Host Institution
UIT The Arctic University of Norway, Faculty of Science and Technology, Department of Geosciences

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WP1 - Prof. Jan Inge Faleide, UiO
WP2 - Assoc. Prof. Sten-Andreas Grundvåg, UiT, Assoc. Prof. Kim Senger, UNIS
WP3 - Adj. Prof. JoLynn Carroll, APN/UiT
WP4 - Prof. Tor Arne Johansen, UiB
WP5 - Prof. Jan Sverre Laberg and Assoc. Prof. Jasmine Nahrang, UiT

ARCEx Board members
Arne O. Smalås, UiT [Chair]
Salve Dahle, Akvaplan-niva AS
Harald Ellingsen, UNIS
Finn Roar Aamodt, Statoil
Geir Birger Larssen, Lundin
Terje Solheim, Aker BP
Kjetil Krathus-Larsen, OMV

Universities:
- UiT The Arctic University of Norway (UiT)
- Norwegian University of Science and Technology (NTNU)
- The University Centre in Svalbard (UNIS)
- University of Bergen (UiB)
- University of Oslo (UiO)
- University of Stavanger (UiS)

Research institutes:
- Akvaplan-niva AS (APN)
- International Research Institute of Stavanger AS [IRIS]
- Norges geologiske undersøkelse [NGU]
- Northern Research Institute AS [Norut]

Industry partners:
- Statoil ASA
- Eni Norge AS
- Aker BP ASA
- Lundin Norway AS
- OMV Norge AS
- Tullow Oil Norge AS
- Engie E&P Norge AS
- AS Norske Shell
- INEOS E&P Norge AS
Design and layout: Torger Grytø, Department of Geosciences, UiT. Cover photo: Gijs Henstra (UiB) investigating a sandstone outcrop in Wollaston Forland, northern East Greenland. The sandstones accumulated as deep-marine gravity flow deposits in a narrow rift basin that developed during the early stages of the North Atlantic break-up. Similar deposits also occur in several deep-marine rift basins in the subsurface of the SW Barents Shelf. Photo Sten-Andreas Grundvåg.

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ARCEx – a multi-disciplinary research centre

ARCEx consists of a complex research program covering complementary subject fields such as geology, environmental risk and technology. Education and training is an integrated part of ARCEx. ARCEx is subdivided into five interconnected work packages addressing different research objectives.

WP1 **Basin analysis:** to understand the regional geology and tectonic evolution in the Barents Sea region and to provide a better basis to assess the petroleum potential and reduce exploration risk in the north.

WP2 **Petroleum systems and play concepts:** to provide detailed knowledge on basin characteristics, summarised in detailed paleogeography reconstructions to improve prediction of the resource potential of the Arctic Basins.

WP3 **Environmental risk management:** to develop new environmental risk management approaches tailored to the unique exploration and future operational challenges for Arctic areas.

WP4 **Technology for eco-safe exploration in the Arctic:** to develop the best possible geophysical data acquisition strategies to use – both with respect to the environment and data quality.

WP5 **Education and outreach:** to offer international top-level petroleum geology, geophysics, biology and ecotoxicology education and to ensure that highly competent candidates will provide a pool of experts for the industry and academia.
In 2017 our focus was to consolidate ARCEX, and to perform research that was both relevant to our industry partners and of interest to the international research community. Through hard work and targeted activities, we raised the bar and produced more high-quality research than ever in the lifetime of ARCEX.

A major activity during 2017 was the preparation and execution of the midterm evaluation. We prepared and submitted all the required written documentation before the summer holidays, and the international expert evaluation panel and representatives from the Research Council of Norway visited ARCEX in September 2017. We keep our fingers crossed and hope for a positive outcome of the evaluation process.

We feel that ARCEX has come of age in 2017, and that the centre has gained the momentum it needs to have a significant impact on the international science scene. Simultaneously, we have continued our work to ensure that the research is relevant for our industry partners. As one can imagine, this is a delicate balancing act that we think we master by now.

It has been a pleasure and a joy to deal with everyone who works so hard to help us succeed. Without devoted employees, co-workers, collaborators and supporters, this work would have been impossible.

Alfred Hanssen
Professor/ARCEX Director

The Research Centre for Arctic Petroleum Exploration, ARCEX, has been a prominent NFR and industry funded national centre of research within the field of oil and gas for the last 5 years, just being mid-term evaluated by the research council. The centre has a holistic approach to the oil- and gas activity being both a research centre and a centre for education of Master’s and PhD students in close collaboration with research institutes and industrial partners.

The use of oil and gas for energy production is a field of controversy due to the climate footprint of fossil fuels. It is, however, political decisions to plan for this industry in the future. The strategy for the university, “Developing the High North”, as well as for ARCEX, is the focus on providing the best possible research results and the best possible candidates for the field of oil and gas exploration new models for environmental risk connected to operations in the Arctic area. This is of interest for Norwegian industry and for the field of oil and gas globally.

UiT is proud of ARCEX and will support the centre, eagerly waiting for their next step forward in research and education.

Anne Husebekk
Rector UiT

Foreword

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Anne Husebekk
Rector UiT
The team

ARCEx is a multi-disciplinary research centre, which is directly reflected in the wide range of competence fields among the researchers.

A partial list of the collection of competences in ARCEx is as follows:

- Geoscience: Basin analysis, tectonics, petroleum systems, sedimentology, glacial dynamics, lithosphere dynamics, structural geology, geophysics
- Technology: Numerical simulations, seismic imaging, rock physics, wave propagation, signal processing, data analysis, remote control, drone technology, measurements and remote sensing
- Environmental risk analysis: marine biology, ecotoxicology, environmental pollution biology, lab experiments, risk analysis

The ARCEx staff contributes in the teaching at all levels, from BSc to PhD, bringing relevant knowledge to the industry and public sector. By the end of the project, ARCEx will have funded 15 PhD students and 14 postdocs.
MANAGEMENT

Jan Inge Faleide
Professor, WP1 Leader, UiO

Jasmine Nahrgang
Associate Professor, WP5 leader, UiT

Ellen Ingeborg Haetta
Administrative Coordinator, UiT

Jan Inge Faleide
Professor, WP1 Leader, UiO

Kim Senger
Associate Professor, WP2 Leader, UNIS

JoLynn Carroll
Adjunct Professor, WP3 Leader, Akvaplan-niva

Tor Arne Johansen
Professor, WP4 Leader, UiB

Sten-Andreas Grundvåg
Associate Professor, WP2 Leader, Deputy leader, UiT

Iver Martens
Advisor, UiT

Stig-Morten Knutsen
Adjunct Professor, UiT/Norwegian Petroleum Directorate

Alfred Hanssen
ARCEX Director, Professor, UiT

Leanne Helen Cowie
Assoc. Postdoc, NFR/NORUSS, UiO

Project:
Supervisors: Jan Inge Faleide, UiO

Jan Sverre Laberg
Professor, WPS leader, UiT

Iver Martens
Advisor, UiT

Stig-Morten Knutsen
Adjunct Professor, UiT/Norwegian Petroleum Directorate

Leanne Helen Cowie
Assoc. Postdoc, NFR/NORUSS, UiO

Project:
Supervisors: Jan Inge Faleide, UiO
**Kjetil Indrevær**  
Postdoc, UiO  
Project: Tectonic inversion in the SW Barents Sea  
Supervisors: Jan Inge Faleide, UiO, and Roy H. Gabrielsen, UiO  
Period: 2015–2018

**Alexey Shulgin**  
Assoc. Postdoc, NFR BarPz project, UiO  
Supervisors: Jan Inge Faleide, UiO  
Period: 2015–2018

**Thomas Berg Kristensen**  
Assoc. Postdoc, Statoil, UiB  
Supervisor: Atle Rotevatn, UiB  
Period: 2014–2017

**Agnar Sivertsen**  
Research Fellow, Norut  
Project: Unmanned aerial systems for detection of sea ice and ice floes  
Supervisor: Rune Storvold, Norut  
Period: 2014–2018

**Kjetil Indrevær**  
Postdoc, UiO  
Project: Tectonic inversion in the SW Barents Sea  
Supervisors: Jan Inge Faleide, UiO, and Roy H. Gabrielsen, UiO  
Period: 2015–2018

**Eric Salomon**  
Postdoc, UiB  
Project: Structure and fluid flow evolution of basin bounding fault systems in rift basins  
Supervisor: Atle Rotevatn, UiB  
Period: 2017–2019

**Frederike Keitel-Gröner**  
Postdoc, IRIS  
Project: Arctic species sensitivity to petroleum discharges with special emphasis on the effects of mechanically and chemically dispersed oil  
Supervisors: Thierry Baussant, IRIS  
Period: 2018–2021

**Nathalie Morata**  
Postdoc, Akvaplan-niva  
Project: Impact of changes in environmental changes on benthic communities  
Supervisors: Paul E. Renaud, APN, and JoLynn Carroll, APN  
Period: 2015–2018

**Willy Reed**  
Adjunct Professor, (former ARCEx Postdoc), UiS  
Project: Application of risk and uncertainty concepts  
Supervisors: Roger Flage, UiS, and Terje Aven, UiS  

**Ingrid Wiedmann**  
Postdoc, UiT  
Project: Arctic pelagic ecosystems and vertical transport of organic carbon  
Supervisor: Paul Wassmann, UiT  
Period: 2016–2019

**Marcus Landschulze**  
Postdoc, UiB  
Project: Simulations of seismics on sea ice: comparison with field data  
Supervisor: Tor Arne Johansen, UiB  
Period: 2015–2017

**Kamaldeen O. Omosanya**  
Assoc. Postdoc, in-Kind, NTNU  
Project: Tectonic evolution and hydrocarbon prospectivity of the Barents and Norwegian Seas  
Supervisors: Ståle Emil Johansen, NTNU  
Period: 2015–2018

**Vikash Pandey**  
Assoc. Postdoc, Akademia, UiT  
Project: Cavitation noise generated by seismic sources: dynamics and mitigation  
Supervisor: Alfred Hanssen, UiT  
Period: 2017–2019
Tore Aadland  
PhD Fellow, UiB  
Project: Disentangling the time represented by siliciclastic sedimentary deposits  
Supervisor: William Helland-Hansen, UiB  
Period: 2014–2018

Muhammad Hassan  
PhD Fellow, UiO  
Project: Basin analysis and numerical modelling  
Supervisor: Jan Inge Faleide, UiO  
Period: 2018–2021

Amando Lasabuda  
PhD Fellow, UiT  
Project: The Cenozoic tectono-sedimentary development and erosion estimates for the Barents Sea continental margin, Norwegian Arctic  
Supervisors: Jan Sverre Laberg, UiT, and Stig-Morten Knutsen, NPD  
Period: 2015–2018

Tyler Appleyard  
PhD Fellow, UNIS  
Project: Sequence stratigraphy of U. Paleocene paralic wedges at Svalbard  
Supervisors: Snorre Olaussen, UNIS, William Helland-Hansen, UiB, and Sten-Andreas Grundvåg, UiT  
Period: 2016–2019

Thomas Birchall  
PhD Fellow, UNIS  
Project: Geological controls on pore pressure in exhumed basins  
Supervisors: Kim Senger, UNIS, and Jan Robert Eide, Statoil  
Period: 2017–2020

Dimitrios Ktenas  
Assoc. PhD fellow, EU FP7 Marie Curie ITN project GLANAM, UiT  
Project: Quantification of uplift and erosion using rock physics and compaction trends in shales  
Supervisors: Erik Henriksen & Tommy Samuelsberg, North Energy/UiT, Karin Andreassen, UiT  

Sigrun Kvendbø Hegstad  
Assoc. PhD fellow, Aker BP, UiT  
Project: XRF core scanning as an analytic tool applied on siliciclastic drill cores from the Barents Sea  
Supervisors: Matthias Forwick, UiT, Sten-Andreas Grundvåg, UiT, and Juha Ahokas, Aker BP  
Period: 2017–2020

Jean-Baptiste Koehl  
PhD Fellow, UiT  
Project: Onshore-offshore fault correlation of SW BS, Troms and Finnmark  
Supervisors: Steffen Bergh, UiT, and Jan Inge Faleide, UiO  
Period: 2015–2018

Maayke Jacqueline Koevoets  
Assoc. PhD fellow, in-kind, UiO  
Project: Upper Jurassic sediments and the invertebrate fauna of Spitsbergen, Svalbard  
Supervisors: Øyvind Hammer, UiO, and Snorre Olaussen, UNIS  
Period: 2014–2017

Aleskandra Anna Śmęrak-Sikora  
Assoc. PhD fellow, in-kind, UNIS  
Project: Fault characteristics and development of the Triassic basins of Svalbard and the Barents Shelf  
Supervisors: Alvar Braathen, UiO, and Snorre Olaussen, UNIS, Jan Inge Faleide, UiO, and Johan Leutscher, Eni Norge  
Period: 2013–2017

Mark Joseph Mulrooney  
Assoc. PhD fellow, in-kind, UNIS  
Project: Growth basin characterization and depositional setting in Svalbard and on the NW Barents Shelf; onshore – offshore link  
Supervisors: Snorre Olaussen, UNIS, Alvar Braathen, UiO/UNIS, William Helland-Hansen, UiB, and Jan Inge Faleide, UiO  
Period: 2013–2017

Malte Jochmann  
Assoc. PhD fellow, in-kind, UNIS  
Project: The regional geometry and sedimentology of the lower Paleogene basin in Svalbard and North East Greenland  
Supervisors: Maria Jensen, UNIS, Snorre Olaussen, UNIS, and William Helland-Hansen, UiB  
Period: 2015–2020

Jean-Baptiste Koehl  
PhD Fellow, UiT  
Project: Onshore-offshore fault correlation of SW BS, Troms and Finnmark  
Supervisors: Steffen Bergh, UiT, and Jan Inge Faleide, UiO  
Period: 2015–2018

Sigrun Kvendbø Hegstad  
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Period: 2017–2020

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Period: 2015–2018

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Period: 2014–2017

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Project: Growth basin characterization and depositional setting in Svalbard and on the NW Barents Shelf; onshore – offshore link  
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Period: 2013–2017

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Project: The regional geometry and sedimentology of the lower Paleogene basin in Svalbard and North East Greenland  
Supervisors: Maria Jensen, UNIS, Snorre Olaussen, UNIS, and William Helland-Hansen, UiB  
Period: 2015–2020
### PhD Students WP3

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Project</th>
<th>Supervisors</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fredrik Wesenlund</td>
<td>PhD Fellow, UiT</td>
<td>Project: Sedimentology and geochemistry of Triassic source rocks in the Barents Sea</td>
<td>Alfred Hanssen, UiT, Jon Halvard Pedersen, Lundin, Jon Erik Skeie, Aker BP, and Olaf Thielissen, Statoil</td>
<td>2018–2022</td>
</tr>
<tr>
<td>Ana Sofia Aniceto</td>
<td>PhD Fellow, Akvaplan-niva</td>
<td>Project: Unmanned aerial vehicles for marine mammal surveys</td>
<td>Martin Biuw, IMR, Ulf Lindstrøm, IMR, and JoLynn Carroll, APN/UiT</td>
<td>2014–2019</td>
</tr>
<tr>
<td>Ryan Dillon</td>
<td>PhD Fellow, Akvaplan-niva</td>
<td>Project: Modeling the behavior and movement of marine mammals</td>
<td>Martin Biuw, IMR, and JoLynn Carroll, APN/UiT</td>
<td>2015–2017</td>
</tr>
<tr>
<td>Babak Khodabandeloo</td>
<td>PhD Fellow, NTNU Norwegian University of Science and Technology</td>
<td>Project: Modeling and reduction of acoustic noise from seismic sources</td>
<td>Martin Landrø, NTNU</td>
<td>2015–2018</td>
</tr>
</tbody>
</table>

### PhD Students WP4

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Project</th>
<th>Supervisors</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rowan Romeyn</td>
<td>Assoc. PhD fellow, UiT in-kind, UiT</td>
<td>Project: Seismic studies in sea ice: A modelling and signal processing approach to wavefield separation</td>
<td>Alfred Hanssen, UiT, Tor Arne Johansen, UiB</td>
<td>2018–2022</td>
</tr>
<tr>
<td>Francesca Siracusa</td>
<td>Assoc. PhD fellow, UiT in-kind, UiT</td>
<td>Project: Geodynamics (isostasy and flexure of the lithosphere)</td>
<td>Alfred Hanssen, UiT, Andreia Plaza Faverola, UiT/SFF/EAGE</td>
<td>2018–2022</td>
</tr>
<tr>
<td>Terje Solbakken</td>
<td>PhD Fellow, NTNU</td>
<td>Project: Geophysical imaging of reservoirs with chemical weathering porosity</td>
<td>Philip Ringrose, NTNU/StatOil, and Christine Fichler, NTNU</td>
<td>2015–2018</td>
</tr>
<tr>
<td>Helene Meling Stemland</td>
<td>PhD Fellow, UiB</td>
<td>Project: Seismic analysis in Arctic environments</td>
<td>Tor Arne Johansen, UiB, Bent Øie Ruud, UiB, Leiv-J. Gellius, UiB</td>
<td>2017–2020</td>
</tr>
</tbody>
</table>

### PhD Students

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Project</th>
<th>Supervisors</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ronny Tammerbakke</td>
<td>PhD Fellow, UiB</td>
<td>Project: Sea ice and erosional uplift: impact on Arctic seismic exploration</td>
<td>Tor Arne Johansen, UiB, and Nils Bakke, Lundin</td>
<td>2015–2018</td>
</tr>
</tbody>
</table>
Selected scientific highlights
High-frequency noise from collapsing bubbles generated by air gun arrays
Underwater vapor cavities can be generated by acoustic stimulation. When the acoustic signals from several air guns are reflected from the sea surface, the pressure drop at some locations is sufficient for cavity growth and subsequent collapse. ARCEX scientists have numerically modeled the generation of multiple water vapor cavities and their collapses and the results are validated by comparing with field data from a seismic air gun array test. In a first modeling attempt where cavity interaction is neglected, a clear but qualitative correspondence between measured and modeled data is identified. An improved correspondence is derived by assuming that the acoustic signal generated by the other cavities changes the hydrostatic pressure surrounding each cavity. This modeling can be used to characterize the amount and strength of high-frequency signals generated by typical marine air gun arrays, given that a calibration step is performed prior to the modeling. (Khodabandeloo et al., 2017; Landro et al., 2017)

Drones for detection of marine mammals
Unmanned Aerial Vehicles (UAVs) have been proposed to be potentially useful for detection of marine mammals in their natural habitats, e.g. during marine operations in the Arctic. An important consideration and possible limitation is the associated uncertainties in animal detection. We have performed field trials using UAVs to carry out image-based monitoring of cetaceans in two fjords in Northern Norway. Through gathering data from twelve missions, we analysed images for animal presence and estimated its associated detection certainty. Images were also assessed for potentially important covariates such as wave turbulence (sea state), luminance, and glare. Aircraft variables such as altitude, pitch and roll were combined into a single variable – pixel size. We recorded a total of 50 humpback whales, 63 killer whales and 118 unidentified sightings. We also recorded 57 harbour porpoise sightings. None of the environmental conditions (sea state, glare and luminance) affected the detection certainty of harbour porpoises. In contrast, increasing sea state and luminance had negative and positive effects respectively, on the detection certainty of humpback and killer whales. The detection certainty was not significantly affected by pixel size for both harbour porpoises as well as humpback and killer whales. Our results indicate that at lower altitudes, variations in aircraft position (pitch and roll) do not have a variable effect on detection certainty. Overall, this study shows the importance of measuring variability in both environmental and flight-related variables, in order to attain unbiased estimates of detectability for UAV-based marine mammal surveys, particularly in Arctic and sub-Arctic regions. (Aniceto et al., 2018)

Sedimentology of the Lower Cretaceous at Kikutodden and Keilhaufjellet, Spitsbergen: implications for an onshore–offshore link
Detailed sedimentological investigations of the Lower Cretaceous succession of southernmost Spitsbergen indicate deposition during a long-term fall and rise in relative sea level. The Rurikfjellet Formation shows an overall regressive development and consists of offshore deposits grading upwards into progradationally stacked shoreface parasequences. The overlying Helvetiafjellet Formation shows a two-fold division reflecting an overall transgressive development. The lower Festningen Member represents a lateral extensive sandstone sheet that was deposited in a braid plain setting with sediment dispersal to the south-east. The unit also includes a lower Barremian subaerial unconformity at its base, demonstrating that uplift and shelf erosion also took place in southern Spitsbergen. Clinoforms observed in seismic data from, amongst others, the Lower Cretaceous in the western Bjarmeland Platform suggest a potential link between the onshore unconformity and the offshore clinoforms. The Festningen Member is capped by a coaly shale unit that represents an expansion surface which marks a change into a high-accommodation distributary fluvial system of the overlying and heterolithic Glitrefjellet Member. The overall transgressive development recorded in the Helvetiafjellet Formation eventually resulted in a marine flooding that eroded and drowned the delta plain depositing an offshore mudstone unit, 5–10 m in thickness, that marks the reestablishment of open marine shelf conditions in the basal part of the Carolinefjellet Member. The succeeding sand-rich part of the Carolinefjellet Formation contains abundant hummocky cross-stratified sandstones deposited in an inner shelf setting, and therefore represents renewed shoreline progradation onto the shallow subaqueous shelf. (Grundvåg and Olaussen, 2017)
Geology

The geology component of ARCEx is covered by work packages WP1 and WP2.

In WP1, integrated and multidisciplinary basin studies are carried out to provide a better basis to assess the petroleum potential and reduce exploration risk in the Barents Sea. The basin architecture and evolution are linked to deep structures and processes with emphasis on tectonic inversion, Cenozoic uplift and erosion, source-to-sink analyses, and numerical and analogue modeling.

The activity in WP2 focuses on petroleum systems and play concepts in the Barents Sea and adjacent basins of the northernmost Atlantic with an overarching goal of contributing with new data and concepts that may aid in exploration and resource potential estimates of this frontier province.

Based on the current status and results achieved within the first period of ARCEx (2013-2017), and results achieved from complementary projects, we have developed a more focused plan for the remaining part of ARCEx (starting from 2018). In this we merge WP1 and WP2 into one combined Geology work package (WP1+2) and define four main tasks we will focus on during the remaining 3 years (2018-2021) of ARCEx.

Associate Professor Sten-Andreas Grundvåg (UiT) will be leader of the combined WP1+2 (Geology) with Associate Professor Kim Senger (Unis) as co-leader. The WP1 leader in Phase 1, Professor Jan Inge Faleide (UiO) takes responsibility for the integration and synthesis task (Task 4) that will run through the entire Phase 2 ending with a final synthesis paper/report on WP1+2 activities at the closure of ARCEx in Fall 2021.

Objectives

- Provide a better basis to assess the petroleum potential and reduce exploration risk in the Barents Sea.
- Linking scales (both vertically and laterally), processes and offshore-onshore.
- Integrating and synthesizing results from ARCEx and complementary projects with focus on timing, causes and implications.
Tasks

Based on status and results achieved within ARCEX Phase 1 (2013–2018) and complementary projects, we have developed a more focused plan for Phase 2 of ARCEX (2018–2021). In this we merge Wp1 and Wp2 into one combined Geology work package (Wp1+2) and define four main tasks:

**Task 1: Basin analysis**
- Contraction/inversion structures: timing and causes
- Marginal basins
- Tectonic/basin modelling
- Cenozoic uplift and erosion: quantification and modelling
- Source-to-sink analysis

**Task 2: Petroleum system elements**
- Reservoir (characterisation/sedimentology/provenance)
- Source rocks
  - onshore–offshore samples, Triassic
- Trap/seal analysis
  - Onshore-offshore stratigraphy and tectonic links
  - Subsurface pressure (well data, Svalbard–Barents Sea)
  - Field studies (East Greenland and Finnmark)
    - faults and fractures: implications for basin formation and fluid flow
    - Comparative studies of selected cases in the Barents Sea

**Task 3: Quantitative analysis of petroleum systems and plays**
- Burial history – petroleum system modelling (Svalbard and Barents Sea)
- Identification of key input parameters, quantification of uncertainties, and sensitivity analysis

**Task 4: Integration and synthesis**
- Basin evolution (mainly Barents Sea – links to Svalbard and NE Greenland)
- Regional tectonostratigraphy: paleogeography and source-to-sink considerations
- Barents Sea petroleum systems – a review of geological exploration risks*

Relation to stakeholders

2017 was an active year for those involved in ARCEX Wp1+2. We have actively participated at several conferences and presented papers in a wide range of relevant topics. Some examples include Kim Senger’s “Review of geological controls on resistivity” presentation at the AAPG International Conference & Exhibition in London in October, providing the basis for better integration of CSEM and seismic data in exploration. In addition, we have contributed with presentations at several conferences and workshops such as the geological winter conference in Oslo in January (Faleide; Grundvåg; Helland-Hansen; Indreær), the Frontier Exploration workshop in Stavanger in June arranged by FORCE (Grundvåg), the TAS International Meeting of Sedimentologists in Toulouse (Helland-Hansen; Olaussen), the Circum-Arctic Structural Events (CASE) conference in Hannover in March (Faleide; Olaussen), and the annual NGU conference in Vienna in April (Lasabuda). In addition, we have contributed to key note lectures at the Arctic Days conference in Svolvær in May (e.g. Lasbuda presented the keynote lecture as a stand-in for Geissler). We have also been active in running conferences, with committee duties at the EAGE Rock Physics workshop in Abu Dhabi (Kim Senger) and at the Cenozoic uplift, erosion and deposition session at the Arctic Days conference in Svolvær (Jan Sverre Laberg; Sten-Andreas Grundvåg).

On the training front, ARCEX researchers from Wp1+2 were as always active in teaching at the various partner institutions, and supervising exciting MSC projects focusing on different aspects of petroleum geology of the Barents Shelf and Svalbard (e.g. Broze, 2017; Eikelmann, 2017; Festøy, 2017; Kalak, 2017).

We realise the importance of ongoing outreach activity and regularly publish updates on the ARCEX website. This is also an outreach arena where our PhD fellows and several of our MSC students are most active, and their contributions are highly welcomed. We also organized an Open Day at Unis to highlight some of the geological research to the population of Longyearbyen – our VR-based tours around the world proved to be a success!

Most of our fieldwork activity in 2017 have involved a wide range of partners, both from national (Unis, UiT, UiO, NTNU, UiB; NGU) and international research institutions (University of Utrecht; Vrije Universiteit), the government (NPD), as well as some of our industry partners (e.g. Aker BP; Statoil).
Fieldwork and data collection

Bjørnøya, summer 2017
**Purpose:** sample more source rock data
**Campaign leader:** Sten-Andreas Grundvåg, UNIS and Atle Mork, NTNU
**Collaborating partners:** NPD/UI/T/NGU/UNIS
**Duration:** 1 week

Storvola/Spitsbergen, July 2017
**Purpose:** Sample deep-water/turbidite reservoir elements for detailed grain-size analysis, porosity and permeability measurements
**Campaign leader:** Yvonne Spylacha, Utrecht and Sten-Andreas Grundvåg, UiT
**Collaborating partners:** UiT/University of Utrecht
**Duration:** 2 weeks

San Andreas field trip, February–March 2017
**Purpose:** The key objective of this project was to study a portion of the San Andreas fault to resolve the kinematics and stress regime that occurred in California. The tectonic reconstruction will then be compared to the sheared margin that formed between Greenland, Norway and Spitsbergen during the final stages of break-up of the NE Atlantic.
**Campaign leader:** Steffen Bergh, UiT
**Collaborating partners:** UiT, San Diego State Univ., Univ. California Santa Barbara
**Duration:** 2 weeks

Finnmark field trip, July 2017
**Purpose:** Complementary fieldwork to find field occurrences of the Langjord–Vargusand fault onshore NW Finnmark
**Campaign leader:** Jean-Baptiste Koehl, UiT
**Collaborating partners:** UiT
**Duration:** 3 days

Summer field campaigns throughout 2016–2017 in Nordenskiöld Land, Spitsbergen,
**Purpose:** Sedimentological investigation of the Hollendardalen Formation. The area represents deltaic progradation of two major clastic wedges around the Paleocene Eocene transition into the Central Tertiary Basin which is otherwise dominated by marine shales. Its relative timing of deposition is tentatively linked to the onset of compression-dominated transpression between Greenland and Svalbard associated with the northward propagation of sea-floor spreading in the North Atlantic, Labrador and Norwegian-Greenland Sea. This fieldwork involves a detailed facies analysis in order to better characterize the depositional environment in addition to a detrital zircon study that is currently ongoing to infer potential sources and/or major shifts in drainage areas. Selected samples are also being processed to extract potentially relevant biostatigraphic data in order to better constrain the timing and paleoenvironmental conditions during Hollendardalen deposition.
**Campaign leader:** Tyler Appleyard, UNIS
**Collaborating partners:** UNIS
**Duration:** Throughout summer seasons of 2016 and 2017

Sarstangen, Oscar II Land, western Spitsbergen, August 2017
**Purpose:** Structural and sedimentological characterization of Sarstangen. Niklas’ MSc project will include two field seasons at Sarstangen in western Spitsbergen to collect both structural and sedimentological data to better constrain the movement history along the basin’s bounding faults and evaluate the depositional environment of the exposed units. This work is envisioned to contribute to improving the understanding of the geological evolution of the Forlandsundet area, which is analogue to sheared basins along the Western Barents Shelf margin.
**Campaign leader:** Niklas Schaaf, and Per Terje Osmundsen, NGU
**Collaborating partners:** UNIS, UiO, NGU
**Duration:** 15 days

Agardhfjellet, September 2017
**Purpose:** Investigation of sand injectites in the Agardhfjellet Formation. Sub-vertical sandstone dykes have been identified within the shale dominated Agardhfjellet Formation. Palynological studies suggest that these sandstones originate from the overlying strata and represent fracture fill. Their structural position near the base of the Agardhfjellet Formation nonetheless suggests that these could also represent upward upward injected sandstone fluidized under pressure. In any case, the sandstones represent a potential seal by-pass system. In this reconnaissance campaign we aim to use drone-based mapping of the extent of the exposed sandstone dykes and sample them for further analyses at Uv: Amsterdam to better their composition and link it with under- and overlying successions.
**Campaign leader:** Kim Senger
**Collaborating partners:** UNIS, Vrije Universiteit, Amsterdam
**Duration:** 4 days

Western Spitsbergen and Edgeøya, August/September 2017
**Purpose:** Sample and log Triassic source rocks in western Spitsbergen (Festningen and Hornsund) and at Edgeøy.
**Campaign Leaders:** Sten-Andreas Grundvåg and Fredrik Wesenlund (UiT) and Snorre Olaussen (UNIS).
**Collaborating partners:** UiT; UNIS; Statoil.
**Duration:** 8 days.

Photos: Fredrik Wesenlund, UiT.
Environment

The exploration and development of resources in the Arctic is often characterized as involving a greater risk and severity of impacts to the environment relative to many other regions. This requires development of new environmental risk management approaches tailored to the unique exploration and future operational challenges for Arctic areas. The aim of the Environment component of the centre is to provide essential knowledge and methodology for exploration in the high north.

The industry needs to develop knowledge regarding key species and ecosystem interactions in an environment that has undergone rapid change (metrics of change), impacts of seismic operations on marine species (data and methods improvements), and monitoring, risk, and impact methods tailored for use in northern areas (methods and assessments).

The research performed in WP3 is producing new insight for industry:

- New knowledge and data on Arctic ecosystems and food webs
- New knowledge and data on the sensitivity of key species to petroleum discharges within northern ecosystems
- Priority areas and time periods for exploration activities in the north
- A theoretical risk uncertainty framework for the Arctic
- Recommended geophysical data acquisition strategies minimizing the impact on living organisms

Objectives

To develop new environmental risk management approaches tailored to the unique exploration and future operational challenges for Arctic areas.

For the three main topics within WP3, the following research goals have been defined:

- Ecosystems: to define food web linkages and the processes that regulate energy transfer through northern ecosystems
- Ecotoxicology: to assess the sensitivity of key species to petroleum compounds in northern ecosystems
- Impact and Risk Assessment methods: to improve monitoring, impact, and risk assessment tools and methods for applications in northern areas

Photo: Sten-Andreas Grundvåg, UiT.
Tasks

Task 1: What is the impact of pelagic productivity on the benthic ecosystem?
› Comparative analysis of benthic biomass and species composition gathered in 2016 ARCEX with historical baseline information.
› Controls of pelagic productivity (T1.1) on benthic ecosystem (T1.1)
› Sampling of benthic transect across the Barents Sea Polar Front during the 2018 ARCEX Training and Research Cruise.
› Analysis of benthic community structure across the Barents Sea Polar Front
› 30 year retrospective of changes in benthic communities across the Barents Sea Polar Front.

Task 2: What are the main drivers of the flux of marine biomass from surface to seafloor?
› Finalize analysis of composition and biomass of material collected in vertical traps during the 2016 ARCEX cruise.
› Compare material composition and biomass with historical baseline information (fjords of Svalbard and Marginal Ice Zone).

Task 3: What are the toxic effects of petroleum compounds on key species in the Barents Sea?
› Develop protocols for ecotoxicology experiments
› Develop more biologically relevant analysis methods to assess lethal and sub-lethal effects of petroleum compounds on key Arctic species
› Conduct experimental studies with oil exposure and dispersants on key Arctic species
› Synthesize and review species’ sensitivity to petroleum compounds on key species in the Barents Sea

Task 4: What are the risk-uncertainty relationships for the Arctic?
› Development of methods to identify health and safety events based on historical practices
› Application of an Arctic risk-uncertainty framework for operations under harsh environmental conditions (weather, ice, darkness)

Task 5: How can we improve research and monitoring of animals in remote marine areas?
› Analysis and synthesis of biological and ecological information on marine mammals to for the development of methods to minimize the impact of seismic activities (WP4)
› Optimize the detection uncertainty when using unmanned aerial vehicles for monitoring marine mammals
› Review and recommendations of autonomous vehicles for the detection and monitoring of marine fauna
› Software development of a processing algorithm for body condition of wild marine mammals

Relation to stakeholders

We develop and disseminate to users, stakeholders and research communities:

Contemporary data on food webs and ecosystem processes for comparison with historical baseline knowledge
- ecotoxicology data for a selection of key species from northern areas exposed to petroleum compounds with evaluation of species sensitivities
- effects of petroleum compounds on individual organisms and populations
- methods to assess safety and environmental risks associated with exploration and development activities in northern areas with applications
- methods and assessment of autonomous technology for monitoring marine mammals during seismic operations
- technology improvements for seismic recording equipment to reduce the impact on marine mammals (WP3/WP4)
- peer-reviewed articles with analysis and synthesis of research findings with applications

The work in WP3 ties together several of the topics within ARCEX:
- biological and ecological information on marine mammals to WP4 to minimize the impact of seismic activities (WP4)
- continuous updating of university courses with the latest information on ecosystems, ecotoxicology, and risk/impact methodologies for petroleum exploration and future resource development (WP5)
- training of early career-scientists through WP3 research and exchanges with industry (WP5)
Achievements/highlights 2017

New ecological data from the Barents Sea and Svalbard fjords: New data sets are being generated from the successful sampling campaign carried out during the ARCEX 2016 research cruise. These data sets are providing new knowledge of the linkages between surface and seafloor food webs in the Barents Sea and in the fjords of Svalbard.

Drones for marine mammal observations: a detailed evaluation of the current state of the art, field experiments, and simulation tests using autonomous aerial vehicles for marine mammal surveys has been completed. The results have led to improved protocols for the use of these vehicles in harsh environments and difficult to reach areas such as the Arctic.

Physiological effects of oil on Arctic key species: Through carefully controlled laboratory experiments, we have shown that polar cod (Boreogadus saida) exposed to dispersed oil and burned oil residue resulted in no long-term physiological effects.

Risk identification in the Arctic: System characteristics such as harsh weather, ice and darkness have been included in a new risk identification method custom tailored for Arctic conditions. The method is based on risk identification from more mature areas.

Fieldwork and data collection

Planning of ARCEX Cruise, August 2018

Location: Marginal Ice Zone/Barents Sea/Arctic Ocean, Svalbard

Purpose: In cooperation with the Arctic Gas Hydrate, Environment and Climate and the Arctic Marine Geology and Geophysics (AMGG), to reconstruct seafloor sediment burial histories in conjunction with environmental variations and the benthic communities. Student training in field-work is a central part of the cruise activities.
Technology

Geoscientific exploration in the Arctic will meet challenges partly different from those we know from exploration of the North Sea and the Norwegian Sea. We will develop the best possible geophysical data acquisition strategies – both with respect to the environment and the data quality – during initial exploration, and, subsequent static and dynamic reservoir characterization.

The first part of the WP4 work package has been devoted to plan and carry out a series of seismic experiments on and within floating ice in Van Mijenfjorden at Svalbard. Also several tests of unmanned remote sensing devices for recording ice drift in the Arctic have been made. Furthermore, experiments on studying effects of seismic shooting on sea mammals (true seals and whales) have been undertaken. This study has also opened for collaboration with WP5. The project has so far gathered a unique data base to use for answering the fundamental questions raised in the research proposal. A series of manuscripts from the first analyses of the data are about to be submitted to international journals. Our experimental data and science problems have already led to requests for international collaboration, among these with Stanford University in USA, Kyushu University in Japan and University of Jilin in China. Scientists from Iceland have also been involved in studies related to possible influence of air guns on large whales. Along with a suggestion from the industry sponsors, a study on how burial and uplift will affect the seismic signatures (reflected and refracted waves) of typical Barents Sea prospects have now been undertaken. This activity intersects with WP1/2 as geological processes are used to predict how geophysical properties evolve with the depth and time history of the main source and reservoir units in the Barents Sea.

The second phase of WP4 will focus on further analyzing the data acquired during the previous field campaigns and to complete field experiments in accordance with what these results bring forward. With the establishment of the Arctic Geophysical Data Laboratory in Svea, ARCEX has now access to a unique facility for performing a whole range of large scale experiments involving instrumentations at the sea bottom, in the water column and on ice. The laboratory will now be extended to include Ground Penetrating Radar (GPR) and in collaboration with the University of Jilin in China, to enable to perform Electro-Magnetic surveying. A larger effort on integration of electromagnetic and seismic data will be undertaken. Furthermore, research on unwanted high frequency noise caused by air guns due to cavitation will be specifically addressed. Experiments in Ny Ålesund, Svalbard, on use of drones for tracking ice drift to help optimizing the planning of survey lines during geophysical exploration will continue in 2018.

Objective

• Develop technology for eco-safe exploration in the Arctic.

Photo: Ronny Tammerbakke, UiB.
Tasks

Task 1: Constraints (technology and timing) for geophysical exploration in ecological vulnerable areas
   › Understand the mechanisms for unwanted high-frequency excitation of sound from marine airguns, and possible ways to reduce such effects

Task 2: Strategies for best possible seismic acquisition within and close to ice

Task 3: Acquisition and processing of seismic data from ice, snow and ice-covered land
   › How to remove unwanted vibrations in sea ice (flexural waves) from seismic data
   › Find the best ways to acquire seismic data in the transition from land onto ice-covered sea.
   › How to separate wave modes propagating within and below ice using 4c-data.
   › Understand how temperature (and melting) of frozen sediments affect their seismic properties

Task 4: Remote sensing technology in support of seismic operations within and close to sea ice
   › Automatization of detection of ice-drift in the Arctic using unmanned aircrafts.
   › Combined use of resistivity and acoustic data for enhanced reservoir prediction – rock physics models
   › Combined use of cSEM and seismic for enhanced reservoir prediction – case study

Task 5: Geophysical imaging of prospects and reservoirs from field analogues on Svalbard and Greenland
   › How seismic signatures of Barents Sea reservoirs can be related to burial and uplift
   › How karst systems can be seen in seismic data

Relation to stakeholders

The scientists from wp4 are very active in collaboration that directly involves both industry and international research partners. New research results are disseminated at international conferences and in international peer reviewed journals.

The majority of the PhD students from wp4 have co-supervisors from industry partners. Published papers are often co-authored between ARCEX personnel and industry collaborators.

At Svea, a large scale well-instrumented Arctic geophysical laboratory has been established as a collaboration between ARCEX, University of Bergen, UNIS, and several industry partners. The Arctic geophysical laboratory has become central to our advanced experimental investigations of seismics on, or in the vicinity of frozen surfaces. In addition, UNIS takes advantage of the Arctic geophysical laboratory for their Master’s/PhD-level course AG-335/835 Arctic Seismic Exploration.

Several projects within wp4 are conducted through collaboration with other work packages. As an example, research to unveil the seismic signatures of erosional uplift involves expertise both from geology and technology. Several projects involve scientists from the environmental work package. E.g., remote sensing of sea mammals by means of drone technology has led to interesting new results. Active field investigations of the impact of seismic sources on seals resting on ice are to our knowledge the first quantifiable results of this kind.
Achievements/highlights 2017

During the spring of 2017 two seismic field campaigns were successfully conducted, which led to a seismic line making a transition from land onto floating ice. Both explosives and airguns were used as sources while the seismic recording facilitated both 4 component nodes, placed at the sea bottom, hydrophones below the ice and geophones on top of the ice. The data comprise a unique data base to study data quality versus experimental set up. The analyses performed provide essential input for optimum survey planning in areas with floating ice. The field works also included a study to outline possible effects of seismic shooting on and below ice on true seals. This was conducted in collaboration with WP3.

Modeling and mitigation of ghost cavitation noise for seismic arrays: By building a mathematical model for ghost cavitation based on the classical Rayleigh-Plesset model, a remarkably good qualitative agreement between modelled and actual measurements has been achieved. This applies to key observables like the overall timing, the spectral content, and the qualitative shape of the signal envelope. The models are now at such a level that they can be used to tune the overall parameters of the seismic array such that the high-frequency ghost cavitation is significantly reduced.

Fieldwork and data collection

Ny-Ålesund Campaign on Svalbard, April 2017
Purpose: Real-time detection of sea ice from drones
Campaign leader: Rune Storvold, Agnar Sivertsen, Norut
Collaborating partners: Norut
Duration: 2 weeks

Husavik, Iceland, June 2017
Purpose: Acquire underwater acoustic signals generated by humpback and blue whales. Due to bad weather, we had only two days in the field. We did not observe any blue whales, but several humpback whales, and we got some registrations of communication signals between humpback whales.
Campaign leader: Martin Landrø, NTNU; Marianne Rasmussen, Univ.Iceland
Collaborating partners: University of Iceland in Husavik
Duration: 6 days

Field campaign #1 2017 in Svea, Feb 2017
Location: Outer part of Kjellstrømdalen, Braganzavågen and inner part of van Mijenfjorden
Purpose: Based on the experiences fra the 2016 campaign, make a large scale seismic survey starting at land and transecting into very shallow ice covered water using various configurations of seismic set ups. The campaign was very successful, a second phase of the experiment was initiated to take place late spring.
Campaign leader: Tor Arne Johansen, UiB
Collaborating partners: UiB, Eni
Duration: 16 days

Field campaign #2 2017 in Svea, May/June 2017
Location: Inner part of van Mijenfjorden, Kapp Amsterdam
Purpose: (1) To monitor effects of seismic surveying on nearby colonies of ringed seals together with PhD student Ana Sofia Aniceto from WP3.(2) To extend experiments from earlier 2017 into deeper water. The campaign was very successful and has provided a unique data base for the ongoing WP4-activities related to seismic within and close to ice-covered surfaces.
Campaign leader: Tor Arne Johansen, UiB
Collaborating partners: UiB, Eni, Akvaplan-niva, IMR
Duration: 12 days

Photos: Norut; Gregory Smith, www.flickr.com/photos/slobirdr/9660851285; Ronny Tømmerbakke, UiB.
The management group in the iEarth consortium. From left, Rie Hjørnegaard [UiO], Anders Matthias Lundmark [UiO], Jostein Bakke [UiB], Bjarte Hannisdal [UiB], Ivar Nordmo [UiB], Ranny Isaksson [UiB], Fredrik Wesenlund [UiT], Kjetil Indrevaer [UiO], Thomas Birchoit [UiS], Amanda Lasabuda [UiT], Ryan Dillon [APK], Ingrid Wiedmann [UiT], and Babak Khodabandeloo [NTNU].

The ARCEX Early Career Forum participants in Malangen in May 2017. From top left: Terje Solbak [NTNU], Jean-Baptiste Koehl [UiT], Malte Jochmann [UNIS], Ranny Isaksson [UiB], Fredrik Wesenlund [UiT], Kjetil Indrevaer [UiO], Thomas Birchoit [UiS], Amanda Lasabuda [UiT], Ryan Dillon [APK], Ingrid Wiedmann [UiT], and Babak Khodabandeloo [NTNU].
Education and Training

ARCEx has been able to maintain high student enrolment rates through a period of general decrease in petroleum related studies nationally.

Research training
ARCEx is presently supervising 13 PhD students and 7 postdocs through the four work packages. In addition, 12 associated PhD students and postdocs that are funded by other sources are involved in ARCEx research. The scientific training of the ARCEx research fellows has consisted of (1) specific focused training courses, organised at each PhD student’s home organisation, according to PhD plan, individual requirements and with relevance to the research projects undertaken by each PhD, (2) attendance and presentation of their research at international conferences (e.g. EGU, EAGE, AAPG, NGR, Arctic Science Summit, Arctic Frontiers), (3) participation in field work and cruises (e.g. a dedicated ARCEx cruise in 2016, several field work campaigns on Svalbard, Bjørnøya and mainland Norway), and (4) targeted training provided by supervisors.

The research schools
The ARCEx PhD students are part of the Petroleum Research School of Norway (nfrP; https://nfrp.no) which aims to provide education of petroleum researchers through coordination and collaboration between the Norwegian universities. ARCEx PhD students in geosciences are also enrolled in the Arctic Marine Geology and Geophysics PhD school (AMGG; https://amgg.uit.no/) that was established at UiT in 2005. The aim of AMGG is to train PhD students and young scientists in the field of arctic marine geology and geophysics. The Department of Geosciences at UiT The Arctic University of Norway is the host of the trainee school. Several cruises, courses and field excursions are arranged through the AMGG research school.
Similarly, our ARCEx PhD students in environmental sciences are enrolled in the Arctic Marine Ecosystem Research Network PhD school (ARCtOS) at UiT that provides an important research network, courses and fieldwork opportunities to its members.

ARCEx Early Career Forum
As a supplement to the national research schools, the ARCEx Early Career Forum (ECF) is an arena for the ARCEx PhD students and postdocs. The aims of the ECF is (1) to provide complementary skills, (2) to create an ARCEx identity for the young scientists and (3) to encourage cross-disciplinary collaboration. The young scientists organise the ECF themselves, and the gatherings are hosted at the different research partners’ locations. In 2017 the ECF was arranged in connection to the ARCEx annual conference in Malangen, 9-10 May 2017. A total of 13 PhD students and postdocs participated in the ECF meeting. The main focus of the ECF in May was professionalizing the graphical illustrations of complex research results, and a short course on photography.

Secondments
A plan for industrial secondments has been initiated and will be launched in 2018. We will have a close initiative to secure that PhD students receive a relevant practice within industry and institutions. This to both ensure industrial relevant technical challenges and work experience, but also to help them increase their network for the post-PhD period.

Master’s program
As of 2017, 18 students are taking their Master’s degree within ARCEx and will deliver their theses by the summer of 2018. The Master’s projects are linked to petroleum research in a variety of ways and supervision takes place across partner institutions. For instance, five of the mentioned Master candidates at UiT write their theses in cooperation with the Norwegian Petroleum Directorate (SPD), and receive frequent supervision from the SPD staff.

ARCEx has continued its work to develop custom tailored courses and high-quality study specializations both at UiT and UiBS.

The Master’s specialization in Petroleum Geosciences at UiT was launched in 2016 and has enrolled 13 Master candidates in the two-year long specialization. The portfolio of the specialization has also been revised to secure a relevant and modern education for the candidates. A new course in Petroleum Management (Geo 3120) is taught by external personnel from SPD, and was launched fall 2016 and has been running for the second time in fall 2017. This course has now been made mandatory to the students of the Petroleum Geosciences specialization at UiT.

At the Faculty of Biosciences, Fisheries and Economics (BFE), the Bachelor program in Environmental Management and Pollution Biology that started in 2014, is being revised to be merged with the Bachelor in Biology, Climate and the Environment. Our Bachelor program at BFE will thereby increase its student recruitment numbers and offer a broad and diverse course portfolio that will integrate ecotoxicology and climate dynamics in a common program. The Faculty is currently also revising its Master’s specializations and ARCEx is actively working to create an ecotoxicology specialization within the Master’s programme in Biology.

At UiBS, the course “Arctic Petroleum: Challenges for Society, Technology, and Environment” (AT333/833) has been taught for the second time in 2017, with a total of 12 Master students and 1 PhD candidate. The students came from 9 different countries (Canada, Germany, USA, Hong Kong, Denmark, Romania, Netherlands, Russia, and Norway) with seven female and six male students. A team of thirteen lecturers covered cross-disciplinary topics connected to petroleum in the Arctic, including petroleum governance, geology, geophysics, ecotoxicology and oil sensing technologies.

Center for Integrated Earth System Education
Finally, ARCEx staff is involved in the new consortium iEarth (Center for Integrated Earth System Education), a national consortium lead by UiB, also includingUiT, UiO and Unis. The consortium has a focus on excellence in education. The consortium has started a process to formulate a proposal for a new SFU (Center for Excellence in Education) in 2019. A full-time coordinator has recently been hired in Bergen, and all participating institutions are committed to the forthcoming proposal to NOKUT (the Norwegian Agency for Quality Assurance in Education).
ARCEX organized its Annual Conference in Malangen, 10–11 May 2017, with a program including all aspects of the broad spectrum of topics within ARCEX. The annual conference gathered approximately 50 participants from research partners, industry partners, authorities and invited guests to learn about the latest research results and ongoing activities.

The topics given by early career scientists and senior scientists within ARCEX included the latest updates on the formation of the Barents Sea, seismic surveying on and within ice, how marine mammals react on seismic activities, and the delicate balance between human activities and arctic marine ecosystems.

Two external invited speakers, Prof. Lars Stemmerik from the University of Copenhagen, and Dr. Lise Doksaeter Sivle, Institute of Marine Research, gave two very interesting talks. Stemmerik’s talk was titled “The Upper Paleozoic carbonate platforms of Spitsbergen and the Barents Shelf: facies, tectonics and link to climate”, giving ideas and input for further ARCEX research. Sivle presented in her talk titled “Do naval sonar disturb whales” research results from a project studying the sound signals travelling in water and their impact on marine mammal behaviour.

In addition to the oral presentations, the early career scientists hosted a poster session, inviting the participants to discuss project results and activities on a one-to-one basis.

As part of the social program this year, the guests were surprised with an intimate concert after the conference dinner. Roy Gabrielsen on electric guitar was the headliner of the band, and together with Alfred Hanssen on electric guitar, Atle Rotevatn on cowbell, and the local musician Jack Bjorkhaug on guitar and vocal, the group entertained the participants through the night.
Meet Adam
ARCEx geoscience student

Adam is a MSc student at the Department of Geosciences, UiT. His supervisors are Sten-Andres Grundvåg (UiT), Iver Martens (UiT), and Rune Mattingsdal (NPD).

After completing my Bachelor’s degree in geology at UiT, I continued with my Master’s studies, specializing in sedimentology. I am writing my thesis with ARCEx, in collaboration with the Norwegian Petroleum Directorate (NPD), Harstad. This collaboration has given me the opportunity to use my skills towards the petroleum industry. During the Master’s program, my fellow students and I visited the offices of Statoil and the NPD in Harstad, to learn how our university projects are put to use in the industry. This inspired me to write my Master’s thesis about the Lower Cretaceous stratigraphy in the Nordkapp Basin, Barents Sea. My work includes the use of 3D seismic data for large, regional study, and cores from the area for ground truthing. The Nordkapp Basin is characterized by salt structures, originally deposited during the Permian, and active during the Mesozoic era. The salt structures complicate seismic interpretation, as they disturb the seismic imaging, and nearby stratigraphy has been upturned and eroded.

The collaboration between ARCEx and the NPD has given me the opportunity to write a thesis about an industry relevant subject, access to high quality data to work with, and supervision from professionals, both within and outside academia. I have also used the opportunity to travel during my project, to Harstad and Trondheim, which has been both useful and fun.
Arctic Geophysical Laboratory

The Arctic Geophysical Laboratory (AGL) has been established as a consequence of experimental work related seismic surveying on and within ice, which is an essential research topic in WP4.

The laboratory consists of a wide range of geophysical instruments needed to facilitate experiments with various seismic sources and receivers to be placed on and below floating ice and at the seabed. The laboratory is fully operated by University of Bergen, UNIS and ARCEX and is at present located in Svea in the inner part of Van Mijenfjorden in Svalbard. AGL now provides a unique resource for performing a variety of large scale geophysical experiments in an Arctic environment. Furthermore, it is a workplace for innovation of technical and logistic performances aiming to operate as safe and efficient as possible under low temperature and harsh weather conditions. The laboratory is also used in the training of master and PhD students at UNIS in Arctic geophysics.

During 2017 two major experimental campaigns were carried out, the first during 10 days of late February and the second during 11 days in late May/early June. The experimental work was carried out as a joint venture between Norge A/S, UoB, ARCEX, and UNIS. During the first period two seismic lines where surveyed, starting at the frozen tundra in the inner part of Kjellstrømdalen and ending out on the floating ice. In Figure 1 these are marked as leg 1 and leg 2. As the line entered on floating ice both hydrophones and ocean bottom seismometers were deployed. Seismic data from leg 3 indicated in Figure 1 was acquired the second period by using seismic sources both on top and below the ice. During the second period true seals with their pets were situated in the water and on the ice close by the study area. In collaboration with WP4 and the Marine Institute the visible response of the seals to seismic shooting using both explosives on top of the ice and an air gun under the ice were monitored and compared to their behavior before and after the experiments took place. The data from the experiments are used to study the various fundamental seismic wave modes generated and to evaluate the optimum instrumental set up with respect to data quality and seismic imaging capability.

To strengthen international collaboration on research of WP4 professor Tor Arne Johansen, WP-leader of WP4, spent 7 months after the second experimental campaign at Geophysics Department at Stanford University. Here joint studies have been initiated: on automatic separation of P and S waves from QC data in collaboration with professor John F. Clearbout, and, on seismic signatures of freezing and thawing sediments in collaboration with professor Gary Mavko. To strengthen this collaboration Helene Mehling Stemland, a PhD candidate from WP4, has been nominated to spend up to one year at the Geophysics Department at Stanford University.

Photos: Ronny Tømmerbakke, UiB.
Welcome to our Arctic geology field laboratory!

All petroleum systems include the following elements: a source rock capable of generating hydrocarbons, a porous or fractured reservoir rock that can store migrated hydrocarbons, and a tight sealing rock to keep them in place.

In addition, large fracture systems, known as faults, act as important migration highways for hydrocarbons as soon as they are expelled from their parent source rock. The presence of a sedimentary basin is also a prerequisite to accommodate all the sedimentary rocks that make up the various elements of a petroleum system.

In general, most sedimentary basins and the petroleum systems they may host are of such large-scale and aerial extent that it is difficult to study their elements (source, reservoir, and seal) in detail. So how then, is it possible to gain detailed knowledge of a petroleum system? Of course, reflection seismic and well data are the most obvious answers. However, seismic data rarely capture subtle changes in the properties of sedimentary rock successions in the subsurface, unless the changes occur at the scale of several tens of meters. Although cores may provide detailed information about the sedimentology and subsurface stratigraphy, they only represent some few cm wide pinpoints. Wells in many offshore areas are also very expensive to drill, particularly if the operation includes coring. Thus, other less expensive options is to investigate outcrops where the petroleum system of interest is exposed or compare it to similar systems exposed elsewhere.

The complex geological evolution of the Arctic, which includes several episodes of basin formation followed by regional uplift, as well as the finishing polish of the last glaciation, has provided us with a unique large-scale geological field laboratory in the Arctic. The cornerstones of our laboratory facility is northern East Greenland, the northern coastline of Finnmark, and the Svalbard archipelago in the north, which also includes the island of Bjørnøya. The latter is located in the Barents Sea halfway between mainland Norway and the southern tip of Spitsbergen, meaning that it has an important strategic location just north of several licenses and announced exploration blocks. All our selected field locations represent so-called exhumed sedimentary basins, meaning that they once have been deeply buried, but because of tectonic uplift, they are presently exposed at surface. This also means that elements of past and once working petroleum systems are readily available for detailed investigations. In addition, by dating faults and investigate the geometry and thickness of a sedimentary succession, we can tell something about the tectonic evolution of a sedimentary basin. In Finnmark for example, our studies have shed a new light on the tectonic processes behind the formation of Late Devonian to Early Carboniferous aged (c. 380–310 Ma) rift basins in the SW Barents Sea.

Svalbard is by far our most important field area because its sedimentary rock succession share much of its history with the rocks hidden beneath the sea-floor of the Barents Sea. Several of our ongoing studies in Svalbard therefore focusses on different petroleum system elements including selected reservoir and source rock units that are known to be important exploration “targets” on the shelf.

Photos: Sten-Andreas Grundvåg, UiT; Torger Grytå; Nasa.
Dear R/V Helmer Hanssen

Ever since our first cruise to the Lofoten Islands in April 2007, I fell in love with you, and I know that I am not the only one.

Generations of marine biologists and marine geologist get this amazed shimmer in their eyes, when they talk about their scientific cruises with you.

You are a bit younger than me. You were built in 1988 as a top ice class stern trawler, and already as a 4 year old you dedicated your life to science. You became a research vessel.

Ever since, you were busy working. You trawled along the North Norwegian Coast, the Barents Sea, and around Svalbard. You meet the ice edge unfeardful, and only true heavy ice condition can stop you, but that is ok. You are not an ice breaker after all.

Together with your two crews of 11 amazing seamen, you are so very helpful, irrespective if we conduct geological surveys, take sediment cores, or measure the temperature and salinity down to 2000 m.

You enable us to catch everything from tiny algae to big fish and to conduct experiments in your cooling rooms, and when we are cold and tired after hours on deck or in the laboratories, your kitchen serves us fantastic food and makes us smile again.

Dear R/V Helmer Hanssen, even if you make me puke sometimes, and I have seconds where I sincerely think of ending our relationship, I could never do that. You and your crew, you are the platform each sea-going scientists can dream of.

Forever yours
Ingrid Wiedmann
ARCEx PostDoc
Seals and seismsics on ice – can they coexist?

A field trip to collect seismic data on sea ice offered an opportunity to investigate environmental impacts.

The PhD students Ana Sofia Aniceto from ÅF and Ronny Tømmerbakke from VR have carried out experiments in Van Mijenfjorden, Svalbard, with the purpose to gather data related to seismic within and close to ice-covered surfaces, and to monitor the effects of seismic surveying on nearby colonies of ringed seals.

For our study of seismic exploration on sea ice, we wanted to gather seismic data from a profile going from onshore over a shallow water transition zone to water depths exceeding 50 meters. The area around Kapp Amsterdam in Van Mijenfjorden, Svalbard was ideally suited for this experiment in May 2017 with good ice conditions of around 60 centimeters thickness.

We were however not the only ones interested in staying on the sea ice as this is the place of a well-known ringed seal colony that time of the year. The effect on seal behavior close to seismic surveying is poorly understood and we saw a potential for scientific collaboration with ÅF. PhD Fellow Ana Sofia Aniceto led a team of two from Akvaplan-niva and IMR to monitor the seals while we, a team of 8 people from UiB and UNIS, acquired seismic on the ice using a variety of sources and receivers on and below the ice sheet.

The data was successfully collected, with the additional benefit of the seal observers acting as additional polar bear watch. The observers monitored the area from their elevated viewpoint primarily to investigate changes in seal density, though on several occasions the scientists on ice received warnings of polar bear activity nearby.

The analysis of the seismic data is currently ongoing with initial results presented at Lofoten-seminaret in August 2017, several manuscripts in preparation for submission, an abstract submitted to SEG 2018, as well as providing valuable data for future work. The findings from the seal activity has been summarized in a manuscript currently undergoing review and will provide relevant input to future operations on the sea ice in the presence of seal populations.
Fieldwork with a polar researcher

Ingrid Wiedmann, Postdoc, UiT

«Further down!» I shout against the wind, standing in the unsteady rubber boat. Gusts throw us into the hull of the research vessel “Helmer Hansen”. Cold water splashes up and salty drops rain down on me. I hardly realize it. My full focus is on the big hook two meters above me. Slowly it descends to us from the crane of the vessel.

We are somewhere east of Svalbard in the drift ice zone. Ice floes around us as far as we can see and only some narrow channels of dark grey open water in between. Everything moves in the swell.

I am a marine biologist and I study how much biological material is sinking out in the ocean. This is important due to two reasons: First, the sinking material provides food to the animals at the sea floor, and second, the more material sinks, the more carbon can be buried in in the sediments at the bottom, and that is critical knowledge in a climate perspective.

To study the sinking biomass, I use plexiglass cylinders attached at different depths to a 200 m long rope, and this array is kept floating by a big surface buoy (see drawing). Retrieval of this set-up always gives me an adrenalin kick, because I really do not want the rope get snagged in the propeller, nor tear it in pieces on the sharp ice floe edges. If it snaps, my equipment would be lost in the ocean.

The rubber boat bounces again into the hull, but finally, Helmer Hansen’s crane hook is close enough. I grab it. It is not easy to hold the heavy crane hook, disentangle the rope with my equipment, and connect it to the hook, while keeping the balance on the unsteady rubber boat. But in the end I manage. Relieved I signal the crew on board to start lifting the rope with my equipment. I am relieved.

Another successful sampling is completed and I am super curious to see my samples. How much and what is sinking out under this drift-ice covered Arctic ecosystem?
On the trace of faults and fluids
- From the cold Arctic to the Mediterranean Turkey

Eric Salomon, Postdoc, UiB

One of the goals of our research in the geology component of ARCEX is to study the evolution of basin-bounding faults in the Barents Sea, with special emphasis on fluid circulation along these structures. Basin bounding faults may serve as conduits or barriers for fluids, and we aim to better understand how such faults may impact fluid transport in the crust during the course of their evolution.

To do this, we decided to investigate a field area of similar geology that is easily accessible and provides excellent rock exposure. We therefore travelled to western Turkey where a graben system was formed in the Miocene. Here, deposits from ancient rivers and lakes were deposited in the fault-controlled basins and juxtaposed against older metamorphic and granitic basement rock. With its Neogene age, this setting is significantly younger than the Mesozoic fault systems along the Barents Sea. This is beneficial for us, as it allows studying how basin-bounding faults behave and effect sediments at an early evolutionary stage. It provides us information that may be difficult to recognize in older settings due to overprinting by subsequent processes.

Field work spanned three weeks in November 2017, and was conducted in cooperation with our local partner Talip Güngör from University of Izmir; a PhD student from UiB also joined us. We visited multiple outcrops of the fault zone and sampled fault gouge, breccias, veins, as well as hanging and footwall rocks. A major outcome of our field investigation is that alteration of the fault system is spatially highly variable. This indicates that fluid circulation is not evenly distributed along the faults, but focused locally. Currently, we are in the process of analyzing the samples to determine the character of these fluids in concert with the structure and evolution of faulting.

These insights provide valuable information on the variability of fluid circulation, both spatially and in time. For our field session in NE Greenland in August 2018, these are important findings, as they will guide us towards identifying such variations and determining the controlling factors, which we hypothesize may include lithology, basement structure, or structural complexity (fault intersections, relay zones etc).
Industry and stakeholder collaboration

Norway’s future economic sustainability will be shaped by the activities of the oil and gas sector in the northern areas. According to the Norwegian Petroleum Directorate, at least 50% of the undiscovered resources on the Norwegian continental shelf are associated with the Barents Sea.

Through ARCEX, an inter-disciplinary team of specialists from leading universities and research institutes are working in partnership with specialists from 8 energy companies to better characterize the geology, understand the resource potential, and to minimize potential environmental risks during operations in the high north. The sharing of scientific and technical knowledge through ARCEX’s unique research-industry partnership is facilitated by several communication and collaboration mechanisms.

The petroleum industry requires a new and higher level of environmental knowledge on the Arctic than is available today. ARCEX specialists are integrating scientific advancements in biology, ecology, ecotoxicology and risk theory to improve existing environmental impact and risk management methods tailored to the unique Arctic ecology. Similar text (written by a geologist) on the main geology/resource potential need. Sentence about (what we are producing by the geology/resource potential!)

ARCEX has led to substantial collaboration between academia, oil companies and authorities through several forums where partners discuss key issues connected to research and organization. The ARCEX management strives to maintain an open dialogue between industry, academia, and authorities, so also informal discussions are encouraged.

The most important links between the various partners are as follows:

- Technical Committee-meetings involving academia and industry partners
- One-to-one meetings where a group of senior experts from ARCEX visits industry partners for direct dialogue. Our experience is that the industry partners are significantly more open in private settings than in plenary meetings involving numerous industry partners
- Co-advisors for PhD and Master’s students
- Co-authorship on publications
- An industry coordinator (Terje Solheim, AkerBP) has been elected to serve as a single point of contact between academia and industry
- Annual conference, active use of the website and the restricted access intranet open only for members.

Photos: Ranny Tammerbakke, UiB; Ingrid Wiedmann, UiT; Sten-Andreas Grundvåg, UiT.
Joint ARCEX field work with industry, authorities and academia

Energy companies, authorities and scientific institutions frequently visit Svalbard to learn more about the sediments of the Barents Sea.

Svalbard is of particular interest as it represents an onshore, exposed part of the sediments and rocks, which can be correlated further south into the offshore rocks situated below the sea bottom, within the energy companies’ exploration licenses. ARCEX staff joined two field cruises on Svalbard late summer 2017. Sten-Andreas Grundvåg and Fredrik Wesenlund (UiT) joined the first field cruise, arranged by Statoil and lead by Prof. Snorre Olaussen (unis), to Spitsbergen, Edgeøya and Hopen (22.08-29.08). The focus for Statoil was Mesozoic (Triassic - Cretaceous periods) sediments. Sten-Andreas Grundvåg, Sigrun Kvendbø Hegstad, and Fredrik Wesenlund then joined the second field cruise, arranged by the Norwegian Petroleum Directorate (NPD) and lead by Prof. Atle Mørk (NTNU), to Bjørnøya (30.08-8.09). The focus for the NPD was Paleozoic (Devonian - Permian periods) sediments.

Our base throughout the field cruises was R/V Stålbas, a ship now rented by unis for scientific purposes. It was previously owned and used by the Norwegian coast guard, and originally constructed for the fishing industry back in 1955. Considering the large distances, e.g. 300 km from Longyearbyen to Hopen, no other means of transportation is practically possible. A Polarcircle Rigid Buoyancy Boat (RBB) was used to go on land from Stålbas with all participants using survival suits. Safety measures, especially in the Arctic, are always given the highest priority.

The focus of ARCEX during the field courses was to observe, make sedimentary logs and collect samples of the Triassic organic rich sediments. These logs and samples will form a crucial part of Fredrik’s PhD project entitled “Sedimentology and geochemistry of the Triassic source rocks in the Northern Norwegian Barents Sea”. The overall goal is to understand the formation and composition of the Triassic source rocks in the North Norwegian Barents Sea by combining sedimentology and geochemistry.
Opportunities abroad
PhD student Helene M. Stemland on exchange to Stanford University

Helene Meling Stemland is a PhD candidate in WP4, working on improved methods for environmental friendly seismic analysis in the ice covered Arctic.

Her supervisor is Professor Tor Arne Johansen, who recently spent 7 months at the Department of Geophysics at Stanford University in 2017 for collaboration on research related to WP4. This collaboration has led to an invitation from Stanford University to Helene to become a visiting student researcher (VSR) for a period of up to one year at the Geophysics Department. Helene signs in at Stanford University 1st of April 2018 to follow up on collaboration initiated with Professors Gary Mavko and John F. Clearbout. Research topics are automatic separation of P and S waves from 4 component (4c) data and seismic signatures of freezing and thawing sediments. She will bring along 4c data for analysis produced by the Arctic Geophysical Laboratory during experiments on ice in the inner part of van Mijenfjorden in Svalbard, and 4c data provided by one of the sponsors of ARCEX.

Academic and industry collaboration
on a PhD project level

Terje Solbakk is a PhD candidate at NTNU in Trondheim, working in WP4 with a link to WP1. He works mainly with karst features and together with co-authors he has recently submitted a manuscript on gravimetry and caves to the Norwegian Journal of Geology.

As part of the ARCEX project I have the opportunity to meet our industry collaborators through various arenas, such as the annual ARCEX meetings, or at their offices, as well as my team of supervisors. Having industry partners provides with an opportunity to present my work to a non-academic, but advanced audience. I also get inspiration and feedback from a more commercial point of view, as in what factors are important to make a karst play model work. In addition, through the industry partners of ARCEX I also get access to example given high-quality seismic data for my work. I receive very valuable feedback from my knowledgeable academic supervisors whenever I need. Philip Ringrose (Statoil/NTNU) is my main supervisor, together with co-supervisor Christine Fichler (former Statoil, now NTNU) and Tore Svåna (former Statoil, now Afraz advisers/ExploCrowd). All three come with strong industry and academic background. They have contacts around the globe, and they have willingly shared their network with me, both in industry and academia. They have suggested conferences and arenas to attend to present my work, and they give me valuable, constructive feedback on my work, and they are great mentors and discussion partners.
International collaboration with AWI and BGR, Germany

ARCEx has initiated an international collaboration including partnership with the Alfred Wegener Institute (AWI) in Germany following a memorandum of understanding between UIT The Arctic University of Norway and AWI.

Later, the Federal Institute for Geoscience and Natural Resources (BGR), Germany also became part of this collaboration. There is a very limited amount of seismic and core data with sparse distribution available from the High Arctic, owned by different institutions. This project is an effort to gather data and experts as part of the ARCEx contribution in exploring the geology of the Norwegian Barents Sea of the High Arctic.

The project focuses on the geological evolution and paleoenvironment of this area related to the mid-late Cenozoic climatic (glacial and paleoceanographic) history of the northeastern Svalbard/northern margin of the Barents Sea continental margin. The seismic data shows a series of glacial-related mass-wasting deposits and contour-related deposits. This suggests an interaction between the ice sheet and along-slope ocean current processes. The most prominent glacial fan is observed at the mouth of the Kvitøya Trough.

For the first time, the glacial erosion of the source area for this margin is analyzed using the mass-balance approach. Our calculations show minor erosion compared to the southwestern margin of the Barents Sea (e.g. Bjørnøya Trough Mouth Fan). These results contribute to a better understanding of the uplift and erosion of the Barents Sea shelf. Parts of the results of this international cooperation have been presented at the NPArctic Days Conference 2017 in Svolvær and 3rd Nordic Geological Winter Meeting 2018 in Copenhagen. The report is in preparation to be submitted to a peer-reviewed international journal. Later this year, ARCEx will arrange a marine geological and geophysical cruise to this area.
Midterm evaluation

In 2017, ARCEx was evaluated by an international team of five experts as part of the mandatory midterm evaluation.

The evaluation committee was lead by Prof. Alison McKay, Leeds University, and consisted in addition of Prof. Ingela Dahllöf, Univ. of Gothenburg, Dr. Angus Best, National Oceanography Centre, Southampton, Dr. Craig Smalley, Imperial College London, and Dr. Fridtjof Røis, NPD, Stavanger.

The ARCEx management and all separate stakeholders submitted a substantial amount of documentation to the Research Council of Norway in June 2017. On September 21, 2017, the evaluation panel accompanied by Department Director Siri Helle Friedemann, Special Adviser Ingrid Anne Munz, and trainee Martin Røsok from the RCN spent a full day with ARCEx personnel in Tromsø. The delegation met with ARCEX management, work package leaders, PhD students, postdocs, board members, and representatives from industry and research partners. The meeting was opened by the Rector of UiT, Prof. Anne Husebekkk.

Based on the written documentation and the discussions during the site visit, the evaluation panel produced a written report that has been made publicly available. The report concludes by presenting a set of recommendations to the centre. We judge the recommendations as constructive and helpful, and we are certain that we can comply with the suggested improvements. The final verdict will be made by the RCN in the end of April 2017.
A visit from the Minister

During the Arctic Frontiers conference in January 2018, Minister Terje Søviknes visited ARCEX at UiT the Arctic University of Norway.

Norway’s Minister of Petroleum and Energy Terje Søviknes visited UiT the Arctic University of Norway on 23 January.

The Deputy Leader of ARCEX, Sten-Andreas Grundvåg, and Administrative Leader Ellen Ingeborg Hætta gave a presentation about ARCEX’ research program, and explained how the centre, through a common effort between academia and industry, coordinates the national research collaboration. The Minister was presented with an overview of the main research questions that ARCEX focuses on, and the research facilities we use to collect relevant data. ARCEX contributes to the understanding of the geology and resource potential of the high north, as well as to the development of new geophysical exploration techniques, and new models for environmental risk connected to operations in the north.

The visit was rounded off with a visit to the high-tech ship simulator used by other research groups and for education.

In the picture: Mattias Forwick (Head of the Department of Geosciences), Arne Smalås (Dean at the Faculty of Science and Technology), Terje Søviknes (Minister of Petroleum and Energy), Ellen Ingeborg Hætta (Administrative Leader of ARCEX) and Bjørn Morten Batalden (Head of the Department of Engineering and Safety).
Organisation

ARCEx is organised with a dynamic management, and a communication structure that is structured according to the research areas/work packages. The defined organisational structure ensures the fulfilment of the ARCEx objectives within the time frame of the project.

The General Assembly serves as an arena for information exchange between the research partners and industry partners. The GA elects members for the Consortium Board. The GA met The General Assembly 2017 took place immediately after the ARCEx Annual Conference, on 11 May 2017.

The Consortium Board has members from research partners and industry partners, with the industry partners in majority. The Research Council and Norwegian Petroleum Directorate are observers to the board. The board is in charge of the overall direction of the centre and the main decision making body. It approves changes to the consortium, allocation of the overall budget as proposed by the management team, and supervises scientific progress. The board met on three occasions in 2017.

The Management Team consists of the Centre Director, WP leaders and administrative coordinator, and is responsible to follow up on the day-to-day scientific, administrative and financial coordination of the centre. The management team is in particular responsible to supervise the activities of the work packages, ensure that all objectives are met and that costs, deliverables and milestones are in line with the plans, and make sure that industry is involved in the research and receives results. The management team meets regularly throughout the year.

The Technical Committees are arenas where the industry partners can interact with scientific staff to ensure relevance, recommend new actions and activities and discuss project progress. Throughout 2017, several meetings were arranged, as technical committees and 1-1 meetings with user partners.
## Accounts

(all figures in NOK 1,000)

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1. UiB, UiO, NTNU, UiS, UNIS, APN, IRIS, NGU, Norut

### Budget 2013–2021

- **The Research Council**: 34% MNO 75,000
- **UiO**: 28% MNO 62,015
- **UiT**: 4% MNO 9,800
- **Troms fylkeskommune**: 3% MNO 9,800
Publication articles

2018


Lasabuda, A., Laberg, J.S., Knutsen, S.M., Safronova, P. (accepted): Cenozoic tectonostratigraphy and pre-glacial erosion: A mass-balance study of the northwestern Barents Sea margin, Norwegian Arctic. Accepted in Journal of Geodynamics, Special Arctic Issue. DOI: 10.1016/j.jog.2018.03.004


2017


Landro, M., Hansteen, F., Amundsen, L. (2017): Detecting gas leakage using high-frequency signals generated by air-gun arrays. Geophysics, vol. 82, no. 2 (March-April 2017); P. A 7–A 12, 5 figs. DOI:10.1190/GEO2016-0483.1


Solbakk, T., Thomsen, E. (2017): Nord-norske oljeventyr. Otta 2017; Volum 2,(315) s. 3-10


Other publications
entation at ARCEX Annual Conference 2017, 10-11 May 2017, Malangen, Norway.


Hannsen, A. (2017): The good, the bad and the bub- bly: a story about bubble physics. Oral presenta- tion at Bubbles to the Top, 6-7 June 2017, Centre for Arctic Gas Hydrate, Environment and Climate (CAGE), Department of Geosciences, UiT The Arctic University of Norway, Tromsø, Norway.


Olesen, S. (2017): Arctic benthic communities structure and functioning during spring sea ices conditions. Oral presenta- tion at Arctic Science Summit Week 4-7 April 2017, Prague, Czech Republic.


Olesen, S. (2017): Arctic benthic communities structure and functioning during spring sea ice conditions. Oral presenta- tion at Arctic Science Summit Week, 4-7 April 2017, Prague, Czech Republic.


Wiedmann, I., Møen, M., Daase, M. (2017): High-end Technology Meets a Well-Established Sampling Technique: Advances of Combining an Acoustic Zooplankton and Fish Profiler With Short-Term Sediment Traps. Poster presentation at Arctic Science Summit Week, 4-7 April 2017, Prague, Czech Republic.
