University of Stavanger

THE NATIONAL IOR CENTRE OF NORWAY

Annual report
2019

The 2019 partners

University of Stavanger

NORCE

IFE

NEPTUNE ENERGY

wintershall dea

eni vår energi

HALLIBURTON

Schlumberger

ConocoPhillips

Lundin Norway

equinor

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Observers

With funding from The Research Council of Norway

NORWEGIAN PETROLEUM DIRECTORATE

petoro

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About

The National IOR Centre of Norway provides solutions for improved oil recovery on the Norwegian Continental Shelf through academic excellence and close cooperation with the industry.

The world needs energy. Up to present day oil and gas have contributed to the primary energy by more than 80 %, and even in the 2-degree scenario of the United Nations more than 50 % of the total energy must come from oil and gas. On the Norwegian Continental Shelf, more than 50 % of the total discovered resources are still left in the ground. By extracting most of the discovered resources using existing infrastructure, we protect the environment while utilizing resources in the best possible way.

The National IOR Centre of Norway provides cost efficient and environmentally friendly solutions for improved oil recovery on the Norwegian Continental Shelf through academic excellence and close cooperation with the industry.

TWO YEARS LEFT

Awarded by the Research Council of Norway (RCN) after a national competition, the Centre started up in December 2013. We were granted 5 + 3 years of financial support by RCN. We are now entering phase II of the Centre's lifetime.

University of Stavanger is the host of the Centre, and the research institutes NORCE (formerly known as IRIS) and IFE are our research partners. Several other national and international research groups, and 9 oil and service companies, complete the Centre's list of partners and collaborators.

The researchers in the Centre work actively in order to improve the oil recovery, whilst reducing costs and mitigating environmental impact. To achieve this goal, it is important that all stakeholders work together, and The National IOR Centre of Norway is an important arena for doing exactly this.

OVERALL AIM

The National IOR Centre of Norway will contribute to the implementation of cost efficient and environmentally friendly technologies for improving oil recovery on the Norwegian Continental Shelf.

SECONDARY OBJECTIVES

- 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.
- Education of 20 PhD students and 8 postdocs during the lifetime of the Centre.

THEME 1: MOBILE/IMMOBILE OIL & EOR METHODS

In theme 1 the main goal is to understand, model, and upscale the microscopic and macroscopic displacement efficiency when various enhanced oil recovery (EOR) fluids are injected into a porous rock. EOR fluids interact with the rock, alter primary mineral phases, and their surface properties. Some EOR fluids are non-Newtonian (e.g. polymeric fluids) and behave highly non-linear in complex and time-dependent flow, which is relevant for porous media. Other injection fluids, such as Smart Water (or low salinity water) interact with the minerals to alter wettability in the reservoir.

To understand these processes, and to solve related challenges we work at the submicron scale to characterize the rock before and after flooding, and to quantify the changes induced by the injection water. We also work at core scale to investigate wettability and wettability alteration processes. And the dynamics of polymeric liquids are investigated experimentally by performing experiments in porous material at various scales. The experimental results are interpreted using molecular dynamic simulations, methods based on statistical physics, and by extending Darcy's law. A multi-scale understanding of the EOR processes secures that the reservoir scale models we develop are consistent with the underlying physical and chemical processes taking place in the pore space. This, in turn, allows us to evaluate, in a robust way, the potential of EOR operations for realistic cases.

The EOR methods based on Smart Water are in principle environmentally-friendly, as they don't contain extra chemicals. The environmental impact of using added chemicals, such as polymers, is addressed through an improved understanding of the optimal amount of chemicals needed to efficiently displace the oil and the fate of the chemicals from the injector to the producer.

THEME 2: MOBILE OIL – RESERVOIR CHARACTERISATION TO IMPROVE VOLUMETRIC SWEEP

In theme 2 we focus on improved reservoir management by developing improved tools for uncertainty quantification, simulation, history matching, optimization, prediction, and decision making. This is done by; integrate information from of all types of data (such as pressure data, production data, seismic data, tracer data, geo-physical data, and geological data into the field scale simulation models) in our work flow; by developing improved simulation tools capable of handle/simulate the complexity of different improved oil recovery (IOR) methods; and by developing new and improved tracers.

We put emphasis on real fields and aim to develop methodologies that ease the decision making of a petroleum producing reservoir. The aim is to develop new and improved methodologies that will support the evaluation and decision making with regards to IOR/EOR pilots at the Norwegian Continental Shelf. This addresses the potential of producing the resources in unswept areas as well as mobilizing the trapped resources in swept areas. The research is focusing on challenges for the entire Norwegian Continental Shelf while demonstrating the improved methodologies on real field cases.

Greetings from the Director

I am honored to serve The National IOR Centre of Norway as new Director in its last two years. I have been following the Centre and working alongside with many of the scientists and PhDs candidates from its very start, and I am proud to say that the Centre has made great scientific achievements and educated many future IOR brains. Yes, IOR does require more brains per barrel. We have, in the past 6 years, published around 150 high-impact paper, almost 700 conference presentations, numerous workshops with our industrial partners, and filled our IOR toolbox with modelling tools such as IORSim, IORCoreSim and OPM, recommended procedures for characterization of rock and core samples, reservoir characterization and modelling, environmental risk of EOR chemicals to marine environment, and more. Our work has established a strong foundation for further increasing the recovery rate in a cost-effective and environmental-acceptable way in the future chapter of oil and gas industry on the Norwegian Continental Shelf.

One of our main challenges in the remaining two years of the current Centre is to deliver more advanced tools and methodologies for future IOR project implementation. The knowledge and tools from our work must show their value and real benefit to the industry and society, in addition to the scientific publications and posters on the wall. We must find ways to apply and implement our new tools and knowledge to solve problems and to overcome showstoppers in new IOR projects which lead to additional value from the existing fields and at the same time with lowered and eventually zero harmful emission to sea and atmosphere.

We have started planning towards tangible deliverables to the industry by 2021. Our ambitions, however, does not stop there. We will try our best to keep the intellectual asset and further mature our tools beyond 2021. We will involve our current and new industrial partners, authorities, and educational and research institutions to build the continuing IOR research and education. We believe that we can contribute to produce the "challenging barrels" (ref. NPD's Resource Report) and utilize our national hydrocarbon resources to a better society.

Greetings from the Chairman of the Board

In 2019, The National IOR Centre of Norway has progressed key activities towards adoption by the industry. Based on the understanding of fluid transport and chemical mechanisms suggested by the nano- and pore scale activities and further studied by core experiments, the Centre developed a core scale simulator describing better the EOR processes. This work, further upscaled in the newly developed full-field EOR simulator, IORSim, will help the industry assess the value and de-risk field EOR projects. The Centre is also progressing on methods to better monitor and improve the effect of existing drainage strategies, through the development of tracers identifying remaining oil in place and the improvement in workflows for automating the history matching for an increasing number of data types including tracer responses and 4D seismic data. The new knowledge and tools have been disseminated with a number of workshops with end users. The Centre's research has more focus on using real field data to test and validate the research results.

The Centre is now entering the last two years of the assignment it originally received in 2013. It has developed a robust work programme in partnership with the industry with the objective to convert the extensive research into industry projects piloting the developed EOR/IOR methods, workflows and softwares. In this period, the Centre will also need to better define its longer term future beyond 2021 to preserve the continuously increasing value derived from the competence developed for all scales from pore to field, from the tight collaboration between NORCE, IFE and UiS, from the education of the next generation of engineers and from the alignment of activities with the industry's needs. The Centre will update the list of challenges it needs to resolve, and capture the learnings from the activities to date.

The clear definition of the longer term future, along with the concrete applications and value from the integration of the various efforts described in the work programme, will allow a continued and growing influence of the Centre on major priorities: Maximization of economic recovery from existing fields and minimization of the impact of our industry on the environment, via a much more efficient extraction, but also by investigating the benefits of CO_2 flooding.

NORCE is a research institute, with expertise in a wide range of fields. Researchers within the Energy Department of NORCE run several of the major projects in the Centre.

The energy group at NORCE conduct research in the field of oil/gas and renewable forms of energy, with a focus on cost-efficient, safe energy production that guarantees the lowest CO_2 footprint possible during the green shift.

IMPORTANT PROJECTS

Researchers at NORCE are involved in several major research projects in task 1, 3, 4, 6 and 7.

- Task 1: The project DOUCS-Deliverable of an Unbeatable Core Scale Simulator aims to develop a tool for improved simulation of EOR processes at the core scale. The project Core plug preparation procedures addresses the importance of representative wettability conditions in SCAL and EOR -experiments and aims to develop methods to determine whether reservoir core plugs are contaminated by mud.
- Task 3: The objective of the pore scale task is to identity mechanisms that influence fluid transport, chemical reactions, and oil recovery. The main topics in this task have been to study the behavior of polymers and the effect of water chemistry on the strength and structure of the pore space.
- Task 4: The IORSim project is a collaborative effort between IFE, NORCE, and UiS to develop a simulator that can bridge the gap between the research prototype simulators and industry standard reservoir simulators. The large (yard) scale project is led by Halliburton with a very good collaboration with activities in Task 1 and Task 5.
- Task 6: Improved modeling methodology and simulation capabilities for IOR are important to perform reliable pilot and full field simulations. In this project, we contribute towards the OPM simulation framework. This is an open source code able of handling industrial relevant models, which provides a platform for testing innovative reservoir simulation developments in general. We anticipate that the resulting improvements will lead to better decision making and, hence, improve oil recovery on the Norwegian Continental Shelf.
- Task 7: The economic feasibility of implementing new IOR methods on a field needs to be evaluated, preferably taking the uncertainty in the reservoir description into account. While optimizing future production, environmental constraints need to be considered. The evaluation will be based on history matched reservoir models. An important focus in this task is to develop better methods for full field history matching using 4-D seismic data. The history matching is done using ensemble-based methods, but we consider use of different types of seismic data for inversion.

IFE is a research institute within energy, health and industrial development. IORSim and tracer technology are the most important IFE contributions in the IOR Centre.

IFE is an independent foundation and one of the world's foremost research communities on energy, located in Halden and Kjeller. They have developed unique skills over 70 years of researchers and international projects in their reactors and laboratories. Offshore, IFE has developed low-emission petroleum technology and advanced digital solutions for management, security and communication. The knowledge, innovation and development at IFE has created hundreds of billion NOK in values for Norway and improved safety, environment and climate both at home and abroad.

IMPORTANT PROJECTS

Researchers at IFE are involved in research projects in task 4 and 5.

- Task 4: The IORSim project is a collaborative effort between IFE, NORCE, and UiS to develop a simulator that can bridge the gap between the research prototype simulators and industry standard reservoir simulators. Major achievement since last reporting is implementation of cross-flow in wells. Ongoing work: i) investigate further the coupling between IORSim and Intersect and ii) use Ekofisk water chemistry data to verify/calibrate IORSim iii) continue our work on the Snorre sector model to simulate silicate plugging.
- Task 5: The overall objective of this task is to improve and develop new tracer technology for in-situ determination of residual oil saturation (SOR) and for improved description of flow fields. Both tracers for investigating the swept volumes between wells (interwell examination) after some period of secondary oil production and for examine the effect of various tertiary recovery methods by push and pull operations in the near well region are developed. The targeted methods are aimed to produce valuable data for evaluation of the need for infill wells, conformance control and evaluation of the most efficient EOR method for a given oil field.

  At present, several scientists one PhD-student (Arun Kumar Panneer Selvam, started in March 2019) is involved in this task. Selvam is working with carbon quantum dots for fracture detection in interwell operations and with nano-carriers for passive water and water-oil partitioning tracers for SOR determination in the near-well zone. In addition, a team of scientists are working with new hydrolyzing ester compounds for near-well SOR determination.

On the use of thermo-thickening polymers for in-depth mobility control – large scale testing

The EOR potential from polymer flooding can be improved by using associative polymers which form intra- and inter-molecular networks. In this work we performed flood experiments at core scale and successfully upscaled the experiments to 1-meter scale. Different test procedures were applied.

Firstly, we mimicked temperature gradient by injecting the polymer through three serially mounted cores at temperature of 20, 60 and 80°C. At 20°C, the associative polymer had flow properties as a regular polymer, while revealing thermo-thickening behaviors when heated to 60 and 80°C. By varying the type of porous media, we observed similar flow behavior in both sandstone cores and high permeability sand columns and could therefore conclude that thermo-thickening is not sensitive to type of porous media. However, thermo-thickening depends on brine salinity and type of associative polymer.

Secondly, we scaled up the experiments from 7-cm cores to 1-meter long column. When injecting the associative polymer at 80°C we observed thermo-thickening over the entire column length. By varying the flow velocity, we confirmed the previous finding, that flow resistance depends strongly on the velocity, i.e., low velocity yields high flow resistance. In the 1-meter column the temperature was, at the end of flood experiment, stepped down.

Figure 1 shows that the on-set temperature for thermo-thickening is between 40 and 60°C for this combination of associative polymer and brine salinity. In the same experiment, the polymer viscosity was measured by in-line capillary tube viscometer, see Figure 2.

The effect of scaling was indeed observed; the flow through capillary tube with radius of 500 µm revealed mobility reduction of 5, while the same polymer through sand column with pore size of 10 µm, yielded significantly higher mobility reduction.

Our next steps are to re-run the 1-meter experiment, then further scale up the column length to a multi-meter experiment, and the results will be used as input to model the experimental observations.

Text: Arne Stavland, leader task 1

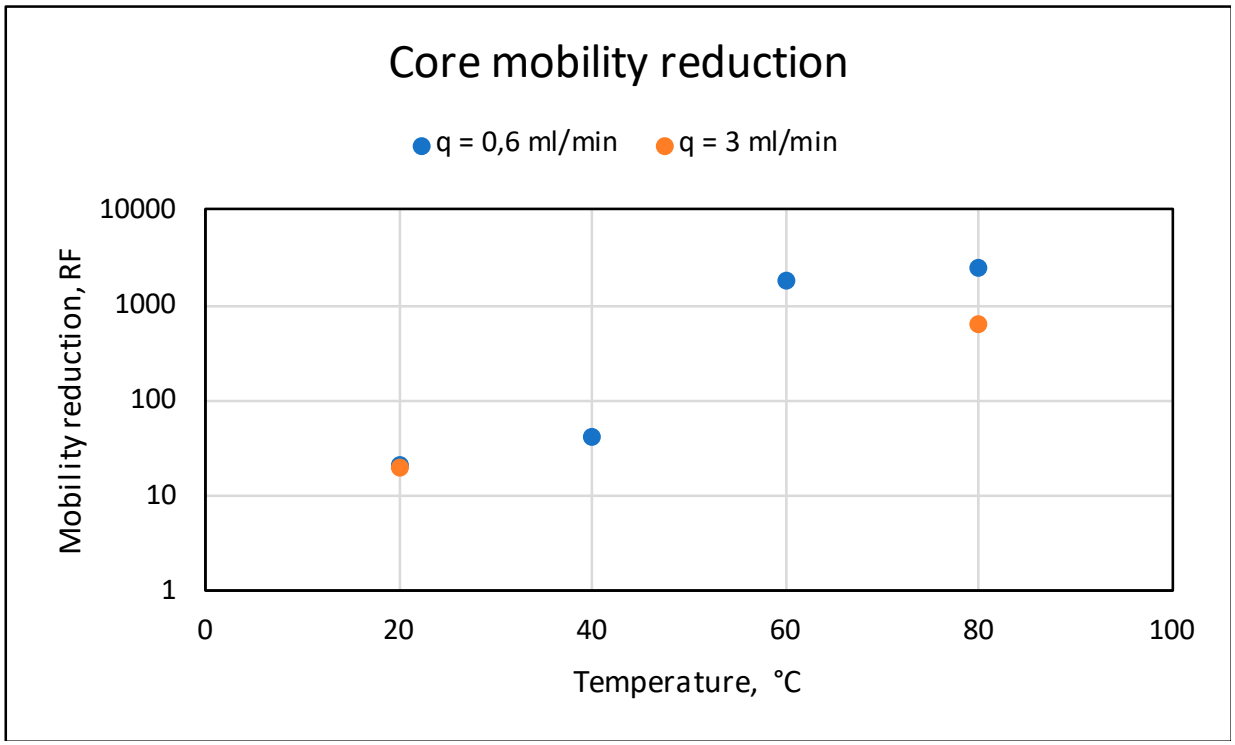


Figure 1 Measured mobility reduction in sand column.

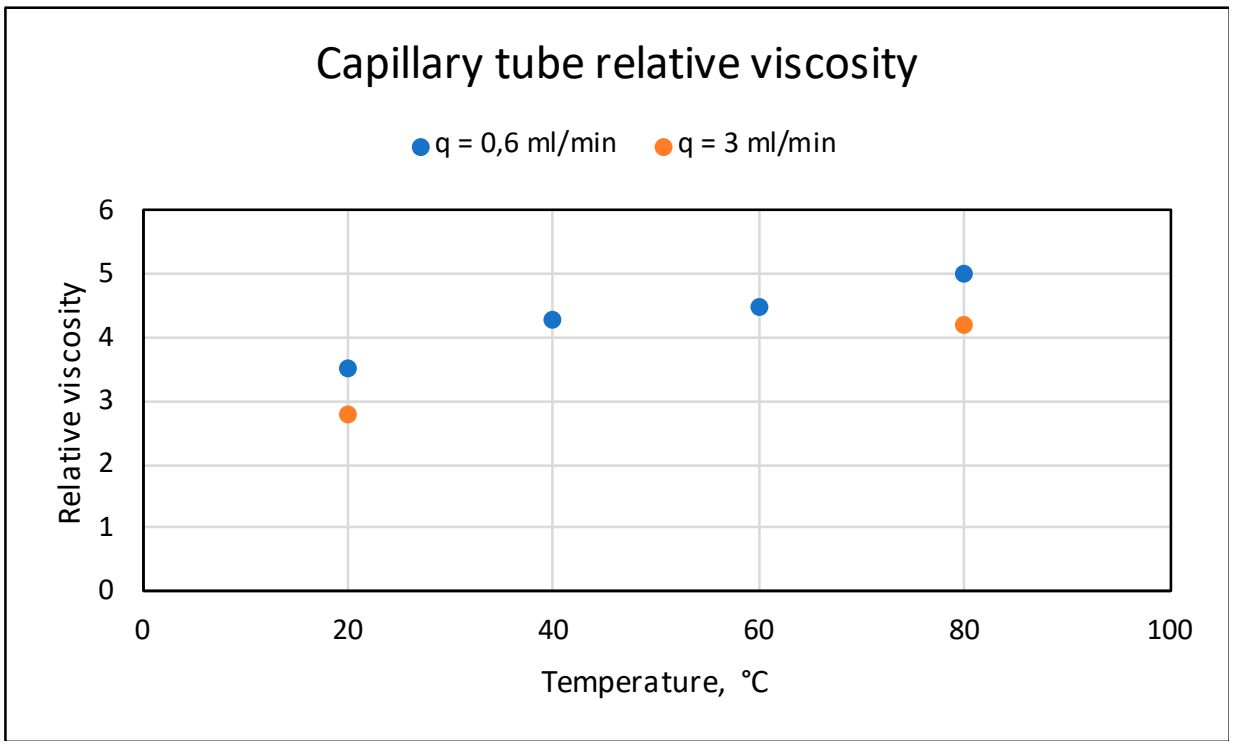
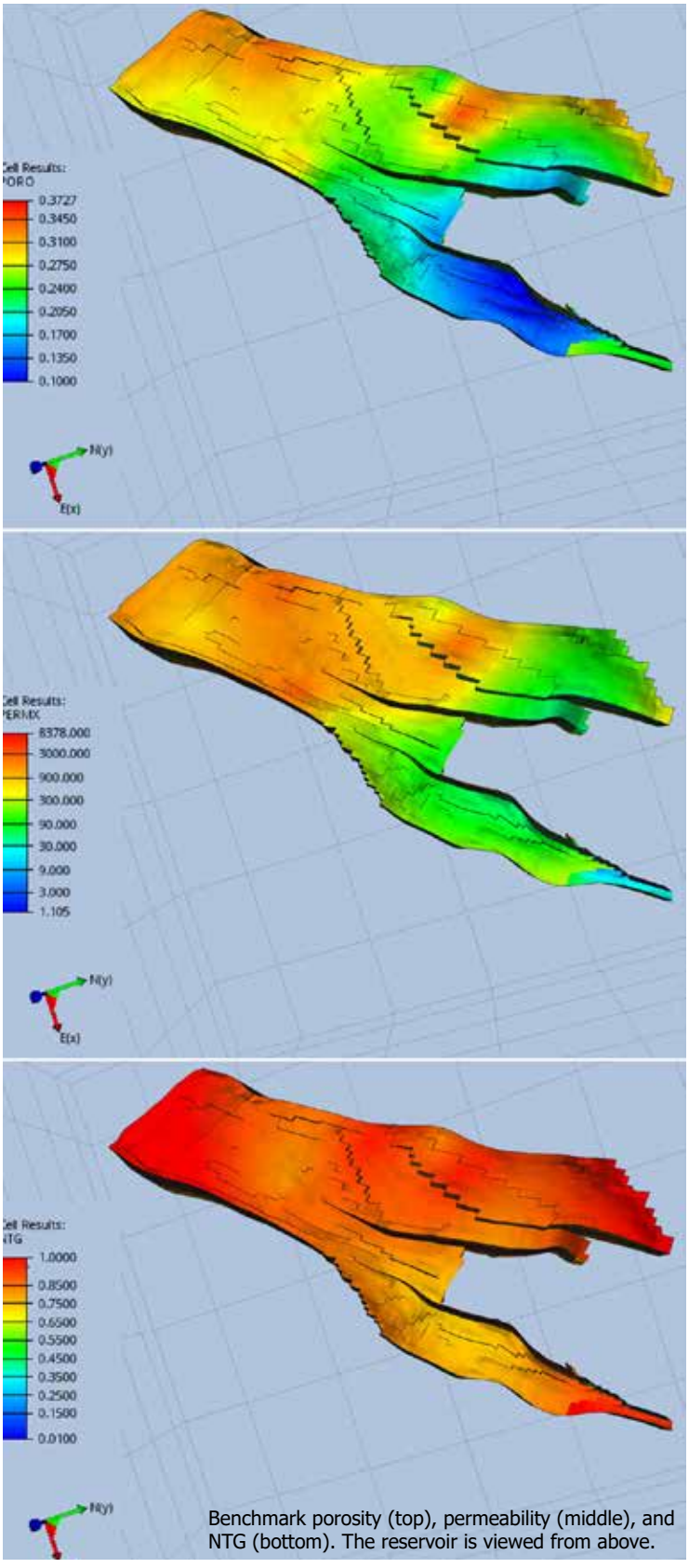


Figure 2 Measured mobility reduction in capillary tube.

Developing the ensemble Kalman filter based approach for history matching



Benchmark porosity (top), permeability (middle), and NTG (bottom). The reservoir is viewed from above.

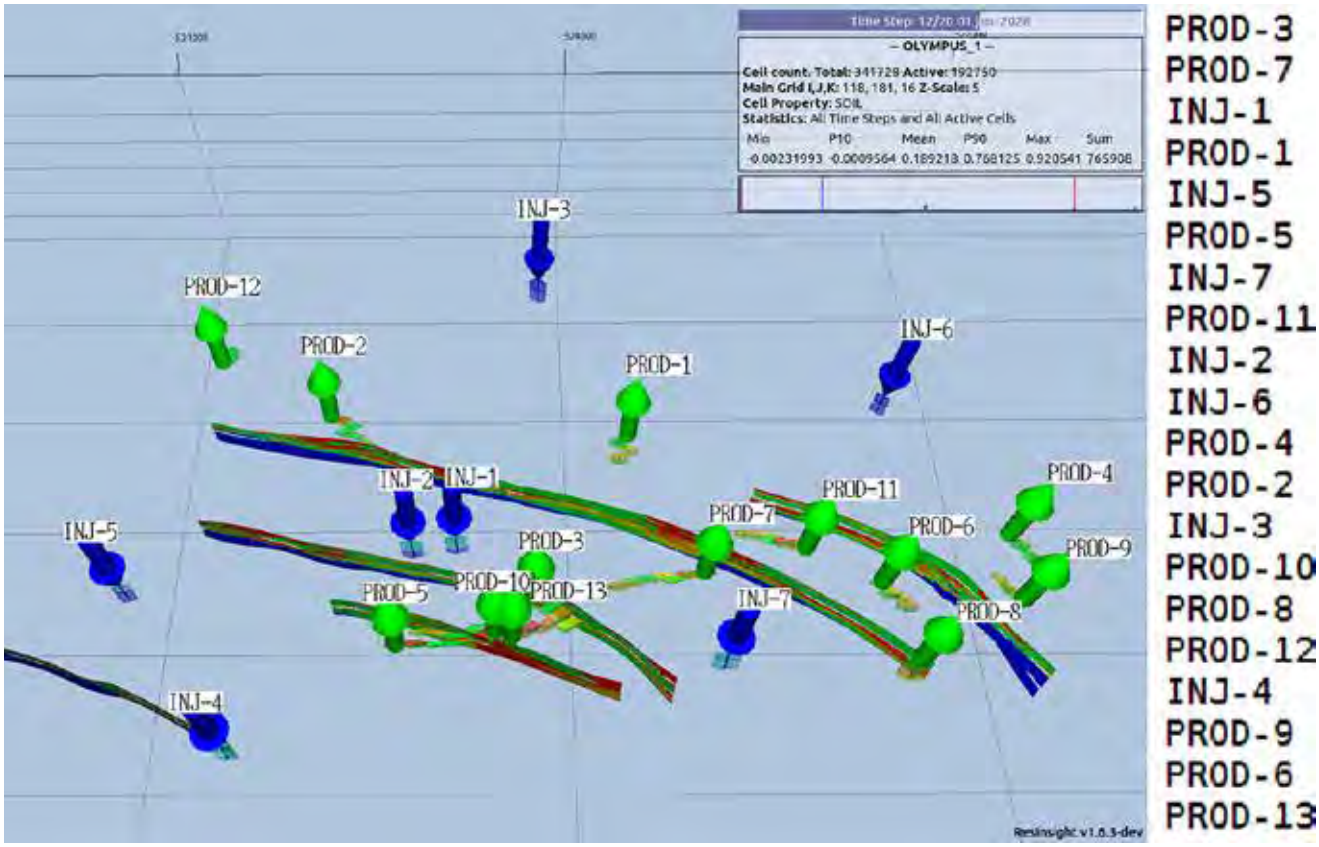
At The National IOR Centre of Norway there has been a focus on further developing the ensemble Kalman filter based approach for history matching. The focus has been on utilizing 4D seismic data in addition to the production data. Combined history matching of 4D seismic and production data is considered as difficult for several reasons. Several obstacles has to be dealt with. The weighting between the production data and 4D seismic data is not trivial. The amount of 4D seismic data is huge, and it is difficult to quantify the uncertainty of these data. Moreover, additional modeling has to be added beyond the reservoir simulation model, depending on how the information from the 4D seismic data is utilized. From the start of the IOR Centre there has been a focus on handling all these issues.

A set of techniques for handling the different problems described above has been developed and demonstrated on synthetic models, before the final test was done on history matching both the production and 4D seismic data on the Norne field case. A first study was presented at a conference in 2018. In that case the production and 4D seismic data was history matched sequentially, first matching the production data and there after the 4D seismic data. This caused a slight deterioration in the qua-

lity of the match of the production data after inclusion of the 4D seismic data. In the most recent study we found that it was better to history match the production and 4D seismic data simultaneously. The result of this study was presented in a paper in Computational Geosciences in 2019 (Lorentzen et. al., 2019). To achieve these results we benefited from a close collaboration with the Petromaks2 project "4D Seismic History Matching".

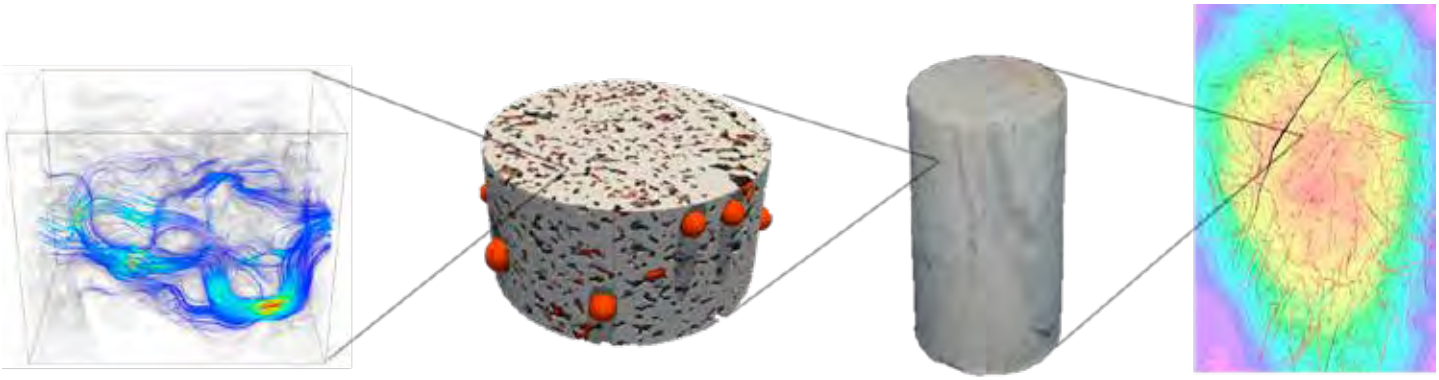
Another application of ensemble based methods are within production optimization, in particular in the cases when one is going to make decisions given an ensemble of reservoir models. Here, in work done together with Equinor, we showed how one can utilize ensemble based production optimization on the new OLYMPUS benchmark study, an exercise consisting both of optimal production with a fixed set of wells, but also planning the location and drilling of new wells. This study was also published in Computational Geosciences in 2019 (Chang et. al. 2019).

Text: Geir Nævdal, leader task 7



Optimal well locations. The drilling order is provided on the right.

Coordinating Upscaling Workflow



The National IOR Centre of Norway with research partners UiS, NORCE and IFE are launching a new project from 2021. This project will coordinate the upscaling efforts within the IOR Centre themes. The different themes and tasks have throughout the Centre work used and developed models including the effects relevant for the different scales with some initiatives on upscaling. The aim is that this project will merge and unify these procedures into an upscaling workflow, and thereby assist the further work in uncovering unresolved effects and knowledge gaps on the different scales. It will be the task of this project to initiate appropriate actions to investigate and fill these gaps.

The main objective is to obtain a robust upscaling of recovery mechanisms observed on pore, and core scale to field scale. This will be accomplished by developing a workflow for upscaling the transport of components and effects of chemical interaction from pore to core to field. We will also develop a similar workflow for obtaining effective rheologies for polymer fluids based on pore scale models and core scale experiments.

A challenge for upscaling is to identify what mechanisms on smaller scales that are important in determining the large-scale behavior. Similarly, it is important to be aware that there are larger scale mechanisms, such as gravitational effects, that may come into action when upscaling a system. An increased recovery observed on the core scale does not necessarily translate to a similar increased recovery on the field scale. Compared to field scales that ranges from meters to kilometers in size, cores are merely centimeters in length, and diffusion and «end effects» are important.

In the reservoir, transport is dominated by advection. Here, large gradients in temperature and chemical composition are possible. The flow will be affected by large scale structures like faults and changes in rock structure (porosity/permeability). For all these reasons, core experiments do not directly translate to the reservoir scale and can only calibrate models designed to facilitate this rescaling. Reservoir simulators usually have resolution on the meter scales, hence heterogeneities on these scales need to be incorporated in effective flow functions and rheologies.

Text: Olav Aursjø, project manager

Interpore – 3rd National Workshop on Porous Media

Professor Bill Rossen, TU Delft was one of the speakers at the Interpore seminar. He is also member of the scientific advisory committee.
Photos: Kjersti Riiber

Professor Aksel Hiorth

The National IOR Centre of Norway was hosting the 3rd National Workshop on Porous Media 16 October 2019 – Interpore.
The event took place in Oljemuseet, Stavanger. Around 40 participants got the latest update on recent technological advances in porous media research, microfluidics, thermo/fluid dynamics, and rheology – theory, modelling, and experiments.

Interpore Norway is providing a platform for the Norwegian porous media researchers/scientists to come together and exchange ideas. For this reason, Interpore Norway arranges an annual workshop for all people who are interested in porous media research and technology.

The presenters this day were

- Bill Rossen, TU Delft
- Dmitry Shogin, University of Stavanger
- Martin Fernø, Universitetet i Bergen
- Johan Olav Helland, NORCE
- Alex Hansen, NTNU
- Gaute Linga, Universitetet i Oslo

New members of the management team

YING GUO, DIRECTOR

Guo has broad experience within IOR and EOR. In addition to leading the Centre she is working as senior business developer at NORCE. She will continue part time in this position. Before this, she was research director for the IOR group at Iris (2015-2017), and she also spent ten years in Total, both as head of the section for R&D Subsurface and as a specialist engineer.

Guo holds a PhD in Reservoir Engineering from NTNU 1988, a Cand Tech from UiS (previous Rogaland Regional College) in Reservoir Engineering and a BSc in Petroleum Engineering from UiS (previous Rogaland Regional College).

TINA PUNTERVOLD ASSISTANT DIRECTOR

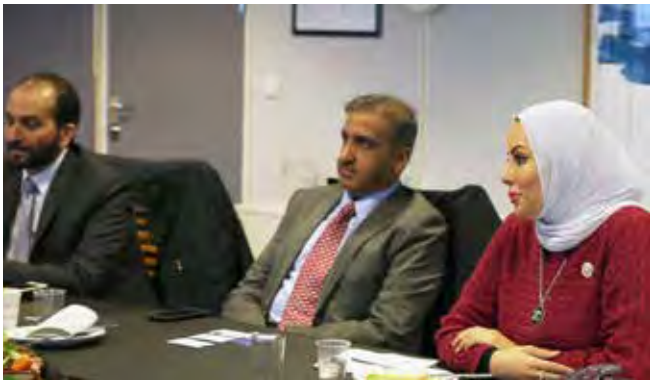
Puntervold is associate professor at UiS. Together with associate professor Skule Strand and retired professor Tor Austad she has established the Smart Water EOR Group at UiS. Her research focuses on reservoir chemistry and water-based EOR, such as Smart Water injection in carbonate reservoirs and Smart Water/low salinity water injection in sandstone reservoirs.

Puntervold has many years experience in petroleum research and teaching. She is one of the most productive researchers at UiS, and her work is often cited. She holds a PhD in petroleum technology (UiS), and a MSc in physical chemistry (UiB). She has also studied Spanish language and Latin America studies at UiB.

MICOL PEZZOTTA ADMINISTRATIVE COORDINATOR

Pezzotta started her job at UiS in September 2019. Most of the time she is handling Centre administration, but she also gives support to PhD students at the Faculty of Science and Technology, and work on EU and NFR applications. Pezzotta holds a Master's degree in Management Engineering (University of Bergamo, Italy) and a PhD in structural engineering (NTNU). She worked for about 10 years in SINTEF industry in Trondheim. «With a background in industrial engineering and management, and a PhD in mechanics, I have carried out research tasks related to the mechanical response of materials and taken on project management roles in multidisciplinary projects,» Pezzotta sums up herself.

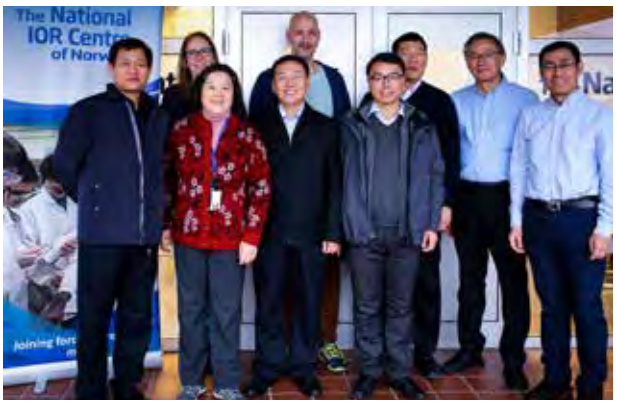
Visitors from all over the world



Ten research direcotors from the Kuwaiti oil company KUFPEC visited University of Stavanger in March 2019. Photos: Kjersti Riiber

Reidar Inge Korsnes gives a delegation from CNOOC (China National Offshore Oil Corporation) a tour in the rock mechanics lab.

Sonja Knudson (left) is head of international office at Memorial University of Newfoundland. Here with Ying Guo and Tina Puntervold.



Sinopec visited University of Stavanger and NORCE in November. Here with Ying Guo (front), Tina Puntervold and Aksel Hiorth.

Great expectations from the Research Council of Norway

Centre director Ying Guo. Photos: Marius Vervik

Leader of technical committee Robert Moe (ConocoPhillips).

The Research Council of Norway visits The National IOR Centre.

Siri Helle Friedemann (right) and Ingrid Anne Munz.

The National IOR Centre of Norway is supported by the The Research Council of Norway (RCN) with 10 million NOK each year. Therefore, RCN is following the Centre closely. The Centre reports twice a year, we have annual contact meetings and they come to visit us every second year – a so-called site visit. 17 October the Centre arranged site visit with three representatives from RCN, two observers from the Norwegian Petroleum Department and several from the university management present. The leaders of board and technical committee at the Centre were also invited. The purpose was to update RCN on our work.

«We are especially eager to see how you have met the recommendations from the mid-term evaluation. Also, a lot of money has been spent on this Centre. Our expectations are equally big. We expect results and added value,» Siri Helle Friedemann from RCN said. She came to the site visit with colleagues Ingrid Anne Munz and Liv Jorunn Jenssen. Munz was concerned about the importance of keeping educating candidates for the petroleum industry.

«You and the other petroleum centres have been very important in this aspect. You have to continue this work,» Munz said.

Dean Øystein Lund Bø at the Faculty of Science and Technology spoke for a broader education.

«The energy and environmental perspective is more important than ever. Therefore we have to broaden our education,» he said.

Centre management got advice from the new UiS-Rector

New UiS-Rector Klaus Mohn gave a "tour" to the faculties and centres at UiS last year. In November he visited the IOR Centre. The purpose was to get to know the IOR Centre management – but also vice versa – the staff at the IOR Centre should get to know the Rector. After a introduction of the Centre and its management, the rest of the meeting was spent to discuss the future. After 2021 there will be no more public funding. If the Centre is to continue its work, it would be with a different business model than today.

Mohn adviced the management to think outside the box when they plan the future Centre. «Transition and insecure times should be met with flexibility. Don't get caught up in the term IOR. Focus on what you can and how you can bring that knowledge forward,» Mohn said.

Meet some of our new PhD and postdoc candidates. They were all hired in 2019, and together they cover six of the seven tasks in the Centre. Despite their different backgrounds, they are all dedicated to contribute to the implementation of environmentally friendly technologies for improving oil recovery on the Norwegian Continental Shelf. Here we get to know their background, scientific interests and their goals for working at the IOR Centre.

Mehul Vora (PhD)

My name is Mehul Vora. Post my bachelor in chemical engineering, I've around 2 years of work experience as an operation engineer with an oil refinery in India, which is my home nation. In Norway, I've studied and completed two master programs, the first in Process technology at Høgskolen i Telemark and the second in Environmental monitoring in northern oil and gas producing regions at University of Stavanger including an exchange semester at St. Petersburg State University. Besides this, I've around 6 months of work experience in environmental consultancy before commencing my PhD studies in March 2019.

My long-term goal is to pursue a research-based career in academia or industry focused on solving issues related to environment and sustainability, more specifically, in the areas of environmental impact and risk assessment from discharges to the marine environment and greenhouse gas emissions to air. However, I'm always open to build on new skills that is in line with the recent development in the areas on environmental monitoring and impact assessment.

The compounds used as a part of improved oil recovery (IOR) solutions - both EOR enhancing compounds (polymers etc.) and process assisting products (e.g. tracers) may ultimately end up in the marine environment. There are presently knowledge gaps regarding possible environmental risk and impacts of discharging these compounds to the sea. There is also lack of knowledge related to increase in emissions to air when implementing different IOR solutions. The objective of our project is to assess environmental impacts and risk associated with the IOR solutions. When this is more clarified, the results can be compared to shortlist the IOR solutions that may enhance oil recovery and be environmentally friendly at the same time. Moreover, the results from environmental risk assessment (ERA) will help to support decision making regarding implementation of risk reducing measures such as re-injection/treatment of produced water or drilling discharges.

André Luís Morosov (PhD)

André Luís Morosov is a 34 years-old Brazilian that joined the IOR Centre in January 2019 as research fellow and PhD candidate. He has worked for 7 years as reservoir engineer at Petrobras, in the corporate reservoir-evaluation team, mainly on field appraisals and development-projects technical reviews. Formerly, he also worked as a wireline field engineer at Schlumberger. Morosov holds a BS degree in electrical engineering from Federal University of Santa Catarina, Brazil and a MS degree in petroleum engineering from University of Campinas, Brazil. Research interests include reservoir management, pressure-transient analysis, subsurface flow simulation, uncertainty assessment and decision analysis.

Contribute to the process of evaluating, planning, and approving EOR field-pilot-tests and projects through decision frameworks and reservoir engineering.

Micheal Oguntola (PhD)

I am Micheal Oguntola from Ogun-State, Nigeria. I had my Bachelor's Degree in pure mathematics from the University of Ibadan, Nigeria. Also, I hold two masters' degrees, one in pure and applied mathematics from the African Institute for Mathematical Science (AIMS), Cameroon and the other one in computational mathematics from the Pan African University, Institute for Basic Sciences, Innovation and Technology (PAUSTI), Kenya.

My scientific interests are in: analysis of partial differential equations, functional analysis, algebraic topology, stochastic processes analysis, fluid and solid mechanics, porous media flow, and numerical and reservoir optimization. I am a PhD student at The National IOR Centre of Norway. Currently, I am working on developing a robust methodology for the optimization and value quantification of EOR methods such as smart water, CO_2, and polymer for hydrocarbon reservoirs with different complexities to improve decision making. Also, I am looking at evaluating the impact of higher-order numerical schemes for subsurface flow on decision making for the EOR techniques.

The major goal for my work at the Centre is to help the energy industries make a better decision for their field operations in other to get maximum economic benefit with minimal environmental impacts. Also, I plan to deliver outstanding results in my field of research that will contribute to maintaining the position of The National IOR Centre of Norway as one of the leading research institutes.

Arun Kumar Panneer Selvam (PhD)

Arun Kumar Panneer Selvam, is a PhD student at the University of Stavanger, affliated with National IOR Center of Norway and Institute of Energy Technology (IFE). He is working on developing nanoparticle tracers for reservoir characterisation, with special focus on nanocarriers for targeted tracer release.

Arun is from Chennai, India, where he did his bachelors in chemical engineering from Anna University. With an aim to pursue further and interests in the oil industry, he chose to do his masters in chemical engineering at Norwegian University of Science and Technology (NTNU) with a specialisation in Surface and Colloid Chemistry. His scientific interests vary over a broad spectrum, ranging from nanotechnology, polymer chemistry to reservoir characterization.

His focus within the IOR center is reservoir characterization by tracer technology. The project is part of task 5 under the umbrella of the IOR center and aims in using nanoparticles for tracer studies. The goal is to create a new methodology to do tracer tests for single well chemical tracer tests (SWCTT) with the use of stimuli-sensitive nanoparticles for targeting the release of tracers in the near well zone of the reservoir. Establishing the new methodology to do SWCTT would be a “greener” alternative as it would require less chemicals and also save time to do these tests compared to its conventional counterparts.

Panagiotis Aslanidis (PhD)

My name is Panos Aslanidis and I am from Greece. I graduated from the Mineral Resources Engineering Department of the Technical University of Crete and been awarded a Master of Science degree in Petroleum Engineering at the same school.

My scientific interests include mainly experimental research in reservoir engineering. I worked several months during my underground thesis at a PVT lab measuring densities of oil mixtures with CO_2 in high pressure and temperature. The past year, since the PhD period started, I am working on wettability alteration in sandstone rocks along with the Smart Water group. At the current phase in my project, I am working on core restoration processes. We are trying to implement a restoration method for sandstones that will provide reproducible results. Optimization of this process will be helpful for further research on the topic and for practical application too.

My goal for this three year period is to provide some additional knowledge around wettability and wettability alteration phenomena in sandstone rocks.

Tine Vigdel Bredal (PhD)

I have a bachelor in Optometry Engineering from HIBU 2003 and have been working as an optometrist for many years. I needed new challenges and started therefor on a bachelor in Petroleum Geoscience autumn 2014 at the University of Stavanger. I planned on a bachelor only, but changed my mind when I figured out that I had just started to learn the interesting stuff. I continued with a Master in 2016, also at the University of Stavanger, and currently in a PhD position at the IOR centre, studying reservoir properties.

One main topic is related to outcrop chalk from Mons Basin (analogue to Ekofisk) which has been artificially fractured and flooded under reservoir conditions in triaxial cell experiment. I further study how the fractured cores affect geomechanical responses compared to non-fractured cores. These responses seems to be linked to mineralogical alteration and distribution depending on the composition of fluid that is injected. Another topic relates to experiments on synthetic calcite and pure dolomite powder, to exclude the impact of clay minerals regarding dissolution and precipitation of new grown minerals. These cores are flooded with different composition of brines under reservoir conditions in triaxial cell experiments. In both these studies, I will use a list of different methods of analysis.

Understanding the alteration of minerals and its distribution is of great importance when predicting reservoir behavior when brine is injected, and especially when it comes to fractured chalk. This will increase accuracy of modelling reservoir. By getting familiar with a great number of methods, I will improve the applicability of an already established “toolbox” for future challenges at the IOR Centre.

William Chalub Cruz (PhD)

I started studying petroleum engineering in Brazil during my bachelor's at the Federal University of Pelotas. After my bachelor's, I did a master’s degree focused on reservoir data assimilation using ensemble-based methods at the State University of Campinas. During this time, I became interested in research areas of History Matching and Statistical Learning. Today, I am a PhD candidate at the University of Stavanger with focus on data assimilation methods using different types of field data. I am part of the Data Assimilation and Optimization group in NORCE, Bergen.

I hope to be able to develop good research that would contribute to the research and development data assimilation community.

Nisar Ahmed (PhD)

I'm currently working as Research Fellow in Applied Geophysics at the Department of Energy Resources, University of Stavanger. In respect of my academic qualification, I have done my M.Sc. in Applied Geology and M.Phil. degree (Geophysics) in 2013 from Institute of Geology, University of the Punjab (Pakistan). My field of interest includes reservoir geophysics and rock physics. At the present, I'm working on '4D seismic frequency dependent AVO inversion to predict saturation-pressure changes' and the objective is to the develop an appropriate theoretical background and workflow, for including the frequency dependence into the time-lapse (4D) seismic AVO inversion and analysis to estimate viscoelastic properties, pressure and fluid saturation changes. This will help to improve the accuracy of the results and at the same time bring additional information about the reservoir formation and resultantly it will potentially improve the recovery from hydrocarbon reservoirs.

Aleksandr Mamonov (postdoc)

I have master's degree in Petroleum engineering and over 5 years of experience working in academia with laboratory analysis related to water-based Enhanced Oil Recovery (EOR) methods and fluid flow in porous media. My main scientific interests are dedicated to mineral surface characterization and fluid-rock interactions in sandstone and carbonate reservoirs. Throughout my research practice, I have gained a strong experience working with chemical analytical methods and advanced core analysis, as well as maintenance of laboratory equipment and technical supervision of master and bachelor student projects.

The main focus of my research work in recent years has been the study of reservoir rock wetability and Smart Water EOR technology. "Smart Water" is ion modified injection water, designed to displace oil more efficiently than other brines and improve oil recovery. Smart Water injection is one of the most promising EOR methods in the modern oil industry and one of the most challenging to study. My current research project in IOR Centre aims to strengthen understanding of Smart Water EOR processes and promote this technology towards industrial applications.

Juan Michael Sargado (postdoc)

I obtained my bachelor and master degrees in civil engineering from the University of the Philippines Diliman, and was employed as instructor and later assistant professor at the Institute of Civil Engineering. Following this, I worked for two years as a member of the scientific staff at the Institute of Structural Mechanics, Bauhaus University Weimar in Germany. In 2014, I moved to Norway and was admitted as a research fellow at the Department of Mathematics, University of Bergen where I carried out research on phase-field approaches for modeling for brittle fracture evolution along with the design and implementation of high-performance software for scientific computing. I received my PhD degree in September 2019 after successfully defending my thesis entitled “Phase-field Modeling and Simulation of Brittle Fracture”. During the latter part of my PhD studies, I was employed as a part-time researcher at the International Research Institute of Stavanger which later on became part of NORCE.

My current research interests lie in the field of computational geomechanics and fracture mechanics, in particular the effect of external processes such as flow, chemical reactions and thermal dissipation on the evolution of complex fracture networks. As a postdoc with the National IOR Centre, I am working to couple the OPM flow simulator to the multiphysics framework BROOMStyx that I wrote during my PhD. The goal of this project is to extend the capabilities of OPM to enable simulation of chemo-mechanical compaction in chalk reservoirs.

Runar Berge (postdoc)

I did my master’s degree in mathematics and physics at the Norwegian University of Science and Technology in Trondheim. After I finished my degree, I moved to Bergen and started a PhD at the Department of Mathematics.

In the fall of 2019 I submitted the thesis: ”Numerical methods for coupled processes in fractured porous media”. This also summarize my main scientific interests which includes numerical methods, modeling, advanced simulations, and fractures in porous media.

The main goal of my work at The National IOR Centre of Norway is to extend the features of OPM to include fracture flow.

PhD Defences 2019

Oddbjørn Nødland defended his thesis «Core scale modelling of EOR transport mechanisms» 8th of January.
Photos: Kjersti Riiber

The 15th of Mars, Remya Nair defended her doctoral degree with the thesis «Smart Water for Enhanced Oil Recovery from Seawater and Produced Water by Membranes».

CENTRE PHDS

Aojie Hong
Kun Guo
Laura Borromeo
Mona Wetrhus Minde
Oddbjørn Nødland
Remya Nair
Mohan Sharma
Samuel Erzuah
Shaghayegh Javadi
Tijana Voake

Coming up:
Jaspreet Singh Sachdeva
Emanuela Kallesten
Dhruvit Berawala

Mohan Sharma defended his thesis «CO2 Mobility Control with Foam for Enhanced Oil Recovery and Associated Storage. Multi-Scale Approach for Field Application» 25th of April.

Shaghayegh Javadi did her public defense the 25th of November with the thesis «Interaction between two calcite surfaces in aqueous solutions. Study of nano-scale interfacial forces using AFM and SFA».

Samuel Erzuah defended his PhD thesis «Wettability Estimation by Oil Adsorption» 24th of September.

Core scale modelling of EOR transport mechanisms

Oddbjørn Nødland

During my PhD period I worked with simulation models for polymer flow in porous media. The focus was on developing, and testing, a new model that can handle all of the non-Newtonian flow regimes commonly observed at the core scale, especially apparent shear thickening and mechanical degradation. Both flow regimes are potential showstoppers for applying polymer flooding offshore; the first because it might lead to excessive pressure build-up at injection wells, and the second because mechanical degradation permanently ruptures the polymer molecules, and thus lowers their ability to improve reservoir sweep. It is therefore very important to understand when these issues become problematic, and to be able to quantify their likely impact.

A particular advantage of our simulation model is that it incorporates properties of both the polymer and the porous medium (e.g., permeability and porosity) directly into the equations solved for. Thus, fewer fitting parameters are required than in other models reported in the literature, which makes it more robust and easier to translate to larger scales. So far, we have applied the model to several laboratory data sets for HPAM polymer solutions flooded through sandstone cores, with good agreement between modelled and recorded pressure data.

The model has been implemented into the IORCoreSim software, which makes it a valuable tool for both researchers and the industry. It can for example be used as part of a screening phase for applying polymer flooding at the field; to interpret what goes on in conducted core floods, as well to explore possible effects of changing the experimental conditions such as flow rates and core heterogeneity.

Smart Water for EOR from Seawater and Produced Water by Membranes

Remya Nair

Sustainable use of scarce water resources and stringent environmental regulations are currently moving the focus towards environmentally friendly and cost-effective injection methods in the offshore oil industry. Water injection is used for most oil reservoirs as pressure support and improved displacement of oil. Most water-based enhanced oil recovery (EOR) techniques consist of chemical injection into reservoirs resulting in hazardous flow back of chemicals and produced water (PW).

Smart Water injection is an alternative and simultaneously represents a sustainable environmental and economic EOR flooding technique. The optimized ionic composition of injection water improves the initial wetting towards more water-wet conditions, which improves displacement efficiency due to increased capillary forces. Smart Water improves oil recovery by wettability alteration in both carbonate and sandstone reservoirs. Seawater is the main injection brine offshore and when enriched in divalent ions such as SO_4^{2-} and Ca^{2+} and depleted in Na^+ and Cl^- is considered smart water in carbonates. Injection brine with salinity below 5,000 mg/L and low in divalent cations are considered suitable as smart water in sandstone reservoirs. The main focus of this research was to determine appropriate technical conditions and limitations of Nanofiltration membranes for producing smart water from seawater and PW.

Wettability estimation by oil adsorption

Samuel Erzuah

Wettability is an indispensable parameter in reservoir multiphase flow due to its effect on fluid phase distribution and flow properties such as relative permeability and capillary pressure. Wettability as defined by Craig (1971) is the tendency of a fluid to adhere to a solid surface in the presence of other immiscible fluids. Numerous wettability characterization techniques exist, notable among them are the Amott and United State Bureau of Mines (USBM) methods. However, these techniques characterize the wettability base on specific measured outputs but do not evaluate the mechanisms that triggered them. The aim of my work was to estimate the wettability by capitalizing on the oil adhesion tendencies of the rock/mineral during Crude Oil Brine Rock interactions. This was accomplished using both experimental and simulation techniques. Experimental techniques employed include flotation, Quartz Crystal Microbalance with Dissipation and Contact angle measurement. Properties and quantities of the rock-fluids employed during the experiment were used as input into the Surface Complexation Modelling (SCM). Not only did the SCM technique predict the trend in the wetting preferences of the rocks/minerals but also the mechanisms that led to the oil adhesion such as direct adhesion of carboxylate (>COO-) onto positive mineral sites, divalent cations (Ca^{2+} & Mg^{2+}) bridging etc. The SCM technique has also been extended to predict wettability of mineral mixtures and reservoir rocks. For the studied sandstone rocks and mineral mixtures, it was observed that though the mineral with the dominant surface area dictates the wetting preferences, nonetheless its effect was overshadowed by the hydrophobic minerals content if the latter was relatively high. The SCM technique has successfully been used to capture the trend in literature data such as zeta potential measurements, spontaneous imbibition in chalk with carbonated water (CW) and wettability measurement using Amott and USBM techniques.

CO_2 Mobility Control with Foam for EOR and Associated Storage

Mohan Sharma

The industry has a proven track record of safely injecting CO_2 into geologic formations, and it is well understood that CO_2 EOR can add value by increasing oil recovery while reducing carbon emissions.However, based on the knowledge gained from field-scale projects, it has been realised that a substantial volume of reservoir remains unswept during CO_2 floods leading to poor performance.

Foam, which is generated using a surfactant, has the potential to overcome the challenges of unstable displacement during CO_2 injection. A few field pilots have been performed. However, only limited information is available to de-risk the technology for implementation in a high-cost and high-risk environment such as the Norwegian Continental Shelf. An international collaboration has been set up between universities and oil companies to perform two field pilots to advance the technology of using foam as mobility control agent for CO_2 EOR, with a focus on integrated reservoir modelling.

My thesis investigates the mechanisms involved in CO_2-Foam displacement, at both small and large scales, for one of the pilots in a carbonate reservoir. The thesis builds upon six scientific papers that present the aspects of a multi-scale approach, and integrate findings from studies performed at pore-scale, core-scale and field-scale.

Interaction between two calcite surfaces in aqueous solutions. Study of nano-scale interfacial forces using AFM and SFA

Shaghayegh Javadi

Chalk compaction and subsequent seabed subsidence has been a major issue in many geological settings and oil reservoirs such as Ekofisk. In my thesis, we discuss the "water weakening" phenomenon, known to be the cause of the chalk compaction. We further investigate the finding that the macroscopic mechanical strength of the carbonate rocks is controlled by the chemical and physico-chemical processes at the grain contacts. We show that the strength of contact bonds at the grain boundaries may be influenced by both the salinity of the confined fluid and the topography of the dynamic calcite surfaces.

Carbonate-bearing rocks in the upper Earth's crust are prone to continuous changes under influences of various physical and chemical processes. The macroscopic mechanical strength of carbonates is generally controlled by the cohesion between contacting grains at a molecular scale. These grains deform in contact regions due to the chemistry of pore fluid. The repulsive and attractive forces that operate at the grain contacts may be affected by the dissolution and recrystallization kinetics at the mineral-liquid interfaces. The processes by which the nano-scale interfacial forces are influenced by changing properties of the confined fluid are largely unknown. In my thesis, I investigate these processes and their possible contribution to the strength of calcite-bearing rocks and materials.

The Atomic Force Microscope (AFM) and Surface Force Apparatus (SFA) are two powerful tools that provide an opportunity of direct observation of mineral reactions to the contacting fluid and measuring the surface forces at nano-scale in air and liquid environments. In this project, we perform an extended number of experiments using the AFM and SFA to improve our understanding of variation in interfacial forces linked to the strength of calcite and calcite-bearing rocks.

In the AFM experiments, we bring an in-situ fabricated calcite probe into contact with an opposing freshly cleaved calcite surface in a fluid cell containing aqueous solutions with varying chemical compositions. We also combine the AFM force measurements with a technique called inverse imaging, for in-situ simultaneous characterization of the calcite probes. Based on these experiments, we discuss that the possible variation in local topography of contacts, together with a strong dependence on ionic strength of the solution, can explain the variation in strength of calcite rocks in aqueous solutions.

With the SFA, we can perform in-situ observations of the possible changes in the surfaces via light interferometry technique while measuring the interfacial interactions at nano-scale. At this scale, interactions between contacting surface asperities define the nature of interfacial forces, repulsive or attractive. We discuss how the crystal growth, dissolution and changes in surface roughness affect these interaction forces and their implications on the strength of calcite-bearing rocks.

Kristin Færøvik in Lundin (left) and former Centre director Merete Vadla Madland. Photo: Marius Vervik

THE SPEAKERS

- Christine Sagen Helgø, mayor of Stavanger
- Rikard Gaarder Knutsen, state secretary
- Karl Johnny Hersvik, AkerBP
- Kristin Færøvik, Lundin Norway
- Knut Åm, Envision
- Roger Flage, UiS
- Remus Hanea, Equinor/ University of Stavanger
- Reidar Bratvold, UiS
- Jon Sætrom, Resoptima
- Kjetil Hove, Equinor
- Alex Hansen, NTNU
- Mario Silva, IFE
- Colin MacBeth, Heriot-Watt University
- Rolf Johan Lorentzen, NORCE

Lundin Norway shares all data from one field

Centre director Merete Vadla Madland got the best present during IOR NORWAY 2019. CEO in Lundin Norway, Kristin Færøvik, gave Madland a giftbox containing data worth 25 billion Norwegian krones. In the giftbox was a memory stick with all the data sets from the field Edvard Grieg in the North Sea. This is the first time a operator on the Norwegian Continental Shelf has shared all data from one field.

Lundin Norway is one of the industry partners at the Centre.

«This is openness and sharing in action. We are giving the access to data worth 25 billion NOK,» Færøvik said. For the researchers at the Centre it is of great importance to have access to real data from real fields.

«See if you can beat us! Hopefully this can serve as an inspiration for other companies,» Færøvik said.

Centre director Merete Vadla Madland was amazed by the great news.

«When we were awarded the Centre, an important prerequisite was that we got hold of field data. We have had this on the agenda for five years, but it has been difficult to get access. We've got a little earlier, but never near an amount like this.»

Eystein Opsahl, PhD student at The National IOR Centre of Norway, was awarded the prize for the best young talent at IOR NORWAY 2019. The Skjæveland Award is the Centre's prize for young researchers. The prize goes to a young researcher within IOR (improved oil recovery) that has shown the ability to innovate within his or her field. Eystein Opsahl was one of the first PhD students to be hired at the Centre. His project «Environmental fate and effect of EOR polymers» seeks to provide understanding about the behaviour and effects of EOR polymers in the marine environment at low concentrations.

Rector Marit Boyesen and winner Eystein Opsahl. Photo: Marius Vervik

PhD student Mehul Vora presented at OG21

PhD student at the IOR Centre, Mehul Vora, did a great job representing University of Stavanger at OG21 in Oslo. OG21 is Norway's national oil and gas strategy. At the OG21-forum high level technology decision makers in the petroleum industry meet to discuss the continued importance of technology and innovation to value creation in Norway and on the Norwegian Continental Shelf.

For the students at The National IOR Centre of Norway this forum has become an important place to meet possible collaborators from the industry. This year it was PhD student Mehul Vora's time to present on behalf of the IOR Centre and University of Stavanger.

The theme for this year's OG21-forum was: «How can technology make our projects faster, with lower costs and reduced emissions?» Mehul Vora presented: «Faster / Affordable / Cleaner - Technology for higher productivity and lower emissions: Improved Oil Recovery (IOR) by Smart Water.»

Mehul Vora (nr. 2 from the left). Photo: Merete Vadla Madland

In Vora's PhD project, the purpose is to develop and implement risk analysis methods and models in support of the IOR Centre efforts to assess and evaluate overall environmental impacts and risks associated with different IOR solutions resulting from the IOR Centre research activities. The IOR solution presented at OG21 was Smart Water.

PhD student of the year

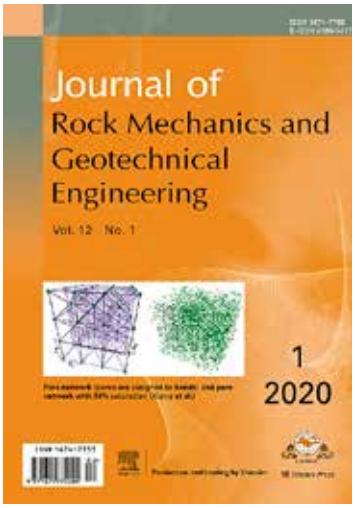
PhD student at The National IOR Centre of Norway, Jaspreet Singh Sachdeva (picture), was honored with the award «PhD student of the year» at the SPE (Society of Petroleum Engineers) gala night. This is SPE Stavanger's prize for students with excellent academic performance at UiS. The gala was arranged Friday 26 April. Sachdeva is writing his PhD thesis on the subject «Effect of wetting property on the mechanical strength of chalk at hydrostatic, and in-situ stress and temperature conditions».

Photo: Helle Navratil / SPE

«A big credit of this award goes to my supervisors and the whole of the IOR Centre as well. All have been helping and supporting me unconditionally during these past years. Thank you very much,» Sachdeva said after receiving the award.
In addition Bjørn Olav Hapnes won the award for BSc student of the year and Espen Dommersnes was awarded MSc student of the year. They're both studying at Department of Energy and Petroleum Engineering.

These are the task leaders' selected papers for 2019.

TASK 1



"Temperature cycling and its effect on mechanical behaviours of high-porosity chalks"
T. Voake, A. Nermoen, R.I. Korsnes, I.L. Fabricius

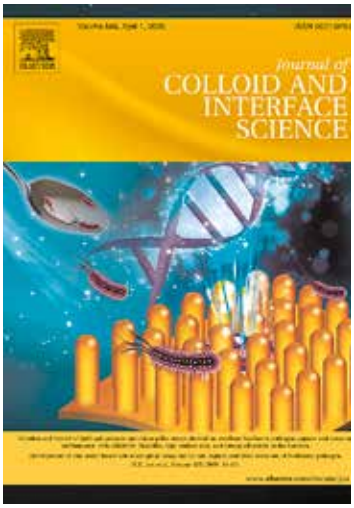
The paper focuses on how temperature history affects chalk core mechanics. During reservoir operations temperature variations are induced by intermittency of cold fluid injection and shut-in. Here, we develop novel chalk core experiments, where samples are exposed to daily warming and cooling, before hydrostatic stress cycles. The temperature, and corresponding stress cycles, were repeated daily 11 times. Each time the reversible and irreversible strains were quantified. This made it possible to compare directly to stress cycles of samples held at constant temperature (see fig). The results display that stiffer/stronger medium porosity chalks (from Kansas, USA), were more sensitive to the temperature variation in the sense that more plastic strain accumulated through the tests, than soft/weak high porous chalks (from Mons, Belgium). Moreover, samples saturated by water accumulated more plastic strain than those saturated by Isopar H oil. The observation that the thermal induced damage prolongs through 10 cycles, imply that the bond-breakage is an ongoing process. For reservoirs, this imply that permanent damage is expected in water-saturated regions, especially the reservoir formations with more lithified and indurated chalks. Elastic re-bound by increased pore pressure will thus more likely occur in oil saturated highly porous chalks. We were the first to study these effects in the laboratory.
https://doi.org/10.1016/j.jrmge.2018.11.010

TASK 2

"Mineral replacement in long-term flooded porous carbonate rocks"
Mona Wetrhus Minde, Udo Zimmermann, Merete Vadla Madland, Reidar Inge Korsnes, Bernhard Schulz, Sabine Gilbricht

We managed to publish a paper based on the PhD work by Mona Wetrhus Minde in the most re-known geochemical journal world-wide: Geochimica et Cosmochimica Actas. This is a major achievement in the field of geosciences and normally only preserved for established scientists. This implies the highest degree of dissemination in the academic context. We published the results as "open access" to maximize the impact of dissemination. The results are extremely important for all researcher and interested parties related to rock-fluid interaction in porous media. We identify high porosity zones as immanent to rock changes – an effect which should be studied further in terms of the IOR Centre's purposes. (The article has been published in 2019 on-line.)
https://doi.org/10.1016/j.gca.2019.09.017

TASK 3



"Adhesive forces between two cleaved calcite surfaces in NaCl solutions:The importance of ionic strength and normal loading"
Javadi S, Røyne A

The mechanical strength of calcite bearing rocks is influenced by pore fluid chemistry due to the variation in nano-scale surface forces acting at the grain contacts or close to the fracture tips. The adhesion of two contacting surfaces, which affects the macroscopic strength of the material, is not only influenced by the fluid chemistry but also by the

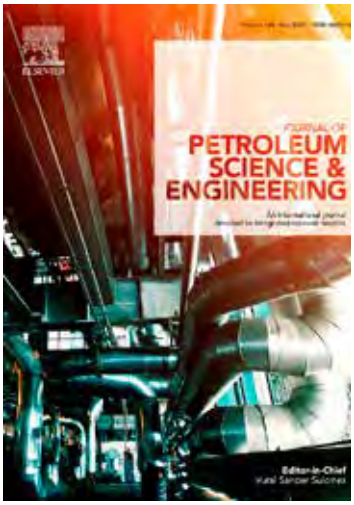
surface topography. In this paper, we use Atomic Force Microscope (AFM) to measure the interfacial forces between two freshly cleaved calcite surfaces in $CaCO_3$-saturated solutions with varying NaCl concentration. We show that calcite contacts become stronger with increasing NaCl concentration (>100 mM), as a result of progressively weaker secondary hydration and increasing attraction due to instantaneous ion-ion correlation. Moreover, we discuss the effect of normal applied force (Fn) and surface roughness on the measured adhesion forces (Fad). We show that the measured pull-off force (adhesion) is linearly correlated with the magnitude of Fn, where an increase in appliedforce results in increased adhesion. This is attributed to a larger number of contacting surface asperitiesand thus increase in real contact area and the contact-bond strength. We discuss that the possible variation in local topography at contacts, together with strong dependence on ionic strength of the solution, can explain the inconsistent behavior of calcite rocks in NaCl solutions.
https://doi.org/10.1016/j.jcis.2018.08.027

TASK 4

"Compaction and Fluid Rock Interaction in Chalk. Insight from Modelling and Data at Pore, Core-, and Field-Scale"
Mona Wetrhus Minde, Aksel Hiorth

This paper address the challenge of upscaling chemical effects observe at the lab scale to reservoir scale. Many of the chalk formations in the North Sea contains large volumes of oil. In some areas, the porosity is higher than 45%. During production, the reservoir pressure is decreased, the effective stress is increased and the reservoir subsequently compacts. Compaction is a significant driver for oil expulsion, and, as an example, for the Valhall field in the North Sea, the compaction is estimated to contribute to 50% of the total recovery. For the Ekofisk field, reservoir compaction has led to seabed subsidence of approximately 9 m, where about 50% of the 9 m is due to pore pressure decline,and about 50% is due to the injected water. In this paper, we argue that the water weakening effect can to a large extend be understood as a combination of changes in water activity, surface charge and chemical dissolution. We apply the de Waal model to analyse compaction experiments, and to extract the additional deformation induced by the chemical interaction between the injected water and the rock. The chemical changes are studied on a field scale using potential flow models. On a field scale, we show that the dissolution/precipitation mechanisms studied in the lab will propagate at a much lower speed and mainly affect compaction near the well region and close to the temperature front. Changes in surface charge travel much faster in the reservoir and might be an important contributor to the observed water weakening effect. We also discuss how mineralogical variations impacts compaction.
https://doi.org/10.3390/geosciences10010006

TASK 5



"Stability assessment of PITT tracer candidate compounds: the case of pyrazines"
Silva, Mario; Stray, Helge; Bjørnstad, Tor

The determination of the residual oil saturation (SOR) in the swept volumes between injector/producer well pairs is a parameter of major importance for the design and/or evaluation of IOR projects in mature oilfields. The partitioning inter-well tracer test (PITT) is used to measure SOR in water-flooded reservoirs. It relies on the simultaneous use of passive and phase-partitioning tracers. There is a lack of qualified water/oil partitioning tracers. A systematic qualification process is necessary in the development process of new PITT tracers. In the present document we report and discuss the findings from stability experiments performed on 2 alkylpyrazines, 1 methoxypyrazine and 2 halogenated pyrazines as PITT tracer candidates. Highlights are:

- The stability of 5 pyrazines was successfully evaluated up to 150 °C during 12 weeks.
- The influence of salinity, typical reservoir rocks and pH was also assessed.
- The stability of the compounds is related to the nature of their substituents.
- Two of the alkylpyrazines are promising phase-partitioning tracer candidates.
- The compound 2-mehoxypyrazine is very sensitive to the presence of clay (kaolinite). It can potentially be developed as a monitor for clay.

https://doi.org/10.1016/j.petrol.2019.106269

TASK 6

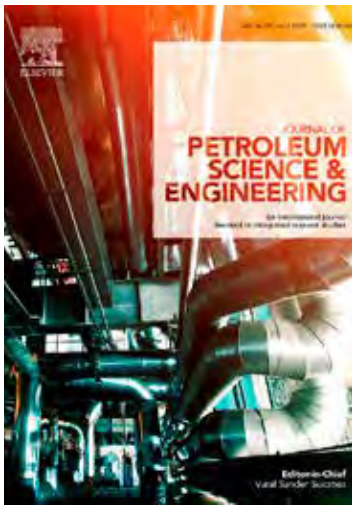
"Comparison of Higher Order Schemes on Complicated Meshes and Reservoirs"
Anna Kvashchuk, Robert Klöfkorn, Tor Harald Sandve.

Accurate numerical modeling of fluid transport is essential in reservoir management, especially for enhanced oil recovery (EOR). A good example of tertiary recovery is the carbon dioxide injection (CO_2-EOR). This technology has a significant potential for increasing the oil production, while directly reducing the CO_2 emissions. Standard simulation tools, used in reservoir management, are based on finite volume techniques, which are known to suffer from the numerical diffusion. This phenomenon is inherent in first order finite volume methods and leads to smearing of fronts, wrong mixing zones and other side effects. For EOR applications this could mean wrong prediction of distribution of the fluids, which, in its term, may lead to misinterpretations of the possible potential of the EOR methods. The inconsistencies and errors are reduced when higher order methods are used.

The paper demonstrates performance and capabilities of two higher-order finite volume methods on several benchmark cases with emphasis on relevance to the practical reservoir simulation. In particular, we use the Norne field open data set, which enables cross validation with other implementations. The methods are compared on multiphase flow problems typical for improved oil recovery: solvent and CO_2 injection. The second order method with linear programming optimization reconstructions outperformed the first order and second order with least squares reconstruction methods on all the test cases, including field case Norne.

All the described implementations are based on an open source reservoir simulator Open Porous Media (OPM) and will be made available in the future. Which means these methods will be accessible for reservoir engineers and can be used with industry-standard modeling setups. The paper originally was published in the SPE Reservoir Simulation Conference 2019 proceedings, and now the revised manuscript is submitted for a publishing in the SPE Journal.
https://doi.org/10.2118/193839-MS

TASK 7



"Simultaneous assimilation of production and seismic data: application to the Norne field"
R. J. Lorentzen, T. Bhakta, D. Grana, X. Luo, R. Valestrand and G. Nævdal

This paper present a flexible workflow for automatic history matching using production and seismic data and show a successful history matching on the the released Norne benchmark dataset. The most severe problem, when applying ensemble-based methods for assimilating large data sets, is that the uncertainty is usually underestimated due to the limited number of models in the ensemble compared with the dimension of the data, which inevitably leads to an ensemble collapse. Localization and data reduction methods are promising approaches mitigating this problem. In this paper, we present a new robust and flexible workflow for assimilating seismic attributes and production data. The methodology is based on sparse representation of the seismic data, using methods developed for image denoising. We propose to assimilate production and seismic data simultaneously, and to ensure equal weight on these data types, we apply scaling based on the initial data match. Further, a newly developed flexible correlation-based localization technique is used for both data types. An iterative ensemble smoother is used for the simultaneous assimilation of production and seismic data. We show that the methodology is robust and ensemble collapse is avoided. Furthermore, the proposed workflow is flexible, as it can be applied to seismic data or inverted seismic properties, and the methodology requires only moderate computer memory. The results show that through this method, we can successfully reduce the data mismatch for both production data and seismic data.
https://doi.org/10.1007/s10596-019-09900-0

SYSLA OFFSHORE

Lundin deler hemmeligheter om Grieg-feltet

Skal samarbeide om ny teknologi

Då Helse Vest fekk høyre om dei nye studieprogramma Applied Data Science og Computational Engineering, tok det ikkje lang tid før planar om samarbeid var i gang.

Del artikkel:

Begge masterprogramma er tidlege og tek sikte på å auke kompetansen blant ingeniørar i industrien. Applied Data Science skal auke IKT-kompetansen hos ingeniørar frå ulike fagfelt, mens Computational Engineering siktar seg inn på å lære studentane korleis dei ved hjelp av modellar kan oppnå betre kunnskap om komplekse problem, der ein ofte ikkje har nok informasjon.

18 ONSDAG 20. MARS 2019 STAVANGER AFTENBLAD

Per Øyvind Seljebotn, fra venstre, Merete V. Madland og Kristin Færøvik gleder seg over UiS-samarbeidet. OLA MYRSET

Vill jubel på Universitetet:

Lundin deler hemmeligheter om Edvard Grieg-feltet

STAVANGER: Olje-selskapet håper å få ut «ekstremt lønnsomme ...

mer ut av feltene på norsk sokkel. I dag er den gjennomsnittlige utvinningsraten ...

klarer å komme tilbake med informasjon som er nyttig for ...

tv vest

Oljeselskap deler oljedata til forskning ved UiS

IOR-konfera... med på lage...

19. mars opnar Det na... konferanse IOR NORW... er det viktig å ha dei u... «olja» det handlar om...

Del artikkel:

MASTER'S

Dette er den femte IOR-konferansen senteret arrangerer. IOR står for «improved oil recovery». På godt norsk handlar det om auka oljeutvinning.

– Eller betra oljeutvinning, føy korrekser det siste, seier Merete Vadla Madland. Ho er leiar for Det nasjonale IOR-senteret.

Her forskar dei på korleis me får mest mogleg ut av oljereservoara våre, ...

Alt blir stadig mer digitalt og elektrisk.

NRK Nyheter

Kunsten å omstille seg

Oljeforskningen står ikke i konflikt med klimautfordringene, ifølge M... Vadla Madland.

– Visste du alltid at oljen var din vei?

Bachelor Student of the Year: Bjørn Olav Hapnes (UiS)

Master Student of the Year: Espen Dommersnes (UiS)

PhD Student of the Year: Jaspreet Singh Sachdeva (UiS)

Who are we?

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Trine S. Mykkeltvedt

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Kjersti Eikrem

Runar Berge

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