DrillWell

DRILLING AND WELL CENTRE
FOR IMPROVED RECOVERY

ANNUAL REPORT 2015

IRIS

SINTEF

Universitetet i Stavanger

NTNU

sfi Centre for Research-based Innovation

The Research Council of Norway

DrillWell

DRILLING AND WELL CENTRE
FOR IMPROVED RECOVERY

About DrillWell

DrillWell (The Drilling and Well Centre for Improved Recovery) was appointed status as Centre for Research Based Innovation (SFI) by the Research Council of Norway in 2011. IRIS is the host, with SINTEF, UiS and NTNU as research partners. The Centre has five industrial partners; Statoil, Wintershall, ConocoPhillips, Det Norske and Lundin Norway. DrillWell is an industry-driven collaboration and innovation environment. The industrial partners give priority and direct the R&D effort towards particular challenges. The Centre is living proof of Stavanger and Trondheim joining forces together with the international oil and gas industry.

The annual budget was approximately NOK 35 million in 2015, and has been stable since the start-up of the Centre. NOK 10 million is granted from the Research Council of Norway, and the five industry partners contribute with a total of NOK 25 million annually. During 2015, three PETROMAKS2 projects have been granted funding by the DrillWell partners and the Research Council of Norway. One INTPART project has been granted funding from the Research Council. The full effect of these spin-off projects will be seen in 2016 and the budget volume will be increased accordingly.

A total of about 50 researchers, ten professors and associate professors, seven PhD candidates and ten graduated MSc students have contributed to the Centre in 2015. This resulted in approximately 50 papers and publications, several keynote speaches and popular publications. An advanced cuttings transport model has been made commercially available through Sekal AS. The Centre organizes one large seminar annually and distributes the DrillWell Newsletter quarterly.

CONTENT

DRILLWELL 2015

DrillWell has developed into an important contributor to innovative drilling and well technology, and interacts closely with the participating oil companies in directing the efforts towards generating useful results. The centre was further strengthened by Lundin Norway joining in 2015. It was an important milestone to get such an important player on the Norwegian Continental Shelf on-board.

The focus on well construction cost reduction increased as the oil price declined and is today the main target of the centre. Reduced costs are important both for exploration and field development, as well as life time extension of producing fields and well plugging and abandonment. The scientific quality of the research has been secured through the establishment of a Scientific Advisory Committee, being involved in developing the Phase 2 plan.

Important results are presented at international conferences and in journal papers. Results of high value to the industry have been obtained within drilling process optimisation, well control, cement integrity and permanent plugging and abandonment of wells. Jesus de Andrade successfully defended his PhD thesis in November. The six additional PhD students involved in Phase 1 will defend their theses during 2016.

The international cooperation is being expanded and is expected to increase the impact of the centre with respect to exploitation of results, science and visibility. By taking the initiative to create a collaborative environment - the NorTex Data Science Cluster, with INTPART funding from The Research Council of Norway, the cooperation with a group of universities in Texas has been expanded jointly with the SFI Offshore Mechatronics in Agder.

A successful seminar was arranged at Sola with participation of the research partners, the participating oil companies and the Research Council. Key recent results were presented and discussed, and were supplemented with presentations from the oil companies on related topics. Key results have also been presented and discussed at the oil companies' offices in Mini-seminars.

DrillWell was successful in PETROMAKS2 applications resulting in three spin-off projects with substantial additional funding, implying that the centre has an annual budget close to NOK 50 million per year in the years to come.

In Phase 2 the scope of work will be focused on Drilling Process Optimisation, Well Control, Cement Integrity and Plug and Abandonment. High level scientific work will be combined with the development and testing of prototype software and tools aiming to unlock petroleum resources.

Sigmund Stokka

Sigmund Stokka
DrillWell Manager, IRIS

DrillWell
DRILLING AND WELL CENTRE
FOR IMPROVED RECOVERY

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Drilling and Well Centre for Improved Recovery

VISION

Unlock petroleum resources through better drilling and well technology.

OBJECTIVE

Improve drilling and well technology providing improved safety for people and the environment and value creation through better resource development, improved efficiency in operations and reduced cost.

Cost reduction
Innovative drilling and well technology is needed to reduce exploration and development costs, as well as well plugging and abandonment.

Improved recovery
Improved wells at lower cost will imply higher recovery of oil and gas by increasing the number of wells and their productivity.

Efficient field development
Improved wells at lower cost will imply cost-efficient field development. Today wells represent 50-60% of the field development cost.

PEOPLE IN DRILLWELL

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ConocoPhillips

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Det norske oljeselskap

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Kjell Kåre Fjelde
UiS

Helga Gjeraldstveit
IRIS

Anouar Romdhane
SINTEF

SCIENTIFIC ADVISORY COMMITTEE

In 2015 DrillWell established a Scientific Advisory Committee (SAC). The Committee is composed of international experts within drilling and well technology that cover the scope of work carried out in DrillWell.

- *The main task of the SAC is to advise and evaluate the scientific performance of DrillWell in relation to the Centre's vision, objective and research plans including PhD projects. The SAC will meet with the Centre's Management Team and Project Leaders once a year. Between meetings, the Centre Director is encouraged to seek advice from the SAC on important decisions relating to the scientific performance of DrillWell, especially for PhD projects.*

SAC's mandate was approved by the Centre board at the DrillWell board meeting in May 2015. The following international experts are members of SAC:

SAC had several meetings in October and November. They provided valuable advice for Phase 2 and especially initiated the work on knowledge gaps and frontiers of knowledge in all the projects.

JOHN THOROGOOD

DRILLING ENGINEERING ADVISOR AT DRILLING GLOBAL CONSULTANT LLP

Following 34 years with BP, now an independent consultant with 43 years industrial experience in drilling engineering and operations. Activities include advisory roles to operators on management systems, frontier exploration projects in deep water and remote areas, shale gas operations, process safety, well control and forensic reviews of operational problems, development and implementation of new technology and R&D programme management.

KITT ANITA RAVNKILDE

ACTING HEAD OF DRILLING & PRODUCTION TECHNOLOGY, DANISH HYDROCARBON RESEARCH & TECHNOLOGY CENTRE, DTU

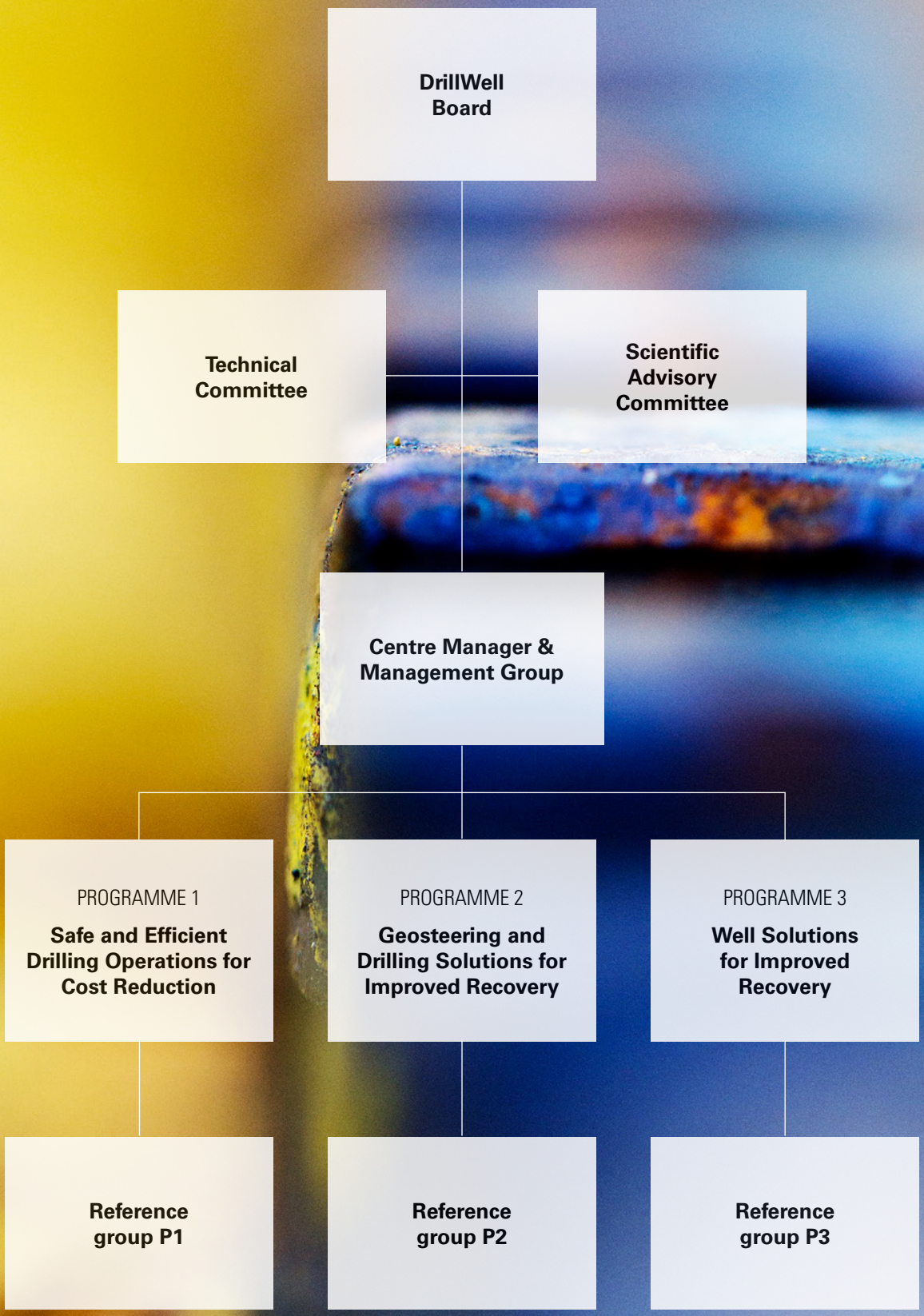
Started her engineering career with Mærsk Oil holding various positions of technical character over a period of 16 years. In April 2015, she was appointed Head of Drilling & Production Technology at DTU. The work involves building up the group to provide the framework for international research and to lay the foundations for relevant, research-based study programmes with the potential to support interdisciplinary and interdepartmental research programmes, merge the scientific results into equipment and services which are provided to the offshore industry.

ANDREW K. WOJTANOWICZ

TEXACO ENVIRONMENTAL CHAIR AND PROFESSOR IN THE CRAFT AND HAWKINS PETROLEUM ENGINEERING DEPARTMENT AT THE LOUISIANA STATE UNIVERSITY:

Had faculty positions at the New Mexico Institute of Mining and Technology and the AGH University of Science and Technology in Krakow, Poland. A UN expert in drilling engineering. Wojtanowicz worked for the oil industry as a drilling engineer, drilling supervisor, and drilling fluids technologist in Europe and Africa. His studies have been reported in 206 publications and eight books. He was Conoco Environmental Fellow 1990-91, served as Editor-in Chief of ASME Transactions Journal of Energy Resources Technology from 2000 to 2011, was SPE Distinguished Lecturer 2003-04, and received several awards from SPE and ASME.

DRILLWELL ORGANISATION



INDUSTRY PARTNER PERSPECTIVES

Stein Børre Torp Statoil

The DrillWell SFI is contributing to improved quality of the drilling process and thus reduced field development investments related to drilling and well construction. Prototype tools for assisting the operational drilling process control are developed and prepared for implementation in existing systems used by the industry partners.

Through industrialization and commercialization of the applications, the results of the SFI work is made available for the industry in general. As an industry partner we appreciate the opportunity to influence the scientific direction of the programme which, for Phase 2, is focusing on four key elements of the life-cycle of oil and gas wells.

Rune Woie ConocoPhillips

The DrillWell programme aligns well within the operators' R&D project portfolio where high impact programmes on both drilling optimization and Plug & Abandonment are key to deliver cost efficient methods and solutions.

The collaboration between academia and operating companies are important for the development of a fit for purpose solution including the ability to deliver results throughout the project phase.

During the next phase of the programme the balance between continued implementation of developed technologies and the development of new cost efficient methods is key for DrillWell success.

Terje Andre Pedersen Det norske oljeselskap

The DrillWell programme has contributed positively towards minimizing the drilling cost of conventional wells and by increasing the probability of reaching drilling targets in a safe way. Within technology for Plug and Abandonment (P&A) of wells in particular, the DrillWell programme has presented significant potential improvements. The projects have improved the knowledge of cement durability and creation of micro-annuli. Some of the test methods within these enterprises have also been considered by service companies to be used to improve their performance.

Also, the research programme has focused upon understanding gas loading and solubility of gas into oil based drilling fluids. The solubility is different for different base oils. This understanding is expected to increase the safety of drilling operations; especially while drilling HPHT wells.

Jan Roger Berg Lundin

The DrillWell Center is a cooperation between the main offshore operators and petroleum R&D institutions, in Norway. It provides an R&D environment which addresses several critical aspects of well technology. A solid scientific foundation has been established in several of the projects. For Lundin Norway it is of vital importance that the research effort is accompanied with an increased effort to merge the scientific results into equipment and services which are provided to the offshore industry.

Torgeir Larsen Wintershall

The R&D program in DrillWell addresses some key challenges within drilling and well technology. It is a strong consortium between the main operators on the NCS and the R&D partners IRIS, SINTEF, NTNU and UiS. For Wintershall it is important that DrillWell produces results and solutions that are useful for the industry. We want to see new solutions that can reduce operational cost and the cost of P&A significantly. The centre has over the last period produced promising results enabling more efficient and predictable operations.

INDUSTRY PARTNERS

Statoil ConocoPhillips DETNORSKE Lundin Norway wintershall

Developing long-term R&D excellence

New research grants and findings from the projects underpin DrillWell's a excellence in 2015. The mission to turn performance into industrial results central to develop a lasting excellence within P&A and drilling optimizatio

«Our focal point is to deliver applicable results to our industrial partners», assures Kristin Flornes, board member of DrillWell and Senior Vice President of IRIS Energy. In 2015, the center received an additional 3 years grant as Center for Research-based Innovation (SFI) under the Research Council of Norway. The process implied a comprehensive evaluation of DrillWell's performance, resulting in stronger guidelines for the organization and its tasks.

«We have prepared a research plan for Phase 2, which splits our three research programmes into two main areas; Plug and Abandonment (P&A) and drilling optimization. In addition, we have assembled a Scientific Advisory Committee and prepared a detailed communication plan», Flornes affirms.

INCREASED SPIN-OFF

Through its industrial partners Statoil, ConocoPhillips, Det norske oljeselskap, Wintershall and Lundin (from March 2015), DrillWell qualifies for several public funding schemes that require partial industrial funding. In 2015, such spin-offs resulted in two grants from the PETROMAKS2 program under the Research Council, as well as two projects from EU´s HORIZON2020 regarding geothermal well technology.

«DrillWell's personnel include the best scientists from its research partners SINTEF, NTNU, University of Stavanger and IRIS. Based on evaluations by international panels of experts, we are Norway´s national team within drilling and well research», Flornes states.

PROMISING RESULTS

Key findings from DrillWell in 2015 include full scale experimental results which support leaving tubing in the hole when plugging and abandoning a well, laboratory results regarding down-hole cement integrity under varying temperatures, a new model for transport of cuttings, and a drilling optimization plan.

«Due to long-term research processes, some findings are built on previous results, which now enter the final phases of testing and verification», Flornes says.

After five years of scientific work, DrillWell has sharpened its R&D profile. The Board now ascertains a growing impatience to implement DrillWell's findings into industrial operations.

«We have located our niche, the conditions for cooperation are optimal, and we have established a firm relationship of trust with our industrial partners. Tight dialogue and implementation opportunities are secured through a reference group for each project», Flornes states.

MASSIVE UPSIDE

According to DrillWell's Chairman Stein Børre Torp with Statoil, the industrial partners hold a large stake in the centre´s research. The current low oil prices dictate a sharpened focus on cost reduction in the industry, which now mirrors the DrillWell's strategy.

«By developing P&A and drilling optimization research, DrillWell focuses the effort where we can achieve top quality results and thereby make a difference. On the other hand, these areas are increasingly important to the industry», Torp states.

When planning a field development, the oil companies make large financial provisions for field cessation including plugging and abandonment of the wells. There is a large potential to be gained from simpler P&A procedures, which would allow for smaller provisions and more capital available for investment purposes.

The project «Tubing left in hole» shows promising results in this regard.

«Still some research and testing remain. If we can leave the production tubing in the hole, both the environment and the industry will be winners», states Torp.

Another DrillWell project of high industrial value is a model for real-time evaluation of hole cleaning by performing transient cuttings transport modelling, a project headed by Chief Scientist Eric Cayeux at IRIS. Sufficient hole cleaning is mandatory in drilling operations, and annual costs run in the billions of NOK. The upside corresponds to an optimization estimate of 25 percent.

«We highly value this model's real-time monitoring capabilities, which provide more predictability to the drilling operation», Torp says.

Improved predictability is also the potential for the DrillWell project on drilling optimization, developing an optimization plan to reduce non-productive time during drilling operations. Even minor improvements could imply substantial savings.

NEED TO DISTINGUISH

DrillWell Chairman Torp's analysis points to a further need for experimenting and testing in order to realize the potential from DrillWell's research.

«If we want to establish an R&D environment to continue the efforts beyond the periode with public grants, we must distinguish ourselves in several ways. We are planning for this, and international collaboration is a key in DrillWell's upcoming profiling efforts. The centre needs to be presented as a unity, not as the sum of the research partners' institutions. They have to collaborate efficiently in the projects, not just allocate tasks between themselves. We have to communicate to the world that DrillWell delivers results», Torp concludes.

Stein Børre Torp,
Chairman of the Board

Kristin Margrethe Flornes,
Board Member

Jan Einar Gravdal,
Programme Manager

PROGRAMME 1:
Safe and Efficient Drilling Operations for Cost Reduction

In a time when cost efficient drilling and well operations is receiving more focus than ever, DrillWell's programme on Safe and Efficient Drilling Operations for Cost Reduction is extremely relevant.

Half of the total cost for a field development in the North Sea consists of the drilling and completions costs (Source: Petoro). Cost reduction, without compromising safety, is of major importance to make new oil and gas fields profitable and to increase oil recovery from existing fields. This research programme aims to deliver technology to improve drilling safety and performance as well as avoiding drilling related problems.

The work in 2015 has spanned from fundamental research to the development of industrial prototypes. Experimental work in the laboratories in Stavanger, Bergen and Trondheim, in addition to the implementation of models from earlier research, has formed the basis for high fidelity computer models. Some of these have reached a very high quality and are recognized internationally in the drilling & well community.

In particular, a novel **transient cuttings transport model** is seen as a very valuable contribution with great potential.

The model for **hook load correction** is also promising, and has in 2015 been evaluated by service companies for commercial use.

Two projects have been run within this programme in 2015:

- Drilling Process Optimization
  (Project Manager: Eric Cayeux)
- Determining Changes in Oil-based Mud during Well Control Situations (Project Manager: Harald Linga)

Experiments in Stavanger and Trondheim will be a part of Programme 1 also in the years to come. The projects are now to a larger extent focusing on testing of prototype software and implementation together with the oil companies.

Meet Anja Torsvik, researcher at SINTEF

At SINTEF's petroleum laboratory in Bergen, among drilling mud samples and advanced testing equipment, you can find Anja Torsvik, researcher within Drilling and Well.

PROGRAMME 1

Name: Anja Torsvik

Age: 44

Education: MSc in molecular biology, PhD in biomedicine, both from the University of Bergen

Department: Drilling and Well, SINTEF

Anja, what are you working on right now?

I am working on a DrillWell project called "Gas influx in oil-based mud". In this project I have performed experimental work to study the impact of gas influx in oil-based drilling fluids at HPHT conditions. I have measured saturation point, density and viscosity for a number of gas/drilling fluid mixtures at temperatures up to 200°C and pressures up to 1000 bar. The results from my measurements can be used as input for computational models for kick detection.

So, in other words, your research results can contribute to safer wells on the Norwegian Continental Shelf?

Yes, that's correct. Gas influx during drilling may lead to serious well control problems. If not detected and handled in time, it may lead to an uncontrolled gas kick. Current kick models are mainly based on measurements at lower temperatures and pressures, and extrapolated to HPHT conditions. In my work I have recorded data at HPHT conditions, so that well control models can be based on true values instead of extrapolations. Results from this project show that there is a significant difference in calculations when using experimentally supported models compared to standard models, so performing these kinds of measurements prior to challenging well operations will improve the safety for the operators on the oil rigs.

Do you see any other future usages of your research results?

Oh yes, quite a few actually, for instance knowledge from this DrillWell project can also be relevant within other research fields. Better understanding of gas/fluid interactions can for example be applied in the development of CCS technology (CCS – Carbon Capture and Storage).

It sounds like there are many benefits working in a research centre with both academic and industry partners?

Absolutely! Through various meetings and seminars, DrillWell offers a unique arena to discuss the ongoing work with industry partners and to learn about the challenges of the petroleum industry. This inspires and gives rise to new project ideas based on problems that the industry needs to address.

Obviously, a lot of things are happening in your research area, where do you see yourself in ten years' time?

By then I have ten more years of experience within the field of petroleum research and I have been the project leader of many interesting research projects related to challenging drilling conditions, gas/fluid interactions and petroleum fluid rheology. I also hope to initiate projects where I can utilize knowledge from my former background, for example microbial precipitates for well integrity or EOR. My goal is that my research from both DrillWell projects and other projects, will contribute to new improved technology solutions for the petroleum industry.

PROGRAMME 1

Drilling process optimisation

Our approach is that the more we know of the processes downhole, the better our ability to drill safer and more efficiently. Downhole instrumentation, as well as accurate and reliable mathematical models play an important role. Through the scientific contributions in Programme 1 we have moved the research front towards better understanding the complex physical processes taking place during well construction.

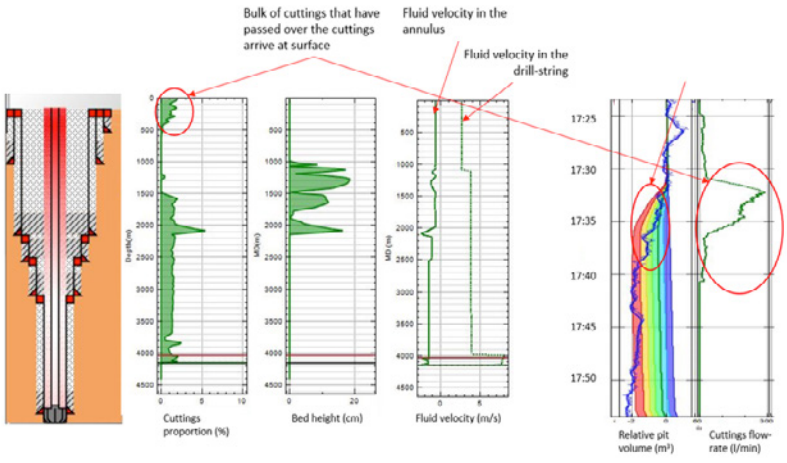
In particular, the transient cuttings transport model developed in the project Drilling Process Optimization, has gained attention and may contribute to large savings. Development of the model is led by Chief Scientist Eric Cayeux at IRIS. The model has drawn attention both nationally and internationally because of its ability to predict in real time the formation and degradation of cuttings beds and the transport of cuttings in suspension. Validation of the model against field data from several North Sea drilling operations has shown very good results.

Sufficient hole cleaning is of major importance during well drilling. The costs associated with cuttings circulation adds up to several billions NOK each year.Estimates show that up to 25% reduced time can be achieved by optimizing of hole cleaning procedures.

– If our model can help to reduce circulation time when cleaning the well we have delivered a major contribution to reduce drilling costs, says Sigmund Stokka, Manager of DrillWell.

In 2015 the model has been incorporated in a planning software, DrillOpPlan, which is now being tested with the oil companies in DrillWell.

For more information about the model, see Cayeux et al (SPE 163492, 2014) and Cayeux et al. (IADC/SPE 178862, 2016).



Comparison of transient cuttings transport model and field data: Drilling at 4150 mMD in the 8 ½-inch section in a North Sea well. The inclination is 40 degrees from around 1000mMD and 80 degrees from around 3000 mMD. Cuttings proportion and cuttings bed height along the well is calculated in real time, as well as cuttings flow rate out of the well. The active volume drops when the cuttings are separated at the shakers. The time and magnitude of the measured reduction in active volume corresponds very well with the predictions.

PROGRAMME 1

Gas in oil based mud

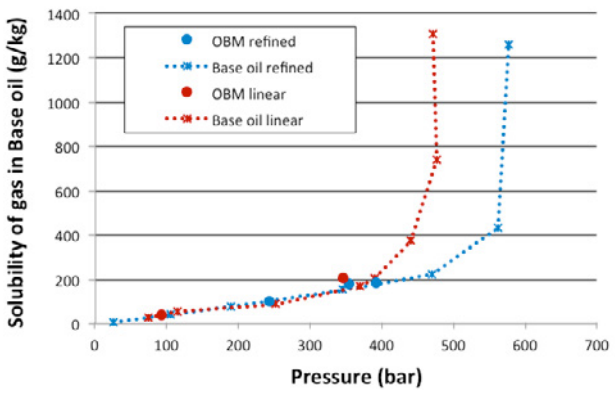
The understanding of formation gas mixed with oil-based muds (OBM) is essential for the planning and execution of safe drilling operations.

Absorption of reservoir fluids and gas leaking from a reservoir into the drilling mud may occur even in an overbalance situation and is more pronounced the higher the pressure. The capability to detect gas at an early stage and to estimate the influx volume is critical. Accordingly, for the selection of drilling mud, such drilling mud features should clearly be addressed, and the operational procedures adjusted accordingly.

In this study two classes of oil-based muds are investigated, one with normal mineral base oil, and one with linear paraffin base oil. The latter is often used in High Pressure High Temperature (HPHT) drilling operations.

The characteristics of gas influx is investigated by experimental studies of the methane-OBM equilibrium conditions at pressure and temperature conditions ranging from standard temperature and pressure conditions to HPHT; 200 deg C/1000 bar. The OBM gas loading characteristics is derived from the determination of the two-phase envelope of methane and OBM. The phase envelope is determined from pressure-volume characteristics of accurately controlled volumes of OBM and methane as fed into a closed cylinder and exposed to internal mechanical fluid mixing, safeguarding fast gas-liquid equilibrium. The two-phase envelope towards single phase liquid is determined for selected temperatures and gas mass fraction of methane in the gas-liquid mixture.

In addition to the gas loading characteristics, the impact on rheology and fluid density from gas loading and predictive performance of commercial software is studied. A separate task on gas absorption kinetics will be completed in 2016.



Gas solubility characteristics at 60 °C for the two classes of fluids compared; refined "normal" mineral base oil, linear paraffin base oil and the corresponding drilling fluids. It is observed, with reference to the figure, that the maximum methane gas loading capabilities for the two OBMs are quite similar and follow a linear relation between max gas mass loading in the liquid vs. pressure at pressures below 400 bar. However, at higher pressures the performance of the OBMs differs distinctively, where far more gas can be absorbed in the OBM with linear paraffin base oil. This OBM enters into the dense phase region at pressures exceeding 400-450 bar, for which the solubility of gas into the liquid goes to infinity. The dense phase region is encountered at approximately 100 bar higher with the normal mineral base oil, reflecting far more attractive characteristics with respect to the capability for gas kick detection and well control.

Anouar Romdhane,
Programme Manager

PROGRAMME 2:
Geosteering and Drilling Solutions for Improved Recovery

On the Norwegian continental shelf (NCS), the costs for drilling wells are high and the remaining hydrocarbons are often located in complex reservoirs.

The drilling of horizontal wells with less surface infrastructure requirements is an adopted strategy in many assets to reduce drilling costs. Consequently, optimal well placement is very important to maximize production from horizontal wells, and is today crucial for the success of IOR projects and field developments.

Well planning is based on pre-drill information (e.g. from surface seismic, offset wells, geological knowledge) with large uncertainties. Geosteering is the process of adjusting the initial well trajectory based on measurements made while drilling, which can include Seismic While Drilling (SWD) and Logging While Drilling (LWD) measurements. In this context, the recently introduced deep electromagnetic (EM) LWD is considered a major enabling technology for proactive geosteering.

When integrated through efficient workflows, measurements acquired near the drill-bit provide valuable information to modify the well trajectory in real-time and maximize recovery and production. However, the current work processes for geosteering are sub-optimal;

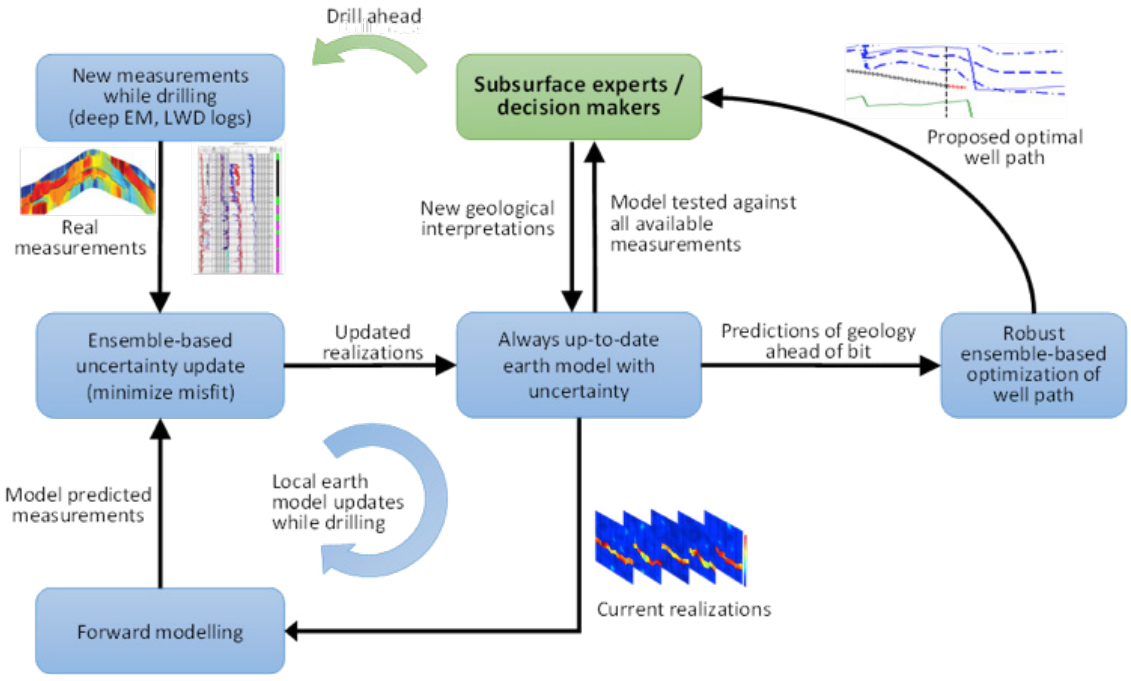
(a) It is highly challenging to develop a methodology that integrates, processes the data generated while drilling (Can be large data set with new LWD sensors), and then calibrate the existing geomodels.

(b) Current earth model representations are not flexible enough to enable effective local updates and handling of complex interpretations while drilling.

(c) There is a clear need for transparent, systematic and consistent workflows that handle complex geological uncertainties while making geosteering decisions.

Our objective in this programme is to develop a new methodology for geosteering where the geomodel is continuously updated based on measurements acquired during drilling. We combine and improve:

a) An ensemble-based geosteering workflow to effectively update the geomodel and the well trajectory under uncertainty during drilling,
b) Advanced 3D seismic and EM tools for modelling and inversion,
c) A new strategy for flexible 3D earth model representation that supports local updates of structure, grid and properties, multi-scale modelling, and local scale uncertainty management,
d) A prototype for decision analytics under uncertainty, and
e) A seismic interferometry methodology for target-oriented imaging.



Meet Sergey Alyaev, researcher at IRIS

At IRIS's Bergen office, there is a young Russian guy you for sure will notice when you visit. Not so much because he wears shorts in the middle of the winter, but because of his energetic appearance and enthusiasm for his field of research.

PROGRAMME 2

Name: Sergey Alyaev

Age: 29

Education: Specialist degree from Saratov State University in Mechanics

Master degree from University of Bergen in Applied and computational mathematics

PhD candidate at University of Bergen, Department of Mathematics

Department: IRIS Drilling and Well Modelling

Hi Sergey, you always seem like you have a lot going on, what are you working on right now?

I am working in the project "Geosteering for Improved Recovery" aiming to provide an integrated solution for assisted geosteering. The project ties together our knowledge from physical and earth modeling, statistical updates and robust optimization, and demonstrates capabilities of all those tools working together to improve reservoir mapping and decision support in geosteering. In 2015 I was helping the team to create a joint prototype to show-case the new workflow. I presented our concept and early results at the Annual Symposium of Society of Petrophysists and Well Log Analysts as well at the annual DrillWell seminar.

At the moment we are trying to apply the knowledge from the geosteering activities to a new project called "Reduced uncertainty in overpressures and drilling window prediction ahead of the bit" that will start in early 2016.

It sounds like an interesting project, what do you in particular find inspiring about it?

The project gave me the opportunity to learn more about ensemble-based optimization and use my creativity for solving particular challenges presented by the oil industry.

So, you say that working in a research centre with both academic and industry partners is beneficial to your research?

That's right. Since DrillWell has tight relations with industrial partners, it opens up for a lot of possibilities. For instance, we got the chance to follow real geosteering operations in ConocoPhillips. This experience reveals every day challenges of oil companies much better than any scientific paper can explain.

So, with all these exciting activities going on in your research field, is this what you will be working with in the future as well?

I hope that the projects we are working on will contribute, among other things, to the dissimilation of ideas that rigorous, computer-assisted workflows can be of use in many industrial applications as well as in everyday life. With this in mind, in 10 years I see myself tending to a management role for building a better, research-driven society.

Deep imaging, geosteering, flexible earth model

The work in 2015 focused on close collaboration with the industry to learn from their geosteering processes, and to identify both how to adapt our suggested workflow to the industry's requirements and how our strategy could contribute to improving existing workflows. An integral part of this work was to identify geosteering cases complex enough to address realistic challenges, yet not too complex to be handled in the present prototype software tools.

We reviewed the geology and production history of a field on the NCS, and participated in a geosteering operation to study the pre-drill geological interpretations, the measurements received while drilling that are used to update the interpretations in this particular field, and the software tools used for support of the decision making process when steering the well. A particular focus was given to deep EM readings and inversion, and how these measurements are applied to steer the well.

In a synthetic case study, we addressed some specific geosteering challenges encountered in a field with many years of production history. Uncertainty in the estimation of water saturation, reservoir boundaries and fault locations were modelled in an integrated framework combining SINTEF's 3D electromagnetic simulator and IRIS' ensemble Kalman filter (EnKF) tool.

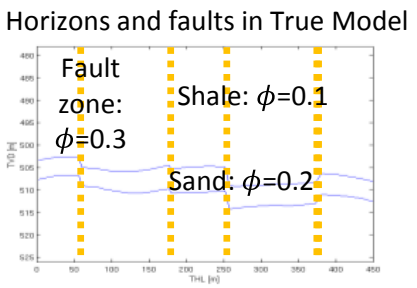
A set of model realizations were set up prior to the drilling operation, and EM measurements were used to modify the realizations while drilling.

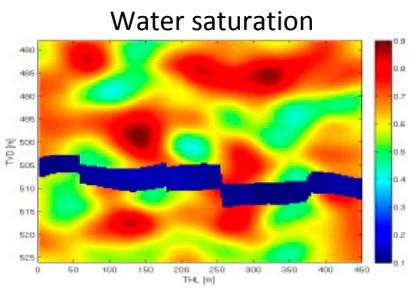
The upper figure shows the True Model with reservoir boundaries and four vertical faults. Porosity is assumed constant for sand, shale and fault zones, respectively.

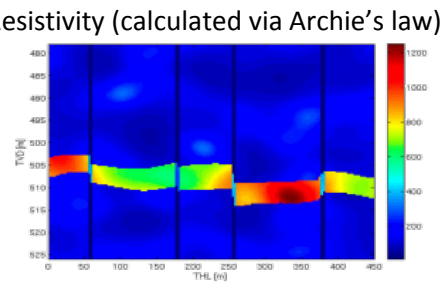
The true water saturation is also displayed, together with the true resistivity calculated from Archie's law. In the lower figure, uncertainties are only shown for the top reservoir boundary in blue, not for the bottom boundary, the faulting or the water saturation.

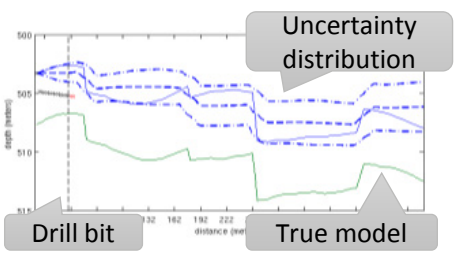
The figure indicates how the initial uncertainties (left) in the reservoir top boundary and fault locations are reduced as deep EM measurements are received while drilling (middle and right). Also the uncertainties in water saturation were reduced. It is easy to extend the developed framework with new and different LWD logs which would further reduce uncertainties.

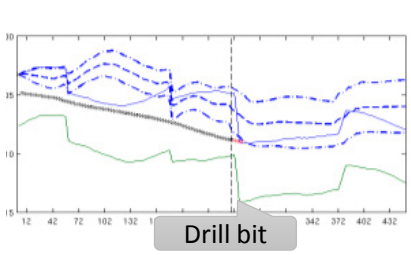
The results were reported in Luo el al., 2015, a conference paper for the 56th SPWLA symposium.

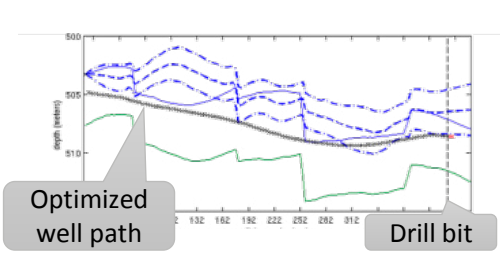








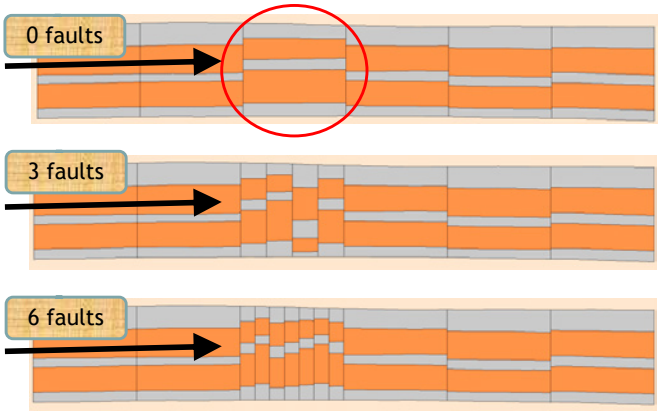




The Flexible Earth Model developments focused on local updates of the geological structure and grid around and ahead of bit while drilling. We demonstrated our locally adaptive gridding strategy by generating multiple realizations representing conceptually different interpretations of the geological evolution in a region ahead of bit. In the figure, the region ahead of bit initially contains no faults. As part of a synthetic uncertainty study while drilling, two new realizations of the geology in the region were automatically generated, one with three and one with six new vertical faults. Each of two realizations was automatically inserted into the global grid as a local update. These two local scale realizations are independent of the rest of the model, and therefore have the flexibility to represent an interpretation of any type of geological evolution.

For direct EM inversion, a synthetic study, using both simple and more realistic reservoir models, has been performed to evaluate the added value of using advanced electromagnetic modelling in the context of model updating while drilling. The effects of faulting and drilling fluid invasion have been studied for various transmitter/antenna combinations. Preliminary inversion tests with the EM 3D inversion tool highlighted the capability of the method to provide a qualitative indication of the presence of a fault ahead of the drill bit.

Within decision analytics under uncertainty, two methods have been adapted to support decision making while drilling; the Myopic method where we optimize only one decision ahead, and the Dynamic Programming (DP) method where the aim is to reach an optimal combination of sequential decisions. DP has been successfully applied in various industries. The methods were compared by calculating optimal well paths over sets of different reservoir geometries given a set of geosteering objectives. On average, the improvement in the net value of the well was between 3% and 31% when using DP instead of the more basic Myopic method.



Regarding seismic interferometry, the developed interferometric scheme, which can be used to perform target oriented imaging, was further tested. Drill-bit noise as well as a combination of surface and borehole seismic data were used. The studies show that the developed scheme may constitute a complementary method to better image and verify existing structures near the well. The results were reported in journal papers in Liu et al., 2016a, Liu et al., 2016b. They were also presented at SEG and EAGE 2015 conferences.

Torbjørn Vrålstad,
Programme Manager

PROGRAMME 3:
Well Solutions for Improved Recovery

Well solutions can contribute to improved recovery in several ways. In Programme 3, the main approaches so far have been on prolonging well lifetime by improving well integrity, reducing costs and uncertainties during plug & abandonment operations, and increasing production by improving water shut-off.

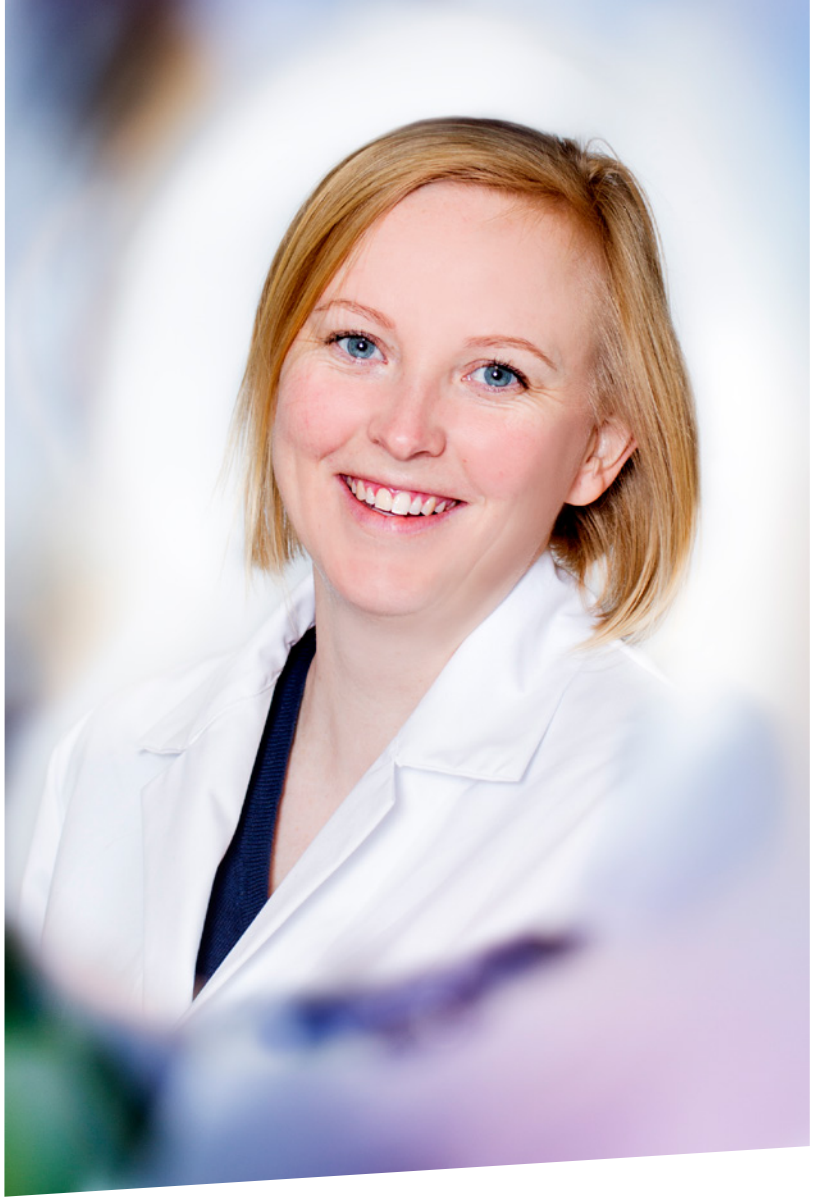
The emphasis in Programme 3 has however been on cement integrity. This work was initiated in DrillWell and it is pleasing to see that within just a few years we have attracted the attention and recognition of operators, service companies and universities alike. For example, a unique experimental set-up for the determination of cement sheath integrity during thermal cycling has been developed, where it is possible to quantify crack formation and debonding as well as the visualization of leak paths and fluid flow. Results from this work have been presented and discussed at various domestic and international events, most recently at the SPE Thermal Well Integrity and Design Symposium in Banff, Canada, and have always been well received. Furthermore, the full-scale cementing tests with tubing left in hole have also attracted attention, and will be presented at the IADC/SPE Drilling Conference and Exhibition in 2016.

An important milestone during 2015 was the successful PhD defense of Jesus De Andrade at NTNU. He is the first PhD student in DrillWell to finish, and thus also the first PhD student in Programme 3 that finishes. He made significant contributions to the work on cement integrity and the successful completion of his thesis was well deserved. There are now three remaining PhD students in Programme 3, so 2016 should bring us three additional PhD defenses to look forward to.

Currently, the work in Programme 3 is in the middle of the transition from Phase 1 to Phase 2 of the DrillWell centre. In Phase 2, the work will be focused even more on various aspects of cement integrity and plug & abandonment. The projects in Programme 3 now cover a comprehensive portfolio, which was recently strengthened by the addition of two KPN projects from the PETROMAKS program. It will therefore be exciting to follow the work during the upcoming year.

Projects in Programme 3:

- P3.2 Life-cycle well integrity
  (Project Manager: Torbjørn Vrålstad)
- P3.3 Improved plug and abandonment
  (Project Manager: Torbjørn Vrålstad)
- P3.4 Chemical water shut-off
  (Project Manager: Dimitrios Hatzignatiou)



Meet Ragnhild Skorpa, researcher at SINTEF

In the innermost of SINTEF's petroleum laboratory in Trondheim, we find a young researcher with a special passion for cement.

PROGRAMME 3

Name: Ragnhild Skorpa

Age: 29

Education: MSc in inorganic chemistry, PhD in Theoretical/physical chemistry. Both from NTNU

Department: Drilling and Well, SINTEF

Ragnhild, I see cement samples all over your desk. A wild guess; cement is a central component in your current research project?

That's correct, I work with thermal cycling experiments to investigate the integrity of a cement sheath located between a formation and a casing. In the DrillWell research centre we have developed a unique laboratory setup to perform realistic and controlled thermal cycling experiments of downscaled samples consisting of rock, cement and casing.

Why do you find this interesting?

The annular cement sheath is one of the most important well barrier elements in the well, both during production and after abandonment. Research related to understanding the mechanisms behind loss of zonal isolation, to help prevent this in the future, inspires me.

You work in close collaboration with the oil and gas industry, would you say this adds any extras to the project?

Undoubtedly. For instance, one gets a more accurate picture of the challenges the industry faces. It is of great benefit to get a chance to work with highly relevant projects and research to provide solutions the industry really needs.

Especially at the moment, we see changes in the industry. Do you see yourself working within oil and gas in ten years' time?

I cannot see why not. By then I have 10 more years with experience of the petroleum industry and I have had the chance to work with many challenging and interesting projects both experimental and theoretical related to the petroleum industry, some purely academic but mostly in close collaboration with the industry.

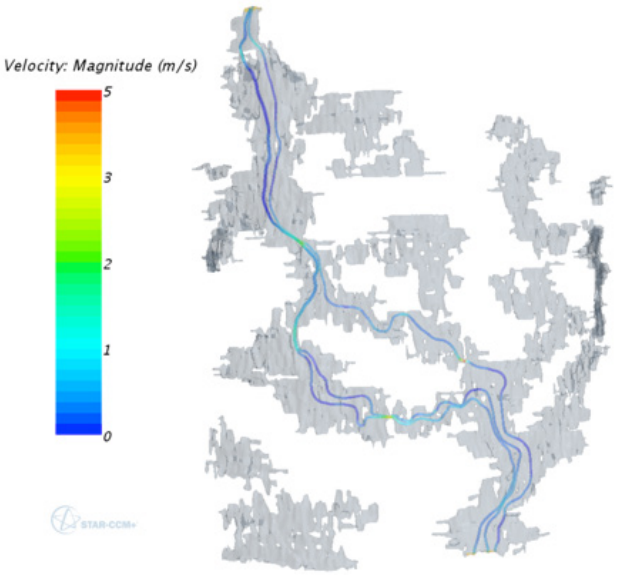
PROGRAMME 3

Life-cycle well integrity

Well integrity during production can be improved by including an emphasis on well integrity already in the well planning phase. By having such an initial life-cycle well integrity approach, several problems and costs can be avoided during production, thereby prolonging well lifetime.

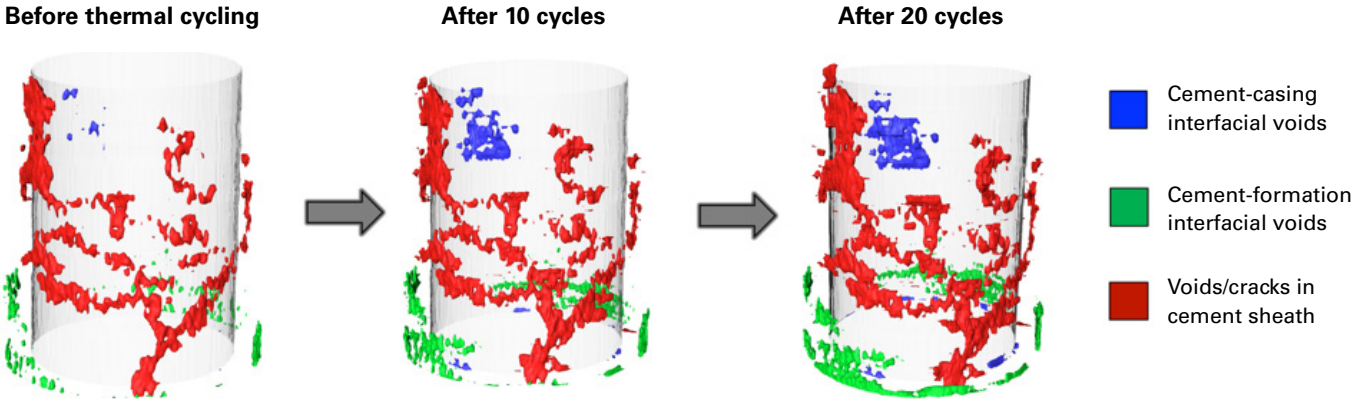
One of the most important well barrier elements is the annular cement sheath, both during production and also after well abandonment. Temperatures in the well cycle up and down as a part of normal production operations, and this thermal cycling can have a detrimental effect on the integrity of the cement sheath. An improved understanding of cement degradation mechanisms will therefore be valuable during well planning, in order to avoid subsequent well integrity problems during production.

A tailor-made laboratory set-up has been built in this project to study the effect of thermal cycling on the integrity of different annular sealants such as cement. The formation of microannuli and cracks in the cement sheath during thermal cycling is visualized in 3D by X-ray Computed Tomography (CT), and the obtained CT data can be imported into a Computational Fluid Dynamics (CFD) simulation tool in order to visualize and quantify fluid flow through the created leak paths in the degraded cement. A unique feature of this method is the ability to distinguish between debonding towards the casing, debonding towards the formation, and cracks formed inside the cement sheath itself.



CFD simulation of fluid flow through cracks in degraded cement sheath. The flow is complex and not easily predicable (Vrålstad et al., 2015).

Major findings so far have been that cement integrity during thermal cycling is dependent upon initial well conditions, such as casing centralization, type of rock, and presence of initial defects in the cement sheath.



CT visualizations of cement sheath integrity during thermal cycling. Initial defects present in the cement grow together during cycling to form a continuous leak path through the cement sheath, i.e. resulting in a loss of zonal isolation (Vrålstad et al., 2015).

PROGRAMME 3

Improved plug and abandonment

Thousands of wells need to be plugged and abandoned at the NCS in the next few decades, which will be both time-consuming and costly. As most plug and abandonment (P&A) operations currently require drilling rigs, it is important to find less time-consuming and more cost-effective methods for P&A operations.

For example, a significant portion of time consumption during P&A operations is spent on removing steel tubular from the well. If the production tubing could be left in the well instead of removed, considerable time and cost could be saved, especially for subsea wells since a drilling rig is required

Picture of 7" tubing cemented inside 9 5/8" casing. Good cement placement is obtained when tubing is left in hole.

for tubing removal. By leaving the tubing in hole, the P&A operation can be simplified and thus potentially be performed rig-less. However, a major concern with such an approach is whether the cement can be properly placed in the annulus due to lack of tubing centralization.

In this project, full-scale tests have been performed to determine if it is possible to obtain a good cement seal when tubing is left in hole. 7" tubings were cemented with both conventional and expandable cement inside 9 5/8" casings, with and without control lines. The quality of the cement placement was evaluated by pressure tests with water, and by visual inspection after cutting the test assemblies at different places. It is seen from the experiments that it is possible to obtain good cement placement when tubing is left in hole.

Furthermore, two PhD students are also involved in the project. One PhD student is preparing and testing different types of rock-like materials known as "geopolymers", and is determining their potential as plugging materials. The other PhD student is developing a probabilistic method for cost and time estimation of subsea multi-well P&A campaigns, which can be used as a planning tool to optimize time consumption during P&A operations.

Picture of 7" tubings cemented inside 9 5/8" casings.

PROGRAMME 3

Chemical water shut-off

After several years of field production, most wells start producing water in addition to oil and gas. This unwanted water production reduces the amount of produced oil and gas, and it is therefore important to find good water shut-off methods in order to improve recovery.

In this project, environmentally friendly, water-soluble silicate systems are used for water management and shut-off applications. Laboratory-based screening and evaluation of a sodium silicate system has been carried out for managing water production in carbonate naturally fractured reservoirs. Furthermore, the addition of certain polymer additives was also studied to evaluate potential improvements on formed gel properties.

Proper understanding of the water source and the reservoir characteristics are of paramount importance for effectively addressing water production problems. The use of environmentally friendly silicates for total zone (near-well and deep-formation) isolation is so far promising.

DrillWell expands with three new projects

During 2015 DrillWell has expanded its project portfolio with three new projects supported by the Research Council of Norway's PETROMAKS2 programme and the industry partners of DrillWell. The projects fit very well with the ongoing activities in DrillWell, and complement the ongoing projects.

CEMENTING IRREGULAR WELLBORE GEOMETRIES

The objective of the project is to improve the current understanding of mud displacement and cement placement in wellbores with irregular shapes, such as hole enlargements and cavities. To achieve this, we plan to conduct displacement and cementing experiments and to develop a numerical model for simulation of the displacement process. The first displacement experiments in the project are planned to take place during the first half of 2016. The project is a collaboration between IRIS and SINTEF, and the University of Stavanger will host a PhD student in the project. International collaboration is planned with the University of British Columbia, Canada.

Project Manager is Hans Joakim Skadsem: **hans.joakim.skadsem@iris.no**

LEAKAGE RISK ASSESSMENT FOR PLUGGED AND ABANDONED OIL & GAS WELLS

The primary objective of this project is to develop a methodology for evaluating the quality of the barrier system of a permanently plugged and abandoned well by expressing the quality of the barrier system in terms of leakage probability and potential future leakage rates. This will be a collaboration project with IRIS and SINTEF as the main partners. The project will benefit from cooperation with the DrillWell industry partners and with the academic partners University of Stavanger, Oklahoma State University and Missouri University of Science and Technology.

Project Manager is Øystein Arild: **oystein.arild@iris.no**

REDUCED UNCERTAINTY IN OVERPRESSURES AND DRILLING WINDOW PREDICTION AHEAD OF THE BIT

The objective is to simulate and predict pressure and mud window ahead of the bit, with special attention to analysis of uncertainties. The uncertainty for both pressure and mud weight window will be automatically narrowed as new updates of pore pressure while drilling is included. The three-year research project will be a collaboration between IRIS, NTNU, École des Ponts and SINTEF Petroleum Research, with tight communication with the DrillWell Centre.

Project Manager is Ane Elisabeth Lothe: **ane.lothe@sintef.no**

The Research Council of Norway

SFI OFFSHORE MECHATRONICS

DrillWell and SFI Offshore Mechatronics collaborating partners

From the left: Jan Einar Gravdal, *IRIS*; Thomas Meyer, *Universitetet i Agder*; Kristin Flornes, *IRIS*; Marit Dolmen, *GCE NODE*

Offshore Mechatronics was first out of 17 new SFI's (Centres for Research-based Innovation) which started in 2015 and which have been given SFI status and granted funding from the Research Council in November 2014.

For DrillWell, with its focus mainly on downhole processes, the collaboration with the SFI in Agder is very complementary. There are many interesting areas for collaboration and in particular, within data analytics and the shared benefit from projects that relate to data variety, volume and velocity (Big Data). SFI Offshore Mechatronics will work on several topics primarily related to top-side machinery and process control, such as hydraulics, motion compensation, robotics, automation and monitoring.

International collaboration

NEW INTPART PROJECT

In 2015 DrillWell accelerated its international collaboration through the new PETROMAKS2 projects and an initiative to establish a long term partnership between Norway and U.S. DrillWell and SFI Offshore Mechatronics have initiated the NorTex Data Science Cluster, a joint collaboration with the U.S research partners.

In October 2015 the collaboration project NorTex Data Science Cluster was granted funding from the Research Council of Norway's INTPART programme. This is a collaboration project initiated by DrillWell and SFI Offshore Mechatronics in Agder, together with Rice University and University of Texas at Austin. IRIS has lead the work with the proposal and is the project leader as host of DrillWell.

The project will finance several activities to stimulate and promote research collaboration between Norwegian and U.S. partners, not limited to the mentioned partners, but will include other academic institutions or industrial companies. Among the activities in 2015 were planning of two workshops for OTC in Houston 2-6 May 2016.

The topics are Drilling & Well Technology, P&A and Research Infrastructure. Speakers are invited from both industry and universities in Texas and Norway. A summer school at NTNU and UiA in June 2016 has also been planned.

With the proposed NorTex Data Science Cluster the partners will generate a long-term active partnership under the already established NorTex umbrella. NorTex is built on the existing initiatives carried out by the Norwegian Consulate General in Houston, Innovation Norway, INTSOK, and the Norwegian-American Chamber of Commerce in Houston.

The main area of focus for the NorTex Data Science Cluster is to initiate and expand collaboration on education and research within Data Science and Data Analytics between universities and industry in Norway and Texas, and further to integrate relevant industry into the different university collaborations.

Project Manager is Fionn Iversen:
fionn.iversen@iris.no

NORTEX DATA SCIENCE CLUSTER | Offshore Data Analytics Drilling & Well Technology

IRIS | GCE NODE GLOBAL CENTER OF EXPERTISE | UNIVERSITY OF AGDER | RICE | TEXAS | SFI OFFSHORE MECHATRONICS | DrillWell DRILLING AND WELL CENTRE FOR IMPROVED RECOVERY

OTHER INTERNATIONAL COLLABORATION PARTNERS:

Delft University of Technology

Oklahoma State University

Missouri University of Science and Technology

Danish Hydrocarbon Research and Technology Centre

École des Ponts, Paris-Tech

University of British Columbia, Vancouver

DrillWell

DRILLING AND WELL CENTRE
FOR IMPROVED RECOVERY

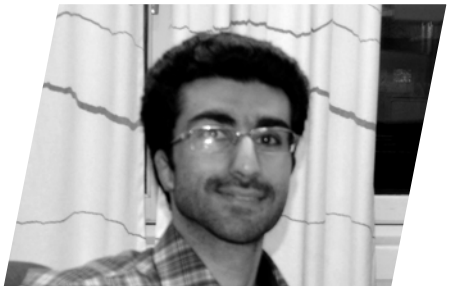
PhD students

KANOKWAN KULLAWAN

Department: Petroleum Engineering, Specialization: Petroleum Investment and Decision Analysis

Main topic of PhD Thesis: Bayesian Framework for Real-Time Optimization of Well Placement

Main contribution to the research field: The overall objective of this project is to improve the decision quality of geosteering processes by introducing a decision analytics framework for geosteering operations. Having a well-established decision process will enable the team to better incorporate a large amount of real-time data, experiences, and expertise to achieve high quality decisions faster.



REZA ASKARINEZHAD

Department: Petroleum Engineering

Main topic of PhD Thesis: Produced Water Management - Chemical Water Shutoff

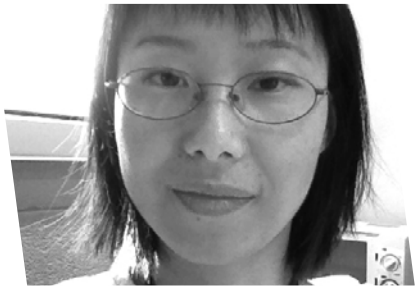
Main contribution to the research field: This project addresses the use of chemicals to control/minimize the production of unwanted water in wells. Although chemical water shutoff techniques are not new and have been applied in numerous wells/fields worldwide, challenges related to environmental constraints, fluid production patterns, and various formation types dictate the use of innovative approaches for new cost-effective solutions in high watercut wells.

ERICH SUTER

Department: IRIS Energy – Drilling & Well modelling and UiS – Petroleum Engineering

Main topic of PhD Thesis: Local Earth Model Updates while Drilling

Main contribution to the research field: New concepts for locally adaptive earth model gridding, including local structural updates, multi-scale gridding and local uncertainty management.



YI LIU

Department: Petroleum Engineering and Applied Geophysics

Main topic of PhD Thesis: Robust Target-oriented Imaging near Borehole

Main contribution to the research field: New method of combining borehole and seismic data to image near the borehole without accurate velocities.

MAHMOUD KHALIFEH

Department: Petroleum Engineering

Main topic of PhD Thesis: Materials Optimized for P&A Performance

Main contribution to the research field: Introducing two new geopolymeric materials. During this PhD work, two new geopolymeric materials were produced and investigated regarding their usability for P&A and zonal isolation. These produced materials are environmental-friendly and have the potential to be used for civil engineering applications.

FATEMEH MOEINIKIA

Department: Petroleum Engineering

Main topic of PhD Thesis: Rigless P&A Technology Availability and Cost Effectiveness of Rigless P&A Operations

Main contribution to the research field: To improve the cost efficiency for P&A operations, a combination of rig-based and rig-less technologies can be employed. This project reviews potentials of light well intervention vessels (LWIV) for subsea well P&A. Correct estimation of cost and time is important for budgetary planning of well abandonment. In this thesis, it is discussed how to structure the probabilistic modeling in line with Oil and Gas UK Guideline for cost and time estimation of P&A operation.

First DrillWell PhD dissertation

In November 2015, Jesus Alberto de Andrade Correia completed his PhD dissertation as the first DrillWell PhD student. His dissertation was entitled: "Cement Sheath Integrity during Thermal Cycling".

The evaluation committee consisted of Associate Professor Runar Nygaard, Missouri University of Science & Technology, Technology Advisor Arild Saasen, Det norske oljeselskap and Adjunct Professor Tor Berge Gjersvik, NTNU. The title of the public lecture was «Recent advances in lost circulation preventive industry practices including the use of managed pressure drilling systems». The main adviser was Professor Sigbjørn Sangesland and co-advisers Professor Michael Golan and Senior Researcher Torbjørn Vrålstad from SINTEF Petroleum Research.

Correia's work is addressing the potential breach of long term well integrity caused by temperature cycling in the wellbore. He has addressed this problem by developing a novel laboratory set-up to investigate deformations and fractures in a scaled down section of a wellbore under pressurized conditions up to 500 psi confining pressure.

The deformation and failure in the cement sheath is characterized using acoustic emission events while running the experiments and inspecting the core between the temperature cycles using computer tomography (CT).

The experimental work main contribution is the design, development and construction of this novel testing apparatus. The use of CT scanning as part of this testing is a pioneering work which he contributed to. The experiments conducted gave new insights into the formation of permeable flow paths in the cement sheath. The second main area of investigation in the thesis is numerical modeling of the cement sheath integrity. The main novel contribution of this work is the evaluation of casing standoff effect on cement sheath integrity.

Jesus De Andrade is currently working at NTNU-IPT as a Post Doc on topics related to Well Integrity and Subsea Production Systems.

ACADEMY

The Centre organizes projects for MSc and PhD students to work on industry-defined topics within the three research programmes.

PhD students and post-doctoral fellows are employed by the University of Stavanger and NTNU.

A total of 51 Master students have completed their master thesis within DrillWell during the years 2012 to 2015, ten of these during 2015.

Communication and dissemination activities

Communication and profiling has been a prioritized issue for DrillWell during 2015, and the centre has accelerated its focus on being visible in different media.

DRILLWELL.NO

www.drillwell.no posts centre news on a regular basis.

NEWSLETTER

Newsletters are distributed every three months.

During 2015, DrillWell received good exposure in media. Teknisk Ukeblad wrote about the centre's research on well kick, while Adjacent Oil&Gas featured DrillWell and its ongoing research within simulation and drilling automation.

Several DrillWell researchers have been invited to conferences as key note speakers and session chairs.

Sigmund Stokka was invited to present and participate in the panel debate at the INTSOK UK – Norway Network meeting regarding decommissioning in Stavanger, on the 20th of May

In September, Jan Einar Gravdal and Fionn Iversen were keynote speakers at the Celle Drilling Conference and the SPE DSATS From Sensors to Solutions conference respectively.

In 2015, DrillWell started a series of mini seminars. The industry partners of DrillWell invited some of the project leaders to give lectures for specially invited people from their organizations. The content of the mini seminars has been on areas of particular relevance for the company's challenges in Norway.

DrillWell had its own stand at the Plug and Abandonment Seminar in Stavanger in October, and attended the SPE Bergen One-day Conference in April with stand and paper presentations.

DrillWell is active on LinkedIn, follow us!

From the left: Ragnhild Skorpa, Helga Gjeraldstveit, Kanokwan Kullawan and Fatemeh Moeinikia

The annual DrillWell technical seminar

About 30 DrillWell researchers, and 20 representatives from clients and cooperative partners were gathered at Sola Strand Hotel on September 22-23 for the annual DrillWell seminar.

They were all invited by DrillWell manager Sigmund Stokka, who opened the seminar by welcoming the new DrillWell board Chairman Stein Børre Torp from Statoil.

Presentations were given from all the three DrillWell programmes, both by DrillWell researchers, PhD students and by representatives from the clients.

DRILLWELL RESEARCHERS

Helga Gjeraldstveit	IRIS	Drilling and well technology
Jan Einar Gravdal	IRIS	Drilling physics
Fionn Iversen	IRIS	Drilling physics
Erich Suter	IRIS	Computer modelling
Erlend H. Vefring	IRIS	Drilling physics
Sergey Alyaev	IRIS	Computer modelling
Jostein Sørbø	IRIS	Drilling technology
Dave Gardener	IRIS	Drilling and well technology
Dimitrios Hatzignatiou	IRIS	Reservoir engineering
Arne Stavland	IRIS	Reservoir physics
Nils H. Giske	IRIS	Reservoir technology
Eric Cayeux	IRIS	Computer modelling
Benoit Daireaux	IRIS	Computer modelling
Erik Dvergsnes	IRIS	Drilling physics
Steinar Kragset	IRIS	Computer modelling
Hans Joakim Skadsem	IRIS	Computer modelling
Gunnstein Sælevik	IRIS	Drilling physics
Johnny Petersen	IRIS	Drilling physics
Rodica Mihai	IRIS	Computer modelling
Robert Ewald	IRIS	Computer modelling
Erlend Randeberg	IRIS	Drilling and well technology
Hans Petter Lohne	IRIS	Drilling and well technology
Sonja Moi	IRIS	Computer modelling
Xiadong Luo	IRIS	Reservoir modelling
Øystein Arild	IRIS	Risk analysis
Liv Carlsen	IRIS	Drilling physics
Reza Askarinezhad	UiS	Petroleum Engineering
Kjell Kåre Fjelde	UiS	Drilling physics

Helge Hodne	UiS	Fluid mechanics
Reidar Bratvold	UiS	Reservoir technology
Terje Kårstad	UiS	Computer science
Kanokwan Kullawan	UiS	Petroleum Engineering
Fatemeh Moeinikia	UiS	Petroleum Engineering
Mahmoud Khalifeh	UiS	Petroleum Engineering
Bård Bjørkvik	SINTEF	Reservoir physics
Knut Steinar Bjørkevoll	SINTEF	Well flow modelling
Anja Torsvik	SINTEF	Fluid rheology
Jan Ole Skogestad	SINTEF	Thermodynamics
Alv-Arne Grimstad	SINTEF	Reservoir physics
Idar Larsen	SINTEF	Reservoir physics
Torbjørn Vrålstad	SINTEF	Well integrity
Velaug Myrseth Oltedal	SINTEF	Well integrity
Ragnhild Skorpa	SINTEF	Well integrity
Bjørnar Lund	SINTEF	Drilling physics
Harald Linga	SINTEF	Drilling physics
Nils Opedal	SINTEF	Well Integrity
Jelena Todorovic	SINTEF	Well Integrity
Ane Lothe	SINTEF	Basin modellig
Johnny Frøyen	SINTEF	Numerics and software development
Anouar Romdhane	SINTEF	Seismics
Peder Eliasson	SINTEF	Seismics
Jan David Ytrehus	SINTEF	Drilling and well technology
Ali Taghipour	SINTEF	Drilling and well technology
Børge Arntsen	NTNU	Applied geophysics
Sigbjørn Sangesland	NTNU	Drilling engineering
Yi Liu	NTNU	Petroleum Engineering
Jesus Alberto de Andrade Correia	NTNU	Petroleum Engineering

DRILLWELL PUBLICATIONS

JOURNAL

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Flornes, K.M. 2015. "Improved recovery and the National IOR Centre of Norway", Stavanger meeting, Politicians and industry.

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IRIS


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DrillWell

DRILLING AND WELL CENTRE
FOR IMPROVED RECOVERY

Drilling and Well Centre for Improved Recovery

VISION

Unlock petroleum resources through better drilling and well technology.

OBJECTIVE

Improve drilling and well technology providing improved safety for people and the environment and value creation through better resource development, improved efficiency in operations and reduced cost.

CONTACT

DrillWell Manager: **Sigmund Stokka**
Email: sigmund.stokka@iris.no
Telephone: (+47) 51 87 52 88 / (+47) 90 13 97 76

Drilling and Well Centre for Improved Recovery
International Research Institute of Stavanger (IRIS)
Box 8046, N-4068 Stavanger, Norway
Prof. Olav Hanssens vei 15, NO-4021 Stavanger, Norway

More information:
www.drillwell.no

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