 2014, Denmark

Convened by: Bodil Wesenberg Lauridsen[1,2] & Morten Bjerager[2]

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Report

Research Networking Programmes

Science Meeting – Scientific Report

Proposal Title: Cold-water Carbonates at high palaeolatitudes from the Palaeozoic to the Recent - Combining outcrops studies with core studies and geophysical imaging

Application Reference N°: 5432

1) Summary

The COCARDE Workshop and Field Seminar in Denmark 2014 were held from June 10th to June 13th and hosted by the University of Copenhagen and Geological Survey of Denmark and Greenland (GEUS). The meeting was attended by 45 scientists belonging to several academic and industrial institutions from Europe and beyond (Appendix 1). Among them, seven young scientists were awarded with a research grant assigned in a competitive context to fully cover their participation in the event; and eight young scientists associated with the University of Copenhagen Denmark. The workshop assessable to the public, attracted in addition c. 30 scientists from the geological society in Denmark.

The workshop was kicked off at the Geological Department at the University of Copenhagen on June 10th with a scientific programme (assessable to the public) including talks on Palaeozoic carbonates and cold-water carbonates from the Cretaceous–Palaeogene of northern Europe. Hereafter seven young researchers made their flash presentations that were followed by a poster session. Day two started with a core workshop hosted by the Geological Survey of Denmark and Greenland on Upper Cretaceous to Danian carbonates and reservoirs from Denmark onshore and offshore. The core workshop was concluded by presentations and discussions facilitated by the young researchers. The workshop continued at the University of Copenhagen with scientific talks on ecology and palaeoenvironments in cold water carbonates.

The two days field seminar comprised guided visits to the Upper Cretaceous – Danian boundary succession along the famous coastal cliff, Stevns Klint that was recently awarded the recognition as a Unesco World Heritage site. The succession in the cliff was studied from the distance by boat, geophysical acquisitions methods were demonstrated in the Boesdal quarry; and hands-on geological studies occurred at several localities. The second day of the field seminar included visits to the Geomuseum Faxe part of Østsjællands Museum followed by outcrop studies on the Danian cold-water coral mounds in the nearby quarry. The workshop and field seminar closure in Faxe comprised a scientific session on Stevns Klint as a World Heritage Site and concluded by outlooks on future cold-water carbonate research in Denmark and COCARDE initiatives.

The workshop and field seminar were co-organized by two supporting institutions of the ESF COCARDE Research Networking Programme: the University of Copenhagen (Bodil W. Lauridsen) and the Geological Survey of Denmark and Greenland (Morten Bjerager and Bodil W. Lauridsen). The field seminar was led by the workshop conveners in collaboration with Finn Surlyk and Lars Nielsen (University of Copenhagen) and the core workshop was led by the workshop conveners together with Jonathan R. Ineson and Peter Frykman (Geological Survey of Denmark and Greenland).

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

The COCARDE workshop and Field seminar in Denmark focussed on cold-water carbonates at high palaeolatitudes from the Paleozoic to the Recent. Fossil cold-water carbonates from Denmark and the Arctic region form excellent reservoirs in the North Sea and they are also targets for oil exploration in the northern part of the Atlantic Ocean. The University of Copenhagen and the Geological Survey of Denmark and Greenland have a very long tradition of doing research in cold-water carbonates that were presented to the COCARDE network both during the workshop and field seminar. The core workshop and field seminar provided an excellent framework for young and senior scientists to discuss their research and ideas on cold-water carbonates while studying the core material and outcrops of Upper Cretaceous chalk and the Paleogene carbonate mounds.

Fig. 1. The Workshop and Field Seminar in Denmark. Danian bryozoan mounds in Stevns Klint from the boat tour (upper left), Faxe Quarry (upper right), K/T boundary at Højerup (Lower left). Examination of cold water corals at the core workshop (lower right).

The meeting started on June 10th with introduction talks on COCARDE-ERN and on the philosophy and content of the present workshop. The first scientific session was on Palaeozoic carbonates with

presentations on Permian cool water mounds in East Greenland and Barents Sea, and on Belgian mud mounds. The session on cold-water carbonates from the Cretaceous and Paleogene carbonates of northern Europe comprised 4 main presentations covering (1) the geological overview of the deposition in the Danish Basin, (2) a detailed study on the biological and physical processes of chalk deposition, (3) a new combined biostratigraphic and isotope based timescale of the Late Cretaceous, and (4) a multiproxy palaeoecological study of Danian cold-water corals mounds. The afternoon session was dedicated to geophysical aspects, including: 3D imaging of mounds, virtual digital imaging and mapping of carbonate mounds, 3D Seismic geomorphology of chalk, oil geology and chalk, and finally by an extensive sets of seismic interpretations on carbonates build-ups. Hereafter seven young researchers gave their flash presentations on COCARDE network related topics including: reef habitat mapping on the Piddington Mound (Lim, A.), cool-water carbonate modelling (Vis, A.), micrabacciid coral skeletons (Janiszewska, K.), shallow shelf deposits of Ireland (McGrath, M.), Macrobenthos biodiversity on cold water coral mounds (Fhaoláin, F.N.), Lebanese microfossil taxonomy in Cretaceous deposits (Maksoud S.), and modelling circulation and productivity in the Chalk Sea (Rosing S.).

The poster session of young grantees and young researchers from the Danish Geological society formed the stage for stimulating scientific discussions, and networking continued into the dinner arrangement at the University of Copenhagen.

Fig. 2 Core workshop at the Geological Survey of Denmark and Greenland.

On the second day (June 11th) the core workshop on Upper Cretaceous – Danian shelf–basin carbonates was organized by Jonathan R. Ineson, Peter Frykman, Morten Bjerager and Bodil W. Lauridsen (Geological Survey of Denmark and Greenland). The participants were subdivided into three groups, and the young researchers of each group were responsible for description and interpretation of the different cored sections on display. At the end they presented and discussed their results in plenum. A reservoir laboratory test was also conducted, that showed the ability of water to expel oil from the pores in a chalk oil reservoir.

The scientific programme continued at the University of Copenhagen with presentations covering ecology and palaeoenvironments in cold water coral mounds, decapod evolution and diversity in relation to reefs, carbonate cycling and bioerosion of cold water coral mounds, Antarctic greenhouse

and icehouse carbonates, and four presentations on macrofossil geochemistry and palaeoenvironmental reconstructions. The last presentation reflected on the role and fate of cold water corals in response to a warming planet.

Fig.3. Demonstration of geophysical aqusition methods in the Boesdal quarry, instructed by Lars Nielsen (upper right).

The field seminar on the third day (12th of June) included a bus trip to the Cretaceous–Danian boundary succession at the coastal cliff Stevns Klint about 50 km south of Copenhagen. The participants were subdivided into two groups of each c. 20 persons. Geophysical acquisition methods were demonstrated on the K/T boundary strata in the Boesdal Quarry. They were organised by Lars Nielsen and associates (University of Copenhagen, Nielsen et al. 2010, 2011). The other group embarked on two boats for a tour along the World Heritage site Stevns Klint studying the Late Cretaceous – Danian succession with large-scale basin topography and Danian bryozoan mound geometries with internal bedding relations (Surlyk et al. 2006, Damholt and Surlyk 2012). The boat trips were guided by Finn Surlyk (University of Copenhagen) and Morten Bjerager (GEUS), respectively. This programme was repeated with the other group. After lunch Finn Surlyk guided all participants to the famous K/T-Boundary sections at Højerup. Here the participants were provided with hands on experience with the rocks and they discussed various geological features observed from the boat trip and from the scientific talks on the previous days. The last stop of the day comprised a combined cultural and geological guided tour to 3D exposures of the Danian

bryozoan mounds in subsurface tunnels in a military fort, the Stevnsfort that was excavated in the Cold War period (Bjerager and Surlyk 2007a, b).

Fig. 4. The K/T boundary succession at Højerup, Stevns Klint. The geology is explained by Finn Surlyk.

Fig. 5. Danian bryozoan mounds in Stevns Klint, with the northern entrance to the Stevnsfort as seen from the boat trip. The same section was later studied in detail on the beach guided by M. Bjerager. Lower right: Detail of bryozoan limstone showing delicate bryozoan fragments and brachiopods set in a muddy matrix.

On June 13th the field seminar continued with a visit to the Faxe Geomuseum adjacent to the Faxe Quarry. Tove Damholt, Jesper Milan and Bodil Lauridsen gave an introduction to the impressive geological collections on display. Hereafter the participants went into the quarry guided by the

conveners to study the well-exposed Danian cold water coral mounds and bryozoan mounds (Lauridsen et al. 2012, Lauridsen and Bjerager 2014). Special attention was on the genesis of the mounds and their relation to the Quaternary counterparts in e.g. the North Atlantic and in the Mediterranean. The highly variable degrees of diagenesis in the mounds were also discussed.

Fig. 6. Geomuseum Faxe with introductions by Jesper Milan (central part in the upper right photo), and Bodil Lauridsen (upper right). Detail of coral limestone with *Dendrophyllia candelabrum* (lower left). Introduction to the coral mounds and bryozoan mounds in Faxe Quarry in a regional context (lower right).

The workshop closure was conducted at the Faxe youth hostel where Tove Damholt presented the application of the famous K/T boundary succession at Stevns Klint as a World Heritage site. Lars Stemmerik gave insights in the future Carbonate research in Denmark and Jean-Pierre Henriet presented the COCARDE related future initiatives. Hereafter the conveners concluded on the successful Workshop and Field Seminar.

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

The workshop and Field seminar in Denmark represented a great framework for the integration of new young scientist and develop further existing networking in the COCARDE-ERN group. The specific aim to share and present the carbonate research on cold water carbonates in Denmark as well as Greenland to the network has been achieved with great success. The event has fostered great amounts of scientific discussions and thereby enlarged the scientific levels and understandings of the presented topics considerably, especially on the Late Cretaceous – Danian cool water

carbonates as excellent outcrop analogues to Quaternary counterparts that mainly are situated in submarine locations.

The young researchers, in particular, benefitted from their participation by obtaining a broader understanding of the cold water carbonates that they can use in their future research. Many of them had previously only been working with the modern and subfossil regime.

The recent nomination of the Stevns Klint as World Heritage Site was of special interest as it may serve as benchmark and guidance to future applications of geological sites to the Unesco list. In this context collaboration between Finn Surlyk and Tove Damholt (Denmark) has been established with Jean-Pierre Henriet (Belgium) to develop the future actions for an application of Moroccan mounds to the Unesco list.

A very beneficial outcome is the mutual interest that was raised between the represented industry and academia, and special focus was on the possible future collaborations with the coming inauguration of the Danish Hydrocarbon Research and Technology Centre.

It was discussed and agreed among the participants to secure and increase the visibility and direct impact of the COCARDE-ERN by acknowledgements in related ongoing and future scientific publications.

New collaborations on scientific research topics have been established on e.g. the cold water mounds at Faxe between GEUS, University of Copenhagen and University of Florida; bioerosion patterns at Faxe compared to the modern regime between GEUS, University of Copenhagen, Østsjællands Museum and Senckenberg am Meer, Germany; on cold water corals from the Great Australian Bight between the GEUS, University of Copenhagen and Milano-Bicocca University; and on cored Cenozoic sediments form the Porcupine Bight between GEUS and University College Cork, Ireland.

The guide book of the field Seminar (Annex 4d) will in addition serve as a first draft for a future publication, which is in line with the guide books of the previous COCARDE Workshops and Field Seminars.

4. Annexes:

Annex 4a: Programme of the meeting
Annex 4b: Full list of speakers and participants
Annex 4c: Abstract volume
Annex 4d: Field guide

Acknowledgements

The COCARDE workshop and field seminar in Sicily 2013 was mainly funded by the European Science Foundation, with contributions from the Geocenter Denmark, Østsjællands Museum, University of Copenhagen and Geological Survey of Denmark. One of the boats was supplied by the University of Copenhagen. The conveners are sincerely grateful to Finn Surlyk, Lars Nielsen and associates for guiding at the field Seminar. Jesper Milan, Dorthe Pedersen and Tove Damholt are thanked for hosting and welcoming at the Geomuseum Faxe. Ane Elise Schrøder proved as the skilled Workshop and Field Seminar coordinator, together with four students (Kasper, Esben, Johanne and Catharina, from the Geological Department, University of Copenhagen) that assisted during the entire event.
Agostina Vertino (external coordinator of the COCARDE-ERN) as well as the Steering committee and Scientific advisors are warmly thanked for support to the workshop.
The pictures included in the report have been partly provided by Ane Elise Schrøder, Aaron Lim, and Marco Taviani.

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Annex 4a: Programme

Programme

Tuesday, June 10th, 2014: Presentations (Auditorium A, Geology section, University of Copenhagen)

Introduction		
08:30–09:00		Registration and coffee
09:00–09:10	M. Bjerager	Welcome
09:10–09:20	D. Basso	Introduction to the COCARDE-ERN
09:20–09:30	B.W. Lauridsen	The COCARDE Workshop and Field Seminar 2014
Palaeozoic carbonate mounds		
09:30–10.00	L. Stemmerik	Permian cool-water mounds, East Greenland and the Barents Sea
10:00–10:20	A.-C., da Silva	Belgian mud mounds, facies and structure and stromatoporoid fauna
10:20–10:50	**Coffee**	
Cold-water carbonates from the Cretaceous- Paleogene of northern Europe		
10:50–11:20	F. Surlyk	Late Cretaceous and Danian cool-water carbonates of the Danish Basin
11:20–11:50	K. Anderskouv	The interaction between physical and biological processes in carbonate mound formation – examples from the Upper Cretaceous of Denmark and the Pleistocene of the Great Australian Bight
11:50–12:20	N. Thibault	A new Late Cretaceous time scale for the chalk of the Boreal realm
12:20–12:50	E. Sheldon, C. Morigi and B.W Lauridsen	Palaeoecology of Danian cold-water coral mounds from Faxe, Danish Basin
12:50–13:50	**Lunch**	

Cold-water carbonate core workshop and data acquisition methods		
13:50–14:20	M. Grasmueck	Full-Resolution 3D Imaging of Mound Interiors: Discovering Order in the Chaos
14:20–14:40	E.V. Sørensen and M. Bjerager	Virtual outcrop studies using cameras: experiences from Faxe Quarry
14:40–15:00	F. Smit, F. van Buchem and I. Schmidt	Seismic geomorphology of the Danish chalks, offshore North Sea
15:00–15:20	M. Willumsen	Cretaceous Cold-Water Carbonates – with an Oil Geologists Eyes
15:20–15:40	P. Lapointe	Seismic interpretation of carbonates build-ups, pitfalls and misinterpretation
15:40–16:00	**Coffee**	
Young researchers flash presentations		
16:00	A. Lim	Piddington Mound: preliminary results from reef-scale geological habitat mapping
16:10	A. Vis	Determination of decisive parameters modelling cool-water carbonate systems using stratigraphic forward modelling
16:20	K. Janiszewska	Skeletal development in micrabaciid corals and the origin of Scleractinia
16:30	M. McGrath	The Quaternary Stratigraphy of contrasting shallow shelf sand dominated seabed; North West Irish Sea and offshore South East Ireland
16:40	F.N. Fhaoláin	The biodiversity of macrobenthos on cold-water coral mounds and off-mound habitat on the Porcupine Bank Canyon Mounds
16:50	S. Maksoud	Redefinition of the Lebanese Cretaceous Formation "Falaise de Blanche" via a micropalaeontological-taxonomic study
17:00	S. Rosing	Modeling the Chalk Sea: Circulation, Productivity and Implications for Chalk Deposition
17.15 – 18:00		Poster session and refreshments in “rød stue” at the University of Copenhagen
18:00		Dinner at the University of Copenhagen

Poster session 17.15 – 18:00		
	T Buls et al	Effects of short-term consolidation time, concentration of clay and organic matter on the erodibility of Cretaceous chalk ooze

	A. Lim et al.	Moira Mound Habitat Mapping and Sedimentology
	A. Vis	Determination of decisive parameters modelling cool-water carbonate systems using stratigraphic forward modelling
	K. Janiszewska	Skeletal development in micrabaciid corals and the origin of Scleractinia
	M. McGrath	The Quaternary Stratigraphy of contrasting shallow shelf sand dominated seabed; North West Irish Sea and offshore South East Ireland
	F.N. Fhaoláin	The biodiversity of macrobenthos on cold-water coral mounds and off-mound habitat on the Porcupine Bank Canyon Mounds
	S. Maksoud	Redefinition of the Lebanese Cretaceous Formation "Falaise de Blanche" via a micropalaeontological-taxonomic study
	S. Rosing et al	Modeling the circulation of the NW European shelf seas – present and deep past
	E. Anzalone	Travertines of central and southern Italy. A short presentation

18:00		**Dinner at the University of Copenhagen**

Wednesday, June 11th, 2014: Cold-water carbonate core workshop and data acquisition methods

Core workshop at "Kernelab" at Geological Survey of Greenland and Denmark		
08:30–10:30	J. Ineson, P. Frykman, M. Bjerager and B.W. Lauridsen	Core workshop on Upper Cretaceous reservoir carbonates; K/T Boundary; Danian bryozoan and coral limestones of Denmark; discussions facilitated by the young researchers.
10:30–11:00	**Coffee**	
Ecology and Palaeoenvironment		
11:00–11:30	J. Raddatz, A. Rüggeberg, V. Liebetrau, A. Foubert, S. Flögel and Wolf-Christian Dullo	Environmental boundary conditions of cold-water coral mound growth over the last 3 Myr
11:30–11:50	A. Klompmaker	Reefs: Cradles of Decapod Crustacean Diversity
11:50–12:20	M. Wisshak, L. Beuck, A. Form, J. Büscher, A. Freiwald	Carbonate cycling and the role of bioerosion in cold-water coral ecosystems
12:20–13:20		**Lunch**
13:20–13:50	M. Taviani	Getting frozen: Antarctic marine carbonates from greenhouse to icehouse
13:50–14:10	C. Korte	Macrofossil Geochemistry: Checking the fidelity of the signal
14:10–14:30	C. Ullmann	Macrofossil Geochemistry: Palaeoenvironmental application
14:30–14:50	M. Studeny, D. Sanders, C. Korte	K/Pg-transition and Lower Paleocene shallow-water limestones at Kambühel (Austria): potential for palaeoenvironmental reconstruction

14:50–15:20	**Coffee**	
15:20–15:40	P. Montagna, M. McCulloch, E. Douville, M. López Correa, J. Trotter, R. Rodolfo-Metalpa, D. Dissard, C. Ferrier-Pagès, N. Frank, A. Freiwald, S. Goldstein, C. Mazzoli, S. Reynaud, A. Rüggeberg, S. Russo, M. Taviani	Li/Mg ratios in scleractinian corals: A new temperature proxy
15:40–16:00		
16:00–16:30	J.-P. Henriet, N. Frank, D. Hebbeln, A. Rüggeberg	Some reflections on the fate and role of Atlantic Cold-water coral graveyards on a warming planet

Dinner on your own…….

Thursday, June 12th, 2014: Field seminar in southern Denmark (30 to 40 participants)
Departure from Øster Voldgade, University of Copenhagen 07:15, Cabinn hotel 07:30

Arriving at Stevns Klint at 9:00.

09:00–11:00	Team 1: 20 participants	Boat trip along the coastal cliffs of Stevns Klint
09:00–11:00	Team 2: 20 participants	Boesdal limestone quarry Geophysical acquisition methods by Lars Nielsen and associates from the University of Copenhagen
11:00–13:00	Team 1: 20 participants	Boesdal limestone quarry Geophysical acquisition methods by Lars Nielsen and associates from the University of Copenhagen
11:00–13:00	Team 2: 20 participants	Boat trip along the coastal cliffs of Stevns Klint
13:00–14:00	**Packed lunch in the field**	
14:00–15:45		Walk along the Stevns Klint from Højerup Church Upper Cretaceous deep-water carbonate reservoir analogues and K/T boundary mass extinction
16:00–18:00		Stevnsfortet Cold War underground Museum and Danian bryozoan mounds in 3D*
18.00–22:00	**Barbeque dinner at Stevnsfortet Cold War underground Museum**	
22:00	**Walk along the coast to accommodation in Rødvig**	

***** For more information on the museum: http://www.kalklandet.dk/english/stevnsfort-cold-war-museum

Friday, June 13th, 2014:

Field seminar in the fossil cold-water coral and bryozoan mound ecosystem at Faxe and workshop closure

09:00–10:00		A visit to Geomuseum Faxe
09:00–12:00		Field seminar to Faxe Quarry: Cold-water coral mounds, bryozoan coral interplay, palaeoecological reconstructions and evolution. Demonstrations of Drone geology if the weather permits it
12:00–13:00	**Packed lunch in the field**	
13:00–15:00	**Workshop closure at Faxe youth hostel**	
	T. Damholt	Stevns Klint - a World Heritage Site
	L. Stemmerik	Future carbonate research in Denmark
	J.-P. Henriet	Future COCARDE initiatives
	M Bjerager & B.Wl Lauridsen	Open debate and closure of workshop
17:00	**Arrival in Copenhagen**	

Annex 4b: List of Participants

Anderskouv, Kresten (University of Copenhagen, Denmark)
Anzalone, Erlisiana (IAMC-CNR, Italy)
Basso, Daniela (University of Milano-Bicocca, Italy)
Bjerager, Morten (Geological Survey of Denmark and Greenland, Denmark)
Buls, Toms (University of Copenhagen, Denmark)
Boussaha, Myriam,(University of Copenhagen)
Da Silva, Anne-Christine (University of Liège, Belgium)
Damholt, Tove (Østsjællands Museum, Denmark)
Fhaoláin, Findabhair Ní (University College Cork, Ireland)
Frykman, Peter (Geological Survey of Denmark and Greenland, Denmark)
Grasmueck, Mark (University of Miami, USA)
Henriet, Jean-Pierre (University of Ghent, Belgium)
Ineson, Jon (Geological Survey of Denmark and Greenland, Denmark)
Janiszewska, Katarzyna (Polish Academy of Sciences, Poland)
Jensen-Maar, Michelle (University of Copenhagen, Denmark)
Klompmaker, Adiël (University of Florida, USA)
Korte, Christoph (University of Copenhagen, Denmark)
Lapointe, Philippe (Associated to TOTAL, France)
Lauridsen, Bodil Wesenberg (Geological Survey of Denmark and Greenland, Denmark)
Lim, Aaron (University College Cork, Ireland)
Maksoud, Sibelle (University of Western Brittany, France)
McGrath, Marian (University College Cork, Ireland)
Montagna, Paolo (ISMAR-CNR, Italy)
Nielsen, Lars (University of Copenhagen, Denmark)
Pedersen Dorthe, (Østsjællands Museum, Denmark),
Raddatz, Jacec (GEOMAR Helmholtz Centre for Ocean Research, Germany)
Rosing, Salik (University of Copenhagen, Denmark)
Schrøder, Ane Elise (University of Copenhagen, Denmark)
Sheldon, Emma (Geological Survey of Denmark and Greenland, Denmark)
Sloth, Kristian Gram (Geological Survey of Denmark and Greenland, Denmark)
Smit, Florian (Maersk Oil, Denmark)
Stemmerik, Lars (University of Copenhagen, Denmark)
Studeny, Martin (University of Innsbruck, Austria)
Surlyk, Finn (University of Copenhagen, Denmark)
Sørensen, Erik West (Geological Survey of Denmark and Greenland, Denmark)
Sørensen, Anne Melin (University of Copenhagen)
Taviani, Marco (ISMAR-CNR, Italy)
Thibault, Nicolas (University of Copenhagen, Denmark)
Ullmann, Clemens Vinzenz (University of Copenhagen, Denmark)
Van Buchem, Franz (Maersk Oil, Denmark)
Vertino, Agostina (University of Milano-Bicocca, Italy)
Vis, Annelike (VU University Amsterdam, The Netherlands)
Wheeler, Andy (University College Cork, Ireland)
Wisshak, Max (Senckenberg am Meer, Germany)
Willumsen, Mads (Maersk Oil, Denmark)