CAGE - Centre for Arctic Gas Hydrate Environment and Climate Report Series, Volume 1 (2013)

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UiT

THE ARCTIC UNIVERSITY OF NORWAY

CAGE - Centre for Arctic Gas Hydrate, Environment and Climate

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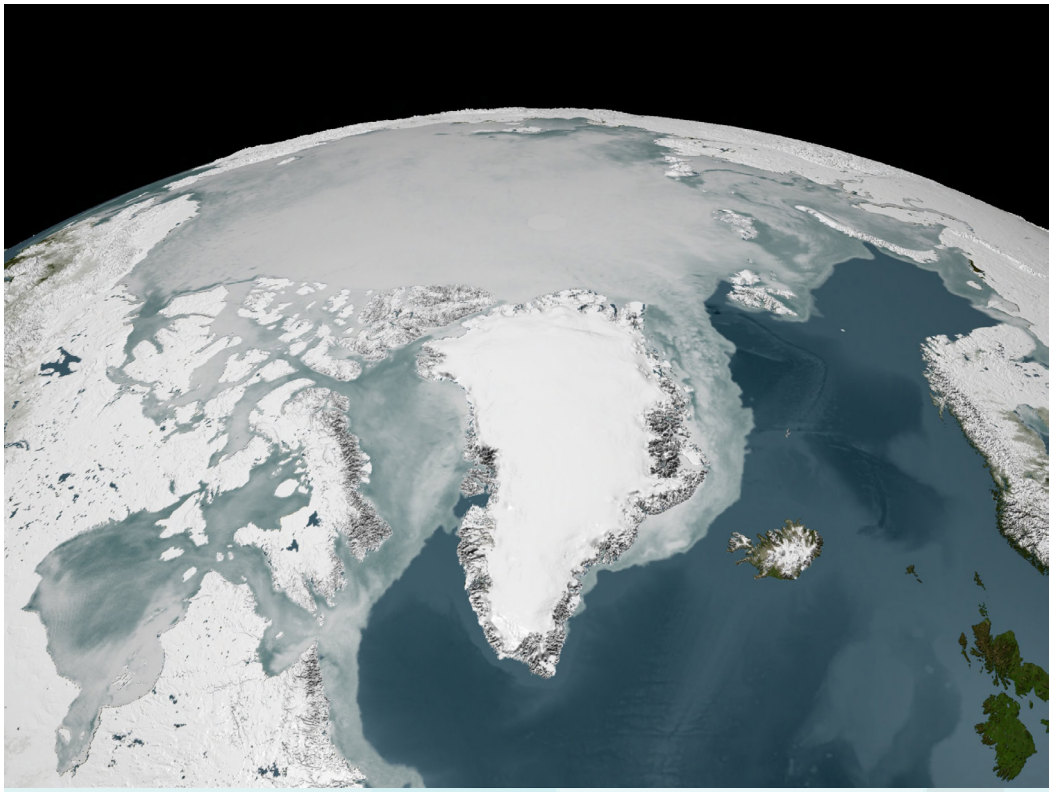
31.03.2014



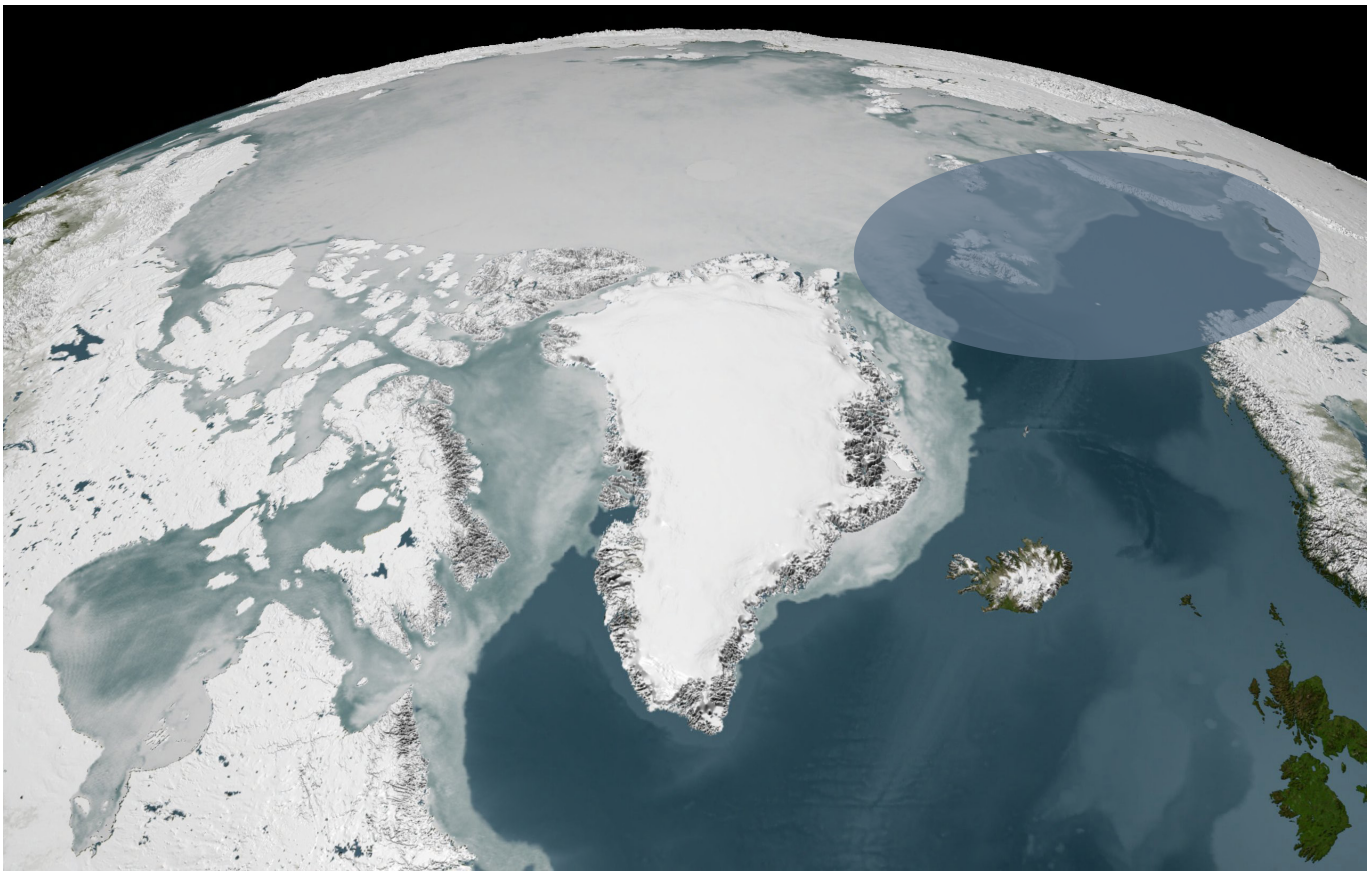
Annual Report 2013

Norwegian Centre of Excellence

UNIVERSITY OF TROMSØ

CONTENTS

2013 IN BRIEF



Earth scientists at CAGE together with colleagues from The Geological Survey of Norway and Akvaplan-niva aim to assess the role of Arctic gas hydrate in past, present and future climate change. For past or present reconstructions we study samples from the sub seabed, the seabed, the water column and the atmosphere and for the future outlook we aim to use modeling with experts from atmospheric science. To accomplish these goals, CAGE contributes to enhanced collaborations and relationships with university and industry research teams at national and international levels.

In November 2012, rector Jarle Aarbakke of UiT the Arctic University of Norway, received the positive news from the Research Council of Norway that Tromsø was selected for this new Centre of Excellence (CoE). CAGE officially started 1st March.

The Research Council of Norway formally opened CAGE in November 2013 at the Department of Geology. Liv Furuberg of the Research Council of Norway presented the plaque of the CoE (Senter for Fremragende Forskning) to the Center's Director Jürgen Mienert. The new rector of the University, Anne Husebekk, welcomed the guests to the new CoE in Tromsø. CAGE will strongly contribute to UiTs fundamental and natural science development during the next decade.

Since 1st March 2013, CAGE has been recruiting new professor/assoc. profs., researchers, postdocs and PhDs in order to systematically build up research teams. We hired a new assoc. prof. Giuliana Panieri from Italy, who is one of the pioneers in methane and proxy research on foraminifera. Another important goal is to develop new infrastructures such as Arctic Ocean observatories, 4 D seismics, and integrated ocean floor, water column and airborne campaigns that will help CAGE scientists address important climate questions. For example: Is Arctic methane on the rise and what are methane filter functions in time and space? Together we develop and integrate existing technologies with industry and international groups in fundamental as well as applied natural science.

We converted the third floor of the "Naturfagbygget" to CAGE offices, allowing integration of master and PhD students, postdocs, and researchers

with the “leaders corner”. The rebuilding started in June 2013 and finished in November 2013. This accomplishment was only made possible with the dedicated assistance of the Institute for Arctic and Marine Biology, the Department of Geology, the Faculty of Natural Science and Technology and UiTs ”bygg og eiendom” (particularly Grete) and our administrative leader Inger Solheim. We were happy to start transition to the third floor and we are grateful for all the support from our University.

Six CAGE research cruises were held in 2013 on RV Helmer Hanssen, which is owned by UiT the Arctic University of Norway. These led us to the western and northern Barents Sea as well as North and West Svalbard to regions of gas hydrates and methane release. Additionally, one research cruise took place on a Russian research vessel to regions of offshore permafrost and methane release in the Kara Sea. Preliminary results and achievements are soon to be presented at AGU, EGU and Gordon research conferences and great progress has been made at the beginning of CAGE. Thank you all!

Jürgen Mienert

Inger Solheim

Field research 2013

Research cruises 2013

Andreassen et al., 2013, Cruise report on Marine geological cruise to Storfjordrenna and Bjørnøyrenna, on R/V ”Helmer Hanssen”, 28th July-4th August, Glacibar & CAGE, Department of Geology, UiT The Arctic University of Norway, p. 1-40.

Andreassen et al., 2013, Cruise report on investigation on glacial geomorphology in the Storfjordrenna, 21st-28th July, GEO8144/3144 and CAGE, Department of Geology, UiT The Arctic University of Norway, p. 1-94.

Rasmussen, T.L., Zamelczyk, K., 2013. Cruise Report: Ocean acidification in the Barents Sea cruise: West Barents Sea slope, Barents Sea, north Norway on R/V Helmer Hanssen, 26th – June 1st May 2013. Department of Geology, University of Tromsø, 2013, pp. 1-13.

Rasmussen, T.L., Nielsen, T., Zamelczyk, K., Kuijpers, A., 2013. Cruise Report: CAGE, OA and Paleo-CIRCUS cruise to Northwest Norway, Jan Mayen and East Greenland: on R/V Helmer Hanssen, 23rd June to 7th July 2013, Department of Geology, University of Tromsø, pp. 1-24.

Buenz et al., 2013, Cruise report on 4D/3D at Vestnesa Ridge and Prins Karl Forland, Northwest Svalbard, 8th-21st July, Department of Geology, University of Tromsø, pp. 1-42.

Mienert et al., 2013, Cruise report on Svalbard Arctic Ocean, R/V Helmer Hanssen, 8th-25th October, Department of Geology, University of Tromsø, pp. 1-42.

ABOUT CAGE

The beginning

Welcome to CAGE - Centre for Arctic Gas Hydrate, Environment and Climate located at UiT The Arctic University of Norway, Tromsø. Here, at the world's northernmost University, the Centre of Excellence (CoE) establishes the intellectual and infrastructure resources for studying the extent of methane hydrate and magnitude of methane release in Arctic Ocean environments on time scales from the Neogene to the present.

In 2002 the Research Council of Norway started establishing centres of excellence (CoE) with funding support for 10 years. Major aims of the CoE program are to establish a critical mass of research teams that drive for excellence at high international science levels. The first 13 centres ended in 2012 (SFF I), the evaluation of new centres (SFF II) resulted in eight new CoEs that began in 2007 and they will end in 2016.

In 2013 the Research Council of Norway selected 13 new centres of excellence (SFF III) out of 139 proposals. Only two of the 13 new centers are within Earth Sciences and one is CAGE (cage.uit.no).

CAGE gives us the opportunity to restructure our geomarine research community and to develop unique and new collaborative scientific and technological solutions to circum-Arctic (Barents-Kara Seas, Barents-Svalbard margins and Beaufort Sea) challenges. CAGE together with its main partner The Geological Survey of Norway, is designed to move the UiT to the forefront of international Arctic gas hydrate research.

Gas hydrate consists mainly of methane and water and is found in great abundance in marine and permafrost regions. But little documentation exists regarding resource accumulations in shallow Arctic subsea areas and its evolution in time and space. Methane hydrate is only stable at low temperature and high pressure. Today's subseabed methane hydrate reservoirs remain elusive targets for both unconventional energy development and as a natural methane emitter influencing ocean environments and ecosystems. It is still contentious how much of the methane ascending from the ocean floor through the hydrosphere reaches the atmosphere. If methane reaches the atmosphere, it acts as a green-house gas several times more potent than CO_2.

Mandate

To unravel the role of Arctic Ocean methane hydrate and methane release systems, we have established CAGE in the Arctic region with one overarching goal: To achieve a quantitative understanding of the feedbacks between methane subseabed reservoirs, the seabed and the ocean. How this coupled system reacts and affects the future ocean, its environment and possibly the atmosphere and climate, is of global importance.

The CAGE CoE starts with a strong foundation on seven research topics: 1. Methane hydrate and free gas reservoirs; 2. The role of ice ages for fluid flow and methane hydrate; 3. Methane release and benthic faunal response; 4. Methane release and gas quantification; 5. Paleo-Methane history from Neogene to Pleistocene; 6. Methane, ocean acidification and CO_2 from the Pleistocene to Present; 7. Atmosphere and methane emissions from the Arctic. We plan to have a strong emphasis on integrating these themes together through the following common questions:

1. Identify and quantify frozen hydrocarbon (methane hydrate), free gas and the total amount of methane available.
2. Perform "real-time" ocean and atmospheric research to assess the magnitude of active methane venting into the ocean and atmosphere and develop environmental response time theories.
3. Develop isotope and faunal studies from the past to the present to detect abnormal "methane ocean" conditions and links to climate change.

Seven integrated research themes

Today's global warming has turned the cold Arctic regions to a "hot spot" for energy, environment and climate research. CAGE strategies are chosen in such a way that they can be tightly linked and based on the need for great expertise required for evaluating: (1) the amount of methane hydrate, (2) the type of methane and geological leakage systems, (3) the methane

leakage history by applying proxy-recorders, and the present-day trend and future predictions using long- term seafloor and land observations. CAGE will develop a detailed understanding of methane in the Arctic Ocean from the Neogene to the present applying geophysical, geobiological, geochemical, ecological and mathematical modeling methods, integrated with state-of-the-art empirical data. It will also reconstruct the paleo-environmental changes over the last 9 million years for the Barents-Svalbard margins, and thereby provide a chronological and environmental framework for the observed gas hydrate and gas accumulations and indications of fluid flow. The seven integrated research themes are discussed below.

WP1: Sub seabed reservoirs
Methane hydrate and free gas reservoirs
Among the greatest uncertainties in the Arctic marine methane supply is the amount of frozen methane in sub seabed sediments. A more important question is how much and at what timescales is this methane released. We are developing new high-resolution geophysical technology within acquisition, processing and interpretation to directly detect and image marine methane hydrate reservoirs in the Arctic. These technologies allow collecting acoustic and electromagnetic data and enable inverse modelling.

WP2: Sub seabed
The role of ice ages for fluid flow and methane hydrate
Today methane exists in many areas just outside of the methane hydrate equilibrium field, but we think methane would have been stable as hydrate during the ice ages, when more than 1,000 metres thick ice 'loaded' the area. We will reconstruct these changes for the Barents Sea and Svalbard margins over the last nine million years. Our goal is to provide new information and improve our understanding of the variability of methane release which can be related to retreating glaciers.

WP3: Seabed
Methane release and benthic faunal response
It is uncertain how, and to what extent, methane release from gas hydrates affects life on the seabed. We will study benthic organisms, communities, and food webs to understand the range of biological responses to varying intensities of natural hydrocarbons seeping from marine sediments in the Svalbard/Barents Sea area over different time periods and spatial scales.

WP4: Water column
Methane release and gas quantification
By understanding the variability of methane release on time scales from hours to a decade and its dependence on oceanographic changes, we can quantify local and regional methane leakages. We use long-term ocean observatories to quantify the methane release from the seabed to the ocean.

WP5: Paleo-methane history
Neogene to Pleistocene
What was the ultimate timing of historic methane leakages from sediments in the seabed? Did they occur periodically over millions of years or rather abruptly? We will develop realistic modelling tools and start a dedicated programme on methane-derived carbonates in the Arctic to shed light over this, and expect to be able to present unique new information.

WP6: Pleistocene to present
Methane, ocean acidification and CO_2
Benthic foraminifera communities are sensitive to methane emissions and methane hydrate dissociation. We are developing multi-proxy approaches focusing on changes in methane release and ocean acidification related benthic responses. To provide records for the global background signal of greenhouse gases and climate change, we will investigate areas largely unaffected by methane and use them as control areas. We will follow the development in seep areas by yearly sampling to study eventual changes in methane release and ocean acidification related to methane emissions over the CAGE project period.

WP7: Atmosphere
Methane emissions from the Arctic Ocean
The overall objective is to quantify the present atmospheric effects of methane from gas hydrates at the seabed, and future potential climate impacts on decadal to centennial timescales. Methane hydrate in ocean seabed sediments is a potential source of methane (CH_4) to the atmosphere, where CH_4 has potential to act as a powerful greenhouse gas. However, current scientific results show diversity in the flux of CH_4 that actually reaches the atmosphere. The MOCA project related to CAGE will apply advanced measurements and modelling to quantify the amount and present atmospheric impact of CH_4

originating from methane hydrate. Furthermore, the project will investigate potential future climate effects from destabilisation of methane hydrate deposits in a warming climate, and will focus on scenarios in 2050 and 2100.

Training through a research school

Our vision for the research school is to become a leading national and international contributor to methane hydrate research. This aim will be achieved through a cooperation with ResClim and the AMGG (Arctic Marine Geology & Geophysics) research school. We will educate a new generation of young scientists towards complex Earth Sciences using observations and modeling in the field of methane and methane hydrates.

Management

The management structure ensures that all Centre activities: (1) coordinate legal contractual, research and technology development, patent applications, ethical, financial and administrative work; (2) organize and complete tasks within expected timescales, resources and quality levels; (3) prepare and deliver reports with expected quality standards. The main decision-making structure will be a Steering Committee (SC) and an Advisory Board (AB). The SC will oversee operational aspects including the relationships to the University, institutes and industry. The AB consists of distinguished experts in their fields to (i) provide networking with other centres and projects for possible sharing of solutions, (ii) point out competitive research developments and (iii) provide advice to guide the Centre towards national and international recognition and activity.

Decisions at the CoE are made in meetings, by the research theme leaders and the director. The CoE achieves internal communication through regular weekly meetings with the theme leaders and the director. Working group- meetings with particular themes are held monthly. CAGE scientific staff (postdocs, researchers) are given the opportunity to get involved in teaching or supervising master and PhD students jointly with professors. The leader of the research school assures communication between researchers, postdocs, PhD students and master students through regular meetings and organized staff meetings outside Tromsø. The management and core research team consists of:

Director: Prof. Jürgen Mienert (JM);
Ass. Director: Prof. Karin Andreassen (KA);
Administration officer: Dr. Inger Solheim (IS);
Information officer: Therese Larsen.

Research theme leaders:
Assoc. Prof. Stefan Bünz (SB) (WP1);
Prof. Karin Andreassen (KA) (WP2);
Prof. II JoLynn Carroll (JC) (WP3);
Dr. Benedicte Ferré (BF) (WP4);
Dr. Jochen Knies (JK) (WP5);
Prof. Tine Rasmussen (TR) (WP6);
Dr. Catherine Lund Myhre (WP7)
Assoc. Prof. Giuliana Panieri (Research School)

Steering committee: The Centre will be governed by a SC with responsibilities for overseeing the strategy for research, training, economy and patent developments. The committee consists of the following members: Prof. Kenneth Ruud (Pro Rector UiT); Prof. Morten Hald (Dean of the NT-Faculty, UiT); Dr. Morten Smelror (Director, NGU, Trondheim); Dr. Jarle Husebø (Statoil); Dr. Nalan Koc (Research Director, Norwegian Polar Institute), Prof. Jürgen Mienert (Director, CAGE). The CAGE director reports to the steering committee.

Members of the steering committee shown are, from left to right: Fred Godtliebsen (assoc. dean), Morten Smelror, Jarle Husebø and Kenneth Ruud.

Advisory board: The Centre seeks advice by an international scientific advisory board on science strategic issues by the following distinguished scientists: Prof. Antje Boetius (Alfred-Wegener Institute for Polar Research, FRG); Prof. Georgy Cherkashov (Institute of Mineral resources of the Ocean, RUS); Dr. Tim Collett/Dr. Carolyn Ruppel (United States Geological Survey, USA); Dr. Scott Dallimore (Canadian Geological Survey, Canada) Prof. Gerald Haug (ETH Zurich, SV). CAGE

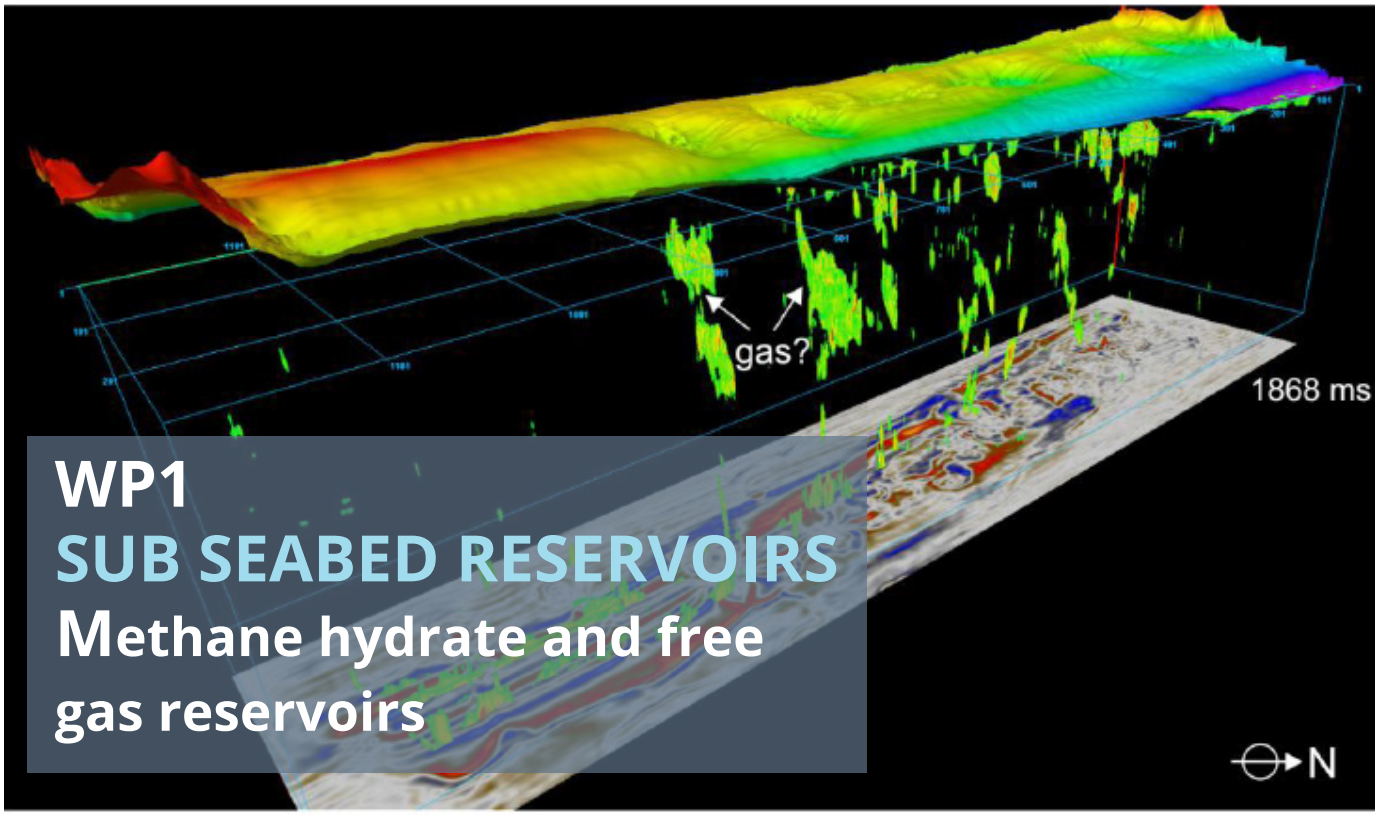
research leaders and the director are reporting to the advisory board. The advisory board meets annually and provides a written recommendation to the CAGE director one week after the AB meeting.

Rector Anne Husebekk (centre) welcomes advisory board members Antje Boetius (left) and Carolyn Ruppel (right).

The CAGE science work plan and implementation strategy outlines a 5-10 year scope for addressing and integrating major scientific objectives in Arctic gas hydrate, environment and climate research. CAGE complements, in particular, teams from Russia, Canada, USA and Europe in the field of subsea gas hydrate and methane release.

Outreach publications

1. Tretten nye sentre for fremragende forskning, november 2012, forskningsrådet.no
2. UiT får nytt Senter for fremragende forskning, november 2012, UiT nyhetsartikkel
3. 140 millioner til UiT-forskere, Tromsø får nytt senter, november 2012, Norlys.no
4. 13 nye fremragende forskingsmiljøer, november 2012, ngu.no, Aktuelt
5. To nye geofaglige SFF-sentre, Ronny Setså, GEO november 2012; Geoforskning.no
6. Vil går bredere og dypere, Jarle Aarbakke, desember 2012, Norlys.no
7. Ti år er gått – ti nye kommer, Halfdan Carstens, GEO desember 2012; Geoforskning.no
8. To nye SFF i geofag, Halfdan Carstens, side 36, GEO desember 2012; Geoforskning.no
9. Isen som brenner, Ragnhild Gustad og Ole Åsheim, desember 2012, Nordlys avis
10. Et unikt gasshydratsystem, Ronny Setså, GEO januar 2013; Geoforskning.no
11. Gulf stream warming and its impact on Norwegian and Arctic continental margins – methane release and instable slopes?, Therese Larsen, januar 2013, Fram Forum
12. Vil bygge observatorier på havbunnen for å forstå "isgassen", Roald Ramsdahl, mars 2013, TU Petroleum
13. Pris til geologiprofessor, Ronny Setså, GEO april 2013; Geoforskning.no
14. Ble satt pris på, april 2013;UiT.no
15. Jordens minst utforskende område, Ronny Setså, GEO juni 2013; Geoforskning.no
16. Startskudd for nytt SFF-senter, Ronny Setså, GEO november 2013; Geoforskning.no
17. Senteråpning: Skal få svar på gasshydratets betydning for klima og miljø, Therese Larsen, november 2013, uit.no
18. Får 400 millioner til forskning på isgass, Rune Endresen, november 2013, 18, Dagens næringsliv
19. Skal bli verdens beste på arktisk isgass, Ole Magnus Rapp, november 2013, A19, Næring
20. UiT åpnet nytt senter, Harald Stavseth, november 2013, Tromsø avis
21. Det fremste i hele verden på området, Harald Stavseth, november 2013, Tromsø avis
22. UiT feirer prestisjesenter i internasjonal toppklasse, Therese Larsen, november 2013, uit.no
23. MOCA mot global oppvarming, november 2013, NILU,
24. Best på arktisk isgass. Bård Amundsen, Bladet Forskning 03/2013
25. Vil kvantifisere metanutslipp fra havbunnen, Ronny Setså, GEO desember 2013, Geoforskning.no
26. Nytt SFF åpner i Tromsø, Synnøve Bolstad, november 2013, Forskningsrådet
27. Nytt SFF-Senter i Tromsø, side 55, GEO desember 2013; Geoforskning.no
28. Norwegian Center of Excellence to Receive Ten Years of Arctic Research Funding, Fire in the Ice Newsletter, 2013.
29. Pink marine sediments reveal rapid ice melt during the Ice Age, Therese Larsen, ScienceNordic, desember 2013.
30. Klimaet var ustabilt i istiden, Therese Larsen, uit.no
31. Rosa leire avslører ustabilt klima i istiden, Therese Larsen, desember 2013, uit.no
32. Will the melting of Arctic frozen methane increase greenhouse gas emissions? Jurgen Mienert; The UARrctic Magazine, pages 14-15, Shared voices 2013
33. Under overflate lurer ustabil isgass, Therese Larsen, Labyrint, Kunnskapsmagasinet fra UiT Norges Arktiske Universitet, Nr. 3, 26-27, 2013
34. Hvorfor valgte du mikrofossiler? - I beste Jurassic Park-stil rekonstruerer Giuliana Panieri seks millioner år gammelt DNA i sin tidligere jobb. Nå skal hun finne ut mer om fortidens klimaendringer ved å studere mikrofossiler i Tromsø, Maja Sojtaric og Therese Larsen, Labyrint, Kunnskapsmagasinet fra UiT Norges Arktiske Universitet, Nr. 3, 42-43, 2014
35. Internasjonal interesse for CAGE, Ronny Setså, GEO januar 2014, Geoforskning.no
36. CAGE støtter formidlingen av geofaglig forskning, GEO 23. januar 2014, Geoforskning.no



WP1
SUB SEABED RESERVOIRS
Methane hydrate and free gas reservoirs

Goals

The main goal of this work package focusses on two key questions: (1) how much carbon is stored in methane hydrate and free gas reservoirs in the Arctic, and how much of it is susceptible to climate change, and (2) at what rates, by which means and under which circumstances is methane expelled from subseabed reservoirs? Both of these key questions link with other work packages on quantification of methane emissions, ecosystem impacts, coupling of ice sheet and gas-hydrate models and potential climate feedbacks.

In order to achieve these goals we employ state-of-the-art technology in sub-seabed imaging using broadband high-resolution data, and develop 4D time-lapse studies of subsurface gas migration to improve models for fluid flow in subsurface sediments.

During the first three years of CAGE, our target areas are the western Svalbard continental margin, the Barents Sea and the Kara Sea, while doing reconnaissance assessment of hydrate occurrence and its stability condition in adjacent basins

Infrastructures

One of the key technologies in CAGE, particularly for WP1 and WP2 is the high-resolution P-Cable 3D seismic system, a national infrastructure developed and located at the University of Tromsø. Together with mini-GI gun sources, these systems deliver high-resolution broadband (30-400Hz) seismic data providing unprecedented detail of subsurface structure and stratigraphy. CAGE has successfully applied to use the seafloor drill rig MeBo from University of Bremen on a research cruise with RV Maria Merian this summer. CAGE plans to drill three locations on the Vestnesa Ridge and collaborates on drilling the upper slope edge of the hydrate-stability zone with colleagues from University of Bremen and Geomar, Kiel.

First year plans

1. Recruit one researcher for a career development track within CAGE for initially 5 years.
2. Recruit one PhD student for developing 4D seismic processing and time-lapse analysis (funded by UiT).
3. Recruit one PhD student for developing seismic detection technologies for gas

hydrates using broadband high-resolution seismic data (funded by CAGE).

4. Repeat high-resolution 3D seismic survey on the Vestnesa Ridge to establish time-lapse seismic monitoring studies of active seeps.
5. Acquire high-resolution 3D seismic data for planning of MeBo drill sites on the upper slope of the W-Svalbard continental margin.
6. Participate on a cruise to the Kara Sea to study gas seepage from permafrost areas.
7. Consolidate and improve the understanding of gas-hydrate occurrence in the SW Barents Sea for future selection of study sites.

First year achievements

1. Recruited Researcher for tenure-track position: Andreia Plaza-Faverola.
2. Recruited PhD student for 4D processing and time-lapse analysis: Sandra Hurter (since June 2013).
3. Recruited PhD student for developing seismic detection technologies for hydrates: Sunny Singhroha (since Feb 2014).
4. Acquired the two planned high-res 3D seismic surveys offshore W-Svalbard.
5. Acquired multibeam and Chirp sub-bottom data in Kara Sea
6. Conducted systematic analysis of hydrate and fluid flow in SW Barents Sea (1 paper publ., 3 subm.)

CAGE conference abstracts

Bünz, S., Chand, S., 2013. Arctic Gas-Hydrates on the Svalbard Margin and in the Barents Sea, EAGE conference and exhibition, London, 2013.

Bünz, S., 2013. Leakage assessment and identification of fluid leakage scenarios at CO2 storage sites (Invited), AGU Fall meeting, abstract no. OS11E-02.

Mienert, J., Chand S., Bünz, S., Vadakkepuliyambatta, S., Rajan, A., Smith A., 2013. Gas hydrate systems in petroleum provinces. 3P Arctic – The Petroleum Potential conference, Stavanger.

Tasianas, A., Bünz, S., 2013.High resolution P-Cable 3D seismic study of pockmarks and shallow fluid conduits at the Snøhvit reservoir in the SW Barents Sea, AGU Fall meeting, abstract no. OS12A-01.


Stefan Buenz (leader)


Chyam Chand


Andreia Plaza Faverola


Sunil Vadakke-puliyambatta


Pavel Serov


Sandra Hurter


Alexey Portnov


Sunny Singhroba


NN, PhD student, from June 2014

CAGE publications

Hogan K.A:, Dowdeswell, J., Mienert J., 2013. New insights into slide processes and seafloor geology revealed by side-scan imagery of the massive Hinlopen Slide, Arctic Ocean margin, 2013, Geo-Mar- Letters, DOI 10.1007/s00367-013-0330-6.

Vadakkepuliyambatta, S, Bünz, S, Mienert, J, Chand, S., 2013. Distribution of subsurface fluid-flow systems in the SW Barents Sea, Marine and Petroleum Geology 43, pp 208-221, 10.1016/j.marpetgeo.2013.02.007.

Portnov, A; Smith, AJ; Mienert, J; Cherkashov, G; Rekant, P; Semenov, P; Serov, P; Vanshtein, B., 2013. Offshore permafrost decay and massive seabed methane escape in water depths > 20m at the South Kara Sea shelf, Geophysical Research Letters 40(15), pp. 3962-3967, 10.1002/grl.50735.

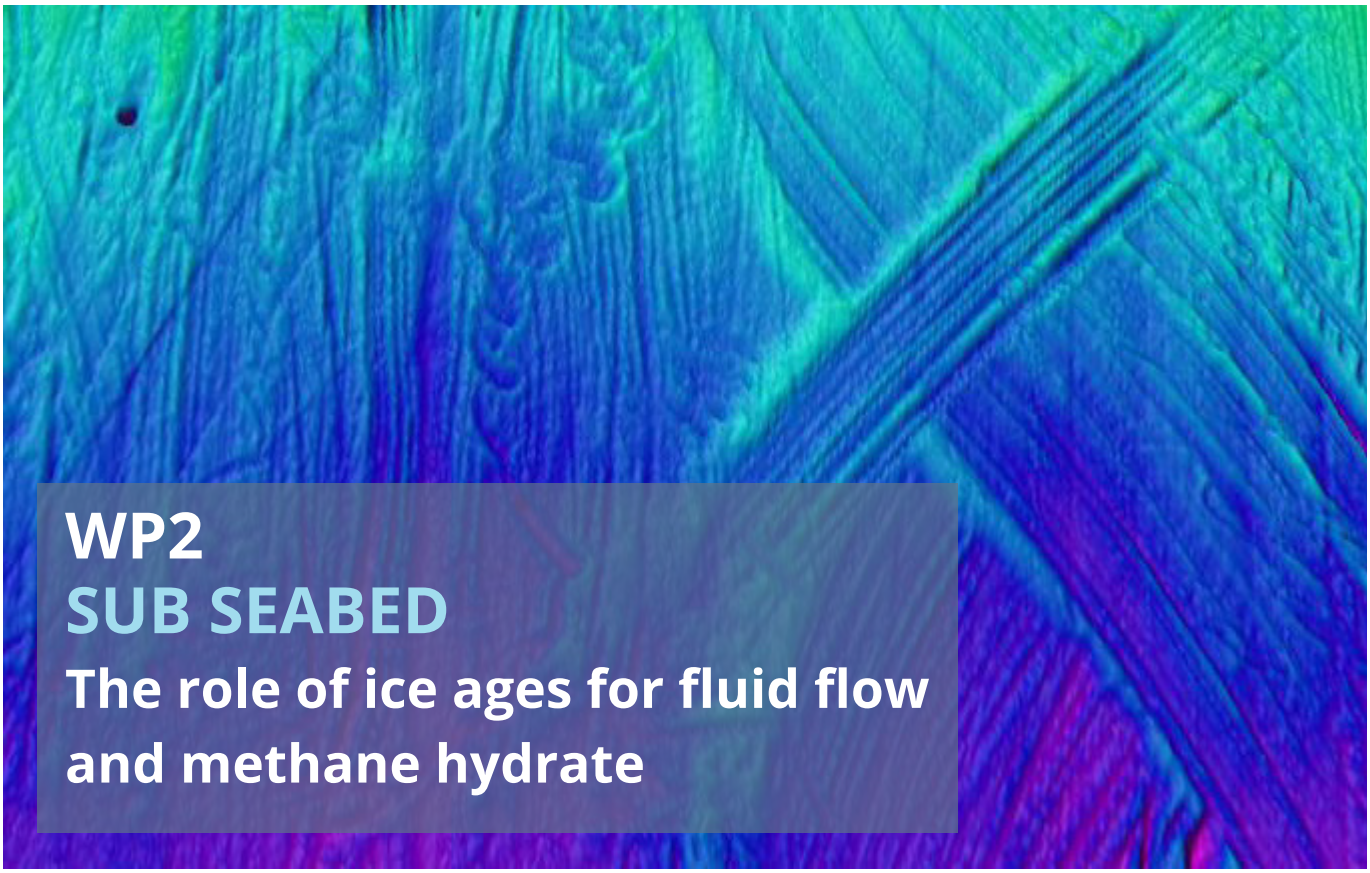
Rajan, A; Bünz, S; Mienert, J; Smith, AJ., 2013. Gas hydrate systems in petroleum provinces of the SW-Barents Sea, Marine And Petroleum Geology 46, pp. 92-106, 2013,10.1016/j.marpetgeo.2013.06.009

Buenz et al., 2013. Cruise report on 4D/3D at Vestnesa Ridge and Prins Karl Forland, Northwest Svalbard, 8th-21st July, Department of Geology, University of Tromsø, pp. 1-42.

CAGE related projects

ECO2: Sub-seabed CO_2 Storage: Impact on Marine Ecosystems (ECO2), funded under the European Commission's Seventh Framework Programme, SB is PI and WP leader.

MIDAS: Managing impact of deep sea resource exploitation, funded under the European Commission's Environmental Programme, JM is PI.



WP2
SUB SEABED
The role of ice ages for fluid flow and methane hydrate

Goals

The main goal of this work package is to reconstruct the response of the fluid reservoirs to ice ages. This will be achieved through the following sub-goals:

1) Reconstruct the extent and dynamics of former ice sheets and paleo-environment in the Barents Sea area through the ice ages.
2) Improve our understanding of the interaction of glacial processes with gas hydrate-, fluid flow- and deeper hydro-carbon systems.
3) Contribute with models for glacial development and P-T conditions in recon-structions of changes in the gas hydrate stability fields through the ice ages.

Sub-goals 2 and 3 will be carried out in close cooperation with the work package on "Methane hydrate and free gas reservoirs". We will provide the other work packages with a litho-, chrono- and environmental framework for the glacial sediments in the chosen study areas, and work closely together with these in investigating methane releases to the Arctic ocean environment, their sub-seabed reservoirs, variations in the past and their potential future. We will also seek relevant information about the pre-glacial stratigraphy and tectonics in chosen study areas.

Information about former ice sheet development, dynamics, processes and paleo environments will be interpreted from 3D/2D seismic, high-resolution sea-floor bathymetry and acoustic data, integrated with results from drilling, sediment coring and numerical modelling. An existing geoscientific database at UiT will be used and supplemented with new industry data and high-resolution geophysical and geological data.

Infrastructures

CAGE will in the start phase use geophysical and geological infrastructure built up through previous activities at UiT, and further develop new high-resolution geophysical technology in acquisition, processing and interpretation of the subsurface. The UiT ice-going research vessel Helmer Hanssen and the new ice-breaker Kronprins Haakon, which is planned to be launched in 2015-2016 with Tromsø as a port, will be used for acquisition of new data in the Arctic.

First year plans

1. Recruit Post Doc for 3D numerical modeling of the Svalbard-Barents Sea -Fennoscandian Ice Sheets through the last glacial cycle (GlaciBar).
2. Recruit researcher for further development of algorithms for ice sheet modeling (Cage).
3. Recruit collaborating sedimentologist for investigations of glacial palaeo-environmental studies (Cage funding).
4. Recruit scientist for integrating results from the Russian Barents Sea in our models (Cage).
5. Recruit two PhD students, for studies of glacial dynamics (GLANAM) and for glacial sedimentology and processes (ResClim/UiT.
6. Identify locations for summer 2014 field studies.

First year achievements

1. Post Doc Henry Patton was hired for 2 years, from 1 December 2013.
2. Prof. Alun Hubbard in 50% position from 1. March 2014.
3. Denise Rüther is hired as Ass. Prof. II (20%) on

CAGE conference abstracts

Andreassen, K., Bjarnadottir, L.R., Ruther, D. and Winsborrow. 2013. Dynamics of marine ice streams as inferred from geomorphology of the Barents Sea continental shelf. EGU General Assembly, Vienna, Austria, 7-12 April 2013.

Andreassen, K., Knies, J., Husum, K. and Akhmanov, G., 2013. Glaciations in the Barents Sea area. 7th Norwegian-Russian Arctic Offshore Workshop, Arkhangelsk, June 17-20, 2013.

Andreassen, K. and Deryabin, A., 2013. Gas-related glacitectonic sediment deformation inferred from 3D seismic data, SW Barents Sea. 30th IAS Meeting of Sedimentology, Manchester 2-5. Sept. 2013.

Bjarnadóttir, J.R., Winsborrow, M. and Andreassen, K., 2013. Deglaciation of the central Barents Sea. International Conference on Past Gateways, St. Petersberg, Russia, May 13-17, 2013.

Laberg, J.S., Safronova, P., Andreassen, K. and Vorren, T.O., 2013. Cenozoic sandy systems and sea floor stability along the western Barents margin and off northern Norway. 7th Norwegian-Russian Arctic Offshore Workshop, Arkhangelsk, June 17-20, 2013.

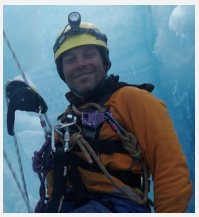
Karin Andreassen (leader)

Emilia Daria Piasecka

Mariana da Silveira Ramos Esteves

Eythor Gudlaugsson

Henry Patton



Alun Hubbard, from March 2014

Leonid Polyak

Spagnolo, M., Clark, C.,Ely, J., Stokes, C., Anderson, J.B., Andreassen, K., Graham, A.G. and King, E.C., 2013. Size, shape and arrangement of mega-scale glacial lineations, and implications for ice stream basal processes. EGU General Assembly, Vienna, Austria, 7-12 April 2013.

Aagaard-Sørensen, S., Groot, D. E., Husum, K. and Hald, M., 2013. Paleoceanographic reconstruction in the western and northern Barents Sea during and after the last deglaciation. EGU, Vienna, Austria, 7-12 April 2013.

CAGE publications

Andreassen, K. Winsborrow, M., Bjarnadottir, L. and Rüther, D., 2013. Ice stream retreat dynamics inferred from an assemblage of landforms in the northern Barents Sea. Quaternary Science Reviews, doi.org/10.1016/j.quascirev.2013.09.015

Bjarnadottir, L.R., Winsborrow, M. and Andreassen, K., 2013. Deglaciation of the central Barents Sea. Quaternary Science Reviews, doi.org/10.1016/j.quascirev.2013.09.012

Gudlaugsson, E., Humbert, A., Winsborrow, M. and Andreassen, K., 2013. Subglacial roughness of the former Barents Sea Ice Sheet. Journal of Geophysical Research – Earth Surface, Vol. 118, 2546-2556, doi:10.1002/2013JF002714

Knies, J., Mattingsdal, R., Fabian, K., Grøsfjeld, K., Baranwal, S., Husum, K., De Schepper, S., Vogt, C., Andersen, N., Matthiessen, J., Andreassen, K., Jokat, W., Nam, S-I and Gaina, C., 2013. Effect of early Pliocene uplift on late Pliocene cooling in the Arctic-Atlantic gateway. Earth and Planetary Science Letters. Vol. 387,132-144, doi.org/10.1016/j.epsl.2013.11.007

Mattingsdal, R., Knies, J., Andreassen, K., Fabian, K., Husum, K.,Grøsfjeld, K. and de Schepper, S., 2013. A new 6 Myr stratigraphic framework for the Atlantic-Arctic Gateway. Online Quaternary Science Reviews. http://dx.doi.org/10.1016/j.quascirev.2013.08.022

Andreassen et al., 2013. Cruise report on Marine geological cruise to Storfjordrenna and Bjørnøyrenna, on R/V "Helmer Hanssen", 28th July-4th August, Glacibar & CAGE, Department of Geology, UiT The Arctic University of Norway, p. 1-40.

Andreassen et al., 2013. Cruise report on investigation on glacial geomorphology in the Storfjordrenna, 21st-28th July, GEO8144/3144 and CAGE, Department of Geology, UiT The Arctic University of Norway, p. 1-94.

CAGE related projects

ARCEx – Research Centre for Arctic Petroleum Exploration. 2013-2021. Project Leader. Research Council of Norway (RCN). PETROMAKSII Programme.

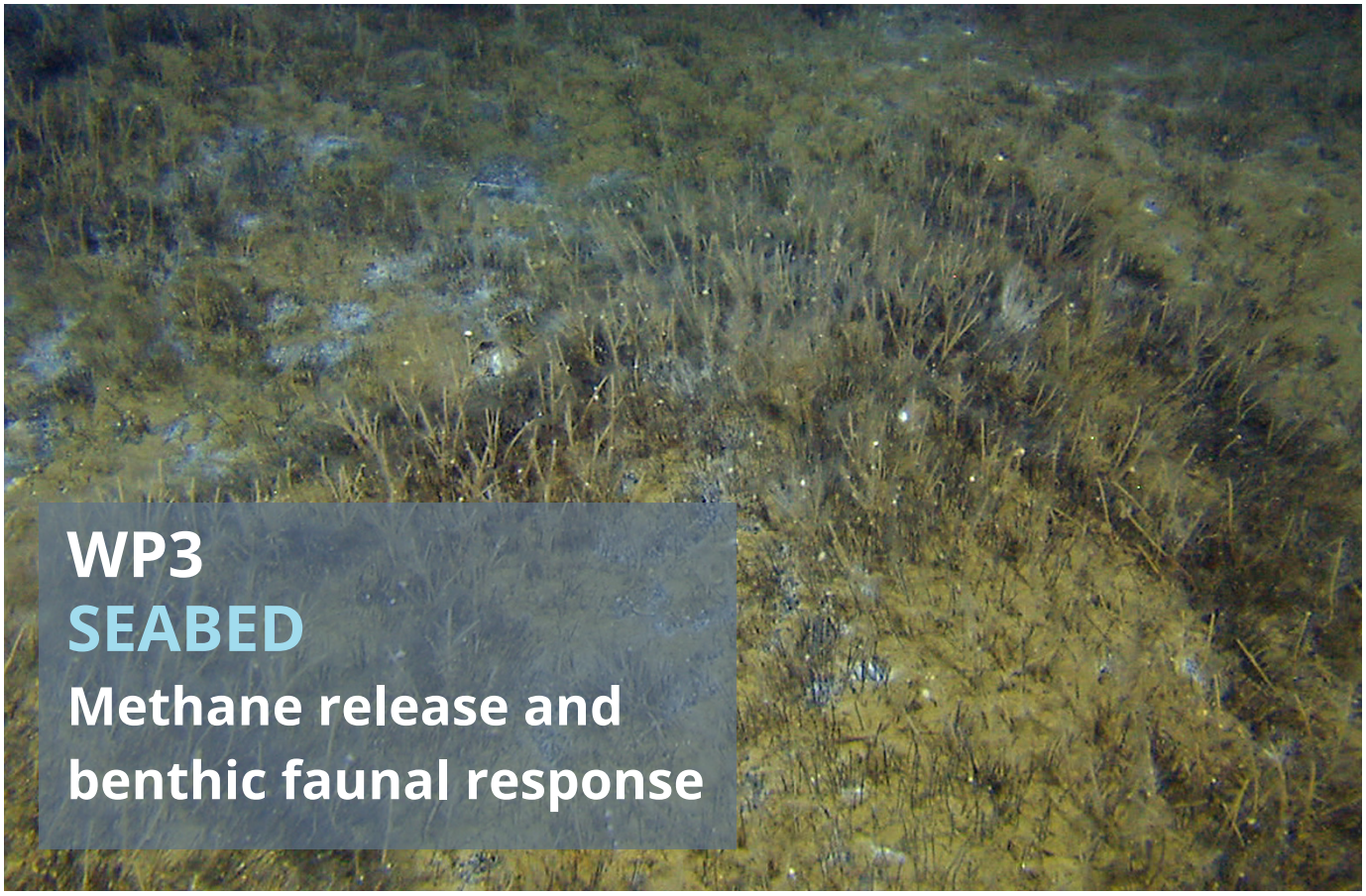
GLANAM – Glaciated North Atlantic Margins. 2013-2015. Principal Investigator (PI). European Commission Marie Curie Trainig Network.

GLACIBAR – Glaciations in the Barents Sea Area. 2010-2015. Project Leader and PI. RCN PETROMAKS Programme.

Ice sheet dynamics and deglaciation of the Barents Sea – Svalbard area. 2014-2018. National Research School in Climate Dynamics (ResClim)/ UiT.

Collapse of a Marine Ice Sheet. 2013-2017. PI. ResClim / UiT.

Modelling the subglacial hydrology of the former Barents Sea Ice Sheet. 2011-2015. PI. ResClim / UiT.



WP3
SEABED
Methane release and benthic faunal response

Goals

The overall goal is to quantify the effects of methane releases from features such as pock marks, gas seeps, and methane hydrates on biological communities associated with the seabed. We examine benthic organisms, communities, and food webs to understand the range of biological responses to varying intensities of natural hydrocarbons seeping from marine sediments in the Svalbard/Barents Sea area over multiple temporal and spatial scales.

We will make direct observations of fauna at seafloor methane release sites and gather sediment samples to monitor physical parameters and sediment geochemistry. This will be augmented with quantitative assessments of bacteria and macrofauna in order to determine species composition and community structure along a gradient of methane intensity. We will use stable isotopic analyses to determine food web structure and to what extent methane is utilized as an energy source in the marine ecosystem. We also develop and test benthic biological monitoring technologies, such as sclerochronology (the analysis of mollusk shell rings), as indicators of biological responses to different types of hydrocarbon leakage.

This technology development activity aims at providing a well-constrained understanding of the range of biological responses and associated effects over multiple temporal and spatial scales to varying intensities of natural hydrocarbon leakages from marine sediments.

The activities in this working group will contribute to an overall assessment of the fate and effect of methane in the Arctic marine environment.

Infrastructures

Infrastructures used to support these CAGE activities include an accredited (ISO9001) benthic faunal sorting and identification laboratory, a chemical analysis laboratory accredited for hydrocarbon analyses in sediments and seawater. We are in negotiation to obtain the use of a benthic lander including a benthic flux chamber for methane flux measurements at the sediment-water interface. Akvaplan-Niva also maintains a laboratory and equipment for sclerochronological processing and analysis. For experimental work in a laboratory

setting, Akvaplan-niva maintains a marine laboratory facility with flowing seawater and temperature regulation which allows experimental work to elucidate processes and to quantify rates. Such work, performed under controlled and continuously monitored conditions, is needed to complement field measurements.

First year plans

1. Identify expertise necessary to carry out the goals for the working group.
2. Recruit a Visiting senior scientist in Arctic Marine Benthic Ecology, Food Web analysis and sclerochronology
3. Recruit a PhD student in Arctic Marine Benthic Ecology
4. Identify the expertise necessary to begin developing a microbial biology expertise.
5. Identify initial locations for field sampling

First year achievements

1. Successfully recruited a senior scientist, Professor William Ambrose to work on CAGE. His first residency period at CAGE will be from July-December 2014.
2. Successfully recruited a PhD student, Emmelie Åstrôm, to begin studies in spring 2014.
3. Successfully recruited a post-doc level researcher, Friederike Gründger, to develop a microbiology program within CAGE
4. Identified and developed a collaboration avenue to make available a benthic lander for in-situ methane flux measurements at the sediment-water interface.
5. Outlined a conceptual plan to develop an experimental laboratory facility to conduct effects studies of methane on individual species and benthic communities, including succession studies, uptake experiments, and food web analyses.
6. Constructed an experimental set-up for pilot experiment in early spring 2014 for maintaining constant CO2 inputs for experimental mesocosm. work

CAGE conference abstracts

Carroll, M.L., W.G. Ambrose Jr., W.L. Locke, S.K. Ryan, B.J. Johnson. 2013. Bivalve Growth Rate and Isotopic Variability Across the Barents Sea Polar Front. 3rd International Sclerochronology

Jolynn Carroll (leader)

Michael Carroll

Emmelie Åström, from April 2014

William G. Ambrose, Jr.

NN Post.doc

NN (PhD student)

Conference, 18-23 May 2013. Bangor, Wales UK
Carroll, M.L., W.G. Ambrose Jr., W.L. Locke, A. Eller. 2013. Extended chronology of Serripes groenlandicus from a high-Arctic fjord in Svalbard, Norway. 3rd International Sclerochronology Conference, 18-23 May 2013. Bangor, Wales UK
Vihtakari, M. W.G. Ambrose Jr., P.E. Renaud, W.L. Locke, J. Berge, M.L. Carroll. F. Cottier, H. Hop. 2013. Bivalve shell mineralogy as a high-resolution environmental proxy in the Arctic. 3rd International Sclerochronology Conference, 18-23 May 2013. Bangor, Wales UK

CAGE publications

Carroll, M.L., W.G. Ambrose, W.L. Locke, S.K. Ryan, B.J. Johnson. 2013. Bivalve growth rate and isotopic variability across the Barents Sea Polar Front. Journal of Marine Systems, 130:167-180.

CAGE related projects

RELIC - Reconstruction of Environmental Histories Using Long-Lived Bivalve Shells in the Norwegian Arctic. Norwegian Research Council, Norway-U.S. bilateral collaboration program.

ARAMACC - "Annually-resolved archives of marine climate change - development of molluscan sclerochronology for marine environmental monitoring and climatology". European Commission, Marie Curie Initial Training Network

ARCEx – Research Centre for Arctic Petroleum Exploration. Norwegian Research Council PETROMAKS programme.

WP4
WATER COLUMN
Methane release and gas quantification

Goals

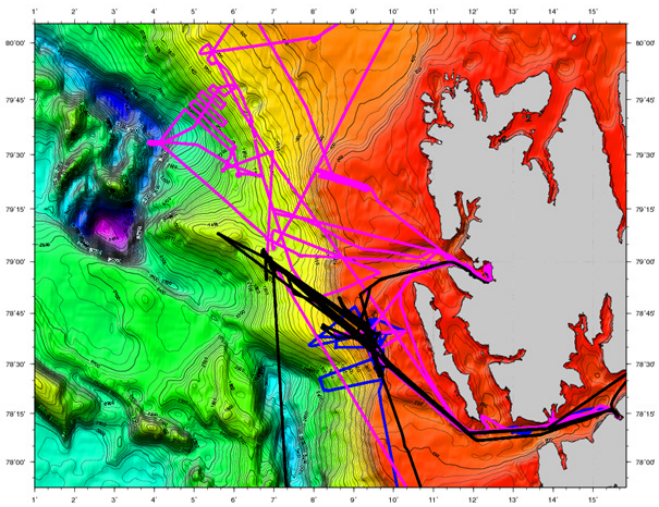
The main goal of this work package is to quantify local and regional methane leakages by evaluating the variability of methane release on time scales from hours to years and its dependence on oceanographic changes. This will be achieved by the deployment of long-term observatories in targeted areas.
Measurements from the seabed, the air and from land stations, along with modeling analysis, will provide the link between potential sources of elevated methane concentrations and the reason for variations

Infrastructures

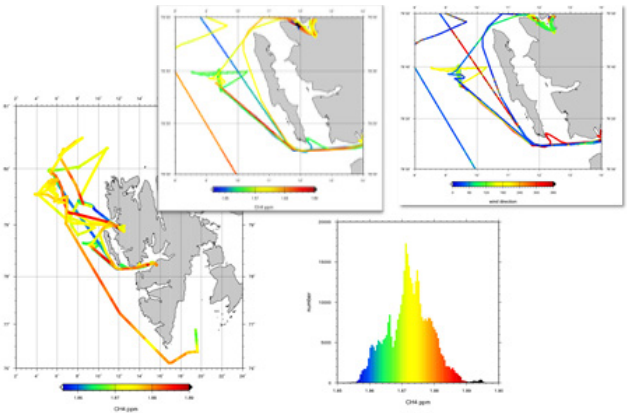
CAGE uses experience from previous observatories like MASOX to plan the observatories that will be deployed. The area being actively trawled, we wish to use the same infrastructure. Other instruments will be installed in the water column with a cable connecting the seafloor and the sea surface with a buoy with telemetry communication.

First year plans

1. Hire a postdoctoral researcher to work on carbon chemistry in the water column and help with the design of the observatory and other instrumentation for methane measurement.
2. Hire 2 PhD students working on time-series and modeling
3. Select the station(s)
4. Develop the observatories to be deployed at the selected stations
5. Buy the instruments and infrastructure necessary for the observatories



Helmer Hanssen 2009 -2011 ship tracks to investigate the NW Svalbard continental margin gas release systems. Picarro atmosphere measurements were carried out during the cruise.



Picarro data collected during cruises (Mienert et al.) next to areas of bubble release from the seabed (Ocober 2009, June 2010, August 2011).

First year achievements

1. A postdoctoral researcher has been hired (Anna Silyakova) who started her position on August 2013.
2. DFKI will be tested in order to obtain high resolution photo mosaic.
3. The stations have been selected and we decided to replicate all the measurements with a twin observatory. We will start by deploying the first pair on a shallow site (~400m depth) offshore Svalbard in July 2014.
4. The 2 PhD students have been selected and we are now in the recruitment process.
5. The instruments are: ADCPs, CTDs, thermistors, methane, CO2, O2 sensors, telemetry buoy. We are also collaborating with Scripps for their HARP system to be deployed in pair next to the observatory. In addition, an AUV prototype from DFKI will be tested in order to obtain high resolution photo mosaic.
6. Our engineers are working together with collegues from the industry on a solution to build the observatories.
7. We are working in close collaboration with MOCA to best organize the cruises and choose the instruments.

CAGE related projects

The University of Tromsø is part of the Fixed-Point Open Ocean Observatories (FixO3) project coordinated by the National Oceanography Centre (UK).

UiT is an active task leader for ensuring the interface with ESONET-EMSO label consortium that defines a set of criteria on specifications of deep-sea observatories.

Benedicte Ferré (leader)

Anna Silyakova

NN, PhD student, April 2014

NN, PhD student, June 2014

Jens Greinert

WP5
METHANE HISTORY
From Neogene to Pleistocene

Goals
The main goal of this workpackage is to investigate the timing of hydrocarbon leakage in the high Arctic and whether it occurred periodically over millions of years or rather abruptly. The research will be conducted on various time-scales including pre-glacial and glacial environmental settings and will provide new knowledge on the impact of tectonic and climatic events on stabilities of gas hydrates and deeper hydrocarbon reservoirs.

Infrastructures
CAGE supports the investment of a new 2G cryogenic rock magnetometer at the Geological Survey of Norway. The new infrastructure has a value of 4.4 MNOK and will primarily help (1) to study rock magnetic properties of seep-related authigenic greigite formation in Ocean Drilling Program (ODP) sites in the Atlantic-Arctic gateway region and (2) to improve the late Cenozoic paleomagnetic timescale and chronostratigraphic framework in the Arctic. The new facilities will be available for graduate and PhD students as well as Post Doc fellows from all national and international partners.

First year plans
The plan during the first year is (1) to establish a continuous late Cenozoic stratigraphic framework for the Atlantic-Arctic gateway region. This new framework will set the baseline for an improved understanding of hydrocarbon leakage episodes in the Arctic during the late Cenozoic. Further (2) we aim to conduct a dedicated study on methane-derived, authigenic carbonate crusts in the Arctic.

A large-scale sampling program has already been initiated in 2013. With this new material, both the exact timing of late Pleistocene fluid-flow events and potential source(s) of gaseous hydrocarbons can be identified. (3) New cold-vent sites have been detected in the SW Barents Sea and the Lofoten margin during numerous cruises, which will be targeted and analysed further in 2014. (4) New drillcores from 2 billion-year-old oil field in Karelia, Russia have been obtained. These new cores, combined with existing outcrop materials will be used in the PhD project that will start in 2014 to study ancient vent/seep systems with the focus on phosphorite formation in such settings and related microbial processes.

First year achievements
A major breakthrough in terms of a new stratigraphic framework for the Plio-Pleistocene in the Arctic is achieved during the first year. A new and robust chronology allows inferences on the impact of pre-glacial tectonic uplift events on the onset of

Northern Hemisphere glaciation and the stability of hydrocarbon reservoirs in the Barents Sea.

The collection of carbonate crusts from various vent sites in the Barents Sea permits the systematic dating of gas hydrate destabilization as a consequence of waxing and waning of Late Quaternary ice sheets in the Barents Sea.

First results from 2.0 billion year old venting systems show the presence of diverse microbial community consisting of methanotrophic archaea and sulfur metabolizing bacteria in phosphorous-rich setting. Habitat for these microbes appears to have established as a consequence of oxygenation of the Earth.

The amount and source of gaseous hydrocarbons escaping the seafloor on the Lofoten margin have been documented. Detailed analyses of the carbonate crusts will provide the timing of the leakage.

Recruitements: ??

Infrastructures

CAGE supports the investment of a new 2G cryogenic rock magnetometer at the Geological Survey of Norway. The new infrastructure has a value of 4.4 MNOK and will primarily help (1) to study rock magnetic properties of seep-related authigenic greigite formation in Ocean Drilling Program (ODP) sites in the Atlantic-Arctic gateway region and (2) to improve the late Cenozoic paleomagnetic timescale and chronostratigraphic framework in the Arctic. The new facilities will be available for graduate and PhD students as well as Post Doc fellows from all national and international partners.

CAGE conference abstracts

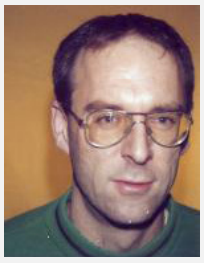
Bøe, R., Bellec, V.K., Rise, L., Buhl-Mortensen, L., Chand, S. & Thorsnes, T., 2013. Catastrophic fluid escape venting-tunnels and related features associated with large submarine slides on the continental rise off Vesterålen-Troms, North Norway. In: Nakrem, H.A. & Haukdal, G. (eds.) Abstracts and Proceedings of the Geological Society of Norway. NGF Number 1, 2013, p. 20. Vinterkonferansen, Oslo, January 8-10, 2013.

Chand, S., Knies, J., Jensen, H., Baranwal, S., Klug, M and Bergan, M., 2013. Subsurface fluid flow and surface anomalies at Veslemøy high, SW


Jochen Knies (leader)

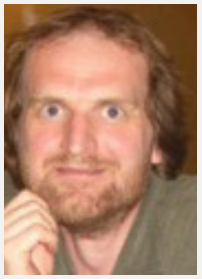

Terje Thorsnes


Soma Baranwal


Reidulv Bøe


Shyam Chand


Antoine Cremiere


Karl Fabian

Barents Sea – What do they tell us about Gas Hydrate prospects in the Barents Sea? Arctic Unconventional resources, 3P Arctic, AAPG, The Polar Petroleum Potential Conference, October, Stavanger.

Chand, S., Rise, L., Thorsnes, T., Brunstad, H. & Bøe, R., 2013. Shallow gas, gas hydrates and pockmarks along the Norwegian offshore: Is there any relation to deglaciation. In: Nakrem, H.A. & Haukdal, G. (eds.) Abstracts and Proceedings of the Geological Society of Norway. NGF Number 1, 2013, p. 20. Vinterkonferansen, Oslo, January 8-10, 2013.

Knies, J., 2013. Influence of early Pliocene uplift on late Pliocene cooling in the Arctic-Atlantic gateay. AAPG 3P Arctic Conference 15 -18 October, 2013, Stavanger, Norway.

Knies, J., Grasby, S.E., Beauchamp, B., Schubert C.J., 2013. Coupling of nitrogen inputs and losses during the Permian-Triassic Biotic Crisis. 2013 Goldschmidt Conference, 25-30 August, 2013, Florence, Italy, doi:10.1180/minmag.2013.077.5.11

Lepland, A., 2013. New insights from the FAR-DEEP drilling program, Invited talk at Gordon Research Conference, Ventura, California, USA, January 28.

Lepland, A., Chand, S., Sahy, D., Noble, S.R., Condon, D.J., Martma, T., Pedersen, J.H., Sauer, S., Brunstad, H. & Thorsnes, T., 2013. Dating the collapse of the Scandinavian Ice Sheet using CH_4-derived carbonate crusts from the Barents Sea. Goldschmidt Conference, Florence, Italy.

Sauer, S., Knies, J., Lepland, A., Chand, S., 2013. Natural hydrocarbon emissions on the continental shelf off northern Norway. Gordon Research Conference Abstracts, Ventura, CA, USA 25.01-01.02.2013, poster presentation.

Sauer, S., Knies, J., Schubert, C., Lepland, A., Chand, S., 2013. Geochemical and acoustic investigations of hydrocarbon seepage on the continental shelf off northern Norway. Goldschmidt Conference Abstracts, Florence, Italy, 25-30.08.2013, p. 2139, poster presentation.

Thorsnes, T., 2013. Seabed mapping in Norwegian waters – using hullborne and AUV/ROV mounted acoustic, optical and chemical systems for habitat mapping and studies of natural gas seepages. University of New Hampshire, USA, 19.4.2013.

Thorsnes, T., Brunstad, H., Lågstad, P., Chand, S., Lepland, A. og Karlsen, A., 2013. Using hullborne multibeam systems, autonomous underwater vehicles (AUVs), Synthetic Aperture Sonar (SAS) and optical systems to map habitats associated with gas seepage Or Finding the needle in the hay stack. GeoHab 2013, Roma, 7-10.5.2013

Joel Johnson

Aivo Lepland

Simone Sauer

CAGE publications

Knies, J., Mattingsdal, R., Fabian, K., Grøsfjeld, K., Baranwal, S., Husum, K., De Schepper, S., Vogt, C., Andersen, N., Matthiessen, J., Andreassen, K., Jokat, W., Nam, S.-I., Gaina, C., 2013. Effect of early Pliocene uplift on late Pliocene cooling in the Arctic-Atlantic gateway. Earth and Planetary Science Letters, 387, 132-144.

Mattingsdal, R., Knies, J., Andreassen, K., Fabian, K., Husum, K., Grøsfjeld, K. & de Schepper, S., 2013. A new 6 Myr stratigraphic framework for the Atlantic-Arctic Gateway. Quaternary Science Reviews, http://dx.doi.org/10.1016/j.quascirev.2013.08.022.

Müller, A. & Knies, J., 2013. Trace elements and cathodoluminescence of detrital quartz in Arctic marine sediments - a new ice-rafted debris provenance proxy. Climate of the past,

2615-2630. doi:10.5194/cp-9-2615-2013.

CAGE related projects

- Seabed processes and hydrocarbon impregnation in the western Barents Sea (2011-2014), Knies, J. (Project leader). Funding: RWE-Dea Norge

- Natural hydrocarbon emissions and their relation to neo-tectonics and glacial dynamics (2012-2015), Knies, J. (Project leader). Funding: RWE-Dea Norge

- Neotectonics and Fluid Flow processes - PHASE III - 201-2016 - Studies of carbonate crusts (2013-2016), Thorsnes, T. (Project leader). Funding: Lundin Norway

WP6
PLEISTOCENE TO PRESENT
Methane, ocean acidification and CO_2

Goals

The methane emission sites are monitored by yearly sampling to study episodicity in methane release and ocean acidification related to methane emissions. Sediment cores (piston- gravity- and multicores) and surface samples are studied to reconstruct methane emissions in the past in relation to climate and oceanographical changes. Past bottom water temperatures are reconstructed by means of Mg/Ca ratios, oxygen isotopes and transfer functions on benthic foraminiferal species. Bottom current activities are reconstructed using sortable silt and mineral magnetics. Ocean acidification related to emission of greenhouse gases to the atmosphere and emission of methane to the water column in the past and present is studied by means of boron isotopes, B/Ca ratios and shell weight of foraminifera (a.o.). Methane emissions are reconstructed through isotopic measurements (carbon and oxygen) of foraminiferal carbonate shells and investigations of secondary mineralization affecting the shells.

To provide records for the global background signal of greenhouse gases and climate change, areas unaffected by hydrocarbon migration are studied as control areas.

Geochemical records from foraminifera shells and fauna analyses will help us evaluate the episodicity of methane emissions, while studies of living and fossil species distribution and abundance of the benthic foraminifera community in methane seep areas will indicate the degree of methane release through time.

Infrastructures

Access to research vessels, home lab facilities and labs facilities abroad.

First year plans

1. Cruises to Vestnesa, Fram Strait, Storfjorden and the Barents Sea for sediment sampling (coring and surface sediments), plankton towing and water sampling for chemical analyses of pH,

CO_2, CH_4, inorganic nutrients and particulate and dissolved organic content.
2. Sediment and fauna analyses (quantitative and qualitative), carbon-14 datings, isotope analyses ($\delta^{18}O$, $\delta^{13}C$, $\delta^{11}B$), element analyses (Mg/Ca, B/Ca, Sr/Ca ratios) a.o. has been performed and continues.
3. SEM imaging and elemental mapping of foraminiferal shell samples for diagenesis investigations.
4. Hire one PhD students working on the reconstructions of seafloor methane emissions in the Pleistocene.
5. Purchase a SEM Hitachi Tabletop Microscope TM-3000 + EDS system. - Build a "Clean-room" laboratory for foraminiferal cleaning
6. Rearrangement of the Laboratory area at the Department of Geology with the aim of accommodate new instruments and the Micropaleontology Laboratory.

First year achievements

Two cruises:

1. Cruise 26 May to 1st June, RV Helmer Hanssen to North Norway, Bjørnøya, and SE Barents Sea. Sampling of gravity cores, plankton net, CTD, and multicores.
2. Cruise 23 June to 7 July, RV Helmer Hanssen, Vøring Plateau, Jan Mayen and East Greenland. Piston- gravity- and multicoring, plankton net, water sampling, seismics and acoustics.

One PhD student has been hired (Andrea Schneider) who starts February 16th, 2014.

CAGE conference abstracts

Olsen, J., Rasmussen, T.L., Reimer, P.J., 2013. North Atlantic Surface Ocean 14C variability between 30 – 40 kyr BP. Abstracts Volume and Programme COST-INTIMATE Annual Spring Meeting, Blair Atholl, Scotland, April 27 to May 5, 2013, Abstracts for Presentations, p. 26.

Inceoglu, F., Olsen, J., Rasmussen, T.L., Singarayer, J., Austin W., 2013. Modeling Surface Ocean ^{14}C Variability during MIS 3 with GENIE-1: An outline. Abstracts Volume and Programme COST-INTIMATE Annual Spring Meeting, Blair Atholl, Scotland, April 27 to May 5, 2013, Abstracts for Presentations, p. 54.

Zamelczyk, K., Rasmussen, T.L., Manno, C., Bauerfeind, E., Bijma, J., 2013. Past and present

Tine L. Rasmussen

Giuliana Panieri

Kamila Sztybor

Katarzyna Zamelczyk

Mohamed Ezat

Simon P. Jessen

Patrycja E. Jernas

water chemistry changes: planktic foraminifera in the Fram Strait (preliminary results and plans). International Conference Arctic Ocean Acidification, Bergen, Norway, 6-8 May 2013. AMAP (Arctic Monitoring and Assesment Programme, Abstract Volume, p. 25.

Davies, S.M., Meara, R.H., Abbott, P.M., Bigler, M., Svensson, A., Austin, W.E.N., Pearce, N.J.G., Wastegård, S., Rasmussen, T.L., Brendryen, J., 2013. Synchronising Greenland ice-core records and North Atlantic marine sequences using tephrochronology during marine isotope stage 5. Abstracts Volume and Programme COST-INTIMATE Spring Workshop, Blair Atholl, Scotland, April 27-May 5, 2013. Abstracts for Presentations, p. 48.

Griggs, A., Davies, S.M., Rasmussen, T., Hall., I., 2013. Constraining rapid climatic events in the North Atlantic using tephrochronology. Abstracts Volume and Programme COST-INTIMATE Annual Spring Meeting, Blair Atholl, Scotland, April 27-May 5, 2013. Abstracts for Presentations, p. 52.

Chauhan, T., Rasmussen, T.L., Noormets, R., Jacobsson, M., Hogan, K., 2013. Glacial history and paleoceanography of the southern Yermak Plateau since 132 ka BP. Proceeding of the Past Gateways, First International Conference and Workshop, St. Petersburg, May 13-17, 2013. ISBN 978-5-54391-0039-2, Publishing house "Renova" 195130, Saint-Petersburg, Khimikov st., 28, p. 31.

Sztybor, K., Rasmussen, T.L., Mienert, J., Bünz, S., Consolaro, C., 2013. Challenges in reading the paleo-record from an extreme environment. Abstracts ICP-X1. 11th International Conference on Paleoceanography, Barcelona, September 1-6, 2013.

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Cruise reports:

Rasmussen, T.L., Zamelczyk, K., 2013. Cruise Report: Ocean acidification in the Barents Sea cruise: West Barents Sea slope, Barents Sea, north Norway on R/V Helmer Hanssen, May 26th – June 1st 2013. Department of Geology, University of Tromsø, 2013, pp. 1-13.

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CAGE related projects:

2011-2015: Late Weichselian ice-sheet dynamics and deglaciation history of the northern and eastern Svalbard margins. UNIS and NFR.

2010-2014: The INTIMATE Project: INTegrating Ice core, MArine and TErrestrial records (60,000 to to 8000 years ago). COST- ES-0709.

2010-2014: Methane release and past climate

change. University of Tromsø, and Tromsø Forskningsstiftelse (Mohn Foundation).

2010-2014: CO2 and the ocean circulation system: Paleoproductivity, carbonate preservation and ocean ventilation in the Nordic seas in relation to natural variations in CO2 during the last 150,000 years (Paleo-CIRCUS). University of Tromsø and Tromsø Forskningsstiftelse (Mohn Foundation).

2012-2015: OA-Ocean Acidification: Effects of ocean chemistry changes on planktic foraminifera in the Fram Strait: ocean acidification from natural to anthropogenic changes. Research Council of Norway NFR. No.216538/E40.

2012-2015: CircumWAIS: Circumpolar deep water upwelling and West Antarctic Ice Sheet Stability. Research Council of Norway NFR, No. 214020.

2012-2017: Tephra constraints on RApid Climatic Events (TRACE). European Research Council (ERC) Independent Starting Grant (Project no. 259253).

2012-2016. North Atlantic radiocarbon reservoir ages and their implications on ocean circulation dynamics during Marine Isotope Stage 3. Grant Carlsbergfondet, Denmark.

2012-2014 "FORMAT-FORaminifera as proxy of changes in Methane releases from ArcTic regions", Italian National Antarctic Program (PNRA); Coordinator: Giuliana Panieri.

01/10/2012-31/03/2013 "Climate control on methane emissions from the Arctic seafloor?", Department of Energy & Climate Change, UK; Coordinators: Rachael H. James, Doug C. Connelly; unique subcontractor: Giuliana Panieri.

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WP7
ATMOSPHERE
Methane emissions from the Arctic Ocean

Goals
The MOCA project is connected to CAGE. MOCA is a project that will apply advanced measurements and modelling to quantify the amount and present atmospheric impact of CH4 originating from methane hydrate. Furthermore, the project will model potential future climate effects from destabilisation of methane hydrate deposits in a warming climate, and will focus on scenarios in 2050 and 2100. The project is a cooperation between CAGE, the Norwegian Institute for Air Research (NILU), and the Center for International Climate and Environmental Research – Oslo (CICERO).

CH_4 has potential to act as a powerful greenhouse gas. However, current scientific results show diversity in the flux of CH4 that actually reaches the atmosphere. Methane hydrate is potentially susceptible to ocean warming, which could trigger a positive feedback resulting in rapid climate warming.

MOCA is an interdisciplinary project that utilises both ship and airborne measurement campaigns and powerful modelling tools in collaboration with international investigators and existing projects. The project is anticipated to generate new knowledge on the entire Earth system and climate change using the region around Svalbard as an experimental test bed to study polar processes

Infrastructures
Planned (Picarro) installations on board Helmer Hanssen will allow to measure methane concentrations for both atmosphere and ocean surface waters. Flight campaigns with international teams are planned in coordination with ship campaigns from CAGE/MOCA.

First year plans
1. Recruit a postdoctoral student to work on Arctic gas hydrate concentrations including industry data
2. Prepare for ship and airborne campaigns
3. Prepare FLEXPART inversions

First year achievements
1. Successfully recruited a postdoc coming from our PhD program
2. Ship and airborne campaigns discussed and now scheduled for 2014
3. Design of ship installations (Picarro) discussed and scheduled

MOCA/CAGE conference abstracts

MOCA/CAGE publications

Related projects

FAAM BAe-146 (Cambridge)
MAAM (Cambridge)

Cathrine Lund-Myhre (leader)

Adam Durant

Ivar S. A. Isaksen

Jürgen Mienert

Gunnar Myhre

Andreas Stohl

RESEARCH SCHOOL

Goals

The Arctic Marine Geology and Geophysics Research School, together with CAGE staff, will provide researchers and students (or Master students and PhD candidates) in-depth knowledge in gas hydrate research.

The Research school offers seminars, international school cruises and workshops through which we will train a new generation of scientists that comprehend the multiple facets of how methane release impacts the marine environment and climate system.

Our Research School is always open to talented researchers and students from a wide variety of fields, from geology to physics, geophysics, biology, oceanography and engineering. Our aim is to go beyond the traditional framework of science and develop a new frontier of interdisciplinary science, international projects and international networking.

First year achievements

First "Winter School on Sea Ice Variability in the Arctic – Past and Present Conditions", collaboration between the Center of Excellence for Arctic Gas Hydrate, Environment and Climate (CAGE) and the National Research School in Climate Dynamics (Resclim).

Topics:

1). Geological and geophysical aspects of sea-ice in the Arctic with lectures on reconstructions of past sea ice extent, oceanography, basic sea ice physics, sea ice/ocean/air interactions and remote sensing. In addition, specific case studies on cutting edge sea ice related topics will be presented.

Details:

The Winter School will take place at the Arctic University of Norway, Department of Geology, Tromsø, March 31 – April 4, 2014.

2). Research school cruise (Geo-3144) June 20-30,2014, on board of RV Helmer Hanssen. The cruise brings PhD students and Master Students together with Leaders from CAGE for extended periods of study and interaction. Students receive class instruction and experience in the field of Arctic research.

Activities:

- The cruise is conducted in a target area on the West-Svalbard Margin focusing on gas hydrates, fluid leakage systems and its biological, geochemical and environmental impacts, and covering disciplines from biogeochemistry, oceanography, geology to geophysics. Lectures on above listed topics are provided;
- Fieldwork;
- Mini-projects to be performed in collaboration with CAGE Leaders and expedition members.

2014 OUTLOOK

CAGE 2014 ship and aircraft campaigns (ocean and air)

January		February		Mars		April		May		June	
1		1		1		1		1	Tromsø	1	
2		2	Forts.	2		2		2		2	PICARRO installation
3		3		3		3		3		3	Ocean methane
4		4		4		4		4		4	Tromsø
5		5		5		5		5		5	Vedlikehold
6		6		6		6		6		6	
7		7		7		7	PICARRO installation	7		7	
8		8		8		8		8		8	
9		9		9		9	GEO-2006	9		9	Tromsø
10		10		10		10	S. Bünz	10		10	M- HRH
11		11		11		11	Test PICARRO	11		11	Test PICARRO
12		12		12		12	Air methane	12		12	Ocean methane
13		13		13		13		13		13	Overfart LYR
14		14		14		14		14	M - JA	14	
15		15		15		15		15		15	
16		16		16		16		16		16	
17		17		17		17		17		17	
18		18		18		18		18		18	
19		19		19	PICARRO installation	19		19		19	
20	M - JA	20	M- HRH	20	Air methane	20		20		20	
21		21		21	M-JA Tromsø	21		21	DLR-Svalbard	21	
22		22		22		22		22	aircraft campaign	22	
23		23		23		23		23	Dassault Falcon 20E	23	GEO-3144
24		24		24		24		24		24	S. Bünz
25		25		25		25		25		25	USGS PICARRO
26		26		26		26		26		26	Ocean methane
27		27		27		27		27		27	NILU PICARRO
28		28		28		28		28		28	Air methane
29		29		29		29		29		29	
30		30		30		30	Forts.	30		30	Forts.
31				31				31			
	CAGE/ MOCA/ NILU		CAGE/ Geologi		NN		CAGE/USGS		OUTREACH		

CAGE 2014 ship and aircraft campaigns (ocean and air)

July		August		September		October		November		December	
1	S. Bünz	1		1		1		1		1	
2	4D seismic	2		2		2		2		2	
3	Svalbard	3		3	FS Maria S. Merian	3		3	M - JA	3	
4	Air methane	4	M- HRH	4	G. Bohrmann	4		4		4	
5	UK BAe-146	5		5	MEBO GH Drilling	5	Longyearbyen	5		5	
6	Longyearb.	6		6	Svalbard	6	M- HRH	6		6	
7	M - JA	7		7	M - JA	7		7		7	
8		8		8		8		8		8	
9		9		9		9		9		9	
10		10		10		10		10		10	
11	K. Andreassen	11		11		11		11		11	
12	Barents Sea	12		12		12	JMienert	12		12	
13	Storfjorden	13		13		13	Fram Strait	13		13	
14	Bjørnøyrenna	14		14		14	Air methane	14		14	
15	Air methane	15	FS Maria S. Merian	15		15		15		15	
16		16	G. Bohrmann	16		16		16		16	Verksted
17		17	MEBO GH Drilling	17		17		17		17	
18		18	Svalbard	18		18		18		18	
19		19		19		19	Longyearb.	19		19	
20		20		20	Kara Sea	20		20		20	
21	ongyearb.	21		21	Tupolev 134	21		21		21	
22	T. Rasmussen	22		22	IPSL/CNRS FR	22		22		22	
23	Air methane	23		23		23		23		23	
24		24		24		24	JMienert	24		24	
25		25		25		25	Fram Strait	25		25	
26		26		26		26	Air methane	26		26	
27		27		27		27		27		27	
28		28		28		28		28		28	
29	Tromsø	29		29		29		29		29	
30		30		30	Forts.	30		30		30	
31		31				31				31	

CAGE/ MOCA/ NILU

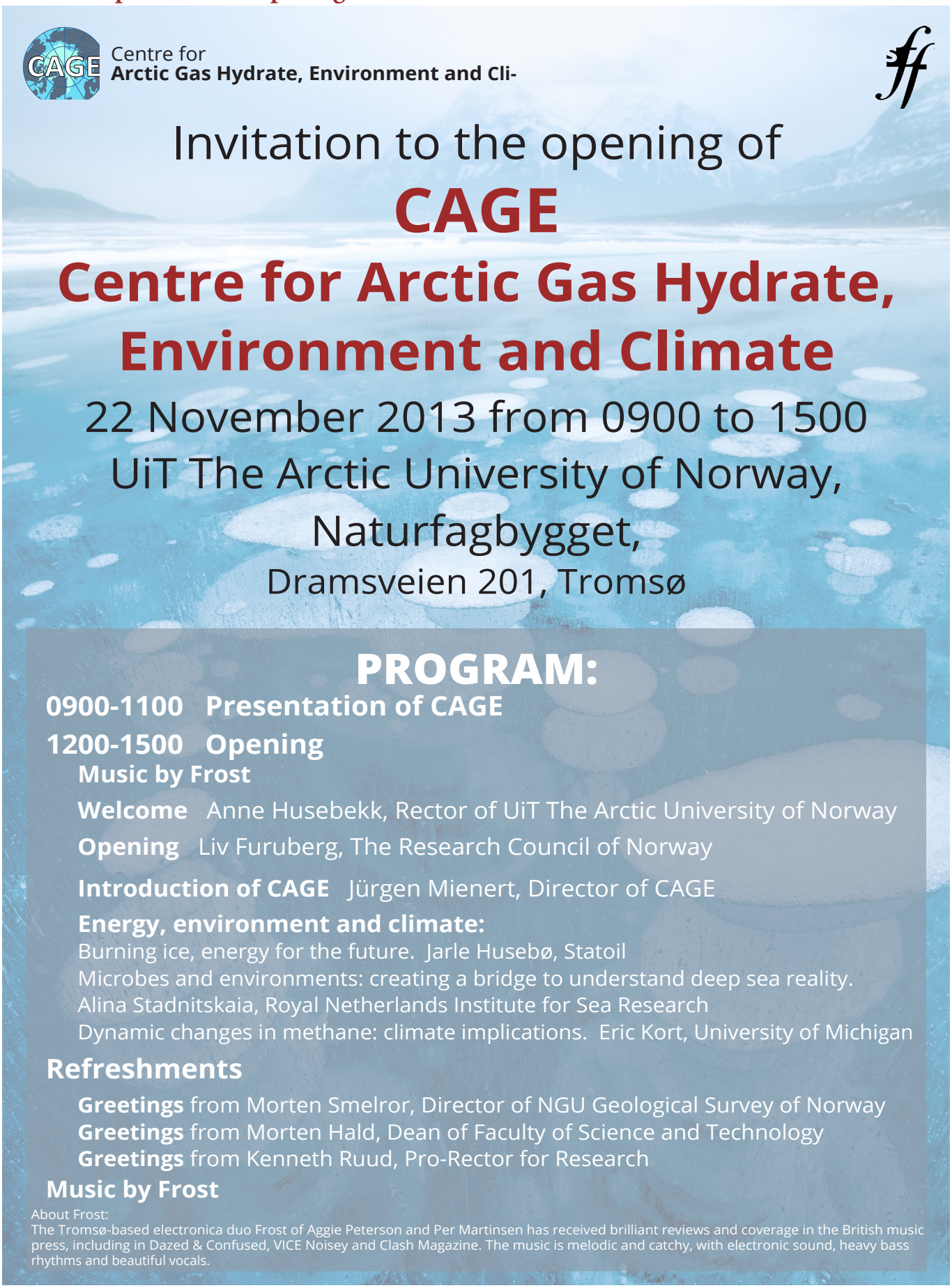
CAGE/ Geologi

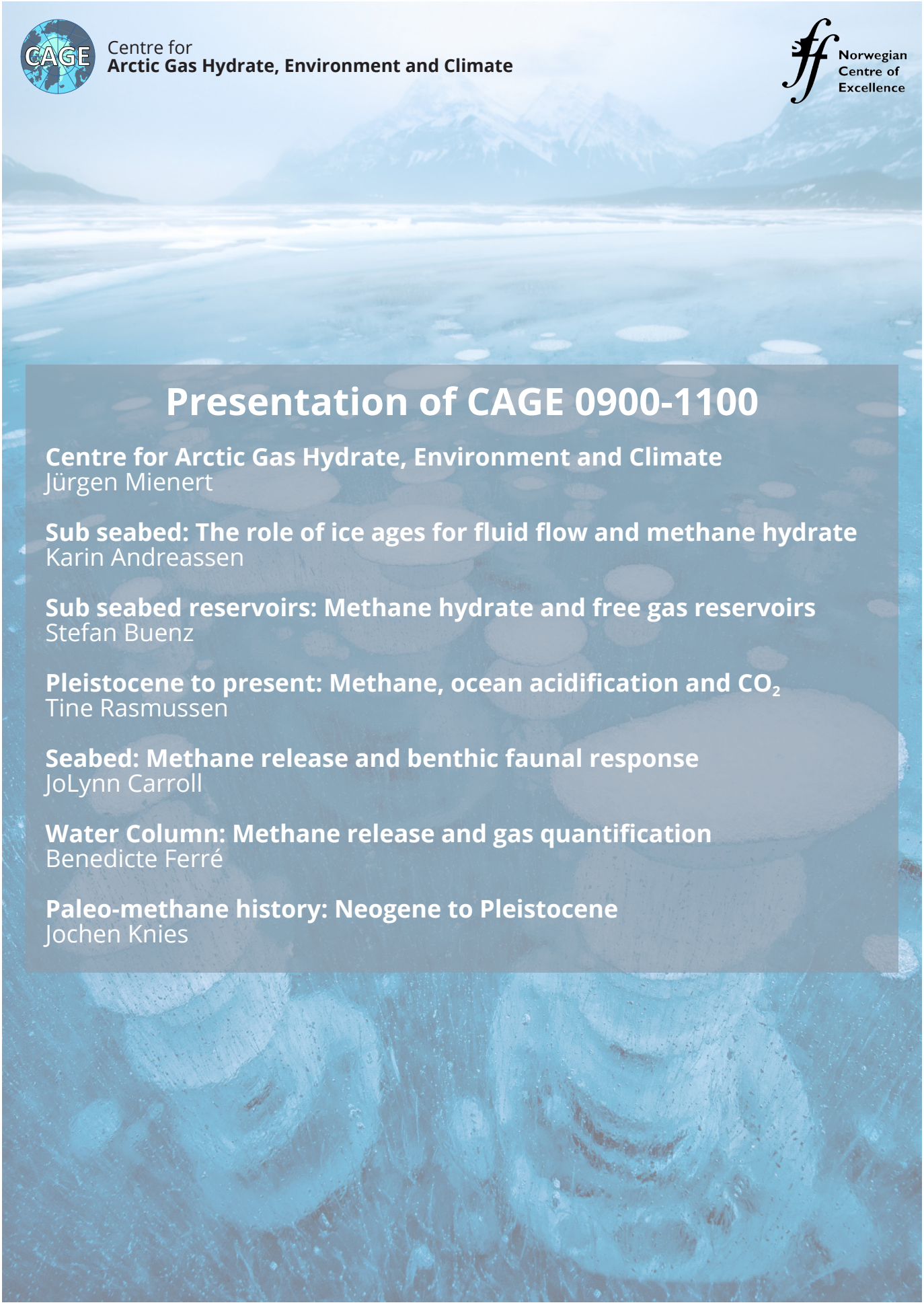
NN

CAGE/USGS

OUTREACH

Invitation poster to the opening of CAGE




CAGE
Centre for
Arctic Gas Hydrate, Environment and Climate
Norwegian
Centre of
Excellence
Presentation of CAGE 0900-1100
Centre for Arctic Gas Hydrate, Environment and Climate
Jürgen Mienert
Sub seabed: The role of ice ages for fluid flow and methane hydrate
Karin Andreassen
Sub seabed reservoirs: Methane hydrate and free gas reservoirs
Stefan Buenz
Pleistocene to present: Methane, ocean acidification and CO_2
Tine Rasmussen
Seabed: Methane release and benthic faunal response
JoLynn Carroll
Water Column: Methane release and gas quantification
Benedicte Ferré
Paleo-methane history: Neogene to Pleistocene
Jochen Knies

Tables

Table 1: Seven team leaders

Name	Institute	Research theme
Stefan Buenz	University of Tromsø	SUB SEABED RESERVOIRS Methane hydrate and free gas reservoirs
Karin Andreassen	University of Tromsø	SUB SEABED The role of ice ages for fluid flow and methane hydrate
JoLynn Carroll	University of Tromsø/Akvaplan Niva	SEABED Methane release and benthic faunal response
Bénédicte Ferré	University of Tromsø	WATER COLUMN Methane release and gas quantification
Jochen Knies	Geological Survey of Norway (NGU)	PALEO-METHANE HISTORY Neogene to Pleistocene
Tine Rasmussen	University of Tromsø	PLEISTOCENE TO PRESENT Methane, ocean acidification and CO_2
Cathrine Lund Myhre	Norwegian Institute of Air Research (NILU)	ATMOSPHERE Methane emissions from the Arctic Ocean

Table 2-1: Researchers and postdocs

Name	Expertise	Employment	Institute	Research theme
Andreia-Plaza Faverola	Marine geophysics	Researcher	University of Tromsø	Gas seepage and gas hydrate reservoirs
Giuliana Panieri	Micro-paleontology	Associate professor	University of Tromsø	Micro-paleontology and geo-chemistry of past methane emissions
Shyam Chand	Gas hydrates	Senior researcher	Geological Survey of Norway (NGU)	Gas seepage and fluid migration pathways, gas hydrate system development
Michael Carroll	Benthic ecology and biological oceanography	Senior researcher	Akvaplan Niva	Arctic marine ecosystems and climate change
Terje Thorsnes	Marine geology, with emphasis on seabed sediments and morphology	Senior researcher	Geological Survey of Norway (NGU)	Seabed sediments and morphology, links between geology and biology within an ecosystem framework, fluid flow and water column acoustics, and application of Synthetic Aperture Sonar fitted on AUV for detailed seabed investigations

Table 2-1: Researchers and postdocs (cont.)

Name	Expertise	Employment	Institute	Research theme
Aivo Lepland	Sedimentology, petrography, diagenesis and geochemistry of marine sediments	Researcher	Geological Survey of Norway (NGU)	Modern methane derived carbonate crusts and phosphorite formation in seep/vents during oxygenation of the Earth two billion years ago
Karl Fabian	Marine geophysics and rock/ environmental magnetism	Researcher	Geological Survey of Norway (NGU)	Multi-parameter rock and paleomagnetic interpretations of iron sulfide and oxide minerals.
Soma Barnawall	Quaternary sediments in the Arctic Ocean	Postdoctor	University of Tromsø	Deciphering methane paleorecords in the Arctic
Anna Silyakova	Physical Oceanography	Postdoctor	University of Tromsø	Water column studies of methane release
Antoine Cremiere	Authigenic carbonates	Postdoctor	Geological Survey of Norway (NGU)	Authigenic carbonate crust, dating and geochemistry
Katarzyna Zamelczyk	Paleoceanography	Postdoctor	University of Tromsø	Abrupt climate change, ocean chemistry changes, and effects of ocean acidification on marine calcifiers.

Table 2-2: PhD students

Name	Expertise	Employment	Institute	Research theme
Sandra Hurter	Marine geophysics	PhD	University of Tromsø	4D seismics
Sunil Vadakkepulyiambatta	Marine geophysics and gas hydrate systems	PhD	University of Tromsø	Fluid migration pathways and their development, gas hydrate stability modeling, heat flow modeling, and gas hydrate system development.
Alexey Portov	Marine geophysics	PhD	University of Tromsø	Offshore permafrost decay and methane release
Mariana da Silveira Ramos Esteves Esteves	Geology	PhD	University of Tromsø	Ice sheet dynamics
Mohamed Ezat	Palaeo oceanography	PhD	University of Tromsø	Ocean circulation, productivity and carbon cycle in the northern North Atlantic during the last 150,000 years.

Table 2-2: PhD students (forts.)

Name	Expertise	Employment	Institute	Research theme
Kamila Sztybor	Methane release, past and present	PhD	University of Tromsø	Distribution of live and fossil foraminifera and their geochemistry to reconstruct past and present of methane
Giacomo Osti	Gas hydrates and morphology of slide areas	PhD	University of Tromsø	Slope stability and gas hydrates along Svalbard margins

Table 2-3: Master students

Name	Expertise	Employment	Institute	Research theme
Jessica Arvo	Marine Geophysics		Department of Geology	
Adrian Lium-Wickler	Marine Geophysics		Department of Geology	
Karoline Jørgensen	Marin Geophysics		Department of Geology	
Robert Virs	Marine Geophysics		Department of Geology	
Glennda Körner	Marine Geophysics		Department of Geology	
Espen Valberg	Marine Geophysics		Department of Geology	
Cecilie Aas	Marine Geophysics		Department of Geology	
Kristian Kjerkreid	Marine Geophysics		Department of Geology	

Table 3: Technical support staff

Name	Expertise	Research theme
Anoop Nair	Engineer	Marine Geophysics
Edel Ellingsen	Engineer	Isotope Laboratory

Table 4: Appointments for Prof. II and Associate prof.

Name	Expertise	Institute	Prof.II/ Assoc. Prof.	Country
Guiliana Panieri	Micropaleontology	UiT	Assoc. Prof	Italy

Table 5: Visiting scientists

Name	Expertise	Institute	Country
Joel Johnson	Marine geology and geophysics, in particular marine gas hydrate systems on passive and active margins	University of New Hampshire	USA
Pavel Serov	Marine Geochemistry in offshore permafrost	Faculty of Geology at Saint-Petersburg State University	Russia
Will Ambrose	Benthic ecosystems sclerochronology	Bates College, Maine	USA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NGU
Norges geologiske undersøkelse
Geological Survey of Norway
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