CAGE - Centre for Arctic Gas Hydrate Environment and Climate Report Series, Volume 10 (2022)

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CAGE Final Report 2017–2023

CAGE – Centre for Arctic Gas Hydrate, Environment and Climate

cage.uit.no

CAGE

Norwegian Centre of Excellence

THE ARCTIC UNIVERSITY OF NORWAY · UIT ·

Statement from the CAGE Science Advisory Committee

As the decade of activities by the Centre for Arctic Gas Hydrate, Environment and Climate (CAGE) draws to a close in March 2023, the Science Advisory Committee (SAC) has reflected on the extraordinary accomplishments, impact, and legacy of CAGE.

Over the past decade (2013-2023), CAGE's dedicated and nimble leadership team and staff have surmounted numerous obstacles to establish the Centre as the premier international research group on topics related to gas hydrates, climate, glaciation, and the linkages between past, present, and future methane dynamics and geosphere-hydrosphere-atmosphere interactions. In an exemplary way, CAGE has performed to the highest standard on all three aspects of publicly funded science – research, education, and knowledge transfer to the public. The numerical metrics are an apt shorthand for demonstrating the resounding success of CAGE: Over 400 peer-reviewed papers published, garnering more than 7000 citations to date; ~1200 outreach products released; 28 doctoral degrees completed; and nearly 100 scientific staff affiliated over the 10-year period. The team also led or participated in nearly 70 research cruises with a cumulative ~2.5 years at sea.

These numerical measures provide only a superficial perspective on CAGE's success though. The Centre has had a major impact on research infrastructure through its participation in planning the state-of-the-art ice-class research vessel FF Kronprins Haakon, its co-leadership of the NorEMSO cabled observatory node, its mastery of technology to routinely acquire and process 3D seismic data, and its support for the establishment of several key laboratories (e.g., ICOM – Ice Oceans and Climate lab, mass spectrometry lab). CAGE has acquired rich, high-quality, multidisciplinary datasets over thousands of square kilometers of Arctic seafloor and retrieved hundreds of unique samples that will continue to be the basis for scientific studies well into the future. The Centre catalyzed key developments in data management and release, which positioned CAGE well for open access requirements that became increasingly common during the final years of the project. CAGE has also been an important innovator in graduate education through novel programming (e.g. via the GReAT Research School, the AKMA project, other past schools and seminar series) that served constituencies ranging from UiT Department of Geology students to early career researchers selected from universities all over the world. The enviable public outreach effort at CAGE has evolved to routinely engage with the public and contribute to primary, secondary, and adult education through social media, traditional print publications, blogs, interviews, a professional Internet portal, and even museum displays and the 2019 Di Caprio-directed "Ice on Fire" feature documentary. CAGE's outreach accomplishments extend to having delivered key messages on Arctic climate, environment, and the cryosphere at COP26 held in Glasgow in 2021. CAGE is also widely-admired as an engine for increasing diversity in the geosciences and associated disciplines. Not only have women been prominent in the leadership of CAGE since its inception, but CAGE students, researchers, and collaborators have come from countries throughout Europe, Asia, North America, and Australasia.

Finally, we commend in the strongest terms Dr. Jurgen Mienert for his vision in launching CAGE and establishing the Centre on a path to maximize its international impact and its scientific success; and Dr. Karin Andreassen for her leadership during the second phase of CAGE as the Centre delivered on so many of its promises and produced scientific results that have altered our understanding of Arctic gas hydrates, methane dynamics, and climate.

February 3rd, 2023
Carolyn Ruppel, Alexander Loy, Doug Connelly and Mads Huuse.

Gas hydrates dissolving in the water column. Photo: Giuliana Panieri.

This report covers the second phase of CAGE, 2017–2023. The first phase Centre 2013–2017 was reported in the CAGE Annual 2016 Report, archived in the CAGE Report Series.
https://doi.org/10.7557/cage.6835

Contents

Cover photo: Research Vessel Kronprins Haakon in the Arctic sea ice. Photo credit: Dimitri Kalenitchenko.

Contents page photo: Crushing through the sea ice during the HACON21 expedition. Photo credit: Marie Stetzler.

Editorial team: Mariana Esteves, Karin Andreassen, Fabio Sarti, & Zeynep Sancak Sert.

Design and layout: Torger Grytå & Siri Jachlin.

CAGE Vision and objectives

CAGE – Centre for Arctic Gas Hydrate, Environment and Science is a national Centre of Excellence, funded by the Norwegian research Council for the period 2013 – 2023.

Overarching goal:

Achieve a quantitative understanding of the feedbacks between methane sub-seabed reservoirs, the seabed and the ocean. How this coupled system reacts and affects the future ocean, its environment and possibly the climate, is of global importance.

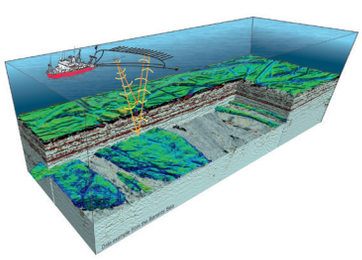
Main research questions:

- How much carbon is stored as gas hydrate?
- How much and by what processes is this carbon transferred from the sub-seabed to the ocean and atmosphere?
- How does this influence the environment and climate?

Transdisciplinary research and methods

CAGE have used transdisciplinary research and methods to investigate complex Arctic gas hydrate and fluid flow systems from the sub-seabed to the atmosphere, over the past, present and future.

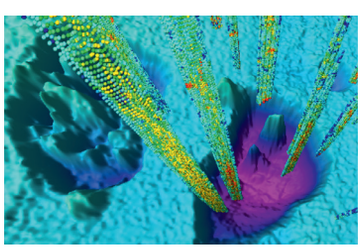
Six work packages (WPs) contribute expertise within different research fields:



WP1

Gas hydrate and free gas reservoirs in the sub-surface

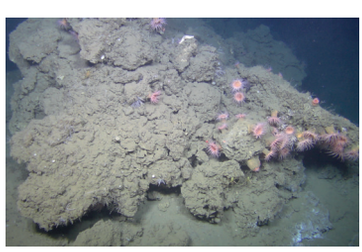
How much carbon is stored in today's Arctic methane hydrate and free gas reservoirs, and how much is susceptible to climate change?



WP2

The role of ice ages

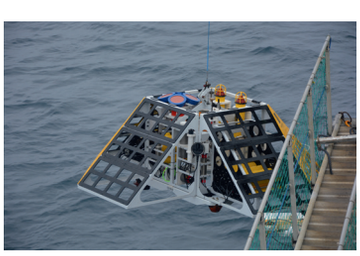
How do ice sheets interact with subglacial carbon reservoirs, fluid flow and gas hydrate systems?



WP3

Cold loving microbes in a warming Arctic

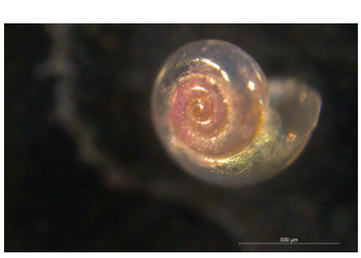
What is the role of biological communities in mediating the exchange of methane from seafloor sediments into the water column?



WP4

Gas in the water column

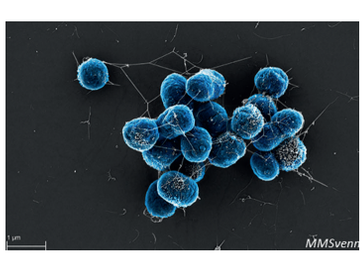
How much methane released from the seafloor reaches the upper water column an atmosphere?



WP5

Methane seepage history

Constraining the timing of methane release throughout the geological past.



WP6

Methane, CO2 and ocean acidification

What are the relationships between methane release, climate variability and ocean acidification.



Karin Andreassen, Monica Winsborrow and Jochen Knies. Photos: private.

Words from the CAGE leadership

After a successful mid-way evaluation of the first phase of CAGE (2013 – 2017), we took over the Centre leadership in August 2017. Our Scientific Advisory Committee states at our last joint meeting in February 2023 that "the Centre has established itself internationally as the leading research group on topics related to gas hydrate, climate, glaciations and the linkages between past, present and future methane dynamics and geosphere-hydrosphere-atmosphere interactions"

Methane in the Arctic

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

Scientific Excellence

CAGE has integrated transdisciplinary research on methane reservoirs beneath the seafloor, conditions at the sea floor, in the water column and in the atmosphere. We have focused on enhanced understanding of the past and present, and developed models to predict future trajectories.

In numbers, our scientific staff and students have during the decade of CAGE produced 465 peer-reviewed scientific publications (62 of these in Nature and Science journals) and 33 book contributions, with contributions from 3502 scientists from over 45 different countries. The Centre has now an H-index of 50 and over 9230 citations. The success of our research builds on integrating state-of-the art empirical data with numerical modelling, and scientific collaborations with academic and industry partners.

Some Highlights

Our location at the doorstep of the Barents Sea and access to the ice-going research vessels Helmer Hanssen and Kronprins Haakon have clearly been a strong advantage. CAGE has since its conception in 2013 led 69 scientific cruises with a cumulative ~2.5 years at sea, and we have continuously strived to use state-of-the-art technologies in data acquisition such as remotely operated vehicles, seabed- ocean-observatory networks, high-resolution 4D seismic surveys, drones and satellite images.

We have developed procedures to detect the amount of carbon stored in reservoirs of gas hydrate and free gas under the seafloor, the leakage from these carbon systems, their faith in water column and to monitor variations in gas flow with tidal and seasonal cycles and currents.

We have developed a toolbox to identify, understand, and date past methane leakage events, and we have highlighted the role of ice sheets in generating hotspots for exceptionally abundant natural seepages of gas and oil across Arctic continental shelves.

Looking ahead

Although CAGE is history from 1st March 2023, large parts of CAGE infrastructure and research will continue and be further developed within the new Centre of Excellence, "Centre for ice, Cryosphere, Carbon and Climate – iC3", which was recently awarded by the Research Council of Norway (RCN) to the Department of Geoscience (IG), UiT for 2023 – 2033. iC3 is led by the two CAGE scientists Jemma Wadham and Monica Winsborrow. In addition, several other research projects initiated by researchers of the Centre will continue within Department of Geoscience, UiT.

CAGE has educated 28 PhDs (14 Male/14 Female), and 69 Master students. Several young CAGE researchers have established their own research groups, with funding from The European Research Council (ERC), The Research Council of Norway (RCN) and Tromsø Research Foundation; two in Norway, two in France, and one in Sweden.

Efforts of CAGE scientists towards future scientific ocean drilling in the circum-Arctic succeeded in 2022. The last IODP science and security panels for our planned scientific drilling expeditions east of Greenland and northwest Svalbard were finally passed, and the planned Expedition #403 is now scheduled for summer 2024.

It has been a privilege to work within CAGE, it has been an amazing journey and a lot to learn. However, our scientific results would not have been possible without the generous funding from RCN and the support from UiT, the Faculty of Science and Technology and the Department of geosciences. We have further been blessed by having access to two fantastic ice-going research vessels, RV Helmer Hanssen and RV Kronprins Haakon. Finally, our largest resource has been the people working within CAGE; our PhD- and Master students, Postdoctoral fellows, Researchers, Professors, and the technical and administrative staff that have supported us. Thank you so much to you all!

Karin Andreassen,
Director (2017-2023)

Monica Winsborrow,
Assistant Director (2017-2023)

Jochen Knies
Assistant Director (2017-2023)

Organisation of the centre (2017–2023)

The Centre for Arctic Gas Hydrate, Environment and Climate (CAGE) was hosted by the Department of Geosciences, Faculty of science and technologies at UiT - The Arctic University of Norway.

CAGE Leadership

Karin Andreassen
Director
(2017-2023)

Monica Winsborrow
Assistant director
(2017-2023)

Jochen Knies
Assistant director
(2017-2023)

Administrative and Technical Staff

Lone Smelror
Administrative Advisor
(2018-2022)

Mariana Esteves
Project leader (Admin. and Communications Coordinator) (2022-2023)
Communication Advisor
(2021-2022)

Zeynep Sancak Sert
Administrative Advisor
(2022-2023)

Maja Sojtaric
Sr. Communications Advisor
(2014-2021)

Jessica Green
Communications advisor
(2018-2019)

Fabio Sarti
Data Manager
(2014-2023)

Work Package (WP) Leaders

Stefan Bünz
Leader WP1
(2013-2023)

Monica Winsborrow
Leader WP2
(2017-2023)
Co-leader WP2
(2014-2017)

Mette Marianne Svenning
Leader WP3
(2017-2023)

Bénédicte Ferré
Leader WP4
(2013-2023)

Jochen Knies
Leader WP5
(2013-2023)

Tine L. Rasmussen
Leader WP6
(2013-2023)

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. The Director of CAGE, reports to the centre board.

Arne Smalås
Prof., Dean NT-faculty, UiT
CAGE Board Chairman
(2021-2023)
CAGE Board Member
(2018-2020)

Elina Halttunen
Head of Department,
Arctic and Marine Biology,
BFE-faculty, UiT
CAGE Board Member
(2021-2023)

Kjersti Løvseth Ruud
Department Director,
Norwegian Geological
Survey (NGU)
CAGE Board Member
(2021-2023)

Nalan Koc
Research Director
Norwegian Polar Institute
CAGE Board Member
(2013-2023)

Ingrid Schjølberg
Prof., Director NTNU Ocean
Science and Technology
(NTNU Oceans)
CAGE Board Member
(2015-2023)

Geir Richardsen
Vice president Exploration
Assets Norwegian Sea,
Equinor
CAGE Board Member
(2021-2023)

Previous Centre Board Members

Kenneth Ruud
Prof., Pro-Rector for
Research and Dev., UiT
CAGE Board Chairman
(2013-2020)

Kristina Helland-Hansen
Vice President Exploration,
Statoil
CAGE Board Member
(2016-2020)

May Britt Myhr
Director of the Norwegian
Geological Survey (NGU)
Trondheim
CAGE Board Member
(2018-2020)

Morten Hald
Prof., Dean NT-faculty, UiT
CAGE Board Member
(2013-2017)

Morten Smelror
PhD, Adm. Director,
Norwegian Geological
Survey
CAGE Board Member
(2013-2017)

The Scientific Advisory Committee

The CAGE International Scientific Advisory Committee gives advice on strategic scientific issues and consists of distinguished experts in their fields.

Prof. Doug Connelly
National Oceanography
Centre, Southampton, UK
(2016-2023)

Dr. Carolyn Ruppel
United States Geological
Survey, USA (2013-2023)

Prof. Mads Huuse
University of Manchester,
UK (2018-2023)

Prof. Alexander Loy
University of Vienna, Austria
(2018-2023)

Previous Scientific Advisory Committee Members

Prof. Georgy Cherkashov
Institute of Mineral
Resources of the Ocean,
RUS (2013-2022)

Prof. Antje Boetius
Alfred-Wegener Institute
for Polar Research, FRG
(2015-2017)

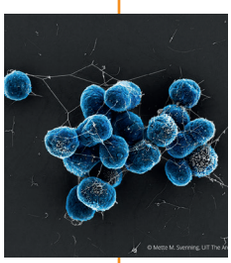
Dr. Jerome Chappelaz
Research Director, CNRS;
Grenoble, FR (2016-2017)

Prof. Gerald Haug
ETH Zurich/Max Planck
Institute, FRG (2013-2015)

Highlights 2017–2023

2

Successful Midterm Evaluation with an 'Exceptional' Assessment Score from the evaluation committee secures CAGE continued funding for 2018-2023.

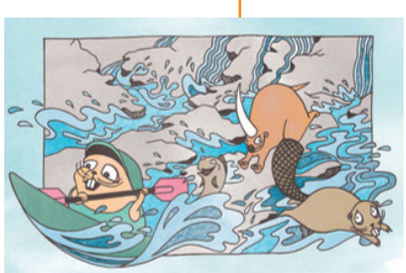


1

CAGE scientists received an infrastructure grant from Tromsø Research Foundation to establish **the Ice-Cold Micro-organisms Laboratory (ICOM).**

2017

2018



3

ICEMAP is an interactive installation and webpage that uses Lenny Lemming to tell the story of the birth and decay of the Eurasian Ice Sheet during the last ice age.

seamstress

CAGE scientist Andreia Plaza-Faverola received two starting grants: 11.1MNOK from Tromsø Research Foundation (TFS) and 8M NOK from The Research Council of Norway (RCN) for the project **Tectonic stress effects on Arctic methane seepage (SEAMSTRESS)**

4

CAGEs first research cruise aboard *R/V Kronprins Håkon*. The new ice-going research vessel and its facilities allows CAGE to use state-of-art equipment, such as the ROV Ægir 6000, to explore new areas of the ice-covered Arctic in unprecedented detail.

2019

ICE on FIRE – a feature documentary with CAGE scientists that that was narrated by Leonardo DiCaprio – premieres at Cannes Film Festival and HBO.

5

CAGE wins UiT Gender Equality Award for consistently ensuring gender equality within the centres staff and students since 2013.

CAGE scientist Dimitri Kalenitchenko receives 8M NOK funding from The Research Council of Norway Young Research Talents award for the **Methanotrophic communities in ice (METHANICE)** project.

Multiple CAGE projects have been funded between 2017-2022.

Environmental impact of Methane seepage and sub-seabed characterization at LoVe-Node 7- EMAN7, a multi-disciplinary project led by CAGE scientist Bénédicte Ferré, officially started.

Since 2017, **19 CAGE PhDs** have successfully defended their PhD thesis.

2020 2021 2022 2023

6

LoVe Ocean Observatory is a network of cabled observatories deployed off the coast of the Norwegian archipelago Lofoten and Vesterålen, making it possible to consistently monitor environmental changes in the ocean throughout the seasons.

7

Methane in a changing Arctic: the final international CAGE conference brought together 140 participants, from 14 different countries, to discuss all aspects of Arctic methane and its role in the global carbon cycle.

CAGE scientist Mohamed Ezat received 12M NOK Tromsø Research Foundation (TFS) Starting Grant for the project **The Arctic Ocean under Warm Climates (ARCLIM).**

8

CAGE scientists awarded funding for Norwegian Centre of Excellence for Outstanding Research at UiT: **Centre for ice, Cryosphere, Carbon and Climate (iC3).**

[1] Methyloprofundus sedimenti is a methane-oxidizing bacterium that originates from seawater west of Spitsbergen. Photo: Mette M. Svenning.
[2] CAGE Director Karin Andreassen. Photo: Maja Sojtaric. [3] Lenny Lemming narrates the ICEMAP story of the last Eurasian glaciation. Illustration: Alice Kvalvik.
[4] R/V Kronprins Håkon. Photo: Dimitri Kalenitchenko. [5] Gender Equality Award. Photo: Maja Sojtaric. [6] LoVe Ocean Observatory: Illustration of one of the nodes at LoVe, consisting in a frame with sonar, current meters and other sensors, as well as a satellite with an underwater microphone and camera. On the back, the platform distributes power and broadband between land and platforms. Illustration: Institute of Marine Research. [7] CAGE Int. Conf. participants that joined us in Tromsø. Photo: Kai Mortensen/UiT.
[8] Professor Jemma Wadham and Associate Professor Monica Winsborrow will lead the new SFF iC3. Photo: Tomas Rolland/UiT.

CAGE funding (2013–2023)

CAGE funding as agreed in contract

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Amount	%
UiT (inc. IG personnel)	18,004	26,002	32,339	37,493	33,786	32,606	33,958	25,459	16,384	14,238	3,159	**273,428**	**64%**
Geological Survey of Norway (NGU)	695	3,773	1,788	1,694	368	962	325	444	503	510	65	**11,127**	**3%**
The Research Council of Norway	8,314	16,721	16,268	13,613	15,084	16,589	14,953	14,362	11,233	5,758	7,205	**140,100**	**33%**
Total funding	**27,013**	**46,496**	**50,395**	**52,800**	**49,238**	**50,157**	**49,236**	**40,265**	**28,120**	**20,506**	**10,429**	**424,655**	**100%**

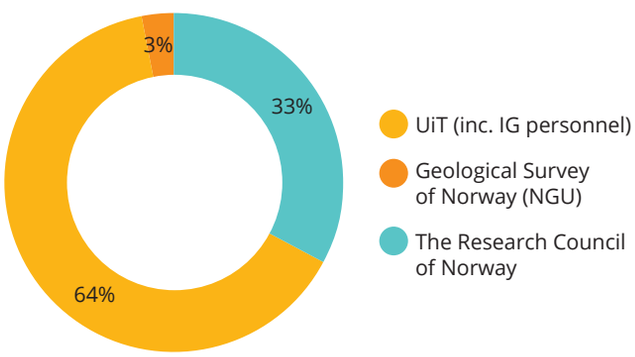
IG (Department of Geosciences, UiT)

CAGE external projects

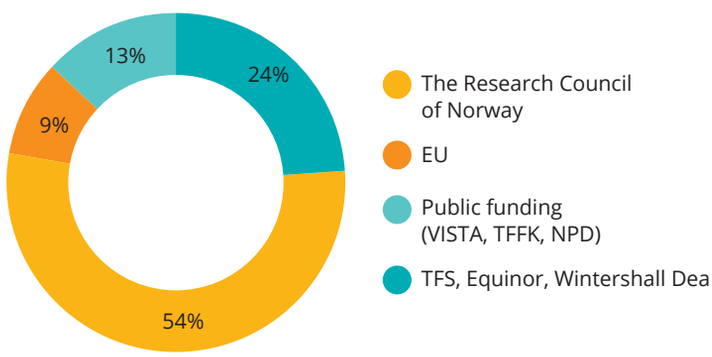
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Amount	%
The Research Council of Norway	0	3,359	5,806	3,704	4,405	7,138	10,076	9,978	8,803	7,367	732	**61,368**	**54%**
EU	0	1,048	863	3,044	1,454	213	1,028	317	275	218	2,114	**10,574**	**9%**
Public funding (VISTA, TFFK, NPD)	0	0	283	753	1,142	1,270	1,368	2,836	3,025	4,000	0	**14,677**	**13%**
TFS, Equinor, Wintershall Dea	0	1,116	933	0	1,100	1,541	5,449	2,776	5,622	8,865	0	**27,402**	**24%**
Total funding external projects	**0**	**5,523**	**7,885**	**7,501**	**8,101**	**10,162**	**17,921**	**15,907**	**17,725**	**20,450**	**2,846**	**114,021**	**100%**

NPD (The Norwegian Petroleum Directorate); TFFK (Troms og Finnmark fylkeskommune); TFS (Tromsø Forskningsstiftelse)

CAGE funding as agreed in contract



CAGE external projects



CAGE in numbers (2013–2023)

CAGE was funded for 10 years. The work in CAGE was supported by the Norwegian Research Council Grant number, 223259.

Personnel

117

117 People (101 employees and 16 visitors)

49-51

Out of the 90 people who worked at CAGE between 2017-2023, 49% were women and 51% men.

22

22 Babies were welcomed to this world by CAGE employees.

28

28 Nationalities. CAGE researchers and visitors came from many parts of the world, joining in Tromsø to collaboratively investigate the role of gas hydrates in Arctic areas.

Publications and Results

465

465 Peer-reviewed publications.

33

33 book contributions.

3502

3502 Scientists from > 45 countries contributed to these publications. Our publications were published in 140 peer-reviewed scientific journals.

>1700

>1700 Media Reports produced. Including popular science publications and news in the media.

75

75 Reports Archived in CAGE Report Series on Septentrio Academic Publishing.

>800

Our scientists spent >800 days at sea and produced 65 cruise reports.

10

10 annual reports have been produced and can be found on the CAGE Report Series.

749

CAGE scientists have presented 749 oral, poster and invited presentations since 2013.

Scientific Expeditions and Database

69

69 multidisciplinary expeditions.

164.000

164.000 km. (88.500 nautical miles) Distance covered during CAGE scientific expeditions.

3380

3380 sampling points for air, bubble, gas, oil, plankton, sea ice, seabed, and water samples.

70

70 deployments at the seabed surface (e.g., observatories, seismometers).

>155000

>155000 pictures (.jpg files) were collected during CAGE expeditions.

>3800

>3800 videos (.mov files) were collected during CAGE expeditions.

>50

>50 TB of raw data was collected during CAGE expeditions.

1

1 Geospatial database. A complete overview of CAGE cruise activities is available on CAGE's interactive geodata web map.

CAGE Report Series: septentrio.uit.no/index.php/cage/index

CAGE Geospatial Database: septentrio.uit.no/index.php/cage/database

WORK PACKAGE 1

Gas hydrate and free gas reservoirs

Members (2017–2023)

Andreia Plaza-Faverola
Associate Professor (2013-2023)
Leader SEAMSTRESS project

Jürgen Mienert
Professor Emeritus

Sunil Vadakkepuliyambatta
Researcher (2013-2021)

Shyam Chand
Researcher (2013-2023)

Jean Baptiste Koehl
Researcher (2019-2020)

Sunny Singhroha
Postdoctoral Fellow (2019-2022)
PhD Candidate (2015-2019)

Malin Waage
Postdoctoral Fellow (2019-2022)
PhD Candidate (2015-2019)

Kate Waghorn
Postdoctoral Fellow (2019-2022)
PhD Candidate (2014-2019)

Claudio Argentino
Postdoctoral fellow (2019-2023)

Rémi Vachon
Postdoctoral fellow (2019-2022)

Hariharan Ramachandran
Postdoctoral fellow (2019-2022)

Frances Cooke
PhD Candidate (2019-2023)

Przemyslaw Domel
PhD Candidate (2019-2023)

Cornelia Mentzoni-Binde
PhD Candidate (2020-2023)

Stefan Beaussier
Research assistant (2019-2020)

Stefan Bünz, *Team Leader*

Professor Stefan Bünz has 25 years of experience in marine geology and geophysics with specific research expertise in: gas hydrates, fluid flow systems, shallow gas accumulations and geohazards, high-resolution 3D/4D and multi-component seismics, CO2-storage in sedimentary basins, seafloor ecosystems, ultra-slow spreading ridges, and tectonic and non-tectonic faulting.

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 estimating the amounts of frozen methane and free gas beneath the seabed, 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.

Technician Steinar Iversen makes a final check of the airgun system before deployment. Photo: Stefan Buenz.

Our group developed world-leading expertise in understanding gas hydrate, fluid flow and methane seepage systems from the very shallow shelf (90m) to the deep Arctic basin (4000m) using unique high-resolution 3D and 4D seismic technology, long-term microseismic monitoring and thermodynamic and tectonic modelling.

Main achievements 2017-2023

1. Dr. Andreia Plaza-Faverola secured prestigious early-career starting grants from Tromsø Research Foundation and the Norwegian Research Council that provided funding for investigating how tectonic and glacial stresses control fluid seepage. Impressive achievements and contributions to science henceforth earned her a permanent staff position at the Department of Geoscience.

2. We published several articles that provided new insights into geological processes governing fluid flow and methane seepage systems at different geological settings in the Arctic, from deep-water to shelf systems including gas-hydrate pingos and seafloor craters. All of those results were based on high-resolution P-Cable 3D seismic data, a crucial state-of-the-art technology that was a key to high-impact science in CAGE.

3. We developed a processing procedure for high-resolution 4D time-lapse seismic data based on the P-Cable system demonstrating its repeatability. 4D seismic data integrated with rock physics and seismic modelling documented the feasibility of the P-Cable system for detecting and monitoring gas leakages in shallow sediments. This technology may hence be particularly useful for its potential to monitor CO2 storage. Detection limits of CO2 are ~30-300 times smaller than detection limits of conventional seismic data at similar depths.

4. We conducted several longterm ocean-bottom seismic experiments to record microseismicity of fluid-release systems on the western Svalbard margin. These records show transient fluid release systems with temporal variations from tidal to seasonal cycles.

5. Analysis of multicomponent ocean-bottom seismic (OBS) data from the Vestnesa Ridge gives much better constraints on gas hydrate saturation, distribution and morphology. Significant variation in gas hydrate and free gas saturation across faults suggests a structural control on the distribution of gas hydrate and free gas in the Vestnesa Ridge and indicates the presence of gas hydrates in faults and fractures.

6. WP1 led several expeditions on RV Kronprins Håkon utilizing a remotely-operated vehicle (ROV) that made a number of first-time discoveries and acievements, highlighted by active oil seepage from the shelf in 90 m water on the western Svalbard margin or the first-ever ROV dives on Arctic hydrothermal vents under permanent ice.

7. We developed a proposal to the International Ocean Discovery Program (IODP proposal 985) that was ultimately scheduled as Expedition 403 from 4 June–2 August, 2024, marking the successful conclusion of 5+ years of work to realize scientific drilling in the Fram Strait.

8. Jürgen Mienert and 4 co-editors published a Springer book entitled "World Atlas of Submarine Gas Hydrates in Continental Margins". WP1 contributed 7 sub-chapters to this book.

The role of ice ages

Members (2017–2023)

Karin Andreassen
Professor (2013-2023)

Jemma Wadham
Professor (2021- 2023)
Professor (20 %) (2019-2021)

Alun Hubbard
Professor (50%) (2014-2023)

Renata Lucchi
Adjunct Professor (20%) (2018- 2021)

Henry Patton
Researcher (2013-2023)

Mariana Esteves
Researcher (2018-2022)
PhD Candidate (2013-2018)

Pavel Serov
Researcher (2022-2023)
Postdoctoral Fellow (2019-2022)
PhD Candidate (2015-2018)

Mauro Pau
Postdoctoral Fellow (2020-2022)

Calvin Shackleton
PhD Candidate (2014-2019)

Craig Hammock
PhD Candidate (University of Swansea/CAGE) (2019- 2023)

Frank Jakobsen
PhD Candidate (2021- 2023)

Nikolitsa Alexandropoulou
PhD Candidate (2014-2023)

Monica Winsborrow , *Team Leader*

Monica Winsborrow is an Associate Professor 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.

About:

Today, vast quantities of methane are sequestered as shallow gas hydrates across the Arctic, 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, and vice versa?
- 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.

Examining a recently recovered marine sediment core. Photo: Mauro Pau.

Our work package is in a world-leading position to integrate high resolution empirical datasets and numerical models of past glacial cycles and processes to assess their concomitant impact on subglacial gas hydrate dynamics in unprecedented accuracy and detail. We have also worked hard to ensure wide impact and engagement around our science.

Main achievements 2017–2023

1. Led successful SFF-V application "iC3: Centre for Ice, Cryosphere, Carbon and Climate" to the Research Council of Norway, that will run for 10 years, starting in July 2023. iC3 will fill a vital knowledge gap in polar science by quantifying impacts of ice sheet change on Earth's carbon cycle and sensitive ocean ecosystems, building in part on CAGE expertise. The centre represents an important collaborative effort between multiple scientists within CAGE, UiT, the Norwegian Polar Institute and numerous national and international institutions.

2. Developed numerical simulations of the Eurasian Ice Sheet complex over the last glacial cycle (~130 000 years) which, in tandem with empirical datasets, have been exploited to provide valuable quantitative insights into a range of topics such as fluid flow-glacial stress dynamics, spatiotemporal patterns of glacial erosion, and fluxes of subglacial hydrocarbon storage and release.

3. Generated wide impact and public engagement around the importance ice sheets to past, present and future climatic and environmental change, via for example contributions to BBC's Frozen Planet II (viewed by over 12 million in the UK since release in October), documentary film Into the Ice (won 6 major film festival awards including Jackson Wild, Planet in Focus & DMFF award), COP26 Climate Summit in Glasgow through several keynote talks and multiple interviews and publication of Ice Rivers (Penguin Press, Longlisted for the Wainwright Prize for Writing on Conservation and shortlisted for the Richard Jeffries Award)

4. Polar Chapter lead for RECCAP2: Regional Carbon Cycling Assessment Project 2, the first assessment of stores of carbon over the ice-to-ocean domains of the Greenland and Antarctic Ice Sheets.

5. Highlighted the role of ice sheets in generating hotspots of exceptionally abundant natural oil and gas seepage across Arctic continental shelves through multiple research cruises (several in collaboration with the Norwegian Petroleum Directorate) and high impact publications.

6. Developed the first, high-resolution, continuous seismostratigraphic framework for the entire western Svalbard-Barents Sea margin over the last 2.7 Ma.

WORK PACKAGE 3

Cold loving microbes in a warming Arctic

Mette Marianne Svenning, *Team Leader*

Professor Mette Marianne Svenning is a microbiologist with research focus on the biodiversity and activity of microbial communities in sub-Arctic and Arctic ecosystems applying different molecular methods with classical microbiology. Studies are done in the field, in controlled laboratory experiments and on pure cultures. Novel methods for isolation, cultivation and experimental studies of methane oxidizing bacteria are used to address their importance as biological filter for methane in terrestrial and marine ecosystems. Our laboratory holds a unique culture collection of methane oxidizing bacteria.

Members (2017–2023)

Arunima Sen
Postdoctoral Fellow (2016-2019)

Dimitri Kalenitchenko
Postdoctoral Fellow (2018-2023)

Friederike Gründger
Postdoctoral Fellow (2013-2018)

Emmelie Åström
PhD Candidate (2014-2018)

Vincent Carrier
PhD candidate (2016-2021

Helge Niemann
Adjunct Professor 20% (2015-2021)

About:

This research group has addressed the 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. Our studies are linked to, and coordinated with, geochemical, sedimentological and water column studies of the CAGE team. In the recent years, WP3 has emphasized 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), has been developed 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 oxidizing 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.
- Get in-depth knowledge of the cold seep microbial structures, adaptations and evolution.

Close up view of the head and forepart of a pingo-crater worm. These Oligobrachia worms are hosts for specific chemosynthetic microorganisms and widespread at Arctic cold seeps. Photo: Arunima Sen and Emmelie Åström.

Methane (CH4) migration from cold seeps sustain a high microbial and macrofaunal biomass and a biodiversity contrasting from the surrounding seafloor. These cold seep biological communities play an important role for the marine food web. The microbial composition has a predominance of archaeal anaerobic methanotrophs (ANME) and sulphate-reducing bacteria (SRB) and high abundance of methane oxidizing bacteria associated to the family Methylococcaceae in the surface sediments and water column.

Main achievements 2017–2023

1. Described Arctic seep prokaryotic and eukaryotic microbial taxa and communities related to geochemical conditions at gas hydrate bearing mounds (marine pingo).

2. The microbial composition has a predominance of archaeal anaerobic methanotrophs (ANME) and sulphate-reducing bacteria (SRB) in anaerobic sediments.

3. Methane oxidizing bacteria within the family Methylococcaceae is the biological methane filter in the surface sediments and the water column.

4. Oceanography and circulation patterns have major impact on methane oxidation in CH4 rich bottom water.

5. Faunal communities have high biodiversity, biomass and abundance, but no seep specialists.

6. Arctic faunal seep communities are distinct compared to lower latitude cold seep communities.

7. Build and equipped a new laboratory for low temperature experimental studies relevant for the Arctic.

8. Educated PhDs and trained Postdocs for future career and work related to Arctic environments.

WORK PACKAGE 4

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, among other tasks, responsible for the development, acquisition and analysis of data related to the seafloor observatory K-lander. She is leader of the PETROMAKS 2 project EMAN7 and co-leader of the INFRASTRUKTUR project NorEMSO.

Members (2017–2023)

Anna Silyakova
Researcher (2013-2021)

Muhammed Fatih Sert
Researcher (2022-2023)
PhD Candidate (2017-2022)

Knut Ola Dølven
Postdoctoral Fellow (2022-2023)
PhD Candidate (2016-2022)

Manuel Moser
PhD Candidate (2017-2023)

Marie Stetzler
PhD Candidate (2020-2023)

Pär Gunnar Jansson
PhD candidate (2014-2019)

Helge Niemann
Adjunct Professor (20%)
(2015-2023)

About:

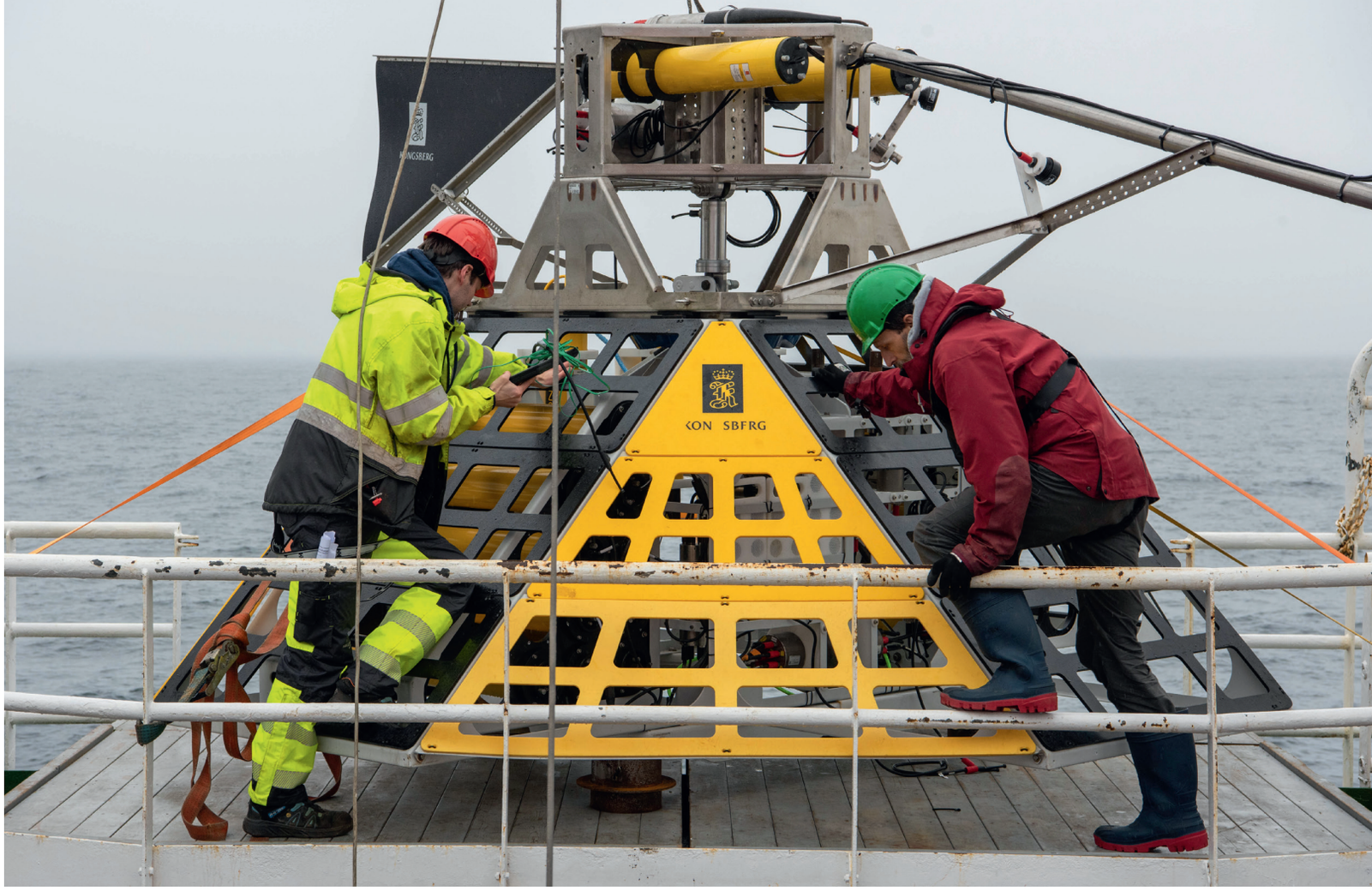
The effects of methane release on underwater ecosystems and our global climate are still unclear. Methane transport in Arctic oceans takes place via bubbles or in dissolved form beneath the seabed and travels vertically towards the ocean surface. However, continuously shifting water dynamics due to changing 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.



K-lander recovery. Photo: Torger Grytå

The team focuses on physical and chemical data collected in the water column and near the seafloor, to understand the link between oceanic settings and methane release and transport. We therefore rely on data collected during experiments at sea, from long-term observatories as well as modeling.

State-of-the-art seafloor observatories make it possible to continuously measure environmental changes associated with methane release at remarkable resolutions and acquire data to tune and force models. We have been focused on activities related to the seafloor observatories in the frame of CAGE but also NOREMSO (Norwegian node for the European Multidisciplinary Seafloor and water column Observatory) as well as starting up the new project EMAN7 (Environmental impact of Methane seepage and sub-seabed characterization at LoVe-Node 7).

Main achievements 2017–2023

1. We showed that methane content in highly active methane seepage areas is controlled by current rather than by vertical methane transport, limiting the escape to the atmosphere.

2. We demonstrated that methane content in highly active methane seepage areas can be controlled by stratification, and part of it by current, limiting the escape to the atmosphere. In addition, we demonstrated that methane seeps are almost halved during cold seasons, therefore questioning existing potential methane budgets from ocean sources.

3. We showed that seepage and hydrothermal vent systems influence the composition of dissolved organic matter.

4. We developed a new tool for predicting the fate of seafloor-emitted methane using a two-phase gas model in one dimension (M2PG1). This tool is to be used to feed 3D oceanographic models.

5. We developed a predicable and reliable method for correcting slow sensor response signal inherent to equilibrium extraction technique that suffers from limited response time, from minutes up to over one hour.

6. We developed, deployed, recovered and analysed the data from both K-landers. Using the previous method, published results at a shallow site Western Prins Karls Foreland show high short term (100-1000 nmol/L within hours) and seasonal variation as well as higher (2-7 times) methane concentrations compared to previous measurements. A negative correlation with temperature fits with hypothesized seasonal blocking of lateral methane pathways in the sediments.

7. We were awarded the new INFRASTRUKTUR project NOREMSO co-led with UiB, where moorings, landers and gliders are deployed in the North Sea to study the physical oceanography and Ocean Acidification. In particular, we are in charge of a mooring south of Svalbard equipped with chemical sensors for CO_2 and CH_4 monitoring.

8. We were awarded the project EMAN7 where we use node 7 from the LoVe cabled observatory network to investigate methane emission dynamics and past evolution, the causality between methane seepage and oceanic parameters as well as climate change, and how it affects biology and in particular coral reefs that leave around the seepage. This project ends in May 2025.

9. We participated to the N-ICE2015 expedition where we collected methane measurement under and above the young sea ice with the Norwegian Polar Institute 's RV Lance frozen into and drifted with the sea ice at 80°N for several months.

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 Vice-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 and EAWAG/ETH in Switzerland. (AWI), Germany, and a visiting professor position at the University of Hawaii, USA and EAWAG/ETH in Switzerland.

Members (2017–2023)

Giuliana Panieri
Professor (2013-2023)

Aivo Lepland
Researcher (2013-2023)

Soma Baranwal
Postdoctoral Fellow (2013-2020)

Wei Li Hong
Postdoctoral Fellow (2015-2020)

Tobias Himmler
Postdoctoral Fellow (2016-2020)

Pierre Antoine Dessandier
Postdoctoral Fellow (2016-2020)

Claudio Argentino
Postdoctoral Fellow (2019-2023)

Antoine Cremiere
Postdoctoral Fellow (2014-2017)

Simone Sauer
PhD Candidate (2014-2017)
Deniz Koseoglu
PhD Candidate (2016-2019)

Kärt Üpraus (prev. Üpraus)
PhD Candidate (2015-2018)

Haoyi Yao
PhD Candidate (2016-2020)

Andrea Schneider
PhD Candidate (2015-2018)

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:

- What caused the evolution of submarine Arctic gas hydrate systems and methane leakage events in the geological past?

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

Left: Great teamwork and high spirits make the heavy lifting easier. Right: Carbonate crust. Photos: Jochen Knies

Technology intensive explorations over the past couple of years, payed off for work package 5 also during 2021: Unique material from various gas leakage sites in the Norwegian and Barents Seas was collected using ROV Ægir and RV G.O. Sars and Kronprins Haakon.

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 in the Arctic.

Main achievements 2017–2023

1. We developed a geochemical, micropaleontological, and numerical toolbox to identify, understand, and date past methane leakage events in the Arctic. We document this success through various applications on borehole material recovered from the Svalbard-Barents Sea continental margin.
2. The team confirmed the model for repeated destabilization of gas-charged sedimentary reservoirs during cryospheric deglaciation on formerly glaciated continental margin through detailed geochronological constraints derived from methane-derived authigenic carbonates and benthic/planktic foraminiferal assemblages coupled to various isotope systems.
3. Through 3D fluid migration modelling, we up-scaled our point observations towards a complete gas hydrate charged fluid flow system and modelled its history from the potential origin of the fluids (source rock) to their final sink (ocean) through time.
4. Our research efforts towards future scientific ocean drilling in the circum-Arctic succeeded in 2022. We finally passed the last IODP science and security panels for our planned scientific drilling expeditions east of Greenland and northwest Svalbard. Both cruises (Expeditions #403 and #404) are now scheduled for summer 2024.

WORK PACKAGE 6

Methane, CO_2 and ocean acidification

Tine Lander Rasmussen, *Team Leader*

Tine Rasmussen is a professor at the Department of Geosciences, UiT The Arctic University of Norway since 2003. Her research interests are focused on abrupt climate and oceanographic changes and changes in greenhouse gases in Arctic to sub-Arctic areas. She is educated in the fields of paleoceanography, paleoclimate, biology/paleobiology, micropaleontology, ecology/paleoecology and stratigraphy. She holds a PhD degree in marine science/paleoecology and micropaleontology from Aarhus University in Denmark, and has professional experience most notably from Copenhagen University (Denmark), Lund University (Sweden) and Woods Hole Oceanographic Institution (USA).

Members (2017–2023)

Katarzyna Zamelczyk
Postdoctoral Fellow/Researcher (2013-2018)

Mohamed Ezat
Researcher (2013-2023) Leader ARCLIM-project

Katarzyna Melaniuk
Researcher (2021-2023)
PhD Candidate (2018-2021)

Naima El bani Altuna
Postdoctoral Fellow (2021-2023)
PhD Candidate (2016-2021)

Ulrike Hoff
Postdoctoral Fellow (2013-2018)

Kamila Sztybor
PhD Candidate (2011-2017)

Siri Ofstad
PhD Candidate (2016-2021)

Griselda Anglada-Ortiz
PhD Candidate (Nansen Legacy project) (2019-2023)

Christine Lockwood-Ireland
PhD Candidate (2020-2025)

Freya Sykes
PhD Candidate ARCLIM (2021-2025)

Adele Westgård
PhD Candidate ARCLIM (2021-2025)

About:

To understand the impact of methane release on past and present environments and climate, WP6 studies both modern environments by the study living micro- and macrofauna and the past by examining fossilized remains of once-living fauna, mostly from around Svalbard, both from seep sites and off seep areas. To better understand the processes of the Arctic carbon cycle and changes seen at methane release areas, WP6 also reconstructs the background paleoceanography and -climatology by the study of marine cores from sites from the Barents Sea, the Nordic seas and Arctic Ocean.
We reconstruct bottom water temperature and its effect on change in degree of methane seepage. WP6 investigates methane seep areas by annual and/or seasonal sampling in order to document changes in planktic and benthic foraminiferal faunas in relation to methane seepage, productivity and ocean chemistry changes over time. Methane rapidly oxidizes to CO2, which can change the carbonate chemistry of the ambient water. This can potentially increase ocean acidification, with detrimental effects on calcifying organisms. In addition, WP6 monitors planktic foraminifera, coccospheres and pteropods by studying their contribution to the organic and inorganic carbon pump.

Main questions:

- What is the impact of increased methane release on marine micro- and macrofaunas?
- Is there a relationship between this release and climate (ocean bottom water temperature)?
- Does methane release contribute to ocean acidification/productivity change?
- What is the impact of climate and ocean warming on ice sheets in the past?

Major aims:

- Investigate methane release and its impact in relation to past climate and ocean circulation and temperature changes
- Investigate methane release and the isotopic signals in living benthic foraminiferal shells and distribution patterns of species in relation to successive stages of seepage
- Apply multi-proxy techniques to reconstruct high-resolution climate and greenhouse gas records
- Detect and quantify planktic foraminiferal and pteropod responses to changes in ocean chemistry and productivity due to methane release, increasing atmospheric CO2 and ocean warming
- Investigate timing of past rapid ocean warmings and impact on ice retreat patterns
- Provide robust quantitative records useful for modelling of the carbon cycle and forecasting future changes as a result of ongoing changes in the polar ocean

Left: Diatom layer deposited when the Arctic front moved northward during the deglaciation. Photo: S.B. Andersen, Geoscience, Aarhus University.
Right: Starfish sampled with box corer, coloured by Rise Bengal. Photo: Christine Lockwood-Ireland.

We work to improve existing standards and intergrate established methods with groundbreaking technologies to estimate CO2 concentrations, productivity patterns, ocean acidification, bottom water temperatures, and ventilation rates of the ocean, sea-ice cover and climate, ice retreat patterns and timings, past and present.

Our work package studies general climate and ocean 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 and micro- and macrofaunas over time can be compared to palaeoceanographic and -climatic developments in order to obtain a better understanding of controlling factors.

Main achievements 2017–2023

1. Neodymium isotope records from the central Arctic Ocean and the Nordic Seas provided a clear evidence of active Nordic seas overturning and transport of deep water to the North Atlantic during the LGM.

2. Reconstruction of bottom water temperature (BWT) for the last glacial period (13–63 ka) through the measurement of Mg/Ca of benthic foraminifera at Vestnesa Ridge on millennial-scale shows that BWT increased up to 5±1°C during the coldest phases. A vast heat reservoir occupied the intermediate water beneath a strong halocline in the North Atlantic and the Arctic Ocean. Furthermore, the reconstruction of BWT by Mg/Ca for the last 18,500 years in Storfjorden Trough showed a close linkage between BWT, ice movements and strength of methane release.

3. Deep ocean 14C ventilation age reconstructions from the Arctic Ocean and 14C age differences in two species of benthic foraminifera have been critically assessed for the last glacial maximum (LGM). Ventilation was reduced in the Nordic Seas, but a persistent exchange between the Arctic Ocean, and the North Atlantic Ocean occurred.

4. Boron isotope records suggest change in the air-sea exchange mode in the Nordic seas from today's prominent CO2 sink to a CO2 source to the atmosphere during times of abrupt changes in regional climate and amopsheric pCO2.

5. Investigation of seasonal distribution of planktic foraminiferal faunas and pteropods over seep sites in the crater area in the Barents Sea revealed no relation between faunal composition, concentration and preservation states in relation to seasonal water chemistry changes, but a potential productivity effect.

6. The study of planktonic foraminiferal and pteropod shell densities measured by X-ray microcomputed tomography (XMCT) reveal clear inter-species differences in shell density and thickness with water depth and ontogenic stages in the Crater area. In addition, XMCT measurements done on foraminifera from the surface sediment, show a large range of dissolution states.

7. Seasonal sampling of planktic foraminifera and shelled pteropods in the northern Barents Sea showed greatest abundances, largest sizes, and highest contribution to carbon standing stocks and export production in summer (August and July) and autumn (December), followed by spring (May), and the lowest in winter (March).

8. The foraminiferal plankton community was studied in the Fram Strait in the Arctic gateway based on new and published data for the last 50 years. The results showed a decadal trend of changes in fauna compositions and shoaling of the living depth habitat recorded by the species.

9. The distribution of δ13C values in living benthic foraminifera from methane seep sites at Vestnesa Ridge, NV Svalbard margin show a clear signal of low values recorded in areas of moderate seepage and aerobic oxidation of methane indicating that they do incorporate methane-derived carbonate into their shells.

10. The Svalbard-Barents Sea Ice Sheet reacted rapidly to the abrupt warmings of the last deglaciation 20–10 ka BP. Ice retreat was nearly instantaneous and about 11,000 km2 of ice broke off in two step correlating with warmings to the Bølling interstadial and Holocene interglacial. Deglacial retreat rates matched modern retreat rates in Antarctica and Greenland (>2 km/year) and were similarly forced by atmospheric and oceanic warming.

11. A new species of chemosynthetic vesicomyid bivalve from Arctic methane seeps off Svalbard at Vestnesa Ridge was described and named Archivesica arctica. Also, a new Late Pleistocene solemyid species of Acharax were discovered, described and named A. svalbardensis. These genera are found in warm water conditions both past and present and show that warm bottom water reached Vestnesa Ridge 17 ka BP.

Starting Grants 2017–2023

Andreia Plaza-Faverola

Project leader

Andreia Plaza-Faverola holds a PhD degree (2010) in marine geophysics from the Department of Geosciences at UiT The Arctic University of Norway and a MSc degree in petroleum geology from the IFP School in France.

Team members

Frances Cooke
PhD Candidate (2019-2024)

Przemyslaw Domel
PhD Candidate (2019-2024)

Hariharan Ramachandran
Postdoctoral Fellow (2019-2022)

Sunny Singhroha
Researcher (2019-2023)

Remi Vachon
Postdoctoral Fellow (2019-2022)

Nabil Sultan
Senior researcher (2019-2024)

Jean Baptiste Koehl
Researcher (2019-2024)

Vera Schlindwein
Professor, AWI (2019-2024)

Stefan Bünz
Professor UiT (2019-2024)

Björn Lund
Senior lecturer Uppsala University (2019-2022)

Hugh Daigle
Senior researcher Texas University at Austin (2019-2022)

Guillaume Sauvin
Researcher, NGI (2019-2023)

SEAMSTRESS – Tectonic stress effects of Arctic methane seepage

- *Tromsø Research Foundation (TFS), 11.1 M NOK.*
- *The Research Council of Norway (RCN), 8 M NOK.*

The project's main goal is to quantify the effect of regional stress (e.g., from mid-ocean ridge spreading and glacial isostacy) on the pressure field that controls Arctic seafloor methane seepage. The project integrates cross-disciplinary expertise (marine geophysics, seismology, geomechanics, petrophysics and geology) to develop field validated models of mechanisms involved in the release of gas at continental margins. Major project outcomes include evidence from both numerical models (i.e., glacial and tectonic stress models) and geophysical data, for intensified fracturing and susceptibility to gas release associated with glacial transitions; petrophysical and seismological evidence for an interrelation between sea-level fluctuations, sub-seabed sediment pressure and the periodicity of gas release; and seismological evidence for the transfer of tectonic stress from the deep crust to Quaternary sedimentary strata at fault controlled seepage sites.

Mohamed M. Ezat

Project leader

Mohamed Ezat is a paleoceanographer and geochemist. He is a former Marie-Curie fellow (2018-2021) at both UiT, Norway and Cambridge University, UK and is currently the leader of the ARCLIM project.

Team members

Naima El bani Altuna
Postdoctoral Fellow (2022-2024)

Tristan Vadsaria
Postdoctoral Fellow (2022-2024)

Adele Westgård
PhD Candidate (2021-2025)

Freya Sykes
PhD Candidate (2021-2025)

ARCLIM – The Arctic Ocean under Warm Climates

- *Tromsø Research Foundation (TFS), 12 M NOK.*

ARCLIM, the Arctic Ocean under warm climates, is a cross-disciplinary project that brings expertise from marine ecology, geochemistry and climate modelling together to develop and apply new methods to quantify Arctic Ocean-cryosphere-climate interactions during some past warm periods; these time periods can work as (semi)analogues of our future climate(s). The project also included infrastructure development at UiT e.g., ARCLIM has established a laboratory for culturing planktic foraminifera that is uniquely tailored to cultivate polar and subpolar species.

Dimitri Kalenitchenko

Project leader

Dimitri Kalenitchenko is a 50% researcher within WP3 Cold-Loving Microbes in a warming arctic at CAGE and an associate Professor at La Rochelle University, France. He holds a PhD degree (2015) in microbial ecology from the Benthic Ecogeochemistry Laboratory, Sorbonne University, France.

Team members

Mette Svenning
Professor, UiT (2022-2026)

Alexander Tveit
Researcher, UiT (2022-2026)

Gabrielle Kleber
Postdoctoral Fellow, UiT (2023-2024)

Ani Saghatelyan
PhD Candidate, UiT (2023-2027)

Andrew Hodson
Professor, UNIS (2022-2026)

Christine Dupuy
Professor, ULR (2022-2026)

Lisa-Marie Delpech
PhD Candidate, ULR (2023-2026)

Nicolas Lachaussée
Engineer assistant, ULR (2022-2026)

Kevin Hand
Researcher, JPL (2022- 2026)

Andrew Bowen
Principal Engineer, WHOI (2022- 2026)

METHANICE – The Methanotrophic communities in ice

- *The Research Council of Norway (RCN), 8 M NOK.*

The Methanotrophic communities in ice (METHANICE) project will identify the role of methane consuming microorganisms (methanotrophs) associated with terrestrial seasonal ice covering sub permafrost methane springs. Seasonal ice forms on top the springs during winter, trapping methane and carbon dioxide in a thick ice layer surrounding massive, pressurised aquifers oversaturated with greenhouse gases. While the aquifers are full of methanotrophs, it is still unknown whether they are present and active as biological methane filter within the ice during winter. Deep-sea engineer and astromicrobiologist will work together to detect and monitor the activity of these microbes. Through this, they will train themselves for the upcoming missions that will explore the icy moons of our solar system. After this first step, we will combine in-situ and laboratory experiment to understand if the ice-associated microbes can use the greenhouse gases trapped in the reservoir and therefore decrease their release toward the atmosphere. Furthermore, we will isolate these microbes to know their physiology and which mechanisms allow them to survive in this cold and oligotrophic environment.

METHANICE

Other projects funded between 2017–2023

Lofoten-Vesterålen cabled observatory (LoVe)
The Research Council of Norway (2016-2025)
PI: Bénédicte Ferré

Pliocene Arctic Climate Teleconnections (PACT)
The Research Council of Norway (2016-2020)
PI: Jochen Knies

Interactive digital map of the last Ice Age in the Barents Sea (ICEMAP)
The Research Council of Norway (2016-2018)
PI: Maja Sojtaric

Norwegian margin fluid systems and methane-derived carbonate crusts (NORCRUST)
The Research Council of Norway (2016-2020)
PI: Jochen Knies

SIOS Item 61 Lander with sensors
The Research Council of Norway (2019-2023)
PI: Bénédicte Ferré

Advancing knowledge on methane in the Arctic (AKMA)
The Research Council of Norway (2019-2023)
PI: Giuliana Panieri

Hot vents in an ice-covered ocean: the role of the Arctic as a connectivity pathway between ocean basins (HACON)
The Research Council of Norway (2019-2022)
PI: Stefan Buenz

Environmental impact of Methane seepage and sub-seabed characterization at LoVe - Node 7 (EMAN7)
The Research Council of Norway (2021-2025)
PI: Bénédicte Ferré

Time-lapse seismic studies to understand the dynamic of gas hydrate provinces of a polar margin
VISTA/DNVA (2016-2019)
PI: Stefan Buenz

Impacts of ocean acidifications on planktonic foraminifera
Framsenteret AS (2016-2017)
PI: Tine L. Rasmussen

Acquisition of geoscientific data in the Barents Sea
The Norwegian Petroleum Directorate (2017-2022) PIs: Karin Andreassen, Monica Winsborrow, Stefan Buenz, Giuliana Panieri

The glacial hydrocarbon pump
VISTA/DNVA (2019-2021)
PI: Karin Andreassen

2260 Ecosystem
Oljedirektorat (2021)
PI: Stefan Buenz

Numerisk modellering og validering av geologiske prosesser
Equinor (2019-2022)
PI: Karin Andreassen

Nansen legacy WP RF2
The Research Council of Norway (2018-2022)
PI: Tine L. Rasmussen

Meltwater release of heavy metals from glacier to ocean in a changing Arctic (METALLICA)
The Research Council of Norway (2023-2026)
PI: Jemma Wadham

Centre for ice, Cryosphere, Carbon and Climate (iC3) SFF V
The Research Council of Norway (2023-2033)
PI: Jemma Wadham & Monica Winsborrow

PhD dissertations 2013–2023

CAGE is proud that 28 CAGE PhD candidates successfully defended their PhD theses between 2013-2023.

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.
https://hdl.handle.net/10037/5486

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.
https://hdl.handle.net/10037/6749

Vadakkepuliyambatta, S.
Sub-seabed fluid-flow systems and gas hydrates of the SW Barents Sea and North Sea margins
Supervisor: Bünz, S.
https://hdl.handle.net/10037/6198

2015

Chauhan, T.
Late Quaternary paleoceanography of the northern continental margin of Svalbard
Supervisor: Rasmussen, T.L., Noormets, R.
https://hdl.handle.net/10037/8258

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.
https://hdl.handle.net/10037/8258

Gudlaugsson, E.
Modelling the subglacial hydrology of the former Barents Sea Ice Sheet
Supervisor: Andreassen, K., Humbert, A.
https://hdl.handle.net/10037/25064

Jessen, S.P.
Ice rafting, Ocean circulation and Glacial activity on the western Svalbard margin 0–74,000 years BP
Supervisor: Rasmussen, T.L.
https://hdl.handle.net/10037/7877

Portnov, A.D.
Role of subsea permafrost and gas hydrate in postglacial Arctic methane releases
Supervisor: Mienert, J., Cherckashov, G.
https://hdl.handle.net/10037/8220

2016

Sauer, S.
Past and present natural methane seepage on the northern Norwegian continental shelf
Supervisor: Knies, J., Mienert, J.
https://hdl.handle.net/10037/9548

2017

Sztybor, 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.
https://hdl.handle.net/10037/24978

Tasianas, A.
Fluid flow at the Snøhvit field, SW Barents Sea: processes, driving mechanisms and multi-phase modelling
Supervisor: Bünz, S.
https://hdl.handle.net/10037/11494

2018

Esteves, M.
Collapse of a marine-based ice sheet
Supervised by: Winsborrow, M., Andreassen, K., Bjarnadóttir, L.R., Rüther, D.
https://hdl.handle.net/10037/21256

Jansson, P.
Methane bubbles in the Arctic Ocean - Quantification, variability analysis and modelling of free and dissolved methane from the seafloor to the atmosphere
Supervised by: Ferre, B.
https://hdl.handle.net/10037/14485

Paiste, K.
Reconstructing the Paleoproterozoic sulfur cycle: Insights from the multiple sulfur isotope record of the Zaonega Formation, Karelia, Russia
Supervised by: Panieri, G., Lepland A.
https://hdl.handle.net/10037/14211

Schneider, A.
Diagenetically altered benthic foraminifera reveal paleo-methane seepage
Supervised by: Panieri, G., Knies, J., Lepland, A.
https://hdl.handle.net/10037/12780

Serov, P.
Cryosphere-controlled methane release throughout the last glacial cycle
Supervised by: Andreassen, K.
https://hdl.handle.net/10037/15559

Åström, E.
Benthic communities at high-Arctic cold seeps: Faunal response to methane seepage in Svalbard.
Supervised by: Carroll, J.
https://hdl.handle.net/10037/12795

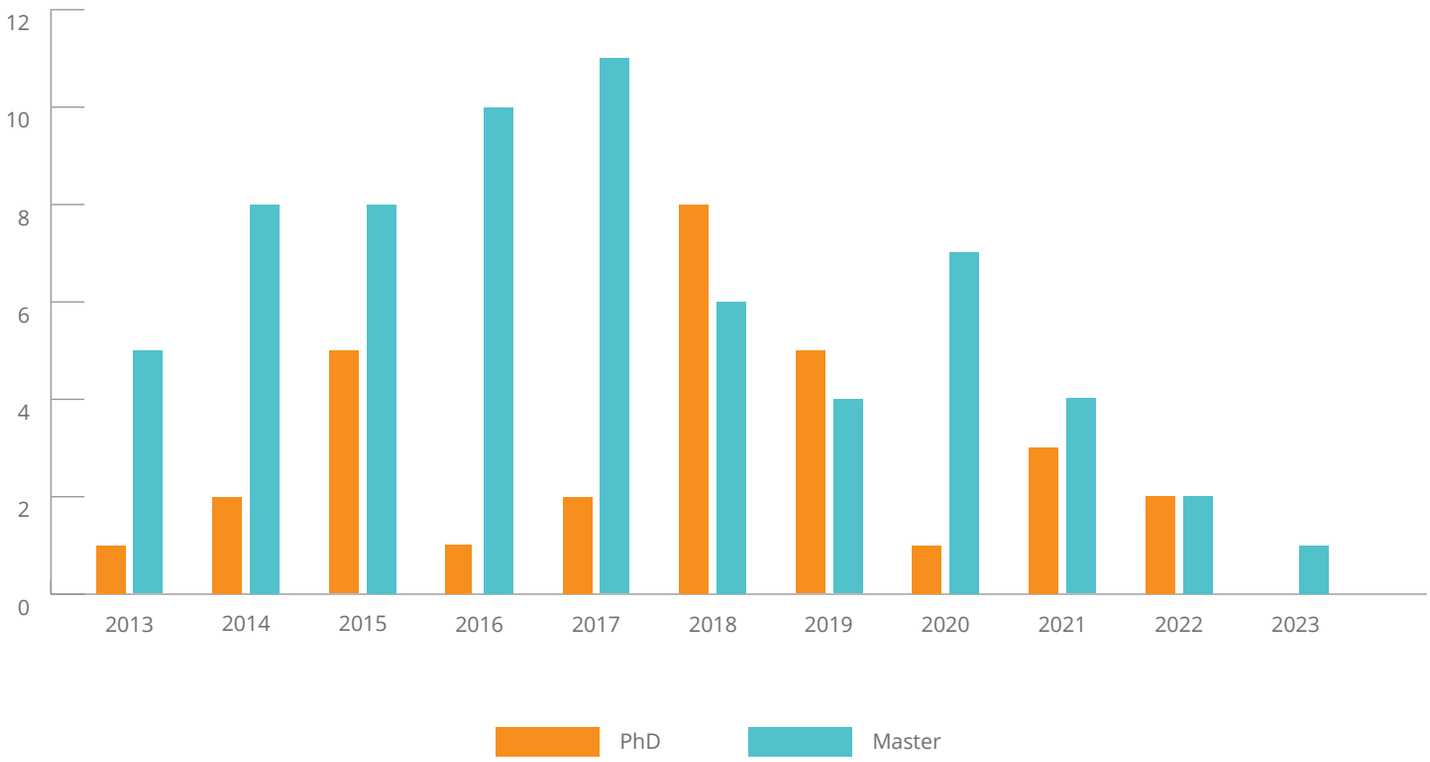
2019

Shackleton, C.
Subglacial hydrology of the Fennoscandian and Barents Sea ice sheets
Supervised by: Winsborrow, M., Andreassen, K., Bjarnadóttir, L. R., Patton, H. https://hdl.handle.net/10037/15815

Singhroha, S.
Distribution and quantification of gas hydrates and free gas in marine sediments of Vestnesa Ridge, offshore W-Svalbard
Supervised by: Bünz, S.,Plaza-Faverola, A., Chand, S.
https://munin.uit.no/handle/10037/15824

Waage, M.
3D and 4D seismic investigations of fluid flow and gas hydrate systems - at sites across the Barents Sea and NW Svalbard margin.
Supervised by: Bünz, S., Mienert, J., Andreassen, K.
https://munin.uit.no/handle/10037/15078

PhD and master 2013–2023



Waghorn, K.A.
Scales of tectonic processes controlling fluid flow systems on the Svyatogor Ridge, Fram Strait
Supervised by: Bünz, S., Plaza-Faverola, A.
https://hdl.handle.net/10037/15813

2020

Yao, H.
Reconstruction of past and present methane emission in the Arctic cold seeps using biogeochemical proxies
Supervised by: Panieri, G.; Niemann, H.
https://hdl.handle.net/10037/17821

2021

Carrier, V.
Microbial community structure associated to Arctic cold seeps
Supervised by: Svenning, M.M.; Kalenitchenko, D.; Gründger, F.; Niemann, H.
https://hdl.handle.net/10037/22978

El Bani Altuna, N.
Millennial-scale variability of Atlantic water inflow in the northern Nordic Seas and the northwestern Barents Sea - Relationship to abrupt climate oscillations, cryosphere and methane seepage from the seafloor
Supervised by: Rasmussen, T.; Ezat, M.
https://munin.uit.no/handle/10037/22253

Melaniuk, K.
Doctoral dissertation. "Assessing the relationship between living benthic foraminifera and methane emission in the Arctic Ocean
Supervised by: Rasmussen, T.; Treude, T.; Zajaczakowski, M.
https://hdl.handle.net/10037/22757

Ofstad, S.
Arctic planktonic calcifiers in a changing ocean - A study on recent planktonic foraminifera and shelled pteropods in the Fram Strait-Barents Sea region
Supervised by: Rasmussen T.; Zamelczyk K.; Meilland J. 110 pages.
https://hdl.handle.net/10037/22757

2022

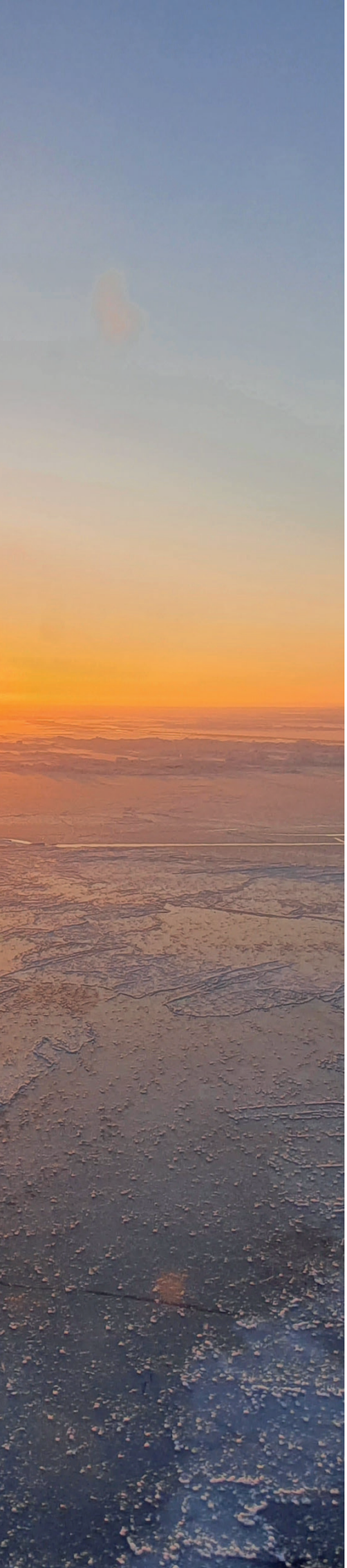
Dølven, K. O.
Measuring Methane in the Arctic Ocean - From legal framework to time series analysis via technology innovation.
Supervised by: Ferré, B., Linke, P.
https://hdl.handle.net/10037/24357

Sert, M. F.
Biogeochemistry of dissolved organic matter in Arctic Ocean waters charged with methane.
Supervised by: Silyakova, A., Gründger, F., Niemann, H.
https://hdl.handle.net/10037/27296

2023

Four PhD candidates are projected to finish and defend their PhD thesis in 2023.

Sunrise at 82N on Monday 4th October, 11:00 in the morning. RV Kronprins Håkon moves through newly formed sea ice on its way to the Aurora Seamount at the western end of the Gakkel Ridge in the Arctic Ocean. Photo: Stefan Bünz



Master theses 2013–2023

Since 2013, CAGE researchers have supervised 69 master students.

2013

Khan, M. I.
Ice stream dynamics inferred from seismic geomorphology from the Bjørnøyrenna and Nordkappbanken area, SW Barents.
https://hdl.handle.net/10037/5207

Lydersen, I. B.
Fluid leakage assessment of the overburden structure at the Sleipner CO2 storage site.
https://hdl.handle.net/10037/5432

Richardsen, M.
Geomorfologi av glasiale sedimenter basert på 3D seismikk fra Nordkappbanken, SV Barentshav.
https://hdl.handle.net/10037/5210

Sommerseth, A. S.
Isstrømdynamikk og havbunnsgeomorfologi fra deglasiasjonen av det sørvestlige Barentshav, basert på 3D-, 2D-seismisk og batymetrisk data.
https://hdl.handle.net/10037/5401

Streuff, K. T.
Landform assemblages in inner Kongsfjorden, Svalbard: evidence of recent glacial (surge) activity. https://hdl.handle.net/10037/5212

2014

Arvo, J.
Relationship between fluid leakage and faulting along the western and northern margin of the Hammerfest Basin.
https://hdl.handle.net/10037/6333

Jørgensen, K.
Development of fault complexes in time and space at Loppa High - SW Barents.

Khan, A.
Integrated Petrophysical and Seismic interpretation of Norne Field, Norway.
https://hdl.handle.net/10037/16196

Njone, I.
Hydrothermal Vent Activities At the Gjallar Ridge in the Vøring Basin, mid-Norway.
https://hdl.handle.net/10037/6914

Valberg, E.
Time-lapse seismic interpretation of injected CO2 plume at the Sleipner Field, North.
https://hdl.handle.net/10037/7603

Villaflor, G. A.
Multibeam bathymetry and backscatter data analysis of pockmarks at Vestnesa R idge off NW-Svalbard.
https://hdl.handle.net/10037/6913

Aas, C.
Focused fluid flow through the gas-hydrate stability zone on the Vestnesa Ridge, offshore W-svalbard.
https://hdl.handle.net/10037/6507

2015

Arnardottir, E. O.
Reconstruction of Holocene Paleoenvironment in Smeerenburgfjorden, northwest Svalbard based on benthic foraminifera and sedimentological investigations.
https://hdl.handle.net/10037/7741

Bjørnøy, K.
The nature of the gas-hydrate/free gas transition zone at the base of the hydrate-stability zone from high-resolution 3D seismic data.
https://hdl.handle.net/10037/7660

Edvardsen, A.
Faulting and the relationship to fluid migration and shallow gas accumulation in the Hammerfest Basin, SW Barents .
https://hdl.handle.net/10037/7701

Hatland, A. M.
A detailed investigation of a geological CO2-storage reservoir.
https://hdl.handle.net/10037/7928

Jönsdottir, B.
High-resolution study of selected Dansgaard-Oeschger events and Heinrich event 4 42,189–33,393 cal. years BP.
https://hdl.handle.net/10037/7752

Lium-Wickler, A.
A shallow gas flat spot anomaly in the Bjørnøyrenna Fault Complex in the Barents Sea: processing and interpretation of P-Cable 3D seismic data.
https://hdl.handle.net/10037/7739

Mikalsen, H.
Reservoir structure and geological setting of the shallow PEON.
https://hdl.handle.net/10037/7930

Nordahl, J. L.
Modeling of seismic amplitude anomalies associated with CO2 underground storage.
https://hdl.handle.net/10037/7932

Tesfay, Y.
Shallow fluid seepage systems in the Hammerfest Basin and adjacent Fault complex.
https://hdl.handle.net/10037/8049

Virs, R.
A comparative seismic study of gas chimney structures from active and dormant seepage sites offshore mid-Norway and west-Svalbard.
https://hdl.handle.net/10037/7742

Westvig, I.
Structural and Stratigraphic Setting and Fluid Flow Features of the Svyatogor Ridge, a Sediment Drift South of the Molloy Transform.
https://hdl.handle.net/10037/7983

2016

Agafonova, O.
Late Triassic channel systems at the Loppa High, SW Barents.
https://Munin.uit.no/handle/10037/8428

Eilertsen, V. T.
Reconstructions of paleoceanography and ice retreat based on benthic foraminifera, stable isotopes and sedimentological investigations from the northwestern Barents Sea south of Nordaustlandet, Svalbard.
https://hdl.handle.net/10037/9703

George, S.
The active methane filter in the high Arctic marine environment.

Hultin, M.
Sedimentation environment during deglaciation and Holocene in Southern Sentralbanken, Barents.
https://hdl.handle.net/10037/9289

Jakobsen, F. W.
Interaction between ice streaming, glacitectonics and fluid flow in Håkjerringdjupet, SW Barents.
https://hdl.handle.net/10037/9239

Kovalenko, B.
Palaeoceanographic development in Leirdjupet Trough, western Barents Sea, during the Holocene: evidence from foraminiferal, isotopic and sedimentological records.
https://hdl.handle.net/10037/8401

Lockwood, C. J.
Reconstruction of ice stream retreat and palaeoceanographic development during the deglaciation and Holocene in the Storfjorden Trough, Svalbard. Based on geophysical data, benthic foraminiferal and sedimentological records. https://hdl.handle.net/10037/9296

Myrvang, K.
Correlation between changes in paleoceanography, paleoclimate and methane seepage on Vestnesa Ridge, eastern Fram Strait - S.
https://hdl.handle.net/10037/8402

Røde, S.
Petrographic investigation of methane-derived authigenic carbonate crusts from Barents Sea and Norwegian.
https://hdl.handle.net/10037/9779

Tesfamariam, D. A.
Seismic Modeling of Free Gas Occurrences and Bottom Simulation Reflection (BSR) Beneath Hydrate-bearing Sediments.
https://hdl.handle.net/10037/8437

Tønnessen, L. A.
Paleoceanographic development in Leirdjupet, during the last deglaciation.
https://hdl.handle.net/10037/9704

2017

Baker, M.
Reconstructing the Holocene: Benthic Foraminifera as a Proxy for the Paleoceanography of the Nordic Seas.
https://hdl.handle.net/10037/11403

Copeland, W. J.
Heinrich events of the late Pleistocene; evidence from a sediment core west of Jan Mayen. An analogue to present day ice sheet collapse?
https://hdl.handle.net/10037/11144

Danielsen, I. K.
Paleoceanographic development during the last deglaciation and Holocene, over the Bear Island slide scar, SW Barents.
https://hdl.handle.net/10037/10615

Gabrielsen, L.
Study of millennial scale paleoclimatic and paleoceanographic changes in conjunction with variations in the East Greenland Current during the late Quaternary.
https://hdl.handle.net/10037/11141

Heimdal, K.
Past methane emissions in the earliest Pleistocene on Yermak Plateau, NW Svalbard.
https://hdl.handle.net/10037/10185

Paulsen, R. S.
Shallow gas accumulations and fluid flow in the vicinity of the Goliat field, SW Barents .
https://hdl.handle.net/10037/11075

Romeyn, R. P.
Processing and interpretation of the Svyatogor 2016 high-resolution P-Cable 3D seismic dataset - Investigating the dynamics of a sub-seabed gas hydrate system with a potential abiotic methane source.
https://hdl.handle.net/10037/11148

Åsheim, J.-E. F.
Changes in paleoceanography and methane release in relation to past climatic variability at Vestnesa Ridge, Svalbard.
https://hdl.handle.net/10037/11621

2018

Hansen, L. L.
The role of diapiric mound structures in the overburden fluid plumbing systems of the Vøring Basin.
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.
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.
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.
https://hdl.handle.net/10037/12857

Wolberg, A. C.
Controls on fluid-flow systems in the Loppa High, SW Barents.
https://hdl.handle.net/10037/12822

2018

Hansen, L. L.
The role of diapiric mound structures in the overburden fluid plumbing systems of the Vøring Basin.
https://hdl.handle.net/10037/12824

Matteis, F. W.
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https://hdl.handle.net/10037/13097

Solheim, M.
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https://hdl.handle.net/10037/12857

Wolberg, A. C.
Controls on fluid-flow systems in the Loppa High, SW Barents.
https://hdl.handle.net/10037/12822

2019

Amdal, F. A.
Cross-disciplinary investigation of gas seepage at Storbanken high and the Olga basin, The northern Barents.
https://hdl.handle.net/10037/15460

Bruvik, K. L.
How is the carbon and oxygen isotope composition of foraminiferal tests influenced by methane seepage?
https://hdl.handle.net/10037/15576

Samuelsen, K. R.
Climatic variations and sediment provenance during the last 16 000 years in the North Hinlopen.
https://hdl.handle.net/10037/25347

2020

Binde, C. M.
Fluid flow and faulting along the northern margin of the Loppa High.
https://hdl.handle.net/10037/18388

Fåne, P.
Novel methanotrophic community assemblages in a terrestrial methane seep in Svalbard.
https://hdl.handle.net/10037/22057

Ødegård Garpestad, T. G.
Glacial dynamics and fluid flow processes in Bjørnøyrenna and the Loppa High area, SW Barents.
https://hdl.handle.net/10037/18490

Haldorsen, J.
The relationship between shallow anomalies and gas-flaring on the flank of the Nordkapp Basin in the SE Barents.
https://hdl.handle.net/10037/18468

Moen, J.-E.
Gas migration and sealing modelling in the Haapet Dome area, Norwegian Barents Sea - analysis of seismic anomalies and water column data.
https://hdl.handle.net/10037/21628

Mol, A.
Microbial community of arctic terrestrial cold seeps.

Selsaas, B.
Stratigraphy, neo-tectonics and mass wasting of deep water drifts in the Fram Strait.
https://hdl.handle.net/10037/18404

2021

Friedrich, J.
Seasonal variability of methane seep distribution and intensity offshore western Svalbard at the edge and outside the gas hydrate stability zone.

Mathisen, M. M.
Reconstruction of the paleocenaography west of Lofoten during the Last Glacial Maximum.
https://hdl.handle.net/10037/21540

Nguyen, H. K
Gas seeps in the Barents Sea – how does the geology influence the natural and well related seeps? https://hdl.handle.net/10037/22393

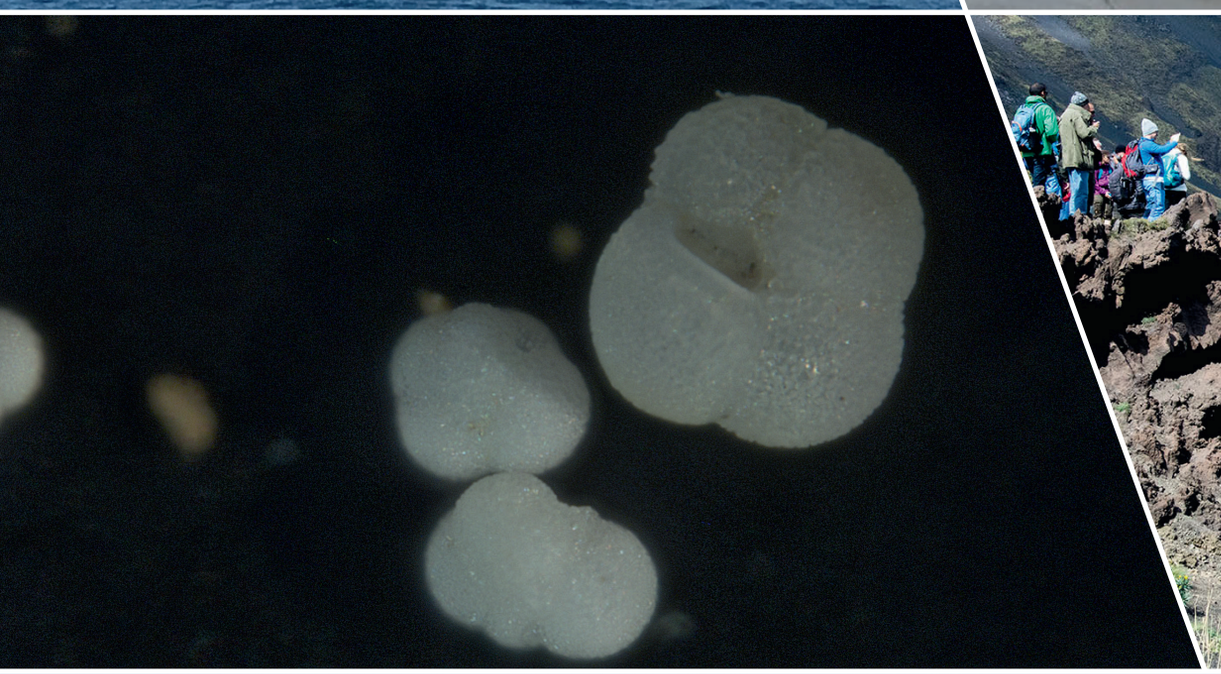
2022

Akinselure, A.
The Use of Foraminiferal Geochemistry to Investigate Methane Seepage at the Svyatogor Ridge, Arctic Ocean.
https://hdl.handle.net/10037/25353

Pearson, H. M.
A Quantitative Analysis of Seasonal and Regional Forcing on the Terminus of Store Glacier, Greenland, from High Resolution Photogrammetry.
https://hdl.handle.net/10037/25279

2023

Enguidanos, E. T.
Climate and sea-ice development between 890 and 1660 CE in SW Greenland revealed by marine diatom studies.
https://hdl.handle.net/10037/28423



Giuliana Panieri
AMGG Leader (2013-2019)
Member of GReAT Board
(2019-2021)

Bénédicte Ferré
Member of GReAT Board
(2021)

Tine Lander Rasmussen
Member of GReAT Board
(2021-2023)

Training a new generation of geoscientists: IG research School

From expeditions and excursions to workshops and transferable skills training, the research school at the Department of Geosciences, (IG), UiT, and led by CAGE staff have offered CAGE PhD's and early-career scientists the opportunity to learn and explore various geoscience disciplines within Arctic research. With close ties to CAGE and other national research schools, the trainee school AMGG (Arctic Marine Geology and Geophysics) and from 2019, GReAT (Geoscience Research Academy of Tromsø), have worked hard to prepare students and young scientists for careers across the Earth sciences..

AMGG Research School

The PhD students of CAGE were from the start of the Centre enrolled in AMGG (The Arctic Marine Geology and Geophysics) research school, which was established in 2005 at the Department of Geosciences (IG), UiT The Arctic University of Norway. AMGG aimed to train PhD students and early-career researchers (ECR) in the field of Arctic continental shelves and margins, glacial processes and products, geo-hazards, fluid emissions and gas hydrates, paleo-climate and -oceanography, energy, and environment.

AMGG offered students and young scientists the opportunity to take part in an array of activities, including: 1) joining scientific expeditions to the Arctic; 2) attending relevant seminars about climate and environmental change; 3) field trips to terrestrial fluid emission sites and other geological relevant areas; 4) specialised workshops with national and international participants; and 5) soft-skill training courses for the new generation of scientists.Transitioning to a new research school

The field of geosciences encompasses numerous disciplines, from marine geology to geochemistry to hard-rock geology, and to promote inclusivity within the different disciplines at IG, it was decided to launch AMGG under a new name and as a new research school: Geoscience Research Academy of Tromsø (GREAT). GREAT is led by a board consisting of three members of permanent staff at IG and three PhD student representatives. From 2020, the PhD students enrolled in GREAT have had to do a mid-way evaluation led by a two-person committee – with one being a permanent staff member of the GREAT Board. All PhD students at IG are evaluated halfway through their PhD program providing an opportunity for the student to obtain feedback and advice on their PhD and duty work.

GReAT Research Academy

AMGG transitioned to the Geoscience Research Academy of Tromsø (GREAT) to cover all topics within IG in 2019. GREAT continues to focus on investigating the Arctic, and now also includes terrestrial Quaternary geology, lithosphere dynamics, and bedrock geology.

GREAT is led by a board consisting of three members of permanent staff at IG/CAGE and three PhD student representatives, many of whom were from CAGE initiated projects. From 2020, the PhD students enrolled in GREAT have had to do a mid-way evaluation led by a two-person committee – with one being a permanent staff member of the GREAT Board. All PhD students at IG are evaluated halfway through their PhD program providing an opportunity for the student to obtain feedback and advice on their PhD and duty work.

Marine and terrestrial scientific expeditions and excursions are offered to student and ECR to the Arctic and to other geologically interesting localities around the globe. In addition, GREAT has organised together with CAGE, IG and the Faculty of Science and Technology, relevant seminars, specialised workshops, and other training courses beneficial to their future careers.

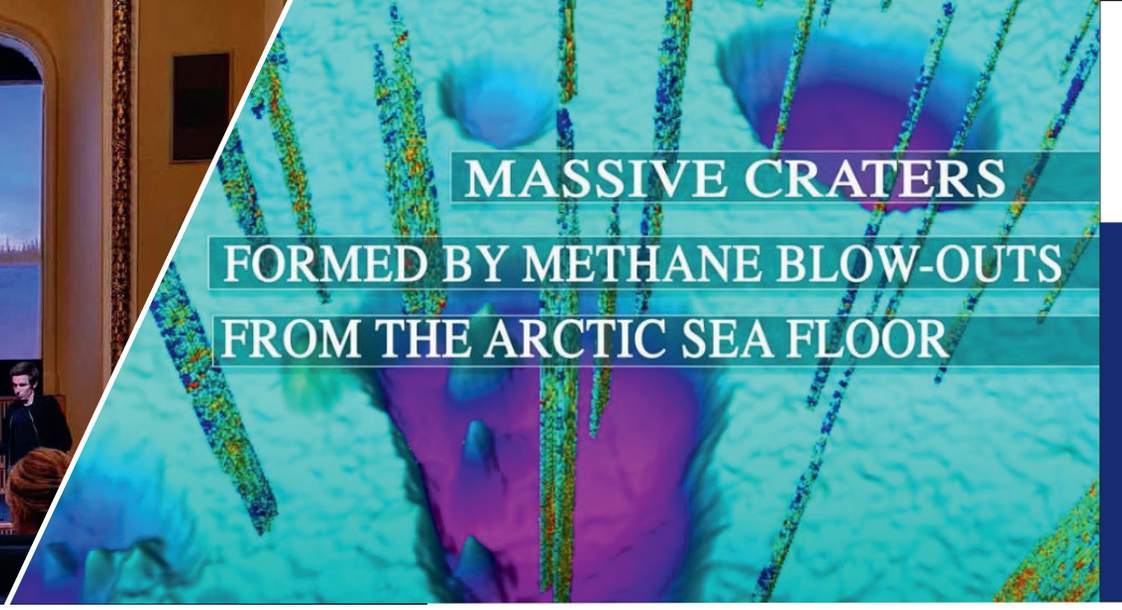
The students can acquire various transferable skills, create their own professional network, and go "across boundaries" of their own research fields. GREAT is closely associated with the national research schools CHESS (Research school on changing climates in the coupled Earth system) and DEEP (Norwegian Research School for Dynamics and Evolution of Earth and Planets).

The GREAT Annual Meeting is held every autumn and is an opportunity for the students to present their projects and discuss about science. GREAT early career scientists participate in JEDI Justice Equality Diversity and Inclusivity group at the Department of Geosciences.

The beautiful nature of Svalbard in the Arctic Ocean, taken at the beginning of an AMGG cruise. Photo: Kate Waghorn | During the field trip in Sicily (GEO-8805), students have been taught how to collect gas samples and recognize relevant mineralogical characteristics or local rocks. Photo: Giuliana Panieri. | Planktic foraminifera from the northern Barents Sea (fossil planktic foraminifera) Photo: Griselda Anglada Ortiz | Students during an AMGG field trip on Mount Etna (Italy) Photo: Giuliana Panieri | The AMGG teaching cruise in 2019 went to Yermak Plateau, North West Svalbard. Photo: Rowan Romeyn.

AMGG Trainee School in Arctic Marine Geology & Geophysics

Geoscience Research Academy of Tromsø



Left: CAGE Researcher Pavel Serov during the naturvitenskapelig filmkveld. Photo: Malin Waage. Right: Animation prepared by Maja Sojtaric. Published on YouTube as an appetizer for a scientific publication in the journal "Science" (Andreassen et al. 2017)

Maja Sojtaric
Senior Communication Advisor (2014–2021)

Mariana Esteves
Project Leader (Admin. and Comms. Coordinator) (2022-2023) Communications Advisor (2021–2022)

Jessica Green
Communications Advisor (2018–2019)

Communicating excellent science since 2013

Over this past decade, CAGE has both strived for and achieved excellent science, establishing itself as a world leading Centre of Excellence on Arctic gas hydrate, environment, and climate. As a result of this and in combination with high exposure of our scientific results through the media, the centres name now resonates through many channels around the globe, both in scientific and non-scientific circles.

Building our identity

Although several of the researchers in CAGE were well established when the centre began in 2013, CAGE started with clean slate - ready for building its own identity and reputation. Today, the centre is a world-leader in gas hydrate research related to the environment and climate, and research dissemination has played a central role in our strategy to reach where we are today.

Our strategy since the beginning has been to share and communicate our scientific findings to the public, industry, stake holders, and media. It has been particularly important to ensure that the science was communicated in an understandable and relatable way, so that it can reach a much larger audience of varying backgrounds and ages and raise awareness of the changing climate and environment in the Arctic.

Looking back, CAGE achieved above and beyond what was expected from its original research dissemination plan in the project description, which promised the completion of only 40 media reports to share with the press. 10 years later and CAGE can be proud to have registered over 1700 media reports on our research.

Entering a world of new media

We have aimed for high exposure of our findings by distributing them through press releases aimed at the public. This has been a great success as our research has been spotlighted by diverse outlets around the globe, including articles in the Washington Post, New Scientist, Siberian Times, Herald, and Sydney Morning.

We have reached, and made an impact, not only on traditional media (television, newspapers, and radio), but also through social media (YouTube, Twitter, Facebook, and Instagram). Over the last years years, we have produced increasingly more media reports, which can be attributed to the increased use of new media (social media, blogs, YouTube).

Even throughout the COVID19 pandemic when the media outlets were less focused on climate research, we were able to keep a reasonable level of activity and impact, using

Left: CAGE was the feature for the Autumn edition of Norway's Arctic University Museum, popular science magazine, Ottar.
Right: Illustration of Lenny Lemming. Illustration: Alice Kvalvik.

digital mediums, including online scientific presentations, radio interviews, social media posts.

Empowering our scientists

Preparing our scientists for outreach events, entering the new media world, and life beyond CAGE, has been a focal point for CAGE communication strategy, with workshops and seminars with a focus on outreach, science communication, research funding, data visualisation, and mental health, having been organised over the years. Together with our early career research school, AMGG and later GREAT (see page 33), we have organised workshops on improving presentation skills and writing techniques for our scientists.

There has been active participation from our scientists in press conferences, such as at the COP26 UN Climate Change Conference, EGU (European Geosciences Union), AGU (American Geosciences Union), and other outreach events to reach different audiences, including even greeting and giving presentations to members of the Norwegian Parliament and ambassadors for multiple countries, including India and France. Our scientists have also been invited to contribute to online panel discussions, such at the North x North Festival at the Anchorage Museum in Alaska.

CAGE scientists have also met with the public through science fairs and popular science talks, including scientific stalls and presentations at the Arctic Bubbles Pint of Science, Forskningsdagene and Geology Day, radio interviews, and creating an original animated educational video together with TED-Ed. The Arctic Bubbles Pint of Science was the final outreach event organised at a local Tromsø venue as part of the CAGE International Conference on Methane in a Changing Arctic. Our aim was to collaborate with Pint of Science Norway, to produce exciting and engaging talks and stalls on methane in a changing arctic and how it impacts our climate. This was an open event for the public and included popular science presentations from CAGE, Pint of Science and four early-career scientists from CAGE. In addition, there were four interactive and hands-on stalls for the public organised by CAGE scientists.

From local exhibitions to the National Geographic to the red carpet at Cannes and Hollywood

CAGE has collaborated with numerous local museums in Tromsø. This has included collaboration with Tromsø Museum to make a permanent geology exhibition, where several of our scientists appear, and is targeted towards children of all ages. Another major outreach project has involved collaboration between CAGE and Nordnorsk Vitensenter to develop the interactive, map-based installation and website, ICEMAP, which allows the users to explore the growth and decay of the large ice sheet that covered northern Europe during the last ice age through the story that Lenny the Lemming tells us. ICEMAP is not only an interactive installation at the vitensenter, but also a website that can be visited by anyone around the globe. The material from this project has even made its way to the National Museum of Northern Ireland in Belfast as part of a permanent exhibition on extinct animals and environmental changes.

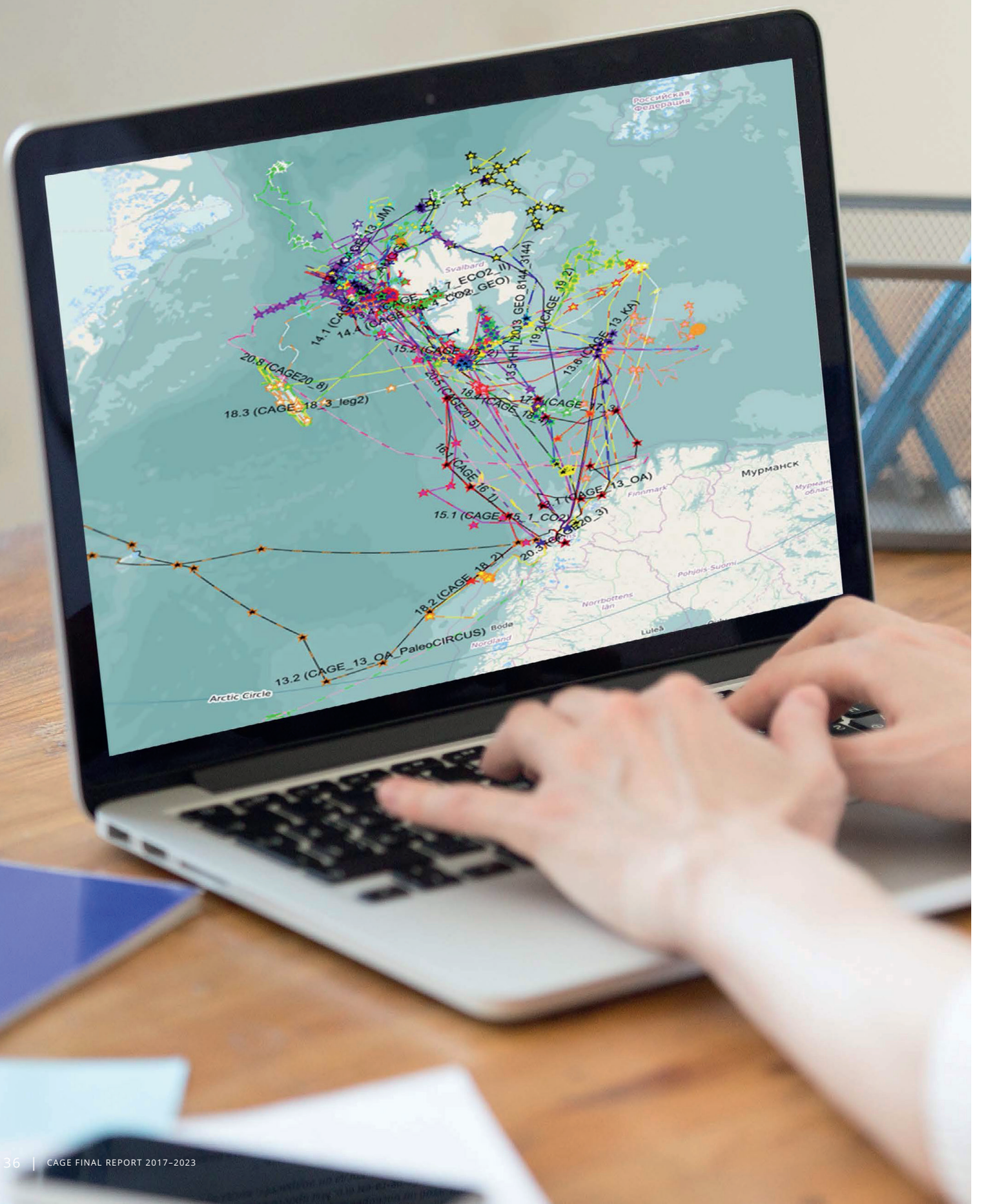
In 2019, CAGE outreach efforts led to red carpet appearances at Cannes Film Festival and Hollywood, to premiere the documentary produced and narrated by Oscar winner Leonardo DiCaprio, ICE on FIRE. Several CAGE scientists participated in this documentary, which highlights the pioneering research driving today's climate science, with a strong focus on climate change, greenhouse gas release and the newly developed technologies that could reverse global warming.

Communication legacy

As CAGE approached the end of its tenure, it was important that we shared highlights from our successes and informed the public where they can access the data and reports from our research. As part of this initiative the CAGE director, our scientists, and the communication and database coordinators, wrote the Autumn 2022 edition of the popular science magazine 'Ottar', which is led Norway's Arctic University Museum. Ottar is written in Norwegian and aimed at people of all ages as it can be found in schools and public libraries for all to enjoy.

A overview of the media reports published on the CAGE website and YouTube can be viewed on the CAGE Centre for Arctic Gas Hydrate, Environment and Climate Report Series, Septentrio Academic Publishing website (https://septentrio.uit.no/index.php/cage/Sciencecommunication). Lastly, the CAGE website (including all press releases and cruise/field blogs) have been transferred to the UiT site (www.site.uit.no/cage) where they will remain visible for years to come.

All communications and outreach work at CAGE has been facilitated and organised initially by senior advisor Maja Sojtaric from the start of CAGE until 2021, and then followed by project leader Mariana Esteves who took over in 2021. Between 2018-2019, Jessica Green was the temporary communication advisor at CAGE. As communication advisors our role has been to write our press releases, manage media contact and social media, in addition to organising seminars and workshops in science communication and data visualisation for employees at CAGE.


Российская Федерация
Svalbard
Мурманск
Finnmark
Pohjois-Suomi
Norrbottens län
Bodø
Nordland
Luleå
Arctic Circle
13.2 (CAGE_13_OA_PaleoCIRCUS)
18.3 (CAGE_18_3_leg2)
20.8 (CAGE20_8)
15.1 (CAGE_15_1_CO2)
13.1 (CAGE_13_OA)

Fabio Sarti, *Database manager*

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

CAGE Database: Sharing our scientific knowledge with the public

Over the past 10 years, CAGE has built up a large, and priceless, archive of publications, reports, materials, and data, from the Arctic. We have worked continuously to ensure that our data and results are as accessible as possible, and as CAGE approached its final year it was crucial to ensure that our scientific knowledge and data was openly available to the public. For this reason, we have created on the UiT Septentrio Academic Publishing website the CAGE report series where we have archived key reports, results, and information on how to navigate the CAGE geospatial database.

The CAGE Database

The CAGE database plays an important Undoubtedly, one of the key factors contributing to our success at CAGE has been our access to state-of-the-art technologies and research vessels for scientific expeditions. Since 2013, CAGE has carried out 68 multidisciplinary expeditions for both research and education, covering over 150,000 km in more than 800 days onboard three research vessel: 1) *R/V Helmer Hanssen*, owned by UiT The Arctic University of Norway; 2) *R/V Kronprins Haakon*, owned by the Norwegian Polar Institute; 3) *R/V G.O. Sars,* owned by the University of Bergen.

These expeditions resulted in extensive datasets, including more than 50 terabytes of raw data, hundreds of thousands of pictures and videos, and thousands of sub-seabed, seabed, water, sea ice, oil, and air samples collected at more than 3300 sampling stations. This massive mobilisation brought all this data and material to offices, laboratories, and storage facilities, enabling us to carry our extraordinary groundwork that underpinned and boosted our scientific output. As a result, we have published over 450 peer-reviewed articles in recognised international journals that have been cited more than 9,500 times, produced more than 70 reports, and achieved over 1,700 media results, all of which have helped to increase CAGE's visibility and impact in the scientific community and beyond.

Septentrio Academic Publishing

CAGE now has an active and complete report series (CAGE – Centre for Arctic Gas Hydrate, Environment and Climate Report Series) on UiT's Septentrio Academic Publishing website, which is a service for open access publishing provided and owned by the UiT library. This project has been crucial for promoting and preserving the CAGE legacy, and has taken nearly two years to complete. The project has gone through several phases, including fine-tuning the publishing workflow and ensuring web content accessibility for impaired users and in the end we are proud that the final result is an easily navigable webpage (https://septentrio.uit.no/index.php/cage) with three distinct sections.

The first section, located under 'Issue Archive', is the core of the CAGE Report Series website. It contains an overview, organized by year, of all CAGE annual and cruise reports that are readily available for download. Metadata and keywords are included to ensure that each report is easily searchable online, and the licensing information provided states the rights to reuse of the documents.

The second section of this webpage is distributed among several tabs under the 'Archives' section and mainly focuses on results, including publications, PhD theses, and scientific communication. Each record registered is equipped with a link to the source, possibly a source opened to the public.

The third section is located beneath the 'About' section in the report series page and includes tabs for: 'Personnel', which includes information on CAGE personnel active between 2013-2023; and 'Database', which is an entry point for the CAGE's Geospatial Database.

Geospatial database

CAGE's geospatial database is an interactive map-based interface that is easily navigable by all users that contains an overview of all CAGE scientific expeditions, including the ship tracks, types of surveys and sampling sites. This map can be accessed through the 'Database' page on the Septentrio CAGE Report Series (https://septentrio.uit.no/index.php/cage/database), which is designed to prepare the users to access and navigate through the geospatial database map. It provides various information, such as a link to the map, instructions for operating and downloading the database metadata, and useful contacts, should the user require additional assistance or access to the data.

The interactive map is hosted on a separate service than Septentrio and once accessed, the 'Layer manager' button acts as a table of contents, providing an overview of all surveys/scientific expeditions carried out by CAGE. In addition, to CAGE expeditions, it is also possible to see information about the core repository database, which is maintained by the Department of Geosciences at UiT.

The geospatial database has played an important role in the Centre's open data strategy. Originally developed as an internal resource, it allowed researchers to get a quick overview of what type of data was already collected within different geographical areas. Now, it is available to everyone globally without any restrictions. Additionally, Septentrio has increased the visibility of the database through its ability to promote keywords on the web.

The CAGE Geospatial Database can be found on the CAGE report series website: https://septentrio.uit.no/index.php/cage/database. Screenshot: Fabio Sarti

Node 7 being deployed from Kronprins Håkon. Photo: Guosong Zhang

The CAGE Toolbox: Combining technology, innovation and research

The success of CAGE has been built upon the integration of world-class empirical and numerical methods and innovative technologies – from drones to icebreakers - to study gas hydrates in Arctic environments and methane as a potential driver of future climate change.

From drones to icebreakers, to state-of-the-art laboratories and models, the CAGE toolbox was used to find the controlling mechanisms for build-up and release of Arctic submarine gas hydrate systems, and how methane release from sub-sea-floor reservoirs has influenced Arctic and global climate. With access to the new icebreaker *R/V Konprins Haakon* (KPH), this toolbox has been applied in permanently ice-covered regions, allowing for new discoveries on potential amplifiers for global change, including methane release from thawing submarine gas hydrates and diminishing sea ice.

Research Vessels

Research Vessels *Kronprins Haakon* and *Helmer Hanssen*

Equipped with a moonpool and dynamic positioning, KPH can deploy large equipment like ROV, AUV and seafloor rigs. The vessel is based in Tromsø, officially owned by the Norwegian Polar Institute, run by the Institute of Marine Research, and largely used by UiT. UiT's *R/V Helmer Hanssen* is regularly used to explore areas with less harsh ice conditions or areas where we are not in need of dynamic positioning. An overview of the CAGE cruises between 2017-2023 can be found on pages 38-41.

Hardware

Birds-eye view using drones

The Mavic 2 pro DJI drone (RO1 pilot License), equipped with a Sentera near - infrared (NIR) sensor is used to map sea ice and terrestrial methane seeps. One goal is to examine whether the red and NIR band can prove useful for mapping variations in ocean cover: From open water, to grease ice – thin, soupy layer of ice which makes the ocean surface resemble an oil slick; as well as from grey young ice to first and multi-year ice. The drone is also used to examine the terrestrial gas seep sites that we are exploring on Svalbard.

Streamer depth-steering system

CAGE recently expanded its capabilities for seismic acquisition by obtaining a streamer depth-steering system. These so–called streamer birds provide depth control for the 2D seismic streamer and allow us to extend its length resulting in bandwidth stability and higher fold improving S/N-ratio. CAGE seismic expeditions in 2020 used these streamer birds for the first time, allowing tripling the streamer length with significant improvements for seismic imaging quality.

Heat flow probe

Estimation of the thermal state of the lithosphere is one of the most challenging topics in Earth Sciences today. The heat flow probe, acquired in 2020 measures the geothermal gradient and thermal conductivity of the sediments. It will add significant value to our understanding of gas hydrate and fluid flow systems and provide constraints for the numerical modelling. It was successfully used for the first time on a KPH cruise in 2020 for systematically measuring heat flux cross Vestnesa Ridge west of Svalbard.

Ocean observatories

The Ocean observatories (K-Landers) developed in a collaboration between Kongsberg Maritime and CAGE were deployed and recovered five 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 us 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

CAGE developed a towed video-camera system through collaboration with WHOI (Woods Hole Oceanographic Institution). 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 leakage sites in the Barents Sea since 2017.

ROV ÆGIR 6000

ROV ÆGIR 6000 is a remotely operated vehicle (ROV). 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 can cary 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. CAGE use of Ægir has resulted in many interesting publications.

4D seismic using P-cable

CAGE uses UiT's national infrastructure P-cable high-resolution 3D seismic system, which CAGE scientists have been involved in developing. Studies of gas hydrates, shallow gas and geological structures in sediments near the seafloor are ideal targets for this system. By repeated P-cable data collection of the same study area over multiple years, we can monitor spatial and temporal variations (4D) of fluid flow in the sediments. The unprecedented resolution of the P-cable seismic provides a unique opportunity to investigate the processes and drivers that regulate past and present gas hydrate, fluid flow systems and methane seepage.

LoVe Ocean Observatory

LoVe Ocean Observatory makes it possible to constantly and in real-time monitor the ocean off the coast of the Norwegian archipelago Lofoten and Vesterålen throughout the seasons. CAGE is involved in the development and implementation of node 7 which is placed near an area of substantial methane seepage, close to cold water coral reefs. The observatory will provide long-term, real-time observations of methane seepage from the ocean floor 270 meters below the surface.

Laboratories

National facility for stable isotope analyses

CAGE has established a stable isotope laboratory, equipped with a MAT 253 Isotope Ratio Mass Spectrometer. The laboratory is an integral part of our paleoclimatic, oceanographic, geobiological and carbon cycling research, and is a part of the national infrastructure FARLAB (Norway's national facility for advanced isotopic research).

Fully automated palaeomagnetic laboratory

CAGE partner, the Norwegian Geological Survey (NGU), has installed a fully automated 2 G Cryogenic Magnetometer in Trondheim. This provides the ability to analyse changes in the polarity, intensity and direction of the geomagnetic field of the Earth over the past millions of years. It also provides a powerful means to trace variations in methane seepage in the sub-seafloor sediments over timescale of millions of years.

ICOM Laboratory

The establishment of Ice, Oceans and CliMate (ICOM) is a cross disciplinary effort by UiT scientists from the Centre of Excellence CAGE at The Faculty of Science and Technology, and The Faculty of Biosciences, Fisheries and Economics. ICOM is designed to conduct low temperature advanced and cutting-edge experimental research on biogeochemical cycles from ice to ocean. The laboratory is expected to lead to breakthroughs in Arctic microbial ecology knowledge, and with changing cold temperature regimes, pinpoint the changing relationships among microbes and activity. ICOM is closely related to another TFS funded project – Cells in the cold.

ARCLIM

The ARCLIM (the Arctic Ocean under warm climates) project has established a culturing lab for marine calcifiers in 2021 at UiT. The lab is equipped with incubators with photoperiodic and temperature control that allow to run culturing experiments down to freezing temperatures at variable light intensities and cycles, two inverted light microscopes with various fluorescent filters, and digital meters for measuring water salinity, dissolved oxygen and carbonate chemistry. The lab is uniquely tailored to culture polar and subpolar planktic foraminifera to establish robust methods for reconstructing past ocean changes in the (sub) polar regions as well as to study the response/impact of polar planktic foraminifera growth and calcification to ongoing climate and ocean changes.

Virtual research cruise

Produced by students and researchers from AKMA project, CAGE and UiT, the VR cruise on-board the R/V Kronprins Haakon can be explored both online through the web browser (can be easily accessed through the AKMA Project website) or with a virtual reality headset, allowing users around the world to experience a research cruise to the Arctic. A total of 10 virtual reality headsets are available for schools to borrow, and they have already ventured around Europe allowing students from several schools in Italy, Norway, and France explore the R/V Kronprins Haakon and virtual cruise

Numerial models

Numerical ice sheet modelling

CAGE developed a high-resolution, 3D reconstruction of the last 120.000 years of glacial cycles 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, subglacial temperature-pressure conditions and sea-level changes.

Numerical gas-hydrate modelling

CAGE developed an integrated gas hydrate stability model coupled with glacial (subglacial temperature-pressure conditions) and isostatic effects but also accounting for changes in sea-level, sedimentation, erosion and paleo temperatures in order to study the spatial and temporal dynamics, processes and feedbacks of gas hydrate systems and methane release in many of the seepage systems on the Barents-Svalbard Margin.

M2PG1 (Marine 2-phase gas model in 1 dimension)

M2PG1 (Marine 2-phase gas model in 1 dimension) is a numerical model meant to better understand the fate of methane emanating from the seafloor. It models bubble size spectra and gas species simultaneously in a finite volume space. This allows for direct coupling with ambient dissolved gases and conditions such as temperature, salinity and turbulence.

Response time correction for membrane sensors

A predicable and reliable method was developed for correcting slow sensor response signal inherent to equilibrium extraction technique that suffers from limited response time, from minutes up to over one hour. This ground-breaking method allows a more reliable measurement of methane in the water and is applicable to other sensors relying on diffusion processes.

Luis Lamar, the director of photography at National Geographic and Avatar Alliance Foundation, diving into the ice-covered Arctic Ocean. R/V Kronprins Haakon in the background. Photo: Robin Hjertenes.

CAGE cruises (2017-2023)

Since 2013, CAGE has completed 68 multidisciplinary expeditions using state-of-the-art instrumentation and research vessels, such as *R/V Kronprins Håkon*, *R/V Helmer Hanssen*, and *R/V G.O.Sars*, to investigate the role of gas hydrates in Arctic areas.

R/V Kronprins Håkon

2018

CAGE18-5: *Remotely-operated vehicle (ROV) investigations of active gas seepage sites in the Barents Sea.* Chief scientist: Stefan Bünz
Cruise Report: https://doi.org/10.7557/cage.6853

2019

CAGE19-3: *Calypso giant piston coring in the Atlantic-Arctic gateway – Investigation of continental margin development and effect of tectonic stress on methane release.*
Chief scientist: Stefan Bünz
Cruise Report: https://doi.org/10.7557/cage.6911

HACON RV Kronprins Håkon
(cruise no. 2019708).
Chief scientists: Stefan Bünz
and Eva Ramirez-Llodra
Cruise Report: https://doi.org/10.7557/cage.6779

2020

CAGE20-6: *Pore-fluid pressure and heat flow surveys along the Vestnesa Ridge, west-Svalbard continental margin.*
Chief scientist: Andreia Plaza-Faverola
Cruise Report: https://doi.org/10.7557/cage.6918

CAGE20-7: *Sediment and water column analyses around flares at Norskebanken, Hinlopen and offshore Prins Karls Forland.*
Chief scientist: Bénédicte Ferré
Cruise Report: https://doi.org/10.7557/cage.6916

CAGE20-8: *Natural gas seepage and past sea ice variability on the NE Greenland margin.*
Chief scientist: Jochen Knies
Cruise Report: https://doi.org/10.7557/cage.6917

2021

CAGE21-1: AKMA-AKER-GReAT.
Chief scientists: Stefan Bünz
and Giuliana Panieri
Cruise Report: https://doi.org/10.7557/cage.6677

Hot Vents in an Ice-Covered Ocean —HACON21 *expedition.*
Chief scientists: Stefan Bünz
and Eva Ramirez-Llodra
Cruise Report: https://doi.org/10.7557/cage.6715

CAGE21-5: *Test of offshore instrumentation for in-situ sediment pressure measurements, west-Svalbard continental margin.*
Chief scientist: Andreia Plaza-Faverola
Cruise Report: https://doi.org/10.7557/cage.6721

2022

CAGE22-2: *AKMA 2/Ocean Senses.*
Chief scientists: Giuliana Panieri and Stefan Bünz
Cruise Report: https://doi.org/10.7557/cage.6755

CAGE22-3: *EMAN7 cruise.*
Chief scientist: Bénédicte Ferré
Cruise Report: https://doi.org/10.7557/cage.6760

R/V Helmer Hanssen

2017

CAGE17-1-Leg1: *Water column observation from CTD and water samples west of Prins Karls Forland, Svalbard.*
Chief scientists: Tine L. Rasmussen
and Helge Niemann
Cruise Report: https://doi.org/10.7557/cage.6941

CAGE17-1-Leg2
Chief scientists: Tine L. Rasmussen,
Tove Nielsen, Troels Laier
Cruise Report: https://doi.org/10.7557/cage.6954

CAGE17-2: *Gas hydrate deposits and methane seepages in Storfjordrenna, Northern Flank of Olga Basin, and West Sentralbanken (Barents Sea): Biogeochemical and biological investigations.*
Chief scientist: Giuliana Panieri
Cruise Report: https://doi.org/10.7557/cage.6955

CAGE-17-3
Chief scientist: Stefan Bünz
Cruise Report: https://doi.org/10.7557/cage.6952

CAGE17-4: *Recovery of observatory and water column survey offshore Svalbard.*
Chief scientist: Bénédicte Ferré
Cruise Report: https://doi.org/10.7557/cage.6953

CAGE17-5: *Marine Geophysical Cruise to the Yermak Plateau and western Svalbard continental margin.*
Chief scientist: Karin Andreassen
Cruise Report: https://doi.org/10.7557/cage.6946

2018

CAGE18-1: *Marine Geophysical Cruise to Storbanken and Olga Basin in the Barents Sea.*
Chief scientist: Andreia Plaza-Faverola
Cruise Report: https://doi.org/10.7557/cage.6846

CAGE18-2: *LoVe site – exploration around node 7.*
Chief scientist: Bénédicte Ferré
Cruise Report: https://doi.org/10.7557/cage.6770

CAGE18-3: *Cruise to the Barents Sea, Storfjorden Trough, East Greenland Ridge (Leg 1, 2), Arctic Ocean Vestnesa Ridge, and PKF, (Leg 3).*
Chief scientists: Tine L. Rasmussen and Tove Nielsen
Cruise Report: https://doi.org/10.7557/cage.6849

CAGE-18-4
Chief scientist: Stefan Bünz
Cruise Report: https://doi.org/10.7557/cage.6850

CAGE18-6: *AMGG Cruise to the northern and eastern Svalbard margin.*
Chief scientists: Jan Sverre Laberg and Tine L. Rasmussen
Cruise Report: https://doi.org/10.7557/cage.6854

2019

CAGE19-1: *Passive and active ocean-bottom seismic surveys at Vestnesa Ridge, west-Svalbard margin within the framework of the SEAMSTRESS project.*
Chief scientist: Stefan Bünz
Cruise Report: https://doi.org/10.7557/cage.6909

CAGE19-2: *Hunting gas flares and launching seafloor observatory.*
Chief scientist: Karin Andreassen
Cruise Report: https://doi.org/10.7557/cage.6910

AMGG Cruise: *to the northern Svalbard Margin and the Yermak Plateau.*
Chief scientists: Tom Arne Rydningen and Amando Lasabuda
Cruise Report: https://doi.org/10.7557/cage.6942

2020

CAGE20-1: *K-lander recovery and water column survey offshore Svalbard and in the Barents Sea.*
Chief scientist: Bénédicte Ferré
Cruise Report: https://doi.org/10.7557/cage.6912

CAGE20-2: *Hunting flares in Hopendjupet and glacigenic sediments in Sentralbankrenna.*
Chief scientist: Henry Patton
Cruise Report: https://doi.org/10.7557/cage.6745

CAGE20-3: *Geochemical and Sedimentological Investigation into Ingøydjupet, Håkon Mosby Mud Volcano and the Sorvestnaget Sand Waves.*
Chief scientists: Kate Waghorn, Malin Waage, Claudio Argentino
Cruise Report: https://doi.org/10.7557/cage.6913

CAGE20-4: *High-resolution 2D and 3D seismic investigations on the Møre and Vøring Margins.*
Chief scientist: Stefan Bünz
Cruise Report: https://doi.org/10.7557/cage.6752

CAGE20-5: *Tectonic stress studies and seismic surveys on the West-Svalbard margin.*
Chief scientist: Stefan Bünz
Cruise Report: https://doi.org/10.7557/cage.6914

CAGE20-WORM: *CAGE Worm-cruise to outer Kvalsund collecting tubeworms and sediment for eDNA and aDNA.*
Chief scientist: Tine L. Rasmussen
Cruise Report: https://doi.org/10.7557/cage.6915

2021

CAGE21-2: *Planktic foraminifera sampling for culturing experiments, central Greenland Sea 75°N.*
Chief scientists: Mohamed Ezat, Tine L. Rasmussen, and Julie Meilland
Cruise Report: https://doi.org/10.7557/cage.6714

CAGE21-3: *Ocean bottom seismics and acoustic surveys on the West-Svalbard margin – a study of local seismicity and its effect on methane seepage.*
Chief scientist: Andreia Plaza-Faverola
Cruise Report: https://doi.org/10.7557/cage.6722

CAGE21-4: *Oil slicks, gas flares and glacial landforms in Hopendjupet and Sentralbanken.*
Chief scientist: Monica Winsborrow
Cruise Report: https://doi.org/10.7557/cage.6703

2022

CAGE22-1: *Environmental geochemistry and seafloor characterization of Repparfjord, Kvalsund, Northern Norway.*
Chief scientist: Claudio Argentino
Cruise Report: https://doi.org/10.7557/cage.6753

CAGE-ARCLIM cruise: *Culturing (sub)Arctic planktic foraminifera Neogloboquadrina pachyderma and Globigerina bulloides: Implications for ocean acidification and paleoceanography reconstructions.*
Chief scientists: Mohamed Ezat, Julie Meilland, Adele Westgård, Tom Chalk, Freya Sykes
Cruise Report: https://doi.org/10.7557/cage.6768

CAGE22-5: *High-resolution 2D and 3D seismic investigations on the Vøring Margin.*
Chief scientist: Stefan Bünz
Cruise Report: https://doi.org/10.7557/cage.6776

CAGE22-6: *GEO-3144/8144 Teaching Cruise: Geologically controlled hydrocarbon seepage in Hopendjupet and the wider Barents Sea.*
Chief scientists: Pavel Serov and Henry Patton
Cruise Report: https://doi.org/10.7557/cage.6769

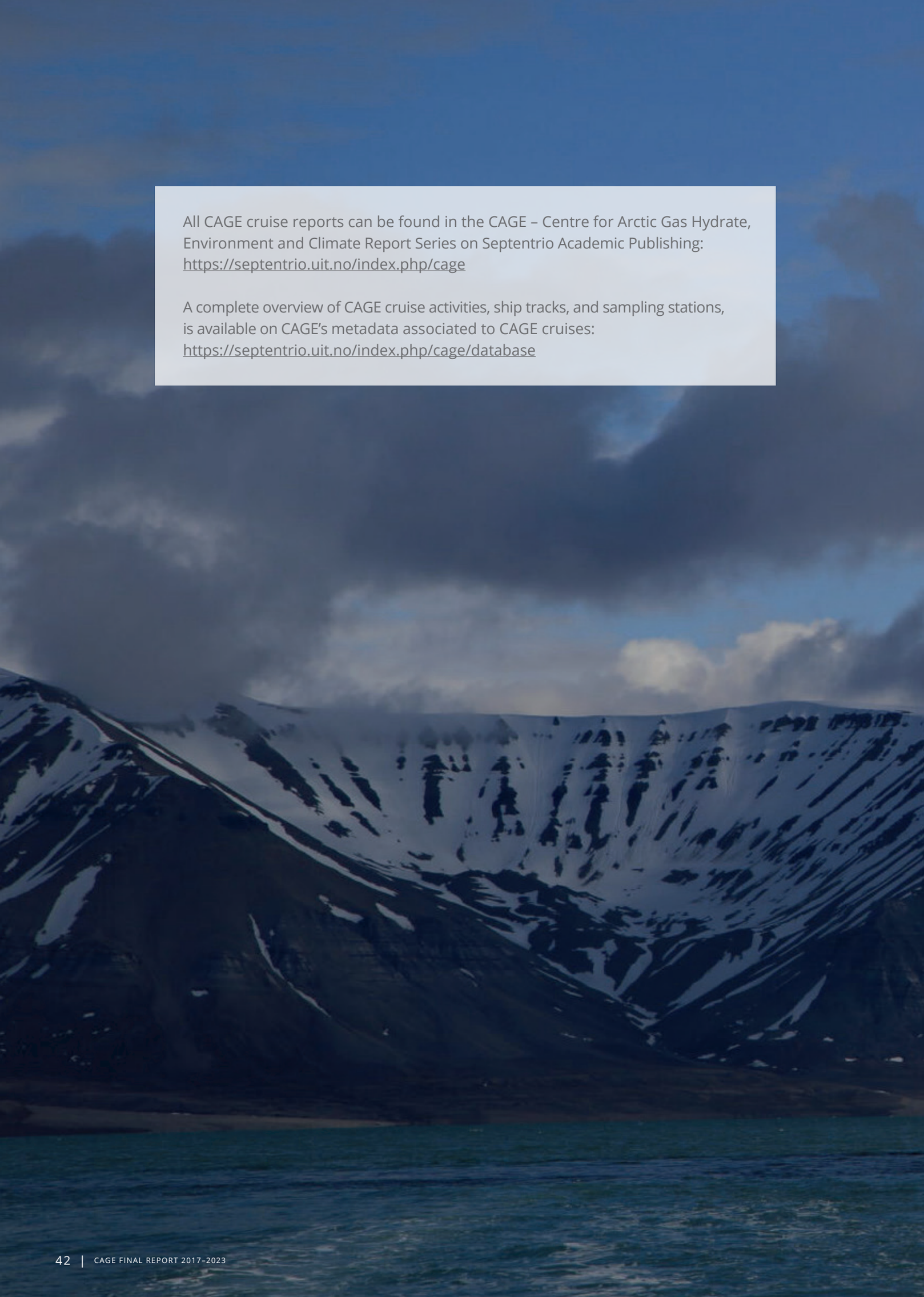
R/V G.O. Sars

2020

CAGE20-0: *From Seep to Source – Lofoten Canyons and PL998 license.*
Chief scientist: Jochen Knies
Cruise Report: https://doi.org/10.7557/cage.6741

2021

CAGE21-6: *Hydrocarbon leakage in Hopendjupet, central Barents Sea.*
Chief scientists: Monica Winsborrow and Jochen Knies
Cruise Report: https://doi.org/10.7557/cage.6675



All CAGE cruise reports can be found in the CAGE – Centre for Arctic Gas Hydrate, Environment and Climate Report Series on Septentrio Academic Publishing: https://septentrio.uit.no/index.php/cage

A complete overview of CAGE cruise activities, ship tracks, and sampling stations, is available on CAGE's metadata associated to CAGE cruises: https://septentrio.uit.no/index.php/cage/database

R/V Helmer Hanssen. Photo: Randall Hyman.

Selected Publications 2017–2023

Between 2013-2023, CAGE scientists published 465 publications in peer-reviewed journals and made 33 book contributions, collaborating with over 3500 scientists from over 40 countries globally. Below we highlight 25 publications that have made the largest impact so far

Andersen, J.L., Margreth, A., Fredin, O., Linge, H., Goodfellow, B.W., Faust, J.C., Knies, J., Solbakk, T., Brook, E.J., Scheiber, T., van der Lelij, R., Burki, V.J., Rubensdotter, B.L.E.F., Himmler, T., Yesilyurt, S., Christl, M., Vockenhuber, C., Akcar, N. (2021) *Rapid post-glacial bedrock weathering in coastal Norway. Geomorphology,* 2021 (0169-555X) 397 (108003) p. 1-19. IF: 4.139

Alexandropoulou, N., Winsborrow, M., Andreassen, K., Plaza-Faverola, A., Dessandier, P.-A., Mattingsdal, R., Baeten, N., & Knies, J. (2021). A Continuous Seismostratigraphic Framework for the Western Svalbard-Barents Sea Margin Over the Last 2.7 Ma: *Implications for the Late Cenozoic Glacial History of the Svalbard-Barents Sea Ice Sheet. Frontiers in Earth Science, 9. https://doi.org/10.3389/feart.2021.656732*

Andreassen, K., Hubbard, A., Winsborrow, M., Patton, H., Vadakkepuliyambatta, S., Plaza-Faverola, A., Gudlaugsson, E., Serov, P., Deryabin, A., Mattingsdal, R., Mienert, J., & Bünz, S. (2017). *Massive blow-out craters formed by hydrate-controlled methane expulsion from the Arctic seafloor. Science, 356(6341), 948–953. https://doi.org/10.1126/science.aal4500*

Carrier, V., Svenning, M. M., Gründger, F., Niemann, H., Dessandier, P.-A., Panieri, G., & Kalenitchenko, D. (2020). *The Impact of Methane on Microbial Communities at Marine Arctic Gas Hydrate Bearing Sediment. Frontiers in Microbiology, 11, 1932. https://doi.org/10.3389/fmicb.2020.01932*

Dessandier, P.-A., Knies, J., Plaza-Faverola, A., Labrousse, C., Renoult, M., & Panieri, G. (2021). *Ice-sheet melt drove methane emissions in the Arctic during the last two interglacials. Geology, 49(7), 799–803. https://doi.org/10.1130/G48580.1*

Dølven, K. O., Ferré, B., Silyakova, A., Jansson, P., Linke, P., & Moser, M. (2022). *Autonomous methane seep site monitoring offshore western Svalbard: Hourly to seasonal variability and associated oceanographic parameters. Ocean Science, 18(1), 233–254. https://doi.org/10.5194/os-18-233-2022*

Dølven, K. O., Vierinen, J., Grilli, R., Triest, J., & Ferré, B. (2022). *Response time correction of slow-response sensor data by deconvolution of the growth-law equation. Geoscientific Instrumentation, Methods and Data Systems, 11(2), 293–306. https://doi.org/10.5194/gi-11-293-2022*

El bani Altuna, N., Rasmussen, T. L., Ezat, M. M., Vadakkepuliyambatta, S., Groeneveld, J., & Greaves, M. (2021). *Deglacial bottom water warming intensified Arctic methane seepage in the NW Barents Sea. Communications Earth & Environment, 2(1), Article 1. https://doi.org/10.1038/s43247-021-00264-x*

Ezat, M. M., Rasmussen, T. L., Hönisch, B., Groeneveld, J., & deMenocal, P. (2017). *Episodic release of CO2 from the high-latitude North Atlantic Ocean during the last 135 kyr. Nature Communications, 8(1), Article 1. https://doi.org/10.1038/ncomms14498*

Ferré, B., Jansson, P. G., Moser, M., Serov, P., Portnov, A., Graves, C. A., Panieri, G., Gründger, F., Berndt, C., Lehmann, M. F., & Niemann, H. (2020). *Reduced methane seepage from Arctic sediments during cold bottom-water conditions. Nature Geoscience, 13(2), Article 2. https://doi.org/10.1038/s41561-019-0515-3*

Gründger, F., Carrier, V., Svenning, M. M., Panieri, G., Vonnahme, T. R., Klasek, S., & Niemann, H. (2019). *Methane-fuelled biofilms predominantly composed of methanotrophic ANME-1 in Arctic gas hydrate-related sediments. Scientific Reports, 9(1), Article 1. https://doi.org/10.1038/s41598-019-46209-5*

Gründger, F., Probandt, D., Knittel, K., Carrier, V., Kalenitchenko, D., Silyakova, A., Serov, P., Ferré, B., Svenning, M. M., & Niemann, H. (2021). *Seasonal shifts of microbial methane oxidation in Arctic shelf waters above gas seeps. Limnology and Oceanography, 66(5), 1896–1914. https://doi.org/10.1002/lno.11731*

Himmler, T., Sahy, D., Martma, T., Bohrmann, G., Plaza-Faverola, A., Bünz, S., Condon, D. J., Knies, J., & Lepland, A. (2019). *A 160,000-year-old history of tectonically controlled methane seepage in the Arctic. Science Advances, 5(8), eaaw1450. https://doi.org/10.1126/sciadv.aaw1450*

Knies, J., Daszinnies, M., Plaza-Faverola, A., Chand, S., Sylta, Ø., Bünz, S., Johnson, J. E., Mattingsdal, R., & Mienert, J. (2018). *Modelling persistent methane seepage offshore western Svalbard since early Pleistocene. Marine and Petroleum Geology, 91, 800–811. https://doi.org/10.1016/j.marpetgeo.2018.01.020*

Larkin, C. S., Ezat, M. M., Roberts, N. L., Bauch, H. A., Spielhagen, R. F., Noormets, R., Polyak, L., Moreton, S. G., Rasmussen, T. L., Sarnthein, M., Tipper, E. T., & Piotrowski, A. M. (2022). *Active Nordic Seas deep-water formation during the last glacial maximum. Nature Geoscience, 15(11), Article 11. https://doi.org/10.1038/s41561-022-01050-w*

Melaniuk, K., Sztybor, K., Treude, T., Sommer, S., & Rasmussen, T. L. (2022). *Influence of methane seepage on isotopic signatures in living deep-sea benthic foraminifera, 79° N. Scientific Reports, 12(1), Article 1. https://doi.org/10.1038/s41598-022-05175-1*

Patton, H., Hubbard, A., Heyman, J., Alexandropoulou, N., Lasabuda, A. P. E., Stroeven, A. P., Hall, A. M., Winsborrow, M., Sugden, D. E., Kleman, J., & Andreassen, K. (2022). *The extreme yet transient nature of glacial erosion. Nature Communications, 13(1), Article 1. https://doi.org/10.1038/s41467-022-35072-0*

Panieri, G., Knies, J., Vadakkepuliyambatta, S., Lee, A.L, Schubert, C.J. *Evidence of Arctic methane emissions across the mid-Pleistocene. Accepted in Nature Communications Earth & Environment.*

Ritzmann, O., & Jokat, W. (2003). *Crustal structure of northwestern Svalbard and the adjacent Yermak Plateau: Evidence for Oligocene detachment tectonics and non-volcanic breakup. Geophysical Journal International, 152(1), 139–159. https://doi.org/10.1046/j.1365-246X.2003.01836.x*

Sen, A., Didriksen, A., Hourdez, S., Svenning, M. M., & Rasmussen, T. L. (2020). *Frenulate siboglinids at high Arctic methane seeps and insight into high latitude frenulate distribution. Ecology and Evolution, 10(3), 1339–1351. https://doi.org/10.1002/ece3.5988*

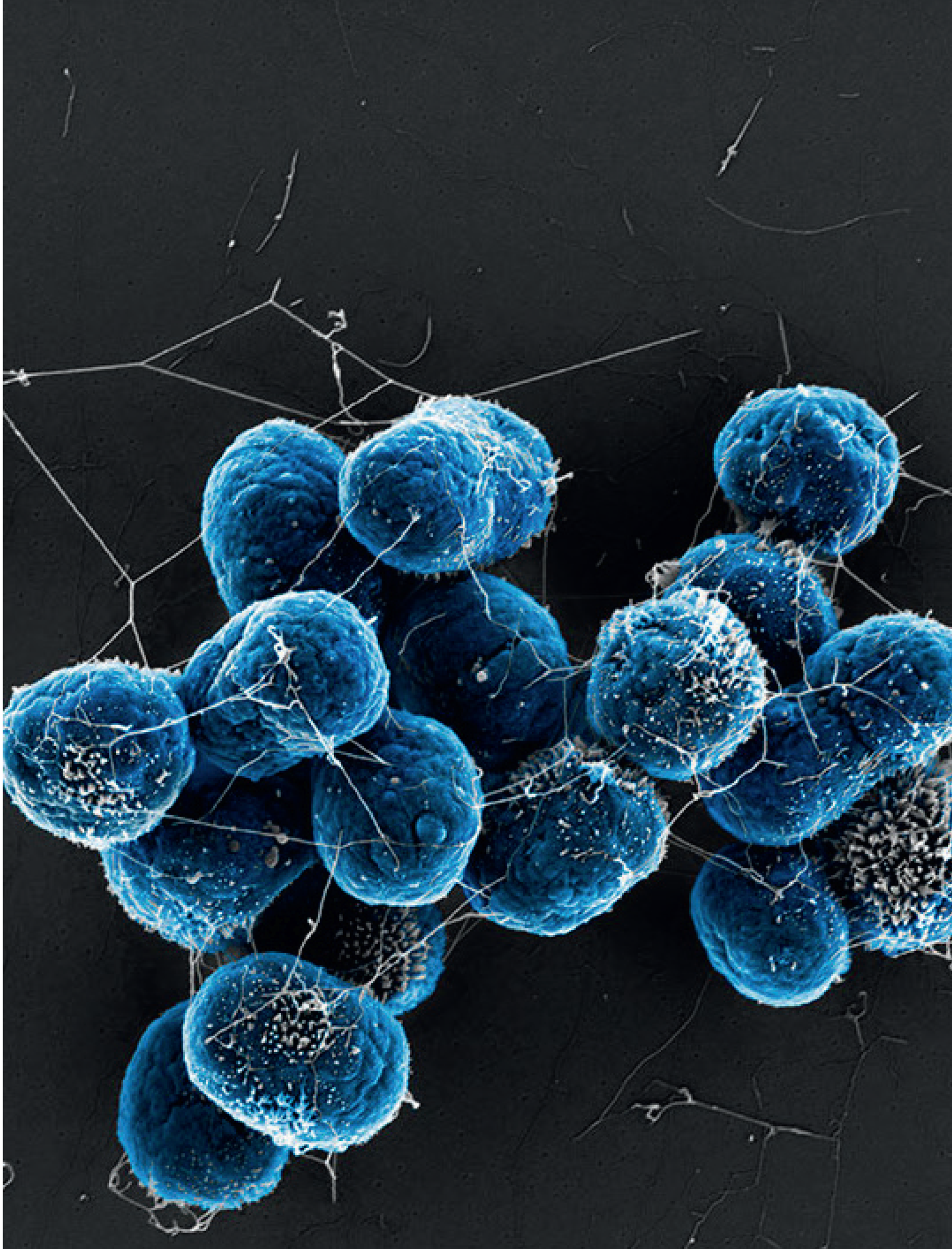
Serov, P., Mattingsdal, R., Winsborrow, M., Patton, H. and Andreassen, K. *Widespread natural methane and oil leakage from sub-marine Arctic reservoirs. Accepted in Nature Communications.*

Sert, M. F., D'Andrilli, J., Gründger, F., Niemann, H., Granskog, M. A., Pavlov, A. K., Ferré, B., & Silyakova, A. (2020). *Compositional Differences in Dissolved Organic Matter Between Arctic Cold Seeps Versus Non-Seep Sites at the Svalbard Continental Margin and the Barents Sea. Frontiers in Earth Science, 8. https://doi.org/10.3389/feart.2020.552731*

Singhroha, S., Bünz, S., Plaza-Faverola, A., & Chand, S. (2020). *Detection of Gas Hydrates in Faults Using Azimuthal Seismic Velocity Analysis, Vestnesa Ridge, W-Svalbard Margin. Journal of Geophysical Research: Solid Earth, 125(2), e2019JB017949. https://doi.org/10.1029/2019JB017949*

Sultan, N., Plaza-Faverola, A., Vadakkepuliyambatta, S., Buenz, S., & Knies, J. (2020). *Impact of tides and sea-level on deep-sea Arctic methane emissions. Nature Communications, 11(1), Article 1. https://doi.org/10.1038/s41467-020-18899-3*

Waage, M., Bünz, S., Landrø, M., Plaza-Faverola, A., & Waghorn, K. A. (2019). *Repeatability of high-resolution 3D seismic data. GEOPHYSICS, 84(1), B75–B94. https://doi.org/10.1190/geo2018-0099.1*

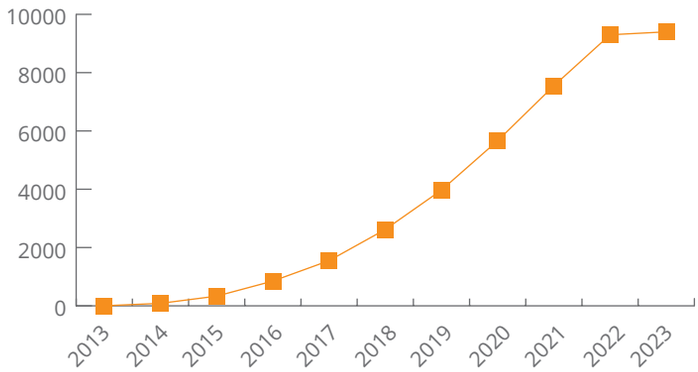


This image of the methane-oxidising bacterium, Methyloprofundus sedimenti, made the cover of The ISME Journal Volume 17 Issue 3 in 2023. Photo: Mette Marianne Svenning.

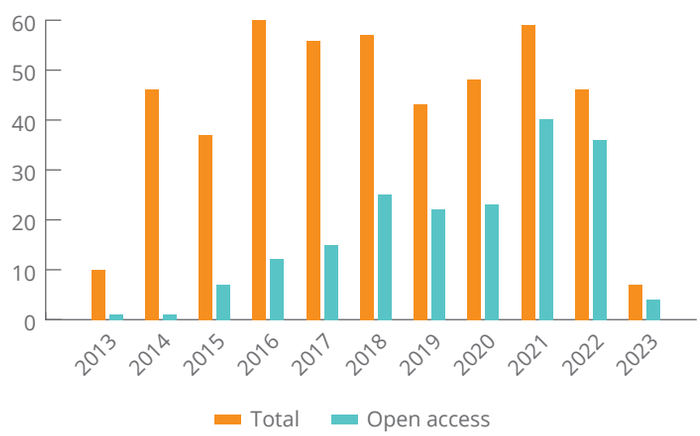
Subject area, publications
Source: Internal

- 65% Earth and Planetary Sciences
- 37% Environmental Science
- 22% Biological Sciences
- 22% Chemistry
- 15% Molecular Biology
- 13% Social Sciences
- 4% Microbiology
- 2% Multidisciplinary

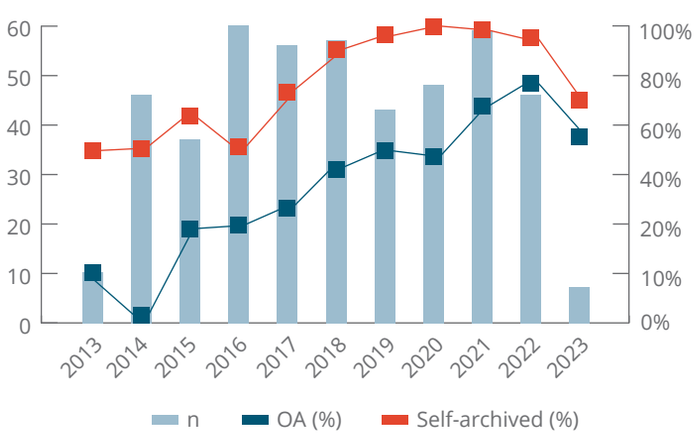
Citations
Source: Web of Science



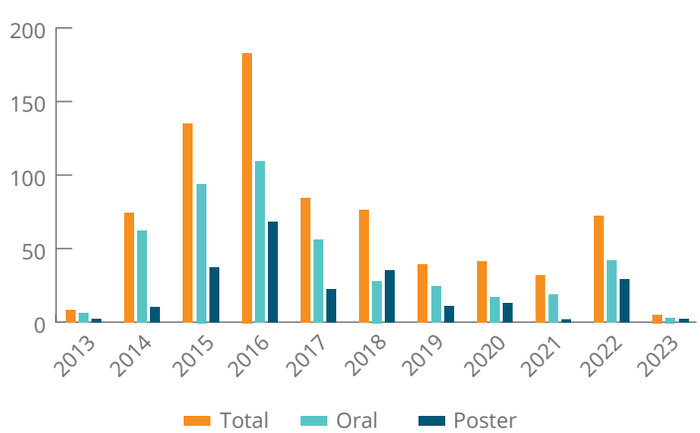
Publications and OA
Source: Cristin



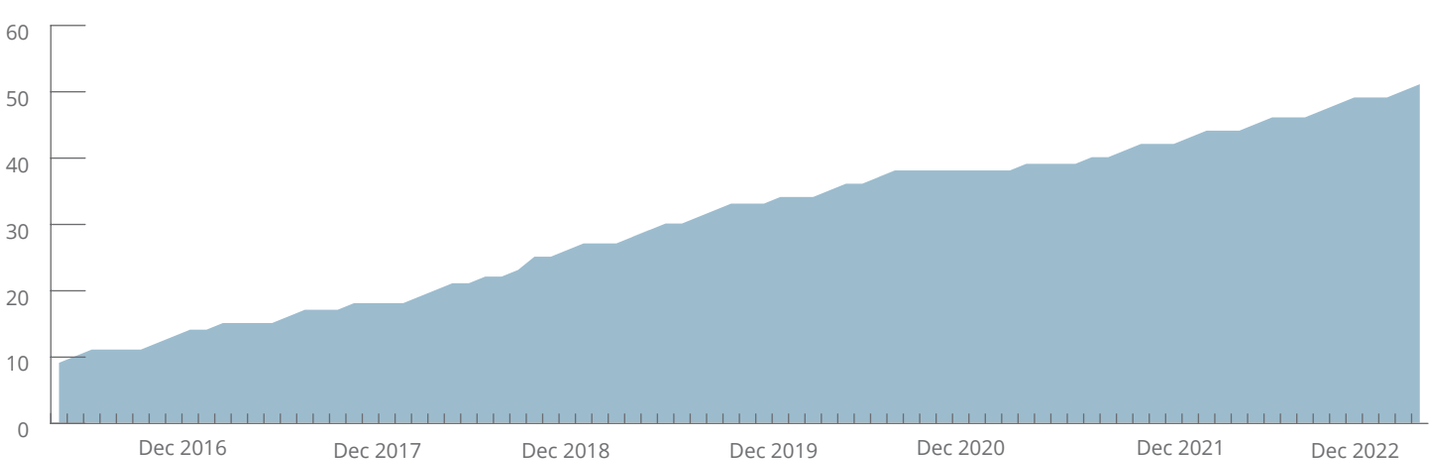
Publications, OA, Self-archiving
Source: Web of Science



Presentations
Source: Cristin



H-Index
Source: Web of Science

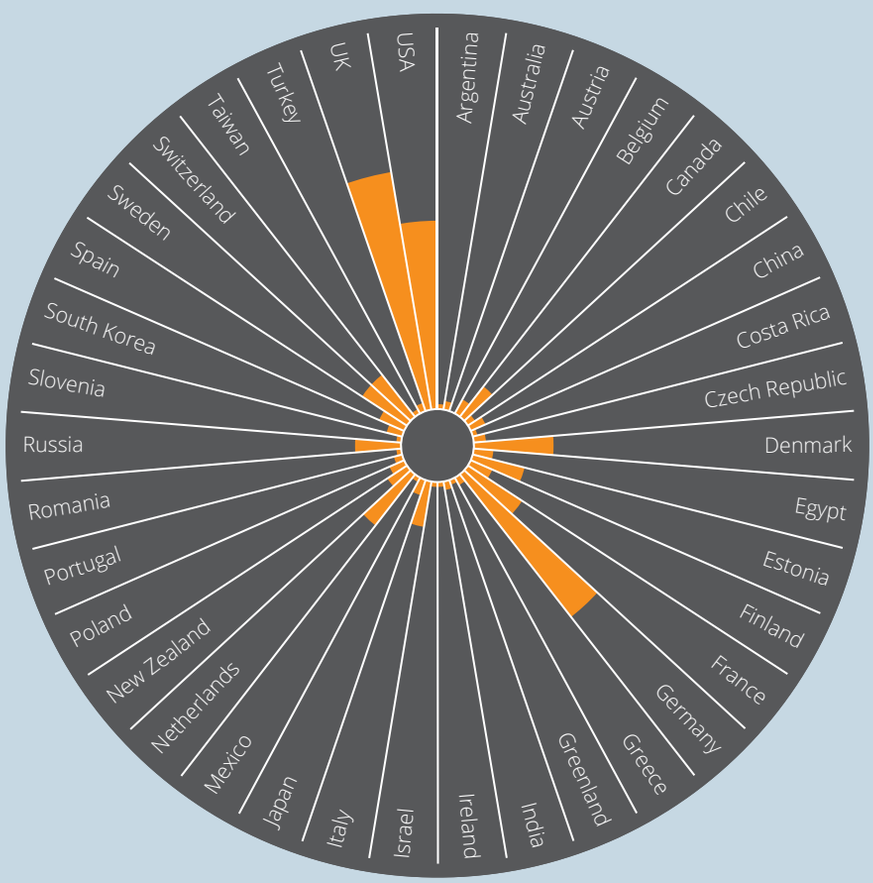


International collaborations 2013–2023

Our projects are connected with international scientific communities that are outlined as important collaborators by RCN and Norwegian Ministry of Foreign Affairs. We participate in EU projects and actions, as well as collaborate with institutions on other continents such as Woods Hole Oceanographic Institution in USA and NCAOR in India. In addition to that we collaborate on papers with relevant colleagues from all over the world.

International collaborations (2013–2023)

Source: Web of Science | Illustration: Torger Grytå; Julian P. Høgset



Overview of CAGE Personnel 2017–2023

We constantly work towards gender equality within our staff. Not only is the centre director a woman, but 4 of 6 work package leaders are women, and 6 of 8 of the administrative/technical staff members are also women. Our overall staff numbers show that we place importance to the subject, with 51% men and 49% women working for CAGE between 2017-2023. We also support young researchers – 52% of our staff are PhD Candidates and Postdoctoral Fellows, where 49% of these are women.

Administrative and technical staff

Lone Smelror,
Administrative Advisor

Mariana Esteves,
Project Leader (Admin. and Communications Coordinator)

Zeynep Sancak Sert,
Administrative Advisor

Tonje Winther,
Administrative coordinator

Maja Sojtaric,
Senior Communications advisor-

Jessica Green,
Communications Advisor (temp.)

Fabio Sarti,
Database manager

Matteus Lindgren,
Manager, Mass Spectrometer Laboratory

Senior scientists

Karin Andreassen,
Professor, Director CAGE

Stefan Bünz,
Professor, Leader WP1

Monica Winsborrow,
Associate Professor, Asst. Director, & Leader WP2

Mette Mariannne Svenning,
Professor, Leader WP3

Bénédicte Ferré,
Researcher, Leader WP4

Jochen Knies,
Researcher, Asst Director, Leader WP5

Tine Lander Rasmussen,
Professor, Leader WP6

Giuliana Panieri,
Professor

Jemma Wadham,
Professor

Alun Hubbard,
Professor 50%

Andreia Plaza-Faverola,
Associate Professor

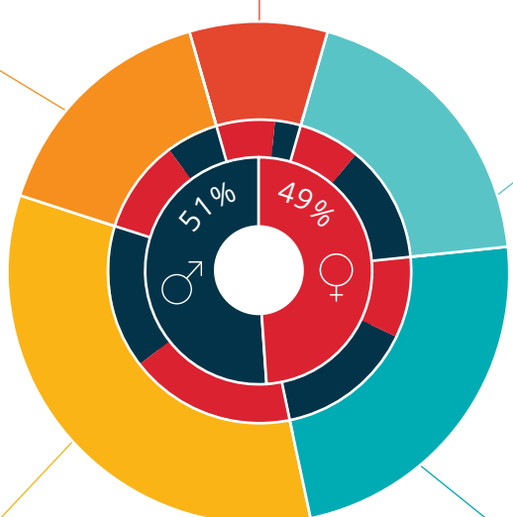
Helge Niemann,
Adjunct Professor

Renata Giulia Lucchi,
Adjunct Professor

Jürgen Mienert,
Professor Emeritus

Researchers

Aivo Lepland
Anna Silyakova
Cathrine Lund Myhre
Chiara Consolaro
Claudio Argentino
Denise Ruther
Dimitri Kalenitchenko
Henry Patton
Jean Baptiste Koehl
Karl Fabian
Katarzyna Zamelczyk
Mariana Esteves
Mohamed Ezat
Muhammed Fatih Sert
Pavel Serov
Peter Franek
Shyam Chand
Sunil Vadakkepuliyambatta
Sunny Singhroha
Terje Thorsnes
Wei Li Hong



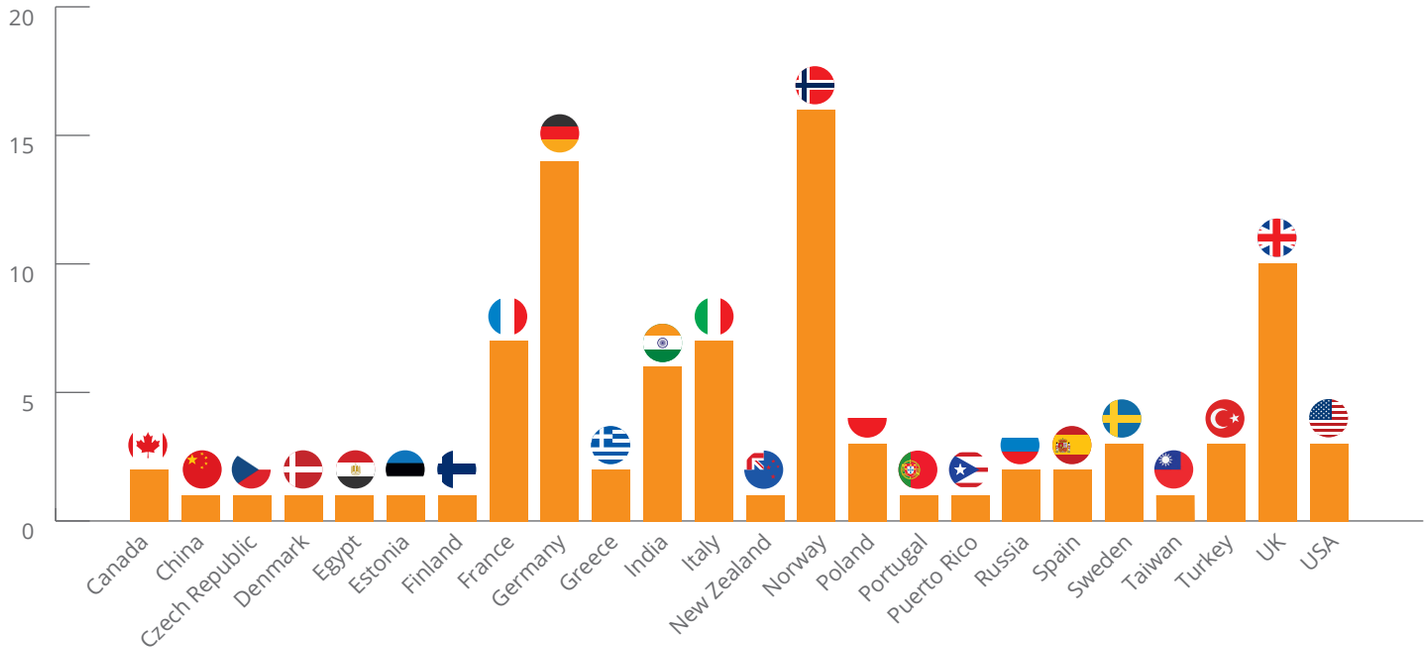
PhD candidates

Adele Westgård
Alexandros Tasianas
Andrea Schneider
Calvin Shackleton
Christine L. Ireland
Colin Sinclair
Cornelia M. Binde
Craig Hommock
Deniz Koseoglu
Emmelie Åström
Espen Valberg
Frances Ann Cooke
Frank Jakobsen
Freya Sykes
Giacomo Osti
Griselda Anglada Ortiz
Haoyi Yao
Henrik Henriksen Stokke
Kärt Paiste (prev. Üpraus)
Katarzyna Melaniuk
Leonard Magerl
Manuel Moser
Marie Stetzler
Mariana Esteves
Naima El bani Altuna
Nikolitsa Alexandropoulou
Pär Gunnar Jansson
Przemyslaw Domel
Siri Ofstad
Vincent Carrier

Postdoctoral Fellows

Arunima Sen
Friederike Gründger
Guillaume Lamarche-Gagnon
Hariharan Ramachandran
Johan Christoph Faust
Kate Waghorn
Knut Ola Dølven
Malin Waage
Mauro Pau
Naima El bani Altuna
Pierre-Antoine Dessandier
Rémi Vachon
Simone Sauer
Soma Baranwal
Thomas Chalk
Tobias Himmler
Tristan Vadsaria

Personnel by country



Nikolitsa Alexandropoulou
(2014-2021)

Karin Andreassen
(2013-2023)

Claudio Argentino
(2019-2023)

Emmelie Åström
(2014-2018)

Soma Baranwal
(2013-2019)

Cornelia Menzoni Binde
(2020-2023)

Stefan Bünz
(2013-2023)

Vincent Carrier
(2016-2022)

Thomas Chalk
(2021-2022)

Shyam Chand
(2013-2023)

Chiara Consolaro
(2019-2020)

Frances A. Cooke
(2019-2023)

Mariana Esteves
(2013-2023)

Pierre-Antoine Dessandier
(2017-2020)

Knut Ola Dølven
(2016-2023)

Przemyslaw Domel
(2019-2023)

Naima El bani Altuna
(2018-2023)

Mohamed Ezat
(2015-2023)

Karl Fabian
(2013-2019)

Johan Christoph Faust
(2018-2019)

Bénédicte Ferré
(2013-2023)

Peter Franek
(2015-2017)

Jessica Green
(2018-2019)

Jens Greinert
(2014-2017)

Friederike Gründger
(2013-2018)

Craig Hammock
(2019-2023)

Tobias Himmler
(2016-2020)

Wei Li Hong
(2014-2019)

Alun Hubbard
(2014-2023)

Frank Jakobsen
(2021-2023)

Pär Gunnar Jansson
(2014-2019)

Dimitri Kalenitchenko
(2018-2023)

Jochen Knies
(2013-2023)

Jean Baptiste Koehl
(2019-2019)

Deniz Koseoglu
(2015-2018)

Guillaume Lamarche-Gagnon
(2022-2023)

Aivo Lepland
(2013-2023)

Matteus Lindgren
(2015-2023)

Christine Lockwood-Ireland
(2020-2023)

Renata Giulia Lucchi
(2018-2021)

Cathrine Lund Myhre
(2013-2018)

Leonard Magerl
(2022-2023)

Katarzyna Melaniuk
(2015-2021)

Jürgen Mienert
(2013-2023)

Manuel Moser
(2017-2021)

Helge Niemann
(2015-2021)

Siri Ofstad
(2016-2021)

Griselda Anglada Ortiz
(2019-2023)

Giacomo Osti
(2013-2017)

Kärt Paiste (prev. Üpraus)
(2014-2018)

Giuliana Panieri
(2014-2023)

Henry Patton
(2013-2023)

Mauro Pau
(2020-2022)

Andreia Plaza-Faverola
(2013-2023)

Leonid Polyak
(2013-2017)

Hariharan Ramachandran
(2019-2022)

Tine L. Rasmussen
(2013-2023)

Denise Ruther
(2013-2019)

Zeynep Sancak Sert
(2022-2023)

Fabio Sarti
(2014-2023)

Simone Sauer
(2015-2019)

Andrea Schneider
(2014-2018)

Arunima Sen
(2016-2019)

Pavel Serov
(2013-2023)

Muhammed Fatih Sert
(2017-2023)

Calvin Shackleton
(2014-2019)

Anna Silyakova
(2013-2021)

Colin Sinclair
(2022-2023)

Sunny Singhroha
(2014-2022)

Lone Smelror
(2018-2022)

Maja Sojtaric
(2014-2021)

Marie Stetzler
(2020-2023)

Henrik H. Stokke
(2021-2023)

Mette M. Svenning
(2017-2023)

Freya Sykes
(2021-2023)

Alexandros Tasianas
(2014-2017)

Terje Thorsnes
(2013-2023)

Rémi Vachon
(2019-2022)

Sunil Vadakkepuliyambatta
(2013-2021)

Tristan Vadsaria
(2022-2023)

Espen Valberg
(2016-2018)

Malin Waage
(2015-2022)

Jemma Wadham
(2019-2023)

Kate Waghorn
(2014-2022)

Adele Westgård
(2021-2023)

Monica Winsborrow
(2014-2023)

Tonje Winther
(2015-2017)

Haoyi Yao
(2015-2020)

Katarzyna Zamelczyk
(2013-2018)

Professor Jemma Wadham and Associate Professor Monica Winsborrow will lead the new SFF iC3. Photo: Tomas Rolland/UiT.

Centre for ice, Cryosphere, Carbon and Climate (iC3)

New Centre of Excellence 2023–2033

About the project

Following tough competition, the Research Council of Norway announced in September 2022 that the Centre for ice, Cryosphere, Carbon and Climate (iC3) led by CAGE scientists, Professor Jemma Wadham and Associate Professor Monica Winsborrow, has been awarded funding through the prestigious SFF funding scheme. CAGE was awarded this same status in 2013, making iC3 the second SFF hosted by the Department of Geosciences, UiT The Arctic University of Norway.

By bringing together world leading experts, iC3 will work to reduce current high uncertainty in the impact of changing ice sheets on polar and global carbon cycles.

Ice sheets host one of the largest biologically-active terrestrial carbon pools on the planet, including ancient soils, lake/marine sediments and deep hydrocarbons buried beneath the ice. They also strongly influence how carbon is cycled through marine foodwebs via their discharge of meltwaters, and associated carbon and nutrients. Despite this, ice sheets are rarely included in global carbon budget assessments. iC3 will quantify carbon storage and cycling beneath present-day ice sheets and in ice-sheet influenced land fringes and oceans, helping us understand how future ice sheet melting may shape carbon cycles and important marine resources. This is essential knowledge for climate impact assessments (e.g. via IPCC) and for polar and global policy and leadership strategies.

iC3 framework and collaboration

Tackling this grand challenge requires expertise from many different scientific disciplines including glaciology, geology, microbiology, geochemistry and oceanography; and iC3 will unite world-leading experts from CAGE, UiT, Norwegian Polar Institute, NORCE and other institutions around the world. At the heart of iC3 is also an ambition is to cultivate and train a new generation of interdisciplinary polar scientists, who together will help engage politicians and the public regarding the importance of this field of research.

CAGE provided a strong foundation for iC3, both in terms of the scientific expertise built up over the 10 years and the invaluable experience of conducting science within the framework of the SFF scheme. However, scientifically there are notable differences. CAGE focused on the release of methane from the Arctic seafloor, and the environmental and climatic consequences of this. In contrast, iC3 will focus on the full spectrum of carbon-cryosphere interactions, from ice sheets to the ocean at both poles, including methane emissions from climatically-sensitive environments and future changes to marine foodwebs upon which human livelihoods depend. iC3 brings in valuable expertise in ocean ecosystem research and modelling from the Norwegian Polar Institute and in Earth system modelling from NORCE, who are partners in iC3.

iC3 will also benefit from world-leading Norwegian infrastructure such as research facilities and polar research vessels, that will enable investigation of carbon-cryosphere interactions across the entire ice-to-ocean domain, in both the Arctic and Antarctic.

NORCE

NORWEGIAN POLAR INSTITUTE

Funded by The Research Council of Norway

UiT The Arctic University of Norway

CAGE website:
cage.uit.no

CAGE Report Series:
septentrio.uit.no/index.php/cage/index

CAGE Database:
septentrio.uit.no/index.php/cage/database

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