

2017 Annual Report

Petroleum Research School of Norway

Nasjonal forskerskole i petroleumsfag (NFiP)

Introduction

Petroleum Research School of Norway (NFiP) includes PhD students from all of the five universities in Norway that provide PhD education within petroleum related disciplines. Education of petroleum researchers at Norwegian universities benefits from coordinated, interdisciplinary collaboration between the Norwegian universities graduating PhD's in petroleum related scientific disciplines.

The Petroleum Research School of Norway was established to provide a national tool to improve the PhD education within petroleum related sciences in Norway. This is achieved by coordinating lectures given by the different universities and providing intensive courses, seminars and conferences for all PhD students in Norway with research projects related to petroleum. The objective is also to establish discussion groups, collaborating opportunities and interdisciplinary meeting places for PhD students and their supervisors in Norway and internationally; for more information please see <https://nfip.no/>.

In 2016 NFiP obtained financial support from The Norwegian Research Council (RNC) amounting to NOK 23mill for the next 8 years. This support enabled NFiP to continue and expand the educational efforts.

Members of the Petroleum Research School of Norway; include University of Bergen, University of Stavanger, University of Oslo, Norwegian University of Science and Technology (NTNU), University of Tromsø and the University Center at Svalbard (UNIS).

Around 950 students (PhD and MSc students) have participated in NFiP activities in total. In 2017 a total of 152 students participated at NFiP arrangements. In addition, around 100 students (PhD and MSc students) participated on activities supported by NFiP.

2017 NFIP Activities

2017 Courses, Conferences and Seminars provided by NFIP and NorTex

During 2017 the following courses, conferences and seminars were provided by NFIP. The IOR Norway and The Lofoten Seminar were supported by NFIP.

DATE	EVENT	COST [NOK]	# STUDENTS	Universities attending
Apr. 25 th – 27 th	IOR Norway	300 000	Ca. 70	UoB, UoS, NTNU, several European Universities
Aug. 15 th – 18 th	The Lofoten Seminar	90 000	Ca. 25	UoB, UoS, NTNU, several European Universities
Oct. 4 th -6 th	CO2 FOR EOR AS CCUS 2017	650 082	60	NTNU, UoB, UoS, Rice, Stanford, Texas A&M, UoHouston, UoKansas, UoNorthDakota, UoTexas, UoTulsa, Colorado School of Mines, Columbia University, SINTEF
Oct. 29 th - Nov. 4 th	Field trip PYREX	373 537	9	NTNU, UNIS
Nov. 6 th – 10 th	Field trip Dorset	139 725	10	UoO, UoB
Nov. 16 th	One Day Seminar	230 041	53	NTNU, UoB, UoS, UoO, UoT, UNIS
SUM		1 783 385	227	

2017 Seminars and courses

1) The Lofoten Seminar

The Lofoten Seminar is a biannual national symposium in petroleum geophysics and was first held in 1993. The purpose of the seminar is to gather universities, research institutions and industry in Norway in order to present ongoing research in petroleum geophysics.

It serves as a meeting place for PhD-students, post docs, university professors and industry professionals to discuss and review important issues to be solved for bringing this research field forward. Also, some internationally recognized researchers will give invited talks.

The Lofoten Seminar is organized by all the universities in Norway involved in research and education in geoscience in Norway. It is supported by NFIP in addition to some industry sponsors.

Link to the seminar: <http://www.unigeo.no/home/page.php?id=23>

2) Geological field trip to the Ainsa area in the Spanish Pyrenees (PYREX)

The course was primarily about clastic reservoir geology. The rocks studied are analogous to a number of important reservoir sections offshore Norway and other parts of the world and the use of analogues was discussed throughout the course. Within the topic of reservoir geology a number of parallel themes were addressed. The course included a mixture of fieldwork and class work. A total of 9 participants (44% females, all master students) attended the course. Participants were from NTNU (7) and UNIS (2).

Link to the course: <https://nfip.no/2017/06/15/pyrex-2017-geological-field-trip-to-the-spanish-pyrenees/>

3) World Heritage Jurassic coast of Dorset; field techniques for sedimentary research

This course provided introduction to the stratigraphy and facies of the siliciclastic and carbonate sediments, and instruction in field logging and sampling techniques appropriate to the various sediment types present. The Jurassic coast provides spectacular exposures of Triassic-Cretaceous sediments, which include outcropping examples of source rocks and reservoirs of the Wytch Farm oilfield, including a number of fossil oil seeps. A total of 10 participants (10% females, 50% PhD) attended the course. Participants were from the University of Bergen (8) and University of Oslo (2).

Link to the course: <https://nfip.no/2017/06/26/world-heritage-jurassic-coast-of-dorset-2017/>

4) Petroleum Research School of Norway Annual Seminar

Petroleum Research School of Norway (NFIP) provided in collaboration with NorTex Petroleum Cluster the conference: *“Sustainable Petroleum Research at Universities in Norway”*, and it was arranged at the Norwegian Petroleum Museum in Stavanger.

A total of 53 participants (26% females) from industry and academia attended the conference program, toured the Petroleum Museum and enjoyed networking during the conference dinner at the museum restaurant. A total of 17 PhD and 31 Master students from the following universities in Norway participated: NTNU (10), SINTEF (1) UiB (7), UiO (8), UiS (15), UiT (1) and UNIS(6).

Link to the seminar: <https://nfip.no/2017/07/03/annual-one-day-seminar-2017/>

2017 Conferences

2) IOR NORWAY 2017: “Recover for the future”

NFiP co-hosted the Improved Oil Recovery (IOR) conference in Stavanger April 24-27th, 2017. A total of 350 attendees discussed sustainability within the oil and gas production. 70 participants were PhD- and Master-students. International experts and Norwegian researchers discussed the future of IOR.

Link to the conference: <http://www.uis.no/research/national-ior-centre-of-norway/ior-norway-2017-in-collaboration-with-eage-the-19th-european-symposium-on-improved-oil-recovery-article112912-13152.html>

3) The 3rd Biennial CO2 for EOR as CCUS Conference

The CO2 for EOR as CCUS symposium is a collaborative on CO2 EOR between universities in Texas and Norway, oil industry in Texas and Norway and other CO2 EOR stake holders. The symposium objectives were to accelerate CO2 research collaboration between Norway and Texas, and to provide opportunity for experts in industry and academia to collectively discuss CO2 research. In addition, post docs and PhD students were provided with current research status and the way forward, and the oil industry was provided with an opportunity to communicate needs to the next generation engineers. Emphasizing CO2 as mean to mitigate negative climate effects in oil production was on the agenda. A total of 85 industry, governmental and academic candidates participated, where a total of 42 PhD and 18 master students from the following universities participated: NTNU (2), UoB (16), UoS (3), Rice University (11), Stanford (2), Texas A&M (2), University of Houston (5), University of Kansas (3), University of North Dakota (3), University of Texas (6), University of Tulsa (2), Colorado School of Mines (3), Columbia University (1), SINTEF (1).

Link to the conference: <https://nfip.no/2017/05/11/co2-for-eor-as-ccus-2017/>

2017 Student/ Researcher Exchange

NFiP promotes and supports collaborative international petroleum research initiatives; preferentially between universities that have signed MoU's with NFiP, by providing financial travel support for students.

NFiP has negotiated 3 additional MoUs during the project period: U. of Texas A&M at Corpus Christi, U. of Barcelona and Danish Technical University. Previously NFiP has signed MoU with 8 universities in the US and 3 universities in Europe.

NFiP Short Term Exchange Program (STEP) financially supports students to spend collaborative research time in counterpart countries of international research collaborations.

During 2017 the following student exchange programs were completed:

First Name	Surname	Affiliation	Destination	From	To
Kun	Guo	University of Stavanger	China University of Petroleum	14.12.2016	01.02.2017
Aojie	Hong	University of Stavanger	University of Texas Austin	19.02.2017	19.05.2017
Shaghayegh	Javadi	University of Stavanger	Santa Barbara University	01.02.2017	15.03.2017
Nitya	Mohan	University of Houston	University of Bergen	02.01.2017	15.01.2017
Mohan	Sharma	University of Stavanger	Rice University	06.01.2017	21.01.2017
Anna	Kvashchuk	University of Stavanger	Geilo Winter School	15.01.2017	20.01.2017
Daniel	Csanadi	Montain University of Leoben	University of Bergen	12.02.2017	26.02.2017
Nitya	Mohan	University of Houston	University of Bergen	30.05.2017	19.07.2017
Anders	Matheson	Iris	Romania	17.07.2017	28.07.2017
Yiteng	Zhang	Iris	Romania	17.07.2017	28.07.2017
Ivar	Sørheim	NTNU	Course Moscow Russia	17.07.2017	28.07.2017
Jaspreet	Sachdeva	University of Stavanger	Research stay Memorial University of Newfoundland, Canada	01.08.2017	01.10.2017
Zachary	Alcorn	University of Bergen	Houston several trips		

During 2017 the following students were supported with maximum 5000 NOK to attend conferences:

First Name	Surname	Affiliation	Destination	From	To
Mario	Silva	University of Stavanger	Oklahoma City	27.03.2017	31.03.2017
Shaghayegh	Javadi	University of Stavanger	Goldschmidt Geochemistry conference in Paris	12.08.2017	19.08.2017
Arthur	Rognmo	University of Bergen	SCA Vienna	28.08.2017	01.09.2017
Sunniva	Fredriksen	University of Bergen	SCA Vienna	28.08.2017	01.09.2017
Fredrik	Wesenlund	University of Tromsø	IMOG 2017 conference, Florence, Italy	17.09.2017	22.09.2017
Bergit	Brattekås	University of Stavanger	IOR symposium Stavanger	25.04.2017	25.04.2017

2017 student exchange programs

PhD student Kun Guo, Univ. of Stavanger, Norway – visit at China University of Petroleum

Project Name: Nano Particles and Heavy Oil
Institution: University of Stavanger
PhD student: Kun Guo
Project Supervisor: Prof. Zhixin Yu and Prof. Svein Skjæveland
Institution Visited: China University of Petroleum
Hosted By:
Period: December 1st, 2016 – January 15th, 2017

Project Summary:

The objective of this project is to perform a systematic study on the effect of metallic nanoparticles on enhanced heavy oil recovery. It aims at exploring the parameters of the nanoparticles (metal type, particle size, shape, content, etc.) and the effects of the thermophysical properties of nanoparticles containing fluids on the recovery efficiency. The characteristics of the heavy oil before and after the catalytic reactions together with the gas phase product will be studied. In this way, the actual chemical reactions could be elucidated and the main cause of viscosity reduction due to metallic nanoparticles could be clarified.

PhD student Aojie Hong, Univ. of Stavanger, Norway – visit at University of Texas Austin

Project Name: CRM as a proxy model for production optimization and VOI assessment
Institution: University of Stavanger, Department of Petroleum Engineering
PhD student: Aojie Hong
Project Supervisor: Professor Reidar B. Bratvold, University of Stavanger
Institution Visited: University of Texas Austin, Petroleum and Geosystems Engineering
Hosted By: Larry W. Lake, Sharon and Shahid Ullah
Period: January 2nd 2017 to June 30th 2017

Project Summary:

Over the past decades, numerical techniques for model-based optimization of subsurface hydrocarbon production have developed rapidly. However, many of these techniques come at significant computational time, as they require a very large number of reservoir simulations, especially for the case where multiple geological scenarios of a grid-based reservoir simulation model are used for geological uncertainty consideration.

Several methods have been proposed to reduce the computational time. One of them is to use a proxy model to supplement a grid-based model under the optimization process. The Capacitance-Resistance Model (CRM) has been shown to be quite accurate for waterflooding systems. Thus, it is a potential candidate to serve as a proxy model. Besides, the CRM for Enhance Oil Recovery (EOR) processes is under development.

A more advanced application of the CRM is to assess the Value of Information (VOI) from history matching. Because VOI assessment involves a large number of production optimization processes, the requirement of computational time reduction is more essential for VOI assessment.

The objectives of visiting the University of Texas at Austin are to collaborate with Prof. Larry Lake who leads a group of experts in CRM, to share the ideas about assessing the VOI from history matching and to search for the applicability of using the CRM as a proxy model for production optimization and for VOI assessment. Through this collaboration, I can learn more about the CRM and the counterpart can learn more about the concept of VOI.

PhD student Shaghayegh Javadi, Univ. of Stavanger, Norway – visit at University of California, Santa Barbara

Project Name: Experimental Investigation of fluid chemistry effect on adhesive properties of calcite crystals
Institution: University of Stavanger, Petroleum Technology Department.
PhD student: Shaghayegh Javadi
Project Supervisor: Dr. Anja Røyne, UiO, Physics Department & Prof. Aksel Hiorth, UiS, Petroleum Technology Department.
Institution Visited: University of California, Santa Barbara, Department of Chemical Engineering
Hosted By: Prof. Jacob Israelachvili, Professor of Chemical Engineering and Materials
Period: February 1st to mid-march 2017

Project Summary:

It has been known for some time that rock fluid interactions can impact the mechanical stability of chalk, however the observations have mostly been made on chalk cores. We believe that it is the short range forces between individual grains in the chalk cores that are affected by the fluid chemistry. In this project the objective is to quantify the short range forces between calcite grains (as the main component of chalk) by the use of Atomic Force Microscopy (AFM) and Surface Force Apparatus (SFA). This project is financed by the National IOR center of Norway, and the main experimental work has been performing at the University of Oslo, physics department since January 2015.

Master student Nitya Mohan, University of Houston – visit at University of Bergen

Project Name: Carbon dioxide sequestration using methane hydrates
Institution: University of Houston
Master student: Nitya Mohan
Project Supervisor: Prof. Michael Nikolaou, in collaboration with Prof. Arne Graue, University of Bergen, Norway, and Prof. George Hirasaki, Rice University
Institution Visited: University of Bergen, Department of Physics and Technology
Hosted By: Prof. Arne Graue and Associate prof. Geir Ersland
Period: January 2nd to January 15th and May 30th to July 19th

Project Summary:

To combat the adverse effects of atmospheric greenhouse gas on global climate, efforts have been undertaken to reduce CO₂ (carbon dioxide) emissions and/or find ways to sequester it. One such method recently proposed is CO₂ sequestration into CH₄ (methane) hydrates. Hydrates are crystalline solids, where CO₂, CH₄, or other low-molecular-weight compounds are captured in cavities of hydrogen-bonded water molecules. Hydrates are formed under high pressure and low temperature conditions. The majority of naturally occurring CH₄ hydrates are found in pore spaces of sediments along the continental margins and are prevalent in depths within a hydrate stability zone (HSZ).

The proposed CO₂ sequestration method involves injecting CO₂ produced from industrial activities into such sediments to permanently replace CH₄. In this way, not only does the produced CO₂ get sequestered, but the CH₄ expelled can be used as fuel with proper production techniques developed for the same. Because CO₂ hydrates are thermodynamically more stable than CH₄ hydrates, the CO₂-CH₄ exchange process is thermodynamically favored. While the feasibility of proposed CO₂ sequestration technology has been pointed out in literature before, there is to date only a few studies that quantify the CO₂/CH₄ replacement process in hydrates, the specific conditions under which such exchange is favored, the efficiency and effectiveness of the approach, and the technological and economic pros and cons of the overall idea. This study aims to address the preceding issues through combination of experimental work in laboratory scale and numerical simulation on a computer.

Nitya Mohan's response after the exchange stay:

"I am grateful to the Department of Physics and Technology at the University of Bergen for hosting me for a good two months. It has been a great experience working and meeting the students and faculty. I was here to work with the Hydrates team. I visited the Hydrates lab and also performed an experiment for the formation of CO₂ Hydrates. Apart from that, I did some numerical simulations using CMG STARS to match the CH₄ hydrate depressurization experiments and got good matches with the numerical model. I also got the chance to visit StatOil at Sandsli with the team and we gave a short presentation of the Hydrates work we intend to do. We met a few people at StatOil and also saw their MRI imaging facility. It was an enriching experience to say the least. My two months in Bergen will be one of my most memorable times. The students have been so friendly and welcoming as have the faculty. As far as my personal trip goes, I explored the city with hikes to Floyen and Ulriken and also attended the Bergenfest. Summer time is beautiful. The people are amazing and the city is absolutely charming."

PhD student Mohan Sharma, University of Stavanger – visit at Rice University

Project Name: CO₂-Foam Onshore Field Pilots
Institution: University of Stavanger
PhD student: Mohan Sharma
Project Supervisor: Prof. Arne Graue, University of Bergen
Institution Visited: Rice University
Hosted By: Prof. George Hirasaki
Period: January 6th to January 21st

Project Summary:

Carbon dioxide has been successfully tested as EOR agent and used in fields, because of its properties of swelling oil, reducing oil viscosity and reducing residual oil saturation under miscible conditions. However, despite its high local displacement efficiency compared to other solvents, the process has poor sweep efficiency due to viscous fingering caused by unfavorable mobility ratio, and gravity segregation caused by density difference between injected and displaced phases. Based on success of laboratory coreflood experiments, it is proposed to improve conformance by injecting foamed CO₂, where foam reduces gas mobility away from the injectors and selectively isolates high permeability zones.

The research aims to identify mechanisms that are observed at lab scale and are required to describe flow at reservoir scale, under CO₂ foam flood by running field pilots. This research involve working with members of collaboration in characterization of numerical models for CO₂-foam pilots planned to be carried out onshore in USA, and sensitivity studies for various production/injection scenarios to understand control variables related to CO₂ foam flood at pilot scale.

PhD student Anna Kvashchuk, University of Stavanger – attended Geilo Winter School

Project Name: Linear Reconstructions for Second Order Finite Volume Schemes on Polyhedral Grids
Institution: University of Stavanger/The National IOR Centre of Norway
PhD student: Anna Kvashchuk
Project Supervisor:
Institution Visited: Geilo Winter School
Hosted By: André Brodtkorb
Period: January 15th to January 20th

Project Summary:

In January 2017 Anna Kvashchuk attended the annual Geilo winter school organized by SINTEF. The school is a meeting place where young researchers can collaborate and exchange ideas and experience. The school last for six days and includes a lot of lectures given by international experts in the field.

There is also reserved time for social events such that participants could establish collaboration and build up professional network.

The theme of Geilo Winter School 2017 was machine learning, deep learning, and data analytics. Machine learning gains a lot of interest and development over the last decade. It has a wide range of applications and became a commonly used tool in many areas. The school provides an introduction to this promising technique, which I could use later in my own research.

Anna Kvashchuk presented a poster with the theme “Linear Reconstructions for Second Order Finite Volume Schemes on Polyhedral Grids”.

Master student Daniel Csanadi, Montan Univesity – visit at University of Bergen

Project Name: CO2 foam flooding with Integrated Storage and EOR
Institution: Montan Univesity
Master student: Daniel Csanadi
Project Supervisor: Prof. Dr. Holger Ott
Institution Visited: University of Bergen
Hosted By: Prof. Martin Fernø, University of Bergen
Period: February 12th to 26th

Project Summary:

The Montan University of Leoben is a MoU-University with the Petroleum Research School of Norway, and this project was the first collaborative research effort and exchange of personnel between the institutions.

Carbon Dioxide (CO₂) has been used as a commercial source for Enhanced Oil Recovery (EOR) for over 40 years. In recent years, the utilization of anthropogenic CO₂ has become more attractive, because of its proven EOR and climate mitigating capability. Despite the EOR potential, it is widely known that many CO₂ injection projects are associated with inefficient gas utilization, poor macroscopic sweep efficiencies and low recoveries caused by effects of gravity segregation and viscous instabilities. Effective and affordable optimization of CO₂ mobility has the potential to prolong the lifetime of existing hydrocarbon reservoirs and recover additional oil with carbon-neutral EOR activity.

The aim for the research is to combine laboratory results with up-scaling techniques to generate robust models for CO₂-foam injections in field pilots. Using Eclipse reservoir simulator, a history matching of the experimental results will be performed. The aim is to obtain satisfactory history match between simulated and laboratory data by conducting sensitivity parameter studies. A validated numerical model, i.e. a model that reproduce the experimental results observed, may be used for upscaling from the laboratory scale towards the field pilot scale.

PhD student Anders Matheson, Iris – attended Summer School on Data Assimilation and its Application in Oceanography, Hydrology, Risk & Safety and Reservoir Engineering in Sibiu, Romania

Project Name: Summer School on Data Assimilation and its Application in Oceanography, Hydrology, Risk & Safety and Reservoir Engineering in Sibiu, Romania
Institution: Iris, Bergen
PhD student: Anders Matheson
Project Supervisor: Andreas Stordal
Institution Visited: Transilvania University, Sibiu, Romania
Hosted By: Dr. Remus Hanea, Prof. dr. Marin Marin and Prof. dr. Arnold Heemink
Period: July 17th to 28th

Project Summary:

The program features lectures from leading researchers in the field, covering both the fundamental concepts of data assimilation, as well as the application of these methods for a variety of problems. Both of these topics are central to my research project. There is also time reserved for social and cultural events so that the participants can establish collaborations and build their professional network.

PhD student Yiteng Zhang, Iris – attended Summer School on Data Assimilation and its Application in Oceanography, Hydrology, Risk & Safety and Reservoir Engineering in Sibiu, Romania

Project Name: Summer School on Data Assimilation and its Application in Oceanography, Hydrology, Risk & Safety and Reservoir Engineering in Sibiu, Romania
Institution: Iris, Bergen
PhD student: Yiteng Zhang
Project Supervisor: Andreas Stordal
Institution Visited: Transilvania University, Sibiu, Romania
Hosted By: Dr. Remus Hanea, Prof. dr. Marin Marin and Prof. dr. Arnold Heemink
Period: July 17th to 28th

Project Summary:

The program features lectures from leading researchers in the field, covering both the fundamental concepts of data assimilation, as well as the application of these methods for a variety of problems. Both of these topics are central to my research project. There is also time reserved for social and cultural events so that the participants can establish collaborations and build their professional network.

Master student Ivar Sørheim, Iris – attended the course “Russian foreign policy and international energy cooperation” at MGIMO in Moscow, Russia

Project Name: Russian foreign policy and international energy cooperation
Institution: NTNU
Master student: Ivar Sørheim
Project Supervisor: Harald Arne Asheim
Institution Visited: MGIMO in Moscow, Russia
Hosted By:
Period: July 17th to 28th

Project Summary:

This is a course focusing on topics such as the Norwegian-Russian petroleum cooperation in the Barents Sea, with a special focus on the Shtokman project.

Cooperation in the Barents Sea between Norwegian and Russian companies is the key to developing this area in the future. With background from Russia, and language-skills, Ivar Sørheim can be a unique resource facilitating collaboration across borders. The future development of resources in the arctic will only become increasingly important as technology develops and oil & gas demand increases. This course was an attempt to learn more about the challenges in the Russian-Norwegian relationship in the arctic.

Ivar Sørheim's response after the course:

«Etter å ha fullført kurset ser jeg virkelig verdien av å ta et slikt kurs. Jeg har benyttet anledningen til å knytte nettverk med flere studenter og professorer i Russland og andre land fra EU og på tvers av kloden. Det var interessant å se forskjellige land sitt perspektiv på energisituasjonen (spesielt gass forsyning til EU). Jeg tror at for fremtidig samarbeid med andre land er slike kurs vesentlig for å ha en forståelse for andre land sine perspektiver.»

PhD student Jaspreet Sachdeva, University of Stavanger – visited Memorial University of Newfoundland (MUN), Canada

Project Name: Chalk reservoirs deforming during the injection of seawater-like brines and evaluation of how different wettabilities dictate the mechanical properties of chalk
Institution: University of Stavanger
PhD student: Jaspreet Sachdeva
Project Supervisor: Anders nermoen
Institution Visited: Memorial University of Newfoundland (MUN), Canada
Hosted By: Lesley James
Period: August 1st to October 1st

Project Summary:

It was planned to carry out studies for wettability estimation using different techniques at Hibernia EOR Laboratory at Memorial University of Newfoundland (MUN) during a period of two months. The project proposal at MUN involved using Kansas outcrop chalk samples (impure), alter core wettability by systematic aging variation, and to determine the wettability index (WI) using contact angle measurements, standard Amott-USBM, and SEM-MLA imaging techniques. Determining WI using these techniques will enable comparison with the WI estimation by in-house chromatographic separation technique (Strand et al., 2006) at UoS.

The aim of this was to use a systematic approach with four different methods to quantify the degree of uncertainty linked to a) WI estimation, and, b) the aging procedure to control wettability of impure chinks. The main objective of these tests, as stated above, was to determine if it is possible to control wettability in Kansas chinks. The repeatability of the WI estimate was tested, i.e. how equivalent experimental protocols lead to repeatable results. WI was determined for different core samples after aging at 90°C for varying aging time.

The visit facilitated a common understanding of how wettability of chinks can be controlled and measured, and facilitates knowledge transfer between institutions. It was a starting point of long term collaboration between NIORC/UiS and MUN.

PhD student Zachary Alcorny, University of bergen – visited Houston several times for project meetings

Project Name: CO2 Foam Enhanced Oil Recovery in Field Pilots
Institution: University of Bergen
PhD student: Zachary Alcorny
Project Supervisor: Arne Graue
Institution Visited: Rice University and field operators
Hosted By: George Hirasaki
Period: Several periods during 2017

Project Summary:

An international collaboration, including 13 universities/research institutions and 10 oil and oil service companies in Europe and USA, combines expertise and the common goal to develop and test CO2 foam systems with mobility control at laboratory and field pilot scale to optimize CO2 integrated EOR and aquifer deposition. CO2 foam systems for mobility control will be developed and tested in four inexpensive confirmed onshore US field pilots, in both clastic and carbonate reservoirs. Assisted by field experience from the US pilots CO2 Foam EOR for field implementation on NCS will be developed.

The project for Zachary Alcorny emphasize on the geological description and reservoir characterization of the fields, conduct relevant CO2 EOR core floods and participate in the numerical up-scaling. The development of new foam systems within the participating institutions in the project will be used by the candidate in core analysis in the laboratory. The research team has experience in development of surfactant systems that generates foam and lowers mobility in the absence of oil, while selectively not foaming in the presence of residual oil. The project will use surfactant systems that form stable foam also in the presence of CO2 residual oil. Thus, these surfactants may be used for selective mobility control in regions without oil or with CO2 residual oil, while allowing CO2 to flow efficiently and produce oil in regions where the oil saturation is higher. Current fundamental knowledge of the physics of foam behavior in heterogeneous rocks is inadequate to satisfactorily describe and predict fluid flow and thus oil recovery. Existing models can describe foam behavior in oil-free systems. A general characteristic of many surfactant systems is that the foam is unstable in the presence of oil at even low saturations. The candidate will focus on core visualization processes and advanced characterization and modeling methods that give a better understanding of CO2 foam. The experimental results will be implemented in a commercial simulator and used to create a validated numerical model to predict the outcome of the field pilots. The integration of experiments and modeling from the pore-level to the field level will lead to new fundamental knowledge and optimized EOR foam strategies.

Researchers within the research team have previously developed formulations for CO2 foam mobility control in both sandstone and carbonate formations. An important finding of this research is that one formulation does not fit all reservoirs. A distinction must be made between sandstone and carbonate/chalk lithologies due to different adsorption characteristics. The candidate will study foam injection for gas mobility control and improved sweep efficiency in heterogeneous reservoirs as a targeted area in a context of upscaling the results to field scale using numerical tools. The experimental values will be used to validate the numerical model with respect to included mechanisms and correlations. The numerical model will be tuned to reproduce the experimental data before an up-scaling approach is adopted for investigation of reservoir heterogeneities and combined EOR techniques.

2017 Board Meetings

Three Board Meetings were held in 2017; Jan. 12th, Sep. 25th and Nov. 10th. Additionally, four case circulations were executed.

2017 Chairman Activities

NFiP and NorTex were promoted by visits and presentations at: Univ. of Texas A&M, Corpus Christi, TX, USA, Rice Univ. and Univ. of Houston, TX, USA, USC, CA, USA, AGH U. in Krakow, Poland, ConocoPhillips, Bartlesville, OK, USA, Imperial College, BP Sunbury and CSLF in London, UK, Repsol, Madrid, Spain, USDOE, Washington DC, USA, CSLF, Abu Dhabi, UAE, DGH in New Delhi, India and OED, NPD and NRC in Norway.

Chairman of the Executive Board of NFiP and NorTex Petroleum Cluster has participated/presented at various occasions and events.

Selected invited scientific talks by the Chairman and coordinator; where NFIP and NorTex were presented:

1. Graue, A.: "CO₂ Foam EOR for Mobility Control in Two Field Pilots in Texas", BP Research Center, Sunbury, UK, Febr. 16th, 2017.
2. Graue, A.: "Two Ongoing Field Pilots in Texas - CO₂ Foam EOR for Mobility Control", US-Norway Bilateral, Climit Summit, Oslo, March 8th, 2017
3. Graue, A.: "CO₂ Foam EOR for Mobility Control – Two Field Pilots in Texas", Univ. of Houston, Houston, TX, USA, March 30th, 2017.
4. Graue, A.: "Upscaling CO₂ Foam EOR for Mobility Control from Lab to Field Pilots", Repsol, Web seminar, April 26th- 27th, 2017.
5. Fernø, M.: "Applications of CO₂ as CCUS: Efficient, Cost Saving and More Sustainable Petroleum Production", Presentation for Norway's Minister of Petroleum and Energy, UoB, April, 2017.
6. Alcorn, Z. P. Sharma, M., Fredriksen, S.B., Rognmo, A.U., Fernø, M.A., and Graue, A.: "CO₂ Foam for Mobility Control for EOR and CO₂ Storage in Heterogeneous Reservoirs", Rice University Consortium Meeting on Flow in Porous Media, Houston, USA, April 5th, 2017.
7. Graue, A.: "Upscaling CO₂ Foam EOR from Lab to Field Pilots", Rice University Consortium Meeting on Flow in Porous Media, Houston, USA, April 5th, 2017.
8. Graue, A.: "CO₂ EOR in Conventional and Unconventional Reservoirs", Repsol, Madrid, May 18th, 2017.
9. Graue, A.: "Upscaling CO₂ Foam EOR for Mobility Control - from Lab to Field Pilots", US-Norway Bilateral CCUS Meeting – USDOE Washington DC, August 28-29th, 2017
10. Graue, A.: "Proposed Business Models for Bilateral Collaboration on Monitoring CO₂ Foam EOR in On-Shore Texas Field Pilots and for International Whole Value Chain CCUS Collaboration Offshore", US-Norway Bilateral CCUS Workshop – USDOE Washington DC, August 30th, 2017.
11. Graue, A.: "CO₂ Foam EOR and CO₂ Injection in Hydrates – CCUS Enablers for Efficient, Cost Saving and More Sustainable Oil & Gas Production", Air Liquide Research Center, Newark, DE, USA, Sept. 27th, 2017.
12. Alcorn, Z. P. Sharma, M., Fredriksen, S.B., Rognmo, A.U., Føyen, T.L., Fernø, M.A., and Graue, A.: "CO₂ Foam Enhanced Oil Recovery Field Pilots", CO₂ for EOR as CCUS Conference, Houston, TX, USA, Oct. 4-6th, 2017.
13. Graue, A.: "CO₂ Foam EOR and CO₂ Injection in Hydrates – CCUS Enablers for Efficient, Cost Saving and More Sustainable Oil & Gas Production: Offshore International Whole Value Chain CCUS Collaboration", "CO₂ for EOR as CCUS", Rice Univ., Houston, TX, Oct. 4-6th, 2017.
14. Graue, A.: "CO₂ Enables Petroleum as Energy Security in More Sustainable Energy for the Future", Senioruniversitetet i Bergen, November 15th, 2017.
15. Graue, A.: "CCUS Enablers for Efficient, Cost Saving and More Sustainable Oil & Gas Production", Annual NFIP Seminar, Thursday November 16th, 2017.

NFiP Web-site

The NFIP web-site was updated in 2017: <https://nfip.no/>

The NFIP secretariat, at Dept. of Physics and Technology, UiB, with Assoc. Prof. Martin Fernø as coordinator, and Else Johannesen as secretary, has been of great value for the 2017 activities.

January 25th, 2018.

Arne Graue

Chairman of the Executive Board