



CAGE - Centre for Arctic Gas Hydrate Environment and Climate Report Series, Volume 6 (2018)

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Modifications:

This version of the annual report has been modified from the original published in 2018.

Below is an overview of the changes made.

- The URL links for the Master theses have been changed to a permanent handle in page 21.
- Impact factor values have been removed from page 34-35 (Publications list)



Annual Report 2018
CAGE - Centre for Arctic Gas Hydrate,
Environment and Climate





Words from the Director

CAGE investigates methane release, a greenhouse gas far stronger than CO₂, from the Arctic seafloor. Vast amounts of methane are trapped at shallow depths below the seafloor as gas hydrates, ice-like mixtures of gas and water. Current ocean warming makes these shallow greenhouse gas reservoirs particularly vulnerable to thawing. CAGE investigates the implications of this to the Arctic climate and environment.

Transdisciplinary cutting-edge research

CAGE's transdisciplinary approach closely integrates knowledge and expertise from different scientific fields to investigate methane release from a warming Arctic, and its impact on environment and climate. We investigate fluid flow from the deep sources of gas seeps, their imprints on the seabed, the water column and atmosphere. We use geological archives to reconstruct the timing, magnitude and drivers of past gas releases, and combine this empirically-based knowledge with numerical modelling to understand contemporary, and predict future, methane cycling.

In the year following our successful mid-way evaluation we have continued to strengthen our position as a world leader in gas hydrate-related environmental and climate research. We publish extensively in top-ranking journals, with 9 out of our 60 peer-reviewed publications in 2018 in *Nature*- and *Science*-journals.

Scientific highlights

CAGE had over 50 research cruise days in 2018, a highlight of which was our inaugural cruise on the new research vessel *Kronprins Haakon* (KPH) in October. KPH opens up new areas of the ice-covered Arctic Ocean and new ways of acquiring data for CAGE. Dynamic positioning enables targeted sampling, balancing tanks allow safe operations regardless of weather, and a large moon pool allows the deployment of much more

advanced and large-scale equipment than previously possible. This is exemplified by our use of the *ÆGIR 6000* ROV (remotely operated vehicle) on our first KPH cruise, allowing us to image and map the seafloor and water column in unprecedented detail.

Collaboration with The Faculty of Biosciences, Fisheries and Economics (BFE) was established, a key component of which is the initiation of an Ice-Cold Microorganisms Laboratory (ICOM), to conduct experiments and gain new insights into how microbial communities work in ice-cold environments. Through DNA sequencing, we characterized the composition of the microbial community at cold seeps.

We developed a new tool for predicting the fate of seafloor-emitted methane using a two-phase gas model. We established high-resolution 3D seismic data as a 4D time-lapse tool to investigate natural geological processes through the development of innovative processing procedures. And, through the successful application of basin modelling we constrained the onset of methane seepage off NW Svalbard to 2 million years before present, demonstrating the close coupling between glaciations and deeper hydrocarbon systems.

Looking ahead

CAGE will continue to combine the development of innovative technologies with cutting-edge transdisciplinary research, and expand our ac-

tivities into the ice-covered Arctic Ocean. We will strengthen our expertise in numerical modelling and quantification through new research projects funded in 2018, some led by young CAGE researchers. Dr. Andrea Plaza-Faverola secured two prestigious early-career starting grants to investigate how tectonic and glacial stresses control fluid seepage, and Dr. Pavel Serov secured postdoctoral funding to examine the effects of glacial "pumping" on fluid flow from deeper hydrocarbon reservoirs.

The focus of CAGE's second phase involving synergies with complimentary world class research teams at UiT will be strengthened by several new projects. Together with research groups in mathematics and physics we will investigate *Ice, ocean, atmosphere interactions in the Arctic - from the past to the future*, whilst together with ARCEX (Center for Arctic Petroleum Exploration) we will focus on *Numerical modelling and validation of geological processes*. PhD and postdoctoral fellows within these new projects will expand our modelling teams, incorporating the transdisciplinary data we collect to upscale and investigate problems across wider timescales, including future predictions.

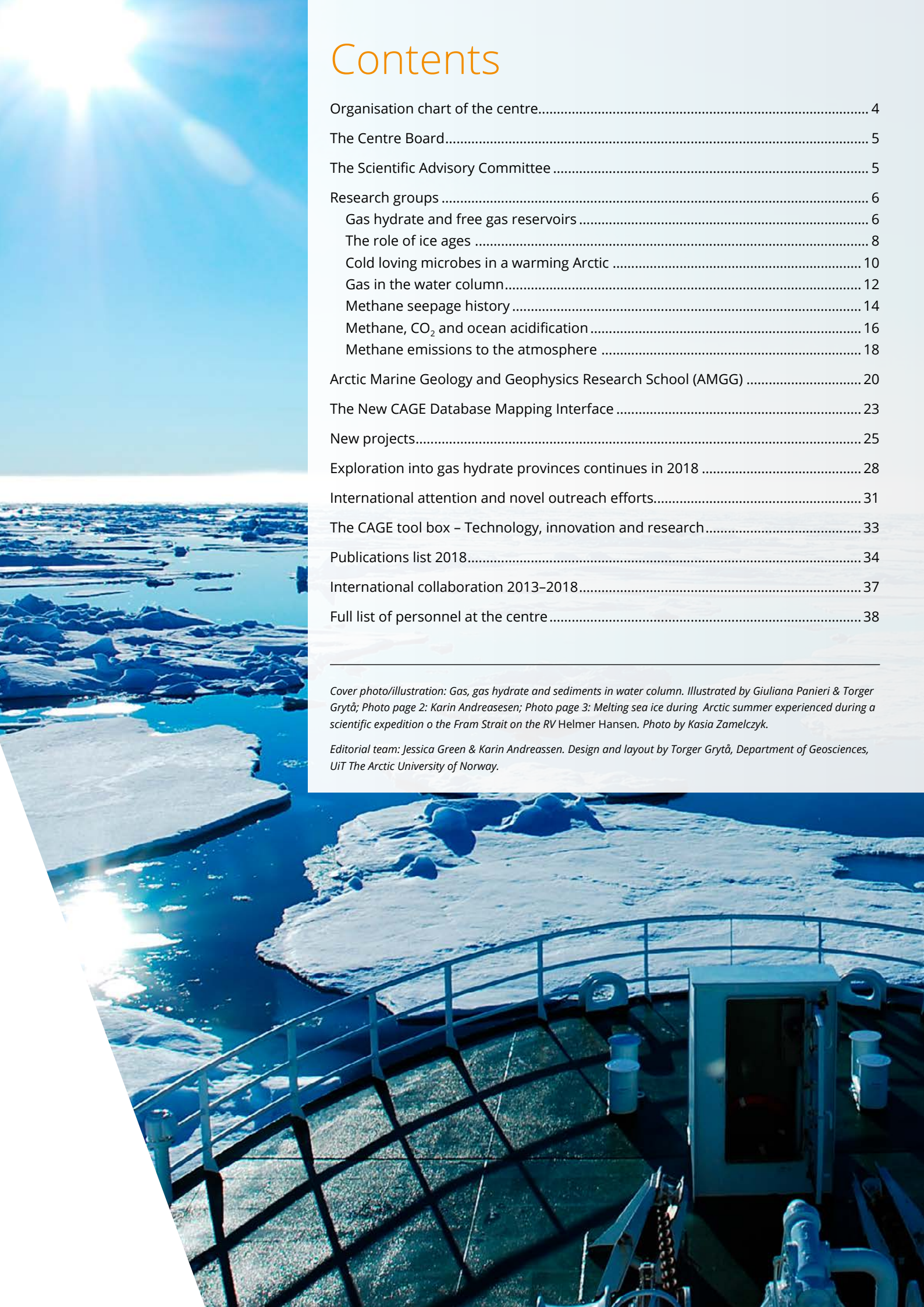
Prof. Karin Andreassen
Centre Director

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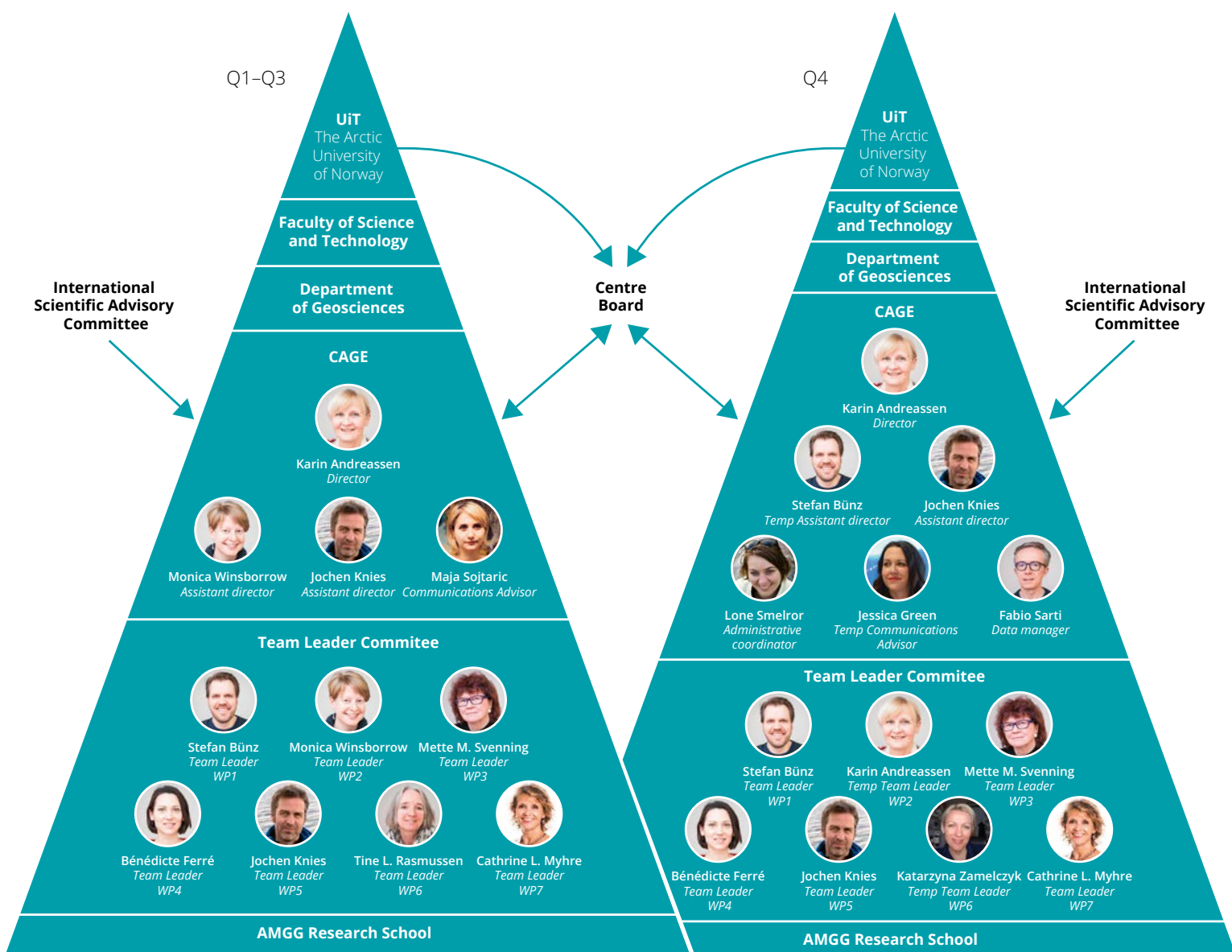
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Cover photo/illustration: Gas, gas hydrate and sediments in water column. Illustrated by Giuliana Panieri & Torger Grytå; Photo page 2: Karin Andreassen; Photo page 3: Melting sea ice during Arctic summer experienced during a scientific expedition o the Fram Strait on the RV Helmer Hansen. Photo by Kasia Zamelczyk.

Editorial team: Jessica Green & Karin Andreassen. Design and layout by Torger Grytå, Department of Geosciences, UiT The Arctic University of Norway.

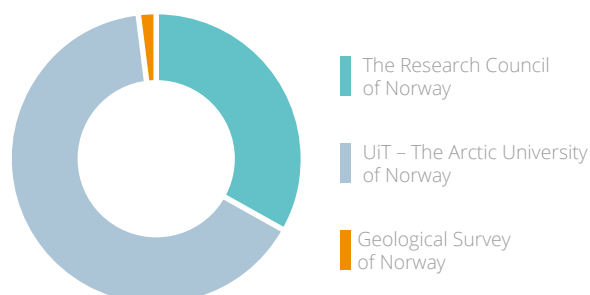


Organisation chart of the centre



Funding 2018

Funding (1000NOK)	Amount	Percentage
The Research Council	16 589	33,1 %
UiT The Arctic University of Norway	32 606	65,0 %
Geological Survey of Norway	962	1,9 %
Total	50 157	100 %



The Centre Board

The centre board is responsible for overseeing the strategy for research, training, economy, and patent developments at the centre of excellence. The board also oversees operational aspects including the relationships to the university, institutes, and industry. Director of CAGE, Professor Karin Andreassen, reports to the centre board.



Kenneth Ruud
*Prorector & Chairman
Prof., Research and Development at
UiT Tromsø*



Arne Smalås
Prof., Dean NT-faculty, UiT



May Britt Myhr
*Director of the Norwegian Geological
Survey (NGU) Trondheim*



Nalan Koc
*Research Director of the Norwegian
Polar Institute Tromsø*



Ingrid Schjølberg
*Prof., Director NTNU Ocean Science
and Technology (NTNU Oceans)*



Kristina Helland-Hansen
*Vice President of International
South Exploration at Equinor Bergen*

The Scientific Advisory Committee

CAGE has an international scientific advisory committee that gives advice on strategic scientific issues and consists of distinguished experts in their fields.



Prof. Doug Connelly
*National Oceanography Centre,
Southampton, UK*



Prof. Georgy Cherkashov
*Institute of Mineral resources of the
Ocean, RUS*



Dr. Carolyn Ruppel
United States Geological Survey, USA



Prof. Mads Huuse
University of Manchester, UK



Prof. Alexander Loy
University of Vienna, Austria

Gas hydrate and free gas reservoirs



Stefan Bünz, Team Leader

Professor Stefan Bünz has 20 years of experience in marine geology and geophysics with specific research expertise in: gas hydrates, fluid flow systems, shallow gas anomalies and geohazards, high-resolution 3D/4D and multi-component seismics, CO₂-storage in petroleum provinces, seafloor ecosystems, ultra-slow spreading ridges, and tectonic and non-tectonic faulting.

Members:

Jürgen Mienert
Professor

Sunil Vadakkepuliambatta
Researcher

Shyam Chand
Researcher

Andreia Plaza Faverola
Researcher

Sunny Singhroha
PhD Candidate

Malin Waage
PhD Candidate

Kate Waghorn
PhD Candidate

About:

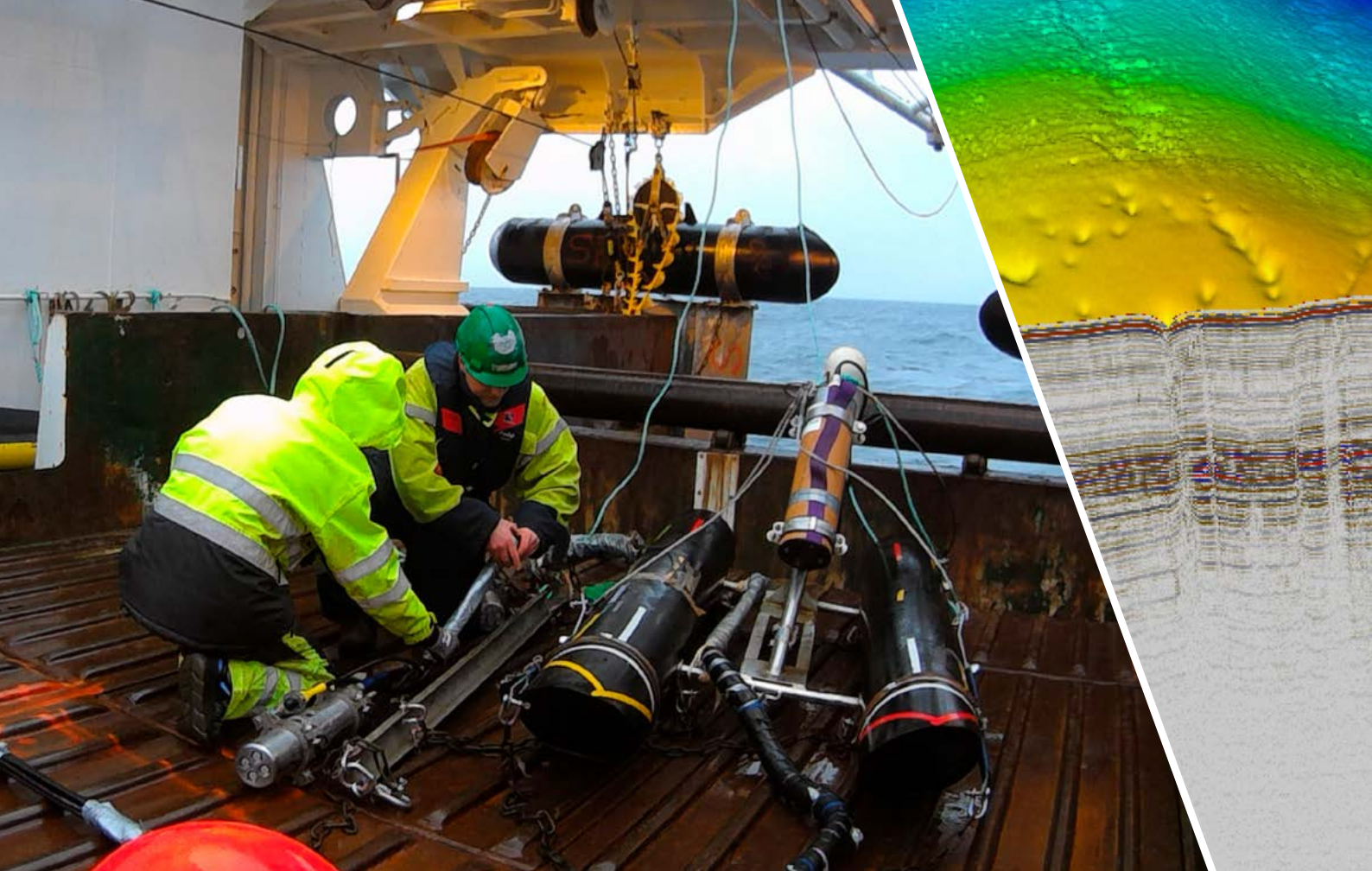
One of the greatest uncertainties regarding the Arctic marine methane supply is the amount of frozen methane that lays hidden beneath the seabed. Equally important are the quantities of methane that have been, or will be, released - potentially impacting ocean life and our global climate. In order to shed light on these mysteries, we rely heavily upon UiT's research infrastructure Geosystem 3D Seismic Imaging (G3), a national facility for the acquisition of high-resolution 3D seismic data based on the P-Cable 3D seismic system. It allows for imaging in unprecedented detail when investigating complex and dynamic geosystems of gas hydrates, geofluids and geohazards in marine environments from the shelf to the deep sea. This data enables us to perform excellent reservoir mapping while measuring the amounts of frozen methane and free gas waiting beneath the sediment, as well as identifying any leakage from within.

Main questions:

- How much carbon is stored in today's methane hydrate and free gas reservoirs in the Arctic and how much is susceptible to climate change?
- At what rates, by which means, and under which circumstances is methane expelled from sub-seabed reservoirs to the seabed?

Major aims:

- Identify and quantify gas hydrate and free gas reservoirs in the Arctic.
- Develop technologies for direct detection of gas hydrate in marine sediments.
- Understand the spatial and temporal dynamics of gas hydrate reservoirs under changing environmental conditions using high-resolution 3D seismic imaging, sediment drilling and sampling, as well as heat-flow measurements and modelling.
- Understand the genesis, mechanisms and governing geological processes of fluid flow.
- Acquire high-resolution 4D time-lapse data to quantify fluid flow through fractured systems.



We focused on investigating both deep and shallow gas hydrate and methane release sub-seabed features in two areas off the shore of West Svalbard, and in the Barents and Kara Seas.

Research cruises with UiT's rv *Helmer Hanssen* provided unique high-resolution 2D, 3D and 4D seismic and hydro-acoustic datasets of gas hydrate and fluid flow systems spanning a range of environments from an Arctic shelf to a deep-water system.

Also of note was our cooperation with the Norwegian Petroleum Directorate (NPD) and the wider hydrocarbon industry, which provided us with exclusive access to commercial geophysical data and supported field campaigns with rv *Helmer Hanssen*. This gave us the opportunity to investigate deeper sediment formations where thermogenic gas from petroleum reservoirs has migrated upwards into the gas hydrate stability zone (GHSZ).

Close collaboration with Russian colleagues provided data from the Kara Sea at a marine gas release site near Yamal Peninsula. This location has received worldwide attention due to the natural blowout craters found there within the onshore permafrost.

Main achievements 2018

1. Dr. Andreaia Plaza-Faverola secured a prestigious early-career starting grant that provides funding for investigating how tectonic and glacial stresses control fluid seepage in Arctic areas. Her initial work on stress field modeling showed that spatial variations in tectonic stress regimes control faulting and fluid seepage distribution.
2. A 4D seismic processing procedure has been established based on data examples from 3 areas, demonstrating the repeatability of P-Cable high-resolution 3D seismic data as a 4D time-lapse tool to investigate natural geological processes.
3. Analysis of high resolution P-Cable 3D seismic data provided evidence for spreading ridge detachment faults sustaining fluid flow and gas hydrate systems.
4. Geophysical data and hydrate stability modeling showed paleo thermokarst structures in

the permafrost regions of the Arctic acting as carbon storage pools.

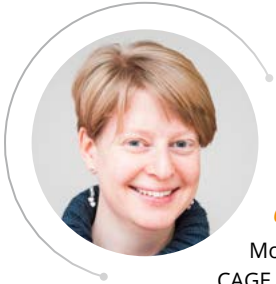
5. WP1 lead the first CAGE cruise on Norway's new, ice-going research vessel rv *Kronprins Haakon* investigating fluid seepage fields in the Storfjord Trough and the Storbanken area in the Barents Sea using another national facility, the deep-diving ROV *Ægir 6000* of UiB.
6. Visual seafloor surveys and seafloor sampling in the Leierdjupet Fault complex documented a highly dynamic fluid seepage system that was detected on hydroacoustic and seismic data in 2017.

Repairing airgun cables on the back deck of RV Helmer Hanssen.

Three-dimensional composite figure of Vestnesa Ridge gas hydrate system.

Photos & illustrations: Stefan Bünz, CAGE.

The role of ice ages



Monica Winsborrow, Team Leader until September 2018 due to maternity leave

Monica Winsborrow is a researcher at CAGE. Her research focuses on the reconstruction of past ice sheets, working to understand the processes and mechanisms that control their evolution and dynamics, and examining their environmental impacts. She holds a PhD in Physical Geography from the University of Sheffield, UK, and worked in both academia and industry before joining CAGE in 2014. She became team leader and assistant director of CAGE in August 2017.



Karin Andreassen, Team Leader from September 2018

Karin Andreassen is a professor in marine geology and geophysics at UiT. Her research career spans 35 years investigating the long-term development of the Barents Sea and the wider Arctic, focusing on ice sheet dynamics and subglacial landforms, sediments and processes, gas hydrates shallow gas and fluid flow from glacial to interglacial conditions.

Members:

Alun Hubbard
Professor (50%)

Renata Lucchi
Adjunct Professor (20%)

Henry Patton
Researcher

Nikolitsa Alexandropoulou
PhD Candidate

Emilia Daria Piasecka
PhD Candidate

Calvin Shackleton
PhD Candidate

Pavel Serov
PhD Candidate

Mariana da Silveira Ramos Esteves
Research Assistant

About:

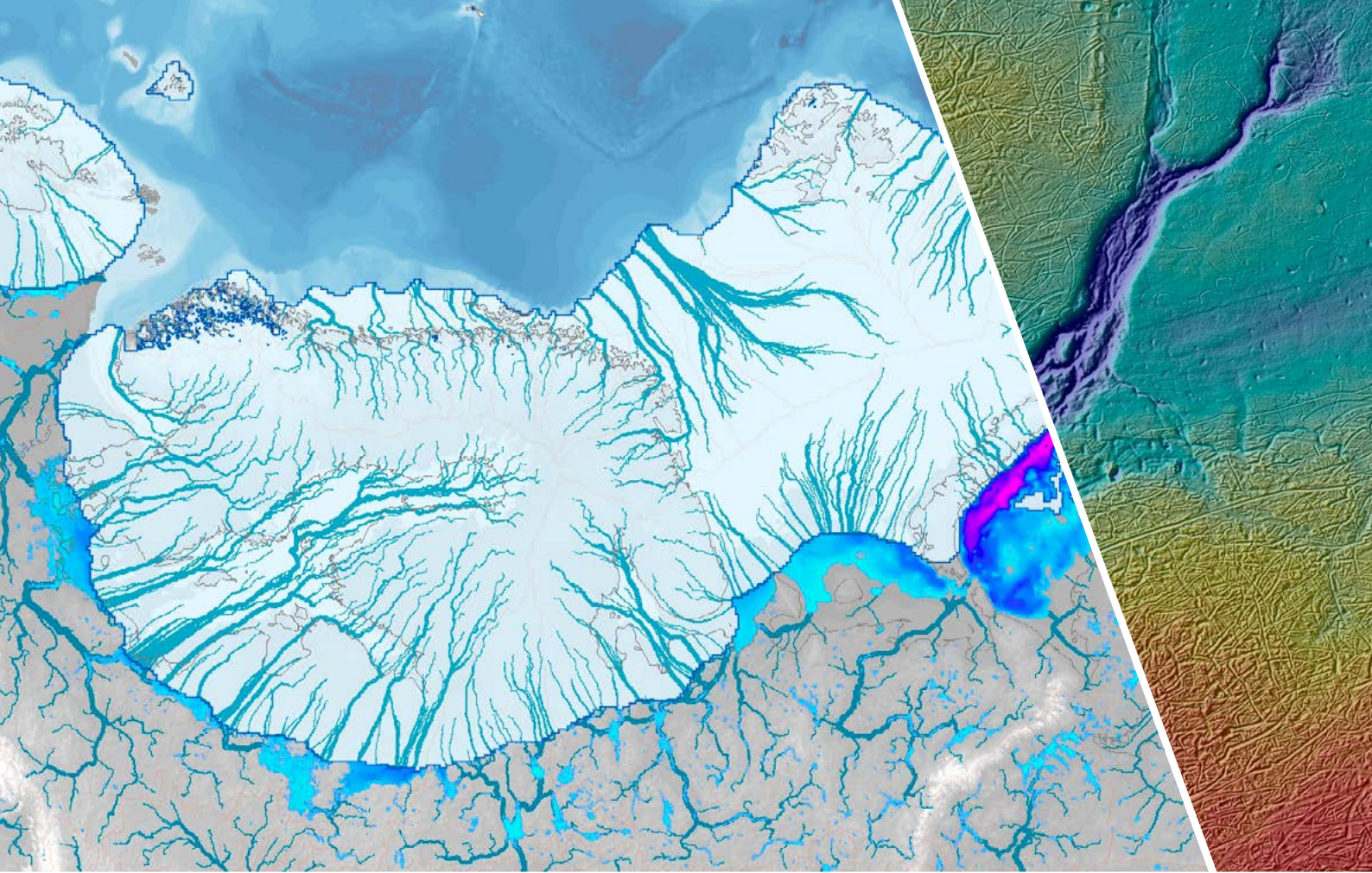
Today, vast quantities of methane are sequestered as shallow gas hydrates across the Barents Sea shelf, fed continuously by gas from deep thermogenic sources. We propose that these hydrate reservoirs were much thicker and more extensive under the extreme conditions of past ice ages, whereby high pressure and low temperature conditions beneath former ice sheets created an environment conducive for stable hydrate formation. We combine state-of-the-art marine geophysical data with high-resolution modelling to provide extraordinary insights into the long-term variability of methane storage and release forced by repeated glacial advance and retreat over the past 2.7 Ma. Our new understanding is crucial to improve the prediction of present and future greenhouse gas release from contemporary Greenland and Antarctic ice sheets.

Main questions:

- How do ice sheets affect fluid flow and gas hydrate systems?
- How does the thickness, extent and volume of gas hydrates change through the ice ages?
- What impact did glaciations have on the Arctic environment?

Major aims:

- Determine, through modelling and empirical observations, the key processes and feedbacks between gas hydrates, fluid flow and ice sheet glaciation.
- Model the long-term impact of past glacial cycles on the Eurasian Arctic, both within and beyond formerly ice-covered regions.
- Isolate critical subglacial controls on past ice sheet and ice stream behaviour and dynamics.
- Develop stratigraphic and environmental frameworks for key CAGE study areas.



Numerical models require accurate constraints provided by high quality empirical data. We continue to acquire state-of-the-art geophysical datasets from strategic field sites across the Norwegian-Barents Sea and Arctic.

Our work package is in a world-leading position to implement models of past glacial cycles and processes to assess their concomitant impact on subglacial gas hydrate dynamics in unprecedented accuracy and detail.

Main achievements 2018

1. Extended ice-sheet model simulations to reconstruct the cyclic evolution of the Eurasian ice-sheet complex over the last glacial cycle (122,000 years) and constrain long-term patterns of subglacial erosion.
2. Advanced understanding of the Barents Sea/ Fennoscandian ice sheet deglaciation sequence from high-resolution geophysical datasets.
3. Investigated the role of subglacial hydrology as a regulator of dynamic ice behaviour during deglaciation of the Fennoscandian and Barents Sea ice sheets.
4. Determined the postglacial response of gas hydrate dissociation to ocean warming and isostatic uplift along the Svalbard continental margin.
5. Developed a multiphase fluid flow and gas hydrate model to quantify subglacial erosion rates of gas hydrate bearing sediments beneath an ice stream.
6. Identified major disruptions to the proglacial routing and storage of freshwater during the last deglaciation.
7. The KLIMAFORSK funded outreach project, ICEMAP (icemap.no), opened a new exhibit at Nordnorsk Vitensenter during 2018. ICEMAP visuals have also been incorporated into the 'Dippy on Tour' exhibition at Ulster Museum, where visitor numbers have exceeded 130,000.
8. Expanded modelling initiatives through two newly funded positions: 1) a VISTA postdoc position (Pavel Serov) examining the effects of glacial "pumping" on fluid flow in the Barents Sea, and 2) a researcher position (Henry Patton) through a modelling collaboration with ARCEX, funded by Equinor, to examine the evolution of the Barents Sea basin through the Late Cenozoic Era.

A modelled reconstruction of ice flow patterns for the last Eurasian ice sheet.

Braided meltwater channel in the central Barents Sea.

Illustrations: Henry Patton; Calvin Shackleton/ MAREANO.

Cold loving microbes in a warming Arctic



Mette Marianne Svenning, *Team Leader*

Professor Mette Marianne Svenning is an internationally recognized expert on methods for isolation and cultivation of methane oxidizing bacteria (MOB), and has a culture collection of representative MOB from Arctic and sub-Arctic regions. Svenning has extensive fieldwork experience from Arctic (Svalbard) and sub-Arctic regions. This includes leadership, management and coordination of fieldwork, methane emission measurements, vegetation analyses and sampling for microbial and molecular studies in the laboratory.

Members:

Helge Niemann
Adjunct Professor (20%)

Friederike Gründger
Postdoctoral Researcher

Arunima Sen
Postdoctoral Researcher

Dimitri Kalenitchenko
Postdoctoral Researcher

Michael Carroll
Researcher

Vincent Carrier
PhD Candidate

Emmelie Åström
PhD Candidate

About:

It is uncertain how, and to what extent, methane release from gas hydrates affects life on the seabed, such as benthic organisms, communities, microorganisms and food web structures. This research group has been established in order to dig further into this mystery. Our studies are linked to, and coordinated with, geochemical, sedimentological and water column studies of the CAGE team. In the coming years, WP3 will emphasize microbiology and the sensitivity of cold adapted microbial sub-seabed ecosystem's importance for methane emissions. A new and unique infrastructure, the Ice-Cold Microorganisms Laboratory (ICOM), will be a novel tool to address biodiversity, activity and evolution of cold loving microbes.

Main questions:

- How is life on the seabed affected by methane release from gas hydrate dissociation?
- What is the role of the seafloor biological communities in mediating the exchange of methane from seafloor sediments into the water column?
- How does the sub-seabed microbial communities and networks respond to changes in temperature and substrate availability?
- How active is the methane oxidising filter in the water column?

Major aims:

- Understand habitat characteristics and locations of seep communities.
- Document the characteristics of microbial communities in sediments and the water column, including methanotrophic activity and community composition.
- Decipher life cycles of macrobenthic and microbial communities, along with the ecological structure and function of communities and food webs associated with seafloor methane emissions.
- Understand responses and evolution of cold seep biological communities.



We have accrued knowledge of cold seep biological communities in the Arctic. Images of the seabed and the fauna at methane release sites were correlated with physical and geochemical parameters for development of methane associated communities.

The experience of Prof. Svenning regarding MOBS, biodiversity, and the activity of microbial communities and their involvement in organic carbon degradation and CH₄ emission in Arctic and sub-Arctic regions, currently represents one of the research platforms of Work Package 3: Addressing adaptive mechanisms to Arctic ecosystems by molecular physiology; combining laboratory experiments with genomics.

Main achievements 2018

1. Established a new collaboration with The Faculty of Biosciences, Fisheries and Economics to strengthen the research and infrastructure platform of UiT The Arctic University of Norway.
2. Began establishing the Ice-Cold Microorganisms Laboratory (ICOM), intended for conducting experiments and gaining new in-

sights into how microbial communities work in ice-cold environments.

3. Initiated the Tromsø Research Foundation (TRF) project called “Cells in the Cold”, led by Alexander Tøsdal Tveit. This project is closely tied to the ICOM lab.
4. Examined sub-surface gas reserves, microbial communities and microbial activity to determine faunal community structures at Arctic seeps.
5. Located the only confirmed chemosynthetic animal living at Arctic seeps, possibly a new species.
6. Discovered that frenulates affect the physical features of seep sites such as carbonate precipitation, and that these sites might be

used as skate egg-case nursery grounds due to their slight temperature anomalies serving as natural incubators.

7. Characterized the composition of the microbial community at cold seeps through DNA sequencing. Large parts of this community still belong to undescribed microbes.

Dimitri Kalenitchenko holds a pushcorer aboard the RV Kronprins Haakon.

An Arctic skate lies in the sediment amongst tiny starfish.

Photos: Mette Marianne Svenning; Giuliana Panieri.

Gas in the water column



Bénédicte Ferré, *Team Leader*

Bénédicte Ferré is a physical oceanographer whose research activities span from sediment resuspension and transport to oceanographic data associated with methane release. She holds a PhD degree in Marine Science from the University of Perpignan, France. Ferré was a post-doctoral researcher at the United States Geological Survey in Woods Hole, USA, before joining the Department of Geosciences at UiT - The Arctic University of Norway as a researcher in 2008 and CAGE as a team leader in 2013. She is involved in many projects related to ocean observatories and is responsible for the development, acquisition and analysis of data related to the seafloor observatory K-Lander.

Members:

Helge Niemann
Adjunct Professor (20%)

Anna Silyakova
Researcher

Knut Ola Dølven
PhD Candidate

Pär Gunnar Jansson
PhD Candidate

Manuel Moser
PhD candidate

Muhammed Fatih Sert
PhD Candidate

About:

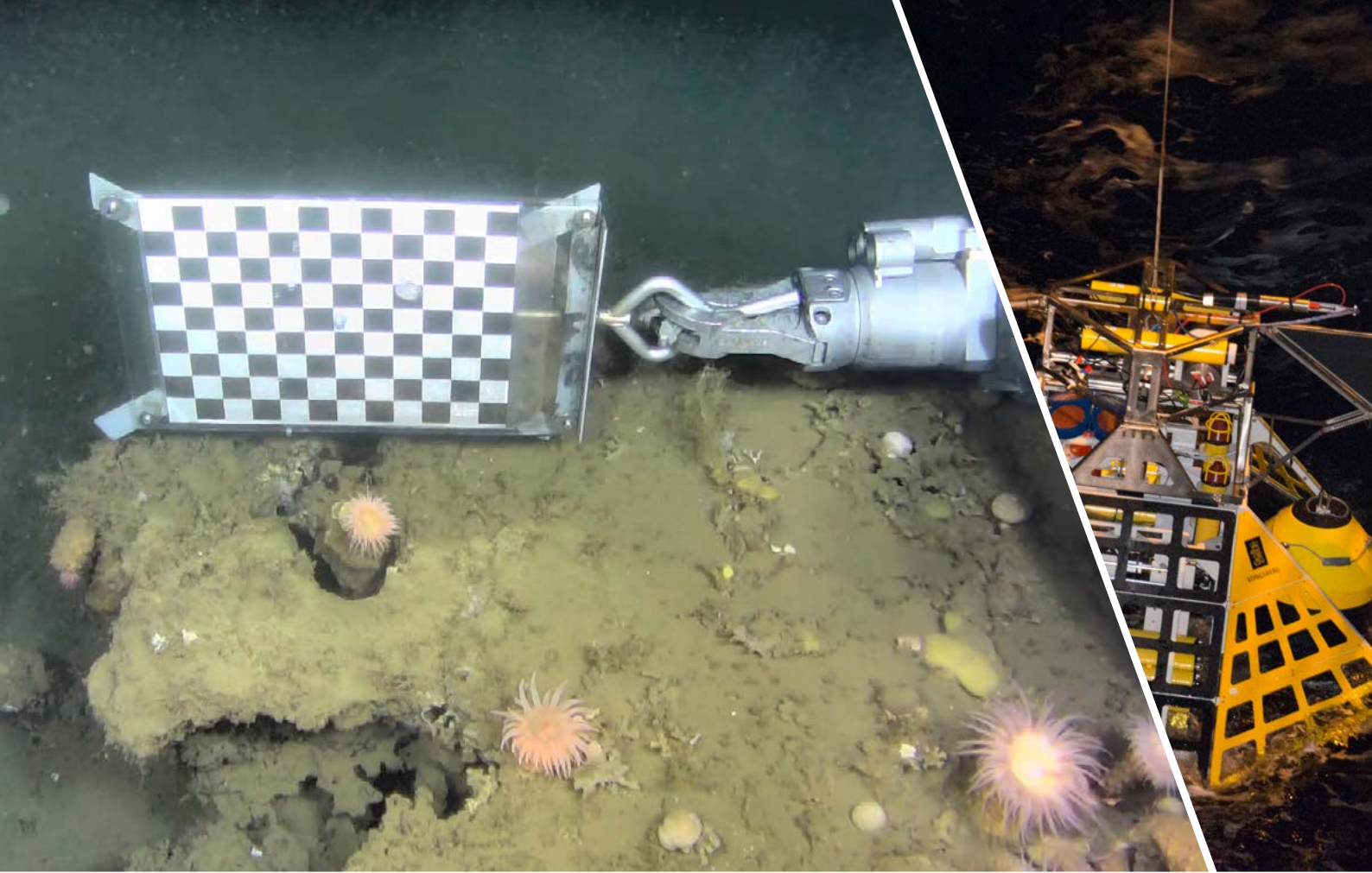
The effects of methane release on underwater ecosystems and our global climate are still unclear. Methane transport in Arctic oceans takes place via bubbles or in dissolved form beneath the seabed and travel vertically towards the ocean surface. However, continuously shifting water dynamics due to changing seasons and other factors can limit vertical methane migration. By understanding the constant evolution of the ocean and the related variability of methane release on a time scale that ranges from hours to years, we can quantify local and regional methane leakages as well as methane transport in the water column over time. This ultimately helps us to determine what effect, if any, this methane has on underwater ecosystems and climate change.

Main questions:

- How much of the methane released from the seafloor reaches the upper water column and the atmosphere?
- Over what horizontal and vertical distances do ocean currents transport methane plumes?
- What is the variability of the methane release and what are the processes involved?
- What are the interactions between the physical, chemical and biological processes that affect methane transport?
- What is the effect of methane seeps on the Arctic Ocean biogeochemistry?

Major aims:

- Observe and model the transport of methane plumes.
- Determine and model methane fluxes from the seafloor to the sea surface.
- Determine physical and chemical boundary conditions of the bottom water that modify methane seep activities.
- Investigate and compare water column biogeochemistry at and around active methane flares



Two ocean floor observatories (K-Landers) were deployed twice off the shore of Svalbard and in the Barents Sea, allowing the placement of multi-sensor technology at key Arctic sites over annual timeframes.

The K-Landers represent a successful cooperation between the maritime industry (Kongsberg Maritime) and academia that is essential for future climate research. This advanced equipment makes it possible to continuously measure environmental changes associated with methane release at remarkable resolutions, and acquire data to tune and force models.

WP4 has also been very successful in obtaining new projects in 2018 while progressing significantly in ongoing ones. These include Lofoten Vesterålen (LoVe), Svalbard Integrated Arctic Earth Observing System (SIOS), Environmental Research Infrastructures (ENVRIplus), and Hot vents in an ice-covered ocean: the role of the Arctic as a connectivity pathway between ocean basins (HACON).

Main achievements 2018

1. Collected manuscript-worthy data regarding the link between methane release and the physical parameters off the shores of Svalbard, based on analysis of the times series obtained on the K-landers.
2. Continued discussions with co-authors regarding data acquired during the N-ICE 2015 experiment in which biochemical measurements were taken under, in and above the young sea ice at 80°N for several months. Results were partially presented at the Ocean Sciences Meeting in Portland, Oregon in February 2018; publication expected by summer 2019.
3. Discussing preliminary results with project partners regarding the 2017 and 2018 sampling for analysis of dissolved organic matter dynamics at strategic sites around the Svalbard archipelago and the central Barents Sea; publication expected in 2019
4. Developed a new tool for predicting the fate of seafloor-emitted methane using a two-phase gas model in one dimension (Jansson et al., 2019).
5. Progressed significantly in the LoVe project with the deployment of a sub-seabed cable connecting 6 landers, allowing us to compare

two very distinct sites in the Hola Trough in terms of methane release and various location-dependent properties.

6. Awarded a collaborative grant within the SIOS InfraNor project to deploy a K-Lander to continue our time series off the shore of Svalbard; deployment expected summer 2019.
7. Collected water column samples and data of unprecedented quality in the Barents Sea using the ROV Ægir (UiB) aboard the new research vessel *Kronprins Haakon*.
8. Invited to participate in the Hacon project, a FRINATECH initiative funded by NFR. Our role is to study the physical characteristics of a water column in a hydrothermal vent in the Gakkel Ridge.

screen capture from ROV CAGE 18-5 showing rising bubbles in front of a checkerboard for scaling.

K-lander deployment using a launcher system.

Photo/Illustration: ROV/CAGE, Bénédicte Ferré.

Methane seepage history



Jochen Knies, Team Leader

Jochen Knies is a senior researcher at the Geological Survey of Norway. He holds a 20% position at CAGE, where he is currently Assistant Director. His research expertise integrates marine geochemical and environmental investigations along formerly glaciated continental margins in the Arctic. Knies holds a PhD degree in Marine Geology from the University of Bremen. His broad professional experience includes, among others, a position as postdoctoral fellow at the Alfred Wegener Institute for Polar and Marine Research (AWI), Germany, and a visiting professor position at the University of Hawaii, USA.

Members:

Giuliana Panieri
Associate Professor

Karl Fabian
Researcher

Aivo Lepland
Researcher

Shyam Chand
Researcher

Soma Baranwal
Postdoctoral Researcher

Terje Thorsnes
Researcher

Tobias Himmler
Postdoctoral Researcher

Pierre-Antoine Dessandier
Postdoctoral Researcher

Wei-Li Hong
Postdoctoral Researcher

Andrea Schneider
PhD candidate

Christiane Schmidt
Postdoctoral Researcher

Deniz Koseoglu
PhD Candidate

Katarzyna Melaniuk
PhD Candidate

Simone Sauer
Postdoctoral Researcher

Kärt Paiste
PhD Candidate

Haoyi Yao
PhD Candidate

About:

To understand the environmental factors that drive methane seepage, we need to better constrain the timing of methane release throughout the geological past. To do this we use authigenic carbonates and microfossils to develop records of palaeo-methane seepage for sites around the Arctic. We then assess the influence of various environmental conditions, for example sea ice extent and glacial isostatic adjustment, on methane seepage history.

Main question:

- How can we identify and quantify carbon during the geological past in time and space?

Major aims:

- Establish geochemical markers and time constraints for "abnormal" methane release from seabed to ocean.
- Determine paleo conditions of ocean life and links to climate change during the geological past.



In 2018, unique material collected by remotely operated vehicle (ROV) supported research cruises with RV G.O. Sars from offshore Svalbard and the Lofoten/Vesterålen Islands was the focus of our research to constrain past methane seepage in the Arctic. This material provided the cornerstone for the characterization of past methane leakage events and will be used to ground-truth our new basin model for the NW Svalbard seepage history.

The alliance with world-class laboratories and academic and industry partners allowed the application of cutting-edge technologies that resulted in a deeper understanding of methane dynamics and interrelated processes for a broader international audience with publications in Science, and Scientific Reports.

Also of note was the graduation of two PhD students, Andrea Schneider and Kärt Paiste who defended their thesis on past methane history from offshore NW Svalbard and environmental changes after the great oxygenation event, 2.3 billion years ago.

Main achievements 2018

1. Successfully applied a basin modelling approach to constrain the onset of methane seepage on Vestnesa Ridge, NW Svalbard, to 2 million years before today. This timing is in overall agreement with the first shelf edge glaciations of the Svalbard-Barents Sea glaciation and indicates a close response of the petroleum system to increased glacially-induced sediment erosion in the study area.
2. Established more detailed insights within characteristics, timing, duration, and driv-

ers of seafloor methane seepage at Vestnesa Ridge throughout the Late Pleistocene and Holocene by combining multiple proxies. Results show that several seepage episodes at Vestnesa Ridge coincide with the Last Glacial Maximum extent of the former Svalbard Barents Sea Ice Sheet, and multiple events occurred in the early Holocene. Geological evidence for enhanced methane flux and seafloor methane seepage imply that glacio-isostatic adjustments during ice sheet advance and retreat are the most important controls on fluid migration and methane seepage at Vestnesa Ridge.

3. Documented unique evidence for the benthic foraminifera species, keystone for the Arctic, *Melonis barleeanus*. The species was found associated with Type I methanotrophic bacteria in Vestnesa Ridge. This is the first documented instance of bona fide living *M. barleeanus* in gas-hydrate sediments and first documentation of a foraminifer living in close association with putative methanotrophs. The same species has also been found to use a novel biomineralization strategy that can affect isotopic (or chemical) measurements. Our observations have implications

to paleoclimate records utilizing this foundational foraminiferal species.

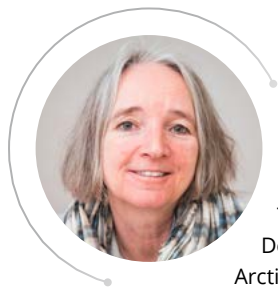
4. Detailed in a Science article the outstanding environmental conditions found in the aftermath of the initial oxygenation of the Earth system at ~2.3 Ga. Our studies, using a rock record of the Onega Basin, Karelia in Russia, have allowed us to reconstruct seawater sulfate levels at approximately 1/3 of present levels (Blättler et al., 2018) and interpret the role of local- vs. global-scale processes influencing carbon and sulfur isotope signatures on changes in the atmospheric-ocean system of the early Earth.

Push coring of bacterial mat in newly discovered methane seep on the continental margin off the Lofoten-Vesterålen Islands.

Earth's oxygenation 2.3 Ga ago has left distinct geochemical and mineralogic fingerprints in sedimentary and volcanic rocks that have been studied in outcrops and drill cores from Karelia, Russia.

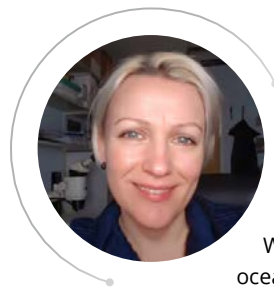
Photos: Jochen Knies; Kärt Paiste.

Methane, CO₂ and ocean acidification



Tine Lander Rasmussen, *Team Leader until August 2018*

Tine Rasmussen is a professor at the Department of Geosciences, UiT The Arctic University of Norway. Her research interests are focused on abrupt climate and oceanographic changes including long paleo time series from Arctic and sub-Arctic areas, include paleoceanography, paleoclimate, ecology and paleoecology, and micropaleontology. She holds a PhD degree in marine science/micropaleontology from Aarhus University in Denmark, and has professional experience most notably from Woods Hole Oceanographic Institution (USA), Lund University (SWE) and Copenhagen University (DK).



Kasia Zamelczyk, *Co-leader from August 2018*

Kasia is a researcher and co-leader of WP6. Her research interfaces modern ocean observations with reconstructions of past climate, oceanography and ocean chemistry changes in the Arctic and subpolar regions. Interests include bio- and geoscience with a focus on ecology, micropaleontology and geochemistry. She has a PhD in marine geology from UiT with experience from numerous research stays e.g. in the Leibniz Institute for Baltic Sea Research (IOW) Warnemünde (Germany), the GEOTP Research Centre in Geochemistry and Geodynamics, Montreal (Canada) and the Alfred Wegener Institute, Bermerhaven (Germany).

Members:

Kasia Zamelczyk
Researcher

Mohamed Ezat
Postdoctoral Researcher

Siri Ofstad
PhD Candidate

Naima El Bani Altuna
PhD Candidate

About:

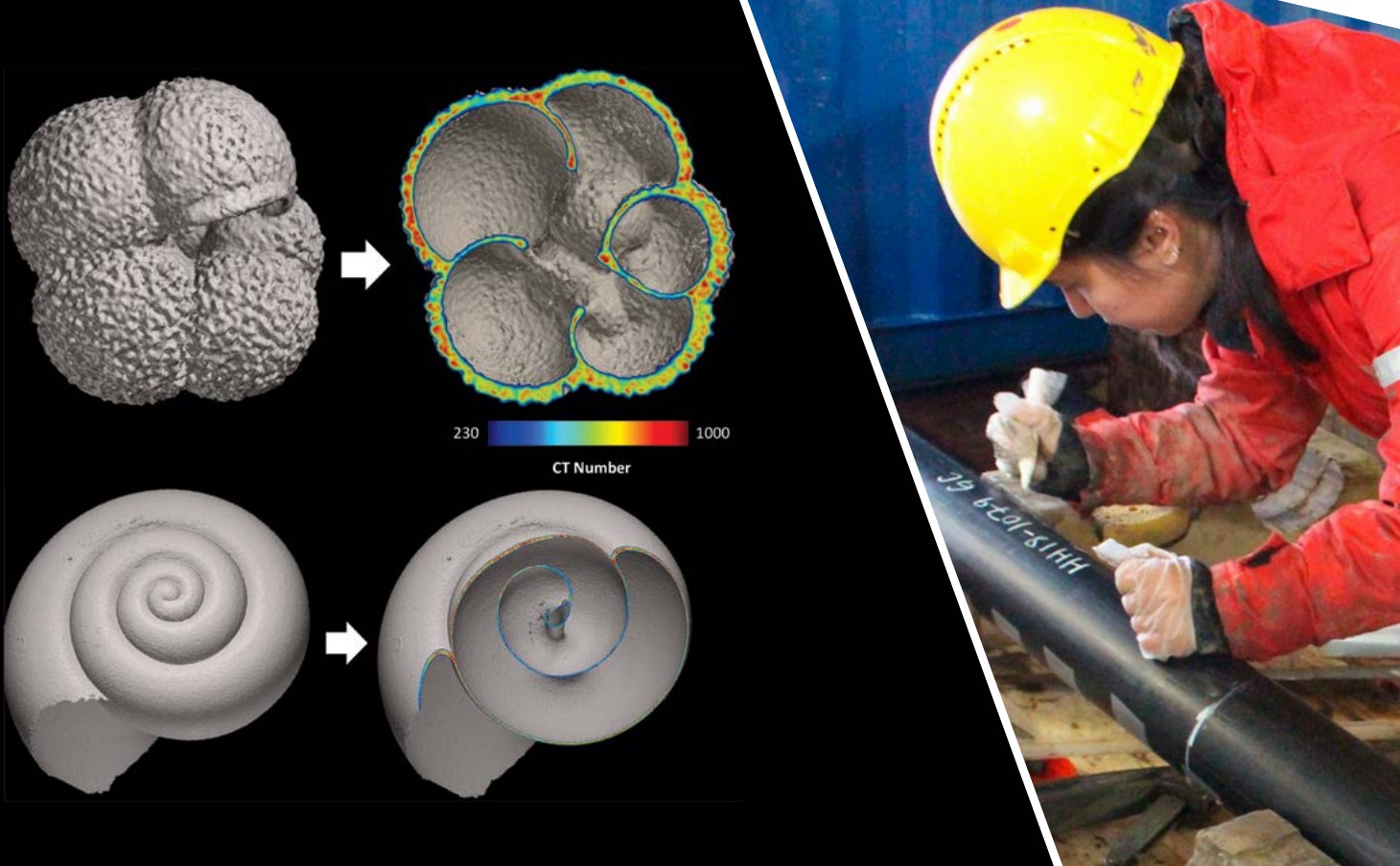
To understand the impact of methane release on past and present environments and climate, we study both modern environments by sampling living planktic and benthic foraminiferal faunas and past environments by examining the fossilized remains of once-living faunas, mostly from the seep sites around Svalbard. To better understand the processes and changes seen at methane release areas, we also reconstruct the general paleoceanography by the study of core sites from the Svalbard margin, the Barents Sea, the Nordic seas and Arctic Ocean. In addition, we investigate methane seep areas by annual and/or seasonal sampling in order to document changes in planktic foraminifera and related ocean chemistry changes over time. Methane released from the seabed rapidly oxidizes to CO₂, which changes the carbonate chemistry of the ambient water. This can potentially increase ocean acidification, which can have detrimental effects on the delicate ecosystem of underwater life. In addition, we monitor the planktic foraminiferal and pteropods response to ocean acidification by studying physical properties of their shells in the past and present.

Main questions:

- What is the impact of increased methane release on marine faunas?
- Is there a relationship between this release and climate (ocean temperature) variability?
- Does methane release contribute to ocean acidification?

Major aims:

- Investigate methane release and its impact in relation to past climate and ocean temperature changes.
- Apply multi-proxy techniques to reconstruct high-resolution climate and greenhouse gas records.
- Detect and quantify planktic foraminiferal and pteropods responses to changes in ocean chemistry due to methane release, increasing atmospheric CO₂ and ocean warming.
- Provide robust records useful for modelling and forecasting future changes as a result of ongoing changes in the polar ocean.



In order to provide insight into past and present ocean conditions, we work to improve existing standards and established methods such as: sediment analysis, carbon dating, isotope analysis, elemental analysis, etc. We also apply emerging technologies and pioneer methods such as Micro-Focus X-ray Computing Tomography and quantification of planktic foraminiferal and pteropod biomass.

Integration of these methods allows us to estimate past CO₂ concentrations, bottom water temperatures, and ventilation rates of the ocean and sea-ice cover. They also help us to identify general circulation patterns of the past in relation to ice sheet advances/retreats and meltwater flows. With this information at hand, variations in methane release from the seafloor and its impact on the environment over time can be compared to palaeoceanographic and climatic developments in order to obtain a better understanding of controlling factors.

Main achievements 2018

1. Exemplified a study of the deglaciation of the Svalbard-Barents Sea Ice Sheet (SBIS) by investigating several core records from Storfjorden southwest of Svalbard, revealing three major deglaciation steps that each correlated with an abrupt and dramatic warming of the atmosphere: the Bølling interstadial at 15,400 years, the Allerød interstadial at 14,300 years and the Holocene at 11,700 years before present. These warming phases also correlated with major inflows of warm Atlantic Water to Storfjorden.
2. Revealed through a 70,000 year ice rafting history (on a millennial scale) of SBIS that local ice rafted material was deposited during the warming phases of the deglaciations of

the last and penultimate glacial maxima, in line with the results from Storfjorden.

3. Reconstructed ocean and climate change and dominating properties of surface water masses during the major climate anomalies of the past two millennia southwest of Svalbard. We identified solar forcing as a possible factor responsible for the short-term variability of the surface conditions superimposed on the multi-centennial warm and cool periods of the past 2000 years.
4. Found first-time evidence of poor preservation of the planktic foraminiferal species *Turborotalita quinqueloba* in deeper water layers above very active methane seeps in the Barents Sea. The water mass was characterized by increased concentration of CO₂ and lower pH.
5. Described a new species of seep-related ostracod from seep sites at Vestnesa. The ostracod may be an indicator-species for paleo-seepage.
6. Published a history of the paleoenvironmental development of the last 25,000 years in relation to the advance and retreat of the SBIS based on the distribution patterns of foraminifera at the edge of the Arctic Ocean;

this was a contribution to a popular book about the changing Arctic under climatic warming.

7. Provided new insights into the history of the Greenland Ice Sheet and its relation to both the East Greenland Current and the sedimentary processes of the Scoresby Sund/north-east Greenland shelf areas. These insights were based on a combination of marine sediment cores, shallow seismics and seabed morphology. Investigations north of Svalbard revealed new locations influenced by gas seepage. We have still not found a suitable control site on the Svalbard shelf and slope that has not faced the influence of thermogenic gas, detailed by the porewater records of 2016-2018.

The MXCT (Micro-Focus X-ray Computing Tomography) measures calcite density, in addition to providing 3D images and high precision morphometrics.

Labelling a gravity core retrieved in Vestnesa Ridge aboard the RV Helmer Hansen in July 2018.

Photos: Siri Ofstad; Naima El bani Altuna.

Methane emissions to the atmosphere

The research project MOCA (Methane Emissions from the Arctic Ocean to the Atmosphere) funded by the Research Council of Norway, ran from 2013 to 2017 independent of CAGE. This project connected the gas hydrate research done at CAGE with atmospheric sciences. The MOCA project was a collaboration between UiT/CAGE, NILU and the Center for International Climate Research – Oslo (CICERO).



Cathrine Lund Myhre, Team Leader

Cathrine Lund Myhre is a senior scientist at the Department of Atmospheric and Climate Research, at NILU- Norwegian Institute for Air Research. She studies natural and anthropogenic greenhouse gases and aerosols, including their sources, concentrations and long-term trends. Lund Myhre's focus is on the Sub-Arctic and Arctic regions. She holds a PhD in Physical Chemistry from the University of Oslo, Norway. Lund Myhre coordinated the project MOCA (Methane Emissions from the Arctic Ocean to the Atmosphere) at NILU.

Members 2013–2017:

Jürgen Mienert
Professor CAGE

Bénédicte Ferré
Team Leader, CAGE

Sunil Vadakkepuliambatta
Postdoctoral Researcher, CAGE

Gunnar Myhre
Senior Researcher, CICERO

Ignacio Pisso
Senior Scientist, NILU

Stephen M. Platt
Scientist at NILU

Norbert Schmidbauer
Senior Scientist, NILU

Andreas Stohl
Senior Scientist, NILU

About:

The MOCA project has investigated the release of methane from the ocean to atmosphere, and the potential effects this greenhouse gas may have on increased radiative forcing and subsequent global warming. The project combined state-of-the-art atmospheric and oceanographic measurements to investigate this powerful greenhouse gas. We also integrated this empirical data with atmospheric models, such as the FLEXPART Lagrangian transport model or OsloCAM3, to achieve impact scenarios for present and future climate change. MOCA contributed to understanding present atmospheric effects of methane released from Arctic seabed sediments. The project ran from 2013 to 2017.

Main questions:

- Does methane release from the seabed into the ocean reach the atmosphere?
- What are the climatic implications of seabed methane seepage?

Major aims:

- Measure and estimate natural methane emissions from the Arctic Ocean floor to the atmosphere.
- Describe the climatic impact and radiative forcing (direct and indirect effects) from seabed methane emissions under present-day as well as future atmospheric compositions.





The atmosphere group uses observation data to constrain models and understand the processes influencing ocean-atmosphere exchange and addresses the question of whether methane from the ocean is an important issue for the future climate.

Main achievements 2013–2017

1. Started the CAGE-MOCA collaboration on 1st October 2013 with the installment of an atmospheric lab on UiT's research vessel (RV) *Helmer Hanssen*.
2. Collected atmospheric gas measurements over a three-year period from across large areas of the Arctic Ocean and Barents Sea from the RV *Helmer Hanssen*. The continuous measurements included methane, CO₂ and CO, in addition to offline bottle sampling for isotope analysis of trace gases ethane and propane.
3. Constrained the methane flux from shallow waters around Svalbard for 2014–2015 for use in FLEXPART atmospheric modelling. The model is constrained by comprehensive sets of atmospheric measurements from

ocean (RV *Helmer Hanssen*), land (Zeppelin Mountain Observatory, Svalbard), and air (flight campaigns using FAAM aircraft).

4. Published a study showing that only a very small amount of methane, insignificant to the global annual atmospheric budget, leaves the ocean during the summer. Methane does not reach the atmosphere in significant quantities, despite the presence of active gas flares at the shallow water depths west of Prins Karls Foreland. Ocean stratification seems to mitigate the release of the gas to the atmosphere in the summer. However, the flux might vary throughout the year.
5. Modelled methane emissions from gas hydrates across the Arctic Ocean over the 21st century. The model indicates that methane

emissions from hydrate dissociation may not be a major driver of global warming.

6. Discovered repeated instances of unexpectedly high methane concentrations along North Svalbard towards the Arctic Ocean. This region is characterized by active methane seeps and water mass stratification very close to the sea surface (<15m). Release of methane from the ocean to atmosphere may be higher in these less stratified water masses.

Zeppelin atmospheric observatory, Svalbard.

Sensor measuring methane and other greenhouse gases on board RV Helmer Hanssen.

Photo: Jerzy Strzelecki; CAGE.



Arctic Marine Geology and Geophysics Research School (AMGG)

The Arctic Marine Geology and Geophysics Research School (AMGG), led by CAGE staff in cooperation with the Department of Geosciences at UiT – The Arctic University of Norway, aims to train PhD students and young scientists in the field of Arctic marine geology and geophysics.

The school has a steering committee, the faculty administration provides the budget support, and there is a PhD appointed as secretary. The PhD student secretary and G.Panieri are responsible for the AMGG website: always updated with new activities, relevant courses for students, and aid and guidance to the PhD fellows (<https://amgg.uit.no>).

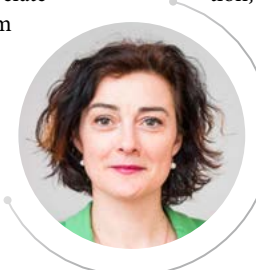
The training focuses on the development of Arctic continental shelves and margins, including topics such as glacial processes and products, fluid emissions and gas hydrates, palaeoclimate and – oceanography, energy and environment and geo-hazards. The PhD trainee school offers scientific expeditions to the Arctic; relevant seminars about climate and environmental change; field trips to terrestrial fluid emission sites and other geological processes; specialized workshops with national and international participants; and soft-skill training courses for the new generation of scientists.

AMGG has students from about 20 different countries. During the organized activities there are not only scientific and educational exchanges, but also cultural exchange between the participants. This promotes the creation of new academic culture, similar to the new concept of the ‘world-class’ university.

AMGG is important because it complements students knowledge, provides the opportunity to go more in depth on subjects they are not exposed to in traditional courses, acquire transferable skills, network and go “across boundaries”.

Giuliana Panieri, AMGG Leader

The research school is led by Associate Professor Giuliana Panieri from CAGE, with coursework developed in close collaboration with the Department of Geosciences, UiT The Arctic University of Norway.



Annual meeting and teaching cruise

A highlight of the AMGG yearly calendar is the annual meeting, where students have the opportunity to network and receive critical feedback on their work from colleagues and invited academic experts. Another important annual event is the AMGG teaching cruise to the Arctic aboard UiT’s RV *Helmer Hanssen*, led by scientists from CAGE and the Department of Geosciences. This cruise allows PhD and Master students to gain valuable experience in the

acquisition and interpretation of state-of-the-art marine datasets. Target areas include the Fram Strait, the Greenland shelf, the Barents Sea and areas around Svalbard.

In 2018, the AMGG PhD teaching cruise focused on glaciated continental margins, gas hydrate deposits and methane seepages in several sites around Svalbard. During the cruise students were introduced to all aspects of data collection, processing and interpretation.

AMGG also offers workshops, lectures and exercises on a wide range of scientific topics, focusing on the theoretical and practical applications of geoscience research from the sub-seafloor, the seabed, and the water column.

A student working on deck during a scientific expedition.

The beautiful nature of Svalbard in the Arctic Ocean, taken at the beginning of an AMGG cruise.

Students during an AMGG field trip on Mount Etna (Italy).

Photos: Giuliana Panieri; Kate Waghorn.



Masters theses 2018

Hansen, L.L.

The role of diapiric mound structures in the overburden fluid plumbing systems of the Vøring Basin. (2018).

Supervisor: Bünz, Stefan.

88 pages. <https://hdl.handle.net/10037/12824>

Matteis, F.W.

Climate reconstruction during the Last Glacial Maximum based on a marine sediment core from Vestnesa Ridge, Svalbard. (2018).

Supervisor: Rasmussen, T.L.

96 pages. <https://hdl.handle.net/10037/13459>

Patel, J.

Paleoenvironmental investigation of the northern flank of the Olga Basin (Barents Sea) during the Late Weichselian deglaciation. (2018).

Supervisor: Panieri, G., Dessandier, P.A.

83 pages. <https://hdl.handle.net/10037/13097>

Solheim, M.

Reconstruction of the bottom current strength of overflow water through the Faeroe-Shetland Channel in relation to climate change during the last 135,000 years. (2018).

Supervisor: Rasmussen, T.L., Junntila, J., Ezat, M.

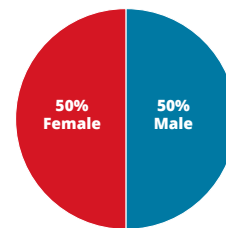
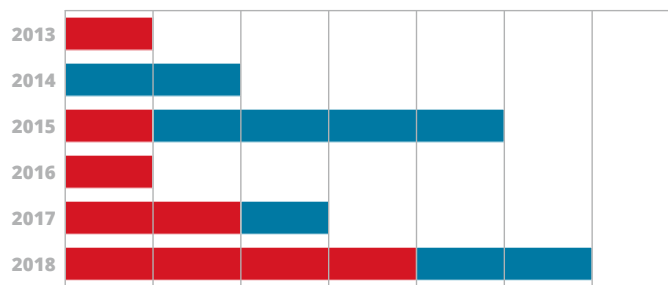
79 pages. <https://hdl.handle.net/10037/12857>

Wolberg, A.C.

Controls on fluid-flow systems in the Loppa High, SW Barents Sea". (2018).

Supervisor: Vadakkepuliambatta, S.

155 pages. <https://hdl.handle.net/10037/12822>



List of PhD dissertations

2013

| Safronova, P.

Distribution, depositional environment and post-depositional deformation of Cenozoic gravity-induced deposits along the western Barents Sea continental margin.

Supervisor: Andreassen, K.

2014

| Faust, J.C.

Environmental response to past and recent climate variability in the Trondheimsfjord region, central Norway - A multiproxy geochemical approach

Supervisor: Knies, J.

| Vadakkepuliambatta, S.

Sub-seabed fluid-flow systems and gas hydrates of the SW Barents Sea and North Sea margins

Supervisor: Bünz, S.

2015

| Chauhan, T.

Late Quaternary paleoceanography of the northern continental margin of Svalbard

Supervisor: Rasmussen, T.L., Noormets, R.

| Ezat, M.

North Atlantic-Norwegian Sea exchanges during the past 135,000 years: Evidence from foraminiferal $\Delta^{14}C$, $d^{11}B$, $d^{18}O$, $d^{13}C$, Mg/Ca and Cd/Ca

Supervisor: Rasmussen, T.L., Groeneveld, J.

| Gudlaugsson, E.

Modelling the subglacial hydrology of the former Barents Sea Ice Sheet

Supervisor: Andreassen, K., Humbert, A.

| Jessen, S.P.

Ice rafting, Ocean circulation and Glacial activity on the western Svalbard margin 0-74,000 years BP

Supervisor: Rasmussen, T.L.

| Portnov, A.D.

Role of subsea permafrost and gas hydrate in postglacial Arctic methane releases

Supervisor: Mienert, J., Cherkashov, G.

2016

| Sauer, S.

Past and present natural methane seepage on the northern Norwegian continental shelf

Supervisor: Knies, J., Mienert, J.

2017

| Szytbor, K.

Late glacial and deglacial paleoceanographic and environmental changes at Vestnesa Ridge, Fram Strait: challenges in reading methane-influenced sedimentary records

Supervisor: Rasmussen, T.L.

| Tasianias, A.

Fluid flow at the Snøhvit field, SW Barents Sea: processes, driving mechanisms and multi-phase modelling

Supervisor: Bünz, S.

2018

| Esteves, M.d.S.R.

Doctoral dissertation. "Collapse of a marine-based ice sheet". (2018).

Supervised by: Winsborrow, M.

| Jansson, P.

Doctoral dissertation. "Methane bubbles in the Arctic Ocean - Quantification, variability analysis and modelling of free and dissolved methane from the seafloor to the atmosphere". (2018).

Supervised by: Ferre, B.

| Paiste, K.

Doctoral dissertation. "Reconstructing the Paleoproterozoic sulfur cycle: Insights from the multiple sulfur isotope record of the Zaonega Formation, Karelia, Russia". (2018).

Supervised by: Panieri, G., Lepland A.

| Schneider, A.

Doctoral dissertation. "Diagenetically altered benthic foraminifera reveal paleo-methane seepage". (2018).

Supervised by: Panieri, G., Knies, J.,

Lepland, A.

| Serov, P.

Doctoral dissertation. "Cryosphere-controlled methane release throughout the last glacial cycle". (2018).

Supervised by: Andreassen, K.

| Åström, E.

Doctoral dissertation. "Benthic communities at high-Arctic cold seeps: Faunal response to methane seepage in Svalbard". (2018).

Supervised by: Carroll, J.





Fabio Sarti, Engineer

Fabio is the centre's data manager and is responsible for data storage, reporting of scientific results, and statistics.

The New CAGE Database Mapping Interface

CAGE data manager Fabio Sarti partners with IT experts to allow public access to cruise data

Traditionally, there has been a trend towards secrecy when it comes to revealing the details of accumulated data and data analysis at universities and research institutions. This applies not only to restricted academic journals that require large fees for access, but also to raw data collected through research projects and never published.

There has been a movement in recent years, however, supporting the idea that publically funded research in Europe should be more easily accessible. It is not only fair to give the public access to something that it has paid for, but open access to research also encourages better-informed and more groundbreaking results. The Norwegian government heavily endorses this movement, and The Research Council of Norway is at the helm in assuring that Norwegian universities and research institutions accept and comply with these new standards.

In 2016, the Centre for Arctic Gas Hydrate, Environment, and Climate (CAGE) decided to start a pilot project at UiT The Arctic University of Norway in developing software that would allow easy access to our raw research data. This mostly includes data from Arctic cruise expeditions, such as samples of the seafloor sediments and water, seismic survey

data, observatory data, bathymetry mapping data, and image/video data. Fabio Sarti was hired as the project manager for the job in cooperation with the IT department at UiT and Avinet, a consultancy company specializing in map and database solutions.

At its most basic, this information is available in what amounts to hundreds of tables and potentially hundreds of thousands of lines of data. While quite comprehensive, navigating these spreadsheets is a time-consuming and frustrating way to find and analyze specific details. An alternate method in accessing the information is through a program that sorts the data into a filing system – an improvement to be sure, but still somewhat cumbersome for the average viewer.

Finally, Fabio and CAGE administration decided that a map interface for the tracking of individual cruise expeditions by illustration would provide the most user-friendly experience in exploring the data. These cruise navigation tracks show the journey of the CAGE scientific cruises from beginning to end, and can be selected at any point in its travels. The user then obtains further information about the cruise, such as surveys and activities, chief scientists, dates of the cruise, any associated

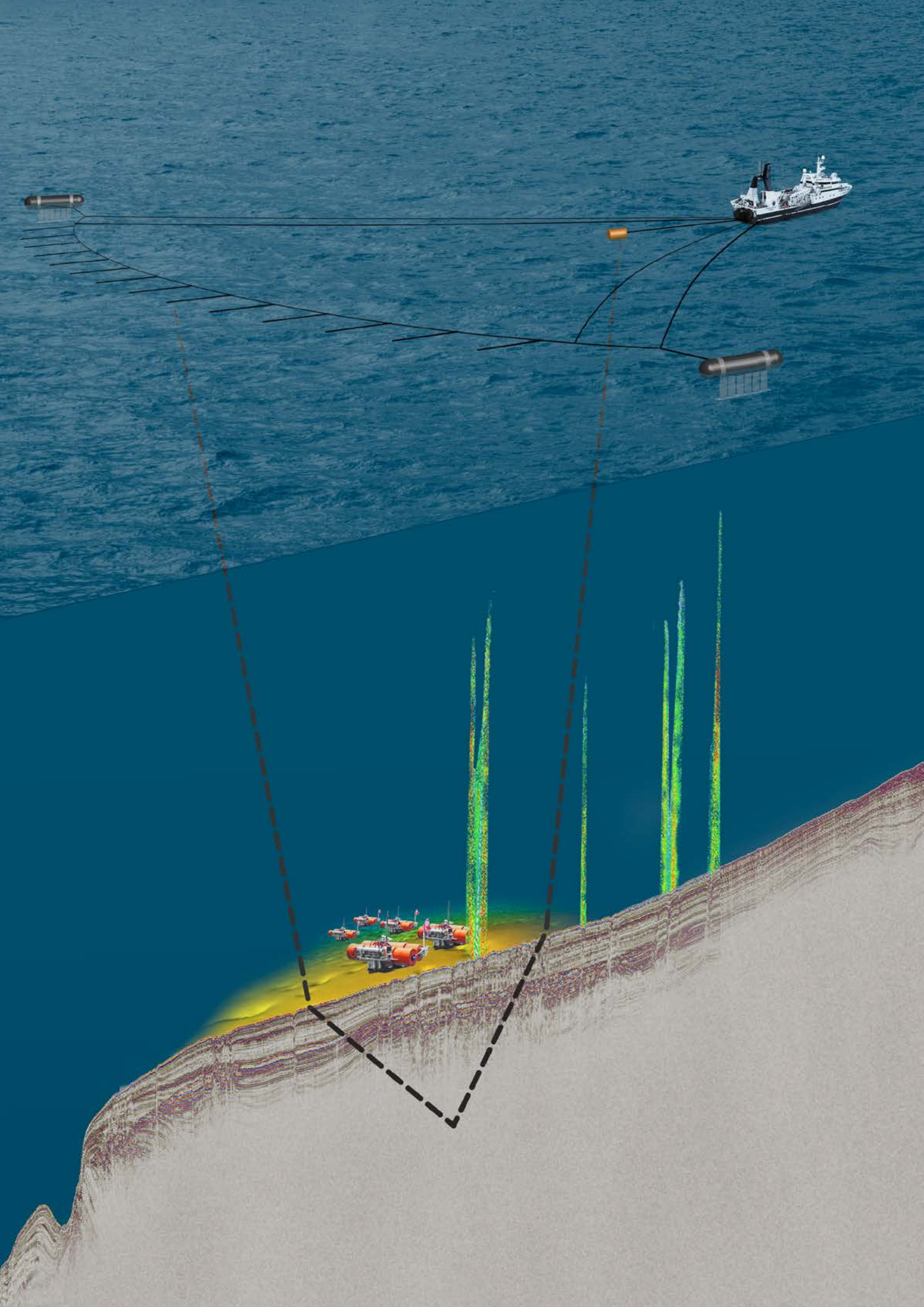
publications, downloadable cruise reports, and more. This map and corresponding data is now accessible through CAGE's new (as of February 2019) website.

Although we are well on our way in moving towards an open-access model at UiT, not all raw data collected by CAGE is currently available for public consumption. Data requires a DOI (Digital Object Identifier) before publication so that future scientists are able to give proper credit to the university or institution behind the research, and assigning these DOIs is a time consuming process.

In the meantime, CAGE data manager and project leader Fabio Sarti has been at the forefront of a major accomplishment. The CAGE map interface has inspired at least two other similar interfaces at UiT: the department of geoscience's 'Core Repository', and the department of Arctic and marine biology's 'Whale Tracker'. We hope that this is only the beginning, and that our expedition into the world of data management will inspire other entities inside and outside of Norway to provide easier access to research results towards a better future.

Illustration: Torger Grytå/Colourbox.

Text: Jessica Green.



New projects

External funding acquired by CAGE researchers has reached new heights in 2018! The first two quarters of 2019 will be a flurry of activity in hiring new PhDs and PostDocs to manage all of the new scientific work, much of which will last throughout the duration of CAGE. Special mention goes to Andreia Plaza-Faverola who raised NOK 34 million through two grants supporting her SEAMSTRESS project in WP1, with a possible third grant in the works.

SEAMSTRESS – Tectonic stress effects on Arctic methane seepage

Project leader: Andreia Plaza-Faverola
Project duration: 2019–2023

The project SEAMSTRESS investigates the effect of regional stress on the dynamics of gas hydrates and near-surface fluid migration across Arctic continental margins. It consists of an experimental phase with 4-cross disciplinary field experiments (geomechanical, seismological, petrophysical and 3D seismics) and a model-building phase. This project is fully funded by the Tromsø Research Foundation (TRF) and the Research Council of Norway (FRINATEK) through their grants for young researchers, and will add to CAGE and the Department of Geosciences an additional 4 positions.

VISTA - The glacial hydrocarbon pump

Project leader: Pavel Serov & Karin Andreassen
Project duration: 2019–2022

The project investigates subseabed and seabed hydrocarbon leakage and gas hydrate dynamics in response to multiple glaciations of the Barents Sea shelf. It combines geophysical observations of present and paleo fluid flow, modeling of long-term evolution of the Barents Sea Ice Sheet and basin modeling. The project is funded by VISTA – a collaborative partnership between Equinor and the Norwegian Academy of Science and Letters, providing 1 new postdoc position. CAGE and UiT – the Arctic University of Norway host and support the project.

Akademiaavtale

CAGE responsible: Karin Andreassen
Project duration: 2019–2022

A collaborative research agreement between UiT and Equinor has funded a new numerical modelling based initiative that will focus on reconstructing the evolution of the Barents Sea basin over the last 3 million years. It will combine modelling and empirical-based expertise within CAGE, ARCEX and Equinor, with two main objectives: 1) to constrain the impact of ice-sheet glaciation on long-term landscape evolution and hydrocarbon systems in the Barents Sea region, and 2) develop a physics based reconstruction of the Barents Sea basin evolution during the Late Cenozoic. It will provide 1 new researcher position to CAGE.

Joint Climate – Ice-ocean-atmosphere interaction in the Arctic – from the past to the future.

Cage responsible: Karin Andreassen and Alun Hubbard
Project duration: 2019–2022

This project is a joint transdisciplinary effort centred around three groups at the Faculty of Science and Technology, UiT The Arctic University of Norway in Tromsø. It involves the Department of Physics and Technology (IFT), the Department of Mathematics and Statistics (IMS), and The Department of Geosciences (IG) through CAGE. The overarching goal is to enhance understanding of the changing Arctic through observationally constrained integrated modelling of ice sheet, ocean, and atmospheric dynamics. The project provides one postdoctoral position to CAGE, investigating ice-ocean interactions during the last glacial cycle and one Adjunct Professor position (20%).

The Nansen Legacy

CAGE responsible: Tine Rasmussen & Kasia Zamelczyk
Project duration: 2018–2023

The Nansen Legacy is a novel and holistic Arctic research project that will provide integrated scientific knowledge on the rapidly changing marine climate and ecosystem in the northern Barents Sea and Arctic Ocean. CAGE has secured one 3.5 year PhD position within the research task 'Human impacts - Ocean acidification' as a part of the project. The focus of this task is to improve our understanding of how human activities influence the northern Barents Sea ecosystem. The Nansen Legacy is funded by the Research Council of Norway and the Norwegian Ministry of Education and Research.

Hot Vents in an Ice-Covered Ocean (HACON)

CAGE responsible: Stefan Bünz, Bénédicte Ferré, Giuliana Panieri, & Mette Svenning
Project duration: 2018–2021

HACON will conduct the first full-scale multidisciplinary study of deep (4000 m) hydrothermal vents under permanent ice cover in the Arctic. It will unravel the geological, geochemical and physical processes that shape the Aurora biological communities and assess the role played by the Gakkel Ridge in connectivity of chemo-

synthesis-based ecosystems between ocean basins. The project is led by NIVA with project partners from CAGE, University of Bergen, the Institute of Marine Research, Woods Hole Oceanographic Institution, the Alfred Wegener Institute, and the University of Aveiro. It is funded by the NFR FRINATEK program.

INTPART AKMA

Project leader: Giuliana Panieri
Project duration: 2019–2022

The INTPART AKMA (Advancing Knowledge on Methane in the Arctic) project will support education and research collaboration between CAGE and the Woods Hole Oceanographic Institution, with a focus on developing long-term, multidisciplinary education and research collaboration on Arctic methane sources, processes, ecosystems and geological history. This will be done through scientific and technical exchanges between partners, a dedicated student training cruise and development of an intensive course in Arctic cold microbe biogeochemistry and related phenomena.

SIOS-InfraNor

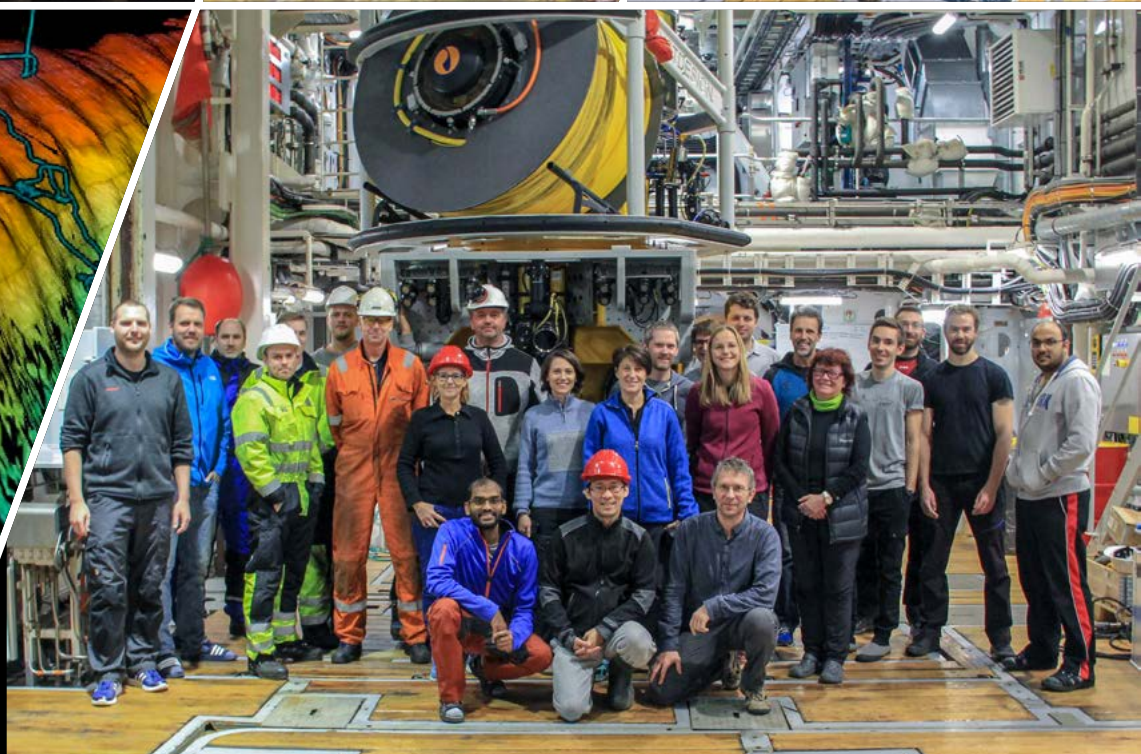
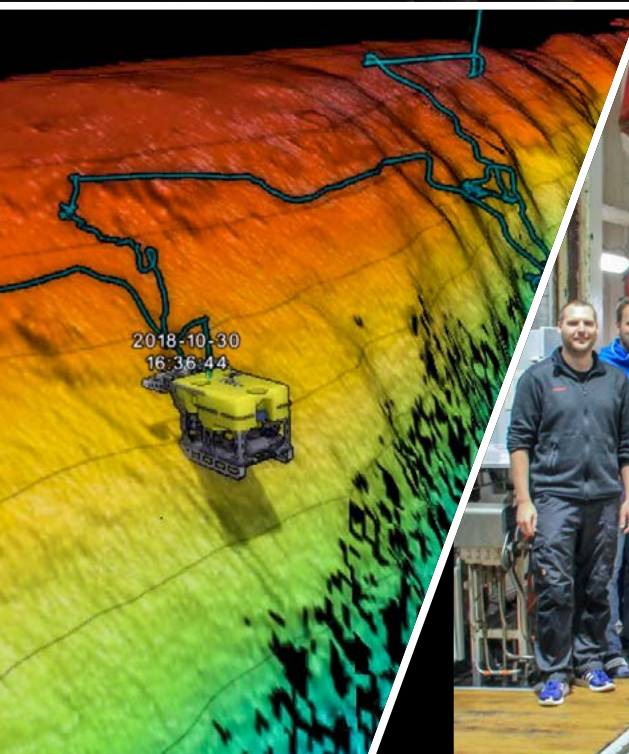
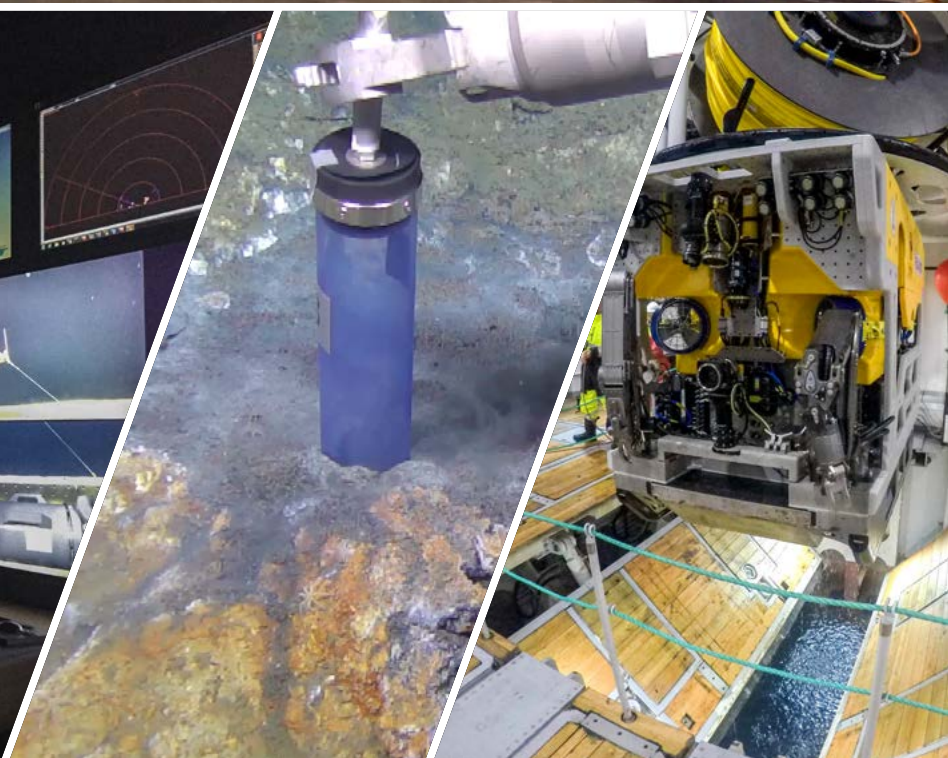
Cage responsible: Bénédicte Ferré
Project duration: 2019–2022

The Research Council of Norway has singled out the Svalbard Integrated Arctic Earth Observing System – Infrastructure development of the Norwegian node (SIOS-InfraNor) project for funding through 2022. It will enable a coordinated and state-of-the-art observation network for marine, terrestrial and atmospheric research to be implemented and operated around Svalbard. CAGE is part of the marine module, and was granted funding to launch the next K-lander deployment offshore Svalbard.

Lofoten-Vesterålen (LoVe) project

Cage responsible: Bénédicte Ferré
Project duration: 2015–2020

The LoVe project, led by IMR, was first launched in 2013 to observe a cold coral reef offshore the Lofoten-Vestrålen area at 258m depth. The full-scaled infrastructure of LoVe 2 will run through October 2020, and includes a network of seven nodes crossing the main oceanographic and biological processes. The cables were installed in summer 2018 and the nodes will be deployed in 2019. CAGE and UiB are in charge of the node 7, located in an area of active methane seepages.



New RV *Kronprins Haakon* is changing what we know about polar waters

The new capabilities of the vessel are making waves in the field of subsea geoscience.

When the new ice-going research vessel christened *Kronprins Haakon* (*KPH*) departed the docks of Svalbard on October 22nd 2018, researchers aboard from the Centre for Arctic Gas Hydrate, Environment, and Climate UiT (*CAGE*) knew that they were in for an adventure. There was much to learn from this newly-built ship with its state-of-the-art sampling equipment, custom laboratories, and capabilities in a variety of weather and ice conditions. But what the scientists didn't know was how much potential the vessel had to change subsea research in the high north forever.

The inaugural *CAGE*/UiT cruise on *KPH* had two main goals. The first was to determine what the vessel itself was capable of: how would it handle, where could it go, and what could it do?

The second goal was to use the ship to transport new, high-tech equipment to an area featuring active methane release systems in the northern Barents Sea. While this region has been well-studied in recent years, researchers from *CAGE* could now view and sample the seabed in ways that have never been possible before.

Dynamic positioning enables targeted sampling

One of the largest problems facing previous cruises was the potential for UiT's research vessel *Helmer Hanssen* to be thrown off course by wind and waves. This made it difficult to keep the ship stationary over a specific area in order to collect samples or examine certain structures and organisms more closely. A useful feature of *KPH* that significantly reduces this problem is its dynamic positioning system, allowing the ship to maintain one position in the sea. Therefore, when the research crew identifies something in the water or on the seafloor that they want to sample, it is possible to remain in the same spot until the item has been collected.

Balancing tanks combat rough waves; seasickness

Another major issue facing previous *CAGE* cruises was the instability of the previous ship when confronted with bad weather, which was a concern about 50% of the time. It was not uncommon for rough waves to cause an epidemic of seasickness across the entire research team and operational crew – sometimes up to 50%

of the passengers were ill for several days. This created a huge problem in terms of lost labor hours.

This is another area where *KPH* shines. Balancing tanks built into the structure of the ship are designed to control the pitch and roll of the vessel caused by rough waves, nearly eliminating all risk of motion-induced seasickness. This means that the vessel can be used even against waves of 4-5 meters, a threat that other research vessels were incapable of handling. In fact, *KPH* will likely introduce research expeditions to the winter months – something that was impossible with other, less stable ships.

Moon pool protects delicate equipment – and personnel

Inclement weather doesn't only affect the comfort and efficiency of passengers, but also the ability to deploy research equipment. If there is too much wind and rain and many high waves, it is difficult to lower equipment over the edge of the ship without the risk of damage to the instrument, or injury to the researchers themselves. That is where a moon pool comes in handy. A moon pool is a feature of some research or drilling vessels that allows equipment to be lowered through a hole in the bottom of the ship to the seabed below, protecting it from the potentially dangerous elements above the water. The moon pool on *KPH* is the largest of any research vessel, allowing for deployment of much more advanced, large-scale equipment, such as an ROV.

ROV allows underwater areas to be seen in stunning detail

On this voyage, *KPH* was carrying a remotely operated vehicle (ROV) named *ÆGIR 6000* from the Norwegian Marine Robotics Laboratory at the University of Bergen. *ÆGIR 6000* is an instrument that is revolutionizing what is known about deep sea areas. The combination of the ROV along with the safe deployment space provided by the moon pool made the first *KPH* *CAGE* cruise a very unique experience.

An ROV is an unmanned submersible tethered to the ship through the moon pool by a long cable. It is a piece of equipment capable of exploring the bottom of the ocean at close range while being remotely operated from the ship.

The arms of the ROV, commonly called manipulators, are equipped with delicate pincers for taking targeted samples, and the unit contains seven cameras that help technicians see what is being grabbed. It also boasts a coring device to collect sediment, a gas sampler to catch gas bubbles, and a water sampler to collect water, making it a full-service deep-sea robot. But perhaps most exciting is the mapping tool that is built into the ROV. For the first time, researchers can view the seabed at a resolution of 5-10 centimeters, as opposed to the 4-5 meters possible with other mapping systems.

Next *CAGE* cruise aboard *KPH* excitedly anticipated

KPH is a research vessel that is shared by several Norwegian-based entities; it is officially owned by the Norwegian Polar Institute, run and maintained by the Institute of Marine Research, and largely used by UiT. The next two cruises with *CAGE* participation are scheduled for the fall, departing September 19th and October 19th respectively. Plans at *CAGE* are already on place for the upcoming cruise as researchers eagerly await their next voyage into the unknown.

The new research vessel Kronprins Haakon is revolutionizing subsea research.

One of the ROV pilots controlling the vehicle from the control room.

Push coring of bacterial mat in newly discovered methane seep on the continental margin off the Lofoten-Vesterålen Islands.

The ROV Ægir 6000 hovers above the moon pool on RV Kronprins Haakon, ready for deployment.

The ROV is able to map the ocean floor at a resolution of 5-10 centimeters.

The research team aboard the CAGE inaugural cruise 18-3 on RV Kronprins Haakon in October 2018.

Photos: Renata Lucchi; Bénédicte Ferré; Jochen Knies; Stefan Bünz; ROV/CAGE; Stefan Bünz.

Text: Jessica Green



Exploration into gas hydrate provinces continues in 2018

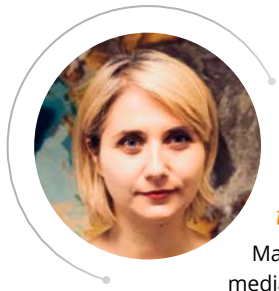
CAGE has now completed 37 research expeditions into Arctic waters since 2013. In 2018 we performed geological controls on NW-Barents Sea seepage, explored node 7 with the LoVe project, investigated methane seepage sites in the Barents Sea, Storfjorden Trough, East Greenland Ridge, Vestnesa Ridge and Prins Karls Forland, led students on a fun and informative AMGG Research School cruise, and more.

Perhaps most importantly, we finally explored the unknown in the new, highly anticipated ice-going research vessel *Kronprins Haakon*. Not only is it a state of the art vessel with new capabilities and features such as dynamic positioning, balancing tanks, a helicopter pad, and an unusually large moon pool, but the interior is designed to make the research and technical staff feel as if they are right at home. After all, when one spends a month on the icy waters of the high north, a 4-person Jacuzzi is an absolute human right.



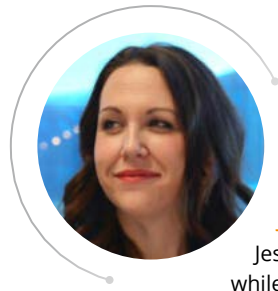
| A view of the helicopter pad on Kronprins Haakon at the docks in Longyearbyen. Photo: Vincent Carrier | Push corners in the sediment among white microbial mats. Photo: ROV/CAGE |
 | RV Helmer Hanssen departs Ny-Ålesund, Svalbard on its way back to Longyearbyen after a fruitful expedition. Photo: Naima El bani Altuna | The ROV Ægir 6000 emerges from
 the moon pool clutching a carbonate crust taken from the seabed. Photo: Bénédicte Ferré | A methane hydrate taken from the seabed in Vestnesa Ridge. Photo: Naima El bani Altuna |
 | Push cores in the lift-basket that bring them back from 380m. Photo: Mette Marianne Svenning | The research team aboard CAGE cruise 18-3 on R/V Helmer Hanssen in July 2018.
 Photo: Anna Mamadzhian | CAGE PostDoc Dimitri Kalenitchenko holds a piece of carbonate crust covered in anemones and hydrozoans, both organisms from the Phylum
 Cnidaria. Photo: Renata Lucchi | Technicians control the movements and observe the progress of the Ægir ROV 6000 from the comfort of the control room. Photo: Stefan Bünz |
 | Chemosynthesis-based community at a newly discovered seep site off the Lofoten islands or northern Norway. Photo: ROV/Norcrust |





Maja Sojtarić,
*Communications Advisor
to October 2018*

Maja writes our press releases, manages media contact and maintains our social media distribution, as well as arranging workshops in communication.



Jessica Green,
*Temp Communications Advisor
from October 2018*

Jessica is filling in as communications advisor while Maja is on maternity leave. Main tasks include website content creation and updates, social media marketing, press releases, photography, etc.

International attention and novel outreach efforts

While the team at CAGE is always on the lookout for new and interesting ways to reach non-academic audiences, 2018 proved that we can still be surprised by the ingenuity of our staff.

While conducting high-quality research is an important component of CAGE, equally important is the ability to share that research with both academic and non-academic audiences in ways that are clear, engaging, and easily digestible. We strive to fulfill this obligation each year, and 2018 was no exception. A focus on narrating excellent results to the general public, industry, stakeholders, and media continues to play an important role in our overall strategy for the centre.

CAGE members rely on social media and grassroots communication

PhD Candidate Naima El Bani Altuna dreamt of delivering her research results to her native Basque community in northern Spain. But how? While on a research expedition into Arctic waters, she created a Basque-language Twitter account that described her research and delivered Arctic-life anecdotes to a Basque audience. She even won an academic contest challenging Basque-speaking PhD students to describe their research in 6 tweets in their native language. This success has earned her interviews in the largest Basque language newspapers, TV stations and other news and media outlets in Basque Country, reaching an audience completely new to scientific communication from the Arctic. She continues to update the Twitter account and has over 800 followers, no small feat for a language with only 1 million speakers worldwide.

In 2018 UiT The Arctic University of Norway celebrated its 50th anniversary. CAGE director Karin Andreassen was invited to contribute to the podcast *Observatoriet* as one of 50 noted scientists making outstanding contributions to scientific excellence at UiT. She was also selected as one of the pioneering women of natural science at UiT, contributing her story to a travelling exhibition aimed at the public. She also participated in the very popular 'Saturday University in Tromsø' – an outreach platform to educate the general public on various UiT research areas.

Associate Professor and AMGG leader Giuliana Panieri was interviewed regarding Arctic and climate science on Italian state television (RAI), in the popular weekly science magazine *TG Leonardo*, and on Italian radio station Rai Radio 1. As a member of the EGU Outreach Committee, Giuliana is deeply involved in activities and decision making that bring the geosciences to the public. She was also interviewed for Norwegian, German, Spanish magazines and journal regarding her own research. Furthermore, she wrote several blogs for the NORCRUST project, and even contributed to a blog writing course for PhD students at CAGE.

Researcher Kasia Zamelczyk detailed ocean acidification and its effects on shells of planktic calcifiers in the past and the present for *WP6 at CO₂ Days*, an event for the public organized by the UiT and hosted at the Northern Norwegian Science Center in April of 2018. It featured lectures, quizzes, experiments, laboratory demonstrations, photo exhibitions and more for the Tromsø community with a special focus on school-aged children.

Finally, researcher and project-leader Andreia Plaza-Faverola assisted in outreach for *WP1* by giving a pop-science presentation to a general audience in connection with her Tromsø Research Foundation funding award. She also organized and lead a CAGE workshop to discuss scientific drilling in the Fram Strait, which was funded by ECORD and covered in their newsletter, a document aimed at the general European public.

ICEMAP gains traction with young minds; new audiences (icemap.no)

CAGE launched ICEMAP in February of 2018 in collaboration with The Science Centre of Northern Norway. ICEMAP is an interactive installation and webpage telling the story of the last ice age, based on cutting edge data visualizations created by CAGE researcher Henry Patton. This tool features a map detailing the birth and decline of

the last Eurasian ice sheet, based on published results from high ranking journals. It is truly a highlight of CAGE-influenced scientific output, communicated with great success to thousands of school-aged children each year. It will be part of the Science Center's permanent exhibition on climate and weather for the foreseeable future.

Sharing these visualizations through digital platforms has also drawn a lot of attention. CAGE Communications advisor and ICEMAP project manager Maja Sojtarić was invited to submit an abstract to the Geosciences Information for Teachers (GIFT) workshop and give an accompanying presentation on the topic. These are two-and-a-half-day teacher enhancement events are held in conjunction with European Geosciences Union annual General Assembly, where top scientists lead discussions centered on a different Earth-science theme each year. Maja's presentation of the ICEMAP was very well received, harnessing a great amount of attention for CAGE.

ICEMAP material has also proven very shareable on social media, contributing to an international conversation on climate change. The material from the project even made its way to the National Museum of Northern Ireland in Belfast as a part of a permanent exhibition on extinct animals and environmental changes.

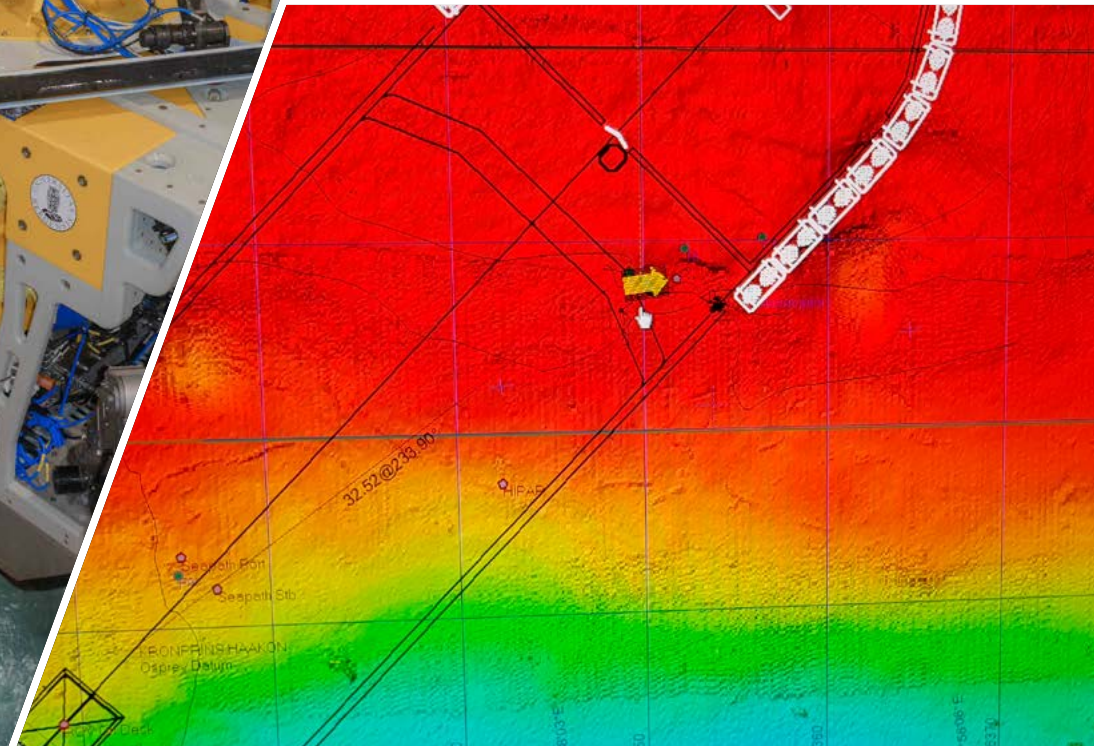
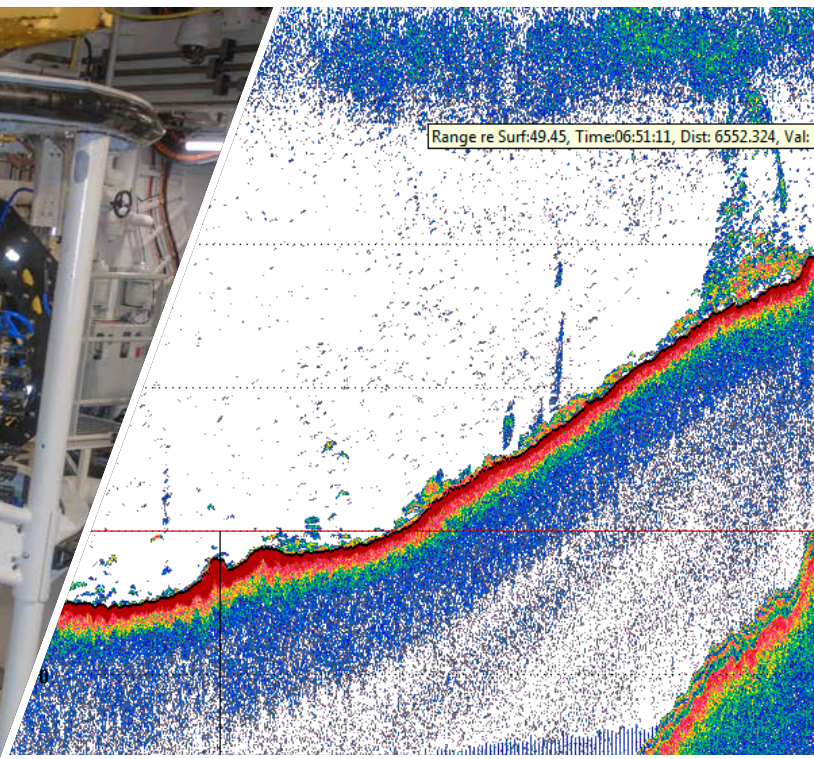
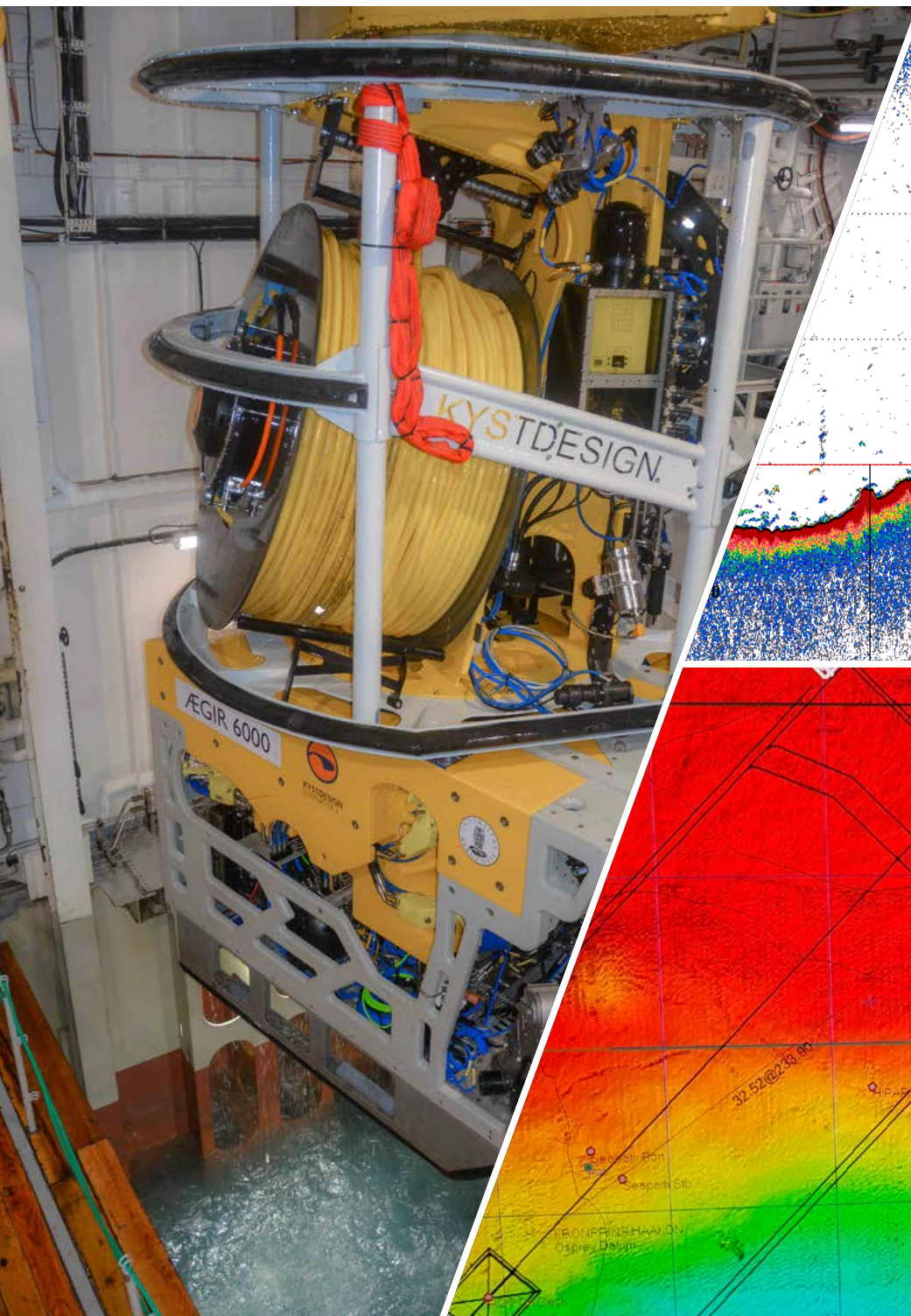
Due to the success of this outreach element, we are paying close attention to funding opportunities for similar projects and welcome all requests for the reuse of this material on a variety of platforms.

Naima El bani Altuna aboard a CAGE cruise in the Arctic.

Lenny Lemming narrates the ICEMAP story of the last Eurasian glaciation.

Photo & Illustration: Naima el bani Atuna; Alice Kvalvik.

Text: Jessica Green & Maja Sojtarić



The CAGE tool box – Technology, innovation and research

The success of CAGE builds upon the integration of world-class empirical and numerical technologies to study Arctic sub-seafloor and ocean-bound methane as potential driver of future climate change. With access to the new icebreaker *RV Kronprins Haakon*, this tool box will be applied in permanently ice-covered regions, allowing for the first-time detailed studies of potential amplifiers for global change, including melting of submarine gas hydrate systems in the Arctic and accumulation of free methane gas below the still ice-covered ocean.

Analogous to these dramatic changes today, we will use our tool box to find the controlling mechanisms for build-up and release of submarine gas hydrate systems in the Arctic and provide answers to what extent methane escape from sub-seafloor reservoirs has influenced Arctic and global climate perturbations.

Ocean observatories

The ocean observatories (K-Landers) developed in a collaboration between Kongsberg Maritime and CAGE were deployed and recovered four times offshore Svalbard and in the Barents Sea, providing unprecedented multi-sensor data on Arctic methane seepage and the physical and chemical properties of the ocean. These give CAGE insights into the frequency of methane release and how this is influenced by ocean conditions, as well as on ocean acidification processes and trends.

CAGE video-camera system

In 2015 CAGE started a collaboration with WHOI (Woods Hole Oceanographic Institution) to develop a towed video-camera system. This digital imaging equipment provides real-time HD video and images of the seafloor, real-time digital depth and altitude, and allows visually guided water column (Niskin bottles) and sediment (multicores) sampling. In addition to dedicated digital imaging campaigns, the CAGE video-camera system plays a vital role in planning ROV operations. The system has been deployed at several methane sites in the Barents Sea in 2017. The system has also allowed to discover new methane sites in the Barents Sea in 2018.

4D seismic using P-cable

CAGE uses UiT's national infrastructure P-cable seismic system, which CAGE members have been involved in developing. Studies of gas hydrates, shallow gas and geological structures in sediments near the seafloor are ideal targets of our P-cable seismic system. By collecting 3-Dimensional (3D) P-cable data at the same study area over multiple years we are able to monitor spatial and temporal variations (4D) in the movement of fluids in the sediments. The unprecedented resolution of the P-cable seismic

provides CAGE with a unique opportunity to investigate the processes and drivers that regulate past and present gas hydrate and fluid flow systems.

National facility for stable isotope analyses

CAGE has established a stable isotope laboratory, equipped with a MAT 253 Isotope Ratio Mass Spectrometer, at the Department of Geosciences, UiT. The laboratory is an integral part of our palaeoclimatic, oceanographic, geobiological and carbon cycling research, and is a part of the national infrastructure FARLAB (Norway's national facility for advanced isotopic research). The lab is also performing analyses for external users, in Norway and Internationally

Fully automated palaeomagnetic laboratory

CAGE partner, the Norwegian Geological Survey (NGU), has installed a fully automated 2 G Cryogenic Magnetometer at their facilities in Trondheim. This equipment gives us the ability to significantly improve the stratigraphic framework of carbonate-poor Arctic sediments by analyzing changes in the polarity, intensity and direction of the geomagnetic field of the Earth over the past millions of years, enabling us to develop a precise chronology for the climate of the past. It furthermore, provides a powerful means to trace variations in methane seepage in the sub-seafloor sediments over timescale of millions of years.

Numerical ice sheet modelling

Numerical modelling is a valuable tool that can be used to explore the role ice sheets have played in shaping and driving changes in the Arctic environment. At CAGE we have developed a high-resolution, 3D reconstruction of the last glacial cycle to have affected the Eurasian continent, constrained and tested against a variety of up-to-date empirical datasets. Data-rich outputs derived from these modelling experiments inform us how the ice sheet developed and impacted with its surroundings through time, including the evolving pattern of crustal warping, hydrological routing and storage,

broad-scale climate distributions, and subglacial temperature-pressure conditions.

RV Kronprins Haakon

The brand new ice-going research vessel, *Kronprins Haakon*, is outfitted with state-of-the-art scientific instrumentation. It is capable of year-round operation in ice-covered waters, where it will monitor the environmental state and the climate state of both the Arctic and the Antarctic. It is equipped with a moonpool, and is capable of ROV, AUV and helicopter operations. The vessel is based in Tromsø, and is officially owned by the Norwegian Polar Institute, run and maintained by the Institute of Marine Research, and largely used by UiT.

ROV ÆGIR 6000

The *ÆGIR 6000* is a remotely operated vehicle (ROV) designed by Kystdesign AS of Norway. It is a national facility that is operated by the Norwegian Marine Robotics Laboratory (NORMAR) at the University of Bergen (UiB). An ROV is an unmanned submersible tethered to the ship through the moon pool. *ÆGIR 6000* has a wide range of payload options to carry utility equipment, e.g. coring devices, a gas sampler to catch gas bubbles, a water sampler to collect water, geochemical and oceanographic sensors or a multibeam system for cm-scale imaging of the ocean floor.

RV Kronprins Haakon.

Thermo-Fisher MAT253 Isotopic Ratio Mass Spectrometry at the Stable Isotope Laboratory (SIL).

ROV Ægir 6000 hovers above the moon pool on RV Kronprins Haakon, awaiting deployment.

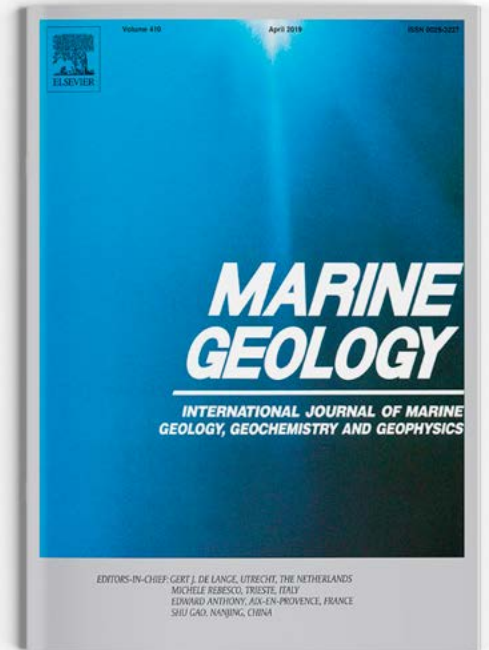
Methane bubbles in the water column imaged by a single-beam echosounder.

Navigation software used for ROV dives in which the multi-colored background is bathymetry showing the seafloor. The yellow arrow shows the positioning of the ROV.

Photos & illustrations: Bénédicte Ferré; Torger Grytå; Stefan Bünz;

Publications list 2018

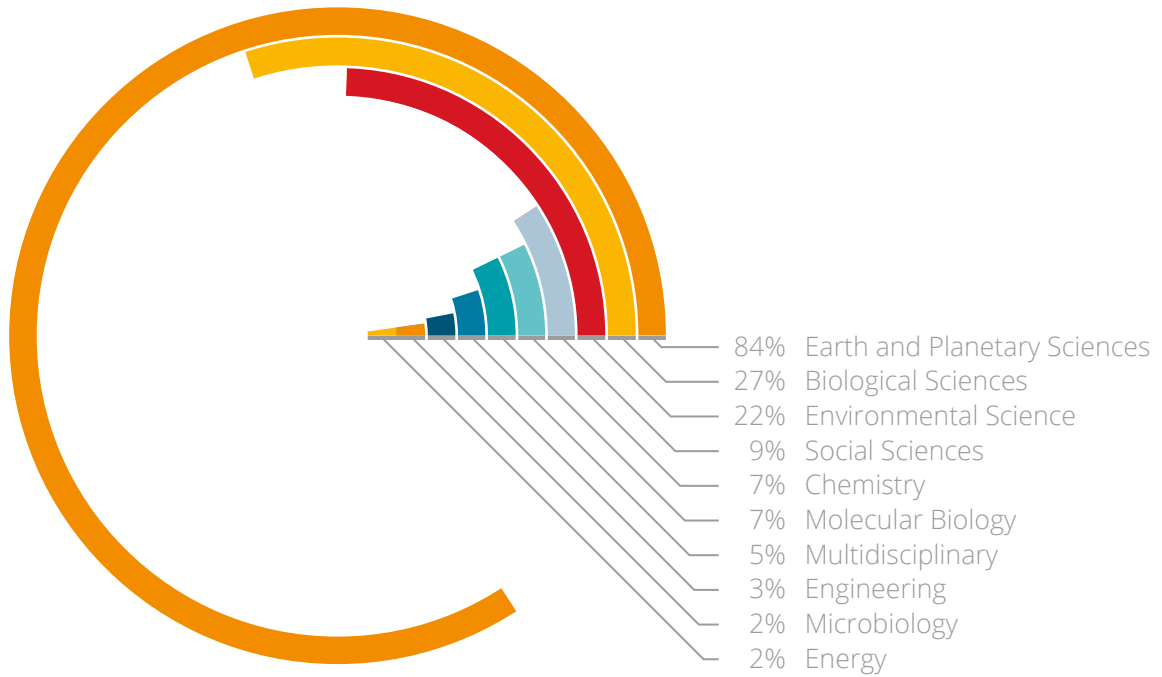
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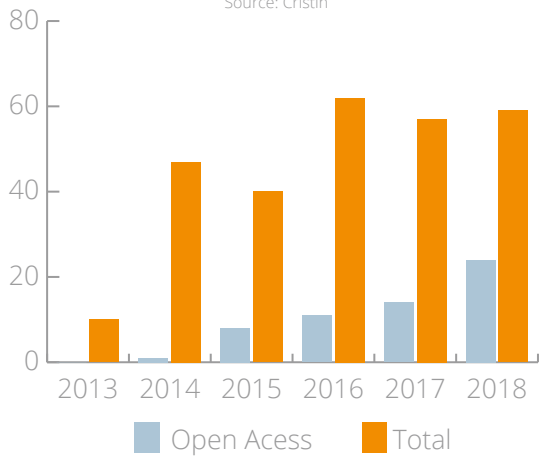
Subject area, publications

Source: Scopus



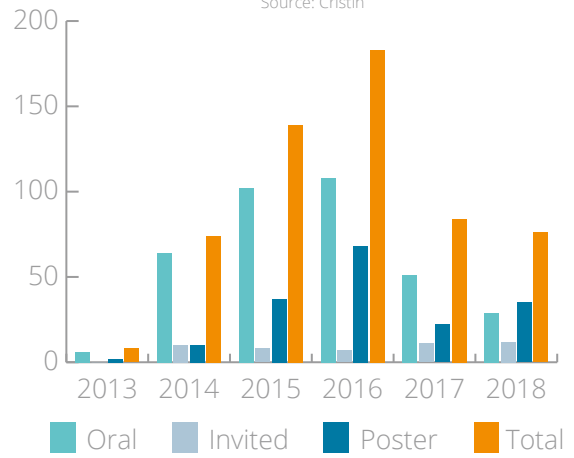
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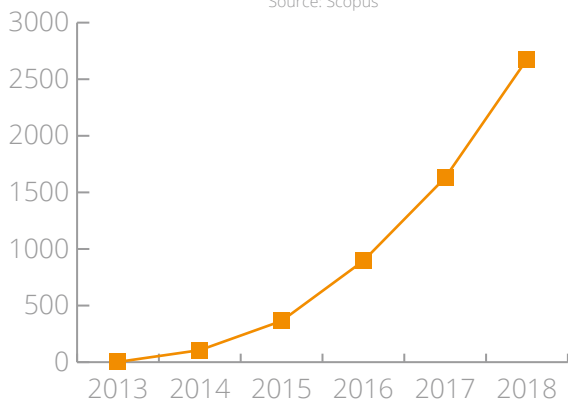
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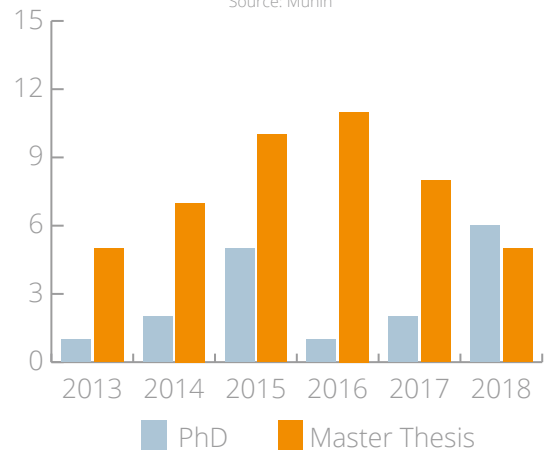
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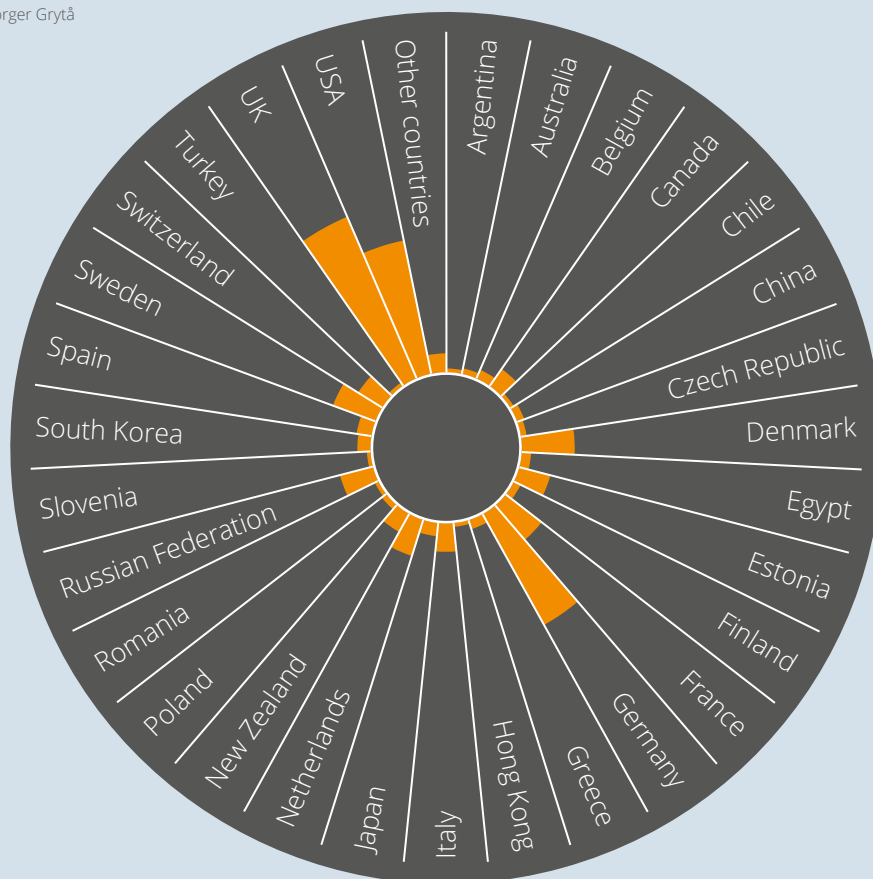


International collaboration 2013–2018

Our research is connected with international scientific communities that are outlined as important collaborators by Norwegian Research Council and Norwegian Ministry of Foreign Affairs. We participate in several EU projects and actions such as: STEM CCS on carbon capture; COST MIGRATE on hydrate quantification; and FIXO3 on environmental observations and technologies. We also lead the PACT project funded by NRCs INDINOR program. It examines how Arctic Ocean warming affected monsoons in the past, in collaboration with Indian institutions NCAOR and Birbal Sahni Institute of Paleobotany. In addition to that we collaborate on papers with relevant colleagues from all over the world.

International collaborations on publications (2013 to present)

Source: Scopus | Illustration: Torger Grytå



Full list of personnel at the centre

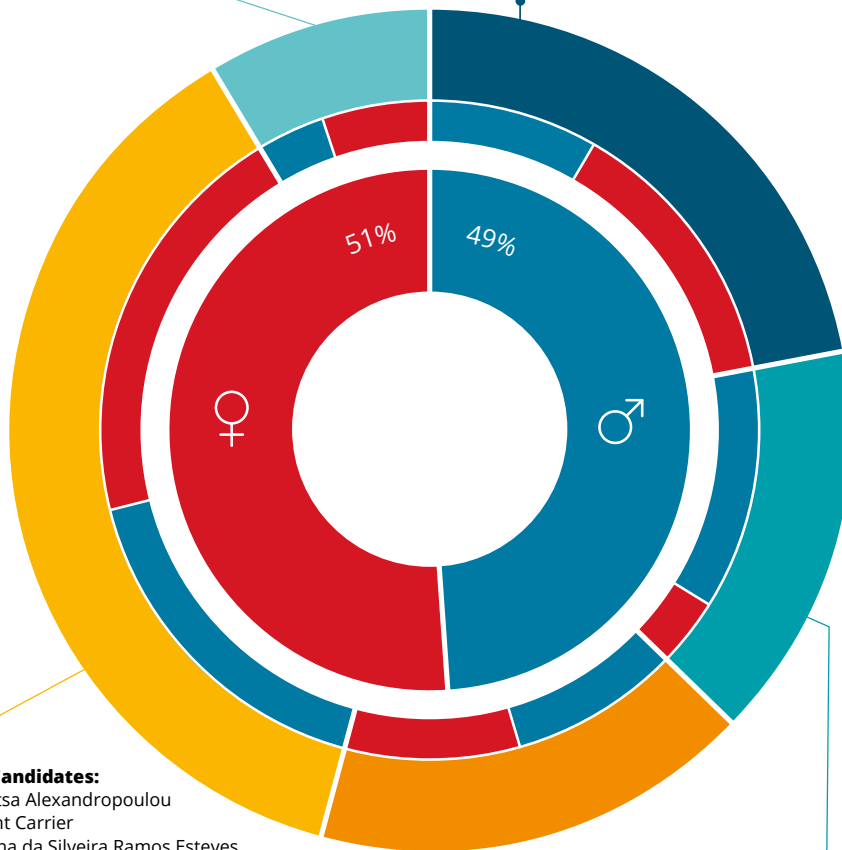
We consistently work towards gender equality in our staff. Not only is the centre director a woman, 5 of the 7 work package leaders are women, and 3 of the 5 administrative staff members are women. Our overall staff numbers also show that we place importance on this topic, with 49% men and 51% women working for CAGE in 2018. That is 30% above the average for women in STEM fields in OECD countries, and 35% above the average in Norway. We also support young researchers – more than 60 percent of our staff are PhD students and early career scientists.

Administrative and technical staff:

Jessica Green, Communications advisor (temporary)
 Matteus Lindgren, Manager, Mass Spectrometer Laboratory
 Fabio Sarti, Data manager
 Lone Smelror, Administrative coordinator
 Maja Sojtaric, Communications advisor

Senior scientific staff:

Karin Andreassen, Director, Temp Leader WP2, Professor
 Stefan Bünz, Temp Assist. Director, Leader WP1/Professor
 Bénédicte Ferré, Leader WP4, Researcher
 Alun Hubbard, Professor
 Jochen Knies, Assist. Director, Leader WP5, Researcher
 Renata Lucchi, Adjunct Professor
 Jürgen Mienert, Professor
 Helge Niemann, Adjunct Professor
 Giuliana Panieri, Research School Leader, Adjunct Professor
 Tine L. Rasmussen, Leader WP6, Professor
 Mette Marianne Svenning, Leader WP3, Professor
 Monica Winsborrow, Assist. Director, Leader WP2, Researcher
 Katarzyna Zamelczyk, Co-leader WP6, Researcher



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 Vincent Carrier
 Mariana da Silveira Ramos Esteves
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 Naima El Bani Altuna
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 Mohamed Ezat
 Friederike Gründger
 Tobias Himmler
 Wei Li Hong
 Dimitri Kalenitchenko
 Simone Sauer
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 Karl Fabian
 Andreia Plaza Faverola
 Aivo Lepland
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 Anna Silyakova
 Terje Thorsnes
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Nikolitsa Alexandropoulou
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Pierre-Antoine Dessandier
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Aivo Lepland
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Siri Ofstad
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Christiane Schmidt
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Maja Sojtaric
 Senior advisor, communications



Katarzyna Zamelczyk
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Soma Baranwal
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Michael Carroll
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Shyam Chand
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Mohamed Ezat
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Bénédicte Ferré
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Communications advisor
(temporary)



Tobias Himmler
Postdoctoral Researcher

Wei-Li Hong
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Dimitri Kalenitchenko
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Jochen Knies
Researcher
Assistant director
Team Leader WP5

Deniz Koseoglu
PhD Candidate



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Manager, Mass
Spectrometer Laboratory

Renata Lucchi
Professor

Katarzyna Melaniuk
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Jürgen Mienert
Professor

Manuel Moser
PhD candidate

Andrea Schneider
PhD Candidate

Helge Niemann
Assoc. Professor (20%)



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Associate Professor

Henry Patton
Postdoctoral Researcher

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Kärt Peiste
PhD Candidate

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Professor
Team Leader WP6

Fabio Sarti
Engineer

Simone Sauer
Postdoctoral researcher



Calvin Shackleton
PhD Candidate

Arunima Sen
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Pavel Serov
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Sunny Singhroha
PhD Candidate

Muhammed Fatih Sert
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Anna Silyakova
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Lone Smelror
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Terje Thorsnes
Researcher

**Sunil
Vadakkepuliambatta**
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