



CAGE - Centre for Arctic Gas Hydrate Environment and Climate Report Series, Volume 3 (2015)

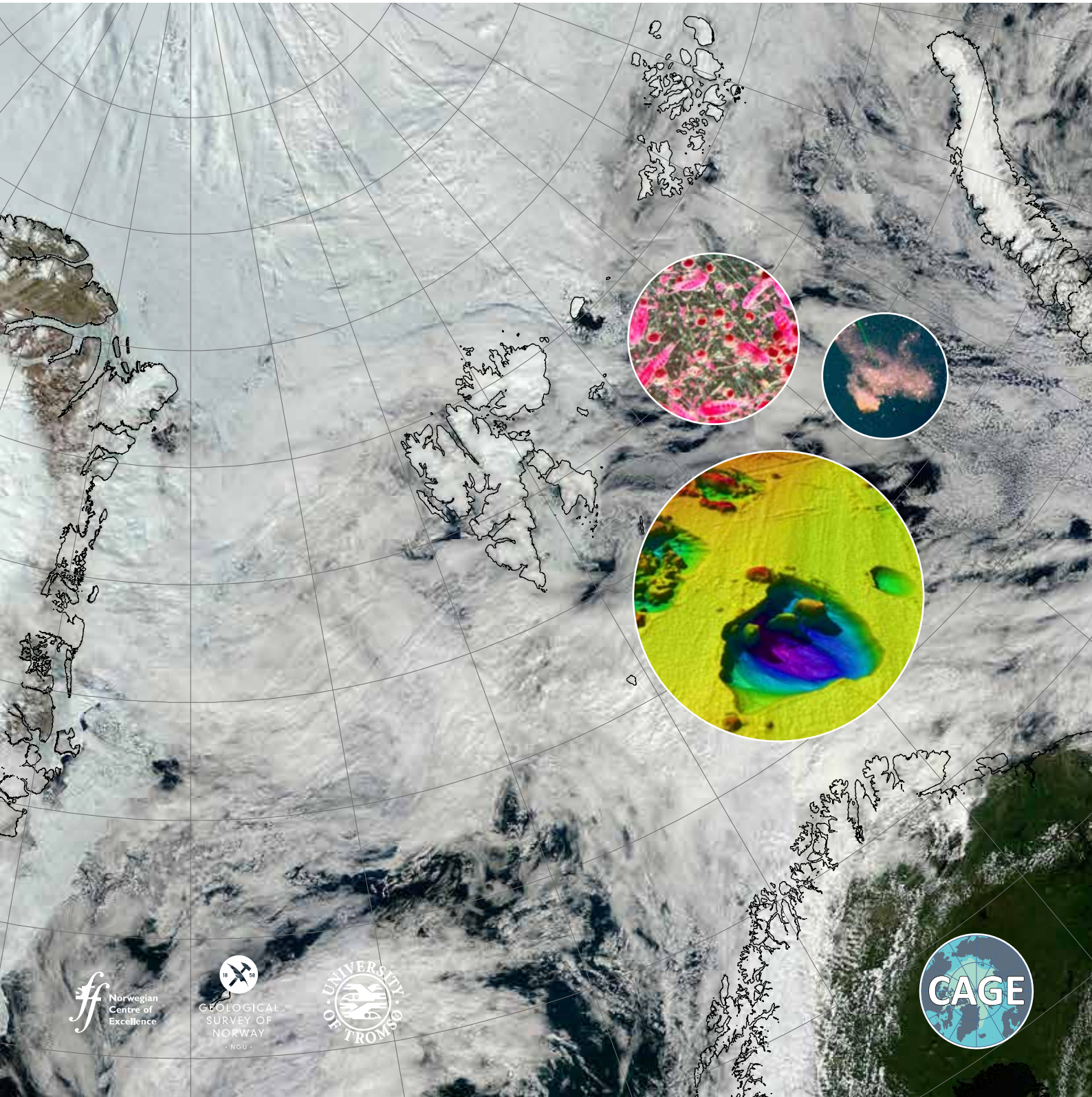
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Professor Jürgen Mienert. Photo: Torger Grytå

A word from the director

Large amounts of the greenhouse gas methane are stored beneath the ocean floor in a stable form called hydrate. Hydrates occur naturally under high pressure and low temperatures. Water molecules freeze and encage methane with ice thus stabilizing it into solid form. The Arctic contains large reservoirs of these hydrates, and they can melt in increasing tempo due to global warming. This could cause more methane to be released from the ocean floor. Methane is much stronger greenhouse gas than CO₂.

Great uncertainty about the quantity

The main objective of CAGE is to quantify the amounts of gas hydrates under the seafloor in the Arctic, both in the past and in the present. Methods for predicting gas hydrate stability in the Arctic show large uncertainties. There are wide variations in the estimates for the total amount of carbon stored in hydrates. The most cited global estimate is 10 000 gigatonnes of methane. But a more recent estimate suggests 74 000 gigatonnes. This shows that there is a need for more precise calculations that give our Arctic research economic, social, and environmental impact.

Energy Assessment – a side effect

Our research will contribute to better understanding of how methane may affect the marine environment and climate systems in the future. We also study how methane emissions affect living organisms that thrive in methane-rich environments, and how microorganisms in turn affect, and potentially regulate, gas emissions from the seabed to the ocean surface. With an ever-decreasing Arctic sea ice and increasing ocean warming these organisms can spread over vast areas.

As part of our work we are quantifying reservoirs of hydrates that represent a potential unconventional energy source, since they store huge quantities of natural gas. Thus, there is a side effect to our work: In the long term we could provide important, basic knowledge of natural gas resources that can be the future of energy.

Expeditions in the Arctic Ocean

CAGE has completed 15 expeditions to the Arctic Ocean since 2014. This gives us access to data about reservoirs dynamics, methane emissions and ice extent over a large area: From Kara Sea in Russia, via the Barents Sea to the Arctic Ocean north of Svalbard, the Fram Strait, and Greenland.

In 2015 we have deployed two pioneering methane observatories on the seabed offshore Svalbard. They were developed for our purposes by Kongsberg Maritime, and will give us long-term, continuous measurements of ocean chemistry. We also cooperated with the Woods Hole Oceanographic Institution (USA), taking over 30,000 photographs of the seabed during an expedition on our RV Helmer Hanssen.

CAGE also participated in the N - ICE2015 expedition led by Norwegian Polar Institute. We measured the methane above, in and below the young sea ice. The expedition saw RV Lance frozen inside an ice floe in the middle of the arctic winter.

Interdisciplinary work pays off

Several papers were published in 2015 showcasing values of unique interdisciplinary work. One example is a study published in Nature Communications. It shows that hydrates were held stable within permafrost during the last glaciation when the large ice sheet was covering what we today know as the Barents Sea. When the ice retreated, permafrost and methane hydrates started to melt during sea level rise, something that led to thousands of years of methane emissions.

We use empirical data collected on our cruises along with computer models, which we develop for the specific purpose of understanding the dynamic behaviour of the Barents Sea ice sheet. It enables us to understand the past, so that we too can understand what is happening under the ice sheet in West Antarctica and Greenland today.

CAGE is getting considerable attention

We have already published results of our work in over 100 scientific papers in some of the world's most reputable scientific journals. Several of our studies have received considerable attention, and our researchers have given hundreds of talks and presented posters worldwide. Over 140 different media reports have covered our research through various channels, from The Washington Post to NRK. We believe that our research is important for a global community that is facing climate change. Our many PhD candidates are therefore offered courses in transferable skills through our graduate school, AMGG, which is part of the National Research School, CHESS.

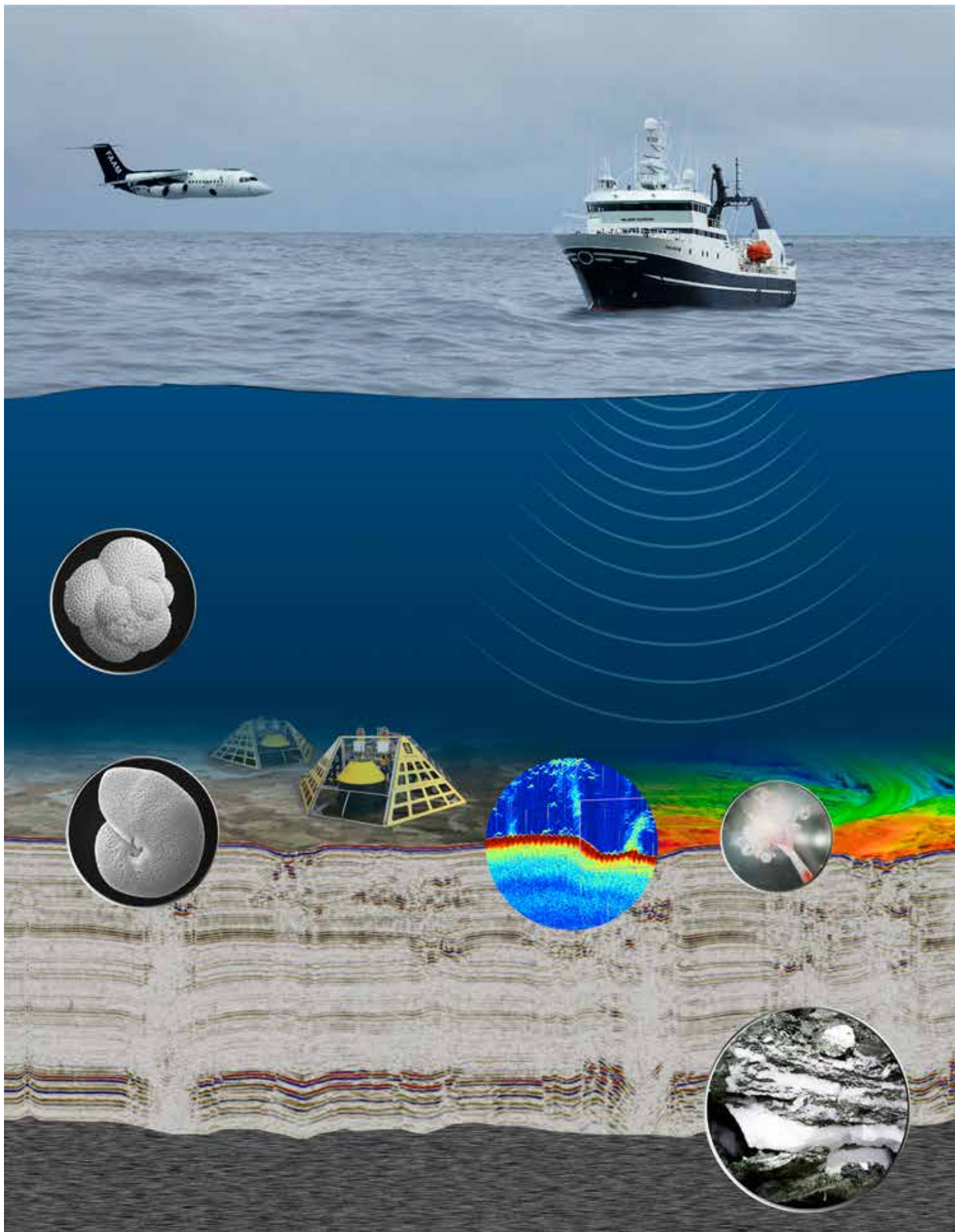
Through collaboration between the research school and CAGE's communications advisor, we have offered candidates workshops in presentation skills; writing for public; and entrepreneurship, design, and communication. ■



Professor Jürgen Mienert, Centre Director

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Steering Committee



Kenneth Ruud
Prof., Pro-Rector for Research
and Development, UiT



Morten Hald
Prof., Dean NT-faculty, UiT



Nalan Koc
PhD, Research Director,
Norwegian Polar Institute



Morten Smelror
PhD, Adm. Director,
Norwegian Geological Survey



Ingrid Schjølberg
Prof., Director, Ocean
Science Technology
NTNU

New member of the steering committee

Professor Ingrid Schjølberg, the director of NTNU Ocean science and technology in Trondheim Norway, has accepted the position as a permanent member of the steering committee for CAGE.

Text: Maja Sojtaric

The steering committee is responsible for overseeing the strategy for research, training, economy and patent developments at the center of excellence. The committee also oversees operational aspects including the relationships to the University, institutes and industry. Director of CAGE, Professor Jürgen Mienert, reports to the steering committee.

The members of the steering committee for CAGE are Prof. Kenneth Ruud (Chairman, Pro Rector for Research and

development, UiT The Arctic University of Norway); Prof. Morten Hald (Dean. Science and technology faculty, UiT); Dr. Morten Smelror (Director, Norwegian geological survey, NGU, Trondheim); and Dr. Nalan Koc (Research Director, Norwegian Polar Institute). The new member Ingrid Schjølberg is a professor in marine technology, and leads NTNU Oceans which is one of four strategic research areas for NTNU. ■

Scientific Advisory Board



Prof. Antje Boetius



Prof. Georgy Cherkashov



Dr. Carolyn Ruppel



Dr. Scott Dallimore



Prof. Gerald Haug

CAGE has an international scientific advisory board that gives advice on strategic scientific issues and consists of distinguished experts in their fields: 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, CHE; Max Planck Institute, FRG). ■

Sub Seabed Reservoirs

Methane hydrate and free gas reservoirs



Stefan Bünz, *Team Leader*

Stefan has ten years of broad research experience in marine geology and geophysics. A great part of his research is aimed to better understand gas hydrate systems, their distribution and their origin. Stefan holds a PhD degree in marine geology and geophysics from UiT The Arctic University of Norway. He has been an associate professor at the Department of Geology at UiT since 2007.



Peter Franek
Postdoctoral researcher



Alexey Portnov
Postdoctoral researcher



Sunil Vadakkepuliambatta
Postdoctoral researcher



Shyam Chand
Researcher



Andrea Plaza Faverola
Researcher



Sandra Hurter
PhD candidate



Giacomo Osti
PhD candidate



Sunny Singhroha
PhD candidate



Alexandros Tasianias
PhD candidate



Malin Waage
PhD candidate



Kate Waghorn
PhD candidate

Main questions:

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?

At what rates, by which means and under which circumstances is methane expelled from sub-seabed reservoirs?



Aims

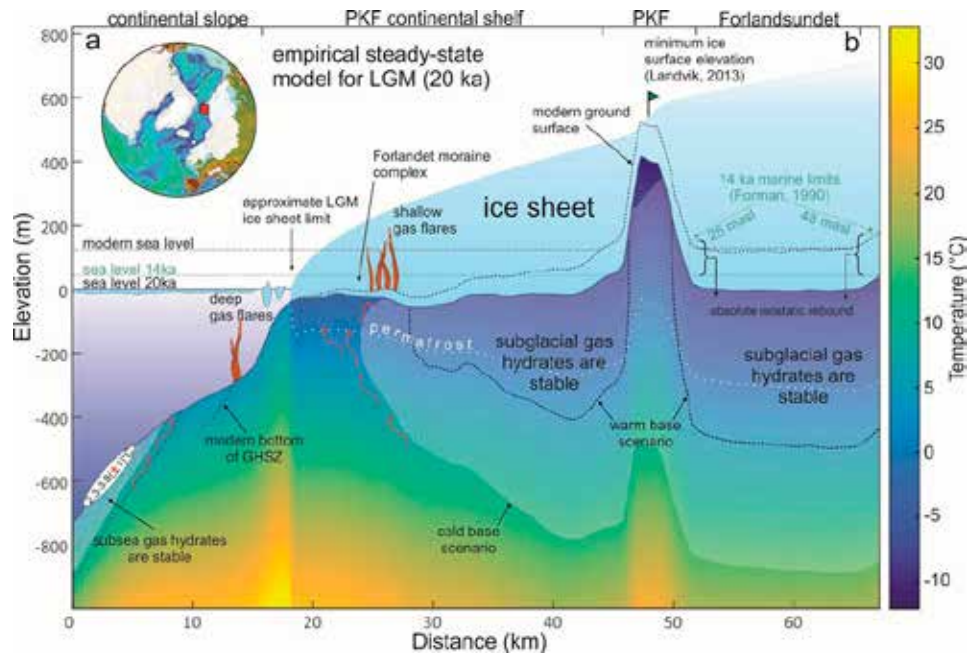
Develop technologies for direct or improved detection of gas hydrates in marine sediments

Better understand gas hydrate dynamics and accumulations through high-resolution 3D seismic imaging, sediment sampling, heat flow probing and modelling.

Develop high-resolution 4D time-lapse seismic studies in order to better understand and quantify the flow of fluids through focused fluid flow systems.

Develop basin-scale models for the evaluation and quantification of gas hydrates and shallow gas systems.

Model gas hydrate systems in response to former and future climate changes.



Ice sheets can create, contain and maintain large amounts of gas hydrates, a frozen form of concentrated climate gas methane. The conservative estimate is that Barents Sea Ice sheet contained a 500-meter thick reservoir of gas hydrates. Illustration: A. Portnov.

Highlights

1. Gas-hydrate stability and glacio-mechanical modeling showed that large amounts of hydrocarbons might have been trapped beneath an ice-sheet on the western Svalbard margin. It also showed that the ice sheet provided a window for methane release that opened up further with the retreat of the ice sheet.
2. We have developed a potential technique to detect and directly map the distribution of gas hydrates in marine sediments, by estimating the seismic attenuation (Quality factor Q) in gas hydrate and free-gas-bearing sediments from high-resolution P-cable 3D seismic data.
3. On the Vestnesa Ridge on the West Svalbard margin, seepage distribution, periodicity and duration has been influenced by surrounding tectonic stress fields and tectonic development and hence, has likely been ongoing since at least 2,7 million years.
4. Prediction of the bottom simulating reflector (BSR) depth for theoretical pressure and temperature conditions constrained by measured seabed gas compositions resulted in a systematic underestimation of the observed BSR depth, implying a significant underestimation of the GHSZ thickness due to unaccounted amounts of thermogenic gas contributing to deeper gas hydrate reservoirs.
5. For the first time an array of five long-term ocean-bottom seismometers was deployed around an actively seeping vent in deep water on the Vestnesa Ridge. The aim was to record and localize subsurface migration dynamics of fluids.
6. Alexey Portnov successfully defended his PhD-thesis on September 2015: *Role of subsea permafrost and gas hydrate in postglacial Arctic methane releases*.

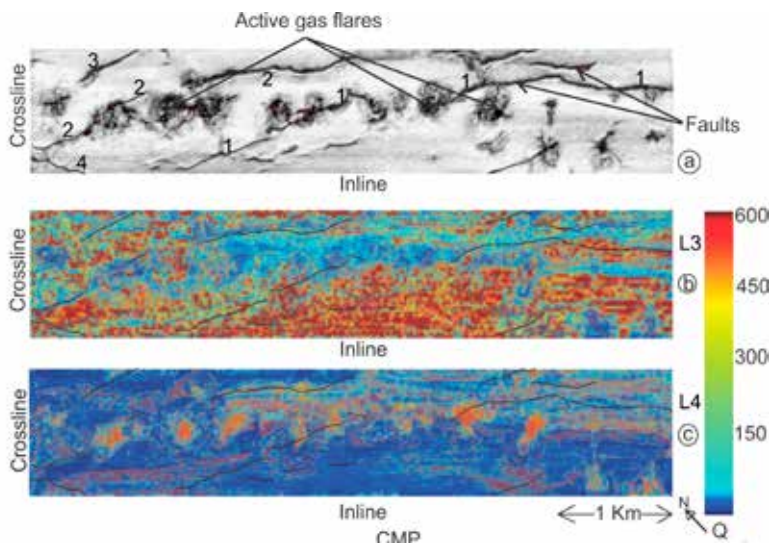
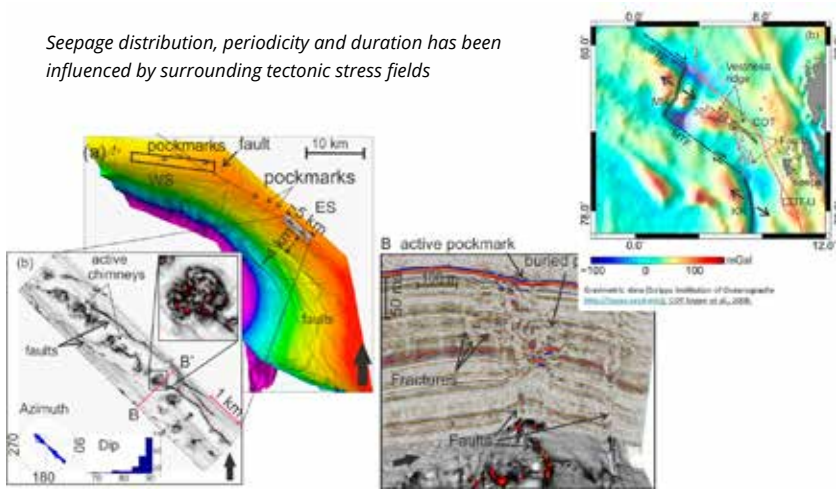
Funded projects

EU H2020: Strategies for Environmental Monitoring of Marine Carbon Capture and Storage (STEMM-CCS), funded 1 PhD student, <http://www.stemm-ccs.eu/>; (2016–2019).

DNVA VISTA: Time-lapse seismic studies to understand the dynamics of gas hydrate provinces of a polar margin – North West Svalbard and the Barents Sea, funded the PhD candidate Malin Waage.

EU – COST MIGRATE, networking action, Stefan Buenz Vice-Chair. http://www.cost.eu/COST_Actions/essem/ES1405/; (2014–2017). ■

Seepage distribution, periodicity and duration has been influenced by surrounding tectonic stress fields



Q-analysis detects areas with high Q above BSR probably associated with the presence of hydrates. Below the BSR, areas with low Q correspond to high gas saturations. Changes in the attenuation anomalies correlate with small-scale faults systems in the Vestnesa Ridge suggesting a strong structural control on the distribution of free gas and gas hydrates in the region. Illustrations: (Top) A. Plaza Faverola; (bottom) S. Singhroha.

Strategy

- Start comprehensive modeling from basin scale petroleum system models for gas hydrates to gas hydrate dynamics, and physical models of fluid flow through focused fluid flow systems.
- Built a heat flow probe for heat flow measurements in sediments.
- Recover and investigate first multi-, long-term microseismic record from an active chimney.
- Rock-physics modeling for quantification of gas hydrates in the Vestnesa Ridge.
- Contribute unique 4D time-lapse seismic studies of active fluid leakage systems on the West-Svalbard margin to the Horizon 2020 project STEMM CCS, which focuses on carbon capture and storage under the ocean floor. ■

Are gas hydrates an environmentally friendly energy source?

That is one of the questions that COST Action MIGRATE is trying to answer. Stefan Bünz was recently elected as Vice Chair of the action, supported by EUs framework program.

By: Maja Sojtaric

In Europe, as elsewhere, demand for natural gas is continuously increasing. Gas hydrate accumulations in continental shelf sediments are considered a promising resource for future gas supply by several non-European countries, such as USA, Japan, China, India, South Korea, and Taiwan. In 2013, the Research Consortium for Methane Hydrate Resources in Japan produced gas during a successful offshore field test.

Recently a *European Concerted Research Action (COST)*¹ designated to marine gas hydrates was established. Stefan Bünz, associate professor at CAGE, was elected the Vice Chair of the action.

The team *Marine gas hydrate – an indigenous resource of natural gas for Europe (MIGRATE)*² will examine the potential of gas hydrates as an economically feasible and environmentally sound energy resource. In particular, MIGRATE aims to determine the European potential inventory of exploitable gas hydrates, to assess current technologies for their production, and to evaluate the associated risks.

CAGE will particularly contribute with a large seismic database from the Svalbard margins. ■

1 <http://www.cost.eu/>
 2 http://www.cost.eu/COST_Actions/essem/Actions/ES1405



The underwater pingos were discovered in the South Kara Sea off the coast of the Yamal Peninsula in Siberia, where several large craters have been discovered in recent years, thought to be the remains of pingos that have exploded due to the build up of gas beneath the ground- Illustration: P. Serov/CAGE

Methane feeds subsea ice mounds offshore Siberia

Huge mounds, pingos, are discovered on the seabed offshore Siberia. They are forming because of the thawing of subsea permafrost and high accumulation of methane.

Text: Maja Sojtaric

Pingos are spectacular landforms associated with permafrost in the Arctic. They are circular or elliptical formations protruding from the level ground of the tundra, and can be up to 60 meters high. In essence, they are huge lumps of ice

covered with soil. Similar structures are now found strewn on the ocean floor in the Arctic shallow seas.

A recent study by Pavel Serov, PhD candidate at CAGE, describes for the first time pingo like features offshore Siberia. The study suggests that they are forming because of

the thawing of the subsea permafrost, and was published in *Journal of Geophysical Research*.

“Pingos are intensively discussed in the scientific community especially in the context of global climate warming scenarios. They may be the step before the methane blows out.” says Serov.

In the area of Yamal peninsula craters

Pingos came to public attention because of the story of the mysterious craters that suddenly appeared in Yamal Peninsula, Siberia. There is a theory that the craters *may have been pingos*¹. Beneath them the methane gas accumulated. The pressure built up under the ice lump due to the thawing of the permafrost and reactivated production of methane in the soil. The whole feature then blew up in one event releasing unknown amounts of gas. Serov and colleagues focused on two subsea pingos that were identified offshore, the very same area of the mysterious Yamal peninsula craters. The study shows how important methane accumulation is for the formation of subsea pingos. The study area lies in the shallow South Kara Sea, at approximately 40-meter water depth. Serov and colleagues, present in their paper a range of scenarios for the formation of the mounds, leading to potential blowouts of methane.

“Our question was: Are these mounds submerged terrestrial pingos? Or are they something different forming under marine conditions? One of the South Kara Sea pingos was leaking a lot of methane but where was the methane coming from?”

Thawing of permafrost and pressure from methane

The CAGE study shows these newly discovered subsea pingos may be quite recent. This may support a hypothesis that states that mechanisms forming pingos on land and mechanisms forming mounds on the ocean floor are completely different.

“The subsea-pingo like formations are significantly larger than the ones on land. Gas leakage from one of the ocean floor pingos offshore Siberia shows a specific chemical sig-

nature that indicates modern generation of methane. We therefore suggest that the mound formed more recently, moving material physically upwards.”

Dissociation of methane ice

On land pingos are mainly formed when the water freezes into an ice core under soil, because of the chilling temperatures of permafrost (at or below freezing point of water 0° C). However, subsea pingos, may be formed because of the thawing of relict subsea permafrost and dissociation of methane rich gas hydrates.

Gas hydrates form and remain stable under a combination of low temperature and high pressure. In permafrost the temperatures are very low and gas hydrates are stable even under the low pressure, such as on shallow Arctic seas. Thawing of permafrost leads to temperature increases, which in turn leads to melting of gas hydrates, therefore, releasing the formerly trapped gas.

“The methane creates the necessary force that pushes the remaining frozen sediment layers upward, forming mounds.” says Serov.

Quiet explosions beneath the Arctic shallow seas

Subsea pingos can potentially blow out, without massive attention, as was the case with the highly visible Yamal craters, but with massive expulsions of methane into the ocean. However, most massive expulsions of methane from subsea pingos go undetected. For petroleum companies these areas may pose a geohazard. Drilling a hole into one of these subsea pingos, can be not only expensive but also catastrophic. During a geotechnical drilling in the close by Pechora Sea, an industry vessel unknowingly drilled a hole into one of these mounds. It triggered a massive release of gas that almost sunk the vessel.

“We don’t know if the methane expelled from the subsea pingos reaches the atmosphere, but it is crucial that we observe and understand these processes better, especially in shallow areas, where the distance between the ocean floor and the atmosphere is short.” says Serov. ■

¹ <http://earthsky.org/earth/new-explanation-for-siberias-mystery-craters>

Sub-seabed

The role of ice ages for fluid flow and methane hydrate



Karin Andreassen, *Team Leader*

Karin Andreassen is a professor in marine geology and geophysics at UiT The Arctic University of Norway. She holds a PhD degree in applied geophysics from UiT. Her main research areas are the Cenozoic developments of the Barents Sea. She focuses on glacial geomorphology, sediments and processes, shallow gas and fluid flow. Andreassen has also been a visiting professor at the University of Cambridge, the University of Montpellier, and the University of Barcelona



Alun Hubbard
Professor



Leonid Polyak
Adjunct professor



Eythor Gudlaugsson
Postdoctoral researcher



Henry Patton
Postdoctoral researcher



Monica Winsborrow
Researcher



**Nikolitsa
Alexandropoulou**
PhD candidate



Emilia Daria Piasecka
PhD candidate



Calvin Shackleton
PhD candidate

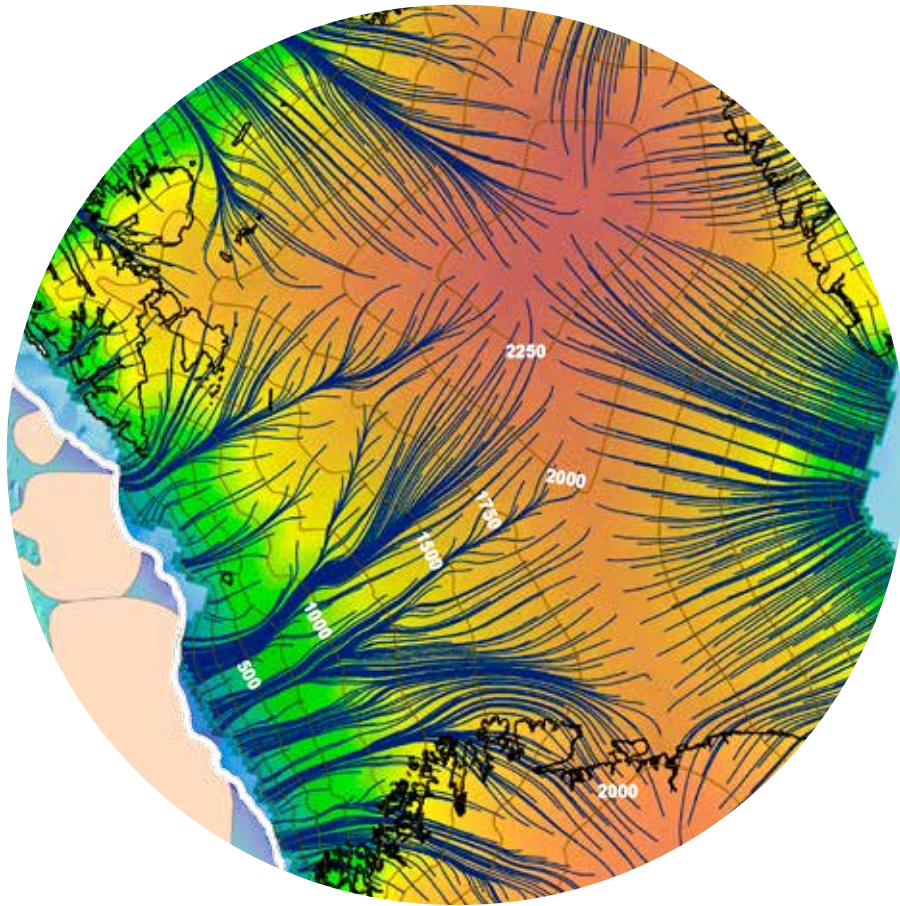


**Mariana da Silveira
Ramos Esteves**
PhD candidate

Main questions:

How do ice sheets affect fluid flow and and gas hydrate systems?

How did gas hydrate stability fields change through the ice ages?

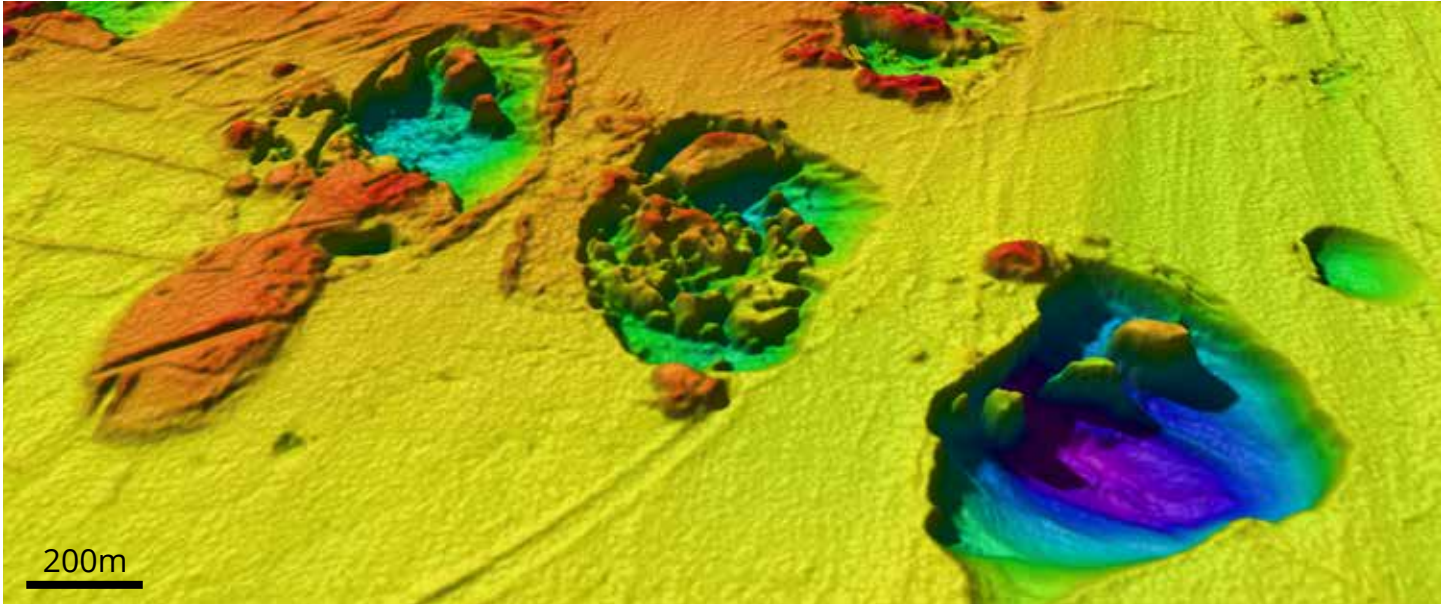


Aims

Investigate the interplay between repeated ice-sheet glaciation and the underlying gas hydrate and hydrocarbon systems.

Reconstruct the drivers and dynamics of past ice sheet behaviour.

Provide litho-, chrono- and environmental frameworks for key CAGE study areas.



Giant craters and mounds carved into bedrock of Bjørnøynna, Barents Sea. These features are the result of large methane emissions from the seafloor that followed ice-sheet retreat at the end of the last glaciation. Continued methane release at this site is under observation. Illustration: Karin Andreassen.

Highlights

Geophysical constraints on the dynamics and retreat of the Barents Sea ice sheet as a paleobenchmark for models of marine ice sheet deglaciation; Patton et al. (2015), *Reviews of Geophysics*

A new theory has been proposed of how subglacial gas hydrate regulates ice stream flows, Winsborrow et al. (in press) *Nature Geoscience*

A collaborative cruise collected unique 3D seismic and detailed seafloor images of a dynamic crater-pingo system, combined with targeted sampling of the seafloor, water column and atmosphere.

A new model allowed to gain insights into gas hydrate dynamics during deglaciation at the W-Svalbard margin, Portnov et al. (2016) *Nature Communications*

Eythor Gudlaugsson successfully defended his PhD thesis on october 2015: *Modelling the subglacial hydrology of the former Barents Sea Ice Sheet*.

Expansion of the ice sheet modelling team with Prof. Alun Hubbard (50%) and postdoctoral researcher Henry Patton.

Funded projects:

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

Curie Training Network. <http://www.glanam.org/>; 1 PhD Emilia Piasecka.

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

Seismic stratigraphy of glacial sediments of the Barents Sea – Svalbard continental margins. 2014-2018. National Research School in Climate Dynamics (ResClim)/ UiT. <http://www.resclim.no/>; 1 PhD Nikolitsa Alexandropoulou.

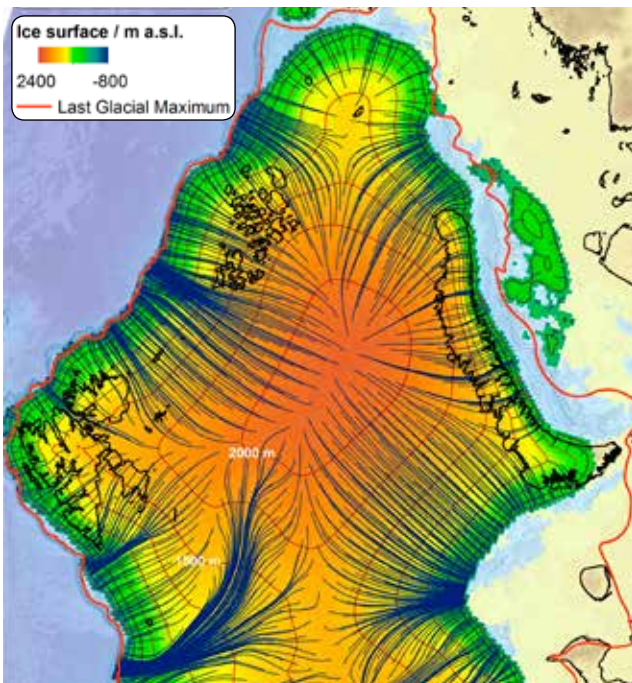
Collapse of a Marine Ice Sheet. 2013–2017. PI. ResClim/UiT. <http://www.resclim.no/>; 1 PhD Mariana da Silveira Ramos Esteves.

Modelling the subglacial hydrology of the former Barents Sea Ice Sheet. 2011–2015. PI. ResClim / UiT. <http://www.resclim.no/>; 1 PhD Eythor Gudlaugsson.

Modelling the subglacial hydrology of the former Barents Sea Ice Sheet. 2011–2015. PI. ResClim / UiT. PhD Eythor Gudlaugsson. ■



The heavily pockmarked seafloor at the bed of the former Håkjerringdjupet ice stream, SW Barents Sea, resulting from the migration of hydrocarbons from an underlying reservoir. Using a combination of numerical modelling and geophysical data, we are investigating how subglacial gas-hydrate formation can affect the flow of overlying ice. Illustration: Monica Winsborrow



Numerical simulations provide important insights into the thickness, flow-partitioning, and subglacial conditions of the former Barents Sea ice sheet – important boundary conditions for calculating the evolution of gas hydrate stability through glacial cycles. At the Last Glacial Maximum, asymmetric growth patterns led to eastern sectors becoming glaciated significantly later than along the western shelf break. Furthermore, depression of the crust by the ice sheet caused much of the Kara Sea to become sub-aerially exposed. Illustration: Henry Patton

Strategy

- Reconstruct the evolution of the Eurasian Ice Sheet system dynamics through the full Weichselian glacial cycles (120 – 8 ka BP).
- Quantify effects of glaciation on landscape evolution, hydrate stability and permafrost through the Quaternary.
- Model fluid flow and gas hydrate system dynamics during deglaciation of Bjørnøy- and Storfjordrenna together with WP1.
- Accomplish a 2016 collaborative cruise deploying ROV/AUV for high resolution seafloor mapping and sampling Bjørnøyrenna and Storfjordrenna regions. ■



Patton wins best poster award

Dr. Henry Patton, researcher at CAGE, won an award for best poster at PAST Gateways conference at Alfred Wegener Institute, Germany, in June 2015. Poster showed how modelling is used to reconstruct the last ice sheet to cover the Barents Sea.

Text and photo: Maja Sojtaric

The ice sheet that Patton and his colleagues at CAGE are reconstructing was a massive complex, stretching from Northern Norway to Siberia. At its maximum it was around 3 kilometres thick.

“My primary research is reconstructing the ice sheet using numerical modelling. I am trying to work out how ice grew and evolved during the last ice age. Ultimately we wish to look into how the ice cover disappeared, and what drove its deterioration.” says Patton.

His poster at PAST Gateways conference focused on the first part of this research: the reconstruction.

“These are the preliminary results showing output of the model, visualizing velocity of the ice sheet. Here I include

several important boundary conditions that drive the growth and collapse of the former ice sheet. One of them is thermohaline ocean circulation.”

Next step in Pattons work is to develop models for deglaciation. It is complex modelling that must include effective ocean warming and shifting climate patterns. If properly constrained the model can help scientists understand marine based ice sheet collapse how it impacted gas hydrates buried in the seabed.

“The way the Barents Sea ice sheet collapsed is thought to be similar to what could happen to the ice sheet in West Antarctica. Implications of getting decent reconstruction of Barents Sea ice sheet are therefore very important for our understanding of future climate change, as it is the only paleo-analogue we have for West Antarctica.” ■



Eythor Gudlaugsson defends PhD in glaciology

Dr. Gudlaugsson defended in December 2015 his thesis “Modelling subglacial hydrology of the former Barents Sea Ice Sheet”. This marks the first PhD in glaciology defended at UiT The Arctic University of Norway.

Text and photo: Maja Sojtaric

The study of the past dynamics of ice sheets, the mechanisms of their movement and melting, is of crucial importance for understanding future impacts of climate warming on our planet.

Due to human activity the global temperatures have increased fast since the industrial revolution. This is causing the melt of the ice sheets and rise of the sea level. Large ice sheets on Greenland and in Antarctica can have strong influence on our oceans and on the climate.

Predicting how quickly they will melt, what is of influence on their movements, and how important the discharge from melting can be is not an easy task.

Many of the secrets are hidden beneath the impenetrable masses of ice. Modern day data on what is happening beneath the ice sheets is difficult to come by. There is however a historical analogue to present day ice sheets: Barents Sea ice sheet that covered large areas of Eurasian Arctic some 20 000 years ago.

This ice sheet melted long time ago, but left behind geological evidence of sub glacial processes that now can be put in numerical models, to test hypotheses of how they may work in modern environment.

In his thesis Eythor Gudlaugsson aimed to investigate these sub-glacial processes of the past Barents Sea ice sheet and to estimate their importance. ■

Modern Seabed Group

Methane release and benthic faunal response



JoLynn Carroll, *Team Leader*

JoLynn Carroll is a marine geochemist who studies marine geochemistry, benthic biology, and environmental pollution. She is an adjunct professor at the Department of Geology, UiT The Arctic University of Norway, and assistant director at Akvaplan-niva, a research-based company providing advisory services and research in aquaculture and marine and freshwater environments. JoLynn Carroll holds a PhD in marine science from the University of South Carolina in Columbia, USA, and has also studied innovation leadership at the Norwegian Business School.



Mette Marie Svenning
Professor
Arctic Marine Biology, UiT



William G. Ambrose, Jr.
Visiting professor



Helge Niemann
Assoc. Professor (20%)



Friederike Gründger
Postdoctoral researcher



Wei-Li Hong
Postdoctoral researcher



Arunima Sen
Postdoctoral researcher



Michael Carroll
Researcher



Pavel Serov
PhD candidate



Emmelie Åström
PhD candidate

Main questions:

Main question: What is the role of the seafloor biological community in mediating the exchange of methane from sediments into the water column?



Aims

Understanding sources and origins – Geological and geochemical factors controlling methane seepage.

Examining biogeochemical cycles – Dynamics of fluid and gas hydrate and their relationships with other elements in the sediments.

Understanding habitat characteristics – Location of seep communities and their visual characteristics.

Documenting microbial communities – Methanotrophic activity and microbial community composition in the water column and sediments.

Documenting macrobenthic communities – Ecological structure and function of macrofaunal communities and food webs associated with seafloor emissions.



Highlights

- Discovery of two new species of specialized bivalves associated with methane seeps
- Bivalve shell horizons in seafloor pockmarks suggest a 1000 year period of methane emissions
- Evidence of strong and localized effects of methane seeps on benthic communities
- Three-dimensional patterns of microbial methane oxidation rates elucidated
- Non-steady state fluid and hydrate systems identified
- Discovery of a shallow gas hydrate and methane leakage system in Storfjordrenna Trough
- Interdisciplinary investigations of shallow and deep water methane seeps. ■

Sediment sampling for microbial methane oxidation and sulfate reduction activity as well as for molecular analyses. On the picture: prof. Mette Svenning, PhD candidate Sophie George, postdoctoral researcher Friederike Gründger. Photo: Giuliana Panieri.



Strategy

- Interdisciplinary investigation of shallow and deep-water methane seep sites
- Mapping and understanding dynamic systems of seafloor features and biological communities
- ROV collection of seafloor microbial mats, authigenic carbonates, macrofauna, and sediments. ■

Microbes from Arctic water, fixed and filtered over special microfilter, are assigned for quantification of methanotrophic bacteria by post.doc Friederike Gründger. Photo: Randall Hyman.



Clams help date duration of ancient methane seeps in the Arctic

A bed of fossilized, methane dependent clams has for the first time been observed in the high Arctic. It tells the story of a thousand year long methane release event.

Text: Maja Sojtaric

Clams, mussels, scallops and oysters, sound like delicious items on a restaurant menu. But bivalves such as these are much more than that: they function as a delicate record of changing environments and climate.

They live for a long time in one place, all the while accumulating information about their environment in their shells.

Precise timing of a climate gas release

17,707 to 16,680 years ago, around the end of the last Ice Age, clams were alive and kicking on the seabed of the Arc-

tic Ocean above 79° North. That is a pretty accurate geological time frame that proves persistent methane release from the Arctic Ocean floor for approximately a thousand years.

CAGE scientists discovered the colonies while X-raying two sediment cores from the ocean floor offshore Svalbard, collected at 1200-meter water depth. The discovery was published in *Geochemistry, Geophysics and Geosystems*.

“We have not discovered these chemosynthetic-based communities in any of the other cores found this far North, and as far as I know they have never been observed in the high Arctic at all.” says principal author, professor William Ambrose, visiting professor at CAGE.

Don't need sunlight to thrive

The clams did not exist in a food chain based on energy derived from the sunlight and CO₂, – photosynthesis. The sunlight does not penetrate this deep into the ocean. Instead they derived large portion of their sustenance from a community of bacteria that convert carbon in the ocean into sugars and other byproducts with the help of methane seeping from the ocean floor.

“Our calculations show that 43 percent of their nutrition came from methane. The rest comes from different sources, among others photosynthetic material falling through the water. But at this depth that is not a lot. The methane is key to this species living there.” says Ambrose.

Hot and cold release

Methane seeps out from the ocean floor in two environments: very visibly from hydrothermal vents, huge plumes of hot smoke that appear close to areas of volcanic activity along ocean ridges. Or from less dramatic cold seeps along continental margins that are more elusive. Both environments however are characterized as deep-sea biological oases that support an abundance of chemosynthetic-based communities.

“Bivalves of this species on the modern seabed as well as in the sediment are a good indicator of methane release.” says Ambrose.

Clams act as natural observatories

The release measured in this study was recorded in Vestnesa Ridge, a sediment drift on the ultra-slow spreading Knipovich Ridge. This is an area known as a gas hydrate province with at least a million years of methane release. Gas hydrates are a solid, ice like form of methane stored under the ocean floor. They release methane gas when they melt.

Several spots in Vestnesa are very active today, even releasing huge columns of gas up to 800 meters high. Others are inactive. How the release gets activated has been established previously by CAGE-research. But the duration of the release event is not easily understood.

“Bivalves act like natural observatories. These clams have average life span up to 30 years. Some species can even be hundreds of years old.”

Think of the clamshells as vinyl records, recording methane release through decades in the grooves of their shells, without missing a beat. A shell bed of 30 cm, such as one found in the sediment core from Vestnesa Ridge, represents a formidable record collection, which can be played back by measuring isotopes and elements in the shells

“By dating when the clams lived, and the isotopic values in their shells, we were able to calculate that methane had to persistently leak out of its natural reservoir at this particular site for a thousand years for this clam collection to form.”

Takes advantage of CAGE expertise

The precise, and robust dating of such an event in our planet's distant history is not a straightforward process, and does not depend on clams alone. A lot of elements must be in place to achieve this degree of precision: microfossils must be dated, carbonate crusts also, and tectonic movements must be understood.

“This study really takes advantage of the close proximity of all the different expertise that is available at CAGE and is a good example of interdisciplinary work.” concludes Ambrose. ■



Expeditions

Since 2014 CAGE scientists have accomplished 15 expeditions to the Arctic Ocean. This provides us with data on hydrate reservoirs, methane release, and glacial history of a large area: From the Kara Sea in Russia, via the Barents Sea, to the Arctic Ocean north of the Norwegian Archipelago of Svalbard, Fram Strait, and Greenland. In 2015 we deployed two state of the art methane observatories on the ocean floor offshore W-Svalbard. They were developed for our purposes by Kongsberg Maritime, and will provide us with long term, continuous measurements of ocean chemistry. We also collaborate with Woods Hole Oceanographic Institution (USA). Using their high definition underwater camera systems (Tow Cam) during a 2015 cruise aboard our own RV Helmer Hanssen, we took over 30 000 images of the ocean floor. CAGE also participated in the N-ICE2015 expedition on RV Lance, lead by Norwegian Polar Institute, Tromsø. We measured methane above, in, and under young sea ice during the expedition that saw RV Lance frozen in an ice floe in the middle of Arctic winter. ■



| Scientists from Grenoble (CNRS) joined us on board RV Helmer Hanssen in late October 2015 to a key area of known methane release off the coast of the Svalbard archipelago in the Arctic Ocean. The aim was to test a groundbreaking mobile spectrometer, that will eventually be used in the quest for the oldest ice in Antarctica. Photo: CAGE | Post. doc. researcher Kasia Zamelczyk taking plankton samples with a plankton net on board RV Polarstern. Photo: Private. | Post. doc researcher Anna Silyakova taking a brine sample with syringe and tube on the N-ICE cruise. Photo: Daiki Nomura. | Lowering of the Tow Cam on the ocean floor offshore Svalbard caused a release of hydrate pavements from the ocean floor. The hydrate dissociates and melts in the water column releasing bubbles of methane gas. Photo: CAGE. |

Water Column

Methane release and gas quantification



Bénédicte Ferré, *Team Leader*

Bénédicte Ferré is a physical oceanographer whose research activities span from sediment resuspension and transport to oceanographic data analysis associated with methane release. She holds a PhD degree in oceanography from the University of Perpignan, France. She was a post-doctoral researcher at the United States Geological Survey in Woods Hole, USA, before joining the Department of Geology at UiT The Arctic University of Norway in 2008 and CAGE in 2013.



Jens Greinert
Visiting professor



Helge Niemann
Assoc. Professor (20%)



Anna Silyakova
Postdoctoral researcher



Anoop Mohanan Nair
Engineer



Pär Gunnar Jansson
PhD candidate

Main questions:

How much methane is released from the sea floor and how much is reaching the atmosphere?

How much methane released actually goes above the bottom boundary layer?

Where does the methane go?

What are the interactions between physical processes and modifications in methane release and transport?



Aims

Estimate the amount of methane released from the seafloor and reaching the atmosphere

Estimate the amount of methane dissolved below the bottom boundary layer

Characterize the oceanographic triggers that modify the seep activities

Model methane flux from the seafloor to the sea surface.



Deployment of CAGE ocean observatories in cooperation with Kongsberg Maritime. The deployment was conducted RV Helmer Hanssen. Photo: Anna Silyakova.

Highlights

1. Successful deployments of two observatories offshore West Svalbard at 90 and 240m depth with Kongsberg Maritime from RV Helmer Hanssen.
2. Successful deployment of a methane sensor and CTD at Hausgarten stationary observatory at 1500m water depth from RV Polarstern.
3. 2015 oceanographic time series analyses for using, CTD casts, multibeam and echosounder surveys at shallow Prins Karls Forland sites. New CAGE assoc. prof. Helge Niemann started methane oxidation rate measurements and colleagues from USGS and University of Rochester (USA) worked on ocean chemistry.
4. Methane measurements in surface water under young sea ice, in and above the sea ice during the N-ICE2015 expedition – mid-winter freeze experiment in the Arctic .
5. Ocean. The analysis was in collaboration with the Norwegian Polar Institute (Tromsø) and the Institute of Low Temperature Science (Hokkaido University), Japan. New infrastructure with a gas chromatograph provides measurements for methane concentrations

Funded Projects

- EU ENVIplus, partner, <http://www.envriplus.eu/> (2015 to 2019)
- EU FixO3, partner, <http://www.fixo3.eu/> (2013–2017)
- NFR LoVe infrastructure project, partner <http://love.statoil.com/>(2016–2020)
- NFR SIOS infrastructure project, <http://www.sios-svalbard.org/servlet/Satellite?c=Page&pagename=sios/>
- EU EMSO ERIC, <http://www.emso-eu.org/site/old-website/about/emso-eric.html> (2015 – submission in progress but without official Norwegian participation. ■



Strategy

- Long-term time series analysis of data from cabled and non-cabled observatories in strategic locations of ocean water masses and climate change.
- Data transfer technology development for ocean observatory, maintenance and re-deployment in cooperation with Kongsberg Maritime.
- Recover technology development for ocean observatories in cooperation with Kongsberg Maritime and GEOMAR.
- Advance progress on ocean-atmosphere flux modeling in cooperation with NILU. ■

Deployment of CAGE methane sensor from the RV Polarstern to the Hausgarten deep-sea observatory in the Fram Strait. The deployment was conducted within the EU project FixO3 in which CAGE participates. Photo: Kasia Zamelczyk.



Scientists and engineers anxiously following the lowering of the observatories to the ocean floor, from onboard RV Helmer Hanssen. Photo: Randall Hyman

Methane observatories successfully deployed in the Arctic

Mysteries still abound about methane release from the ocean floor. Two state of the art observatories have been deployed offshore W-Svalbard this summer, to try and unveil the secrets of natural release of the greenhouse gas.

Text: Maja Sojtaric. Photos: Anna Silyakova

It is not only the space agencies that launch landers with sensors to far away places. Marine science institutions have a lot of unknown ground to cover in their quest for knowledge. Also they are depending on groundbreaking lander and sensor technology to lead them to new knowledge.

CAGE recently deployed two observatories on the site of the methane seeps in the Arctic Ocean. Kongsberg Maritime built the two observatories that are now comfortably placed on the ocean floor in two locations offshore Svalbard. These are the sites where flares of gas bubbles have been observed, indicating release of methane gas to the water column. The observatories are placed at the depth of 90 meters and 240 meters respectively.

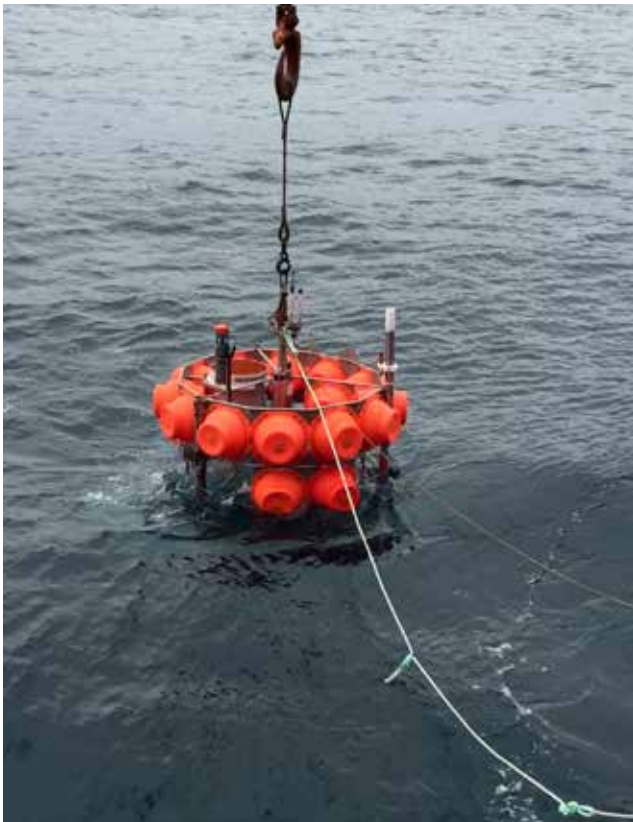
“The launch went perfectly,” says chief scientist on the cruise, Dr. Anna Silyakova.

Methane is a potent climate gas that can amplify the global warming if released into the atmosphere. However, there is still a lot to be learned about the release of methane from the ocean floor, and what happens to it in the water column. Does it get dispersed with the currents? Do bacteria consume it? Or is it released in the atmosphere?

The observatories include several instruments which will monitor methane release from the seabed to the water column as well as CO₂, ocean acidification and circulation. The data from these observatories will provide knowledge that will help understand processes related to climate change. The observatories will stay put in their locations, collecting crucial data for a full year. ■



PhD candidate Pär Jansson holding a methane sensor that was installed to the ocean floor using the lander below. Photo: Kasia Zamelczyk.



The deep lander is deployed at 2500 meters water depth. It's a free falling instrument so when it is released at the sea surface it will fall through the water column slowly until it lands on the deep seafloor. Photo: Pär Jansson.

New methane sensor installed in the Arctic Ocean

German research vessel Polarstern went to the Fram Strait on an expedition this year. On board were two scientists from CAGE, with a mission to install a methane sensor at the deep-sea observatory Hausgarten.

Text: Maja Sojtaric, Photo: Kasia Zamelczyk/CAGE

PhD Candidate Pär Jansson and post. doc. researcher Kasia Zamelczyk from CAGE participated on the second leg of the RV Polarstern-expedition to the deep-sea observatory Hausgarten. The observatory is a network of 21 stations at water depths ranging between 250 m and 5500 m in the Fram Strait.

RV Polarstern has revisited the observatory annually for the past 17 years, collecting long-term ecological data sampled by different instruments throughout the network. Scientists expect to obtain a time series record of bottom water properties such as temperature, salinity and pressure as well as methane concentrations. The instruments were deployed at a water depth of 2500 meters, where no direct methane emission is expected. The data acquired at this location will mainly serve as a reference to compare with other sensors placed in active emission sites. Methane is a potent greenhouse gas that is naturally seeping from the ocean floor.

This work was conducted within the EU FixO3 project, which seeks to integrate European open ocean fixed-point observatories.

Additional sampling offshore Svalbard

In addition Zamelczyk and Jansson collected CTD profiles and water samples for methane concentration measurements at active methane seep locations close to Prins Karls Forland, Svalbard.

“Water sampling will result in methane concentration profiles for 12 different depths. These profiles will help us to estimate the magnitude of methane emissions and how high the methane can reach in the water column. In total 48 bottles were collected in an area where we have seen a lot of methane seeping from the seafloor” says Jansson.

Also, zooplankton net and surface sediment samples were collected at the same locations. These samples will be used to study the impact of methane release from the ocean floor on shells of planktonic (living in the water column) and benthic foraminifera (living at the ocean floor). ■

Paleo-methane History

Pleistocene and Beyond



Jochen Knies, *Team Leader*

Jochen Knies is a senior researcher at the Geological Survey of Norway in Trondheim. He does marine geological and environmental investigations along the continental margin of Northern Norway, the Barents Sea, Svalbard and the Arctic Ocean. Jochen holds a PhD degree in marine geology from the University of Bremen. He was a post.doc at Alfred Wegener Institute for Polar and Marine Research, Germany, and a visiting professor at the University of Hawaii, USA.



Soma Baranwal
Postdoctoral researcher



Antoine Cremiere
Postdoctoral researcher



Shyam Chand
Researcher



Aivo Lepland
Researcher



Karl Fabian
Researcher



Terje Thorsnes
Researcher



Deniz Koseoglu
PhD candidate



Simone Sauer
PhD candidate

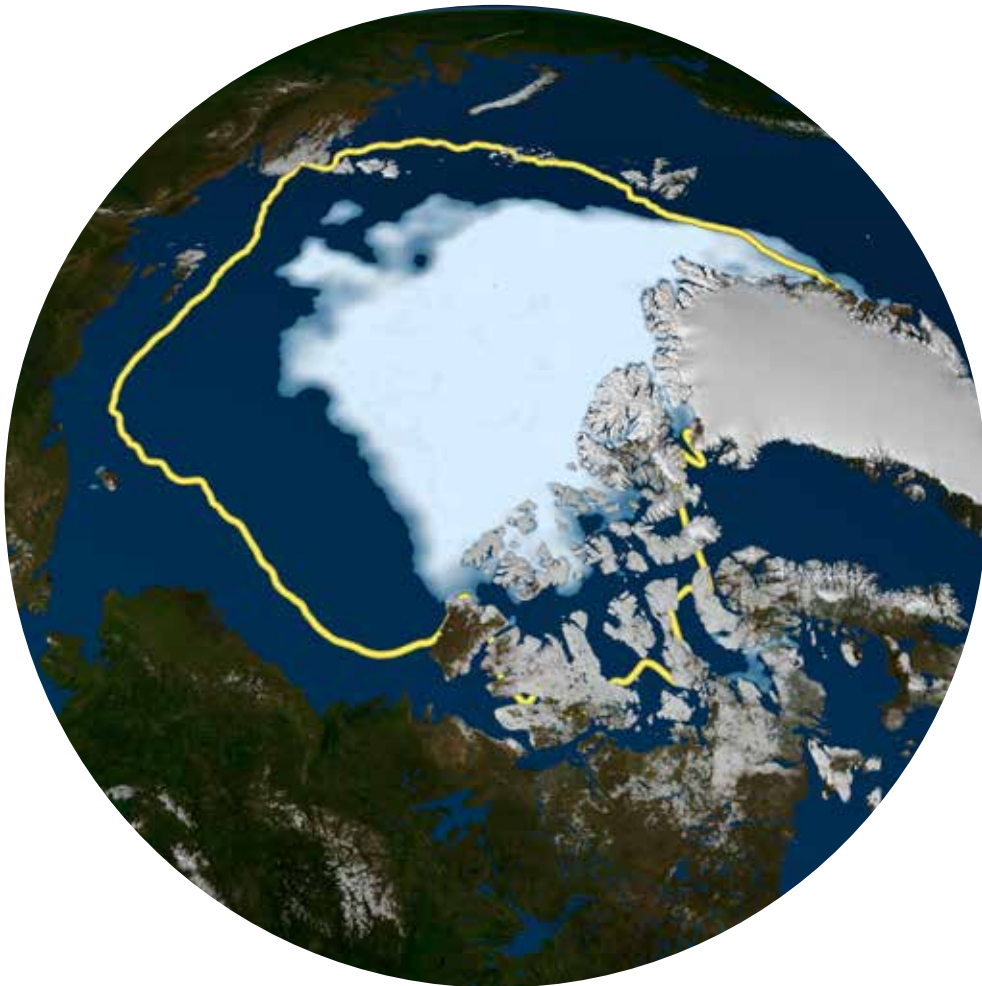


Kärt Upraus
PhD candidate

Main questions:

Main question: What is the effect of pre-glacial and glacial uplift/erosion on the gas hydrate system in the Eurasian Arctic?

How can we quantify hydrocarbon leakage from “fossil” seep sites and determine the timing of leakage during the geological past?



Aims

Establish geochemical markers and time constraints for “abnormal” methane ocean – atmosphere conditions and links to climate change during the geological past.

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.



In her PhD project Kärt Üpraus studies the global environmental changes and establishment of new habitats in the aftermath of the oxygenation of Earth that led to the formation of oldest worldwide phosphorites 2 billion years ago. No such very old geological formations exists on the world ocean floor, thus her studies must concentrate on unique formations on land. She uses geochemical and isotopic methods in her studies with the focus on sulfur isotopes that afford deciphering the importance of sulfur metabolizing microbes in phosphorite formation. Her field work was conducted in the Russian Karelia in 2015, with much interest from local media. Photo: Privat.

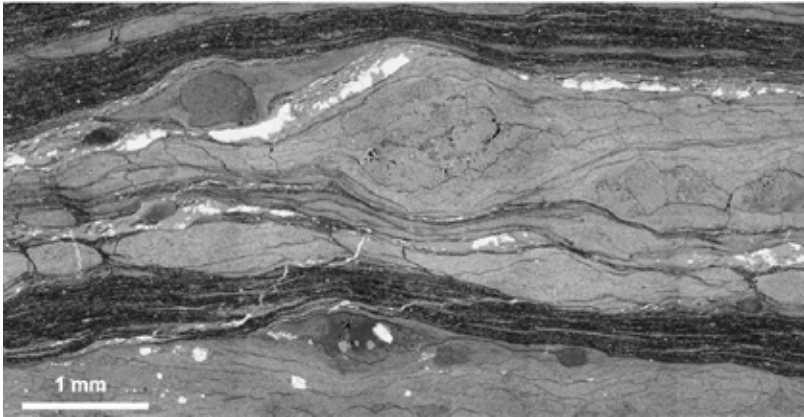
Highlights

1. The PhD project of Kärt Üpraus has produced unique results of microbial methane and sulfur cycling mediating phosphorite formation 2 billion years ago during Paleoproterozoic oxygenation of the Earth.
2. The onset of methane seepage on the Vestnesa Ridge off western Svalbard is constrained to 2 million years ago.
3. Geochronologic studies of methane derived authigenic carbonate crusts from seepage sites along the Norwegian margin have allowed the assessment of timescales of past gas hydrate dissociation and methane release in response to the ice retreat during last deglaciation.
4. The principal investigators in “Paleo-Methane History” are involved in two successful applications to Norwegian Research Council in 2015 involving in total 4 new Post Docs, which will be recruited to the team in 2016.

WP5 Funded projects

NFR Petromaks2 “NORCRUST - Norwegian margin fluid systems and methane-derived carbonate crusts - Recent scientific advances in service of petroleum exploration” (2016–2020)

NFR INDNOR “PACT - Pliocene Arctic Teleconnections” (2016–2020). ■

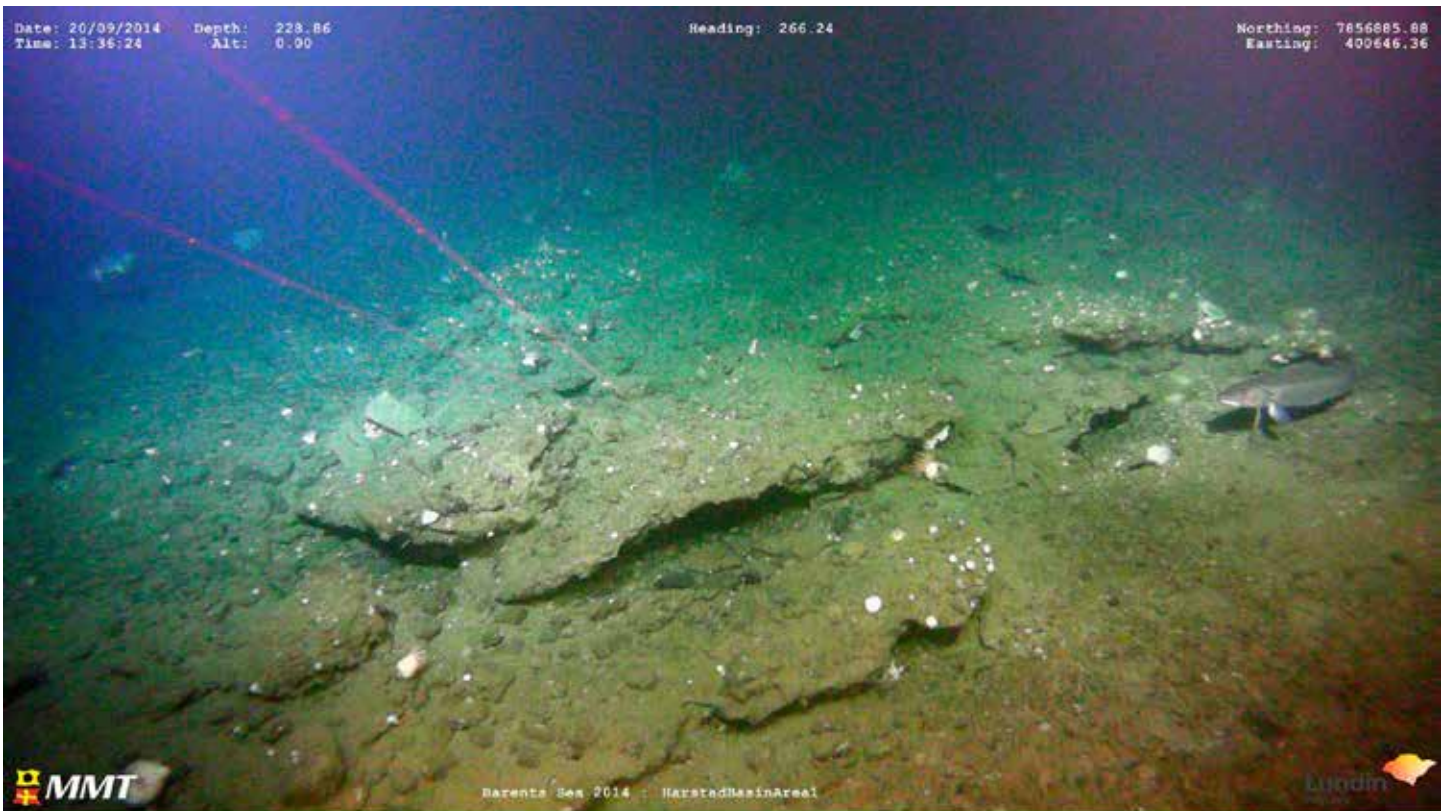


Phosphorite layers and nodules (gray) in organic-rich mudstone (black) in the 2 billion year old sedimentary rocks from Russian Karelia. Photo: Kärt Upraus.



Strategy

- Industry-academia cooperation to install a new seabed cabled monitoring observatory at a newly discovered seep site off the coast of Vesterålen.
- Establish workflows for Cryogenic Magnetometer analyses for a national and international facility.
- Provide our expertise to the planned MeBo gas hydrate and authigenic crust drilling and ROV operations that CAGE is planning in 2016. ■



Methane-derived authigenic carbonate crusts are often detected in areas of cold seep sites and present an archive for past methane seepage towards the seafloor. Detailed geochemical and chronological studies may reveal the source of seeping methane and the timing of past events. In the Barents Sea, strongest activity of methane release occurred during the last deglaciation, when ice sheets retreated, gas hydrates melted and enormous amounts of methane were released from the seafloor. Photo: NGU/CAGE.



Monsoon is a dramatic and often dangerous weather phenomenon associated with South Asian countries such as India and Bangladesh. Photo: Bunty Surav/Wikimedia Commons

What does Arctic Ocean have to do with Indian monsoons?

The sea ice cover in the Arctic is important to more than polar bears and seals. It is also contributing to seasonal weather changes that each year affects millions of people.

Text: Maja Sojtaric

Weather in India is not the first thing that comes to mind when you think of the of the Arctic sea ice. However, higher temperatures in the Arctic may have an effect on the weather all over the globe.

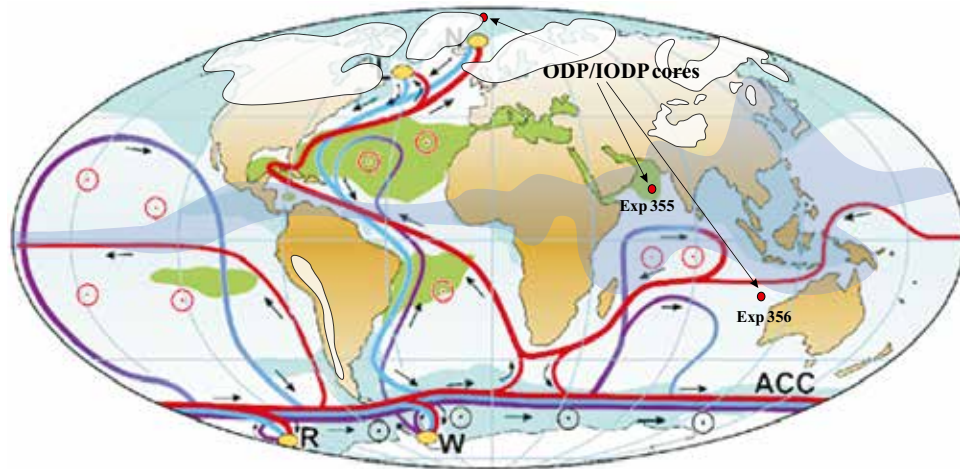
CAGE has been awarded 6 million NOK to study how Arctic Ocean warming affected monsoons in the past.

“One of the most important objectives is to study the response of the monsoon to past episodes of global warmth and enhanced concentration of greenhouse gases. One of

such periods, which has been identified for high-resolution study, is the early to middle Pliocene Epoch (3.3–3.0 Ma). The atmospheric CO₂ concentration was 400 ppm, which is more or less the same as we see today. The mean temperatures were around 3°C warmer than today, says project leader Jochen Knies.

Analogue for current warming ocean

Pliocene Epoch, some three to five million years ago, is an analogue for our current warming ocean. It is the time in the relatively recent history of our planet when sea ice conditions in the Arctic Ocean were similar to the ones we observe now. The ice cover was also strongly reduced during



this period something that we may experience in our recent future due to global warming. Variability in sea ice cover can have immense implications on the Earth’s climatic exchange between the ocean, land, and atmosphere.

All of the world oceans are interacting through exchange of cold and warm water, creating the weather phenomena that we experience. One such phenomenon is monsoon, a seasonal change in atmospheric circulation and rainfall associated with the asymmetric heating of land and sea.

And one of the batteries fueling that system, which most commonly is associated with South Asian countries such as India, is actually the Arctic Ocean.

Sea ice effects are not a local Arctic phenomenon

The warming of the Arctic Ocean becomes important to more than local life in the North. Monsoons are not to be trifled with: in 2013 over 10 000 people were killed in monsoon floods in India alone. So what if the warming of the Arctic Ocean changes the pattern and intensity of the monsoon?

That is one of the questions that PACT will try to answer.

The project is looking into the past to see if that happened, long before there were any humans to be harmed. Through studies of sediment cores from the Arctic and Indian oceans

we will look into the geological past, trying to unveil the connection between the two when the Arctic Ocean was likely summer ice free.

“PACT project will increase quantitative estimates of the Mid-Pliocene Warmth in the Arctic Ocean by implementing innovative scientific approaches on well established Pliocene Arctic sediment sequences. This will improve our understanding of how world ocean and atmospheric circulation patterns generate and maintain Mid-Pliocene warmth through the use of a fully coupled atmosphere-ice-ocean model,” the proposal states.

“Our researchers will also participate in International Ocean Discovery Program expeditions to the Arabian Sea and Australia. We hope that samples from these expeditions will improve our understanding of large-scale teleconnections between the Arctic Ocean and Asian/Australian monsoon system, says project leader Jochen Knies.

Facts: PACT – Pliocene Arctic Climate Teleconnections, funded by the Norwegian Research Council (grant No. 248793) for 4 years. PACT is led by CAGE at the University of Tromsø, The Arctic University of Norway. PACT partners are the Geological Survey of Norway, Plymouth University (UK), University of Leeds (UK), the National Centre for Antarctic and Ocean Research (India), and the Birbal Sahni Institute of Palaeobotany (India). ■

Pleistocene to Present

Methane, ocean acidification and CO₂



Tine Lander Rasmussen, *Team Leader*

Tine Rasmussen is a professor at the Department of Geology, UiT The Arctic University of Norway. Her research includes paleoceanography, paleoclimate, paleoecology, micropaleontology, abrupt climate and oceanographic changes, long time series, Arctic, and sub-Arctic areas. She has a PhD in marine micropaleontology from the University of Aarhus (Denmark). She has worked at Royal Netherlands Institute for Sea Research, University of Copenhagen (Denmark), Woods Hole Oceanographic Institution (USA), Lund University (Sweden) and The University Centre in Svalbard.



Giuliana Panieri
Associate professor



Chiara Consolaro
Postdoctoral researcher



Ulrike Hoff
Postdoctoral researcher



Katarzyna Zamelczyk
Postdoctoral researcher



Mohamed Ezat
PhD candidate



Katarzyna Melaniuk
PhD candidate



Andrea Schneider
PhD candidate



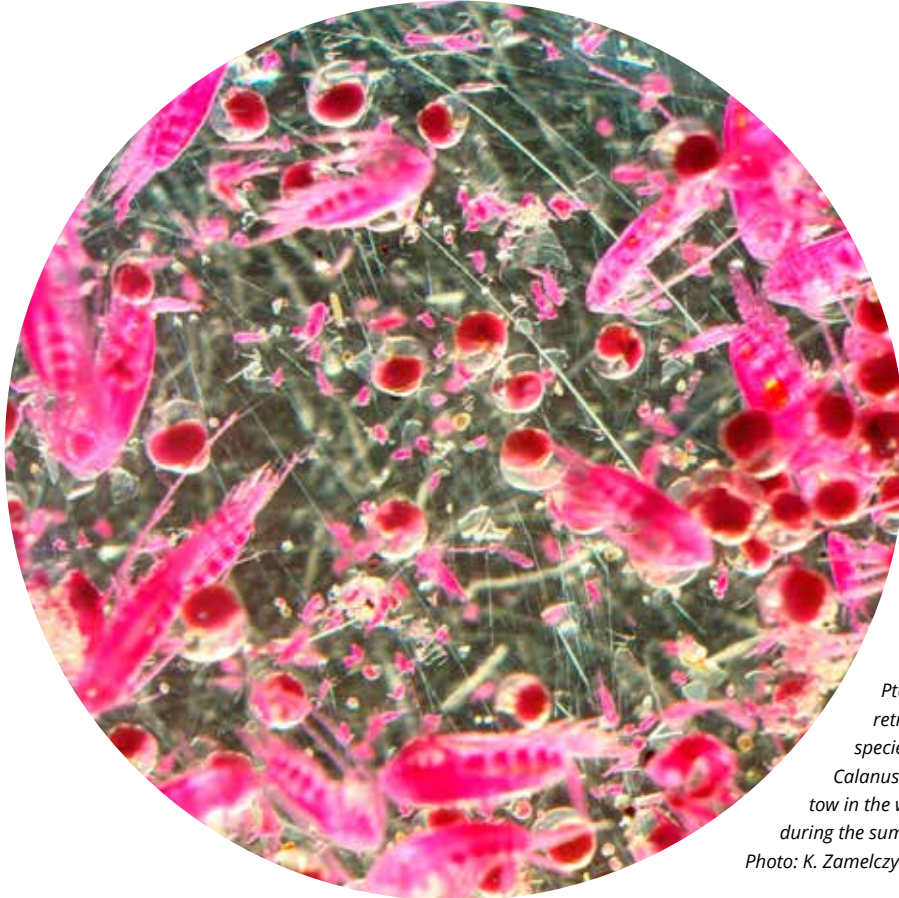
Kamila Szybor
PhD candidate



Haoyi Yao
PhD candidate

Main questions:

Are foraminifera sensitive to methane emissions, methane hydrate dissociation and CO₂?



Pteropods Limacina retroversa (subpolar species) and copepods Calanus collected with plankton tow in the western Barents Sea during the summer cruise in 2015.
Photo: K. Zamelczyk/CAGE

Aims

- To apply multi-proxy approaches to reconstruct high-resolution climate and greenhouse gas records.
 - to detect and quantify biochemical responses to changes in ocean chemistry due to methane release, increasing atmospheric CO₂ and global warming.
 - to provide records useful for modeling and forecasting future changes as a result of ongoing alterations in the Arctic ocean.
-



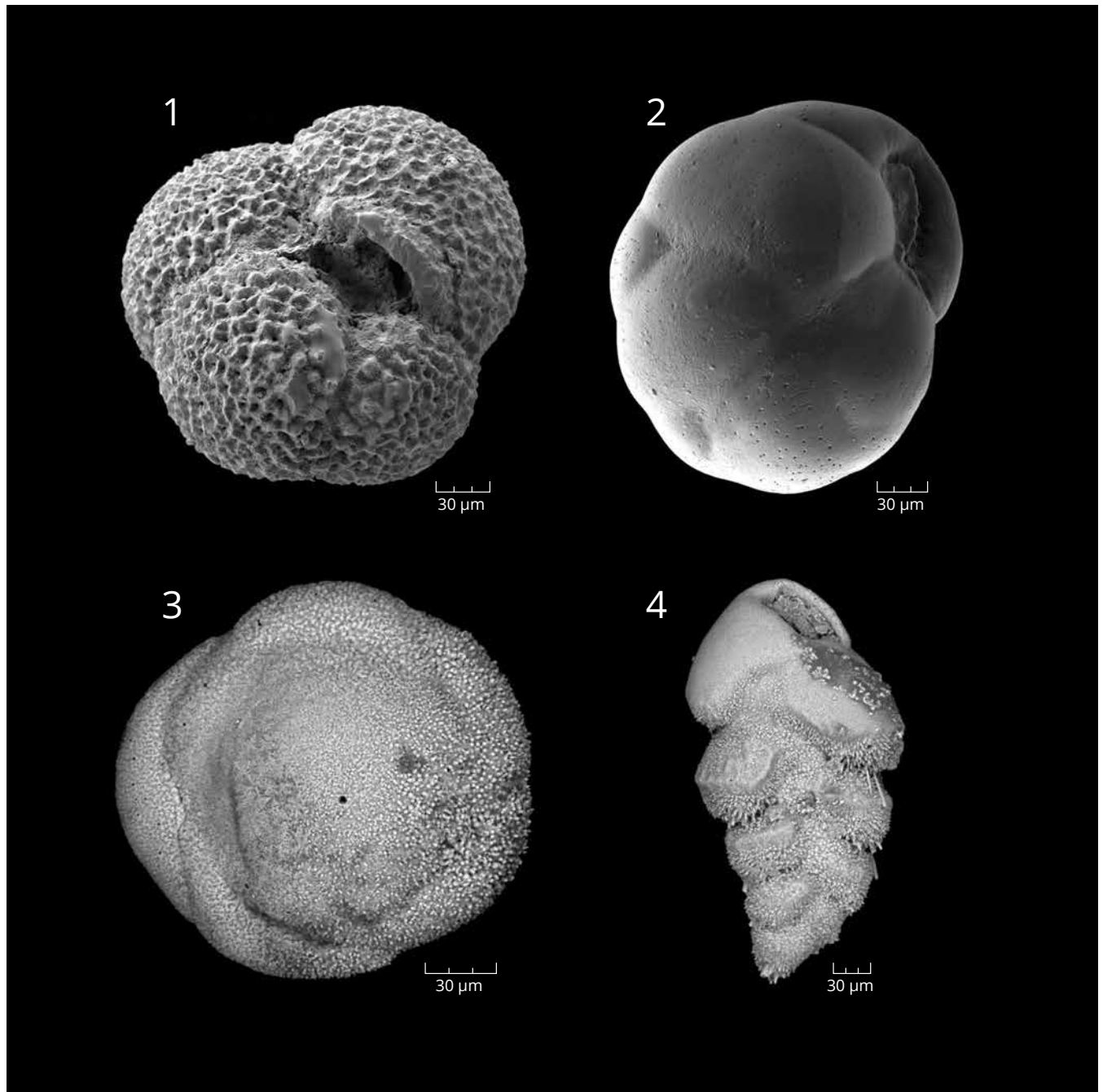
SEM (Scanning Electron micrographs) of marine diatoms from records of sea surface temperatures and sea-ice distribution based on diatom studies are under preparation at CAGE. The photo shows as example freshwater diatoms from Kamchatka peninsula published in a 2016 calender from the Micropalaeontological Society in the UK. Photo: Ulrike Hoff

Highlights

1. Planktonic and benthonic foraminiferal and diatombased reconstructions of ocean temperatures, sea ice extent, ocean chemistry changes in the Arctic and northern North Atlantic on centennial to millennial time scales show strong linkages between ocean circulation, distribution of sea ice, pH, surface and bottom water temperatures.
2. Isotopic values of foraminifera carbonate tests are sensitive to methane seepage. In the primary shell and in the authigenic carbonate precipitation on the shell, foraminifera act as a proxy for tracking methane emissions events. Several key sites in the Arctic show that methane seepage has been ongoing for thousand of years. Increase in methane release apparently occurred during major phases of the deglaciation.
3. In addition to biological and geochemical studies, physical studies of grain-size and sortable silt to reconstruct of bottom current activity at the western and northern Svalbard margin on orbital and millennial time scales for the last 74,000 years also show clear linkages to climate with stronger bottom currents during warm climatic phases and low activities during cold phases.
4. On a global scale study of the 'bipolar seesaw' have shown from where, when and how deep ocean warming occurred in the past. The bottom water warming constitutes a potential trigger for gas hydrate instability. Our climate study provides new hints which areas in the North Atlantic correlates to the climate development as seen in Green-land ice cores and which correlates to the development seen in Antarctic ice cores.
5. Climate changes in the past: Three PhDs that were successfully defended by the candidates supervised by WP6 in 2015.
6. CAGE 15-2 cruise (May 16-29): Expedition leader Giuliana Panieri collaborated with scientists and engineers at Woods Hole Oceanographic Institution's MISO Deep-Sea Imaging Facility with the aim was to get a proper view of the deep Arctic Ocean floor. 30,000 high definition images were taken at known methane release sites in the Arctic Ocean north of Norway.

WP 6 Funded projects:

OA-Ocean Acidification: Effects of ocean chemistry changes on planktic foraminifera in the Fram Strait: ocean acidification from natural to anthropogenic changes. Supported by the Research Council of Norway NFR. Grant No.216538. (2013–2015). ■



SEM photos of foraminifera from the northern Svalbard margin north of Nordaustlandet: Cold water species: 1) planktonic foraminifera *Neogloboquadrina pachyderma* (sinistral); benthic foraminifera: 2) *Cassidulina reniforme*; Warm water species: benthic foraminifera 3) *Eilohedra nipponica*; and 4) *Sagrina subspinescens*. The photos are from the PhD thesis of Teena Chauhan.

Strategy

- Improve our understanding of biological survival systems of benthic foraminifera in methane influenced environments through experiments and culture studies.
- Improve methods and knowledge of postdepositional diagenetic effects on both planktonic and benthic foraminifera in sedimentary records.
- Enlarge data sets (collection of samples from new areas) and monitor already known locations for seasonal sampling and ocean acidification studies.
- Maximize our understanding of CO₂ and CH₄ variations in the past applying paleoreconstructions together with modeling. ■

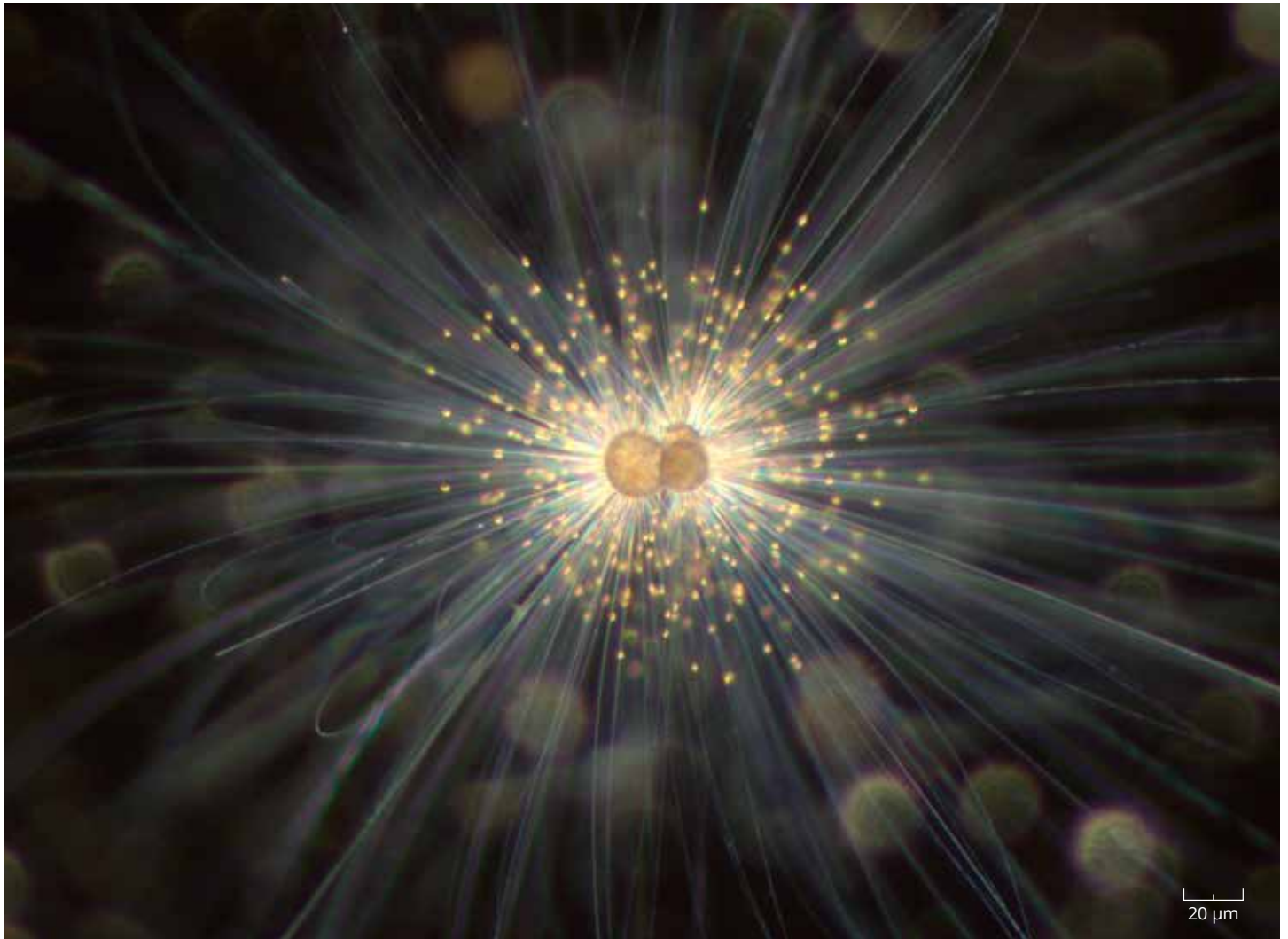


Photo: Howard Spero.

Foraminifera record ocean acidification

*Text: Kasia Zamelczyk. Photo courtesy of Howard Spero, SCOR workshop, Catalina Island, 2015
From CAGE blog: Facts from the field*

Foraminifera are single-celled organisms that live in the ocean. They have shells that are easily affected by changes in ocean chemistry. There are about 4000 different species of so-called “forams”.

Only 52 species are planktonic – floating in the water. All other are benthic species, which means that they are living at the seabed. They are abundant as fossils for the last 540 million years.

Their abundance, the type of species present in the water column, distribution, shell size and trace element composition

of their shells can inform us about ocean environmental conditions.

With a calcium carbonate shell, they are commonly used in the reconstruction of past changes in carbon chemistry of the ocean. Their reliability as environmental index depends on assumption of equilibrium condition at the time of growth and absence of subsequent alteration. For this, at CAGE we have developed forefront methods to investigate the state of preservation of foraminiferal shells.

Ocean acidification

Anthropogenic release of CO₂ into the atmosphere has increased enormously since the industrial revolution. About 25 % of the atmospheric CO₂ is absorbed by the oceans, which causes a chemical reaction that leads to the oceans becoming

more acidic. Since the beginning of industrial revolution the acidity of the oceans has increased by 30 percent.

The planktonic foraminifera constitute one of the major groups of calcareous marine microplankton and depend on carbonate in the ocean water for creation of their shells. When the water becomes acidic, the carbonate is depleted.

Think of Coca Cola that is eroding the enamel of your teeth. This happens partly because the drink is very acidic with a pH value of 2.5. (pH scale ranges from 0 to 14, with 0 being the most acidic and 14 being the least acidic—or most alkaline).

In the same way, the ocean acidification has the potential to adversely affect the process of calcification of the shells of planktonic foraminifera. Forams may be particularly vulnerable to future CO₂ emissions, and give us early warnings on chemical changes in the ocean that could further reduce the ocean's ability to absorb additional CO₂ from the atmosphere. This in turn could affect the rate and scale of climate warming as well as the ecosystem of the ocean.

Shells of forams record the physical and chemical state of the ocean in which they live. With mass spectrometry techniques we can measure minute differences in isotopic

compositions and trace elements of their shells. In addition, counts of particular species and the total abundance of planktonic foraminifera in the samples can tell us about various physical parameters of the prevailing water masses that the forams live in.

Methane and CO₂

Methane oxidizes into carbon dioxide both in seawater and in the atmosphere, adding to the carbon dioxide levels in both these realms.

In the Arctic, where vast amount of methane are stored along continental margins the subject (or matter) of release of methane needs to be understood. Despite the fact that we are not observing a very clear picture of ocean acidification increases, the on-going warming of the ocean and the predicted ice-free conditions (blue-ocean) as early as 2020 in the Arctic Ocean could lead to destabilization of shallow gas hydrates, and associated methane release that may increase ocean acidification.

In CAGE we develop methods of investigating the fate of the methane and its impact on ocean acidification in the Arctic, where the most intense future climate warming is predicted. ■

Climate changes in the past

Mohamed Ezat investigated climate changes in North Atlantic seas through the past 135 000 years. This was a part of his PhD thesis at CAGE, one of three PhDs that were successfully defended by the candidates supervised by WP6 in 2015.

Ezat, Mohamed “North Atlantic–Norwegian Sea exchanges during the past 135,000 years: Evidence from foraminiferal $\Delta^{14}\text{C}$, d^{11}B , d^{18}O , d^{13}C , Mg/Ca and Cd/Ca ”. Supervisors. T.L. Rasmussen (CAGE) and J. Goeneveld, AWI-Bremerhaven, Germany.

Simon P. Jessen: “Ice Rafting, Ocean Circulation and Glacial Activity on the Western Svalbard margin 0–74 000 Years”. Supervisor T.L. Rasmussen.

Teena Chauhan: “Late Quaternary Paleooceanography of the Northern Continental Margin of Svalbard”. Supervisors T.L. Rasmussen CAGE, and R. Noormets, UNIS, Svalbard. ■

Atmosphere

Methane emissions from the Arctic Ocean



Cathrine Lund Myhre, *Team Leader*

Cathrine is a researcher at NILU – Norwegian Institute for air research and the project leader of the MOCA project. She has a PhD in physical chemistry from University of Oslo, Norway. Her main research is on atmospheric compositional change and atmospheric measurements. In particular she works with natural and anthropogenic emissions of greenhouse gases and aerosols. She studies their sources, concentrations and long term trends, especially in Arctic and Sub-Arctic regions.



Jürgen Mienert
Professor, CAGE, UiT



Gunnar Myhre
Researcher, CICERO



Andreas Stohl
Researcher, NILU

Others involved

NILU: Stephen M. Platt, Ove Hermansen, Norbert Schmidbauer, Ignacio Pisso, Sabine Eckhardt, Ann Mari Fjæraa
Cicero: Øivind Hodnebrog, Stig Dalsøren and Ragnhild B. Skeie
CAGE: Anna Silyakova, Sunil Vadakkepuliambatta, Pär Jansson, Benedicte Ferré

Main questions:

What is the present atmospheric effects of methane from gas hydrates at the seabed?

What is the future potential climate impacts on decadal to centennial timescales?

We want to learn more about atmosphere-ocean interaction in the Arctic

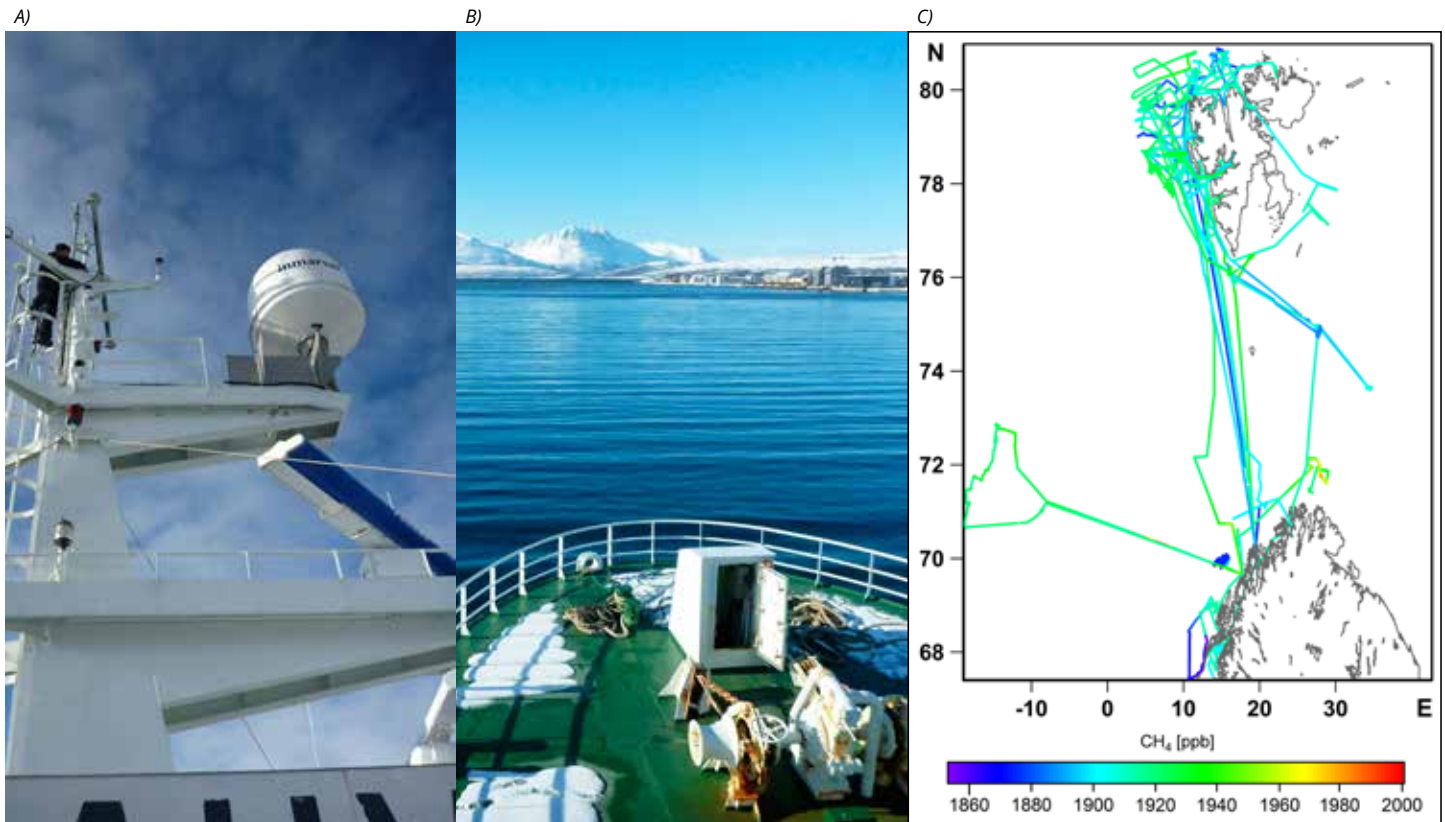


Figure 1N: Panel a: Development of the atmospheric inlet of air to the laboratory. Panel b: View from the mast at Helmer Hanssen. Panel c: The CH₄ levels collected at Helmer Hanssen over the period June 2014 – November 2015. Photos: NILU/CAGE

Interaction between the ocean and atmosphere in the Arctic

The MOCA project “Methane Emissions from the Arctic Ocean to the Atmosphere: Present and Future Climate Effects” shares scientific driving questions with CAGE, and complements CAGE by adding the atmospheric component, both measurement and modelling activities. This includes contributions from climate modelling group working on greenhouse gases and changes under various climate scenarios.

As a part of the work we have developed an atmospheric laboratory at the RV Helmer Hanssen to measure CH₄ concentration close to the sea surface, continuously during the ships cruises in the Arctic. The data is transferred from the ship in near-real-time to NILU (Norwegian Institute for Air Research, Oslo). This is a major achievement, and the laboratory is finalised and continuous measurements of CH₄ since June 2014 is ready for further analysis to seek for potential hotspots and emissions from the ocean. Figure N1 panle c) show the ship track and CH₄ data for this period.

Analysis of the extended campaign outside Prince Karl Forland in 2014 is still ongoing but indicates strongly that there

is a large methane release from the Arctic seabed west of Svalbard, but a small release to the atmosphere during this two weeks summer period. This is based on the complementary measurements at the sea floor, in the ocean, and in the atmosphere from land-based, ship and aircraft platforms during summer 2014.

We will now perform further analysis of the data compiled so far using state-of-the-art atmospheric and climate models. At the same time, we will continue with targeted cruises with an extended sampling program, including other trace gases: e.g. ethane, propane, d¹³CH₄ and to capture seasonal changes at various locations. ■



Outreach and communication

Over 100 stories of our research have been told through national and international outlets over the past year. That is a result of concentrated effort to reach out to global general public with important climate research.

2015 has been a successful year for our outreach efforts. We have made several of our studies well known to an international audience, setting the stage for further advancement of knowledge about the Arctic.

We are constantly analyzing current media coverage to find platforms for our content, which we primarily release on our web page and through science news services. We have employed several strategies for search engine optimization and social media distribution throughout the year 2015. This is a part of a long-term communications strategy that we hope will show significant results going forward.

Google Analytics data show that our web page has been viewed close to 70 000 times from the start of measurements in October 2014.

The Washington Post, with largest online readership of all the traditional US newspapers, has covered a paper written by our PhD Pavel Serov. So has The Daily Mail. The Daily Mail reached a milestone of almost 200 million unique monthly visitors in December 2014, making it the largest English-language newspaper website. They also covered our research on new methane sources in the Arctic, based on a paper written by visiting professor Joel Johnson. Several national outlets such as NRK and forskning.no have covered our research as well.

We have also participated in the “new media”, such as the popular YouTube Channel Jacks Gap with over 4,5 million followers. Their short documentary Our Changing Planet, which featured CAGE professor Alun Hubbard, has been viewed close to 800.000 times since December 2015.

Our efforts are not only limited to media outlets. Our young researchers are encouraged to participate in public discourse. In 2015 PhD students Emmelie Åström, Calvin Shackleton, Mariana Esteves and Giacomo Osti participated in Norwegian Science Festival. PhD students and post docs have also contributed to our blog site Facts From the Field, which we established together with our research school AMGG during a field trip to Italy in October 2015. It will be further developed throughout 2016. The early career scientist have also participated in workshops on writing skills (by Maja Sojtaric, CAGE) and presentation techniques (by Melissa Marshall, from Penn State University).

All of our communications and outreach work is facilitated and organized by our communications coordinator Maja Sojtaric, who also develops strategies for our outreach. She has worked for a decade as a science journalist and editor, before joining CAGE as a full time advisor. She writes our press releases, manages media contact and maintains our social media distribution, as well as arranging workshops in communication. ■



Our web page is visited by a global audience. 40 percent of the readers come from Norway, followed by USA and UK. Illustration: Google Analytics.



The popular You Tube Channel has predominantly teenage and young adult audience. Photo: Screenshot



The answer is yes. According to our PhD- candidate Pavel Serov who wrote this blogpost from the fieldwork in the Italian Apennines. Photo: Pavel Serov

Outreach highlights

Washington Post: Remember those weird Siberian craters? Scientists say they may have an underwater version. November 23, 2015

The Daily Mail: Enormous mounds of methane found under the Arctic sea: Underwater pingos may reveal 'worrying' clues about climate change. November 19, 2015.

NRK: Frykter metaneksplosjoner i Nordishavet. December 2, 2015 – Also reported in *Sydney Morning Herald*, *Alaska Dispatch News*, and *The Siberian Times*, *forskning.no*.

The Daily Mail: Will methane in the Arctic speed up global warming? New source of gas found in North Pole - and there may be more of it than first thought, April 15, 2015

Deutschlandfunk: Treibhausgas: Neue entdeckte Methanquelle in der Arktis. April 17, 2015 – Also reported in *Reporting Climate Science*, *Environmental News Network*, *Phys.org*, *GEO 365*, *forskning.no*, *Science 2.0*

Live Science: Never-Before-Seen Photos of Colorful Life on Arctic Seafloor. July 2, 2015

Gizmondo (ESP): Excepcionales fotos de los escapes de metano bajo el Océano Ártico, July 23, 2015

The Guardian: Global warming is causing rain to melt the Greenland ice sheet, July 14 2015 – Also reported in *Videnskap.dk*, *Forskning.no*, *Science World Report and Tech Times*.

Welt am Sonntag: Schatz aus der Tiefsee. March 1, 2015.

Science Daily: Are gas hydrates a source of environmentally friendly energy? April 22, 2015.

Science Newsline: Ocean currents disturb methane-eating bacteria, May 4, 2015.

NRK: Slik skal forskere lære mer om gassutslipp på havbunnen. September 8, 2015

Scandinavian Review: Methane: Promise and Peril of the Arctic. Autumn 2015

Reporting climate science: Methane Seeping from Arctic Sea for millions of years. February 5, 2015. – Also reported in *forskning.no*, *geoforskning.no*, *Nature World News*, *International Business Times*, *A1 Pakistan and Science Newsline*.

Jacksgap (Youtube Channel): Our Changing Climate. December 20, 2015 ■



The field trip to Italy took our students to unfamiliar places. Such as this gypsum quarry where they could observe the traces of the Messinian Salinity Crises, a dramatic example of environmental change in the geological record. Photo: Maja Sojtaric

AMGG

The Arctic Marine Geology and Geophysics Research School (AMGG), led by CAGE staff, provides researchers and students in-depth knowledge of Arctic marine geology and geophysics, in cooperation with the Department of Geology.

The Research School offers scientific expedition cruises, relevant topic seminars, specialized workshops with national and international participants, and courses through which it trains a new generation of scientists. The aim of AMGG is to understand the multiple facets of Arctic oceans and how methane release impacts the marine environment and climate system.

Highlights of 2015

March

“Write Better” - One day workshop by CAGEs communication advisor Maja Sojtaric

“Annual AMGG workshop” for students and supervisors. The purpose of the annual workshop provides the students with the opportunity to present their project and explore various aspects of the research process in a supportive environment with supervisors.

February

“Resclim Annual Meeting”. AMGG has actively participated to the ResClim annual meeting with student’s presentations and supervisors. ResClim is the Norwegian Research School in Climate Dynamics with the main objective to establish an internationally recognized research training environment for PhD candidates in climate dynamics.

April

“Present Your Science: Transforming Technical Talks Course” by Melissa Marshall from the Department of Communication Arts & Sciences at Penn State University. The course was dedicated to transform the scientific presentations skills of participants. Enable participants to utilize effective strategies for content, structure, slide design and delivery of scientific presentations. (Responsible: M. Sojtaric & G. Panieri)

“Course in ArcGis”. The course combines theoretical lectures, practical exercises and examples.

July

“AMGG school cruise” (Geo-3144/8144), chief scientist Prof. Tine Rasmussen) 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. Target area: West-Svalbard Margin focusing on Greenhouse gases in the ocean and climate change.

Activities: students received class instruction and experience in the field of Arctic research; Mini-projects to be performed in collaboration with CAGE leaders and expedition members. During the cruise, students have also compiled reports on a given topic required for evaluation subsequent to the cruise.

September

“Fluid emission fossil analogues in the Northern Apennines, Italy”. The main objectives of the field course were to get a sense of the timing of geological processes related to methane formations and expulsions; comprehend specific biological and geochemical processes strongly connected to and affected by methane seepage systems, understand various scales to interpret seismic images and realise the limitations in terms of vertical and horizontal resolution. During the five days of the field trip, the students were in the field during the day and had lecturing in the evening. Field trip guides were international top experts on important topics which were covered during the excursions. (Responsible: G. Panieri)

Activities: Students received instruction and experience in the field. During the field trip, students have compiled a presentation on a given topic required for evaluation subsequent to the field trip. During and after the field trip the students received feedback from field trip leaders on their presentations.

The students have also created a blog to document and present the outcome of the field course (can be visited at the following address: <https://factsfromthefield.wordpress.com>).

“AMGG Workshop – Greenhouse gases in the ocean and climate change” (GEO-8145). Associated workshop to the AMGG research school cruise. During the five days of the workshop, students and invited speakers, many who are world-renowned experts in their field, presented their current research and applied proxies. The workshop program



Photo: Torger Grytå

Leader: Associate professor Giuliana Panieri

Giuliana is research leader at CAGE and Associate professor in environment and climate at the Department of Geology, UiT The Arctic University of Norway. She holds a PhD degree in Paleontology, University of Modena and Reggio-Emilia, a Research Post-Doctorate, University of Bologna. She has professional experience from the University of Barcelona (Spain), the University of Oldenburg (Germany), LSU Louisiana State University (USA), ISMAR CNR (Italy), and as a micropaleontology consultant for petroleum companies. She is using micropaleontology and geochemistry to study present and past methane emissions and methane hydrate dissociations. ■

offered more than 25 hours of lectures and exercises focused on theoretical and practical applications of methods. Talks given during the meeting raised a wide range of subjects related to marine sediments and foraminiferal research. (Responsible T.L. Rasmussen, organized by K. Zamelczyk)

December

CHESS, Research School on Changing Climates in the Coupled Earth System. (duration 2015-2023) Climate change has led to an increasing demand from society on the climate research community for process understanding, improved scenarios, reduced uncertainties, and more reliable data for mitigation and impact studies. This requires a new generation of researchers that have strong in-depth knowledge in their specific parts of the climate system, but at the same time are equipped with a broader knowledge to comprehend the overall picture in the coupled Earth System. The Norwegian Research School on Changing Climates in the coupled Earth System (CHESS) is a direct response to this demand (Responsible: G. Panieri). ■

Infrastructure

Besides from deploying observatories and sensors in the Arctic Ocean (see page 30-31), we have also established two new laboratories in 2015.

A stable isotope laboratory was constructed a MAT 253 Isotope Ratio Mass Spectrometer equipped for clumped isotope measurements. This makes our laboratory one of very few in the world that can make such measurements. The lab will be a part of FARLAB, the new National Facility for Advanced Research on Light isotopes at the University of Bergen, and affiliated with the Bjerknes Center.

Also a new 2G Cryogen Magnetometer has is being installed by our partner Geological Survey of Norway (NGU) in Trondheim. The instrument will be used to date past climate and environmental changes by studying magnetic iron minerals.

Other infrastructure available at CAGE:

- The P-cable 3D seismic system
- Research Vessel Helmer Hanssen
- 3D-seismic laboratory
- Micropaleontology laboratory, including a wet lab, clean room and variety of microscopes such as three new and modern scanning electron microscopes, including a Hitachi Analytical TableTop Microscope / benchtop SEM TM3030, a ZEISS Merlin Compact VP and a Zeiss Sigma.
- XRF logging System (Avaatech XRF core scanner and a Bruker S8 Tiger XRF spectrometer). ■





| Boarding RV Helmer Hansen in Longyeabyen, Svalbard. Photo: Torger Grytå. | The new ice-going research vessel Kronprins Haakon will be an important part of infrastructures for Arctic research in Norway in the years to come. Illustration: Rolls Royce. | CAGE director Jürgen Mienert visited the new 2G Cryogen Magnetometer in Trondheim. Along side were ass. professor Giuliana Panieri, and researcher Jochen Knies. Also present, researcher Andrea Plaza Faverola. Photo: Maja Sojtaric | WHOI Tow Cam System that along with CAGE instruments was deployed in the Arctic Ocean during a cruise in May. Photo: Dan Fornari. | From the bottom: The new mass spectrometer in the stable isotope laboratory. Photo: Torger Grytå. |

Budget

Cost plan (in NOK 1000)	2015	NFR	UIT
Payroll and indirect expenses	27.895	11.649	16.246
Procurement of R&D services (NGU)	500	500	
Equipment	327	327	
Other operating expenses	27.399	9.517	34.127
Totals	56.120	21.993	34.127

Personnel

We have achieved gender equality in our scientific staff. 5 out of 7 of our work package leaders are in addition women. This is way above the average of 21 percent women in STEM fields in the OECD countries, and significantly above the average of 16 percent in Norway. More than 60 percent of our staff are PhD students and early-career scientists.

- Senior scientific staff:**
- Jürgen Mienert, professor
 - Karin Andreassen, professor.
 - Tine L. Rasmussen, professor.
 - Alun Hubbard, professor.
 - Stefan Bünz, associate professor.
 - Giuliana Panieri, associate professor
 - JoLynn Carroll, adjunct professor
 - Cathrine Lund Myhre, senior scientist.
 - Leonid Polyak, adjunct professor.
 - William Ambrose, visiting professor
 - Jens Greinert, visiting professor.
 - Helge Niemann, visiting professor.

- Researchers:**
- Michael Carroll
 - Shyam Chand
 - Karl Fabian
 - Bénédicte Ferré
 - Jochen Knies
 - Aivo Lepland
 - Andreia Plaza Faverola
 - Andreas Stohl
 - Terje Thorsnes
 - Monica Winsborrow

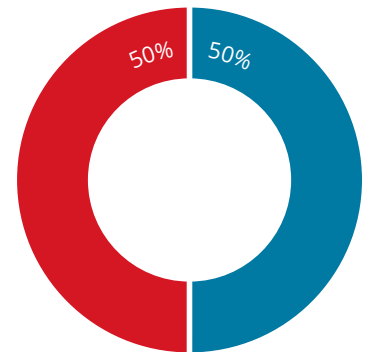
- Postdoctoral Researchers:**
- Soma Baranwal
 - Chiara Consolaro
 - Antoine Cremiere
 - Mohamed Ezat
 - Peter Franek
 - Friederike Gründger
 - Eythor Gudlaugsson
 - Wei li Hong
 - Henry Patton
 - Alexey Portnov
 - Arunima Sen
 - Anna Silyakova
 - Sunil Vadakkepuliambatta
 - Katarzyna Zamelczyk

- PhD Candidates:**
- Nikolitsa Alexandropoulou
 - Sandra Chopard
 - Mariana da Silveira Ramos Esteves
 - Pär Gunnar Jansson
 - Deniz Koseoglu
 - Katarzyna Melaniuk
 - Siri Ofstad
 - Giacomo Osti
 - Emilia Daria Piasecka
 - Simone Sauer
 - Andrea Schneider
 - Pavel Serov
 - Calvin Shackleton
 - Sunny Singhroha
 - Kamila Szybor
 - Alexandros Tasianas
 - Kärt Üpraus
 - Malin Waage
 - Kate Waghorn
 - Haoyi Yao
 - Emmelie Åström

- Administrative and technical staff:**
- Gabrielsen Mikalsen, Lill-Iren, executive officer
 - Lindgren, Matteus, engineer
 - Sarti, Fabio, Data manager
 - Sojtaric, Maja, communications coordinator
 - Winther, Tonje Merete Moe, executive officer



Staff and gender



Gender

CAGE supervised Master students:

Olga Agafonova, Erna Ósk Arnardóttir, Kirsti Bjørnøya, Karianne Drage, Anders Edvardsen, Vårin Trælvik Eilertsen, Eira Triguero Enguidanos, Linda Gabrielsen, Anna Maria Hatland, Karianne Heimdal, Monica Hultin, Frank Werner Jakobsen, Björg Jónsdóttir, Nils Karlsen, Håkan Karlsten, Christine Kollsgård, Boriss Kovalenko, Adrian Lium-Wickler, Christine Joanne Lockwood, Lena Mathisen, Lisa Mathisen, Håkon Mikalsen, Karoline Myrvang, Janita Nordahl, Renate Strugstad Paulsen, Thomas Rochmann, Rowan Peter Romeyn, Silje Røde, Daniel Adhanon Tesfamariam, Yohannes Tesfay, Vårin Trælvik Eilertsen, Lasse Aase Tønnessen, Carita E. Eira Varjola, Mariann Vestgård, Robert Virs, Ingvild Westvig.

Collaborations

CAGE is collaborating on different levels with several national and international research institutions and offshore industries.

National Collaboration:

Institute for Energy Technology (IFE), Kjeller
 Center for Earth Evolution and Dynamics (CEED), University of Oslo
 Centre for Autonomous Marine Operations and Systems (AMOS)
 Department of Arctic Marine Biology, UiT The Arctic University of Norway
 The University Centre in Svalbard (UNIS)
 Norwegian Defence Research
 Centre for Geobiology (CBG), University of Bergen
 Centre for Autonomous Marine Operations and Systems (AMOS), NTNU
 Institute of Marine Research

Other:

Norwegian Petroleum Directorate
 Statoil
 P-Cable AS and VBPR AS, Oslo
 NORSAR AS, Kjeller
 Lundin, Norway
 DEA-Group Norway
 Akvaplan-niva
 Kongsberg Maritime
 NILU

International collaboration:

National Oceanographic Centre (NOC), UK
 Heriott-Watt University, Edinburgh, UK
 British Geological Survey, UK
 Durham University, UK
 Natural History Museum of Wales, UK
 Isotope geosciences laboratory, NERC, UK
 University of Cambridge, UK
 University College London, UK
 Royal Holloway University of London, UK
 Facility for Airborne Atmospheric Measurements (FAAM), University of Cambridge, UK
 University of Manchester, UK
 University of St. Andrews, Scotland, UK
 Byrd Polar Research Center, USA
 College of Earth, Ocean, and Atmospheric Sciences (CEOAS), Oregon State University, USA
 School of Oceanography, University of Washington, USA
 Department of Earth Sciences, Indiana University, USA
 Purdue University, Indianapolis, USA

Bates College, USA
 Woods Hole Oceanographic Institute, USA
 University of New Hampshire, USA
 Southern Methodist University, Texas USA
 United States Geological Survey (USGS) USA
 Columbia University, USA
 GEOMAR, Kiel, Germany
 Alfred Wegener Institute, Germany
 MARUM, University of Bremen, Germany
 German research centre for geosciences (GFZ), Potsdam, Germany
 Max Planck Institute for Microbiology, Germany
 University of Victoria, Canada
 NEPTUNE, Canada
 McGill University, Montreal, Canada
 French Research Institute for Exploitation of the Sea (IFREMER), France
 LGGE, Laboratoire de Glaciologie et Geophysique de l'Environnement, France
 LSCE: Laboratoire des Sciences du Climat et de l'Environnement, France
 Moscow State University, Russia
 P.P. Shirshov Institute of Oceanology, Russia
 Department of sedimentology, St. Petersburg State University, Russia
 University of Basel, Switzerland
 EAWAG Aquatic Research, Switzerland
 Swiss Federal Institute of Technology, ETH, Switzerland
 National Institute of Geophysics and Volcanology, (INGV) Italy
 National institute of oceanography and geophysics, (OGS) Italy
 University of Liege, Belgium
 Hokkaido University, Japan
 GNS Science, Wellington, New Zealand

International Programs and Networks:

ICDP: International Continental Scientific Drilling Program
 IODP: International Ocean Discovery Program
 ICOS: Integrated Carbon Observation System
 ACTRIS: Aerosols, Clouds, and Trace Gases Research Infrastructure Network
 ENVRIPLUS: Environmental and Earth System Research Infrastructures
 FIXO3:

Arctic Ocean preparations in search for the oldest ice in Antarctica

A CAGE – cruise to the Arctic Ocean was the ideal place to test and proof the performance of a new instrument that will be used in search of the oldest ice in Antarctica.

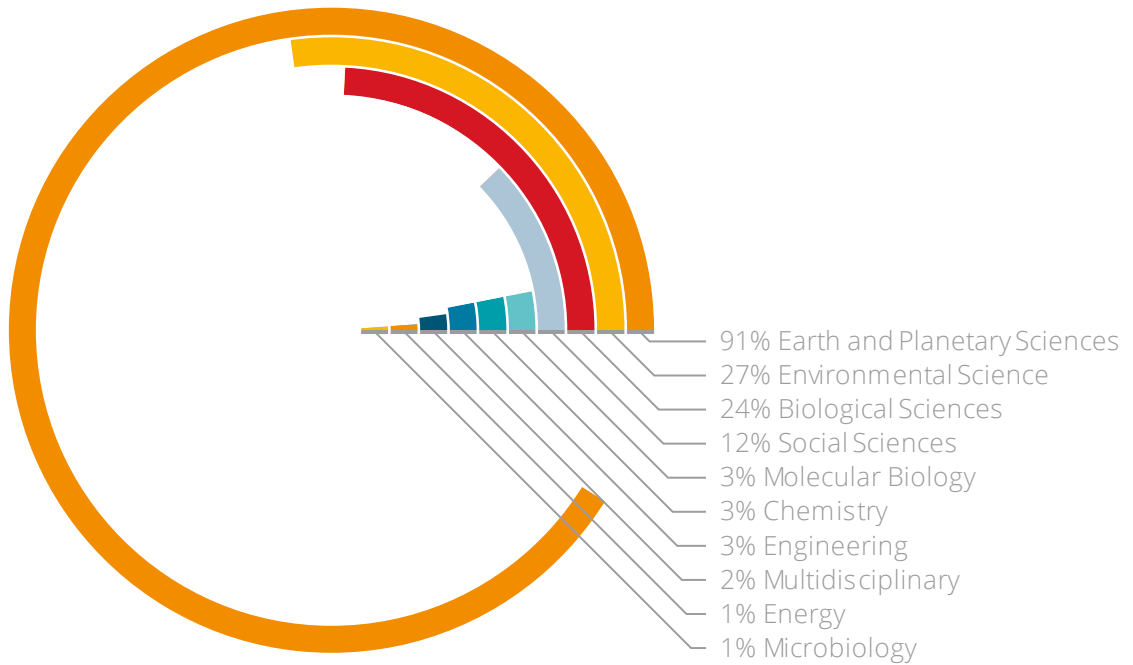
Ice cores are spectacular records of past climate change because they contain traces of climate gases, such as methane. Most spectrometers that perform these measurements are bulky and usually installed in laboratories. A team from CNRS in Grenoble, France has now developed a compact laser spectrometer and gas extraction system, which, linked together, can do very fast and precise measurements.

The instrument was tested in the Arctic Ocean in collaboration with CAGE during our October cruise in 2015.

The results from the Arctic Ocean campaign will be published early this year. “Exciting developments”, say Directeur de Recherche at CNRS Jerome Chappelard and the director of CAGE Jürgen Mienert. ■

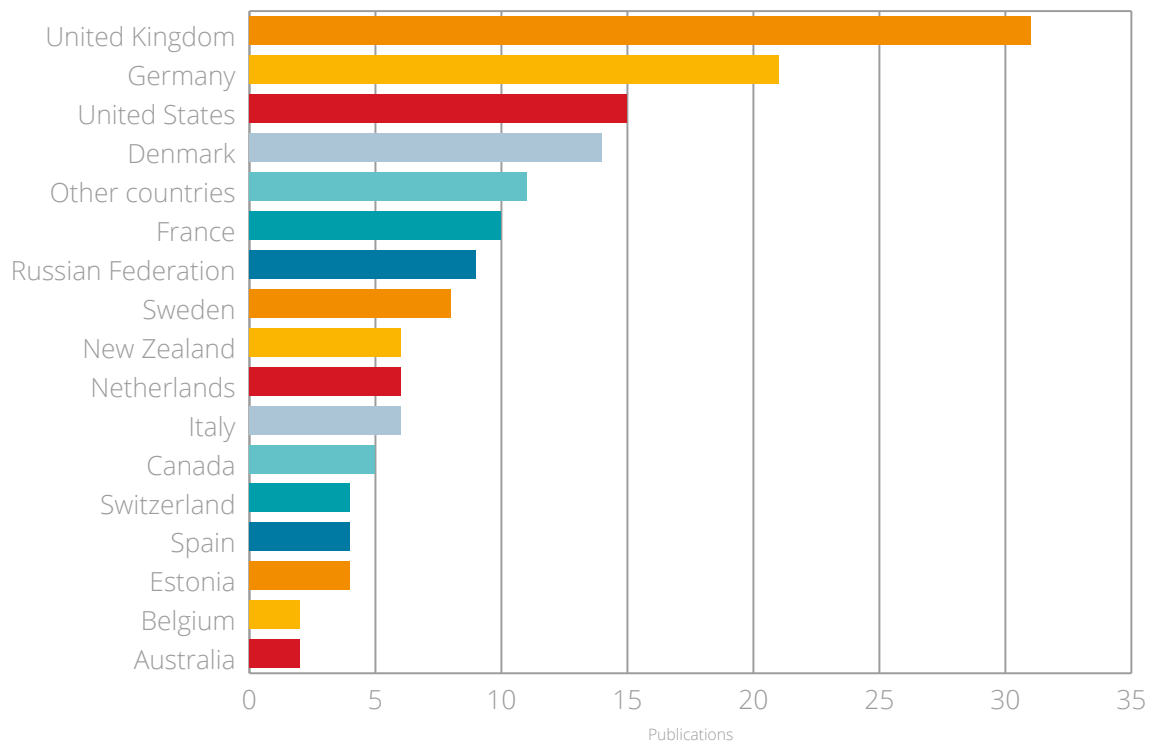
Subject area, publications

Source: Scopus



International collaborations on publications (2013 to present)

Source: Scopus



Publications

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2. **Belt, S. T., Cabedo-Sanz, P., Smik, L., Navarro-Rodriguez, A., Berben, S. M. P., Knies, J., Husum, K.** *Identification of paleo Arctic winter sea ice limits and the marginal ice zone: Optimised biomarker-based reconstructions of late Quaternary Arctic sea ice.* *Earth and Planetary Science Letters*, 2015 (0012-821X) 431 p. 127-139
3. **Boulton, S. J., Smart, C. W., Consolaro, C., Snider, A.** *The Miocene-Pliocene boundary and the Messinian Salinity Crisis in the easternmost Mediterranean: Insights from the Hatay Graben (Southern Turkey).* *Sedimentary Geology*, 2015 (0037-0738) 332 p. 51-67
4. **Bøe, R., Skarðhamar, J., Rise, L., Dolan, M. F. J., Bellec, V. K., Winsborrow, M., Skagseth, Ø., Knies, J., King, E. L., Walderhaug, O., Chand, S., Buenz, S., Mienert, J.** *Sandwaves and sand transport on the Barents Sea continental slope offshore northern Norway.* *Marine and Petroleum Geology*, 2015 (0264-8172) 60 p. 34-53
5. **Carrasco-Navarro, V., Jæger, I., Honkanen, J. O., Kukkonen, J. V. K., Carroll, J., Camus, L.** *Bioconcentration, biotransformation and elimination of pyrene in the arctic crustacean Gammarus setosus (Amphipoda) at two temperatures.* *Marine Environmental Research*, 2015 (0141-1136) 110 p. 101-109
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7. **Chauhan, T., Noormets, R., Rasmussen, T. L.** *Glaciomarine sedimentation and bottom current activity on the north-western and northern continental margin of Svalbard during the late Quaternary.* *Geo-Marine Letters*, 2015 (0276-0460) p. 19
8. **Cook, J., Edwards, A., Hubbard, A. L.** *Biocryomorology: integrating microbial processes with ice surface hydrology, topography and roughness.* *Frontiers in Earth Science*, 2015 (2296-6463) 3(78) p. 6
9. **Dijkstra, N., Junttila, J., Husum, K., Carroll, J., Hald, M.** *Natural variability of benthic foraminiferal assemblages and metal concentrations during the last 150 years in the Ingøydjupet trough, SW Barents Sea.* *Marine Micropaleontology*, 2015 (0377-8398) 121 p. 16-31
10. **Doyle, S. H., Hubbard, A., van de Wal, R. S. W., Box, J. E., van As, D., Scharer, K., Meierbachtol, T. W., Smeets, P. C. J. P., Harper, J. T., Johansson, E., Mottram, R. H., Mikkelsen, A. B., Wilhelms, F., Patton, H., Christoffersen, P., Hubbard, B.** *Amplified melt and flow of the Greenland ice sheet driven by late-summer cyclonic rainfall.* *Nature Geoscience*, 2015 (1752-0894) 8(8) p. 647-653
11. **Findlay, H. S., Gibson, G., Kędra, M., Morata, N., Orchowska, M., Pavlov, A. K., Reigstad, M., Silyakova, A., Tremblay, J.-É., Walczowski, W., Weydmann, A., Logvinova, C.** *Responses in Arctic marine carbon cycle processes: conceptual scenarios and implications for ecosystem function.* *Polar Research*, 2015 (1751-8369) p.
12. **Forwick, M., Laberg, J. S., Hass, H. C., Osti, G.** *The Kongsfjorden Channel System offshore NW Svalbard: downslope sedimentary processes in a contour-current dominated setting.* *arktos The Journal of Arctic Geosciences*, 2015 (2364-9453) 1(1) p. 1-17
13. **Griggs, A. J., Davies, S. M., Abbott, P. M., Coleman, M., Palmer, A. P., Rasmussen, T. L., Johnston, R.** *Visualizing tephra deposits and sedimentary processes in the marine environment: the potential of X-ray microtomography.* *Geochemistry, Geophysics, Geosystems*, 2015 (1525-2027) 16 p. 4329-4343
14. **Gruendger, F., Jiménez, N., Thielemann, T., Straaten, N., Lüders, T., Richnow, H. H., Krüger, M.** *Microbial methane formation in deep aquifers of a coal-bearing sedimentary basin, Germany.* *Frontiers in Microbiology*, 2015 (1664-302X) 6 p.
15. **Jessen, S. P., Rasmussen, T. L.** *Sortable silt cycles in Svalbard slope sediments 74-0 ka.* *Journal of Quaternary Science*, 2015 (1099-1417) 30(8) p. 743-753
16. **Johnson, J. E., Mienert, J., Plaza-Faverola, A., Vadakkepuliambatta, S., Knies, J., Bünz, S., Andreassen, K., Ferré, B.** *Abiotic methane from ultraslow-spreading ridges can charge Arctic gas hydrates.* *Geology*, 2015 (0091-7613) 43(5) p. 371-374
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26. **Pathirana, I., Knies, J., Felix, M., Mann, U., Ellingsen, I.** *Middle to late Holocene paleoproductivity reconstructions for the western Barents Sea: a model-data comparison.* *arktos The Journal of Arctic Geosciences*, 2015 (2364-9453) 1(1) p. 1-17
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41. Veloso, M., Greinert, J., Mienert, J., De Batist, M. *A new methodology for quantifying bubble flow rates in deep water using splitbeam echosounders: Examples from the Arctic offshore NW-Svalbard*. Limnology and Oceanography: Methods, 2015 (1541-5856) 13(6) p. 267-287 ■

Presentations, abstracts, posters

- Andreassen, K. *Methane-leaking craters in the Arctic*. Presentation at Burst. Seminar ved Kunst og Designhøyskolen, Cinemateket, Bergen 17. oktober 2015.
- Alexandropoulou, N., Andreassen, K., Winsborrow, M., Faleide, J. I., Nystuen, J. P. Poster. *Late Cenozoic evolution of the western Barents Sea-Svalbard continental margin. Case study: Upper Bjørnøya Fan, western Barents Sea margin*. International Conference on Arctic Margins, 2015-06-02 - 2015-06-05, Trondheim, Norway
- Alexandropoulou, N., Andreassen, K., Winsborrow, M. Oral presentation. *Late Cenozoic evolution of the western Barents Sea - Svalbard continental margin. Case study: Upper Bjørnøya Fan, western Barents Sea margin*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Ambrose, W., Panieri, G., Schneider, A., Plaza-Faverola, A., Carroll, M. L., Åström, E., Locke, W., Carroll, J. Poster. *Bivalve Shell Horizons in Seafloor Pockmarks of the Last Glacial-interglacial Transition Suggest a Thousand Years of Methane Emissions in the Arctic Ocean*. AGU Fall Meeting 2015, 2015-12-14 - 2015-12-19, San Francisco, USA
- Ambrose, W., Panieri, G., Schneider, A., Carroll, M., Åström, E. K. L., Svenning, M. M., Plaza-Faverola, A., Locke, W. Oral presentation. *Reconstructing millennial-scale methane emission history from in situ core profiles of carbonate-bearing organisms and bacteria in the high Arctic*. The 44th Annual Benthic Ecology Meeting, 2015-03-04 - 2015-03-07, Quebec City, Canada
- Andreassen, K., Bjarnadóttir, L. R., Winsborrow, M., Patton, H., Hubbard, A. L. Poster. *Patterns of past ice-sheet flow in the Barents Sea*. International Conference on Arctic Margins, 2015-06-02 - 2015-06-05, Trondheim, Norway
- Andreassen, K., Plaza-Faverola, A., Winsborrow, M., Deryabin, A., Mattingsdal, R., Vadakkepuliambatta, S., Serov, P., Mienert, J., Büinz, S. Oral presentation. *Pingos, craters and methane-leaking seafloor in the central Barents Sea: signals of decomposing gas hydrate releasing gas from deeper hydrocarbon reservoirs?*. AGU Fall Meeting 2015, 2015-12-14 - 2015-12-19, San Francisco, USA
- Andreassen, K., Winsborrow, M., Hubbard, A. L., Patton, H., Bjarnadóttir, L. R., Rütther, D. C., Auriac, A. Oral presentation. *Retreat patterns of the former Bjørnøyrenna Ice Stream, polar north Atlantic*. International Union for Quaternary Research Congress, 2015-07-26 - 2015-08-02, Nagoya, Japan
- Andreassen, K. Poster. *The role of ice ages for fluid flow and methane hydrate*. CAGE - Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Auriac, A., Whitehouse, P. L., Bentley, M. J., Patton, H., Hubbard, A. L., Lloyd, J. M. Oral presentation. *Modelling of glacial isostatic adjustment in the Barents Sea region: Earthrheology inferred from various ice load scenarios for the last glacial cycle*. EGU General Assembly 2015, 2015-04-12 - 2015-04-17, Vienna, Austria
- Baranwal, S., Knies, J., Sauer, S. Oral presentation. *Foraminiferal communities of hydrocarbon seeps from the continental shelf offshore Vesterålen, Northern Norway*. International Conference on Arctic Margins, 2015-06-02 - 2015-06-05, Trondheim, Norway
- Bjarnadóttir, L. R., Winsborrow, M., Andreassen, K., Esteves, M. d. S. R., Shackleton, C. Oral presentation. *The influence of subglacial hydrology on glacial dynamics*. PAST Gateways, 2015-05-18 - 2015-05-22,

- Bjarnadóttir, L. R., Winsborrow, M., Andreassen, K.** Oral presentation. *Subglacial hydrology of the marine-based Barents Sea Ice Sheet during deglaciation*. International Union for Quaternary Research Congress, 2015-07-26 - 2015-08-02, Nagoya, Japan
- Brader, M. D., Lloyd, M. J., Bentley, M. J., Barlow, N. L. M., Newton, A. J., Patton, H., Spada, G., Hubbard, A. L.** Poster. *Postglacial relative sea-level change and the deglaciation of northwest Iceland*. UK Sea Level Science Meeting, 2015-03-12 - 2015-03-13, Liverpool, United Kingdom
- Brough, S., Hubbard, A. L., Hubbard, B.** Poster. *Reconstructing Glaciers on Mars*. AGU Fall Meeting 2015, 2015-12-14 - 2015-12-18, San Francisco, USA
- Bünz, S.** Poster. *Sub seabed reservoirs – Methane hydrate and free gas reservoirs*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Carroll, J.** Poster. *Seabed – Methane release and benthic faunal response*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Carroll, J.** Oral presentation. *Seabed methane release and benthic faunal response in Arctic Ocean environments*. Advisory Board Meeting, 2015-01-20, Tromsø, Norway
- Carroll, M., Svenning, M. M., Panieri, G., Søreide, J., Ambrose, W., Åström, E. K. L., Gründger, F., Tøsdal, T. A., Starrlight, A., Damm, E., Graeve, M., Hong, W.-L., Jager, T., Carroll, J.** Invited talk. *Methane and climate change: Exploring the impacts on seabed ecology in Svalbard*. Arctic Frontiers 2015, 2015-01-18 - 2015-01-23, Tromsø, Norway
- Chand, S., Bünz, S.** Oral presentation. *The visco-elastic AVO signature of gas hydrates*. Lofoten seminar 2015, 2015-04-14 - 2015-04-17, Svalbard, Norway
- Chopard, S., White, J., Marchant, B., Chadwick, A., Bünz, S., Mienert, J.** Oral presentation. *CO₂ leakage detection and quantification using time-lapse P-Cable seismic datasets: a case study from the Snøhvit field*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Christoffersen, P., Doyle, S., Hubbard, B., Young, T. J., Hofstede, C., Box, J., Todd, J., Bougamont, M., Hubbard, A. L.** Poster. *Preliminary results from hot-water drilling and borehole instrumentation on Store Glacier, West Greenland*. AGU Fall Meeting 2015, 2015-12-14 - 2015-12-18, San Francisco, USA
- Christoffersen, P., Hubbard, B., Doyle, S., Young, T. J., Hofstede, C., Bougamont, M., Todd, J., Toberg, N., Nicholls, K., Box, J., Walter, J. I., Hubbard, A. L.** Oral presentation. *The Subglacial Access and Fast Ice Research Experiment – SAFIRE – on Store Glacier, West Greenland*. AGU Fall Meeting 2015, 2015-12-14 - 2015-12-18, San Francisco, USA
- Consolaro, C., Rasmussen, T. L.** Oral presentation. *Benthonic and planktonic foraminifera of the last 14 ka from a pockmark field on the Vestnesa Ridge, eastern Fram Strait*. The Micropalaeontological Society. Foraminifera and Calcareous Nannofossil Groups, Spring Meeting, 2015-06-14 - 2015-06-18, Plymouth, United Kingdom
- Consolaro, C., Rasmussen, T. L.** Oral presentation. *Carbon isotope excursions and palaeoceanographic evolution of the eastern Fram Strait in the last 14 kyr*. CRES conference, 2015-11-18 - 2015-11-18, Plymouth, United Kingdom
- Consolaro, C., Hart, M., Smart, C.** Oral presentation. *The Holocene separation of Jersey from France: the microfossil evidence*. The Micropalaeontological Society, Foraminifera and Calcareous Nannofossil Groups, Spring Meeting, 2015-06-14 - 2015-06-18, Plymouth, United Kingdom
- Consolaro, C.** Oral presentation. *The use of foraminifera to study methane emissions: an example from the last 14 kyr in the Vestnesa Ridge (NW Svalbard)*. AMGG Research School Workshop, Greenhouse Gases in the Ocean and climate change, 2015-09-21 - 2015-09-25, Tromsø, Norway
- Cremiere, A., Wing, B. A., Bui, T. H., Prince, J., Lepland, A., Brunstad, H., Thorsnes, T.** Oral presentation. *Sulfur isotope records of microbial sulfate reduction in cold seep carbonates*. Goldschmidt Conference 2015, 2015-08-16 - 2015-08-21, Prague, Czech
- Cremiere, A.** Oral presentation. *Timescales of methane seepage on the Norwegian margin following collapse of the Scandinavian Ice Sheet*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Dijkstra, N., Juntila, J., Husum, K., Carroll, J., Hald, M.** Oral presentation. *Natural variability of benthic foraminiferal assemblages and metal concentrations in the Ingøydjupet trough, SW Barents Sea*. Arctic Workshop 2015, 2015-05-10 - 2015-05-13, Bergen, Norway
- Doyle, S., Hubbard, A. L.** Poster. *Will ice flow in land-terminating regions of the Greenland ice sheet accelerate under future climate warming?*. AGU Fall Meeting 2015, 2015-12-14 - 2015-12-19, San Francisco, USA
- Esteves, M. d. S. R., Bjarnadóttir, L. R., Rütther, D. C., Winsborrow, M., Andreassen, K.** Poster. *Potential subglacial basins in the Central Barents Sea; implications on the dynamics and retreat patterns of Sentralbanken*. International Symposium on the Hydrology of Glaciers and Ice Sheets, 2015-06-21 - 2015-06-27, Höfn in Hornafjörður, Iceland
- Esteves, M. d. S. R., Bjarnadóttir, L. R., Rütther, D., Winsborrow, M., Andreassen, K.** Oral presentation. *Potential subglacial basins in the Central Barents Sea; implications on the dynamics and retreat patterns of Sentralbankrenna*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Franek, P., Mienert, J., Bünz, S.** Oral presentation. *Long-term deployment of the OBS on West Svalbard continental shelf*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Franek, P.** Oral presentation. *Microseismicity at the MASOX site and 2015 OBS array deployment at Vestnesa*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Greinert, J., Pohlman, J., Silyakova, A., Mienert, J., Ruppel, C., Casso, M.** Poster. *Atmospheric methane emissions coupled to a CO₂-sink at an Arctic shelf seep area offshore NW Svalbard: Introducing the “Seep-Fertilization Hypothesis”*. EGU General Assembly 2015, 2015-04-12 - 2015-04-17, Vienna, Austria
- Gründger, F.** Oral presentation. *Microbial activity at Arctic methane seeps*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Grosfeld, K., De Schepper, S., Fabian, K., Husum, K., Baranwal, S., Andreassen, K., Knies, J.** Poster. *New age constraints and palaeo-environmental reconstruction of the sediments around the Miocene/Pliocene boundary in Yermak Plateau ODP Hole 911A using marine palynology*. Norsk Geologisk Forening Vinterkonferansen 2015, 2015-01-12 - 2015-01-14, Stavanger, Norway
- Grosfeld, K., Eidvin, T., Knies, J., Riis, F.** Poster. *New age constraints of the Molo Formation on the central mid-Norwegian Margin*. Norsk Geologisk Forening Vinterkonferansen 2015, 2015-01-12 - 2015-01-14, Stavanger, Norway
- Hoff, U., Rasmussen, T. L., Ezat, M.** Oral presentation. *Subarctic marine diatom assemblages off the Faroe Islands – warm vs. cold*. 5th Polar Marine Diatom Taxonomy and Ecology Workshop, 2015-07-16 - 2015-07-24, Salamanca, Spain
- Hong, W.-L., Panieri, G., Sauer, S., Plaza-Faverola, A., Schneider, A., Ambrose, W.** Oral presentation. *Elevated pockmark activity along eastern Vestnesa Ridge for the past <5 centuries*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Hong, W.-L.** Oral presentation. *Methane removal, fluid, gas hydrate and life*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Hubbard, A. L., Chauche, N.** Invited talk. *Partitioning of Submarine Melt and Calving across the front of Store Glacier, Greenland*. AGU Fall Meeting 2015, 2015-12-14 - 2015-12-18, San Francisco, USA
- Hubbard, A. L., Ryan, J., Toberg, N., Todd, J., Christoffersen, P., Snooke, N., Box, J.** Oral presentation. *Tidewater Dynamics at Store Glacier, West*

- Greenland from Daily Repeat UAV Survey. AGU Fall Meeting 2015, 2015-12-14 - 2015-12-18, San Francisco, USA
- Jansson, P.** Oral presentation. *Geochemistry and fluxes of cold seeps*. AMGG Research School Workshop, Greenhouse Gases in the Ocean and climate change, 2015-09-21 - 2015-09-25, Tromsø, Norway
- Jansson, P., Ferré, B., Silyakova, A., Greinert, J., Mienert, J.** Oral presentation. *Hydroacoustic quantification of seafloor methane release on the North Western Svalbard shelf*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Jansson, P., Ferré, B., Silyakova, A., Veloso, M., Greinert, J.** Poster. *Ocean floor methane seeps in north-western Svalbard - a snapshot of the oceanography and benthic methane release*. Arctic Frontiers 2015, 2015-01-18 - 2015-01-23, Tromsø, Norway
- Jansson, P.** Oral presentation. *Variability of free gas emissions inferred from repeated hydroacoustic surveys on the Arctic shelf margin west of Svalbard*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Jernas, P. E., Kuhn, G., Hillenbrand, C.-D., Forwick, M., Rasmussen, T. L., Mackensen, A., Schröder, M., Smith, J., Klages, J. P.** Poster. *Modern foraminifera assemblages in the Amundsen Sea Embayment*. Norsk Geologisk Forening Vinterkonferansen 2015, 2015-01-12 - 2015-01-14, Stavanger, Norway
- Knies, J., Daszinnies, M., Mattingsdal, R., Chand, S., Plaza-Faverola, A., Bünz, S., Mienert, J.** Oral presentation. *Finding the source for hydrocarbon leakage on the Vestnesa Ridge, NW Svalbard*. AAPG 3PArctic Conference & EXhibition, 2015-09-29 - 2015-10-02, Stavanger, Norway
- Knies, J.** Poster. *Paleo Methane History: Neogene to Pleistocene*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Knies, J.** Oral presentation. *Paleoproductivity and inferences on organic carbon storage and basin reconstructions*. AMGG Research School Workshop, Greenhouse Gases in the Ocean and climate change, 2015-09-21 - 2015-09-25, Tromsø, Norway
- Knies, J.** Oral presentation. *Paleoproductivity reconstruction from marine organic carbon burial; Examples from the high latitudes*. AMGG Research School Workshop, Greenhouse Gases in the Ocean and climate change, 2015-09-21 - 2015-09-25, Tromsø, Norway
- Knutsen, T., Hultin, M., Vatne, B., Rütther, W., Andreassen, K.** Poster. *Deglacial and Holocene sedimentology in Northern Bjørnøyrenna, Barents Sea*. Norsk Geologisk Forening Vinterkonferansen 2015, 2015-01-12 - 2015-01-14, Stavanger, Norway
- Mienert, J., Andreassen, K., Bünz, S., Carroll, J., Ferré, B., Knies, J., Panieri, G., Rasmussen, T. L., Myhre, C. L.** Poster. *Arctic Gas hydrate, Environment and Climate*. EGU General Assembly 2015, 2015-04-12 - 2015-04-17, Vienna, Austria
- Mienert, J. Invited talk.** *Arctic Gas Hydrate, what are they, and why do we care?*. Ambassadors visit to UiT, 2015-06-03, Tromsø, Norway
- Mienert, J. Invited talk.** *Arctic Gas Hydrates – Are They Melting And Are Methane Emissions On The Rise?*. Polar Gordon Research Conference - Session on Carbon Cycling In Antarctic And Arctic Shelves, 2015-03-15 - 2015-03-20, Barga, Italy
- Mienert, J.** Oral presentation. *Arctic Gas Hydrates – Greenhouse gas emissions from the Arctic Ocean*. Nasjonalt geofagråd, 2015-04-28, Tromsø, Norway
- Mienert, J., Andreassen, K., Myhre, C. L., Panieri, G., Portnov, A. D., Bünz, S. Invited talk.** *Arctic Warming: Greenhouse gas methane releases on the rise?*. Arctic Frontiers 2015. Part I. Arctic climate change – global implications: Greenhouse gas emissions in the Arctic., 2015-01-18 - 2015-01-23, Tromsø, Norway
- Mienert, J.** Oral presentation. *A Centre of Excellence – CAGE – Centre for Arctic Gas Hydrate, Environment and Climate*. Fakultet for naturvitenskap og teknologi, Fakultetsstyremøtet, 2015-02-11, Tromsø, Norway
- Mienert, J.** Oral presentation. *Metanis i Arktis - en kilde til global oppvarming eller til fremtidens ukonvensjonelle energi?*. Gjenreinsningsmuseet, 2015-11-20, Hammerfest, Norway
- Mienert, J.** Oral presentation. *Metanis i Arktis - en kilde til global oppvarming eller til fremtidens ukonvensjonelle energi?*. Kulturhuset, Forum, 2015-11-14 - 2015-11-14, Tromsø, Norway
- Mienert, J., Stohl, A., Myhre, G.** Oral presentation. *Understanding of present and future methane release from the ocean*. MOCA 2nd general meeting, 2015-02-04, Tromsø, Norway
- Mohamed, E., Rasmussen, T. L., Honiesch, B., Olsen, J., Groeneveld, J.** Oral presentation. *A 135kyr record of near-surface pCO₂, ventilation and nutrient utilization levels from the south-eastern Nordic seas*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Mohamed, E.** Oral presentation. *A 140 kyr record of near-surface pCO₂, ventilation and nutrient levels from the southeastern Nordic seas*. Resclim annual meeting, 2015-03-05, Hurtigruten, Norway
- Myhre, C. L.** Poster. *Atmosphere*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Myhre, C. L.** Oral presentation. *CH₄ in the atmosphere: Status of joint MOCA-CAGE measurements in 2015, and plans for 2016*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Nomura, D., Granskog, M. A., Fransson, A., Silyakova, A., Hudson, S., Chierici, M., Assmy, P., Delille, B., Kotovitch, M., Dieckmann, G. S., Steen, H.** Poster. *Mid-winter freeze experiment in the Arctic Ocean: Norwegian Young sea ICE cruise (N-ICE2015)*. Arctic Science Summit Week, 2015-04-23 - 2015-04-30, Toyama, Japan
- Osti, G., Mienert, J., Laberg, J. S., Bünz, S.** Oral presentation. *Multiple Slope Failures at the Spitsbergen Fault Zone and Evidences for Gas Hydrates*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Panieri, G. Invited talk.** *Arctic climate and methane emissions. Emerging Leaders - for the Arctic challenge*. Arctic Frontiers, 2015-01-14 - 2015-01-20, Tromsø, Norway
- Panieri, G. Invited talk.** *CAGE, The Center of Excellence for Arctic Gas Hydrate, Environment and Climate: special focus on Climate and Environment*. Energy, climate, environment, engineering and safety. Finland network program, 2015-10-09, Tromsø, Norway
- Panieri, G.** Oral presentation. *Foraminifera and seepage of methane: examples from the past*. AMGG Research School Workshop, Greenhouse Gases in the Ocean and climate change, 2015-09-21 - 2015-09-25, Tromsø, Norway
- Panieri, G., Leland, A., Graves, C., Schneider, A., Consolaro, C., Hong, W.-L., James, R., Mienert, J.** Oral presentation. *Fossil bioarchives to discover and track methane releases in the Arctic*. 7th International Conference on Arctic Margins, 2015-06-02 - 2015-06-05, Trondheim, Norway
- Panieri, G., Rasmussen, T. L., Consolaro, C., Schneider, A., Szybor, K., Zamelczyk, K.** Oral presentation. *Methane emissions in the Arctic Ocean: from the past to the future*. Arctic Frontiers 2015. Part I. Arctic climate change – global implications: Greenhouse gas emissions in the Arctic., 2015-01-18 - 2015-01-23, Tromsø, Norway
- Panieri, G.** Poster. *Pleistocene to Present: Ocean acidification and CO₂*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Panieri, G., Mienert, J., Fornari, D., Torres, M., Leland, A. Invited talk.** *Reconstructing Methane Emission Events in the Arctic Ocean: Observations from the Past to Present*. AGU Fall Meeting 2015, 2015-12-14 - 2015-12-18, San Francisco, USA
- Panieri, G.** Oral presentation. *Research School*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Patton, H.** Oral presentation. *Modelling the Eurasian Ice Sheet Complex during the Late Weichselian*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway

- Patton, H., Andreassen, K., Winsborrow, M., Auriac, A., Hubbard, A. L.** Oral presentation. *Numerically modelling extensive glaciation of the Eurasian Arctic*. International Conference on Arctic Margins, 2015-06-02 - 2015-06-05, Trondheim, Norway
- Patton, H., Andreassen, K., Winsborrow, M., Auriac, A., Hubbard, A. L.** Oral presentation. *Numerically modelling glaciation in the Barents and Kara Sea*. International Union for Quaternary Research Congress, 2015-07-26 - 2015-08-02, Nagoya, Japan
- Patton, H., Andreassen, K., Winsborrow, M., Hubbard, A. L.** Oral presentation. *Numerically modelling glaciation of the Barents-Kara seas*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Patton, H., Andreassen, K., Winsborrow, M., Auriac, A., Hubbard, A. L.** Poster. *Numerically modelling the growth and collapse of the Barents Sea ice sheet*. PAST Gateways, 2015-05-18 - 2015-05-22, Potsdam, Germany
- Piasecka, E. D., Andreassen, K., Winsborrow, M., Stokes, C. R.** Oral presentation. *Reconstructing the retreat dynamics of the Bjørnøyrenna Ice Stream based on 3D seismic geomorphology from the Central Barents Sea*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Piasecka, E. D., Andreassen, K., Winsborrow, M., Stokes, C. R.** Poster. *Reconstructing the retreat dynamics of the Bjørnøyrenna Ice Stream based on 3D seismic geomorphology from the central Barents Sea*. International Union for Quaternary Research Congress, 2015-07-26 - 2015-08-02, Nagoya, Japan
- Pini, G. A., Strasser, M., Boschetti, A., di Blasi, F., Ogata, K., Panieri, G., Festa, A.** Oral presentation. *Large-scale Mass Transport Deposit in a Satellite Basin of the Nankai Accretionary Wedge: Internal Features and Depositional Mechanisms*. 7th international symposium on Submarine Mass Movements and Their Consequences, 2015-11-01 - 2015-11-04, Wellington, New Zealand
- Platt, S., Hermansen, O., Schmidbauer, J. N., Pisso, I., Silyakova, A., Ferré, B., Lowry, D., Percival, C., Mienert, J., Myhre, C. L.** Poster. *Methane Emissions from the Arctic Ocean to the Atmosphere*. EGU General Assembly 2015, 2015-04-12 - 2015-04-17, Vienna, Austria
- Plaza-Faverola, A., Vadakkepuliambatta, S., Waghorn, K. A., Johnson, J., Mienert, J., Büinz, S.** Oral presentation. *The carbon potential of Vestnesa Ridge: a hydrate system close to the oceanic ridges of Fram Strait*. International Conference on Arctic Margins, 2015-06-02 - 2015-06-05, Trondheim, Norway
- Plaza-Faverola, A., Vadakkepuliambatta, S., Büinz, S., Mienert, J., Waghorn, K. A., Wei-Li, H., Chand, S., Greinert, J.** Oral presentation. *Dynamics of the 100 km long thermogenic gas hydrate system at Vestnesa Ridge, offshore west-Svalbard*. Lofoten seminar 2015, 2015-04-14 - 2015-04-17, Svalbard, Norway
- Plaza-Faverola, A.** Oral presentation. *High resolution 3D seismic studies of gas hydrate systems*. Japan Scientists visit to CAGE, 2015-03-17, Tromsø, Norway
- Pohlman, J., Greinert, J., Ruppel, C., Silyakova, A., Vielstadte, L., Magen, C., Casso, M., Büinz, S., Mienert, J.** Oral presentation. *Simultaneous quantification of methane and carbon dioxide fluxes reveals that a shallow arctic methane seep is a net sink for greenhouse gases*. AGU Fall Meeting 2015, 2015-12-14 - 2015-12-19, San Francisco, USA
- Portnov, A. D., Vadakkepuliambatta, S., Mienert, J., Hubbard, A. L.** Oral presentation. *Arctic methane Storage and release across a formerly glaciated polar margin*. International Conference on Arctic Margins, 2015-06-02 - 2015-06-05, Trondheim, Norway
- Portnov, A. D., Vadakkepuliambatta, S., Mienert, J., Hubbard, A. L.** Oral presentation. *Arctic methane storage during LGM and methane release across a formerly glaciated margin*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Portnov, A. D., Mienert, J., Serov, P.** Oral presentation. *Climate-sensitive subsea permafrost and related gas expulsions on the South Kara Sea shelf. Field studies and modeling results*. EGU General Assembly 2015, 2015-04-12 - 2015-04-17, Vienna, Austria
- Rebesco, M., Özmaral, A., Urgeles, R., Accettella, D., Lucchi, R. G., Ruther, D., Winsborrow, M., Llopart, J., Caburlotto, A., Lantzsch, H., Hanebuth, T.** Poster. *Evolution of a high-latitude sediment drift inside a glacially-carved trough based on high-resolution seismic stratigraphy (Kveithola, NW Barents Sea)*. AGU Fall Meeting 2015, 2015-12-14 - 2015-12-19, San Francisco, USA
- Richner, D., Niemann, H., Steinle, L., Schneider von Deimling, J., Urban, P., Hoffmann, J., Schmidt, M., Treude, T., Lehmann, M.** Poster. *Short-term variations of methane concentrations and methanotrophic activity in a coastal inlet (Eckernförde Bay, Germany)*. EGU General Assembly 2015, 2015-04-12 - 2015-04-17, Vienna, Austria
- Ryan, J., Hubbard, A. L., Box, J., Snooke, N.** Poster. *Albedo and its relationship with seasonal surface roughness using repeat UAV survey across the Kangerlussuaq sector of the Greenland Ice Sheet*. AGU Fall Meeting 2015, 2015-12-14 - 2015-12-18, San Francisco, USA
- Sauer, S., Knies, J., Lepland, A., Chand, S., Eichinger, F., Cremiere, A., Schubert, C. J.** Oral presentation. *Hydrocarbon seeps on the northern Norwegian shelf: Clues from geochemical investigations*. Goldschmidt Conference 2015, 2015-08-16 - 2015-08-21, Prague, Czech
- Schneider, A., Panieri, G., Lepland, A., Knies, J.** Oral presentation. *History of seafloor methane emissions and relationship to Pleistocene climatic events*. 45th International Arctic Workshop, 2015-05-11 - 2015-05-13, Bergen, Norway
- Schneider, A., Panieri, G., Lepland, A., Knies, J.** Oral presentation. *History of seafloor methane emissions and relationship to Pleistocene climatic events*. Resclim annual meeting, 2015-03-05 - 2015-03-07, Hurltgruten, Norway
- Schneider, A.** Oral presentation. *The use of micropaleontology in tracing past methane emission*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Serov, P., Portnov, A. D., Mienert, J., Smenov, P., Carroll, J.** Oral presentation. *Methane discharge as a potential driving force to form the pingo-like features at the South Kara Sea shelf and Storfjorden Trough, Svalbard*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Serov, P., Mienert, J., Portnov, A. D.** Poster. *Methane Release and Pingo-Like Feature Across the South kara Sea Shelves, an Area of Thawing Offshore Permafrost*. AGU Fall Meeting 2015, 2015-12-14 - 2015-12-18, San Francisco, USA
- Serov, P.** Oral presentation. *Sources and Origins of methane reaching the seabed*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Serov, P.** Oral presentation. *The use of foraminifera to study methane emissions: examples from the past*. AMGG Research School Workshop, Greenhouse Gases in the Ocean and climate change, 2015-09-21 - 2015-09-25, Tromsø, Norway
- Shackleton, C.** Oral presentation. *Empirically based reconstruction of the Barents Sea Ice Sheet*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Shackleton, C., Bjarnadóttir, L. R., Winsborrow, M., Andreassen, K.** Poster. *Meltwater landforms in the central Barents Sea and their implications for former subglacial drainage*. International Symposium on the Hydrology of Glaciers and Ice Sheets, 2015-06-21 - 2015-06-27, Höfn in Hornafjörður, Iceland
- Shackleton, C., Bjarnadóttir, L. R., Winsborrow, M., Andreassen, K.** Oral presentation. *Meltwater landforms in the central Barents Sea and their implications for former subglacial drainage*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Silyakova, A., Greinert, J., Jansson, P., Ferré, B.** Oral presentation. *Methane from shallow seep areas of the NW Svalbard Arctic margin does not reach the sea surface*. EGU General Assembly 2015, 2015-04-12 - 2015-04-17, Vienna, Austria

- Silyakova, A.** Oral presentation. *Methane in the water column and at ocean-atmosphere boundary*. Advisory board meeting Early Career Scientist Presentation, 2015-01-20, Tromsø, Norway
- Silyakova, A.** Oral presentation. *Oceanographic setting dominates methane transport through the water column in the shallow area west of Prins Karls Forlans, Arctic Ocean*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Silyakova, A.** Oral presentation. *Six weeks on drifting sea ice in the Arctic Ocean: a story and personal experience in photographs*. CAGE Brown Bag Seminar, 2015-05-12, Tromsø, Norway
- Silyakova, A.** Poster. *Water column and gas quantification*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Singhroha, S., Büinz, S., Plaza-Faverola, A., Chand, S.** Oral presentation. *Gas hydrate and free gas detection using seismic quality factor estimates from high-resolution P-Cable 3D seismic data*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Sojtaric, M.** Oral presentation. *Outreach and Communication*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Steinle, L., Maltby, J., Engbersen, N., Zopfi, J., Bange, H. W., Elvert, M., Hinrichs, K.-U., Kock, A., Lehmann, M., Treude, T., Niemann, H., Ferré, B.** Poster. *Environmental Controls on aerobic methane oxidation in coastal waters*. AGU Fall Meeting 2015, 2015-12-14 - 2015-12-18, San Francisco, USA
- Strasser, M., Jurado, M. J., Henry, P., Kanamatsu, T., Moore, G., Panieri, G., Pini, G. A.** Oral presentation. *Dynamics of Large Submarine Landslide from Analyzing the Basal Section of Mass-Transport Deposits Sampled by IODP Nankai Trough Submarine Landslide History (NanTroSLIDE)*. 7th international symposium on Submarine Mass Movements and Their Consequences, 2015-11-01 - 2015-11-04, Wellington, New Zealand
- Sztybor, K., Rasmussen, T. L., Mienert, J., Büinz, S.** Oral presentation. *Methane release and its impact on the marine sedimentary record*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Tasianas, A.** Oral presentation. *Investigation of the potential for CO₂ leakage at Snøhvit, Barents Sea and implications on global warming*. Resclim annual meeting, 2015-03-05, Hurlgruten, Norway
- Upraus, K.** Oral presentation. *Isotope proxies tracking formation of 2Ga phosphorites*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Upraus, K.** Oral presentation. *Ocean acidification in Earth History, what can we learn?*. AMGG Research School Workshop, Greenhouse Gases in the Ocean and climate change, 2015-09-21 - 2015-09-25, Tromsø, Norway
- Upraus, K., Lepland, A., Zerkle, A., Oduro, H., Patel, N. K., McLean, F., Kreitsmann, T., Kirsimae, K., Wing, B. A., Martma, T., Romashkin, A. E., Rychanchik, D.** Oral presentation. *Origin of 2.0 Ga Phosphorites and Associated Carbon and Sulphur Isotope Anomalies, Zaonega Formation, NW Russia*. Goldschmidt Conference 2015, 2015-08-16 - 2015-08-21, Prague, Czech
- Vadakkepuliyambatta, S.** Oral presentation. *Hydrate modeling over the Arctic region. Intergration of GHS model with a future climate model from CICERO*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Vadakkepuliyambatta, S., Chand, S., Büinz, S.** Oral presentation. *Ocean warming-induced gas hydrate dissociation in the SW Barents Sea*. EGU General Assembly 2015, 2015-04-10 - 2015-04-17, Vienna, Austria
- Vadakkepuliyambatta, S., Chand, S., Büinz, S.** Oral presentation. *Ocean warming-induced gas hydrate dissociation in the SW Barents Sea*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Wadham, J., Chandler, D., Nienow, P. W., Doyle, S., Tedstone, A., Hubbard, A. L.** Oral presentation. *Rapid growth and seasonal persistence of efficient subglacial drainage under kilometre thick Greenland ice*. AGU Fall Meeting 2015, 2015-12-14 - 2015-12-18, San Francisco, USA
- Waghorn, K. A., Büinz, S., Plaza-Faverola, A., Westvig, I., Johnson, J.** Poster. *Origins and Driving Mechanisms for Shallow Methane Accumulations on the Svyatogor Ridge, Fram Strait*. AGU Fall Meeting 2015, 2015-12-14 - 2015-12-19, San Francisco, USA
- Waghorn, K. A., Büinz, S., Plaza-Faverola, A.** Oral presentation. *Seismic Exploration of the Svyatogor Ridge: First Results*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway
- Waghorn, K. A.** Oral presentation. *Svyatogor Ridge 3D seismic interpretation*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Winsborrow, M., Andreassen, K., Hubbard, A. L., Plaza-Faverola, A., Gudlaugsson, E.** Oral presentation. *Gas hydrate regulation of ice stream flow*. International Conference on Arctic Margins, 2015-06-02 - 2015-06-05, Trondheim, Norway
- Winsborrow, M.** Oral presentation. *Interactions between ice sheets, gas hydrate and deeper hydrocarbon reservoirs*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Winsborrow, M., Andreassen, K., Hubbard, A. L., Plaza Faverola, A., Gudlaugsson, E.** Oral presentation. *Shallow gas and gas hydrate as a control on ice stream sticky spots*. International Union for Quaternary Research Congress, 2015-07-26 - 2015-08-02, Nagoya, Japan
- Yao, H.** Oral presentation. *Using biomarker and foraminifera $\delta^{13}C$ to assess relationship between methane emission and environmental changes*. AMGG Research School Workshop, Greenhouse Gases in the Ocean and climate change, 2015-09-21 - 2015-09-25, Tromsø, Norway
- Yao, H.** Oral presentation. *Using biomarker and foraminifera $\delta^{13}C$ to assess the relationship between methane emission and environmental changes*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Zamelczyk, K., Rasmussen, T. L., Manno, C., Bauerfeind, E.** Poster. *From the surface to the bottom of the ocean: Planktonic foraminifera response to Arctic warming and ocean acidification*. Polar Gordon Research Conference - Session on Carbon Cycling In Antarctic And Arctic Shelves, 2015-03-15 - 2015-03-20, Barga, Italy
- Zamelczyk, K., Rasmussen, T. L., Manno, C.** Poster. *Planktonic foraminifera response to climate and ocean chemistry changes during the past two millennia in the Arctic*. Arctic Frontiers, climate and energy 2015, 2015-01-21 - 2015-01-23, Tromsø, Norway
- Zamelczyk, K., Rasmussen, T. L., Manno, C., Bijma, J.** Poster. *Planktonic foraminifera response to climate and ocean chemistry changes during the past two millennia in the Fram Strait*. Final Workshop & Short Course on Culturing of Planktonic Foraminifera, 2015-08-31 - 2015-09-04, Catalina Island, USA
- Åström, E.** Oral presentation. *Benthic macro fauna at Arctic methane seeps*. CAGE – Christmas 2015 Seminar, 2015-12-09 - 2015-12-10, Sommarøy, Norway
- Åström, E. K. L., Carroll, M., Ambrose, W., Carroll, J., Silyakova, A., Andreassen, K.** Poster. *Benthic macro fauna in Svalbard methane seeps: Community structure and signs of novel methane-associated species*. Arctic Frontiers Meeting, 2015-01-18 - 2015-01-23, Tromsø, Norway
- Åström, E. K. L., Ambrose, W., Carroll, J., Silyakova, A., Andreassen, K., Oliver, G.** Oral presentation. *Benthic macrofauna at Arctic seeps: Community structure and seep-associated species, Svalbard, Norway*. The 44th Annual Benthic Ecology Meeting, 2015-03-04 - 2015-03-07, Quebec City, Canada
- Åström, E. K. L., Carroll, M., Ambrose, W., Silyakova, A., Andreassen, K., Carroll, J.** Oral presentation. *Chemosynthetic-influenced benthic macro faunal communities in Svalbard, Norway*. AMGG Research School Workshop, 2015-03-23, Tromsø, Norway ■



Professor William G. Ambrose, Bates College

I chose to spend my sabbatical from Bates College with the CAGE group because it gave me the unparalleled opportunity to work with an extraordinary group of scientists all working to understand methane hydrates. I participated in two CAGE-led cruises; analyzed previously collected sediment cores; interacted with senior scientists, researchers, and graduate students; and wrote one paper and contributed to two others.

I am interested in the processes which structure seafloor communities. Methane seeping from methane hydrates is well known to support specially adapted animals that form unusual communities. Very little is known about these communities in the high Arctic and less about how long methane seeps and their communities persist. Collaborating with micropaleontologists, geochemists, geophysicists, and other ecologists, I was able to demonstrate that a methane seepage event persisted for about 1000 years around 17,000 years ago and was most likely associated with regional stress-related faulting and the subsequent release of over pressurized fluids. The paper was published in the journal *Geochemistry, Geophysics, Geosystems* in November 2015. This work would not have been possible without the contributions of a very diverse group of collegial scientists all of whom were within a few steps of my office. ■



Photo: Maja Sojtaric.

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CAGE Christmas seminar 2015

In December each year we arrange a Christmas Seminar to sum up our scientific progress. In 2015 we went to the picturesque island of Summary close to Tromsø for a two day meeting. The seminar was attended by most of the scientific staff who contributed with presentations and posters on scientific highlights and participated in discussions about future progress of the Centre of excellence.

