



# ANNUAL REPORT 2014

**The National  
IOR Centre  
of Norway**

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# THE PARTNERS



GDF SUEZ



DONG energy

HALLIBURTON

Schlumberger

ConocoPhillips



# THE MANAGEMENT

Aksel Hiorth  
Director of Research

Merete V. Madland  
Centre Director

Kristin M. Flornes  
Assistant Director

Geir Nævdal  
Director of Research

Svein M. Skjæveland  
Director of Academia

Sissel Opsahl Viig  
Director of Field Implementation

# THE BOARD

Kåre Vagle, ConocoPhillips (Chairman)

Randi Elisabeth Haugdal, Statoil

Roar Kjelstadli, BP

Mailin Seldal, GDF Suez

Yngve Brynjulfsen, Eni Norge

Tore Bjerklund Gimse, IFE

Ole Ringdal, IRIS

Øystein Lund Bø, UiS

Observers:

Ingrid Anne Munz, RCN

Mariann Dalland, NPD

Erik Søndena, Petoro

# TECHNICAL COMMITTEE

Consists of representatives from each user partner

Chairman of the TC:

Steinar Kristiansen, Wintershall Norge

# THE VISION: JOINING FORCES TO RECOVER MORE



**THE CENTRE'S GOAL IS TO DEVELOP NEW  
KNOWLEDGE AND TECHNOLOGY IN ORDER  
TO INCREASE RECOVERY BEYOND  
PROJECTIONS UNDER TODAY'S FIELD  
OPERATION PLANS**

Secondary objectives include:

- Robust upscaling of recovery mechanism observed on pore and core scale to field scale
- Optimal injection strategies based on total oil recovered, economic and environmental impact
- Educating some 20 PhDs and six postdocs during the eight-year period, as well as 50 MSc students per year

# ORGANISATION



The Centre is a consortium of three research partners UiS, IRIS and IFE and 12 partners from the industry. UiS is the host institution. The Centre director is Prof. Merete V. Madland (UiS). She has two assistant directors of research: Prof. Aksel Hiorth (UiS/IRIS) and Dr. Geir Nævdal (IRIS) and one representing academics, Prof. Svein Skjæveland (UiS). The assistant Centre director is Dr. Kristin M. Flornes. Sissel Opsahl Viig (IFE) is Director of Field Implementation. They all have relevant management experience with international research projects and constitute the management team of the Centre.

The Centre director is in charge of the overall progress and performance of the Centre and reports to the Centre responsible (UiS) and the Centre board. The two assistant directors support the director, conduct research, and together with senior scientists they support and advice doctorate students and postdocs. In addition to the management team, Bente Dale is hired as administrative coordinator and Mari Løvås as

communications advisor.

The Centre administration is located at UiS. A General Assembly for all partners is organized annually. The General Assembly is the ultimate decision making body of the project, and will elect the Centre Board. The Board is the operative decision making body for the execution of the project, and reports to, and is accountable to, the General assembly. The Centre board will include representatives from UiS, IRIS, IFE, and industry partners. The Centre's industry partners have the majority of the board to ensure industry relevance and involvement. The Research Council of Norway, Petoro and The Norwegian Petroleum Directorate will have observer status. All board members have assigned deputy representatives. We plan for a minimum of two board meetings in 2015. The Technical Committee is the technical advisory body of the board and consist of representatives from each of the 12 user partners. The TC wil hold a minimum of two meetings a year. The research is organised in two

R&D themes with seven main Tasks, which are specified by a research plan covering deliverables, milestones and methodology (see 9. Progress plan). Senior scientists from UiS, IRIS, and IFE core group of researchers will serve as task leaders. As an overall strategy in these tasks, we will involve researchers coming from different research environments (IOR/EOR, reservoir, chemistry, geology, geochemistry, geophysics, mathematics, nano- science/technology, biochemistry, environmental, industrial economy) from the partners as well as national and international collaborators. Efficient and good working routines have been established.

Tasks and theme leaders meet bi-weekly and the task leaders participate in regular project meetings with the project leaders. This ensures a steady flow of information between the participants of the Centre.

# THE DIRECTOR'S VIEW

## *Joining forces to recover more!*

The National IOR Centre of Norway - a consortium of 15 partners was officially declared opened by the Minister of Petroleum and Energy 26th of March 2014. The grand Opening took place at the University of Stavanger and rector Marit Boyesen had the pleasure to welcome more than 300 people from academia, national and international research institutions, industry and authorities. In her speech she quoted the vision of the university, and further concluded that the new research centre "... is a realization of something bigger than the aspirations of petroleum researchers. It is the realization of the vision for the entire university," which highlights not only knowledge development and international research, but also creativity and innovation.

Innovation is simply creating new and better solutions which are then put into practice, and that is exactly what this new national research centre for improved recovery of petroleum resources is all about. The Centre's vision: Joining forces to recover more, promotes an active interplay between the authorities, universities, independent research institutions, the operating oil companies, and the service companies who perform the tasks in practice. For mature fields the low-hanging fruits already have been picked and creative solutions are thus needed for each extra percent oil recovery we are trying to gain. Together with the industry-experts as well as several national and international collaborators, UiS, IRIS and IFE have already started the work



to find the best injection strategies to be used on the Norwegian shelf.

At the time being we have more than 30 R&D projects running, and I would like to highlight one of the activities: The IORSim is a collaborative project between IRIS, UiS and IFE in which we develop a simulator that can be used as an add-on tool to the oil companies' own reservoir simulators. The IORSim will enable to predict IOR potential for specific fields and a first version of this simulator will be demonstrated at IOR NORWAY 2015.

I am looking forward to be seeing you all at our first annual IOR conference at UiS, 28-29 April 2015. WELCOME!

**Merete Vadla Madland**  
Centre Director

**“INNOVATION IS  
SIMPLY CREATING  
NEW AND BETTER  
SOLUTIONS WHICH  
ARE THEN PUT INTO  
PRACTICE”**

## ABOUT THE CENTRE'S

# HISTORY



Awarded by the Research Council of Norway after a national competition, the Centre started up in December 2013. The Centre's goal is to develop new knowledge and technology in order to increase recovery beyond projections under today's field operation plans.

The National IOR Centre of Norway is led by University of Stavanger, with research institutes IRIS and IFE as core partners. Several other national and international research groups, and 12 oil and service companies, complete the Centre's list of partners and col-

laborators .

The Centre will contribute to the implementation of environmentally friendly technologies for improving oil recovery on the Norwegian continental shelf.





CHAIRMAN KÅRE R. VAGLE

*"During 2014 the number of researchers has gradually increased. At 31st December 3 PhDs, 5 Post Docs and 24 Master students were fully engaged." - Kåre R. Vagle*



## MESSAGE FROM THE



# CHAIRMAN

The National IOR Centre of Norway experienced a kick-start with the first partner meeting on 5th February, followed by the constitution of an Interim Board on 13th February. The Interim Board was composed of three members from the research partners (University of Stavanger, IRIS and IFE) and five members from the industry (ConocoPhillips, BP, Eni, GDF SUEZ, Statoil) and with observers from Petoro, The Norwegian Petroleum Directorate and the Research Council of Norway.

The main focus in the initiation phase was to get the Consortium Agreement accepted by all partners and to establish good communication and reporting routines. As several research activities had been started towards the end of 2013, the scientific performance was already at a high level and according to the initial work plan outlined in the application to the Research Council of Norway. A technical committee with participation from all partners was established to ensure scientific excellence and to provide guidance to the Interim Board.

Building Centre identity has been another important focus. A website was therefore established, the IOR Centre participated with stand at the ONS 2014 Exhibition and it was decided to launch an annual IOR conference starting in 2015.

The first General Assembly was held 29th August and a permanent Board was established with the same partners as in the Interim Board. During 2014 the number of researchers has gradually increased. At 31st December three PhDs, five Post Docs and 24 Master students were fully engaged. Going forward the most important aspect is to obtain sufficient field data from the user partners to ensure the research activity is highly relevant and most suitable for field implementation.

**Kåre R. Vagle**  
Chairman of The board

## THE CENTRE'S

## MANAGEMENT



### MERETE VADLA MADLAND

Merete Vadla Madland is professor at University of Stavanger within reservoir technology, and in autumn 2013 she became director of the new national research Centre for improved recovery of petroleum resources on the Norwegian Continental Shelf. She has a PhD within geomechanics from the University of Stavanger. The last 17 years she has worked on how to most effectively extract oil from reservoir rocks. She has been heading several RCN funded projects and numerous industry funded projects. The research has focused on understanding the physical and chemical interactions between rocks and fluids on the pore (micro) scale and how these can be transferred to the field (macro) scale. She has more than 40 publications in peer reviewed journals, and 60 international conference papers.



### KRISTIN FLORNES

Kristin M. Flornes is Senior Vice President at IRIS and head of the Energy Department. She has been the vice director of the National IOR Centre of Norway since the start. Flornes holds a PhD in mathematics from Norwegian University of Science and Technology, NTNU. She has worked in the oil and energy business since 1998 and held various senior and management positions in Schlumberger, Point Carbon and since 2005 in IRIS. Her research includes work within reservoir management, assisted history matching, reservoir simulation and CO<sub>2</sub> storage. Flornes is a board member of COREC, Centre for Oil Recovery and has been member of the programme board of CLIMIT, the R&D programme for CCS in Norway.



### AKSEL HIORTH

Aksel Hiorth is Chief research scientist within enhanced oil recovery (EOR) at IRIS and Professor within reservoir technology at the University of Stavanger. Currently he is research director at the National IOR Centre of Norway. He has a PhD within theoretical physics from University of Oslo, and has been principal investigator within several large research projects supported by the industry and the research council of Norway. In the last decade he has mainly worked with developing simulation models that can describe the physical and chemical processes taking place during multiphase flow in porous rocks. He has more than 40 publications in peer reviewed journals and 20 presentations at international conferences.



## GEIR NÆVDAL

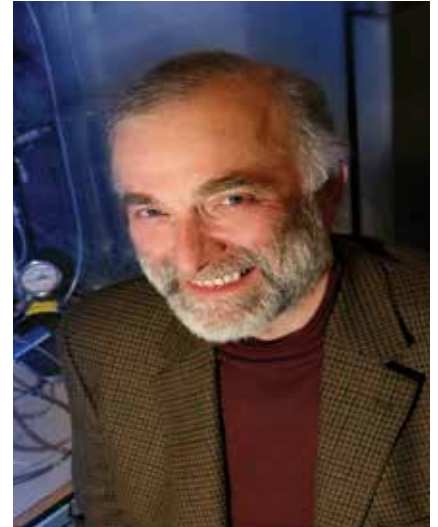
Geir Nævdal is a chief scientist at International Research Institute of Stavanger. In autumn 2013 he became assistant director of research of the new national research Centre for improved recovery of petroleum resources on the Norwegian Continental Shelf heading Theme 2 "Mobile oil: Reservoir characterization to improve volumetric sweep" in the Centre.

He has a PhD in mathematics from NTNU (1991). He has been working at IRIS since 1997. His research areas includes improved reservoir management, reservoir characterization, production optimization and data assimilation. He is an associate editor for SPE Journal.



## SISSEL OPSAHL VIIG

Sissel Opsahl Viig is holding a position as a senior scientist with the Petroleum Technology Division at Institute for Energy Technology (IFE). She has a master degree in nuclear chemistry from the University of Oslo. She has more than ten years of experience in tracer technology and works with development of tracer methods for reservoir evaluation (interwell studies), tracer methods for determination of residual oil saturation, and analytical chemistry.



## SVEIN M. SKJÆVELAND

Svein M. Skjæveland is a reservoir engineering professor at the University of Stavanger (UiS) with a PhD from the Norwegian University of Science and Technology in engineering physics and a PhD in petroleum engineering from Texas A&M University. At UiS (Rogaland Regional College) he worked to establish the master and PhD programs in petroleum engineering and geoscience and to develop the research organization IRIS (Rogaland Research). He is an appointed "Oil Man of the Year", and has won many prizes. During 1992-94 he was an elected rector and has held many administrative positions in academia. He enjoys teaching and has published many papers in the fields of physics, reservoir engineering, and multiphase flow in porous media.

# MEETINGS

## WITH BOARD AND COMMITTEES

**A Board and a Technical Committee have been elected to ensure the Centre is run appropriately.**



Three meetings have been held with the Technical Committee (TC) in 2014. The TC is the technical advisory body to the Board, consisting of representatives from each of the 12 user partners. A general assembly of all partners is organized annually. The Board was elected at the annual general meeting in 2014. The General Assembly does not have operational responsibility, but works to ensure that the Board performs its duties in accordance with the

Centre's consortium agreement and contract with the Research Council of Norway (RCN). The Board monitors the implementation of the projects and approve annual work plans and budgets. The Board also ensures that the activities described in the project description, financing plan and annual work plans are completed within a defined timeframe, and this includes in-kind contributions from the two service companies delivered as specified.

The Centre's board consists of one representative from each research partner; UiS, IRIS, IFE, and a representative from five of the user partners (industry). The user partners hold a majority of the Board to ensure industry relevance and engagement. RCN, Norwegian Petroleum Directorate and Petoro have observer status on the board. Four board meetings were held in 2014.

## RESEARCH PLANS AND ACHIEVEMENTS IN THEME 1:

# MOBILE AND IMMOBILE OIL AND EOR METHODS

### The primary objective of Theme 1:

**Optimize the microscopic and macroscopic displacement efficiency in a porous rock from the chemical and mineral compositions of pore fluids and rock grains, considering the sustained diagenesis and translate this knowledge to industry applications.**

#### SECONDARY OBJECTIVES OF THEME 1:

- Develop methods of up-scaling pore and core oil recovery to field scale
- Develop methods that can predict transport of chemical compounds from core to field
- A fundamental understanding of wettability and its role in porous media flow from pore, to core and field scale
- An understanding of the impact and long term effect of EOR technologies on the reservoir
- Evaluate the environmental impact of the EOR methods.

This year our main focus has

been to develop a project portfolio consisting of basic research (~30%) and applied research (~70%). Using the application as a basis, we had a call for proposal last year and received 10 applications, four of these applications were funded without any modification and three of them were funded after revision of the budget and scope of the work.

The technical committee has been actively involved in giving feedback to the on going projects and suggested new projects targeting specific needs. In particular we have been very active in contacting operators and licenses

in order to discuss specific needs they have in order to evaluate pilot work and planned pilots. This approach has been very successful and we have now received field data, and permission to use core data from several fields. During the autumn of 2015 and in 2016 several of the project activities will focus towards field data and specific needs of licenses. By keeping a good dialogue with the operators we believe that this collaboration between the National IOR Centre and the operators will lead to high quality journal papers.

# TASK 1: CORE SCALE

## WHAT ARE THE MAIN ASPECTS OF YOUR TASK?

The aim of Task 1 is to construct models that capture the transport mechanisms observed in core scale experiments.

## DESCRIBE THE 2014 PROJECTS:

This is some of what we have been working on:

- The need for better interpretation of core scale experiments. This is addressed through the project DOUCS – development of a tool for improved simulation of EOR-processes at the core scale.
- Identify the different IOR methods in terms of potential on the Norwegian continental shelf (NCS). This has been addressed through the two projects on EOR screening and application on the NCS, and on building a prototype database including experimental work performed at IRIS and UiS during the last 30 years.
- Standard core preparation procedures developed for SCAL experiments is not always optimum for EOR experiments. This is addressed through the project “Core plug preparation procedure.”

The current version of the IOR-CoreSim allows for relative permeability and capillary pressure interpolation, conductive heating of core, thermal heat expansion and molecular diffusion of com-

ponents, and is connected to a geomechanical model. The model parameters will be used on sector and pilot scale.

One project, “From SCAL to EOR” addresses the potential of combining experimental EOR studies with SCAL. Core material used for SCAL experiments has been released and additional EOR experiments will be performed. The results will be matched with simulations.

There is fruitful cooperation with external research groups; projects at NTNU on “Transport of emulsion droplets through porous media,” and at UIB on “Integrated EOR for heterogeneous reservoirs.”

## DID YOU COMPLETE ANY PROJECTS IN 2014?

The project “Determination of droplet size distribution in oil – water emulsions passed through a porous material studied by low field NMR” is completed and important knowledge on transportability of emulsions in reservoirs/porous media has been gained. A new phase of this project is initiated under Task 3.

## HOW WILL YOU SUM UP 2014?

Several important research tasks have been initiated. Cooperation between the different research partners has been established. In addition, there is a strong involvement from the supporting com-



**TASK LEADER:  
ARNE STAVLAND**

panies.

## WHAT WILL YOU BRING WITH YOU TO 2015, AND IN THE FUTURE?

The IORCoreSim model will be further developed and used to simulate typical EOR experiments, such as the combination of polymer and low salinity water.

## DID YOU PLAN/ATTEND ANY IMPORTANT MEETINGS OR WORKSHOPS IN 2014?

A multiscale approach to interpret chalk core experiments, by Janne Pedersen et al., was presented at the 35th Workshop & Symposium IEA Collaborative project on EOR, Beijing, China, 2014.

## TASK 2:

# MINERAL FLUID REACTIONS AT NANO/SUBMICRON SCALE

### WHAT ARE THE MAIN ASPECTS OF YOUR TASK?

Description, analyses, quantification, interpretation, and understanding of mineralogical and chemical changes of carbonates after flooding experiments for EOR purposes.

To gain this the projects will go ahead in the following steps:

- Study chalk and carbonates with different analytical tools to understand changes after flooding
- Apply the tool-box to unflooded chalk to control the material which is used for experiments
- Apply the tool-box to flooded chalk to determine changes
- Apply the tool-box to reservoir chalk
- After the descriptive analysis of the chemical and mineralogical changes we will quantify the changes

This will end in 2016/2017.

From 2015 on, we will start with the same process for clastic sedimentary rocks:

We will characterize clastic reservoir rocks and will develop a tool-box for the monitoring and understanding of the mineralogical and chemical changes after flooded and for EOR purposes.

### DESCRIBE THE 2014 PROJECTS:

“Geological studies on carbonates (including chalk) and chert for the further understanding of rock material for EOR research and applications.”

The objective of this project is to develop the final tool-box kit for the research on chalk; combining rock mechanical data with geological data on rock types affected by fluid flow in natural environments or by in-house

experiments on chalk and chert. Modeling of data is one of the major issues of The National IOR Centre of Norway and these projects are trying to evaluate the received data in terms of their representative value for the studied object and their possibility of being reproduced. The deliverables of this project will be publications in international peer-reviewed journals and numerous congress abstracts (which has already been started), involvement of MSc and BSc students in the IOR Centre on a research level for EOR purposes; application of methodologies never used to the problem field of EOR in chalk and determining the direct significance for results of rock mechanical tests and assisting of the interpretation of these experiments.

“New methodologies at the IOR Centre for EOR purposes.”

The objective here is to develop methods for the Centre and any EOR related research. New methodologies are paramount for any approach to a scientific problem – here we will deliver clear ‘recipes’ for EOR research or studies which are then routine; industry can then react quickly and apply these methods for their interests. Parts of the results are now in the publication process, hence evaluated by independent professionals of being useful and productive. Involvement of MSc and BSc students in the IOR Centre on a methodological level and, obviously, the methodologies themselves will be part of the deliverables.

The research within this project is embedded in a well functioning international network of state-



**TASK LEADER:  
UDO ZIMMERMANN**

of-the-art laboratories which will assist in the Raman research (Università degli studi de Milano Bicocca, Italy for microRAMAN) and the Centre de Recherche public Gabriel Lippmann (Luxembourg for nanoRAMAN).

“Installation of XRD (X-ray diffractometer) and method development for the IOR Centre.”  
Installment of a brand new state-of-the-art X-Ray Diffractometer and the necessary laboratory are financed by UiS and made available for the Centre.  
At UiS, IRIS and even in greater Stavanger such an analytical facility does not exist and the implementation of a XRD is novel for Rogaland, as XRD technology allows for mineralogical and compositional identification and even semi-quantification of any rock and organic material. It can be used for any possible research project for testing unflooded and flooded rock material for EOR application. As such this X-Ray Diffractometer will lead to more research output, unlimited sample

analyses, quicker through-put of projects, education of researcher, post-graduates and graduates, tailor-made application for EOR research.

“New horizons: Analytical advances related to chalk - training and applications of TEM, FE-SEM, and Nd isotopes.” The objective of this project is to expand the range of analytical methodologies to study chalk, and other types of rock at micro-and nano-level. The focus will be set on TEM, nanoSIMS, nanoRaman, FE-SEM, AFM (Atomic force microscopy) and EMPA (electron microprobe analyses), as well as on new unexplored isotope systems. Then, secondary fluid flow will be monitored with these high sensitive applications, and the extended tool-box will then be applied to clastic rocks.

This goes hand-in-hand with a second approach to test standards on the different available applications (FE-SEM and TEM). TEM analytical procedures do assist in understanding fine-grained material, but so far this technique has not been applied to chalk. No systematic research had been carried out in this field, and been applied together with nanoSIMS, nanoRaman, SEM, AFM. TEM is available at the University of Stavanger, and has already been fronted by the IOR Centre as a method of studying mineralogical alteration. Therefore, first systematic research using this equipment will enable new horizons of projects between industry and academics. Part of the deliverables will be a methodological ‘recipe’ for the study on chalk for the IOR at UiS to enhance the analytical knowledge as well as education of young scientists and students on state-of-the-art analytical methods, unseen in Norway to the benefit of industry. We also plan for international peer-reviewed publications.

#### 2014?

None are completed as they all started in 2014.

#### How WILL YOU SUM UP 2014?

These are some of the highlights from 2014:

- Purchase of the XRD machine
- Yielding the participation of a world-class clay mineralogist to set-up the laboratory and to develop the methodologies
- After 9 months of research; submission of four peer-reviewed papers in international journals (two accepted, two in review still)
- We investigated unflooded chalk and carbonate with optimal microscopy, X-ray diffraction (XRD), electron microscope applications (SEM-BSE-CL-EDS), whole-rock geochemistry, MLA (Mineral Liberation analyser)/ QEMSCAN studies, stable isotope geochemistry (C-O-D-H-Si), nano-ionprobe (nano-SIMS) as well as with Raman spectroscopy and electron microprobe analyses (EMPA). Recently, we visited Houston to strengthen research collaboration with the University there and are applying Sr-Sr isotope geochemistry on unflooded, flooded and reservoir chalk. The final results are pending.
- We managed to map flooded chalk with FE-BSE-MLA for the first time and could identify Mg-rich calcite phases.
- We carried out a project on chert in chalk to identify the origin of chert and then diagenetic opal and quartz in chalk. We could identify and separate hydrothermal grown chert from organic chert. The paper is in preparation.
- Standardizing and calibration of micro-Raman for carbonates.
- Measurements of flooded chalk samples with micro-Raman in 10 minutes (from sample to result)

- We developed a technique to identify minerals in flooded chalk with Raman applications. We are in the process in developing a quantifying technique to estimate the content of these secondary minerals.
- We analysed a chalk sample (ultra long term test) from ‘sampling to result’ in less than 10 minutes!

#### WHAT WILL YOU BRING WITH YOU TO 2015, AND IN THE FUTURE?

There will be more publications as a number of projects will be finished. We will complete the set-up of the XRD machine and installation of the XRD laboratory. We will finish the mentioned short projects with all their outcomes. The research will be intensified with another PhD position. We will also be able to see the first quantification of chemical changes in flooded chalk and we will work on new projects on clastic rocks.

#### DID YOU PLAN/ATTEND ANY IMPORTANT MEETINGS OR WORKSHOPS IN 2014?

We attended several meetings on international level and workshops:

- Several contributions for the NGF “Vinterkonferansen” in Stavanger and at various international meetings in 2014
- In spring, autumn 2014 we arranged research visits at the Bergakademie Freiberg (MLA and EMPA), University of Edinburgh (C-O isotopes), University of Houston (Sr-Sr isotope geochemistry), University of Córdoba (Argentina; XRD) and at the University of Milano Bicocca (Raman spectroscopy).
- Several abstracts have been successfully submitted and published at international congresses in 2014.



## TASK 3:

# PORE SCALE

### WHAT ARE THE MAIN ASPECTS OF YOUR TASK?

The main aspect of the task is to study and understand how changes on the pore scale, be it physical or chemical, influence the microscopic displacement efficiency. Introduction of fresh brines into porous rocks will cause both changes of the geometry of the pore space due to mineral dissolution/precipitation which will influence the capillary pressure curves. It is also well established that the introduction of electrolyte solutions can change the surface energies which again will effect the wettability of the rock. The pore geometry is important for the effective behavior of polymers, hence changes in pore geometry could also affect the Darcy scale rheology of polymer solutions. The main deliverables will be to pinpoint the pore scale mechanisms that will have noticeable effect on the Darcy scale.

### DESCRIBE THE 2014 PROJECTS:

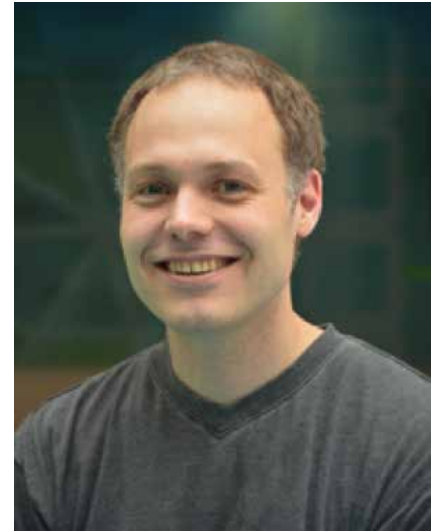
“Determination of Droplet Size Distribution in Oil – Water Emulsions Passed Through a Porous Material Studied by Low Field NMR” (Camilla I. Dagsgård, NTNU). This is phase one of a project on how to use low field NMR to study the transport of emulsion of droplets with different radii through filters with different mask sizes. The objective is to characterize the change in droplet sizes before and after filtration. The findings can be checked by direct observations through a microscope. To be able to observe how emulsion behave in porous media, it would be important for the evaluation of different IOR methods by answering questions of emulsion stability (will droplets coalesce, break up or be unaffected). The deliverable of this project is a written report, and an evaluation of the method. Another project is “Peridynam-

ics simulation of chalk – from nanometer to centimeter” led by Anders Malthe-Sørenssen, UiO. The objective of this project is to predict material properties of rock samples at different length scales using numerical simulations based on FIB-SEM images of chalks. The aim of this project is to make the first steps towards a numerical investigation of pore scale processes that involves the interaction of mechanical strength, deformation of the chalk matrix, and fluid flow. This work is part of a PhD-project.

“Pore scale processes” is led by Janne Pedersen at IRIS and is divided into two parts:

- 1) Extension of the lattice Boltzmann geochemical model (BADChIMP) to Darcy scale processes with overgrowth of primary minerals by secondary mineral deposition. The model will be compared with a long term core flooding experiment. One important aspect of this simulation is to evaluate the applicability of standard rate equations to long term test. Chemical effects are usually up scaled by the use of effective rate equations, hence the knowledge of which parameters one needs to introduce to improve the match to long term experiments will be of importance when evaluating the effects of chemical EOR methods on the field scale.
- 2) The application of the lattice Boltzmann model to high Rayleigh number environments. The system used in this study is based on an experiment conducted at UiS (R. Time et al.) of CO<sub>2</sub> dissolution in water, where the flow patterns are visualized by pH-indicators. We will deliver two journal papers one on each topic.

DID YOU COMPLETE ANY PROJECTS IN



**TASK LEADER:**  
**ESPEN JETTESTUEN**

### 2014?

“Determination of Droplet Size Distribution in Oil – Water Emulsions Passed Through a Porous Material Studied by Low Field NMR”

The low field NMR technique gave successful results for measuring the droplet size distribution. Besides the written report “Filtration of Emulsions”, there will also be an extension of technique in a phase 2 project in 2015.

### HOW WILL YOU SUM UP 2014?

During December there has been an increase in project applications, which will increase the number of projects at the beginning of next year. We have also noticed that there is good synergy between tasks 1, 2, and 3, as modelling and experimental work complement each other.

### WHAT WILL YOU BRING WITH YOU TO 2015, AND IN THE FUTURE?

We think that it is important to keep the good cooperation between the tasks in theme 1, which should lead to projects residing in more than one task.

## TASK 4:

# UPSCALING AND ENVIRONMENTAL IMPACT

### WHAT ARE THE MAIN ASPECTS OF YOUR TASK?

One of the main challenges within IOR research is to translate knowledge from lab studies to field applications. To scale up lab results to field scale is not only important in order to evaluate the economic potential for specific fields, but also to avoid that too much research is done in the lab on EOR methods that never will have a potential on the field scale. In this task we have had a very successful collaboration with the two service companies in the IOR Centre, Halliburton and Schlumberger. This collaboration has been crucial for the development of projects that targets specific needs of the operating oil companies.

### DESCRIBE THE 2014 PROJECTS:

Halliburton is managing a project "Shear degradation of polymer", where the aim is to test the fate and transport of polymer solutions from the platform into the reservoir. We will test how the quality of the polymer solution changes from the injection point, and when it passes through constrictions (chokes and valves) on its way to the reservoir. We will test commercial valves in order to suggest which one to use and/or improvements that need to be done to secure that the polymer solution does not degrade before it enters the reservoir. We will use realistic pipe dimensions (~10-100m) and high rate pumps in a custom made setup, and compare with lab flow rates and dimension (~1m). An extension to this project for (2016) is to use large sand packs at the end of the flow line to investigate the fate of the polymer solution in the reservoir. If this project is successful,

the National IOR Centre will have infrastructure that potentially could be used to perform pilot studies on shore, which would greatly reduce the cost compared to off shore pilots, and lead to a faster implementation of EOR operations off shore.

"Designer water" is a project that is led by Prof. Bilstad at UiS, which targets how to make the optimal water quality using membrane technology. It has been shown in many lab studies and field studies that injecting an optimal water offshore can improve the microscopic sweep efficiency. However, the additional oil recovered must be compared with the additional cost of switching from seawater to a more optimal water composition.

A third project, "IORSim", is a collaborative project between IRIS, UiS and IFE. In this project we develop a simulator that can be used as an add-on tool to the reservoir simulator Eclipse. The technology builds on a previous simulator, ArtSim developed at IFE for fast and accurate tracer simulator. This simulator has been redesigned and extended to account for not only non-reacting tracers but also for EOR chemicals. The ultimate goal of this simulator is to use output from a history matched reservoir model and predicting the potential of water based EOR injection. This year we have coupled geochemical reactions to the reservoir flow, and we are thereby capable of predicting the produced water composition and the reservoir pore water pH and composition. The next step of this simulator is to feedback information from IORSim to Eclipse, e.g. if viscosity is changed



**TASK LEADER:  
AKSEL HIORTH**

due to the EOR chemicals we can update the viscosity in Eclipse and if significant precipitation/dissolution occur we can update the porosity and permeability of the reservoir simulator. In order to do this backward coupling to eclipse, we have a close dialogue with Schlumberger.

A slightly separate but closely related project is that we are simulating the temperature profile in the reservoir by the use of IORSim. Many reservoir models ignore the temperature gradients induced by injecting cold water into a hot reservoir. A correct temperature profile in the reservoir is not so important for predicting the oil and water production from a reservoir under a "normal" water flood, but it is crucial if EOR chemicals are to be injected, because the performance of the EOR chemicals are greatly dependent

on the reservoir temperature. So far we have received reservoir temperature data from Statoil, BP, and ConocoPhillips which we will use to make better temperature models and more robust predictions of the performance of EOR operations.

**DID YOU COMPLETE ANY PROJECTS IN 2014?**

None of the projects were completed in 2014.

**HOW WILL YOU SUM UP 2014?**

The highlight is that the first work with the IORSim is showing great progress, and we look forward to show it at the first annual conference by The National IOR Centre of Norway; IOR NORWAY 2015.

**WHAT WILL YOU BRING WITH YOU TO 2015, AND IN THE FUTURE?**

All projects will continue in 2015, and we are excited to keep working.

**DID YOU PLAN/ATTEND ANY IMPORTANT MEETINGS OR WORKSHOPS IN 2014?**

A one day workshop was held with Schlumberger in December 2014 and a simulation workshop was held at IRIS December 2014. Meetings like these are very important in order to maintain a good relationship with our partners, and of course to share results and research across themes and tasks.



## RESEARCH PLANS AND ACHIEVEMENTS IN THEME 2:

# MOBILE OIL

## - RESERVOIR CHARACTERISATION TO IMPROVE VOLUMETRIC SWEEP

**Theme 2 will focus on the integration of field data such as pressure, temperature, seismic data, tracer data, geophysical data, and geological data into a field scale simulation model.**

Integrating available field data into an improved reservoir model gives us a better opportunity to produce the reservoir efficiently. Within Theme 2, we will focus on utilizing available data in an efficient manner, with a special focus on the use of 4D seismic and tracer data. Development of tracer technology has been an area of research at IFE for decades, and in Task 5, we will aim at developing new tracers. One of the reservoir properties that these tracers provide are the remaining oil saturation.

There are many successful applications of 4D seismic data at NCS. Still there is room for improvement when it comes to integrating these data into a reservoir simulation model. This will be one of the focus areas within the Centre. Another issue that we consider is the updating of a coupled

geomechanical/reservoir model using 4D seismic data.

Even if we use all field data available, our models will contain a substantial amount of uncertainty. While optimizing the future production of a reservoir, we strive to take into account this uncertainty. This leads us to robust production optimization as one of the subtasks.

To simulate different EOR processes investigated under Theme 1 there is a need for improved reservoir simulation tools. We aim at developing such tools. To facilitate both the need of having a reservoir simulator that can simulate full fields, and at the same time has the potential of including new features, we have decided to work on the Open Porous Media (OPM) simulator, an open-source reservoir simulator

that is freely available.

In 2014, we have focused on the following areas within Theme 2:

- Further development of tracer technology
- Improvement of reservoir simulation tools
- Robust production optimization
- Better history matching through the use of 4-D seismic data
- Evaluation of economic potential
- Investigating the connection between reservoir complexity and recovery factor potential

## TASK 5:

# TRACER TECHNOLOGY

### WHAT ARE THE MAIN ASPECTS OF YOUR TASK?

The main purpose is the development of tracer technology to measure reservoir properties and conditions during production. The most important condition is the (remaining) oil saturation, either in the flooded volume between wells or in the near-well region out to some 10 m from the well.

The deliverables from this task will be field-applicable methods and procedures to carry out such measurements in reservoirs.

### DESCRIBE THE 2014 PROJECTS:

The industrial relevance of such studies is high since this kind of data (remaining saturation maps) can hardly be obtained by any other technology. In favorable cases, 4D seismics may produce relative saturation maps. However, the data has to be calibrated, for instance, with specific information from wells in the swept volume or by the use of tracer data from interwell or from single-well push-and-pull tracer examinations.

2014 has been an introduction year with program and project definitions, some literature studies and with focus on hiring two post.docs (0.5 + 0.5) and one PhD-student. For the PhD-student one needed two application rounds where none out of 43 applications were found sufficiently qualified in the first round. By the end of 2014 the 2nd round attracted 30 applications to be evaluated in January 2015.

### DID YOU COMPLETE ANY PROJECTS IN 2014?

No projects have been completed in 2014, except from hiring two post.docs who started work in

late October 2014.

### HOW WILL YOU SUM UP 2014?

2014 has been an introductory year with focus on detailed project definition manning the projects.

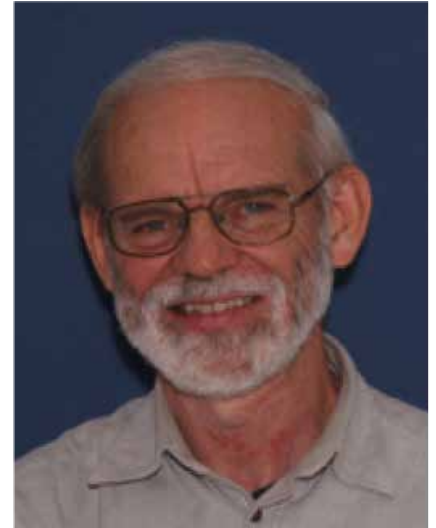
### WHAT WILL YOU BRING WITH YOU TO 2015, AND IN THE FUTURE?

2015 will hopefully be a productive year where we can report interesting experimental results both on oil/water partitioning tracer development, mainly from the PhD-study, and from the post.doc.-projects which will concentrate on developing functional (smart) tracers based on nanoparticle technology.

### DID YOU PLAN/ATTEND ANY IMPORTANT MEETINGS OR WORKSHOPS IN 2014?

We attended the following conferences/workshops with oral presentations:

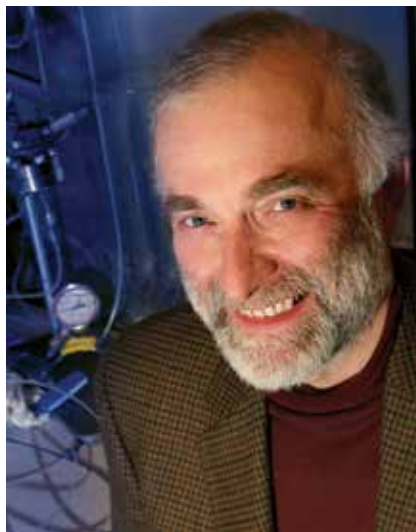
1. Sissel Opsahl Viig: SPE Workshop - Tracer Technology for Improved Reservoir Management, Dubai, UAE: "A new class of partitioning tracers to measure oil saturation in interwell regions"
2. Sissel Opsahl Viig: The 4th NPF Conference on Mature Fields, Business opportunities and challenges, Stavanger: "Phase-partitioning tracers and their role in interwell monitoring of remaining oil saturation"
3. Tor Bjørnstad: Upstream Petroleum Symposium, King Abdullah University of Science and Technology, KAUST, Saudi Arabia: "The Role of Tracers in Optimization of EOR/IOR Operations",
4. Tor Bjørnstad: Technical Seminar at University of Oslo, "A flavor of nano-particles as tracer agents in IOR"
5. Tor Bjørnstad: Meeting with GEO, DEUS and DTU, Lyngby, Denmark: "Brief about tracer technology and the National IOR Centre"
6. Tor Bjørnstad: MEOR – from theory to field implementation FORCE seminar, Stavanger, 18- Nov. 2014: "Aspects of how tracers compounds can contribute to optimize EOR/IOR processes"
7. Thomas Brichart: Technical Meeting at IFE, Petroleum Sector, "Fluorescent nano-particle tracers for oil reservoirs"



**TASK LEADER:  
TOR BJØRNSTAD**

## TASK 6:

## RESERVOIR SIMULATION TOOLS

TASK LEADER:  
STEINAR EVJETASK LEADER:  
SVEIN SKJÆVELAND**WHAT ARE THE MAIN ASPECTS OF YOUR TASK?**

For the work at IRIS, the primary objective is to provide innovative simulation capabilities to support needs arising from the other tasks within the Centre. Secondly, we hope to contribute to the general state of the art regarding simulation methodology. The PostDoc at UiS works on mathematical modeling of up-scaling between core scale and field scale with main focus on brine-dependent EOR in fractured reservoirs. Deliverables will be papers, conference presentations, and computer programs.

**DESCRIBE THE 2014 PROJECTS:**

At IRIS the main effort has been contributions towards the OPM simulation framework. This provides open source code able of handling industrial relevant models, thus offering a flexible environment for testing out new modeling concepts and methodologies.

PostDoc at UiS: The goal is to improve the geological/chemical description in the reservoir simulators. Aiming at creating a simplified chemistry system that can capture the lab behavior and is efficient enough to be applied in a field simulator. The proof of the concept will be done through history matching lab data and upscaling by comparison with numerical code.

**DID YOU COMPLETE ANY PROJECTS IN 2014?**

IRIS: Completed a minor literature study related to scope and concepts for a near-well reservoir simulator. This is likely to result in a proof-of-concept implementation within the OPM framework

during 2015.

PostDoc UiS: Completed two papers, one for presentation at the IOR conference in Dresden April 2015: 'An Analytical Model for Imbibition Experiments with Porous Plate'. It will be submitted for journal soon as well. The other is for SPEJ: 'A model for wettability alteration in fractured reservoirs'.

**HOW WILL YOU SUM UP 2014?**

IRIS: Made significant contributions to the OPM development. Assembled the task-team. OPM was finally able to run the complete Norne field model.

PostDoc UiS: The candidate finished his PhD at UiS in May, and started thereafter as a PostDoc.

**WHAT WILL YOU BRING WITH YOU TO 2015, AND IN THE FUTURE?**

At IRIS the year 2014 mainly was spent on establishing a basis, demonstrating state of the art industrial simulation capabilities within the OPM framework. From 2015 onwards we will start challenging this basis by introducing new modeling features as well as improved simulation methodology.

The PostDoc at UiS has in particular obtained better understanding of fractured reservoirs.

**DID YOU PLAN/ATTEND ANY IMPORTANT MEETINGS OR WORKSHOPS IN 2014?**

IRIS: Arranged an IOR simulation workshop in Stavanger, December 11th.

PostDoc UiS: Participated in: IOR Symposium in Tulsa, April 2014. OPM workshop arranged by the IOR Centre. IOR summer school in Delft.

## TASK 7:

# FIELD SCALE EVALUATION AND HISTORY MATCHING

### WHAT ARE THE MAIN ASPECTS OF YOUR TASK?

This task is focusing on four different subtasks. The first task is concerned with robust production optimization. Here, the focus is on developing methodology to optimize the future production taking the uncertainty in the reservoir description into account. A particular focus is paid to optimizing the production using EOR methods. The second subtask is on data assimilation (history matching) using 4-D seismic data. This is the largest part of this task with work done at IRIS, Schlumberger and TNO. Besides updating reservoir models using 4-D seismic data, attention is paid to the interaction between geomechanical and reservoir effects, including the effects of compaction. The third subtask is on evaluation of economic potential of IOR/EOR projects. Finally, a literature study on the connection between reservoir complexity and recover factor potential has been performed.

### DESCRIBE THE 2014 PROJECTS:

- "Robust production optimization – PhD student." We will investigate different optimization approaches for injection strategies of relevance for the NCS starting with waterflooding and Water Alternating Gas (WAG) and continuing to EOR processes. In the evaluation, we will take into account the fact that the reservoir model is uncertain and search for robust solutions under this uncertainty. In particular, we will develop methodology to find optimal injection strategies for EOR processes, taking into account the uncertainty in the reservoir description.
- "Robust production optimization – cooperation with TU

Delft."

This work focus on further development of methodology for ensemble based production optimization. Better theoretical understanding of the methodology is leading to potential improvements in the performance of the algorithms. A study on multi-objective optimization is part of the work. Currently two journal papers are in preparation.

- "Data assimilation using 4D seismic data." "We will investigate ensemble-based methods for joint history matching of 4D seismic and production data. A special focus is paid to the importance of uncertainty quantification of 4D seismic data. Prototype software for ensemble based 4D seismic history matching will be developed. We will also study the effects of improved uncertainty quantification of 4D seismic data on the history matching.
- "4D seismic history matching of coupled geomechanical/reservoir flow models." Data assimilation with a coupled geomechanical and reservoir simulator has been demonstrated in combining production and subsidence data. We will investigate rational methods for building coupled geomechanical/reservoir flow models. Techniques for data assimilation of these models will be developed taking into account 4D seismic and production data. In fractured reservoirs the understanding of how dynamic stress changes in the reservoir open and close the fracture systems as a result of the injection strategy is of key importance with respect to optimal depletion. Finally, methodology should be developed to utilize the assimilated models for safer well



**TASK LEADER:  
GEIR NÆVDAL**

placements taking into account dynamic stress changes in the overburden.

- "Data assimilation using 4-D seismic data: PostDoc at TNO." The project aim is to implement TNO's ensemble-based history matching workflow in an extensive field case study. This will be done with aid of a PostDoc working at TNO financed by the Centre. The PostDoc will start in 2015.
- "Improved history matching under compaction." This project aims for better reservoir parameter estimation using time-lapse seismic inversion for compacting reservoirs with quantification of associated uncertainty. In particular, focus will be on improving the knowledge about strengths and weaknesses of various seismic attributes.
- "Evaluation of economic potential." A realistic evaluation of the economic viability is essential to any IOR/EOR projects. Industry

experts will review input parameters like oil and gas prices, discount rates, capital and operational costs. We will use the same type of valuation model as in the petroleum industry, and tax issues will be addressed. When capital and personnel are scarce, a particular relevant metric is net present value (NPV) index, in which the value generated is seen in relation to the use of scarce input factors. We will also analyse the effect on production over time (relevant for production targets of the companies), and effects on accounting metrics like Return on Average Capital Employed (RoACE). Finally, we will discuss how the IOR/EOR projects affect bonus schemes prevalent in the oil companies and we will challenge them to consider EOR from day one.

IOR/EOR projects in mature fields often have a marginal profitability to companies. To society, the net present value will be higher, partly due to a lower discount rate, and partly because society benefits from gains achieved in all licenses. Part of the project is to analyse the impact of taxation on IOR/EOR projects and whether targeted tax changes can be made for such projects.

- “Reservoir complexity and recovery factor potential.” In this project a literature review of previous work discussing the

connection between the reservoir complexity and the recovery factor potential was performed. In addition a small database based on open data sets available from NPD was built. The database contained information from all fields at NCS. Based on this one can map relationships between certain parameters and the recovery factor for the fields at NCS, but more information, that is not available in open sources, might be needed in an attempt to describe the reservoir complexity of a given field.

#### DID YOU COMPLETE ANY PROJECTS IN 2014?

Reservoir complexity and recovery factor potential. See above for description.

#### HOW WILL YOU SUM UP 2014?

In the first year of The National IOR Centre we have started activities according to the original plan in the proposal. Some additional energy has been spent in recruiting of personnel, one PhD student is recruited, and three PostDocs. Two of the PostDocs will start working for the Centre in 2015, one started in 2014. In addition to the recruitment, we have aimed to establish connections between the different groups working within Task 7 (currently involving personnel from IRIS, UiS, Schlumberger and TNO). In addition, there has been coop-

eration with Dutch researchers. Besides establishing connections between the groups working within Task 7, efforts have been focused on building connections with other groups working on the IOR Centre. One of the means to achieve this was through a workshop on Tracer and 4-seismic held in March (see below).

#### WHAT WILL YOU BRING WITH YOU TO 2015, AND IN THE FUTURE?

The activities started in 2014 will continue into 2015. Better relationships have been built by the researchers working at different institutions within Task 7 and between those working on this task and the other tasks. In addition, more connections to the user partners of the Centre have been built.

#### DID YOU PLAN/ATTEND ANY IMPORTANT MEETINGS OR WORKSHOPS IN 2014?

We arranged a workshop with title “Tracer and 4-d seismic workshop” at IRIS March 27 (the day after the official opening of the Centre). There were participants from TNO, Schlumberger, IFE, IRIS and UiS and presentations from four of the companies present. At the end of the workshop there was a discussion bringing forward ideas for how the different companies could work efficiently together within the Centre.



# COLLABORATION

**We aim for an open Centre structure. Cooperation and openness are keywords for the Centre, and we strive to maintain a good contact with our collaborators. Through an active collaboration, we aim to promote applicable research of a high scientific level.**

We emphasize research exchange programs for students and researchers, collaboration in the Research Tasks, and participation in other activities like conferences, workshops and expert panels for the industry partners.

## NORWAY

We have a fruitful collaboration with several research institutes in Norway, such as the Ugelstad lab at NTNU led by Johan Sjøblom. We also work with prof. Dag Dysthe at UiO and with prof. Arne Graue's research team at UiB.

## USA

UiS is one of the participating institutions in NorTex Petroleum Cluster which is a collaborating initiative with universities and industry in Norway and Texas to facilitate coordinated collaboration on petroleum education and research between participating institutions. The Cluster will assist in facilitating industry funding for adjunct and chair positions at the collaborating universities; especially emphasizing the NorTex collaboration.

A productive collaboration with Professor Lawrence M. Cathles III

of Cornell University has already been established. Through the Centre this collaboration will be further strengthened. Particularly interesting research areas covered by Professor Cathles' are the physical and chemical phenomena that occur when two fluid phases are present. He has developed geochemical models describing induced chemical changes when fluids flow through rocks, across temperature gradients, under varying pressure and salinities.

## JAPAN

The Institute for Study of the Earth's Interior (ISEI) in Misasa (Japan) is a Center of Excellence for the 21st Century and is one of the most prestigious laboratories in geosciences, cosmosciences and micro-/nano technology in the world. The director, Professor Dr. Eizo Nakamura, is personally interested in the Centre. The pedigree and the track record of this institution are exceptional as are the analytical facilities all positioned in an ultra-clean environment of exceptional quality. We plan for exchange of both visiting scientists as well as PhDs/postdocs who will gain invaluable experiences in the field

of analytical procedures and techniques. This can in turn only be of benefit for building competence and thus transfer of exceptional experience to our IOR Centre.

## DENMARK

The three Danish institutions GEO, GEUS and DTU collaborate closely and have been partners in projects with UiS-IRIS for many years through e.g. Joint Chalk Research. They all have unique and valuable expertise useful in the Centre. GEUS and DTU are in addition involved in the new national research center to boost oil and gas research in Denmark. Efforts will be made to coordinate our research with the Danish centre.

## THE NETHERLANDS

The two Dutch institutions TNO and TU Delft collaborate closely and have been collaborating with IRIS for a number of years in the field of history matching, EnKF and production optimization. With their expertise in seismic, 4D seismic, and history matching they will give valuable contributions in the Tasks on history matching.



THE OFFICIAL  
OPENING OF  
THE NATIONAL IOR  
CENTRE OF NORWAY  
26 MARCH



VISITING FRIENDS AT  
THE OPENING OF THE  
DANISH HYDROCAR-  
BON RESEARCH AND  
TECHNOLOGY  
CENTRE AT DTU

# HIGHLIGHT



UPSCALING FROM  
LAB TO PILOT SCALE,  
COLLABORATION  
WITH HALLIBURTON  
IN A LARGE SCALE  
YARD TEST TO IN-  
VESTIGATE POLYMER  
SHEAR DEGRADATION



COOPERATION WITH  
TU DELFT ON  
IMPROVING ENSEMBLE  
BASED OPTIMIZA-  
TION IN RESERVOIR  
MANAGEMENT



ELECTION OF THE  
BOARD - AN IMPOR-  
TANT MILESTONE FOR  
THE CENTRE

# HTS 2014



MEETINGS AND EX-  
PERIENCES: HERE WE  
ARE SHARING EXPERI-  
ENCES WITH ARCEX

# THE OPENING

**The Minister of Petroleum and Energy, Tord Lien, officially opened The National IOR Centre of Norway at UiS campus on 26 March 2014.**

In his opening speech, the minister pointed out that oil recovery on the Norwegian continental shelf is 46 per cent, which is high compared to the global offshore average of 22 per cent.

«However, even with this high rate, we still leave more than half of our resources in the ground» said Mr Lien.

#### 75 OPERAS

Raising the Norwegian recovery rate by just one per cent means some 300 bn NOK in extra sales value. Improved oil recovery has, therefore, been a matter of national importance for successive governments.

«Just a one percent increase in the recovery rate would finance an additional 75 new operas identical to the one in Oslo» he said.

#### COLLABORATION

«Close contact with industry is crucial for this centre. That will ensure relevant research, and this is why Stavanger is the perfect location for this kind of collaboration,» said the minister in his speech.

The minister acknowledged the importance of researching into renewable energy solutions as

well as fossil ones, but stressed that both are necessary.

«Oil and gas will have to cover a large portion of the world's energy needs for decades to come. This is the case even when renewable energy is expected to increase its share of the energy mix.»

#### HEROES

The cabinet minister expects great results from the Centre, both in terms of scientific papers and educating a new generation of scientists through master and PhD programs.

«It is usually the scientists that are the real heroes of this industry,» concluded Mr Lien.

#### INTERNATIONAL SYMPOSIUM

The Research Council of Norway and other policy makers greeted the new centre in front of an audience of some 300 representatives of industry, government and academia.

A scientific symposium with participants from cooperating universities in Europe, USA and Japan followed the opening ceremony.

**“IT IS USUALLY THE SCIENTISTS THAT ARE THE REAL HEROES OF THIS INDUSTRY”**

**- TORD LIEN**

**MINISTER OF PETROLEUM AND ENERGY**



### Pictures from the official opening of The National IOR Centre of Norway.

1. The Centre was opened by the Minister of Petroleum and Energy of Norway, Tord Lien.
2. Merete Vadla Madland, Director of The National IOR Centre of Norway with the Minister of Petroleum and Energy, Tord Lien, on the opening day.
3. The Management Team in appropriate gear for maximizing the oil recovery on the Norwegian continental shelf.



# RECRUITMENT 2014



Recruitment for Research fellowships for each of the seven tasks was announced as a joint announcement January/February 2014. There were qualified applicants for four of the positions, for the other three a new announcement was proposed. Of the four who were offered the positions, we ended up with three employ-

ees; Task 1, Task 2, and Task 7. The candidates started their doctoral projects in September/October.

The vacant positions were announced for the second time, in addition to one PhD position related to task 1. The application deadline was set to mid November 2014. Three candidates were

offered positions related to task 3, task 6 and task 4 in the beginning of 2015.

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## PHD PROJECTS:

### Task 1: Core scale modeling

Candidate: Oddbjørn Nødland

Title: "Development of models that describe the transport mechanisms observed in core-scale experiments."

Supervisors: Arne Stavland (IRIS) and Aksel Hiorth (UiS/IRIS)

### Task 2: Mineral Fluid reactions at nano/submicron scale

Candidate: Laura Borremo

Title: "Which alternations observed on nano/submicron scale may affect changes in surface properties, e.g. wettability?"

Supervisor: Udo Zimmermann (UiS)

### Task 7: Robust production optimization

Candidate: Aojie Hong

Title: "Mathematical models for optimization of oil and gas production allowing for an uncertain reservoir description."

Supervisors: Geir Nævdal (IRIS) and Reidar Bratvold (UiS)

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## Post doc positions

A total of five postdocs were employed during 2014. 2 at IFE (50% each), 2 at IRIS, 1 at UiS. The percentage of female is 60%.

### The Post Docs:

- Tomas Brichart, IFE
- Mürside Kelesoglu, IFE
- Kjersti Solberg Eikrem, IRIS
- Trine Solberg Mykkeltvedt, IRIS
- Pål Østebø Andersen, UiS

# EDUCATION

## The Department of Petroleum Engineering at the University of Stavanger is at the forefront of petroleum engineering education worldwide.

The Department offers undergraduate and graduate programs in petroleum engineering and petroleum geology. MSc in Petroleum Engineering is uniquely focused on the specific needs of the upstream petroleum industry. The MSc in Petroleum Engineering has an international profile and accommodates both Norwegian and international students. From the academic year 2014/2015 the program will offer three specialisations: Well Engineering, Reservoir Engineering and Natural Gas Engineering.

MSc in Petroleum Geosciences Engineering is focused on the specific needs of exploration and production of the petroleum industry. The program has an international profile. A graduate of the program will be able to solve geosciences problems by integrating different types of surface and subsurface data used in the oil industry and to integrate such information with petroleum engineers.

The Department of Mathematics and Natural Sciences offers a Master of Science in Mathematics and Physics, primarily focusing

on mathematical and physical modelling from the academic year of 2014/2015. The main learning outcome of the program is advanced knowledge about modelling of mathematical and physical systems. Furthermore, the students should be able to demonstrate fundamental physics related to petroleum exploration, the ability to synthesize appropriate mathematical concepts and methods in order to analyze and solve relevant problems.

A master program in Environmental Technology offered within the same department with two specialisations Offshore Environmental Engineering and Water Science and Technology. The Offshore Environmental Engineering combines courses in offshore oil and gas exploration, production technologies and environmental management. The specialisation in Water Science and Technology focuses on aquatic chemistry and ecology, and technologies for water and wastewater treatment.

### STATUS OF STUDENTS IN 2014

24 M.Sc theses within Petroleum Engineering, Environmental technology and Geosciences Engineer-

ing.

31 BSc theses within Petroleum Engineering, Geosciences Engineering and Mathematics and Physics.  
Examples of thesis titles linked to the National IOR Centre of Norway:

- Study of a Model for Spontaneous Imbibition as a Mechanism for Oil Recovery in Naturally Fractured Reservoirs (Professor Steinar Evje)
- Correct Sampling of Gas Condensate Reservoir with Liquid Drop Around the Well (Professor Svein Skjæveland)
- The Effect of Stress Level and Temperature on Water Weakening of Chalk (Professor Merete Madland)
- "Risk Matrices" A study of Risk Matrices Their use in the Oil&Gas industry (Professor Reidar Bratvold)
- Smart Water for EOR by Membranes (Professor Torleiv Bilstad)

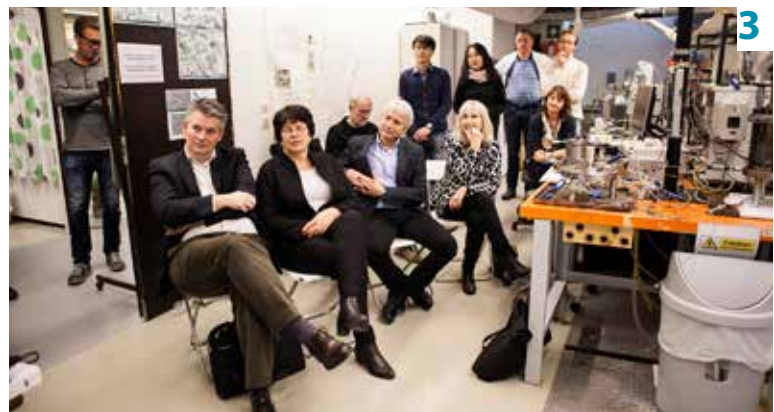
# DISSEMINATION



1. The University of Stavanger and IRIS shared a stand promoting The National IOR Centre of Norway at ONS 2014.



2. Merete Vadla Madland, Director of The National IOR Centre of Norway with the President of Ghana during a visit to IRIS.



3. Secretary of State, Bjørn Haugstad, visited the labs of The National IOR Centre of Norway at University of Stavanger.



4. Parts of the Management Team at a press conference at ONS 2014.



**“It is vital to show that the researchers at The National IOR Centre of Norway are working hard to find the best possible solutions to improve the recovery rate”**

The National IOR Centre of Norway has invested in ways to better the communication, both internal and external. In 2014 we employed a communications advisor who handles most of the external communication, as well as parts of the internal communication. Communication will continue to be a priority in the future.

It is vital to show that the researchers at The National IOR Centre of Norway are working hard to find the best possible solutions to improve the recovery rate.

The National IOR Centre of Norway sends out two newsletters; one internally to strengthen solidarity within the Centre, and one external newsletter to inform others about what is happening at the Centre. This is used to maintain a well-functioning flow of communication with our partners and the industry in general. We work to secure a broad national involvement.

Through the University of Stavanger, the Centre has also received a well-functioning website ([uis.no/ior](http://uis.no/ior)), which is frequently updated. The long term plan is to produce and publish research news, but also to continuously publish news about what's happening at the Centre, such as visits, workshops and important meetings. Research news will also be published on platforms such as [forskning.no](http://forskning.no).

From 2015 we will host an annual IOR Conference, IOR NORWAY, and we will also host smaller workshops several times a year.

The National IOR Centre of Norway has been represented on a number of occasions, including in popular scientific context. Centre Director Merete Vadla Madland has presented on numerous events, both academic and public events. Some examples are Girl Geek Dinner, for the president of Ghana, government delegations and for school classes. This is in addition to all scientific presentations that have been made.

93 reports, articles, presentations, etc., aimed towards the Centre's target group, have been made in 2014. In addition, a total of 139 articles have been published in various medias about the Centre. We aim to be present and visible, and all the Centre's researchers are encouraged to present their work as often as possible.

The Management of the Centre works actively to maintain a good relationship with the industry partners, and also potential new partners. On several occasions, representatives have presented the Centre and its vision for the industry. This also helps to show our position in the region, and we have repeatedly received feedback that we appear to be present, which is also our goal. We want to form a true base for the IOR competence in Norway.

# ECONOMY

<b>OPERATING INCOME AND OPERATING COSTS</b>	<b>2013</b>	<b>2014</b>	<b>Total 2013 and 2014</b>
<i>(All numbers in 1000)</i>			
Remaining as per 31.12 previous year	0	-54	
UiS - own contribution	306	8 873	9 179
RCN	0	8 167	8 167
User partners	0	22 000	22 000
User partners - in kind	0	2 345	2 345
<b>Total operating income</b>	<b>306</b>	<b>41 331</b>	<b>41 691</b>
Payroll expenses	318	9 391	9 709
Procurement of R&D services	0	20 922	20 922
R&D services - in kind	0	2 345	2 345
Other operating expenses	42	1 793	1 835
<b>Total operating expenses</b>	<b>360</b>	<b>34 451</b>	<b>34 811</b>
<b>Operating profit</b>	<b>-54</b>	<b>6 880</b>	

## COMMENTS TO OPERATING INCOME AND EXPENSES IN 2013:

- ▶ Income and expenses were charged to a pilot project and to the faculty.
- ▶ Own contribution relates to payroll expenses for Management and operating expenses.
- ▶ Payroll expenses in 2013 relates to Management and administration.
- ▶ Other operating expenses relates to travel costs, profiling etc.
- ▶ Negative operating profit is transferred to 2014.

## COMMENTS TO OPERATING INCOME AND EXPENSES IN 2014:

- ▶ A project structure was built for the IOR Centre at UiS.
- ▶ Decision was made in May 2014 that the IOR Centre is subject to VAT. This is an exception from government financial.
- ▶ Own contribution from UiS covers 26 % of reported operating expenses.
- ▶ Income from RCN includes NOK 502' for 2013 and NOK 7665' for 2014. Remaining amount for 2014 NOK 251' will be transferred from RCN in 2015.
- ▶ Income includes payments from 10 user partners. They each paid NOK 200' for 2013 and NOK 2.000' for 2014.
- ▶ Halliburton and Schlumberger each contribute by providing work in kind.
- ▶ Payroll expenses includes IOR Management, administration, R&D, PhDs, laboratory personnel and student assistants. Real costs versus RCN rate for PhDs
- ▶ Procurement of R&D services includes both 2013 (NOK 765') and 2014 (NOK 20157'). This relates to services from IRIS, IFE and NTNU.
- ▶ Positive operating profit is transferred to 2015.

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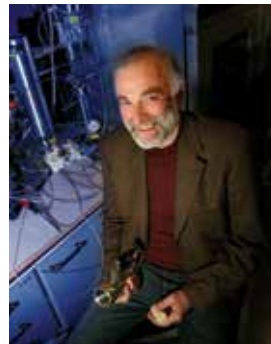
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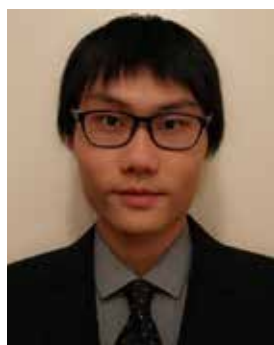


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